LEONARDO TIMES

Journal of the Society of Aerospace Engineering Students 'Leonardo da Vinci'

SPACE SHUTTLE ABORT MODES

A FASCINATING STORY ABOUT MAKING SPACE SHUTTLE OPERATIONS SAFER

Year 28 | N° 2 | Summer 2024


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EDITORIAL

PREPARING FOR NEW HEIGHTS

The academic year has come to an end, and so the final edition from the current editors of the Leonardo Times has been brought to your doorstep. This edition is once again filled with a large variety of articles with stories from all the different disciplines within the field of aerospace. We also have the pleasure to welcome yet another new Member of Honor of the VSV 'Leonardo da Vinci'! Arjan Meijer, currently the CEO of Embraer Commercial Aviation, will be installed together with Arnaud de Jong during the next Extraordinary Members Assembly in November in Delft.

The articles in this edition of the Leonardo Times tell about how engineering is able to push the boundaries of what is possible in the sky and in space. From the remarkable achievements of the two Voyager probes and their contributions to the scientific community, to the steps we have taken towards making space exploration accessible to people with disabilities, this edition showcases the role that space has in making our own world a better place. Furthermore, it delves into the topic of safety in aerospace operations, researching how today's aircraft flight safety manual evolved, and how safety was engineered into the abort modes of the space shuttle. These are just a few highlights of what is included in the journal you are holding in your hands.

I would like to close my last editorial by extending many heartfelt thank yous to all the people that have been involved in publishing this journal over the past year. First and foremost to Lisanne, our Managing Editor, and Arham, our Final Editor, for their hard work and dedication to making the most of our year managing the Leonardo Times, it was a pleasure to work alongside you these months! This year would not have been the same without the work of the team of Editors that contributed to the articles and texts in these four editions, we are all grateful for your motivation to always fill the pages with interesting and unique stories that give insights into the scientific (and non) aspect of the industry we all love. I would also like to thank Penny and Ralf for working with us to maintain the level of quality of the texts and layout that the journal has kept over the years.

And on this note, I would like to pass the torch to the next Board of the Leonardo Times Editors. Gerard and James, you have been an absolute pleasure to work with as Editors of the Leonardo Times, and we are all excited to see you take up the responsibility of managing the journal next year!

Finally, I would also like to thank you, our readers, for making this journal worth creating, and wish you an enjoyable read and a happy summer!

Yours truly,

Ruth Euniki Vraka
Editor-in-Chief,
Leonardo Times

Last edition...

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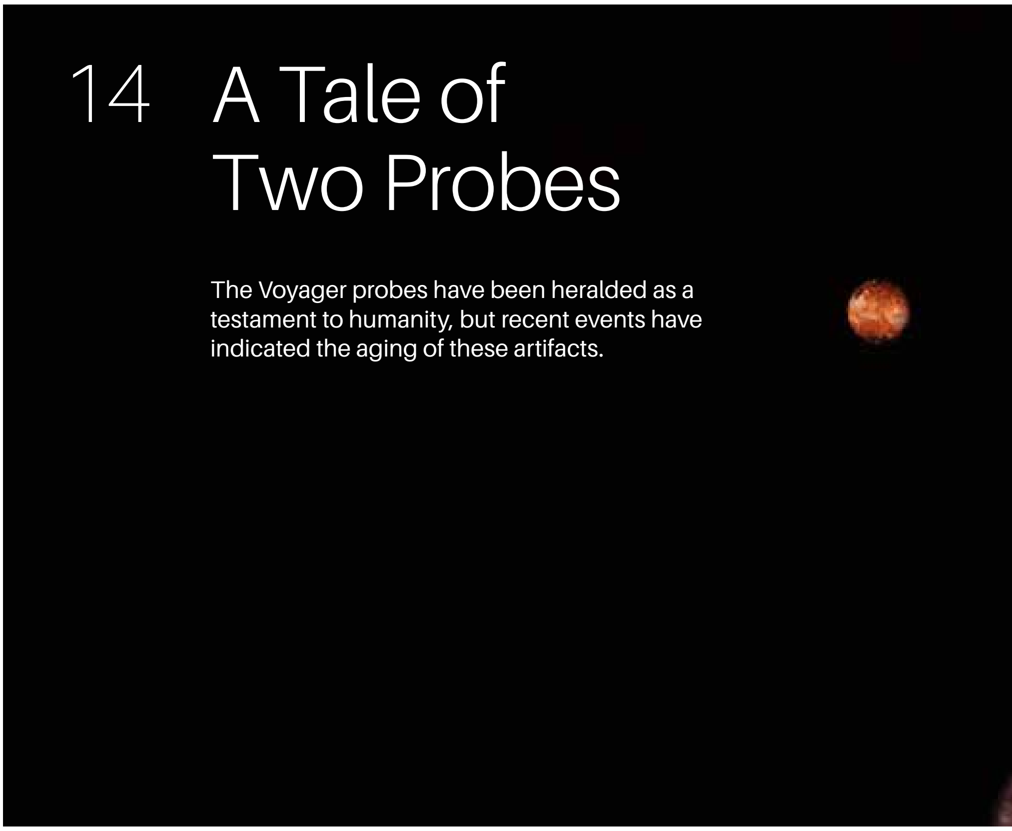
We want to make sure that all the mailed Leonardo Times reach the hands of people who are interested in reading them. So, if for any reason you would like to remove your address from our mailing list, please unsubscribe by using the form in the QR code. We will be sorry to see you go!

CONTENTS

18

Effective Altruism in the Air

Discover the endless possibilities to work on globally meaningful challenges with an aerospace background and a drive to improve the world.



14

A Tale of Two Probes

The Voyager probes have been heralded as a testament to humanity, but recent events have indicated the aging of these artifacts.

39

Boeing's Descent

In the last five years, Boeing has faced a series of unprecedented challenges and disasters. This article delves into the root causes, key events, and the urgent need for reform.

Lambach Aircraft

Lambach Aircraft's commitment to providing a space for aircraft design and the importance of projects on a small scale.

Learning from Curb Cuts

Improve your design by using the power of inclusivity: the benefits, principles, and examples of designing for everyone!

COLOPHON

Year 28, NUMBER 2, Summer 2024

The 'Leonardo Times' is issued by the Society for Aerospace Engineering students, the VSV 'Leonardo da Vinci' at the Delft University of Technology. The magazine is circulated four times a year with a circulation of around 2500 copies per issue.

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A MESSAGE FROM THE BOARD

Dear reader,

Having completed yet another year of studying aerospace engineering, it is now time to unwind in the sun and enjoy the summer edition of the Leonardo Times. It has always struck me how students and staff go above and beyond during the workweek to educate, be educated, or do research. This drive naturally comes in twofold, so now it is time to kick back and enjoy the newest articles written by our editors. In this edition, safety within the aerospace industry has a prominent role on the podium.

During our pre-lustrum week in May, we revealed our lustrum theme for the sixteenth lustrum: "Ignite"! You may have seen the theme, accompanied by its beautiful yellow and red colors in the faculty. The lustrum logo will be a frequently recurring image that will set next year's activities alight!

This pre-lustrum week featured the reveal of the lustrum caravan, the sale of lustrum merchandise, a movie, a silent disco, and a mini symposium. We ended the week in style by hosting our faculty party Limitless, which took place next to the Fellowship.

The next academic year will also mark the start of an intimate connection between the VSV 'Leonardo da Vinci' and two new Members of Honour. The first is Drs. Arnaud de Jong. Mr. de Jong is currently managing director of the high-tech department at TNO. In his previous role as CEO of Airbus Defence and Space Netherlands, he chaired the 2020 space symposium.

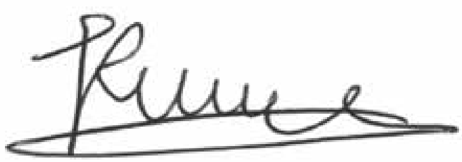
The second Member of Honour that will be installed is Ir. Arjan Meijer. Arjan Meijer, being an alumnus of our faculty, is now CEO of Embraer Commercial Aviation. He helped our association by laying connections between us and various partners of ours. In addition to this, he was the chair of the day of the 2021 aviation symposium.

I can confidently say that this year can be called a success. A wide array of activities has been organized, each one fitting into one of our three core pillars: Education, career, and social activities. Before ending this message, I would like to thank all active members and board members for making this year possible. You have done a tremendous job organizing these activities. I hope to see you next year with a new set of activities, new members, and a new board.

For now, sit back, relax, and enjoy this magazine!

On behalf of the 79th Board
of the VSV 'Leonardo da Vinci',

With winged regards,



Jim Ruysenaars
President of the 79th Board of the
VSV 'Leonardo da Vinci'

BLUE ORIGIN RETURNS

Blue Origin is poised for a triumphant return to space tourism flights after a two-year hiatus. This pause followed the investigation by the US Federal Aviation Authority (FAA) into the September 2022 explosion of an uncrewed mission. The incident involved the Blue Shepherd rocket launcher failing roughly 20 minutes after takeoff, leading to the ejection of the rocket capsule mid-flight, which carried important payload. The malfunction was attributed to higher-than-expected operating temperatures affecting the first-stage booster. In response, the FAA mandated Blue Origin to implement 21 modifications, including an engine redesign and organizational changes.


BLUE ORIGIN

The upcoming mission, NS-25, marks Blue Origin's seventh human flight and will feature a crew of six members, notably including Ed Dwight, America's first black astronaut candidate, aged 90, who was never selected to fly to space with NASA. His participation has been made possible through sponsorship by Space for Humanity, a non-profit dedicated to democratizing space exploration. Scheduled to launch on Sunday, May 19th, from its Texas launch site, the reusable launcher is expected to return to its original position after liftoff. The spacecraft capsule will ascend to a height of 106 kilometers from the Earth's surface, providing passengers with a ten-minute experience before a parachute-assisted landing brings them safely back to Earth.

CHANDRAYAAN-4

After the launch of Chandrayaan-3 and the successful landing of a lunar rover in August 2023, the Indian Space and Research Organization (ISRO) is now planning its next mission to be launched no earlier than 2028. Chandrayaan-4 , similar to its forerunner, targets the Moon. However, this time with the aim of sampling the Lunar surface and returning the samples to our home planet.

The mission consists of five modules being a Propulsion Module, a Descender Module, an Ascender Module, a Reentry Module and the Transfer Module. In the first phase of the mission, the Propulsion Module, the Descender Module and the Ascender Module will be launched by India's Geosynchronous Satellite Launch Vehicle Mark III. The Propulsion Module will take both the Descent and Ascent Module to a Lunar orbit, where they will detach and land. The modules will land very close to the landing site of its predecessor, Chandrayaan-3, as was announced in May 2024. The site is located 600 km from the lunar south pole and is named "Statio Shiv Shakti", derived from two Hindu deities: Shiva, who is associated with the Moon and Shakti, related to the fundamental cosmic energy. ISRO was, with Chandrayaan-3 , the first one to land on the lunar south pole.

When the Descent module, armed with a robotic arm, has gathered the samples, it will dock to the Ascend Module to transfer the samples, after which it will lift off and reunite with the Propulsion Module. In phase 2, the Polar Satellite Launch Vehicle (PSLV) will launch the Transfer Module and the Re-entry Module. The Transfer Module, carrying the Reentry Module, propels to the Ascend Module. After docking with the Propulsion Module, it will transfer the samples to the Reentry Module, which detaches and goes back to Earth.


MSN.COM

SEARCH FOR MH370 TO BE RESUMED

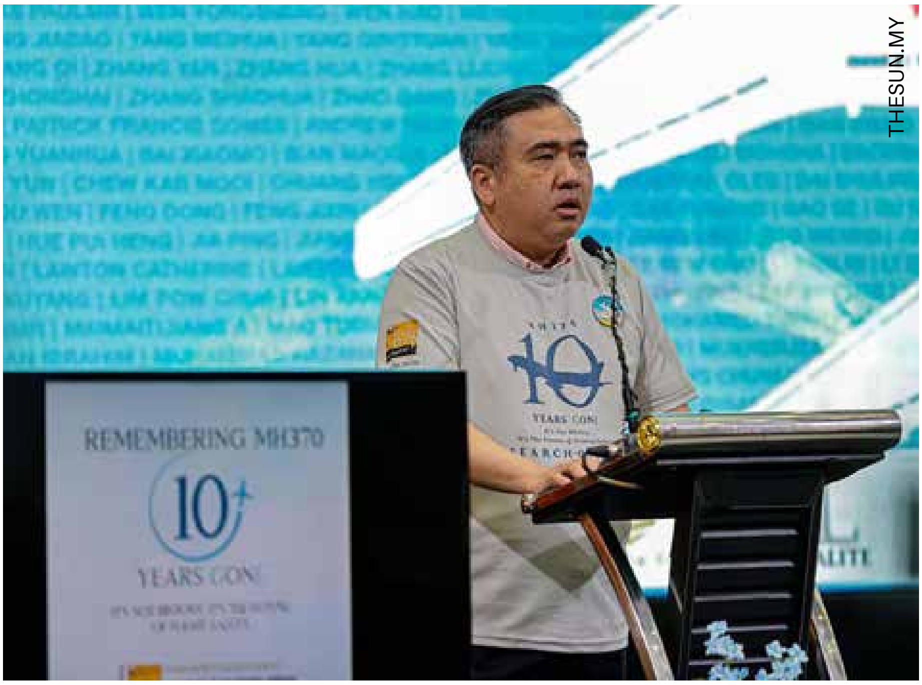
On the 3rd of March, 2024, the Malaysian Transport Minister Anthony Loke spoke the words that many had been waiting for for 10 years: "It is our commitment and our promise that the search [for MH370] will go on".

After the several-year-long search for Malaysian Airlines Flight 370 was ended, many were left without the proper closure, and had been fighting for the search to continue.

On 2021, aerospace engineer Richard Godfrey and Dr. Robert Westphal started investigating a novel technique that showed promise in tracking aircraft flight paths. This research was extensively perfected and presented to Ocean Infinity, a private underwater search company that had previously worked on the search for MH370 when it disappeared. After careful consideration, and the technique having been validated, Ocean Infinity committed themselves in March 2022 to resume the search. Over the years, they have been massively improving their search technology.

In March of this year, the Malaysian government reviewed Ocean Infinity's proposal and has accepted to resume the search under the guarantee of a "no find no pay" policy. This statement, by minister Anthony Loke, led to the Australian government to offer support for this new search.

The search is set to resume in November of 2024. We may be one step closer to finding MH370, thus bringing closure to the families of the 239 passengers on board.



THESUN.MY

TURBULENCE

On the 21st of April 2024, a Boeing 777-300ER experienced extreme turbulence on a flight from London to Singapore. The aircraft was cruising at an altitude of approximately 37 000 feet when it encountered extremely unstable air for a duration of about 90 seconds. This caused the aircraft to drop and climb several hundred feet twice. The turbulence happened about 10 hours into the flight, in the airspace above Myanmar. After the event, the pilots declared a medical emergency and diverted to Bangkok Suvarnabhumi International Airport. The plane from Singapore airlines housed 211 passengers and 18 crew members during this particular flight. In the accident, at least 71 people were injured, ranging from bruises to broken bones, and one man died from a suspected heart attack.

Turbulence can have three causes: mountains, jet streams or storms. Turbulence that is created by a mountain is comparable to the interaction between waves and a rock. As the air hits the mountain, the airflow can be disturbed and turbulence arises. Secondly, turbulence can be caused by friction between faster and slower moving air. The last class of turbulence contains patches of turbulence that are created far from the storm itself, due to the rapid growth of storm clouds creating a spherical pressure wave that can break up and form turbulent air.

NYTIMES.COM

ARJAN MEIJER

New Member of Honour of the VSV 'Leonardo da Vinci'

Last April, a new Member of Honour was asked for the VSV 'Leonardo da Vinci'. Arjan Meijer, currently CEO of Embraer Commercial Aviation, was asked to come to the air traffic control tower of LVNL at Schiphol for a secret meeting. There, the 79th board awaited him and he was asked to become a Member of Honour of the VSV. In this way, we are thanking Mr. Meijer for all of his effort for students in the past years and he will keep closely connected to our study association.

Ir. Arjan Meijer started his career with an internship at KLM during his studies of Aerospace Engineering at the TU Delft. Here, he conducted research on the ideal fleet composition from the perspective of costs and revenues. His career continued in 1999 at Royal KPN, where he was responsible for the installation and maintenance of global satellite communication transmission equipment. In 2001, he returned to KLM to successively focus on strategic fleet management and Part-M quality control. In 2010, he became technical director at KLM Cityhopper, being responsible for fleet management and development. In this period, the first Embraer aircraft were introduced. From 2014 to 2016, he lived in Norwich as the managing director of KLM UK. In 2016, he started at Embraer in Amsterdam, where he has been the CEO of Embraer Commercial Aviation since 2020.

Ir. Meijer has been connected to the VSV through his close contact with the board, his role as chairman during the aviation symposium in 2021, and an Interview To Inspire in 2023. He will be officially installed together with Arnaud de Jong during the Extraordinary General Members Assembly on November 29th in the city hall of Delft.

KEEPING TRACK OF JETSETTERS

Private jets, climate change, and lawyers

James Perry, Leonardo Times Editor

A protest at Schiphol airport against the use of private jets

If you know where to look, it is quite easy to track where pretty much any celebrity with a private jet has been flying. The celebrities don't take kindly to this and sometimes threaten to sue those who share this publicly available information. Why is this all online in the first place, and should it be?

In 2022, the digital marketing agency Yard published a report detailing "Celebs with the worst private jet CO_2 emissions" [1]. The report came with a disclaimer that they were tracking only the aircraft, not the celebrities themselves, and indeed some PR teams responded stating the aircraft were loaned out and used by other individuals. It would make attributing all the associated emissions to one individual unfair, but it is equally hard to tell to what extent this is actually the case. Taylor Swift was reported to be the biggest emitter, with her plane making 170 flights in just the first half of that year. It amounts to 2,971 tonnes of CO_2, 418 times more than the Dutch emit per capita for an entire year [2]!

The report also mentions the average flight distances, highlighting the shockingly small distances celebrities' jets sometimes fly. For example, Kylie Jenner's average flight lasts just under 25 minutes [1]! Of course, some celebrities and businesspeople may use private jets to reach locations required for their jobs – which is itself called into question in a world increasingly dominated by video call meetings. But there also seems very little excuse when a train, or even car, ride could easily accomplish the same distance. Taylor Swift was also called out for making a flight of just 45km within the same city of Saint Louis, as was reported by University of Central Florida student Jack Sweeney [4]. Despite receiving an initial backlash, it was later revealed that the aircraft was sold very soon after, indicating the flight was likely for demonstration or maintenance purposes. It just goes to show that jumping to conclusions can be a mistake.

Sweeney owns several social media accounts that report the activities of private jets, including names such as Taylor Swift and Ron DeSantis, a Floridian politician who signed a bill into law to redact information about his use of state and private planes. Elon Musk accused the account tracking his aircraft of being responsible for a suspected stalker following his children's car, although police found no such link [4, 5]. Musk threatened legal action and as CEO of Twitter, as it was known at the time, suspended any accounts tracking the locations of private airplanes [5, 6]. In response, Sweeney's lawyer just pointed out that nothing he did was against the law [5]. Simply taking data on the position of aircraft, publicly available in one location on the internet, and sharing it with another is not a crime. Yet it has big consequences, for better or worse.

IN THE NAME OF SAFETY

How does the location of these private jets become something you can so easily find then? These aircraft are equipped with ADS-B (Automatic Dependent Surveillance-Broadcast) transponders, which transmit their GPS location to anyone who can set up a receiver to listen [7]. The reason for this is safety: keeping nearby aircraft and air traffic controllers aware of the locations of every aircraft helps avoid collisions. In November 1996, a Boeing 747 operated by Saudi Arabian Airlines collided midair with a Kazakhstan Airlines Ilyushin Il-76 just West of Delhi, sadly killing all 349 passengers and crew aboard both aircraft [8]. This accident was caused by a failure in communication between the Kazakhstani crew and ATC, and it is assumed that they misunderstood the altitude assigned to them due to poor English. The controller failed to to spot the mistake because the airport lacked secondary surveillance radar, meaning the aircraft transponders were not being received [8].

Traditional transponders, like those equipped on these aircraft, receive interrogating radio signals from ground stations and respond by broadcasting a four-digit code and, depending on the mode, the pressure altitude. It means that air traffic controllers can see, in addition to the horizontal position of the aircraft using primary radar, the altitude and an identifying code for each flight under their control. Since the 2000s however, nations have increasingly required a more advanced ADS-B system [9]. This system is backwards compatible with previous radar systems but, instead of a four-digit code, each aircraft broadcasts a unique 24-bit message containing the aircraft address, position, altitude, and velocity without the need for interrogation [7]. This in turn allows ACAS (the Airborne Collision Avoidance System) to warn pilots of any nearby aircraft presenting a collision threat [9]. If imminent, the system will also instruct pilots to conduct a maneuver - hopefully avoiding the other aircraft.

The benefit of this system is that it is completely independent of ground stations and far more accurate, meaning that potential collisions can be detected and avoided regardless of the circumstances [9]. The side effect is that the aircraft is locatable, and therefore tracked, by anyone with a suitable, inexpensive antenna and computer software. For the most part, this just means that aviation enthusiasts can track flights nearby. It means aerospace engineering students at TU Delft can be excited by the particular type of aircraft flying miles overhead and that loved ones can keep an eye on your flight for reassurance. It means that everyone can see when a flight is delayed, but most importantly, ADS-B keeps everybody safe.

But it also allows us to see where private jets fly. Although the ownership of an aircraft may not be known immediately, it is often fairly easy to determine based on either official registries or the flight patterns in relation to where a particular celebrity happens to show up. Online communities come together to piece together these clues and write programs to automatically monitor their activity and sometimes, as in the case of Jack Sweeney, post it to social media.

EASY AS PI

Flight-tracking data is easily found online on websites such as Flightradar24 or FlightAware, but they have to get it from somewhere. While ATC organizations own networks of specialist radio stations, these internet-based services are not at such a liberty. Instead, they rely on enthusiasts to set up their own ground stations, sometimes provided by the website's company, and report the data back [10]. Using multilateration, a type of triangulation, it is even possible to calculate rough information about the position, altitude, heading, and speed of aircraft equipped with just an ordinary transponder. This data is compared with airline schedules, satellite data, route information, and data from the Federal Aviation Administration to paint a complete picture of what's happening in the skies [10].

It is even possible to build your own receiver using commercially available parts and a Raspberry Pi to get information on aircraft within range without involving the internet. Most commercial and private aircraft locations are not just accessible online - they are broadcast 24 hours a day to absolutely anyone willing to listen. With little to no technical knowledge required, it is little wonder that Flightradar24 alone has over 7,000 receivers, covering the majority of skies over land in the whole world. In Europe, roughly 99% of the airspace is covered [10]. This makes it pretty

Donald Trump's private Boeing 757-200, an aircraft designed for over 200 passengers impossible to fly anywhere without it being visible to the whole world.

LAWYERS V. EARTH

While nothing is unlawful about receiving or distributing these signals, celebrities frequently threaten to sue those who do. For example, in 2022, Taylor Swift's lawyers accused Jack Sweeney of stalking, which is a crime, and Elon Musk referred to his accounts as sharing "assassination coordinates" [11]. Imagine being tracked everywhere you went, and every time you turned up at work or university, there was always a crowd waiting, who may not always have the best intentions at heart. Imagine if every time you took a journey, you knew that there was someone, somewhere, shouting to the whole world exactly what you were doing and making judgments about you for doing it. Imagine if it wasn't even you. If a friend had borrowed your bicycle one evening but you were scolded for wherever they happened to end up. Perhaps it is the price of fame, but at the end of the day, we are all only human.

On the other hand, the average person does not fly to work. The average person does not pollute more CO_2 in forty minutes than a car does in a year, all while their collective wealth continues to increase. With private jets and yachts, the investments and assets of just twelve billionaires produce more emissions than two million average homes [12]! That's just under five coal-fired power stations. The average person spends more money than they might otherwise do to make sustainable purchases, a factor almost three-quarters of us prioritize [13]. We are told that fighting climate change is a team effort, and everybody must play their part if we are to succeed. How is it fair that those with money are exempt from this societal obligation? Should they not be held accountable for their actions if they choose to ignore it?

Aircraft calculate their position and transmit ADS-B Out signals. This is used by both Air Traffic Control and other aircraft, which receive ADS-B In and display traffic information to pilots

There is, of course, a simple way for celebrities to avoid being tracked in this manner. Simply fly less and make use of other modes of transport when possible. Earlier this year, Taylor Swift flew from her tour in Tokyo to Las Vegas the same night to watch her partner Travis Kelce play in the Super Bowl in Las Vegas [11]. She returned to Australia later that week to continue her tour the same week. While some admire her dedication, others point out that such a lifestyle is unnecessary, unsustainable, and unfair. If flights must be made, commercial airliners per passenger are far better for the environment and will continue to become greener with time. An increasing number of government officials fly commercially to save money and reduce their carbon footprint [14]. It proves it can be done, even with the burden of fame, and increases pressure on those who refuse to. When all is said and done, lawyers and court cases will be meaningless if there is nobody left to sue.

Taylor Swift's private jet flew just 45km across Saint Louis, on the border of Kentucky and Missouri, USA

CONCLUSION

We must share a certain sympathy with celebrities who fall victim to crime enabled by internet flight tracking. But the system responsible for the lives of millions of passengers every day exists and will continue to exist regardless. It allows the public to hold celebrities accountable for their dangerous habits and increases awareness and pressure to subdue them. These people choose to jet around the world, but the rest of us and the environment pay for it. Nobody is above the laws of reality.

A TALE OF TWO PROBES

The past, present, and future of NASA's well-traveled twins

Danny Tjokrosetio, Leonardo Times Editor

Artist's rendering of a Voyager probe

Somewhere at the edge of the solar system, a car-sized contraption emerges through the interstellar medium. With outstretched spindly arms and a gleaming white conical dish, this megaphone-like boxy structure has seen it all, from the volcanoes of Io to the fragility of our home from afar.

Now hurtling through the void at 17 kilometers per second, Voyager 1 is the furthest artificial object over 24 billion kilometers away from the nearest (and only) service point. Although it continues to phone home, a recent case of communication hiccups has waved an air of concern about its impending end. Meanwhile, Voyager 2, its identical twin at over 20 billion kilometers, continues to run under no system redundancies. It is a matter of when, not if, the seemingly immortal twins heed the calls of Father Time. Stuck in the past, the probes continue to extend their impressive mileage on half-century-old technology.

SAVING SCIENCE, ONE PIECE AT A TIME

The Voyager program was a successor to the four-probe Grand Tour program of the 1960s, conceived to take advantage of a rare alignment of outer planets that occurs once every 175 years [1]. This alignment would allow a single spacecraft to visit all four outer planets—Jupiter, Saturn, Uranus, and Neptune—by slingshotting through their gravitational fields to reduce the fuel needed for the journey. The first pair of probes would visit Jupiter, Saturn, and Pluto (still a major planet at the time), and the second would visit the ice giants Uranus and Neptune, in addition to Jupiter. The Grand Tour program was ultimately canceled due to program costs of over $1 billion and the allocation of NASA's shrinking budget to the Space Shuttle program,. The Grand Tour, however, never really died.

Engineers and scientists responsible for the probe's development at the Jet Propulsion Laboratory (JPL), were reluctant to waste any opportunities and devised a plan. An approved proposal was made for replacing the original Grand Tour program with cheaper Jupiter and Saturn-bound probes derived from the highly successful Mariner program. Two probes were launched for redundancy. While the mission's scope was downscaled, it still utilized the Grand Tour's launch window and the probes would proceed to the ice giants upon the successful completion of a Saturn mission. With every ounce of determination to build a spacecraft able to live long enough to see Uranus and Neptune, JPL worked quietly to design and upgrade long-lasting systems.

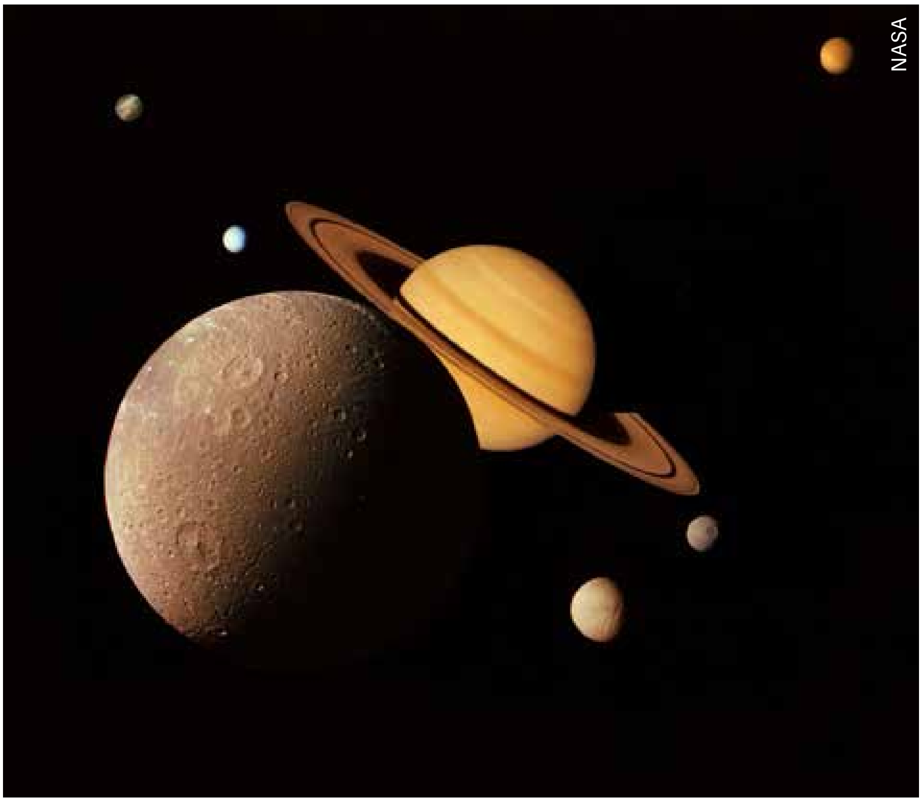
In piecemeal fashion, the possibility for ice giant visits was integrated into the project, funding the new "Grand Tour" periodically. Thanks to the data returned by Pioneers 10 and 11 during the development of the new probes, the crucial need for new systems to survive Jupiter's harsh radiation environment was proved. Additional funds were approved for technological enhancements wherever necessary, such as new programmable computers and nuclear batteries. Eventually, the so-called "Mariner-Jupiter-Saturn" probes became completely different from the original Mariners, while the design of the mission evolved along with the spacecraft. The probes would be christened "Voyager" only months before their launch [2].

A ROCKY START

In August 1977, Voyager 2 began the adventure of its lifetime strapped aboard a Titan IIIE rocket. Numbered by their order of arrival at Jupiter, Voyager 2 was launched first to keep the possibility of the Grand Tour open. Voyager 1 was launched just two weeks later on a faster trajectory to visit only Jupiter and Saturn. In December 1977, Voyager 1 overtook the distance of its twin while they were both cruising the Asteroid Belt. However, the first leg of Voyager 2's mission, was not exactly smooth sailing. The failure protection system of Voyager 2's new computers was accidentally left on during launch [2]. Its internal gyroscopes, needed for attitude control only after the spacecraft's separation from the launch vehicle, went into overdrive under launch vibrations. Fortunately, the problem fixed itself as the system automatically restarted after launch [2].

Several months into the trip to Jupiter, Voyager 2 automatically switched from its primary radio receiver to its backup after an

Composite image of Jupiter and its major moons taken by Voyager 1



Composite image of Saturn and its moons taken by Voyager 1

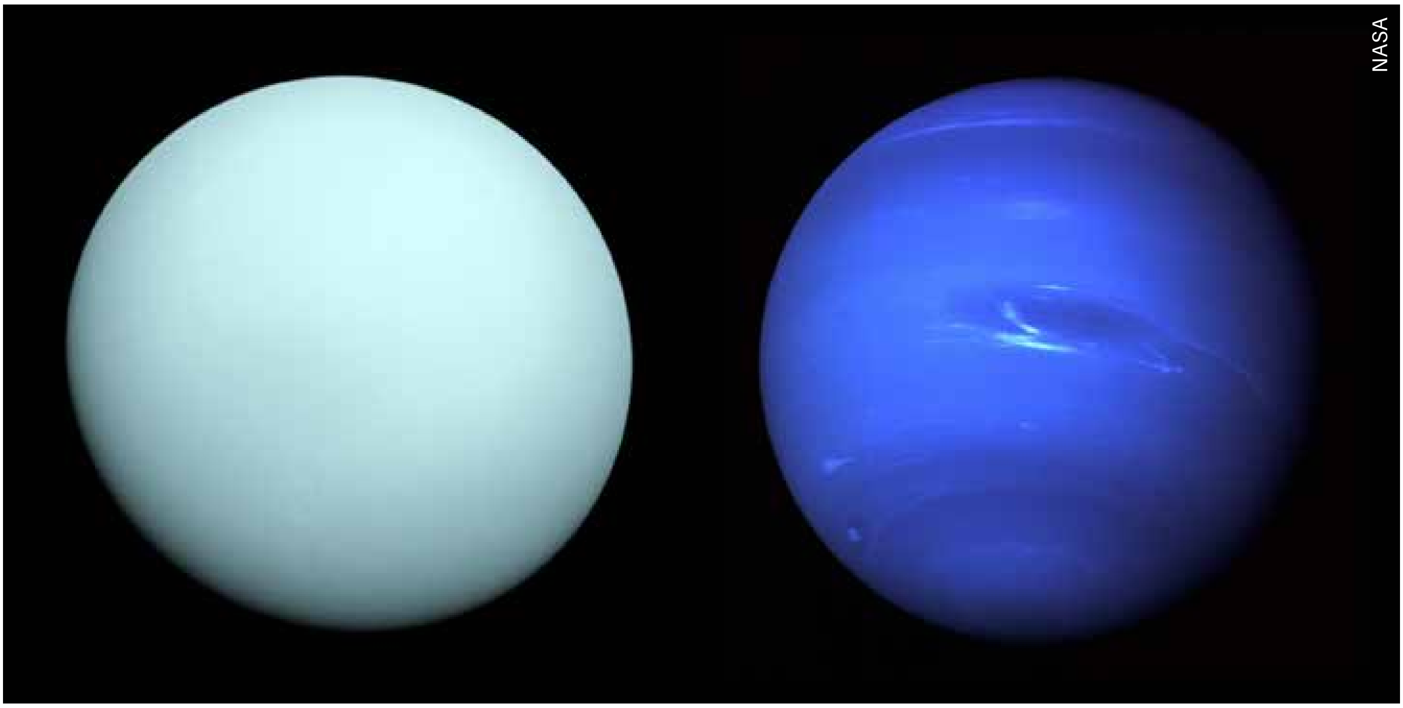
operator had forgotten to set a timer to send a regular signal to the spacecraft. The back-up, however, was faulty. The spacecraft was rendered unresponsive for a week after discovering that the primary receiver failed after switching back. Thanks to the probe's reprogrammable systems, contact was regained with the backup receiver, which required detailed and continuous frequency adjustments to uplink transmissions.

TOURISTIC TWINS

Lennon and McCartney. Bonnie and Clyde. Jobs and Woz. Marie and Pierre Curie. History has seen its fair share of dynamic duos revolutionizing different fronts; Voyagers 1 and 2 are undoubtedly the most iconic pair in the realm of planetary science. Throughout their travels, they have returned postcards from the planets that stumped mission scientists. As it zipped past Jupiter, Voyager 1 opened a trove of surprises for its sister to study in further detail, including the presence of a thin ring system and the discovery of active volcanoes on Io. At the time, Earth was the only known body in the Solar System with volcanic activity; Io, at roughly the size of our Moon, experiences a tenfold of our volcanic activity due to the constant cyclic stretching of its surface imposed by Jupiter and other major moons such as Europa and Ganymede. Snapshots returned swirling patterns at Jupiter's bands and the infamous Great Red Spot, revealing convective and cyclonic activity.

The trips to Saturn brought back the most scenic of views and a wealth of science, namely the complex structure of Saturn's rings, polar auroras just as seen on Jupiter, and the discovery of additional moons. Of all the moons, Titan was of primary interest, and it was to be Voyager 1's final Saturnian stop before being flung into the abyss. During the quick flyby, an atmosphere of nitrogen was revealed, along with images of a hazy atmosphere leading to the speculation of rivers and lakes of soupy hydrocarbons; they were later confirmed in the early 2000s by the Cassini-Huygens mission.

Voyager 2 soldiered on to Uranus and discovered two rings and eleven moons. High-resolution images showed Miranda's grooved and complex terrain, providing



Voyager 2 images of Uranus (left) and Neptune

clues of its violent past; it was hypothesized that a collision with another body caused it to break apart and eventually reassemble itself. The swing through Neptune not only led to the discovery of more previously undetected rings and six moons, but also an elliptical swirling storm, similar to Jupiter's "Great Red Spot", aptly named the "Great Dark Spot". Before going into the great beyond, Voyager 2 took a final look at Triton. It revealed further unusual volcanic activity elsewhere in our neighborhood, with cryovolcanoes (or "ice volcanoes") spewing nitrogen gas.

On Valentine's Day of 1990, we received the last series of photos from the Voyager program. Voyager 1 turned around to take one last glance at our cosmic village and snapped away. The album consists of sixty photos of the planets to construct a "family portrait" of the Solar System; one image, in particular, instantly became one of the most important images in human history. At first glance, this grainy image taken six billion kilometers away may not show much other than bands of light. Entitled "Pale Blue Dot", this humbling image is the furthest photograph ever taken of Earth, seen as a blue speck smaller than a pixel.

SPACE JAM

The Voyagers cannot be left without a playlist for their lonely lifelong road trip, also intended for anyone out there to listen to in case they stumble upon the travelers. Enter astronomer Carl Sagan -not only well known for his efforts in science communication but also for compiling the hottest mixtape in the cosmos. Described by Sagan as "a message in a bottle, cast into the cosmic ocean" [3], each probe carries a foot-long gold-plated copper record, or "The Golden Record", which serves to paint a picture of life and culture on Earth. It consists of 118 images, 55 greetings in ancient and current languages, the sounds of nature including thunder, wind, and various animals, and 90 minutes of music from diverse genres. The onboard playlist is an eclectic mix of traditional music from various countries and the classical works of Beethoven and Bach; extraterrestrials were even granted the chance to rock out to Chuck Berry's "Johnny B. Goode" [4].

WHERE ARE THEY NOW?

The Voyagers are commonly mistaken for having left the Solar System. In 2012 and 2018, Voyagers 1 and 2 crossed the heliopause respectively, being the boundary between the sphere of influence of solar winds and interstellar medium [5]. Interstellar space by definition, however, does not mark the edge of the Solar System—Voyager 1 first has to pass the Oort Cloud, a spherical shell of ice and leftover debris from the formation of the Solar System. First postulated by Dutch astronomer Jan Oort, this theoretical region could be the birthplace of comets. It is estimated that Voyager 1 will penetrate the Oort Cloud within 300 years and take another 30,000 years to pass through [5].

THE LITTLE PROBES THAT COULD

The Voyagers are the longest-running space missions in history and continue to collect data on interstellar plasma. This is largely due to radioisotope thermoelectric generators (RTG) as power sources, where electrical power is generated by radioactive decay; at such great distances, the probes cannot rely on solar energy. However, at nearly 47 years old, these power sources are beginning to wane. To prolong the RTG's lifetime, more instruments have been shut down. It is estimated that the RTG will be unable to power any instrument by 2030, but will still supply enough juice to keep the probe transmitting data until 2036.

Over the past few years, the probes have continued to power through (pun not intended) and overcame every obstacle despite showing their age on various subsystems, such as thruster clogging and degradation [7][8] and plagues of life-threatening glitches.

POKES AND SHOUTS TO SENILE SPACECRAFT

Major software and communication glitches have been making recent headlines for both probes since 2020, when Voyager 2 automatically shut down all surviving instruments after the delay of a scheduled maneuver. The probe was saved after shutting down a power-intensive internal system, and the instruments have been in power-sharing mode ever since. Running on backup systems with no remaining redundancies, Voyager project manager Suzanne Dodd said "Everything on both spacecraft is single-string".

In July 2023, a glitch in a series of routine commands caused Voyager 2 to point its antenna 2° away from Earth, losing all contact with the spacecraft. A faint signal detected nearly two weeks later confirmed it was still alive and well. After sending an amplified radio signal, or an "interstellar shout" using their Deep Space Network Facility in Canberra, Australia, NASA successfully regained communications with the probe, which has been operating normally since [9].

From then on, the saga only continued. On November 14, 2023, Voyager 1 started to beam incomprehensible data. Nothing useful but repeating strings of binary nonsense were received as if the spacecraft had gone senile and started speaking gibberish. For five months of radio silence, concerned engineers have worked around the clock to re-establish communications with Voyager 1. A geriatric spacecraft failing to speak coherently raised concerns about its looming end. On March 1, 2024, NASA "poked" the probe by sending a signal prompting it to return an insightful readout of its entire memory structure [10]. Diagnostics pointed the fault to a hardware issue in its data storage system. A faulty chip responsible for a sizable portion of its memory corrupted the data, rendering it unreadable. On April 20, NASA began the workaround solution by moving the chip's code elsewhere. As no other component could store the entire code, unused parts were deleted and the remaining lines were sliced into appropriate segments for allocation elsewhere within the spacecraft's memory. "Hi, it's me," the probe tweeted the following Monday on X [11]. Voyager 1 confirmed that it was alive and well, reporting the status of its engineering systems. On May 22, NASA announced that two of its four remaining instruments have resumed operations, with further completion underway [12].

Zoomed version of "Pale Blue Dot"

The Golden Record (right) and its protective cover (left), consisting of instructions to play the record, a pulsar map showing the location of our sun (lower left), and a depiction of the lowest state of a hydrogen atom (lower right)

CONCLUSION

The loss of these precious probes will not be scientific or technical, but sentimental. They have, literally speaking, gone above and beyond their original mission. These eternal wanders are not only technological triumphs, but carry the legacy of our species for eons to come. Regardless of operational status, the Voyagers will live on forever, taking all humankind with them.

EFFECTIVE ALTRUISM IN THE AIR

Maximizing your impact on land, sea and air

Topias Pulkkinen, Leonardo Times Editor

The EA movement uses the lightbulb as its symbol

Effective Altruism is a global movement officially founded in 2011 with the primary aim of "using evidence and reason to figure out how to benefit others as much as possible and taking action on that basis". Aerospace engineers often don't view their work through an altruistic lens, but maybe they should.

Effective Altruism (EA) is a modern global philosophical and social movement, with its main tenets formulated in the 2000s by a group of various philosophers, economists and scientists across the Western World [1]. Since then, the group has grown to a more global prevalence, being held in rather high esteem across many of the world's top universities. TU Delft is no exception and, since 2022, has also had its own branch of Effective Altruism: EA Delft [2]. The "evidence and reason" part refers to ensuring value neutrality in its actions, as EA aims to maximize its impact to drive global development and lessen human suffering, be it through orthodox or heterodox ways [1].

At first glance, one would think that there is little crossover between Effective Altruism and aerospace engineering. Most aerospace engineering serves various human needs from the advancement of science to the need for transportation. Despite their mutually reversible acronyms, the two have little overlap in terms of focus, right? Let's discover together.

One way to link Effective Altruism to aerospace engineering is through cause area prioritization and research. Effective Altruism collaborates with a plethora of organizations around the world, such as the 80,000 Hours organization, and their shared brainchild, the "Effective Thesis". The Effective Thesis initiative aims to provide university students and researchers with topics they think should receive more research attention and funding due to their potential impact [3]. A common metric on which these topics are recommended is their neglectedness, the discrepancy between the current received attention and possible impact.

For example, EA certainly recognizes the issues involved with many possible climate change scenarios, but views it as a cause area that already gets sufficient attention. On the flip side, one major cause area that is currently neglected compared to its potential implications is AI safety and the lack of global regulation and oversight for its foreseeable development [1]. The research topics outlined by Effective Thesis range from the social sciences to engineering and encompass many things in between for both quantitatively- and qualitatively-oriented professionals [3]. Some of their current suggestions for people working in aerospace engineering include looking at the research priorities agenda of the Space Futures Initiative (SFI), a US-based non-profit [4].

The Space Futures Initiative Research Agenda looks at a variety of space-related niches and fields of study. Some of the more neglected ones include, for example, space conflict, the use of AI in space, space governance and norms, space sustainability and space resources and property rights [4]. These fields are subdivided into further categories on which research should be conducted. For example, space governance and norms are categorized into enforcement, norms and values, distribution of benefits, and governance mechanisms. These

There currently is no global space police, but UNOOSA is as close as it gets

categories are then divided further so that each contains a list of questions for research for anyone with the academic background, means and interest to produce academic literature about the topic.

Aerospace engineers interested in altruism and society may be l drawn towards one particular area - space governance. It is one of the areas advocated by the SFI Research Agenda. The current United Nations Office for Outer Space Affairs (UNOOSA) framework sets ground rules for peaceful state-actor conduct in space but will require updates in the coming decades with the changing face of the New Space Race as well as the wide-scale commercialization of the outer space domain [5]. This is especially critical at a time when countries around the world are in the process of creating their own "Space Forces". Some critical questions asked by the SFI are the just distribution of power between supranational, national and more localized actors in taking legislative and executive action in the space domain. Furthermore, topics such as how should the science community tackle the prospects of a "Regulatory Race to the Bottom", culminating in the creation of the technologically most advanced space ecosystem in whichever country is most willing to bend the rules of good conduct. Additionally, questions about the economic aspects of space use are raised and the proposal to open dialogue about the treatment of space-generated data as a public vs. private good is presented.

On the enforcement side of the equation, many more unanswered questions remain. In particular, the scalability of national enforcement mechanisms is brought into question, and harboring goodwill and trust between private and state actors is raised as a point that requires a more systematic framework [4]. Furthermore, questions are raised regarding the parties that would end up responsible for space object databases, perhaps a space traffic management (STM) system, and if new international bodies will need to be created for this stated purpose.

There is no need to worry for those who don't possess a background in engineering. Effective Altruism and its affiliate organizations fund and encourage research in many fields, such as biosecurity, animal welfare, AI governance & safety, ((heterodox) developmental) economics and global affairs [1].

"Aerospace engineers most often don't view their work through the altruistic lens, but maybe they should."

CONCLUSION

In conclusion, without a doubt, a career in aerospace engineering should be no obstacle for those wanting to work towards furthering altruistic goals. With ever-expanding possibilities to conduct cross-disciplinary research, combining elements from both the hard sciences and the humanities, many global issues can be alleviated through one's rigorous will to improve lives across the world. The aerospace community's analytical approach to things most certainly won't make it any less effective.

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5. Personalized training programs

With an enormous number of learning courses available, it's easy to feel overwhelmed and you may need guidance on how to best approach your development. To help our people navigate all this learning content, we've built a global community of in-house learning and development experts. They know everything about ASML's learning and development opportunities and can set up personalized learning programs for you. That training trajectory will set you up for success in your chosen career path.

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SPACE BEYOND BARRIERS

Embracing disabilities in space exploration

Naomi Lijesen, Leonardo Times Editor

ASTROACCESS

AstroAccess facilitates a parabolic flight so a group of people with physical disabilities can experience weightlessness, and test microgravity accessibility tools

In November 2022, ESA made history by selecting John McFall, a former Paralympian and surgeon, as the first astronaut with a physical disability, opening a long-closed door with one pioneering move.

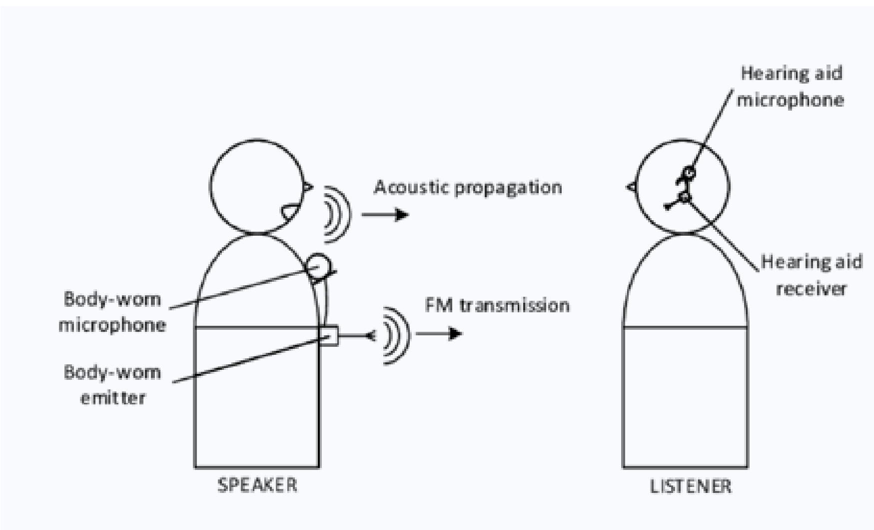
Astronauts traditionally represent the elite – highly skilled, well-educated and in peak physical health. Space exploration, filled with risk, prompts agencies to put their best foot forward when selecting people to launch into orbit. ESA's Parastronaut Feasibility Project is among the first to include the 15% of individuals on Earth who have a disability in space exploration. In addition to rigorous psychological and educational requirements, candidates with lower limb deficiencies, pronounced leg length differences, or short stature are now also considered in the agency's selections. McFall's objective within the Parastronaut Feasibility Project is to assess the options for including astronauts with physical disabilities in future space missions. After losing his leg in a motorbike accident at age 19 and relearning how to walk with a prosthesis, he took up running and went on to win a Bronze medal at the Paralympics for the UK. Since his selection two years ago, he has moved to ESA's Astronaut Centre in Cologne, Germany, to begin preparation for living and working in space. McFall has already experienced weightlessness in the zero-gravity flight, appropriately nicknamed the 'vomit comet' and, most recently, he became the first amputee to undergo testing in the centrifuge – used to simulate the extreme gravitational forces experienced during launch – so that we can better understand how blood flow is affected within the body [1]. Much of the Feasibility project involves assessing how people with physical disabilities are affected within the typical mission training, and what modifications to spacecraft and spacesuits may be necessary to accommodate them. For example, adjustments to the exercise equipment astronauts aboard the ISS use for two hours per day. In McFall's case, the flexibility of his running blade will need to be different when using ISS's anti-gravity treadmill compared to treadmills on Earth [1]. Another example is how the microprocessor in his day-to-day prosthesis must be recalibrated for zero-gravity conditions [1]. The range of necessary modifications requires thoroughness.

ESA is not alone in this initiative, the United Nations Office for Outer Space Affairs has a

"Space for Persons with Disabilities" project which advocates inclusive development in the space sector. It promotes accessible technologies and engages decision-makers for disability at conferences globally. Private spaceflight and space tourism generate possibilities for a diverse group to experience outer space or weightlessness. Initiatives such as AstroAccess aim to provide those with disabilities these experiences, without needing to become an ESA astronaut and endure their demanding hiring process. They collaborate with disabled scientists, veterans, students, athletes, and artists to test accessibility tools in microgravity and explore how to design spacecraft environments to ensure all astronauts, regardless of disabilities on Earth, can work and thrive in space [3].

So, why include astronauts with disabilities? The scientific and technological breakthroughs founded from space exploration are vast. The International Space Station – not just a shockingly expensive floating home – is an exceptional research facility with highly skilled minds dedicated to advancing science and developing technologies for the betterment of lives on Earth. Including astronauts with disabilities in this already fruitful field means benefitting from their extraordinary perspectives and resilience, thereby accessing new talent, understanding and innovation. The stigma that declares disabled persons to be less qualified for space is one that needs challenging. The fact that the existing technology will need adjustments should not overshadow the unique advantages that individuals with disabilities bring to life and work in space. Diversity is not being introduced into this field just for the sake of diversity.

An example where people with a disability may be better suited to life in space are Deaf and hard-of-hearing individuals as they have a natural resistance to motion sickness. Nausea and illness result from conflicting signals from the inner ear, eyes and other sensors in the body. Therefore Deaf individuals without a functioning inner ear do not experience these symptoms. In the first few days of spaceflight, astronauts must adjust to space-related motion sickness and are, therefore, distracted and less prepared or alert for potential issues at the beginning of their mission. Recognizing this particular advantage even in the 1950s, alongside the possibility of reducing training time and costs, NASA recruited deaf men to participate in studies and training, naming the group the Gallaudet 11 [2]. Despite this, they were ultimately declared unfit for spaceflight. The introduction of sign language or newly developed FM-like systems (see Figure 3) as alternate modes of communication would introduce extra cost and training hours into an already long and expensive education process. However, it also solves the problem of hearing degradation due to long-term exposure to machinery noise on the ISS. An issue that will only become more relevant in future manned missions on Lunar and Martian bases [2].



COURTOIS ET. AL, 2014

Diagram illustrating the utilization of an FM system on Earth to transmit audio signals into a hearing aid receiver via a designated FM radio channel [2][4]

Similarly, blind or visually impaired individuals also present capabilities that are advantageous in space. In emergencies where vision is limited, for example, if the lighting fails, blind astronauts do not need to wait for their eyes to adjust or look for a flashlight in the dark – they are already heading to the source of the problem and are onto the next course of action as they are practised in relying on memory for the orientation and location of their surroundings. Moreover, creating space safety systems accessible to blind astronauts would also assist sighted astronauts in darkness via tactile and auditory cues. In critical moments, this innovation could be life-saving. It illustrates an important theme - accessibility often drives innovation that benefits all.

People with paraplegia, partial paralysis or amputations, like Mr McFall, would arguably find it easier to assimilate into a space mission. The weightlessness of space removes several obstacles that they would experience here on Earth. In some instances, chronic pain disappears when weightless, and so their quality of life and ability to function is better suited to space. Furthermore, someone accustomed to relying on assistive technologies (i.e. a wheelchair) might find it easier to maneuver in microgravity environments.

Lastly, in certain cases, individuals with chronic illnesses could also potentially be well-suited to life in space. For example, people who use ostomy bags would have the advantage of not needing to rely on the complex and costly space toilets. Additionally, individuals accustomed to regular health assessments and self-management of their health conditions might find the routine of astronauts, who undergo continuous health monitoring, as less intrusive and easier to adjust to [2].

In general, living with a disability can foster a high level of resilience and mental toughness, which are critical traits for handling the stress and isolation of long-duration space missions.

The Gallaudet 11 research participants communicate in sign language while seated in a zero-gravity aircraft prior to departure

But, where should the inclusivity end? Dutch ESA Astronaut Andre Kuipers notes in a conversation with Leonardo Times that "there are exceptions [to who space agencies can select]. You have to be realistic about addressing the safety concerns that might arise, for instance, if a blind astronaut needs to escape quickly. But I was wearing glasses when I got selected; nobody's perfect. Disabilities come in all kinds of levels. We're not birds. We're not fish. But we can fly, and we can go underwater. Space is simply the next step."

Indeed, while solutions are being presented for the inclusion of certain disabilities, specifically deafness/hard of hearing, blindness, paraplegics and amputees from the waist down, it is important to note that these are but a portion of the vast array of disabilities that currently exclude people from going to space. Certain neurodiverse conditions and learning disabilities are not yet being explored. Neither are more complicated chronic illnesses and whilst it is conceivable that they may introduce prohibitive risks with microgravity and the isolated environment of space, only further research will tell. ESA's Parastronaut Feasibility Project is somewhat limiting as it primarily focuses on those with physical impairments in the lower body. So, companies like AstroAccess and other initiatives must strive to continue expanding accessibility in space exploration. Ultimately though, feasibility must address safety and also budget constraints that might inevitably arise due to the modifications in infrastructure across entities like Axiom Space, NASA, and SpaceX as well as modifications to the astronaut training. As with many things in the pragmatic world of aerospace engineering, this will require a trade-off.

Whilst disabilities manifest themselves in various forms, not every person with a disability will be suited to life in space – just as not every other person in the world is. However, they share common advantages over those considered "normal" – their exceptional and natural adaptability and attention to detail. In navigating a world designed for the able-bodied, individuals with disabilities have honed their capacity to adjust and innovate. These natural skills are arguably among the most valuable character traits of any astronaut. Astronaut Samantha Cristoforetti astutely points out "In space, we all have a disability", suggesting that those accustomed to overcoming physical or cognitive challenges may possess invaluable experience for space exploration. Utilising these natural skills as well as unique biological conditions (for instance, the lack of motion sickness due to deafness) can reduce training and costs whilst accessing an entirely new perspective and knowledge base. It will only become more relevant in the future of manned spaceflight as missions such as Artemis progress and humans travel to the Moon and Mars. Perhaps space agencies got it wrong when they set the precedent all those years ago. Perhaps those of us with disabilities possess a depth of expertise that marks them as the better hire. Perhaps when we think about putting our best foot forward, we should consider that it might just be a prosthetic one.

John McFall of the ESA Parastronaut Feasibility Project experiences weightlessness in a parabolic flight

GENERAL

THE EVOLUTION OF FLIGHT SAFETY

How regulations and tragic lessons shaped air travel safety

Muhammad Arham Elahi, Final Editor and Gerard Mendoza, Leonardo Times Editor

Flight attendant demonstrating how to fasten the oxygen mask

THE FIRST PREFLIGHT SAFETY BRIEFING

The preflight safety briefing performed by flight attendants during every flight has been mandated by regulation since its introduction in 1965, with the obligation of showing people the emergency exits of the aircraft [1]. This regulation has been continuously evolving since. Most of these evolutions have come from experimental analysis, but most are "written in blood". One of the most crucial steps of air safety investigations is to see what went wrong, and how we prevent this from recurring. Most of the preflight safety briefing instructions stem from previous incidents during aircraft accidents. So, what is the reasoning behind every point of the preflight safety briefing?

BRACE POSITION

"You can find instructions for the brace position on the safety card located in the seat pocket in front of you."

Why is there a "standard way" to position yourself during a crash? Well, the answer comes from the Kegworth air disaster. In 1989, British Midland Airways Flight 092 crashed while performing an emergency landing at the East Midlands Airport. Surprisingly, 79 out of the 126 occupants of the aircraft survived the impact. A survivor recounts the commands by the pilot to brace. At the time, there was no predefined brace position. After the accident, an analysis of what the survivors did during the crash allowed investigators to introduce several generic requirements to enhance the survivability of the passengers. The main point was that passengers who had restrained their head and torso, for example, by covering them with their arms and pushing down, had had a higher survivability rate [2]. This is mainly because the sudden deceleration causes the head and back to suffer a whiplash effect that is usually incompatible with life. There were 31 recommendations from the report, and many others also led to changes in the safety procedures and, thus, the pre-flight safety briefing, as we will see later.

SEAT BELTS

"To fasten your seatbelt, insert the metal fitting into the buckle. Tighten by pulling on the loose end of the strap. To release, lift the buckle cover."

The importance of seat belts was initially underscored in the automotive industry, where their adoption became standard practice. In airplanes, this safety measure was inherited due to its proven track record. However, in 1947, there was some resistance from certain airlines, who argued that tight belts could potentially harm internal organs in the event of a crash. This concern, even if true, is outweighed by the overwhelming evidence of the safety benefits of seat belts. The seat belts used

The wreck of the infamous British Midland Airways Flight 092 after the Kegworth disaster

in earlier cars and airplanes were the "lift-lever buckles," which have remained familiar in airline industry practices [3]. In contrast, the automotive sector has progressed to using three-point harnesses, which incorporate a push-button alongside a shoulder harness, which is now the standard in modern cars. However, airplanes have not followed suit, citing various reasons. Firstly, the adoption of a shoulder harness in airplanes necessitates robust connections, requiring airframe reinforcement and adding extra weight to the aircraft [13]. Additionally, the lift-lever buckle strikes a balance between ease of opening and resistance to accidental opening, which a push button may not provide, especially if struck by a flying object. Moreover, the forces experienced by airplanes during turbulence primarily act in the vertical plane of motion, making the lift lever buckle sufficient to withstand these loads. Finally, the lift-lever buckle is a mature, reliable technology that is cost-effective to manufacture and install [3].

The significance of seat belts in aviation safety was highlighted in incidents like Aloha Airlines Flight 243, where the entire roof of the aircraft tore off mid-flight. Remarkably, the pilots managed to land the plane safely, with only one fatality – a flight attendant who was not wearing a seat belt at the time [4]. Furthermore, during the Kegworth survivability studies, it was also concluded that wearing a seat belt during the crash enhanced the survivability of the passengers [2]. Seat belts prevented more passengers from being ejected from or inside the aircraft, underscoring their critical role in saving lives during emergencies.

EVACUATION PROCEDURE

"There are [N] exits on this aircraft. In case of an emergency, floor-level lighting will guide you to the nearest exit. Please take a moment to locate the exit nearest to you, keeping in mind that the nearest exit may be behind you. More detailed information on the evacuation procedures can be found on the safety card located in your seat pocket."

The evacuation route and procedure were some of the first items in the preflight safety briefing. In 1928, a Fokker F.III operated by KLM taking passengers on an aerial sightseeing tour crashed during take-off from Waalhaven Airport. The plane went into the water and started to fill with water. Of the 6 occupants, only one perished, but investigators determined that if the location of the emergency exits had been briefed before takeoff, the crash would have had no casualties [6]. This is what led to the first preflight safety briefing mandate in 1965.

Nowadays, commercial aircraft usually have between 4 and 6 exits, so one would think that by having this increase in exit possibilities, the egress of the aircraft could be performed quickly and uneventfully. Well, what if we told you that in 1985, an aircraft had 55 fatalities despite not even taking off and having 6 exits? You would think this is impossible. But it did happen. It is not only about the number of exits but also the escape route characteristics and the availability and operation of the exits. This event was deemed the Manchester Airport disaster. After aborting a take-off, due to hot brakes and a fuel tank burst, the Boeing 737-236 started to catch on fire. Due to the disposition of the aircraft with respect to the wind, it was impossible to use 3 of the 6 exits: the left overwing door and the 2 aft doors. During the evacuation, a bottleneck formed at the forward galley as the passageway was only 57 cm wide [6]. This slowed the evacuation drastically and obliged the flight attendants to unclog the bottleneck by literally pulling people out. Something similar happened in the right overwing exit. It was located in an inaccessible point, as it did not perfectly align with the space between seat rows, and thus was partially covered. Currently, many mandatory instructions issued during the preflight safety briefing stem from actions taken or, that should have been taken during aircraft accidents [6].

The safety board concluded that an overhaul of the cabin layout was needed such that the exit route was wide enough to accommodate the outflow of people and not hinder the speed of the evacuation [6]. Passengers should always remember not to carry any luggage to prevent further blockage, and to remove pointy shoes and potentially-puncturing items, preventing damage to the chutes.

EXIT ROW REQUIREMENTS

"Do you speak English? Are you at least 18 years old? Are you willing and able to assist

As unlikely as a water landing may be, having life jackets onboard is imperative, as they can save hundreds of lives.

in the event of an emergency evacuation?" If you have ever sat at one of the overwing exits, you may have been asked some of these questions, and shown how to operate the door. But why? Well, while the aft and forward exits are located at arm's reach from the cabin crew, as their seats are located in the galleys, the same can not be said of the overwing exits. In case of an evacuation, the cabin crew focuses on leading the evacuation through these exits, while the passenger seated next to the overwing exits is responsible for operating them. The stringent requirements and in-depth explanation of the operation of these doors also came after the 1985 Manchester Airport disaster [6].
During the fire, a passenger sitting in the right overwing exit did not understand how to operate the door, leading to a big bottle-neck. When the door was opened, many passengers desperately crawled over the seats to reach the exit as the aft exits were unusable and the heat was reaching intolerable levels. In the meantime, the seat back of the overwing exit collapsed forward, further blocking the exit. The door was also removed and placed inside the aircraft, hindering the outflow of passengers. Most of the casualties were located around this exit [6].

Since then, passengers have been briefed on how to operate and lead the evacuation, and if unable or unwilling, they will have to swap seats with another passenger.

OXYGEN MASKS

"In the unlikely event of a loss of cabin pressure, oxygen masks will drop from the panel above you. Pull the mask towards you to start the flow of oxygen. Place the mask over your nose and mouth, and secure it with the elastic band. Even if the bag does not inflate, oxygen is flowing. Be sure to secure your own mask first before assisting others."

Oxygen masks serve a critical role in aviation safety, particularly in the event of depressurization occurring above 14,000 feet (4300 meters). At such altitudes, there is insufficient oxygen to sustain human consciousness, necessitating the use of oxygen masks to provide a breathable

Flight attendant demonstrating how to fasten the oxygen mask

supply. The crew initiates a controlled descent to lower altitudes where the air is breathable, as the oxygen masks draw from a limited reservoir and cannot sustain all passengers for an extended period.

But why pull on the mask? A common misconception is that the oxygen is stored in the reservoir tanks in gaseous form. However, this is not the case. Two solid chemicals in the reservoir combine and produce oxygen as a side product during their reaction, making "pullin'" a vitally important step.

The emphasis on the order of using oxygen masks in announcements is also crucial due to the rapid onset of hypoxia, particularly depending on an individual's health and the altitude of the aircraft. In such situations, individuals may quickly lose the ability to assist others if they do not prioritize donning their own masks first.

Despite the vital role oxygen masks play in emergencies, there is a potential downside: the risk of fire. Therefore, if a fire is already present on board, oxygen masks are not deployed to avoid adding fuel to the fire. In the history of aviation, there has been only one fatal accident attributed to the presence of oxygen on board: the ValuJet Flight 592 incident in 1996. This tragedy was caused by an expired and improperly labeled oxygen generator, highlighting the importance of proper maintenance and labeling of onboard oxygen equipment to prevent such accidents [7].

LIFE JACKETS

"Your life jacket is located [under your seat/in the overhead compartment/etc.]. Slip the jacket over your head and secure the strap around your waist. To inflate the jacket, pull down firmly on the red tab after exiting the aircraft. If needed, the jacket can also be inflated by blowing into the tube. The life jacket is equipped with a whistle and a light to attract attention."

As unlikely as a water landing may be,

The remains of British Airtours Flight 28M after the Manchester Airport disaster

One of the simulations presented in the report after the Kegworth disaster displaying the dynamics of the brace position

having life jackets onboard is imperative, as they can save hundreds of lives. The location of life jackets varies by aircraft: some are stored under the seat, others under the seat in front, and some in the overhead panel. This is why the introductory line for the announcement is the jacket's location. During the ditching of US Airways Flight 1549, many of the passengers did not manage to locate their life vests, which could have resulted in tragedy [16].

Unlike the more common type of life jackets, those present in aircraft are not intrinsically buoyant. Having a full life jacket for every passenger would occupy too much space. Thus, the airliner life jackets inflate by pulling a cord, which opens a CO_2 canister rapidly filling the jacket. If the canister malfunctions, the jacket can be inflated manually by blowing into a tube [16]. This procedure also leads to a crucial point in the safety announcement: life jackets should only be inflated once outside the aircraft to prevent passengers from getting stuck inside a sinking aircraft, as the inflated jacket can obstruct movement in confined spaces.
A tragic example highlighting this importance is the crash of Ethiopian Airlines Flight 961. The flight was hijacked and instructed to fly to Australia but lacked sufficient fuel for the journey. It crash-landed in the Indian Ocean, with the pilot managing to bring the plane close to an island for quicker recovery [8]. However, many passengers had prematurely inflated their life jackets inside the aircraft. When water began rushing in, the inflated jackets hindered their ability to exit, especially as the aircraft had turned upside-down and the exits were below the water, resulting in only 50 of the 175 passengers surviving the crash [8]. This incident underscores the necessity of following safety instructions regarding life jackets to maximize the chances of survival in an emergency.

SMOKING

"Smoking is strictly prohibited throughout the duration of the flight."

Smoking on flights was a contentious issue in the late 20th century, with consumer rights advocates and the Association of Flight Attendants on one side and airlines on the other. As public awareness about the health dangers posed by smoking grew, the opinion of flyers became increasingly one-sided. Governments were prompted to take action by the tragic losses in Varig Flight 820 and Air Canada Flight 797, which resulted in a combined total of 146 fatalities. Both incidents were caused by fires in the lavatory. The exact origin of the fire remains unclear, but there is a very likely candidate [9][10]. These events led to a smoking ban on flights, particularly in lavatories. However, regulations still require ashtrays and smoke detectors in aircraft lavatories to ensure that if someone does break the law and smokes, there is a safe way to dispose of the cigarette, reducing the risk of a fire hazard.

AIRPLANE MODE

"The use of electronic devices is permitted during the flight, provided they are switched to Airplane Mode."

Could the fact that I am using my phone on the plane cause it to crash? It turns out that the answer is as easy as it seems: no. The concerns about electronic devices causing interference with aircraft systems have been an issue since the 1980s. The fact that cell phones emit radio waves caused concerns among airlines and pilots that systems may be disturbed. Several operators carried out extensive research but were inconclusive [11]. This is unsurprising. Usually, the electromagnetic spectrum usage is clearly defined and divided, and the radio waves received by phones are completely different from those used by aircraft communications and navigation [11][13].

The ban is related to ground networks and infrastructure. Carrying hundreds of radio wave emitters in the air may jam cell service infrastructure on the ground. It is not much of an issue at cruising altitude because of the distance, but at lower heights, this may become a significant issue [11][12]. There also appears to be some debate on the validity of these statements. However, in a conservative approach, regulatory bodies

Turns out the answer to whether forgetting to turn on Airplane mode can cause your plane to crash is as easy as it seems: no.

Flight attendants learning the deployment and use of the emergency landing evacuation slides

still retain this rule [13].

THE SAFETY CARD

"We kindly ask you to take a moment to review the safety card. It contains essential information, including evacuation procedures, to ensure your safety during the flight."

Not all of the information can be mentioned during the preflight safety briefing, so the details on the instructions are visible on the safety card. The information displayed here varies with the airline, but generally, you can identify the items mentioned by the crew, such as the lifejacket use, oxygen mask use, etc., as well as details on the evacuation procedure [14]. For example, if t ditching occurs, the aft doors must remain closed. If fire or danger is seen outside one of the exit doors, it shall not be used [14]. There is usually also information on certain restrictions during each phase of flight, such as when big electronic devices may be used, or when you can disconnect Airplane Mode. Finally, examples of the brace position are also displayed [14].

A vital characteristic of these cards is that they must be understood by every passenger. Usually, the preflight safety briefing is performed in English and the language of the departure airport, complimented by a visual demonstration. However, some passengers might still not have understood it or have doubts about it. Thus, the card is generally not written in any language, but instead is highly ideographic with descriptive pictures to illustrate what to do in drawings and universal symbolism, making it less open to interpretation and more memorable. This is called the picture superiority effect, based on dual-coding theory, which states that information is processed and represented in both verbal and visual forms in the brain simultaneously [15].

FINAL CABIN CHECK

"As we prepare for take-off/landing, we kindly ask that you fasten your seatbelt, raise the window blinds, return your seat to the upright position, and stow your tray table and any large electronic devices."

After the briefing and before take-off, as well as before landing, the cabin crew will perform a check to "secure the cabin". Take-off and landing are the most critical phases of flight, where most accidents accumulate, so it makes sense to take extra precautions. There are 4 main checks performed (1) seat belts fastened, (2) trays stowed and seats in the upright position, (3) window blinds up, and (4) overhead bins closed.

The first two items make perfect sense. Survivability is enhanced if you can perform the brace position without being hindered or hindering others, thus trays and seats must be in a comfortable configuration. Several simulations were performed after the Kegworth air disaster, and the highest survivability was achieved by people wearing seat belts and having this configuration [2]. The last item is also understandable. During a crash or heavy turbulence, the last thing you would want is to have objects flying around the cabin that could damage passengers. However, what is the deal with the third point? There are 3 main reasons. Firstly, by dimming the cabin lights and allowing the outside light (or lack thereof) to enter the cabin, in case of an emergency, your eyes will have already adapted to the situation [10]. Secondly, having all windows up also allows the cabin crew to alert the pilots when they see something amiss [17]. Finally, in the event of a crash landing, the subsequent evacuation will not always be carried out through all doors. Thanks to the open window blinds, the passengers and the crew leading the evacuation can better determine the usable and unusable emergency exits [17].

"CABIN SECURED."

For frequent flyers, the preflight safety briefing is just routine, and they will disappear into their book or headphones to wait for take-off. For first-time flyers, the briefing may stir up their nerves a little and they may pay the utmost attention. However, the undeniable and universal fact is that the preflight safety briefing has saved lives, and may save yours one day. As we have seen, they are constantly changing and evolving, the fruit of investigations on how survivability could have been enhanced. This is why - whether a frequent or first-time flyer - any passenger should listen to it for their own benefit and the safety of others. In the end, this briefing is one of the key pillars that make aviation the safest means of transport in the world.

LAMBACH AIRCRAFT

The forefront of aircraft design for the aspiring engineers

Pavel Kelley, Lambach Chairman

Members of the Board 2023 - 2024

When we think of the world of engineering and the teams that comprise the many great projects of this century, our minds often drift to the big projects. These big projects are led by big teams split between several departments. This also applies to teams developing cutting-edge aircraft/spacecraft designs. However, it is still important to recognize that innovation can come from teams as small as 2-5 people working on similarly small projects. This is the idea behind Lambach Aircraft, a student society committed to small-scale aircraft design and expanding education to the practical level.

THE TRIALS AND TRIBULATIONS OF ENGINEERING

Lambach Aircraft started as a committee of the VSV 'Leonardo da Vinci' in 1989 to rebuild and fly the HL-II, a biplane designed in 1936 by Hugo Lambach. Both the name of the aircraft and the society hail from him. With the first flight taking place in 1995, Lambach Aircraft soon switched to maintaining the replica and trying their hand at their own aircraft designs. This came with mixed results as the society continued to learn about aircraft design and make progress on Impuls and S-Vision, but faced difficulty with manufacturing full-sized aircraft. Aircraft design on this scale presents a large challenge to those just learning the ways of engineering.

In 2015, the society would experience an issue with the inflow of new members coupled with older, more experienced members leaving. This caused the HL-II project to be severely understaffed and under-equipped to maintain the aircraft. With this being the case, Lambach would eventually donate the aircraft to the "Stichting Vroege Vogels" (Early Birds Foundation). It led to discussion about the future of the society and what would be possible going forward.

After much discussion, Lambach switched to a society focused on the design of UAVs. Although a difficult decision, it led to an overall brighter future, as now the society could build and design aircraft on a smaller scale without contending with larger overheads in cost and maintenance. With this decision, the boards for the following years would focus on winning European UAV design challenges. Along with the addition of Introduction to RC UAV, a program providing new members with experience in UAV design, the society settled into its new role as the society on campus for small aircraft design.

SHIFTING FOCUS

The change of focus paved the way for Lambach to remain at the forefront of aircraft design and construction within TU Delft, but now on a much smaller and more manageable scale. UAVs allow for the rapid testing and design of aircraft concepts or subsystems. This allows for projects to be completed within one year, helping to alleviate issues with information and project transfer. It permits self-contained projects which, while building on one another, allow for small but very manageable goals for all involved within the team.

However, Lambach is not just about designing UAVs and small aircraft but also ensuring the continuing education of its members on a practical and theoretical level. Programs such as "Intro to RC" provide opportunities for new members to build their aircraft and learn (sometimes the hard way) the challenges of putting theory into practice. This provides an incredible practical inspection of UAV design since what works on paper may need significant changes to perform well in reality. This does not mean that members entirely dispose of the theoretical in favor of the practical, but instead, balance the two with prototype testing and verification before flying their first aircraft.

SMALL BUT STRONG

As part of our initiative to design and construct UAVs with small-scale teams, the question arises: What do we mean by small teams? As Kelly Johnson, an influential aerospace engineer of the 20th century, put it: "The number of people having any connection with the project must be restricted in an almost vicious manner. Use a small number of good people (10% to 25% compared to the so-called normal systems)" [1]. Simply put a limit on the number of members for any given project to simplify it. While this requires team members to be more well-rounded, it allows for quicker communications and less confusion regarding deliverables and responsibilities. For Lambach, it means that while we have many members, they are all split into a few main projects. Each project contains a maximum of ten people, limiting what the team can achieve, but forcing them to choose what should be done and what they would like to achieve.

This choice is an important aspect of project management - otherwise many teams keep

An Intro to RC team

Another team celebrating a successful test flight

stacking on the number of features they want their aircraft to have. This creates over-budget and behind-schedule projects that take up time and resources to get back on track or to get rid of. With small team sizes and timeline limitations, many teams will need to stick to their primary goal With the added benefit of shorter communications and a more motivated team, a small team composition becomes an obvious choice.

THE FUNDAMENTALS OF ENGINEERING

While the small team approach to solving engineering problems certainly allows for efficient work, does it allow for new creative thinking? The answer is yes, it allows for advancements to be made and it also allows for projects to be conducted to increase research and understanding of the topics. Lambach is committed to the education of its members along with aircraft design. Projects or teams working on something that has been entirely done in the past is not uncommon. On the surface, these projects may seem unnecessary and wasteful. Why would someone complete a project just for the sake of doing so?

Despite taking a "well-trodden" path, projects such as these provide an opportunity for students to participate in the fundamental aspects of design. In this way, the principles of flight are viewed once more with the physical lens of a UAV project. On this topic specifically, Carl Sagan, a renowned astronomer and planetary scientist, comments: "Basic research is where scientists are free to pursue their curiosity and interrogate Nature, not with any short-term practical end in view, but to seek knowledge for its own sake" [2]. While Carl Sagan was not exactly referring to projects such as these, it is still important for engineers to "seek knowledge for its own sake", improving their understanding of the world around them by leaps and bounds.

A FINE LINE

However, this does not come without peril, as small teams splitting resources across a society pose a problem. This is compounded by the fact that small teams often lack specialization. Specialization, or more specifically specialists, often bring the technical know-how for a particular subject to a project. However, with a small team composition, the average team member is more "well-rounded" and "less specialized". It leads to either a team that poorly covers the areas in which it is lacking in know-how, or a team that rapidly brings in members faster than it can figure out how to manage them. To overcome these challenges, managers of teams must know how to walk the "fine line" of recruitment and leadership.

This can be remedied by implementing the concept of "consultants", which are skilled but not assigned to the current project. Instead lending their advice and knowledge to help solve a single problem without becoming heavily involved. Maintaining the core team of a project can also provide its benefits, as a small group of tightly knit people often motivate one another heavily, pushing each other to go above and beyond in their roles. This idea is also held by Ricardo van der Plujim, an engineer at NLR, who states about this strategy: "This approach keeps communication lines short, boosts efficiency and team spirit, and ensures everyone remains focused on the project. I have seen the benefits of this firsthand." In larger teams, the necessity of subdivisions and sub-teams may isolate the team members from one another. It is why many engineering firms, Lambach Aircraft included, choose small but strong.

BMFA competition team with their prototype after a flight test

CONCLUSION

Lambach aircraft remains at the forefront of aircraft design for aspiring aerospace engineers. From rebuilding replicas to designing large aircraft and finally settling on many simultaneous UAV projects, Lambach Aircraft plans to continue to push forward, while also educating its members on the practical level. With the utilization of small engineering teams to stay flexible and unburdened, Lambach allows students to reexamine what they think they understand and explore further into what they don't.

Ever since its foundation, TNO has been active in the field of advanced optical instruments, and for over 50 years has been developing instruments for use in space, astronomy, scientific research and manufacturing industry. Examples of this work include the development of instruments for measuring the ozone layer (GOME and TROPOMI) and a space telescope (GAIA). The measuring instruments contribute to dealing with important social issues, spur on science and form the basis for industry and job opportunities in the Netherlands.

This is the time for innovative solutions.
Join our team of experts

Benjamin Brenny,
Optical Designer

‘At TNO, you can truly immerse yourself in technology.’ ‘A great project I worked on was Sentinel 5, an ESA satellite that monitors air pollution. This pollution is detected by means of a telescope and spectrometers. Gases like CO_2, SO_2 and NO_x each absorb light in their own way. As a designer, I am involved in the beginning of a project.

Optical design deals with optimising and aligning lenses and mirrors, aided by specialized computer software. I also have a role in the performance analysis of the design, before and after it has been built. For example, what is the impact of minor manufacturing errors with respect to the model?’

I like the collaboration with industry, but above all the societal relevance. Take the satellite that measures air pollution or the medical instrument that detects eye diseases. Contributing to these instruments gives me great satisfaction. It’s not without reason that I do so many different things, as I am still searching for what I like best – but that’s allowed here!

SPACE SHUTTLE ABORT MODES

A fascinating story about making space shuttle operations safer

Ruth Euniki Vraka, Editor-in-Chief, and Gerard Mendoza Ferrandis, Leonardo Times Editor

SPACE

Parachutist testing a mockup of the bailout system

The space shuttle was a very unconventional vehicle, to say the least. However, unconventionality usually comes at the price of higher risk. Abort modes were established for every phase of flight to make this state-of-the-art vehicle safer. How were these procedures? Did they change with time? What other safety mechanisms were considered?

THE SPACE SHUTTLE

When space access became increasingly coveted by leading international powers, a need arose for a reusable transportation option. Within the United States and NASA, this took the form of the spaceplane known as the Space Shuttle. The Space Shuttle, officially called Space Transportation System (STS), operated from 1981 to 2011. During the time of STS, five Space Shuttles were built and flew a total of 135 missions, with 852 payloads [1]. They also played a role in constructing the International Space Station (ISS) and launched, among others, satellites, probes, and the Hubble Space Telescope.

The five Space Shuttles built were named; Columbia, Challenger, Discovery, Atlantis, and Endeavour (delivered to Kennedy Space Center in this order). Columbia and Challenger were subjects of accidents in 2003 and 1986, respectively. Each Space Shuttle is composed of three main components (see Figure 1): the orbiter, an external tank, and two solid rocket boosters. The orbiter houses the mission crew and payload. Once ready to launch (in a vertical position), lift-off is achieved using the two solid rocket boosters for the first two minutes of flight. The solid rocket boosters are separated at approximately 45 km and recovered after parachuting to Earth. The external tank carries fuel for the main engines of the orbiter and burns up in the atmosphere after separation at approximately 113 km, when the orbiter has almost reached its orbital velocity.

WHY ABORT MODES?

Every space launch system developed since the start of the space race has had an abort procedure. These usually consisted of rapidly separating the crew from the vehicle once a major fault was detected. The conventional way of doing this, from the Mercury program to Skylab, was through the so-called "Launch Escape System" (LES) or "Launch Abort System" (LAS). It consisted of a tower with several small solid rocket motors that could pull the spacecraft away from the launch vehicle in an emergency.

How can a similar system be designed for such an unconventional launcher like STS? The Shuttle's orbiter-tank-booster configuration posed difficulties in separating the crew from the whole launch vehicle. Thus, the next best way to ensure crew safety was to carefully design an abort procedure for all phases of the flight. This, however, brought some limitations to the payload-to-orbit. Despite the first STS launch being fully abortable, it was decided that consequent launches would focus on maximum payload, so there would be some windows where no abort modes were possible [2].

This would change after the Challenger disaster. It was determined that a revision of these modes was necessary, so new modes were implemented to minimize the time of total loss of crew and orbiter [2].

THE BASICS

The launch and flight of the Space Shuttle is a complicated procedure, and there are various phases in which things could go wrong. During each of these phases, emergencies are handled differently. The first main differentiation is made between pre-launch and post-launch abort modes. Roughly 6.6 seconds before launch, the three main engines ignite. If an anomaly is detected in their performance, monitored by computers, the engines shut down and the countdown timer is reset. This abort mode is called "Redundant Set Launcher Sequence" (RSLS). RSLS occurred four times in the history of the Space Shuttle, to Columbia, Challenger, Discovery (during its maiden flight), and Endeavour. Atlantis was the only Space Shuttle not to experience RSLS [3].

Once the main engines are operating and solid rocket boosters have ignited at T=0, liftoff begins. During the first minutes of lift-off, until the separation of the solid rocket boosters - aborting is impossible [4]. During the remaining ascent time, there are various specified abort modes, distinguished between "intact" and "contingency" aborts. Intact aborts are aborts with which the orbiter returns to a runway or other landing site, or orbits at a lower height than planned, usually due to the failure of one main engine. Contingency aborts were initiated after any other failures, failure of more than one main engine, or when the orbiter failed to reach the runway [2][5].

The aforementioned abort modes are automated, called by crew, or called by ground missions control, depending on the type and situation. Intact aborts due to the loss of a main engine were automated, while contingency aborts were mainly called by crew with assistance from ground operations. However, manual abort conditions were not always certified because of the difficulty of planning and simulating all possible failure conditions. Therefore, further automation of aborts was recommended to allow for better verification of flight software and sequences [2].

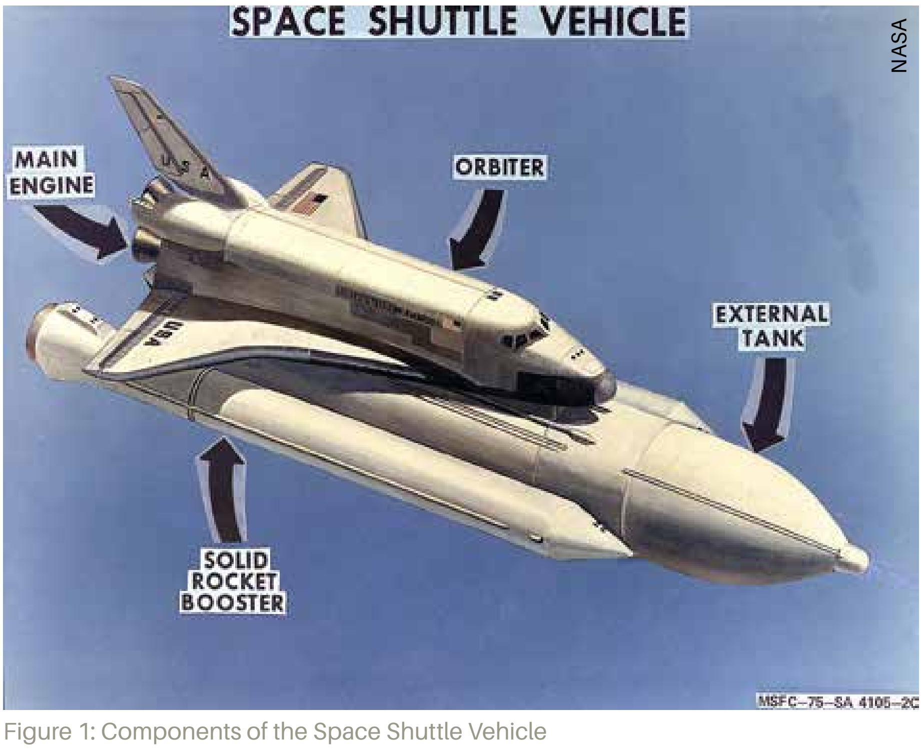


Figure 1: Components of the Space Shuttle Vehicle

THE ORIGINAL FOUR

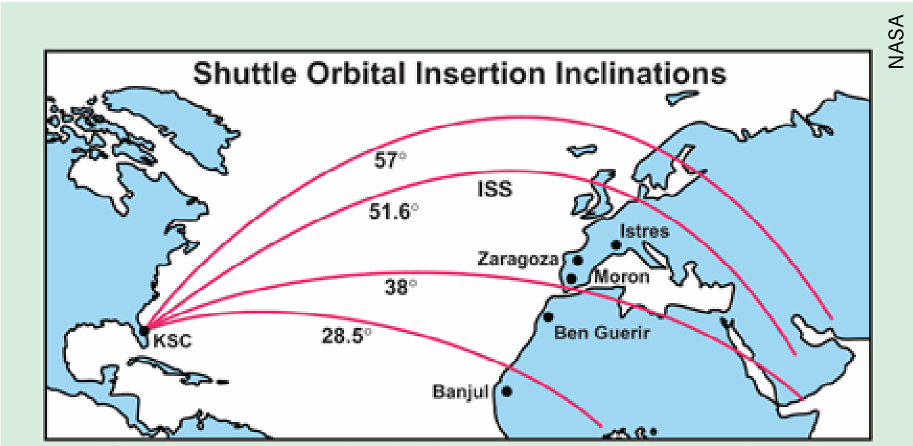
There are four main intact abort modes, with a defined order of preference of use. The choice of an abort mode is based on criteria such as the type of failure, failure time, and amount of performance loss. If performance loss was the only reason for an abort, the order of preference is the one used in this section. If a different failure occurred that compromised support systems such as vehicle cooling, cabin leaks, etc., the abort might have been chosen based on how fast the mission could end. It is also important to note that a contingency abort was only chosen if no intact abort was possible [5].

ABORT TO ORBIT (ATO)

The ATO abort mode was the abort mode preferred by NASA. In a nutshell, ATO was just a version of the mission where, due to a single Space Shuttle Main Engine (SSME) failure, the crew would aim for a lower orbit [2]. It was the only intact abort mode ever performed and occurred during the 19th mission (STS-51-F) when one of Challenger's main engines had an early shutdown. This abort mode could engage from either T+4min35s or T+4min07s depending on whether the orbit had a low or high inclination, respectively [4]. The orbit would be reached after changing the burns by the Orbital Maneuvering System (OMS) to a different point in time - putting the orbiter into a lower circular orbit [6]. By going into a lower orbit, the crew would have more time to consider their options and decide if they wanted to perform the mission at this lower orbit or if they needed to return [2]. The abort mode was called by mission control, and the crew would either choose ATO on the abort mode selector on the panel or simply perform the OMS burns at the new targets [6].

ABORT ONCE AROUND (AOA)

If the AOA abort mode was initiated, the orbiter would fly once around Earth, making a normal entry and landing approximately 90 minutes after liftoff [5]. This maneuver could only be initiated if the engine failure occurred from about T+3min40s and would be initiated similarly to ATO by either selecting the AOA abort mode in the panel or performing the OMS burns at the new targets [6]. The maneuver would be completed with two sequences: a deorbit maneuver and a nor-



A shuttle liftoff at 57 degrees inclination to the equator is considered high inclination, 38 to 45 degrees is mid-inclination, and 28.5 degrees is low-inclination. TAL sites are selected depending on launch inclination. All flights to the International Space Station are launched on a 51.6-degree inclination.

Figure 2: Shuttle orbital insertion inclinations

mal entry sequence. AOA is used should the flight performance reduce to a level the planned orbit cannot be achieved. It is also used if there is not enough propellant to reach the planned orbit and be able to deorbit [4]. AOA is also used if a critical support system malfunctions (e.g. cabin leak) and the mission must be ended [5]. Even though it is the second on the list of preferences, AOA is the least likely abort mode. In most cases where AOA can be used, early deorbiting opportunities are also possible with ATO. AOA is preferred if performance is below normal on the earliest abort times [2].

TRANS-ATLANTIC LANDING (TAL)

The TAL abort mode is a ballistic trajectory that results in an intact landing on the other side of the Atlantic Ocean. TAL is the second quickest option to land the vehicle and is used when a critical failure occurs after the last RTLS (Return to Launch Site, see section below) opportunity or when there is not enough power for an AOA mode [7]. The time to land is approximately 35 minutes, compared to the 90 minutes of AOA. A graph of the TAL trajectory compared to the nominal trajectory is illustrated in Figure 2.

This abort method covers the gap for a main engine failure after the last RTLS opportunity and the first AOA opportunity. It is also an ideal option when a system failure occurs to the orbiter after the last RTLS opportunity, and landing as soon as possible is necessary. The landing site of TAL is chosen based on the nominal ascent ground track of the orbiter and requires the necessary runway length, weather conditions, and U.S. State Department approval [5]. The three main landing sites identified for potential use were Moron Air Base (Spain), Zaragona Air Base (Spain), and Istres Air Base (France). Other landing sites that were temporarily used were Banjul (the Gambia), Dakar (Senegal), and Ben Guerir (Morocco). Banjul replaced Dakar in 1988 due to the latter being found to have unsatisfactory runways and geographic conditions. Ben Guerir replaced Casablanca (used as a contingency landing site in 1986) in 1988 and was used for STS-111 in 2002 [9].

The TAL abort mode is initiated by placing the abort rotary switch in the position for TAL and AOA. It must be depressed before the main engine cutoff, if it is done after, the AOA abort mode will be initiated. While the orbiter is steering towards the landing side, the OMS propellant is dumped (by burning it with the OMS and reaction control system engines) to reduce the vehicle weight and increase performance. In this manner, the center of gravity is also optimized for vehicle control. Then, the TAL entry is a nominal entry [5][7].

RETURN TO LAUNCH SITE (RTLS)

RTLS is the quickest of all abort modes, returning the orbiter, crew, and payload to the launch site within 25 minutes after lift-off. It is used when one space shuttle's main engine is lost (or there is a different system error) within the first four minutes and 20 seconds after launch [5]. The RTLS mode consists of three stages: the powered stage, the external tank separation, and the glide phase.

During the powered stage, the space shuttle's main engines are still operational. The abort is initiated by the crew after SRB separation, by positioning the abort rotary switch to RTLS and depressing the button. The exact time the button is depressed depends on the conditions of the abort. If RTLS is called due to one engine loss at lift-off, it is done early, at approximately 2 minutes and 20 seconds after SRB separation. On the other hand, RTLS is delayed to three minutes and 34 seconds for a three-engine RTLS [5]. In this stage, the shuttle dissipates all excess main engine propellant, keeping only enough to turn around, fly back towards the launch site, and achieve the necessary speed, pitch, and altitude conditions to glide to the runway after the external tank separation. The OMS propellant is also dumped similarly to TAL to reduce the weight and optimize the center of gravity location for improved performance and control, respectively [7].

The external tank separation stage is the most critical and reaches the cutoff point when the vehicle has less than 2 percent excess propellant remaining in the external tank. Twenty seconds before cutoff, a pitch-down maneuver ensures that the correct altitude and pitch rate are achieved for separation. Once the main engine cuts off, the tank separation begins. Systems such as the reaction control system are in place to ensure that the orbiter does not come in contact with the external tank and that the pitch required for the glide phase is established [5].

POST-CHALLENGER CONSIDERATIONS

After the tragedy in 1986 with STS-51-L, when it blew up 73 seconds into launch, commonly known as the Challenger Disaster, many recommendations were made to improve the crew survivability. As the reader may have noted earlier, up to the Solid Rocket Booster (SRB) separation - no abort modes were planned for the shuttle [2]. A nomenclature was also defined for the survivability zones: green was used when the crew and orbiter would survive, yellow when the crew must bail out to survive, and black for unsurvivable regions. These so-called "black zones" were the main concern after Challenger, and NASA aimed at reducing these black zones to a minimum by adding the "contingency abort" [2]. It was decided then that if only one SSME failed, the typical intact abort mode profiles could be used. However, if two or all of the SSMEs fail, the contingency abort mode profile will be called for. Depending on whether the contingency abort occurred during a green or yellow zone, the crew would have to either attempt a landing or bail-out, respectively [10].

Some black zones remained after the incorporation of the contingency modes. For the 2-SSME failure, most of the black zones were eliminated [2]. However, there was still uncertainty during the PPA phase of RTLS due to the aerodynamic loads [10].

On the other hand, approximately four black zone groups remained for the 3-SSME failure. During the initial part of the ascent phase, there was a black zone group as the orbiter could be destroyed due to a potential structural failure, excessive airspeed, or controllability issues caused by the excursion of the CG and the separation dynamics [10]. After the RTLS mode was selected, there were still three black zone groups: (1) while performing the PPA due to excessive airspeed, (2) if there is a controllability, attitude, or excessive airspeed issue close to when the shuttle achieved a relative speed of zero, and (3) loss of control close to Main Engine Cut-Off (MECO) [10].

When not in these black zones, the crew could either land back at the Kennedy Space Center (KSC), Bermuda (BDA), perform a TAL, or even land at the East Coast (ECAL). If landing was not possible, a bail-out would occur. Part of the changes introduced to the STS was using pressurized suits for these situations [2][10]. If a bail-out was necessary, the crew hatch could open, a rod would extend, and the crew would slide down the rod and parachute back to Earth. It was a big technical challenge, with NASA first considering propelling the astronauts out with rockets [11][8]. Eventually, the rod design was chosen as the most reliable, and the design of a life support system began [11]. The parachute had to be able to deploy from the back of the pressure suit and deploy automatically in case the crew became unconscious, and contained survival equipment for landing in the ocean. No bailouts were required during the STS era [11][8]. The bail-out method is depicted in the 2000 Clint Eastwood movie "Space Cowboys".

This evolution of contingency aborts for the first seconds of flight is illustrated in Figure 3. It has been adapted and enhanced from Henderson and Nguyen's report [2][10]. It shows the color-coded survivability zones for the ascent and RTLS phases under different SSME failure conditions, both for the pre- and post- Challenger Disaster.

OTHER SAFETY PROCEDURES

Several other safety procedures were considered during the development of the space shuttle. A pair of ejection seats were designed by Lockheed Martin and installed in the Endeavour orbiter during the Orbital Flight Test program [2][12]. It accounted for possible unexpected design flaws, as usually done during test campaigns on aircraft and spacecraft. These ejection seats were also available during the first four flights of

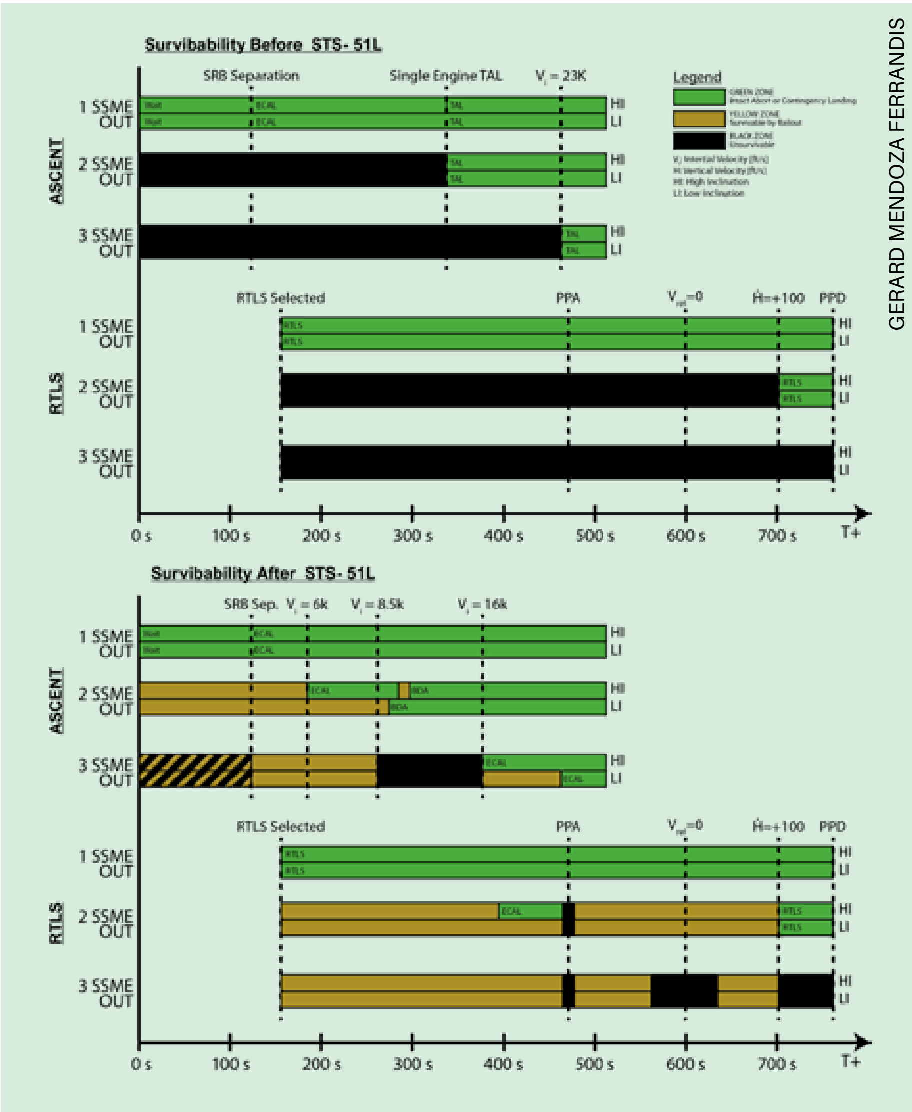


Figure 3: Evolution of survivability during the initial phase of an STS launch

Figure 4: Atlantis and Endeavour on the pads at the same time. Endeavour was designated as the rescue spacecraft as part of the CSCS program

the shuttle, flown by Columbia. However, the ejection seats were eventually removed. As aforementioned, all missions after STS-4 carried a crew size larger than two [2]. Evacuating the whole crew through an ejection seat mechanism would have been an impossible technical challenge, as some were located in the middle deck. Furthermore, the ejection seats had a very limited envelope of use; only during some final phases of landing and a short period during take-off. This was outlined by STS-1 astronaut Robert Crippen, who mentioned he did not feel like parachuting off the orbiter with potential flying debris and the plumes of the SRBs[13].

The latter issues of the envelope of use of ejection seats and the exposure to the elements could have been resolved by introducing crew ejection capsules. Individual capsules were considered, as well as having a common crew compartment that ejected. However, it goes without saying that even though considered, the technical difficulties it would bring with the redesign of the orbiter and the additional failure point put that option to rest [14].

After the tragic loss of STS-107 during reentry, also known as the Columbia disaster, however, an additional safety precaution was taken: the "Launch On Need" (LON) missions [15], also later referred to as "Contingency Shuttle Crew Support (CSCS) Rescue Flights" [16]. These missions were labeled as STS-3xx and would be prepared in case the main mission reached orbit, but the crew could not return. The only exception to this was STS-400, designated as the rescue mission for the STS-125 Hubble Space Telescope servicing mission (Figure 4). Due to the higher orbital inclination, the rescue procedures changed and were given a new name.

The main concern for CSCS missions was damage to the thermal protection system, either at launch or due to space debris. The inability to return could be determined after inspecting the orbiter by using the Orbiter Boom Sensor System (OBSS), an attachment that could be added to the Canadarm. Using the OBSS, the crew would inspect critical parts of the orbiter and, if necessary, request the CSCS Rescue Flight be initiated [16]. Only 12 LON missions took place. Thankfully, none had to be activated.

CONCLUSION

It is undeniable that NASA's Space Shuttle program revolutionized space travel. From the initial introduction of the ejection seats to the development of abort modes, the evolution of these and the introduction of new inspection methods after the Columbia and Challenger disasters is a testament to the commitment to crew safety and mission success by NASA, and what has helped them maintain their extraordinary safety record through the years.

BOEING'S DESCENT

Unraveling five years of crisis and controversy

Muhammad Arham Elahi, Final Editor and Thomas Muller, External Editor

NPR

The last half-decade for Boeing has been a turbulent rollercoaster, with significant events and challenges affecting every department and aspect of the company. This article aims to construct a timeline of these events and build a coherent narrative regarding Boeing's troubles, their underlying causes, and interactions with entities such as the FAA and their supplier Spirit AeroSystems.

ORIGINS OF THE 737 AND ITS COMPETITORS

Boeing conceived the design of the 737-100 in 1968. It was intended as a short-hop commuter jet and was first introduced in West Germany. Aviation looked very different back then; there were no jetways to board passengers and no motorized belt loaders to load cargo. Boeing's low-to-the-ground aircraft design enabled passengers to board the aircraft with folding metal stairs built into the airframe, removing the need for stair trucks. Additionally, the cargo hold's low height enabled ground crews to lift heavy luggage manually [1].

These advantages played a big part in establishing the dominance of the 737 family of aircraft over its primary initial competitor, the McDonnell Douglas DC-9 and its variants. However, in 1987, a new contender came into the picture: Airbus, a fledgling company based in Europe, introduced the A320 design. This aircraft was built according to a completely different set of modern requirements and was positioned significantly higher off the ground to accommodate the growing size of engines after the introduction of the more efficient turbofan engines. Slowly but surely, Airbus continued to close the gap between itself and Boeing and began to surpass Boeing in sales figures after 2003. Faced with competitive pressure, Boeing needed an answer, and fast. That is when it announced its plan to introduce the 737 MAX. Sales rapidly recovered, particularly driven by the introduction and success of the 737-800 model between 2012 to 2018. To speed up the design process and reduce both airline and manufacturing costs, Boeing opted against a complete redesign, still retaining many elements from its original 1968 design. And then disaster struck [2].

THE 737-MAX SAGA AND BOEING'S RESPONSE

Due to the low-to-the-ground design, the engine needed to be shifted forward with respect to the wing, causing a pitch-up moment at high angles of attack. To counteract this came the installation of a system called the Maneuvering Characteristics Augmentation System (MCAS). Contrary to popular be-

The Original Boeing 737-100

lief, MCAS was not a stall prevention system; it was implemented to improve the aircraft handling characteristics when approaching a stall. Thus, the control feedback/feel for the pilots would be extremely similar to what they were used to in the rest of the 737 family. This negated the need for them to undergo extra training for the 737 MAX, greatly reducing airline costs and making the 737 MAX a much more attractive option. Although Control Augmentation Systems are commonplace in aviation and were first introduced by Airbus in their A320 family, MCAS had a critical single point of failure. Even though Angle of Attack sensors are notoriously unreliable, a single faulty sensor of the two onboard could trigger the MCAS system. This led to the Lion Air Flight 610 crash and the Ethiopian Airlines Flight 302 crash in 2018 and 2019, respectively, leading to the death of 346 passengers and crew [3].

After the crash of Lion Air Flight 610 in October 2018, Boeing's response was initially centered on defending the design and safety of the 737 MAX. The company issued an Operations Manual Bulletin (OMB) to airlines, which provided procedures to address erroneous data from the aircraft's Angle of Attack sensors. This bulletin did not explicitly mention the MCAS system but included instructions for dealing with the specific scenario that had led to the crash, emphasizing the importance of following the runaway stabilizer procedure.

Additionally, there was reluctance to admit that the design had fallen short. Boeing promoted a narrative that blamed the "foreign pilots" for the crashes, suggesting they were not competent enough to handle the 737 MAX. Conversations at Boeing focused on how the pilots from Lion Air Flight 610 had failed to properly manage the aircraft using the thumb switch to trim the plane. This blame-shifting narrative ignored the critical design flaws of the MCAS system and reflected a troubling bias within the company. Boeing's pilots, predominantly older White men, had long shared derogatory jokes about the competence of international crews, which contributed to a dismissive attitude toward the foreign pilots involved in the crashes [12].

Despite this, only one American pilot "survived" an erroneous MCAS activation in a flight simulator on the first try. He was a trained FAA pilot, coached by Boeing officials before the test - other pilots took anywhere between six and sixty seconds too long to respond correctly [12]. This insult to the deceased pilots was highlighted further in an interview with Boeing's new CEO, David Calhoun, in March 2020. Calhoun implied that pilots who "don't have anywhere near the experience that they have here in the U.S." shared blame for the crashes. When pressed to clarify whether American pilots could have saved the planes, Calhoun asked to go off the record, and when reporters refused, he added, "You can guess the answer." [9]

Boeing built an unsafe plane, and blamed the pilots when it crashed.

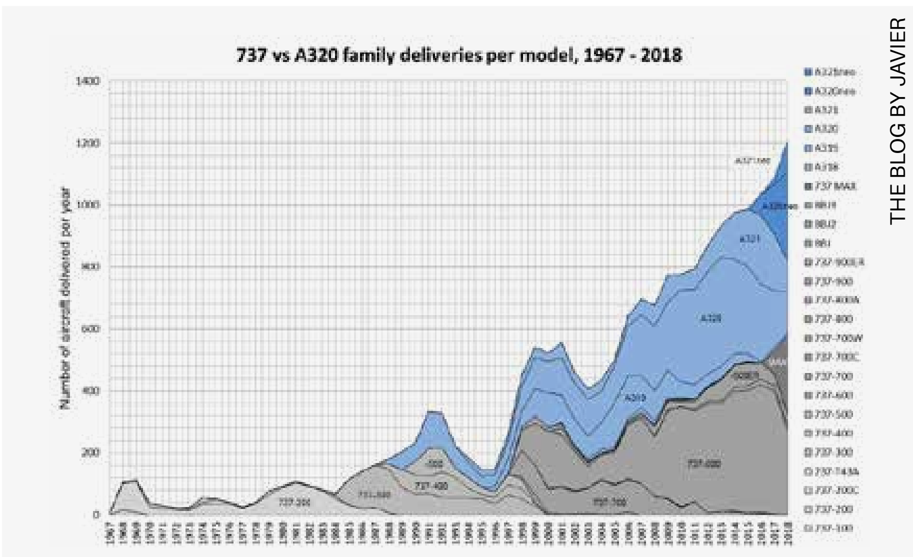
However, when Ethiopian Airlines Flight 302 crashed in March 2019 under similar circumstances, the global response was swift and severe. Within days, aviation authorities worldwide, including the Federal Aviation Administration (FAA), grounded the 737 MAX. This time, the reaction was markedly different. Boeing's CEO, Dennis Muilenburg, issued a statement expressing deep sorrow for the loss of lives and committed to supporting the investigations. The company acknowledged the similarities between the two crashes and pledged full cooperation with regulatory bodies.

At the FAA, engineers began scouring their files for information about the software in question and discovered incomplete and inaccurate work by the Boeing employees entrusted to oversee safety matters as the FAA's authorized representatives. The system safety assessment for MCAS had been turned over to the agency just four months before the plane was officially certified. The Boeing deputy, who had vetted the software design had categorized the risk of failure as relatively minor [10].

But the documents on file reflected the software's earlier design, not the more powerful version later added in flight tests. The documents showed the stabilizer could adjust a plane's ascent or descent by 0.6 degrees. However, in its final form, the stabilizer could make adjustments at four times that angle [11]. "When they changed the design it drastically changed the potential criticality of the MCAS feature," says an FAA engineer, who asked not to be identified because he isn't authorized to speak publicly. "And that was not communicated to the FAA engineers who find compliance [with regulations]. In fact, they didn't even know about it." [12]

THE RESURGENCE OF ISSUES

That wasn't the end of Boeing's problems. In 2023, just as it seemed Boeing was back on track and resuming normal production, another wave of issues hit. In April 2023, Spirit AeroSystems, a Boeing supplier responsible for building the fuselage of the 737 and 787, found a defect in the fittings that connect the vertical tail to the fuselage. Fortunately, they identified the issue early in the design process and pinpointed all affected aircraft. This



Boeing 737 and Airbus A320 deliveries compared from 1967 to 2018

Lion Air Flight 961 - Boeing 737 MAX 8

only caused a minor delay in deliveries with no far-reaching consequences [4].

In August 2023, Boeing discovered a potentially widespread manufacturing quality issue related to some fastener holes in the aft bulkhead of the 737 MAX being misdrilled and misaligned. While this issue was not an immediate safety concern and could be checked during routine maintenance, it required the inspection of up to 500 holes for each aircraft. This represented a significant time and cost investment and was a bad omen for things to come [5].

In December 2023, an undisclosed international airline noticed a missing nut in the 737 MAX's rudder control system. Boeing validated this as a systemic issue since an undelivered 737 MAX was also found to have the same problem. Given that this fault was not identified early in the production cycle, all the 737 MAXs in service needed to be inspected to ensure the rudder was functioning properly [6].

The situation culminated on January 5th, 2024, when Alaska Airlines Flight 1282 suffered uncontrolled decompression six minutes into flight. Fortunately, due to the low altitude, there wasn't any significant damage to the aircraft, and it landed safely with no major injuries. It is theorized that a door plug panel attached to the airframe was missing bolts and blew off mid-flight. This theory was supported further by other airlines finding loose bolts on their 737 MAX aircraft [7].

It was the last straw for the FAA, which ordered a second grounding of all 737 MAX jets and gave Boeing 90 days to propose a plan for quality control improvements. During this period, the FAA performed 89 product audits on Boeing, of which they failed 33. Although the FAA did not provide specifics, such a failure rate is unprecedented and highlights the production issues happening behind the scenes. Spirit AeroSystems, partly responsible for many of the aforementioned issues, was also audited 13 times, failing 7 of these audits. Specific instances of non-compliance included using a hotel key card to check for a proper door seal and using Dawn liquid soap as a lubricant for the door seal fit-up process, which they then cleaned with a wet cheesecloth [8].

Amid these manufacturing troubles, Boeing faced a serious cyberattack perpetrated by the ransomware group LockBit, known for its double extortion tactics. This group breached Boeing's systems in late October 2023 and threatened to leak a substantial amount of sensitive data unless ransom was paid by November 2, 2023. The stolen data included technical supplier information, financial details, internal training materials, and more. The hackers likely targeted Boeing, expecting to uncover incriminating information that would compel the company to meet their demands. Despite initial negotiations, Boeing did not pay the ransom, as it determined that the data compromised by LockBit was not critically sensitive. Consequently, LockBit began leaking the data on November 6, 2023 [14][15].

WHISTLEBLOWERS

These ongoing problems culminated in a wave of whistleblowing that brought to light deep-seated issues within Boeing. Employees, driven by concerns over passenger safety and frustration with the company's handling of quality control problems, have come forward with alarming reports. For instance, John Barnett, a quality manager at Boeing for nearly 30 years, reported seeing "metal shavings and debris" inside the fuel tanks of 787 Dreamliners. He faced retaliation, being reassigned and eventually pushed into retirement after raising these safety concerns. Former senior manager Ed Pierson, another whistleblower, testified before Congress about the chaotic production environment at the 737 MAX factory, describing it as "dysfunctional" and warning that it compromised safety. Pierson claimed that Boeing's relentless focus on production speed over quality contributed to the 737 MAX disasters [13].

Tragically, two Boeing engineers who were instrumental in highlighting these issues recently died. Paul Njoroge, who became a prominent advocate for aviation safety after losing his family in the Ethiopian Airlines crash, tirelessly campaigned against the 737 MAX, arguing that it should never have been certified. He emphasized the need for thorough regulatory oversight and was a vocal critic of Boeing's management practices. Similarly, Peter Lemme, a former Boeing engineer and expert in flight controls, repeatedly raised concerns about the design flaws in the 737 MAX. Lemme's warnings about the potential dangers of the MCAS system were among the earliest and most detailed critiques.

Alaska Airlines Flight 1282 - Boeing 737 MAX 9

CONCLUSION

Many of these issues could have been prevented had Boeing listened to its engineers. Instead, when employees began to whistleblow or critique the company, they were often punished, reflecting a troubling culture that prioritizes production over safety. As Pierson stated, "It's a broken safety culture, and it has to change." The sheer number of whistleblower reports and the ongoing FAA audits underscore the urgent need for substantial improvements in Boeing's quality control and oversight practices [13].

IGNITE

Preparations for the 16th lustrum of the VSV 'Leonardo da Vinci'

Pre-Lustrum Committee of the VSV 'Leonardo da Vinci'

Prelustrum 16: Theme reveal party (2024)

The upcoming year we celebrate the 80th birthday of the study association, VSV 'Leonardo da Vinci'. It has been a long set tradition that these birthdays are celebrated with what we call a lustrum. This is a 5-yearly celebration, making upcoming year the 16th lustrum. This lustrum was opened last May with the pre-lustrum week, but that is only the start of what's to come after the summer. But before diving into what is set to happen next year, let's first go back in time.

After being founded on the 18th of July 1945, the first lustrum was celebrated in 1950. Even though very different from how a lustrum is celebrated these days, there are still some traditions that stem from this very first lustrum, such as the extraordinary GMA. This is a special GMA, held in the old municipality building. During this GMA, new members of honor are installed, which is celebrated by a stunt at the beginning of the GMA. Over the years many crazy things have been organized, such as the board ziplining from the tower of the New Church, a hovercraft crossing over the market, a complete aircraft nose being driven over the market, and entering the municipality building by means of an aerial work platform. All of this while hearing the VSV song being played by the New Church bells.

But not only during the extraordinary GMA a stunt is organized, it is also a long-held tradition that during the lustrum year, the VSV tries to set a new record, or at least make it to the (local) news. In 1995 they actually ended up in the Guinness Book of Records by building the largest paper airplane ever. Other stunts include the longest row of kites, washing or pulling a B747, and the design of the Da Vinci Satellite.

During the lustrum year, a wide range of extra activities are organized. In the past, there used to a be a lustrum airshow, organized at both Gilze Rijen (Lustrum 11) and Seppe Airport (Lustrum 13). Besides this, there is also a lustrum gala that previously has been held in the Pier in Scheveningen. Another old tradition is a VSV edition of the famous Dutch television show: "Ter Land, Ter Zee en in de Lucht" (Translation: on land, the ocean or in the sky), where people build wooden soapboxes and are driven off a ramp into the water. During lustrum 12,13 and 14 this was organized in the Delft canals under the names of "Met je Romp in de Plomp", "Met een Zucht door de Lucht" and "Volle Kracht in de Gracht".

Since the 12th lustrum, an addition to the lustrum has been the choice of a general theme. After starting this, the 12th lustrum got the name "Living Life on a Leading Edge", followed by lustrum 13 with the name "Shockwave: Beyond Mach 13", lustrum 14 "Up, Up and Away" and the last lustrum, lustrum 15 "Endeavour". This theme is accompanied by colors that are also painted on, for example, the lustrum caravan. Although unsure where this tradition comes from, it has been a set fact for many lustra that a lustrum caravan is bought and painted. This caravan can then be used to sell merchandise from and promote the lustrum.

The coming year, it is 5 years since the last lustrum. Unfortunately, many of the planned activities were canceled last minute due to the COVID-19 pandemic. That is why the excitement for the 16th lustrum is even bigger. Nowadays the lustrum has become too big to organize in a single year, which has led to the introduction of the pre-lustrum committee. This is a committee active the year before the lustrum, which was this academic year, and it is responsible for arranging things that have to be set well in advance before the lustrum year (such as the theme, colors, and first lustrum activities). But the most important job was the organization of the pre-lustrum week. During this week the lustrum theme of the 16th lustrum, "Ignite", was revealed, as well as the colors (yellow-red-blue) during a student party and a theme reveal including a caravan reveal for students and employees during lunch. Other activities included a special Wednesday night drink in "de Atmosfeer" (faculty bar) with a silent disco, a mini aviation symposium, and finally a closing of the week with the faculty party "Limitless".

CONCLUSION

The pre-lustrum week was only the tip of the iceberg of the lustrum that is to come this new academic year. A lustrum committee has been installed and they will do everything in their power to organize an amazing 16th lustrum. This will include an opening party in Q1, a lustrum gala in Q3, and a whole lustrum month in May of 2025. Although it is not yet possible to tell what all of this will exactly look like, we can promise it will be one big party and we cannot wait to celebrate the 16th lustrum, "Ignite", with as many aerospace students as possible!

Lustrum 13: Met een zucht door de lucht (2010)

Prelustrum 16: Caravan reveal (2024)

Lustrum 9: Flying with KLM helicopters (1989)

Lustrum 11: Airshow (2000)

Lustrum 10: World record throwing paper airplanes from the aula (1995)

LEARNING FROM CURB CUTS

The benefits and key strategies of inclusive design

J. VAN BOVEN & A. VAN NOYE

When considering improvements in diversity and inclusion, one usually considers the direct environment. Although this can have a positive effect, it is very restricted in reach and impact. Engineers and designers have the potential to increase their impact early in the design process, as the product could be used by hundreds, thousands, or even millions of users.

BENEFITS

The benefit of inclusive design is often underestimated. Traditionally, only the most obvious physical disabilities are considered. An example of this is the use of wheelchairs: from buildings to pavements, wheelchair accessibility is considered and implemented in the form of elevators, slopes, or lowered curbs. Even though initially, only wheelchair users might have been considered, these features benefit so many more people: people with limited mobility, parents with baby carriages, and cyclists. The positive impact is broader than expected beforehand, this effect is called the Curb Cut Effect [1].

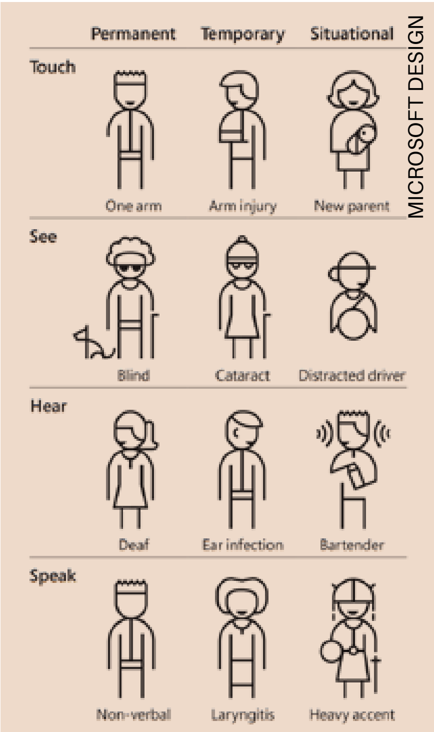
The effect is not to be ignored, Microsoft Design made an estimation for this effect for those unable to use their arms effectively. Yearly, in the USA, 26 thousand people suffer from a permanent loss of arms. An equivalent of 13 million people (about twice the population of Arizona) have a temporary arm disability, for example after an injury. Lastly, an equivalent of 8 million people have a situational disability of using arms, for instance, a parent carrying a baby. Including the temporary and situationally disabled, the number of arm disabilities increases to 21 million. Designing for amputated arms can thus benefit 21 million people yearly, rather than just the 26 thousand permanent amputated users [2]. More examples of this effect are visualized in the Curb-Cut Effect sketch. When this idea is extrapolated, it becomes clear that everyone will face limitations at some time or another, highlighting that inclusive design benefits everyone.

PRINCIPLES OF INCLUSIVE DESIGN

To summarize the most important aspects of inclusive design, principles have been set up by multiple instances. The Institute for Human Centered Design has set up the following principles [3]:

1. **Equitable Use:** The design does not disadvantage or stigmatize any group of users
2. **Flexibility in Use:** The design accommodates a wide range of individual preferences and abilities
3. **Simple and Intuitive Use:** Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. **Perceptible Information:** The design communicates necessary information effectively to the user, regardless of the environment or the user's abilities.
5. **Tolerance for Error:** The design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. **Low Physical Effort:** The design can be used efficiently and comfortably and with a minimum of fatigue.
7. **Size and Space for Approach & Use:** Appropriate size and space are provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.

Next to these principles, other practices are being used, such as user-centered design. When the needs, wishes, and disabilities of a diverse group of users are found and evaluated, they can be considered during the design process and validated. Another good practice is to consider as many diverse situations as possible. Frequently, the users who do not have defined or legally recognized disability are forgotten. This indicates that not only a diverse group of users is required, but also a diverse set of circumstances should be considered for an inclusive design.

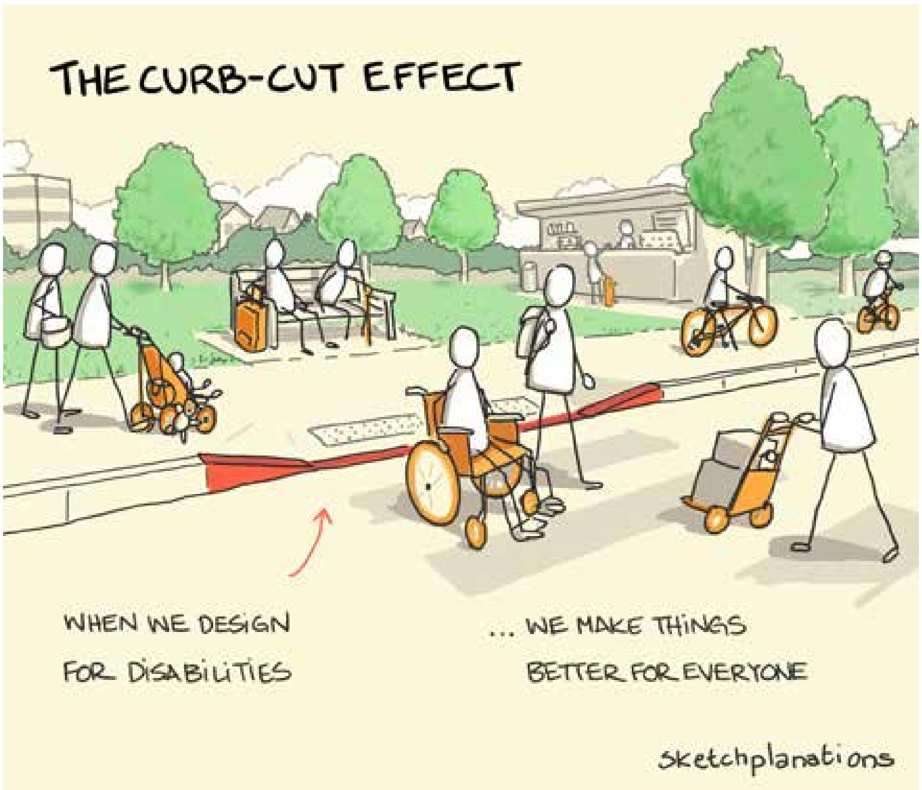


Permanent, temporary and situational limitations

CHALLENGES

Several challenges come up when considering inclusive design. Starting with the lack of awareness and understanding, which is a very common occurrence, as everyone has unconscious biases. The biases lead one to quickly think of the average person and to unintentionally exclude other groups. Recognizing and identifying these biases can be challenging, nevertheless, it is an important step in an inclusive design. Working in a diverse team reduces the lack of awareness and understanding, as more perspectives can be given.

Secondly, when the different users and circumstances are identified, the product needs to be designed and tested continuously with them in mind. The feedback of the user is crucial to create a valuable design and iterations need to be performed to match the product to the wishes of the users as well as possible. Many leading companies from different sectors are applying this approach, with big names like Microsoft, Google, and Airbnb.



CASE STUDIES AND EXAMPLES

To make the perspectives given in this article more concrete, some inclusive designs are highlighted. The first one is the vegetable peeler of OXO. The idea started when the wife of the founder, an arthritis patient, complained about a vegetable peeler, as it was hurting her hands. Determined to solve this issue, Sam Farber experimented with various materials and tested multiple movements with arthritis patients. As a result, rubber was used for the first time in a kitchen tool and a bigger handle was developed to reduce the pain experienced by arthritis patients. These choices made the utensils easier to use for arthritis patients, but also for those without arthritis, showcasing the broader benefit of designing for one group. OXO is still a well-known kitchen utensils manufacturer due to its inclusive design [4].

Subtitles are an obvious, yet under-recognized form of inclusive design. Originally made for deaf or hard-of-hearing people and to show movies in other countries, the use of subtitles has expanded beyond its intended purposes. When learning new languages, subtitles can improve both listening and reading skills during a relaxed activity. In noisy environments, subtitles allow the viewer to keep following the movie. Even when subtitles aren't necessarily required, people are sometimes reading subtitles to follow the conversation better. From various streaming services, it was determined that more than half of their clients use subtitles regularly [5].

CONCLUSION

To put these perspectives into action, take a moment for yourself to appreciate how you have benefited from solutions that were originally designed for someone with different disabilities. Observe and realize that everyone else will be excluded at some point from something you can do without barriers. Every decision can raise or lower the barrier of participation in society. Embracing inclusive design helps you and the rest of the world to make society inclusive for everyone. Let's commit to designing with everyone in mind!

REFERENCES

KEEPING TRACK OF JETSETTERS

[1] Yard Digital PR Team (2022, July 29). Just Plane Wrong: Celebs with the Worst Private Jet CO_2 Emissions. Yard. https://weareyard.com
[2] Ritchie, H., & Roser, M. (2024, January 22). CO_2 emissions. Our World in Data. https://ourworldindata.org
[3] Smith, R. (2024, February 9). Taylor Swift's private jet flew on 13-Minute journey to travel 28 miles. Newsweek. https://www.newsweek.com
[4] California police say member of Elon Musk's security team is a suspect following stalker claim. (2022, December 20). NBC News. https://www.nbcnews.com
[5] Wendling, B. M. (2024, February 21). Jack Sweeney: The planespotting student who angers Taylor Swift and Elon Musk. BBC News. https://www.bbc.com
[6] Wile, R., Collier, K., & Helsel, P. (2022, December 14). Elon Musk threatens legal action, suspends Twitter account that tracks his jet. NBC News. https://www.nbcnews.com
[7] International Civil Aviation Organization. (n.d.). Overview of Automatic Dependent Surveillance-Broadcast (ADS-B) Out [Slide show]. https://www.icao.int
[8] Lahoti, R. C. (1997). Report of Court of Inquiry on Mid-Air Collision between Saudi-Arabian Boeing 747 and Kazakhstan IL-76 on 12th November, 1996 near Delhi - India (Charkhi-Dadri, Haryana). Government of India Ministry of Civil Aviation. https://www.baaa-acro.com
[9] Arbuckle, D. (2021, January 29). Future ADS-B applications [Slide show]. Technical On-Line Workshop for the NAM/CAR Regions. International Civil Aviation Organization. https://www.icao.int
[10] Petchenik, I. (2015, October 30). From Plane to Screen—How Raw Data Becomes FlightRadar24. Flightradar24 Blog. https://www.flightradar24.com
[11] Matza, B. M. (2024, February 7). Taylor Swift threatens to sue student who tracks her private jet. BBC News. https://www.bbc.com
[12] Laville, S. (2023, November 22). Twelve billionaires' climate emissions outpollute 2.1m homes, analysis finds. The Guardian. https://www.theguardian.com
[13] Gen Z cares about sustainability more than anyone else – and is starting to make others feel the same way. (2022, March 18). World Economic Forum. https://www.weforum.org
[14] World leaders' travel arrangements. (n.d.). CBC News. https://www.cbc.ca

A TALE OF TWO PROBES

[1] Butrica, A. J. (n.d.). Voyager: The Grand Tour of Big Science. Retrieved May 21, 2024, from https://www.nasa.gov/history/SP-4219/Chapter11.html
[2]: Pyle, R. (2019). Interplanetary Robots: True Stories of Space Exploration. Rowman & Littlefield Publishing.
[3] Sagan, C. (1980). Cosmos. Ballantine Books.
[4]: Sagan, C., Drake, F. D., Druyan, A., Ferris, T., Lomberg, J., & Sagan, L. S. (1978). Murmurs of Earth: The Voyager Interstellar Record. http://ci.nii.ac.jp/ncid/BA65883342
[5]: NASA JPL (n.d.). Voyager - Mission Status. Retrieved May 24, 2024, from https://voyager.jpl.nasa.gov/mission/status/#where_are_they_now
[6]: NASA JPL (n.d.). Voyager - Voyager 1 fires up thrusters after 37 years. Retrieved May 24, 2024, from https://voyager.jpl.nasa.gov/news/details.php?article_id=108
[7]: NASA JPL (n.d.). Voyager - Voyager 2 to switch to Backup Thruster set. Retrieved May 24, 2024, from https://voyager.jpl.nasa.gov/news/details.php?article_id=98
[8]: Clark, S. (2023, October 24). NASA wants the Voyagers to age gracefully, so it's time for a software patch. Ars Technica.Retrieved May 24, 2024, from https://arstechnica.com/space/2023/10/nasa-wants-the-voyagers-to-age-gracefully-so-its-time-for-a-software-patch/
[9]: Hill, D. (2023, August 5). Mission Update: Voyager 2 Communications pause - The Sun Spot. Retrieved May 24, 2024, from https://blogs.nasa.gov/sunspot/2023/07/28/mission-update-voyager-2-communications-pause/
[10]: Hartono, N. (2024, April 22). NASA's Voyager 1 resumes sending engineering updates to Earth - Voyager. Retrieved May 24, 2024, from https://blogs.nasa.gov/voyager/2024/04/22/nasas-voyager-1-resumes-sending-engineering-updates-to-earth/
[11]: X.com. (2024, April 22.). X (Formerly Twitter). Retrieved May 24, 2024, from https://x.com/NASAVoyager/status/1782454547446890633
[12]: Greicius, T. (2024, May 22). Voyager 1 Resumes Sending Science Data from Two Instruments - Voyager. Retrieved May 24, 2024, from https://blogs.nasa.gov/voyager/2024/05/22/voyager-1-resumes-sending-science-data-from-two-instruments/

EFFECTIVE ALTRUISM IN THE AIR

[1] Effective Altruism, retrieved 11 May 2024, https://www.effectivealtruism.org/
[2] Effective Altruism Delft, retrieved 18 May 2024, https://www.eadelft.org
[3] Effective Thesis, retrieved 18 May 2024, https://effectivethesis.org/
[4] Space Futures Initiative, SFI Research Agenda, 2022, retrieved 11 May 2024, https://spacefuturesinitiative.org
[5] UNOOSA, UN Sustainable Development Goals, retrieved 18 May 2024, https://sdgs.un.org/

SPACE BEYOND BARRIERS

[1] Morelle, R., Francis, A., & BBC. (2024, May 9). John McFall: Para-astronaut on a mission to open up space. https://www.bbc.com/news/science-environment-68939004
[2] Timmers, S. R. (2020). On the advantages of the disabled in space. College of Arts & Sciences Senior Honors Theses. University of Louisville.
[3] AstroAccess. (n.d.). If we can make space accessible, we can make any space accessible. AstroAccess. https://astroaccess.org/
[4] Courtois, G., Marmaroli, P., Lissek, H., Oesch, Y., & Balande, W. (2014). Implementation of a Binaural Localization Algorithm in Hearing Aids: Specifications and Achievable Solutions. 136th Convention of the Audio Engineering Society, (p. 10). Berlin.

THE EVOLUTION OF FLIGHT SAFETY

[1] Elliott, C. (2018, June 27). Why are you tuning out preflight safety announcements? Because you can tune in to your devices. Washington Post. Retrieved May 8, 2024, from washingtonpost.com
[2] Air Accidents Investigation Branch (AAIB). (2014, December 10). 4/1990 Boeing 737-400, G-OBME, 8 January 1989. GOV.UK. Retrieved May 8, 2024, from gov.uk
[3] Nosowitz, D. (2018, January 29), Decoding the Design of In-Flight Seat Belts. Atlas Obscura. Retrieved May 16, 2024, from.atlasobscura.com
[4] NTSB (1989, June 14). Aircraft Accident Report--Aloha Airlines Flight 243, Boeing 737-200, N73711, near Maui, Hawaii, April 28 1988, NTSB. Retrieved May 16, 2024, from ntsb.gov
[5] AVIACRASH.NL (2007, February 23). H-NABR crashes in the Waalhaven. Aviacrash. Retrieved May 9, 2024, from aviacrash.nl
[6] Air Accidents Investigation Branch (AAIB). (2014, December 10). 8/1988 Boeing 737-236, G-BGJL, 22 August 1985. GOV.UK. Retrieved May 9, 2024, from https://www.gov.uk/aaib-reports/8-1988-boeing-737-236-g-bgjl-22-august-1985
[7] NTSB (1997, August 19). In-Flight Fire And Impact With Terrain Valujet Airlines, Flight 592 DC-9-32, N904VJ Everglades, Near Miami, Florida May 11,1996, NTSB. Retrieved May 16, 2024, from ntsb.gov
[8] ECAA (1998, May 4). Ethiopian Airlines B767 (ET-AIZ) Aircraft Accident In the Federal Islamic Republic of the Comoros, in the Indian Ocean on November 23, 1996, ECAA. Archived September 24, 2015, from fss.aero
[9] BEA (1976, April 6). RAPPORT FINAL, de la Commission d'Enquete sur l'accident survenu au BOEING 707 P P-V J Z de la Compagnie Varig a SAULX-les-CHARTREUX, le 11 juillet 1973, Aviation Safety Network. Retrieved May 16, 2024, from reports.aviation-safety.net
[10] NTSB (1984, August 8). Air Canada Flight 797, McDonnel Douglas DC-9-32, C-FTLU, Greater Cincinatti International Airport, Covington, Kentucky, June 2 1983, NTSB. Retrieved May 16, 2024, fromlibraryonline.erau.edu
[11] Auerbach, J. (1999, October 4). Airlines ban

cell phones -- but why? zdnet.com. Retrieved May 10, 2024, from zdnet.com
[12] Kiger, P. J., & Crosby, T. (2024, March 6). Can You Use Your Phone on a Plane? Furthermore, Should You? HowStuffWorks. Retrieved May 10, 2024, from electronics.howstuffworks.com
[13] Hsu, J. (2009, December 21). The Real Reason Cell Phone Use Is Banned on Airlines. Live Science. Retrieved May 10, 2024, from livescience.com
[14] Cleynhens, K. (2024, May 9). Safety Cards. airlinesafetycards.be. Retrieved May 10, 2024, from airlinesafetycards.be
[15] Roberts, B. R.T., MacLeod, C. M., & Fernandes, M. A. (2023, September). Symbol superiority: Why $ is better remembered than 'dollar'. Cognition, 238(0010-0277), 105435. https://doi.org/10.1016/j.cognition.2023.105435
[16] Ahlgren, L. (2021, February 26). How do aircraft life jackets work? Simple Flying. Retrieved May 10, 2024, from simpleflying.com
[17] Schiphol Airport. (2018, July 25). Why do the window blinds have to be open for take-off and landing? Newsroom Schiphol. Retrieved May 10, 2024, from news.schiphol.com

LAMBACH AIRCRAFT

[1] Lockhead Martin. (2014, January 5). Kelly Johnson's 14 rules of Project Management. https://web.archive.org/web/20140105030139/http://www.lockheedmartin.com/us/aeronautics/skunkworks/14rules.html
[2] Sagan, C. (1995). The Demon-Haunted World: Science as a Candle in the Dark. Ballantine Books

SPACE SHUTTLE ABORT MODES

[1] NASA. (2024, February 6). Space Shuttle. Retrieved May 5, 2024, from nasa.gov
[2] Henderson, E., & Nguyen, T. L. (2011). Space Shuttle Abort Evolution. AIAA SPACE 2011 Conference & Exposition. DOI: 10.2514/6.2011-7245
[3] Rosenstein, S. (2023, March 28). Historic scrubs and aborts that could happen to Starship. Retrieved May 5, 2024, from nasaspaceflight.com
[4] Baker, D. (2021). NASA Space Shuttle Owners' Workshop Manual (6th ed.). Haynes. ISBN 978 1 84425 866 6
[5] Tyreus. (2001, January 31). Space Shuttle Ascent Profile and Abort modes. The Space Experience (TSE). Retrieved May 5, 2024, from space-shuttle.com
[6] NASA-JSC (1980, February 1). Flight Procedures Handbook: Ascent/Aborts. JSC-10559, Final. NASA Johnson Space Center.
[7] Neufang, R.K. (1998, January 27). Space Shuttle East Coast Abort Modes for High Inclination Launches [THESIS]. AFIT/GA/ENY/97D-3. Air Force Institute of Technology.
[8] NASA. (2002, January 31). Implementation of the Recommendations of the Presidential Commission on the Space Shuttle Challenger Accident. Retrieved May 5, 2024, from nasa.gov
[9] NASA. (2006, December). Space Shuttle Transoceanic Abort Landing (TAL) sites. https://www3.nasa.gov
[10] USA (2007, February 14). Space Flight Operations Contract: Contingency Aborts 21007/31007. USA005671, Revision D. United Space Alliance.
[11] Betancourt, M. (2020, September 24). They said it wasn't possible to escape the space shuttle. These guys showed it was. Smithsonian Magazine. Retrieved May 5, 2024, from smithsonianmag.com
[12] Wright, R. (2006, May 26). NASA Johnson Space Center Oral History Project (Interview Transcript). NASA Johnson Space Center.
[13] Lethbridge, C. (1998). SPACE SHUTTLE ENTERPRISE (OV-101) Fact Sheet. spaceline.org. Retrieved January 7, 2011, from spaceline.org
[14] Cowing, K. (2003, March 26). Safety panel to NASA: Build a "Full envelope" shuttle escape system - SpaceRef. SpaceRef. Retrieved May 5, 2024, from spaceref.com
[15] NASA-JSC (2004, September 2). Flight Requirements Document STS-300: Launch On Need (LON) Crew Rescue. NSTS 17462-300, Rev. 005. NASA Johnson Space Center.
[16] NASA-JSC (2004, July 12). Contingency Shuttle Crew Support (CSCS)/Rescue Flight Resource Book: Mission Operations Directorate. JSC-62900, Final. NASA Johnson Space Center.

BOEING'S DESCENT

[1] Vartabedian, R. (2019, March 15). Must Reads: How a 50-year-old design came back to haunt Boeing with its troubled 737 Max jet. Los Angeles Times. Retrieved May 20, 2024, from https://latimes.com/
[2] Competition between Airbus and Boeing (May 20, 2024), Retrieved May 20, 2024, from https://en.wikipedia.org/
[3] Maneuvering Characteristics Augmentation System (May 20, 2024), Retrieved May 20, 2024, from https://en.wikipedia.org/
[4] Gates, D. (2023, April 18). New Boeing quality issue means fewer 737 MAXs for airlines this summer. The Seattle Times. Retrieved May 20, 2024, from https://www.seattletimes.com/
[5] Gates, D. (2023, Sep 7). Boeing and top supplier under pressure as defect cuts jet deliveries, profits. The Seattle Times. Retrieved May 20, 2024, from https://www.seattletimes.com/
[6] Levenson, M. (2023, Dec 28). Boeing Urges Airlines to Inspect 737 Max Planes for Possible Loose Bolts. The New York Times. Retrieved May 20, 2024, from https://www.nytimes.com/
[7] Chokshi, N. and Walker, M. (2024, Jan 9). Panel on Boeing Plane May Not Have Been Properly Attached, Agency Says. The New York Times. Retrieved May 20, 2024, from https://www.nytimes.com/
[8] Walker, M. (2024, Mar 11). F.A.A. Audit of Boeing's 737 Max Production Found Dozens of Issues. The New York Times. Retrieved May 20, 2024, from https://www.nytimes.com/
[9] Kitroeff, N. and Gelles, D. (2020, Mar 5). 'It's More Than I Imagined': Boeing's New C.E.O. Confronts Its Challenges. The New York Times. Retrieved May 20, 2024, from https://www.nytimes.com/
[10] Federal Aviation Authority (FAA). (2020, June 29). Timeline of Activities Leading to the Certification of the Boeing 737 MAX 8 Aircraft and Actions Taken After the October 2018 Lion Air Accident. OIG. Retrieved May 20, 2024, from https://www.oig.dot.gov/
[11] Joint Authorities Technical Review. (2019, Oct 11). Boeing 737 MAX Flight Control System FAA. Retrieved May 20, 2024, from https://www.faa.gov/
[12] Robinson, P. Flying Blind: The 737 MAX Tragedy and the Fall of Boeing by Peter Robison. Doubleday Publishing
[13] Statement of Edward F. Pierson Before the Senate Permanent Subcommittee on Investigations. HSGAC. Retrieved May 20, 2024, from https://www.hsgac.senate.gov/
[14] Carmela Lim, J. Boeing sensitive data allegedly leaked after ransomware gang threat 'ignored'. Aerotime. Retrieved May 20, 2024, from https://www.aerotime.aero/
[15] Lyons, J. Impatient LockBit says it's leaked 50GB of stolen Boeing files after ransom fails to land. The Register. Retrieved May 20, 2024, from https://www.theregister.com/

LEARNING FROM CURB CUTS

[1] Blackwell, A. (2017) The Curb-Cut Effect. Stanford Social Innovation Review. https://ssir.org/articles/entry/the_curb_cut_effect#
[2] Shum, A. Holmes, K. Woolrey, K. Price, M. Kim, D. Dvorkina, E. Dietrich-Muller, D. Kile, N. Morris, S. Chou, J. Malekzadeh, S. (2016) Inclusive Microsoft Design https://inclusive.microsoft.design/tools-and-activities/Inclusive101Guidebook.pdf
[3] Connell. B, Jones, M. Mace, R. Mueller, J. Mullick, A. Ostroff, E. Sanford, J. Steinfeld, E. Story, M. Vanderheiden, G. (1997) Principles of Inclusive Design https://www.humancentereddesign.org/inclusive-design/principles
[4] Wilson, M. (2018) The untold story of the vegetable peeler that changed the world https://www.fastcompany.com/90239156/the-untold-story-of-the-vegetable-peeler-that-changed-the-world
[5] Ideal Insight (2023) Netflix Caption https://idealinsight.co.uk/infographics/netflix-captions