The Effects of Visual Aesthetics in Aircraft Design

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Kangyi Peng

Spring 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Dr. Kent Wayland, Department of Engineering and Society

“What role, if any, does visual aesthetics play in the design and marketability of an aircraft?”

Introduction

There is a common saying in the field of aerospace engineering: "If it looks right, it flies right", suggesting that an aircraft’s design and performance can be evaluated on its visual appearance. This is an intuitive statement because an aircraft's design can indeed have a significant impact on its performance and handling characteristics. A well-designed aircraft will generally be more stable, efficient, and maneuverable than a poorly designed one.

As an aerospace engineering student, my capstone project is to write a detailed proposal for a hybrid electric turboprop aircraft to compete in the 2022 American Institute of Aeronautics and Astronautics (AIAA) Design Competition. The primary objective is reducing the overall fuel consumption on a typical mission by 20%, while ensuring that the aircraft design is based on realistic technologies capable of entry into service by the year 2035. In addition to the various technical requirements for the aircraft, in the Request for Proposal (RFP) document the AIAA recommends the teams to “make the aircraft visually appealing so it will be marketable."

In the world of product design, it is widely understood that aesthetics not only plays a critical role in shaping consumer’s emotional response to the products (Norman, 2004), but also helps determining user satisfaction and loyalty (Kujala and Kauppinen, 2010). Considering that design aesthetics has traditionally played such important roles in product designs, its effects on aircraft functionality and market performance is rather rarely explored. This STS paper will investigate the role that visual aesthetics play in the design and marketability of an aircraft.

Background

Flying has become an indispensable part of modern life, allowing people to connect with others, experience different cultures, and conduct business globally. In 2019 alone, there were approximately 4.5 billion passengers (Statista, 2021) worldwide, carried by approximately 28,000 commercial passenger aircraft in service (International Air Transport Association, 2020). Of those 28,000 commercial aircraft in service, 100% of the fixed-wing aircraft fleet have tubular fuselages as opposed to the blended wing-body configuration (Wilkinson, 2019) shown in **Figure 1**. Using single-aisle jetliners as an example: As illustrated by **Figure 2**, all four models of aircraft have nearly the exact same aerodynamic configuration and exterior appearance, even though they are made by four different manufactures in four different countries. In fact, modern commercial aircraft have become so similar to one another, the average passengers could not distinguish the make and model of the aircraft they are flying on. When compared to other transportation products such as automobiles which different makes and models look clearly different for the average consumers (**Figure 3**), the design of commercial jetliner looks identical and never changes throughout the years. In this case, why does aircraft manufactures design products with the same visual appearances? What is the value in this?

Figure 1. (Left) Example of Tubular Fuselage Aircraft, Photo: Aero Icarus.[10] (Right) Example of Blended Wing-Body Aircraft, Photo: Airbus.[11]

Figure 2. (Top Left) Embraer 190, Photo: Venkat Mangudi[12]. (Top Right) Airbus A320, Photo: Jetstar Airways[13]. (Bottom Left) COMAC C919, Photo: Weimeng[14]. (Bottom Right) Boeing 737, Photo: Jeff Hitchcock[15].

Figure 3. (Top Left) Audi A4, Photo: Alexander-93[16]. (Top Right) Mercedes C-Class. Photo: Alexander Migl[17]. (Bottom Left) BMW 3-Serie, Photo: Alexander Migl[18]. (Bottom Right) Genesis G70, Photo: Alexander Migl[19].

Going back to the saying "If it looks right, it flies right", the philosophy is that the design aesthetics of the aircraft often reflects its performance and handling characteristics in the air. Popular design choices such as retractable landing gears (**Figure 4**) which reduces aerodynamic drag and increase cruise speed and fuel efficiency on a jetliner, angled stabilizers (**Figure 5**) which reduces radar signature for stealth fighters, large diameter tires (**Figure 6**) which improves ground clearance for bush planes tend to stick around and become the norm for designers and

users alike. It could be argued that because aircraft are typically complex machines purchased with utilitarian purposes in mind, design features that actually help serve its purposes are preferred, unlike in the world of automobile design where exterior features are sometimes chosen purely for the aesthetic values (**Figure 7**). With many of those utilitarian features being combined to create a functioning aircraft, it is not a surprise that many aircraft ends up looking similar to one another aesthetics wise, even though they are created by different designers. Much like Darwin's theory of natural selection, successful aircraft designs could be considered the results of "survival of the fittest" in the competitive market for efficient and reliable machines.

Figure 4. The Retractable Main Landing Gears on a Boeing 747, Photo: Olivier Cleynen[20]

Figure 5. Angled Stabilizers on a Lockheed Martin F22, Photo: aircraftrecognitionguide.com[21]

Figure 6. Large Diameter Tires on a Piper Cub, Photo: Steve Pierce[22]

Figure 7. Fake Grills on Tesla Model S. (Left) 2012 Model. (Right) 2016 Model. Photo: timdorr[23]

However, this is not to say that aircraft as utilitarian machines are devoid of aesthetics value, quite opposite actually. One could argue that using the popular definitions of beauty which rest upon attributes such as symmetry and proportions are applicable for successful aircraft designs. When attributes such as similarity and repetition are considered, it could even be argued that popular aircraft designs are inherently "aesthetically pleasing" because they are wide-spread and successful as a commercial product. Following this train of thought, it is plausible that being "aesthetically pleasing" is simply a synonym to being "similar to the successful norm". All and all, the definition of aesthetics will be further elaborated in the following section as part of literature analysis.

Literature

In the past, the perspective of aesthetics as an objective property have developed many aesthetics design rules, such as Gestalt principles, which attribute beauty to symmetry, proximity, similarity, repetition, continuance, and closure (Lewalski, 1988; Baxter, 1995). It is important to mention that the Gestalt principles do apply to object in general, not just aircraft.

Symmetry is one of the Gestalt principles that describes how humans tend to perceive objects that are balanced and harmonious when their parts are arranged in a symmetrical manner. For example, architects often use symmetry in the design of buildings to create a sense of balance and harmony. The Taj Mahal in India (**Figure 8**) is a symmetrical structure that is often

described as one of the most beautiful buildings in the world. The symmetry of the building's design helps to create a sense of balance and harmony that contributes to its overall beauty.

Figure 8. The Taj Mahal in India, Photo: Yann[24]

Proximity in Gestalt principles describes how humans tend to perceive objects that are close to each other as a single group or unit. A common example of which is a family portrait. When we look at a family portrait, we tend to perceive the family members who are physically close to each other as a single group or unit. If the parents are standing close to each other and their

children are standing on either side of them, we might perceive the parents and children as two distinct groups rather than as individual family members.

Similarity describes how humans tend to perceive objects that are similar in appearance as belonging to the same group or category. For example, when we look at a row of buttons, we would likely perceive the buttons that are the same color or shape as belonging to the same group. This is because the buttons that are similar in appearance (**Figure 9**) are often perceived as belonging to the same category or group. As an aircraft designer hoping to design a reliable and effective aircraft, it is important that the new design have a similar appearance to the last successful models. Because the end goal is to make a successful aircraft, and successful aircraft tend to benefit from similarities with its own kind and repetition from market share boosting their aesthetics, the term being “aesthetically pleasing” sometimes is simply codename for being “similar to the successful norm” in the world of aviation.

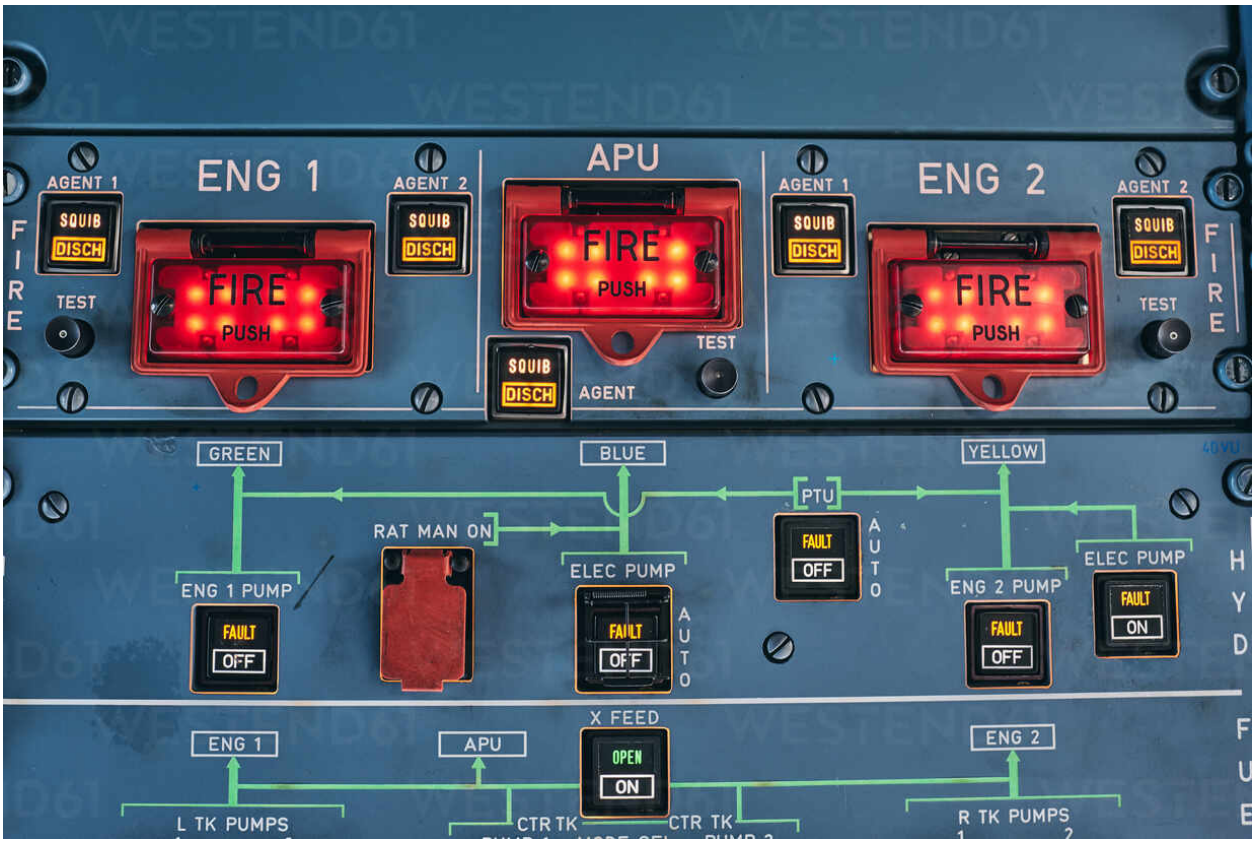

Figure 9. Fire Buttons in Cockpit, Photo: Westend61[25]

Repetition is another Gestalt principle that describes how humans tend to perceive objects that are repeated in a consistent manner as belonging together or forming a pattern. For example, a row of windows on a building or a wallpaper pattern can be perceived as a pattern rather than a collection of individual elements because they are repeated in a consistent manner, creating a sense of unity and rhythm in a design.

Continuance describes how we humans tend to perceive objects that are arranged in a continuous or flowing manner as belonging together, like a winding road. When we see a winding road, we tend to perceive it as a continuous path rather than a collection of individual segments. This is

because the road is arranged in a continuous, flowing manner that creates a sense of movement and direction. In graphic design, designers can use continuance to create a sense of movement.

Closure describes how humans tend to perceive objects as complete or whole even when they are not fully depicted. An example is fuselage mockups (**Figure 10**) typically shown at airshows. Though those mockups are by no definition complete aircraft, our brains automatically fill in the missing parts to create a sense of closure and completeness.

Figure 10. The CRAIC CR929 forward fuselage mockup makes its first appearance at a Zhuhai air show, Photo: Vladimir Karnozov.[26]

Method

With regards to aesthetics in aircraft design, those six design rules in the Gestalt principles can be applied, though some are more applicable more than the others. When assessing the objective standard of beauty for aircrafts, we take all six design rules into consideration, much like a mathematical formula. Since many aircraft models have their specifications published online, it is possible to look into their designs and history of market performance, apply the Gestalt principles, and investigate the role of aesthetics in the design and marketability of an aircraft.

In addition, once the role of aesthetics in the design and marketability of an aircraft has been clarified, I can apply the same method to analyze our aircraft design for the AIAA Competition.

Results

In the world of aviation, symmetry is ubiquitous in aircraft designs. For the purpose of maintaining balance of rolling moment, most fixed-wing aircraft are symmetrical across the centerline (**Figure 11**). That being said, some asymmetrical designs (**Figure 12**) had been developed for experimental purposes, but their real-world applications were rather limited. Rather interestingly, even though asymmetrical aircraft like the Burt Rutan Boomerang may seems unsettling, the aircraft is perfectly balanced in the air with excellent maneuverability. This is because even symmetrical aircraft generates asymmetrical torque due to its one-way spinning propellers or jet engines, and thus resulting the use of aileron trim which generate additional drag. The Burt Rutan Boomerang's unique asymmetrical design is designed to counteract the torque produced by its twin turboprop engines without relying on excessive aileron trim, making it highly efficient during cruise. Another example of asymmetrical aircraft are helicopters, in

which the engine torque problem is much more obvious, resulting in the need for a propeller at the tail pushing/pulling air towards one side to counteract it. Nonetheless, asymmetrical designs are not used often in fix-wing designs because of their difficulty in manufacturing and development. Afterall, if you can build the one side of a symmetrical aircraft without a problem, you can build another side without problem neither. With non-symmetrical aircraft, not so much. This makes symmetrical aircraft dominant, thus enforcing the “symmetrical beauty” concept.

Figure 11. Aircraft Flying Overhead. Photo: Jeffrey Milstein[27]

Figure 12. The Asymmetrical Burt Rutan Boomerang, Photo: Chad Slattery[28]

Proximity can also been seen throughout the field of aircraft design. Afterall, it is not uncommon for a family of aircraft from the same manufacturer to share the same design language. For example, Airbus's extensive use of side-sticks in their cockpits (**Figure 13**) versus Boeing's use of center-yokes (**Figure 14**) in the cockpit of their planes. Neither of the control interface, side-stick or center-yoke, is better than the other, especially considering when pilots fly the aircraft manually, their one hand controls the yoke/sidestick and another hand controls the throttle in the middle. However, a pilot trained to fly a Boeing aircraft going to have an easier time transitioning to another Boeing aircraft than an Airbus aircraft. This keeps the airlines loyal to the brand, since retraining plots cost money, and it makes sense for marketability reasons.

Figure 13. Side Sticks in an Airbus A380 Cockpit, Photo: Naddsy[29]

Figure 14. Center-Yokes in a Boeing 747 Cockpit, Photo: saitama[30]

Similarity is another aspect that could be easily seen in aircraft design. As previously discussed, successful aircraft designs typically shares identical exterior elements (**Figure 2**). This is not only because being similar to the successful norm can invoke a sense of familiarity, but also because the already market-selected features have been proven reliable and effective. When many of those reliable and proven features come together to produce an aircraft, it makes sense that they all look similar to one another, despite coming from different manufacturing origins.

Repetition is strongly connected with the concept of similarity. Afterall, when almost all of the commercial jetliners lookalike, it is hard to argue that repetition doesn't play a role in this case. Another prime example of repetition is the sharing of aircraft "family name" in the military. The name "Thunderbolt" is both used for the Republic P-47 (**Figure 15**) and the Fairchild Republic A-10 (**Figure 16**), despite one of them being a WWII era piston engine warbird and another being a Cold-War era jet engine tank buster. However, they do share many commonalities: Both aircraft were used heavily in ground-attack and close-air support roles. Both aircraft are rugged and reliable, capable of sustaining heavy damage and still return home. Both aircraft are not-so-good-looking, with the P-47 being nicknamed the "Jug" and the A-10 nicknamed the "Warthog". Both aircraft were made by the same manufacturer (Republic later merged with Fairchild). The list of commonalities goes on and on. With both aircraft being incredibly successful during their time in service, the name "Thunderbolt" gets repeated over and over with the connection to the reliable, dependable, and heavy-duty aircraft from Republic Aviation.

Figure 15. Republic P-47 Thunderbolts. Photo: Paul Bowen[31]

Figure 16. Fairchild Republic A-10C Thunderbolt II, Photo: Master Sgt. William Greer, USAF.[32]

Continuance can be used to create a sense of movement and flow in aircraft design, as well as to guide the viewer's eye in a particular direction. One example of continuance is the use of aerodynamic lines that create a sense of continuity and flow throughout the design. For instance, the sleek streamlines of the Boeing 787 Dreamliner (**Figure 17**) or the Airbus A350 (**Figure 18**) create a sense of forward motion and continuity, emphasizing the speed and agility of the aircraft. By using a continuance design, the aircraft “looks fast while sitting on the ground”.

Much like seeing a Ferrari parked by the sidewalk, people stop and think “that’s a fast ride”, even though the car is not moving at the present. It’s the same principle here.

Figure 17. Boeing 787 Dreamliner, Photo: pjs2005[33]

Figure 18. Airbus A350 XWB, Photo: Gerard van der Schaaf[34]

Closure is also often used in aviation as well. Besides the aforementioned use of fuselage mockups at airshows, there are also stylized airline tail flags on vertical stabilizers (**Figure 19**) used in every airport terminal big or small. By displaying the iconic triangle shape of the vertical stabilizers with airline livery, it creates the sense of connection with the complete airliner. Therefore, for any new aircraft design, having a vertical stabilizer is important. Afterall, without a vertical stabilizer, there is no place to put a tail flag on an aircraft.

Figure 19. Stylized Airline Tail Flags, Photo: Dribbble[35]

Discussion

While treating aesthetic values as a result of the six aspects of Gestalt principles made sense, not all of those inputs should have the same weight in this "formula". An aircraft could be lacking in all other areas of the Gestalt principles except a few, and still be incredibly successful as a product. For example, the NASA Super Guppy (**Figure 20**) and similar cargo aircraft such as the Boeing Dreamlifter (**Figure 21**) and Airbus Beluga XL (**Figure 22**), all designed for large and

bulky cargo transport. In terms of their external appearance, these aircraft typically have a bulbous, rounded shape with a distinctive hump on top of the fuselage to accommodate the oversized cargo. This shape is designed to maximize internal volume while minimizing weight and drag, allowing the aircraft to carry more cargo more efficiently. Their unconventional design hardly follows the Gestalt principles, but nonetheless their utilitarian ability of being able to transport large and bulky cargo soon made them popular for aircraft manufactures to transport parts such as wings and fuselages. Because of their success, it could be argued that their similarities and repetition eventually had a positive effect. Afterall, Airbus clearly loved the Beluga Xl enough to give it a custom livery (**Figure 22**) resembling the marvelous beluga whale.

Figure 20. NASA's Super Guppy Turbine Cargo Aircraft, Photo: NASA/Tom Tschida.[36]

Figure 21. Boeing Dreamlifter, Photo: ERIC SALARD[37]

Figure 22. Airbus Beluga XL, Photo: Julien.jeany[38]

When talking about the significance of aesthetics on design and marketability of an aircraft, one should not overlook the potential for a feedback loop. Afterall, there are plenty of examples (Super Guppy, P-47, A-10 etc.) in which an aircraft lacking aesthetics eventually became very successful and popular because they are good at doing their mission, thus improving their image via the similarity and repetition aspects of the Gestalt principles. Therefore, since we know aesthetically-lacking aircraft can still be successful, why bother with aesthetics in the first place?

While it could be argued that while there are certainly successful aircraft on the market that doesn't follow the design principles laid out in the Gestalt principles, in the competitive

commercial aviation market, where established players like Boeing and Airbus holds 99% of market share combined (Statista 2021), any newly designed aircraft would need every bit of help it could get, and we do know that aesthetics count.

Conclusion

Aircraft design is a complex process involving a variety of factors, including aerodynamics, structural engineering, material science and much more. While it is difficult to quantify the exact impact of aesthetic values on an aircraft's market performance, all such aircraft in the end had good aesthetic values according to the Gestalt principles, whether due to their inherent designs (proportion, symmetry etc.) or later success (similarity, repetition). In any case, unless the aesthetic consideration conflicts with the aircraft performance metrics, it is always beneficial to design an aircraft using all six design rules laid out in the Gestalt principles: Symmetry, proximity, similarity, repetition, continuance, and closure. However, in case aesthetic consideration does conflict with the aircraft performance metrics, it is important to know that whether it is a "similar to the successful norm" design or "never seen before" design, if it is successful on the competitive market its looks will eventually be accepted and loved by everyone, just don't count on the looks to make the sale right out of gate.

Armed with this finding, I analyzed our hybrid-electric aircraft design proposal – the Songbird-E (**Figure 23**) - submitted to the AIAA design competition. It being a traditional design that's extremely similar to the traditionally successful ATR-42 turboprop (**Figure 24**) configuration, ensures that it is considered aesthetically pleasing, thus fulfilling that particular RFP objective.

Even though the newly proposed aircraft employs many innovative technologies yet to be proven in real-world operations, the fact that its exterior resembles that of the successful ATR-42 turboprop is certainly a plus in this case.

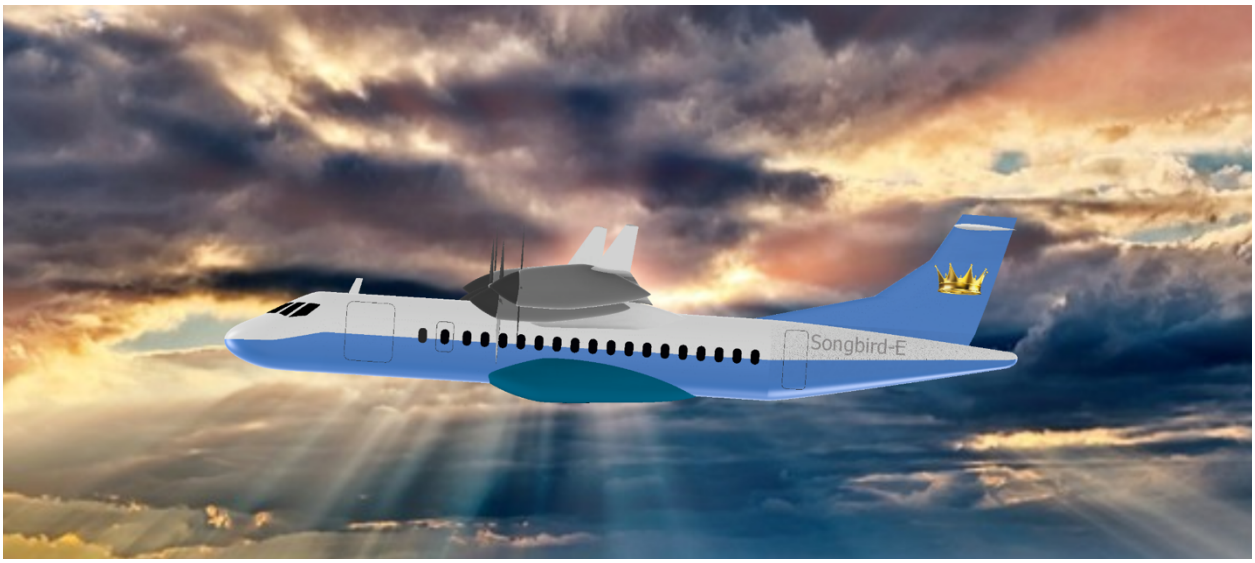

Figure 23. Songbird-E Hybrid Turboprop Proposal, Photo: Skykings Technical Report

Figure 24. ATR 42 Regional Turboprop, Photo: Laurent ERRERA[39]

References

1. Norman, D. (2004). Emotional Design: Why we love (or hate) everyday things. Basic Books.

2. Kujala, S., & Kauppinen, M. (2010). Exploring the role of aesthetics in product usage experiences. Journal of Design Research, 8(2), 158-176.

3. American Institute of Aeronautics and Astronautics. (2023). 2023 Undergraduate Team Aircraft Design Request for Proposal – Hybrid Turboprop. https://www.aiaa.org/get-involved/students-educators/Design-Competitions#2023-design-competition-rfps

4. Statista. (2021). Number of air passengers worldwide from 2006 to 2021 (in billions). https://www.statista.com/statistics/564769/airline-industry-passenger-traffic-globally/

5. International Air Transport Association (IATA). (2020). IATA annual review 2020. https://www.iata.org/en/publications/store/iata-annual-review/

6. Wilkinson, J. (2019, May 20). Why the basic fuselage model has never changed. Simple Flying. https://simpleflying.com/why-the-basic-fuselage-model-has-never-changed/

7. Lewalski, C. (1988). The role of Gestalt principles in graphic design. Design Issues, 5(2), 66-82.

8. Baxter, G. D. (1995). The use of the Gestalt principles in the design of instructional materials. British Journal of Educational Technology, 26(3), 182-191.

9. Statista Research Department. (2021, January 15). Commercial aircraft deliveries by manufacturer - worldwide 2020. Statista. https://www.statista.com/statistics/264695/deliveries-of-aircrafts-by-air-manufacturers/

10. Aero Icarus (2011). Cathay Pacific Boeing 777-200. [Photograph]. https://www.flickr.com/photos/46423105@N03/6052920447/

11. Airbus (2021). ZEROe Blended-Wing Body (BWB). [Photograph] https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe

12. Mangudi, Venkat (2017). JetBlue Airways ERJ-190. [Photograph] https://upload.wikimedia.org/wikipedia/commons/8/8f/N247JB_KJFK_%2837103752403%29.jpg

13. Jetstar Airways (2004). An Airbus A320-200 of Jetstar inflight over France. [Photograph] https://upload.wikimedia.org/wikipedia/commons/b/bc/Jetstar_Airbus_A320_in_flight_%286768081241%29_crop.jpg

14. Weimeng (2017). Photo of a COMAC B-001A taken at Shanghai - Pudong International Airport. [Photograph]

https://upload.wikimedia.org/wikipedia/commons/8/8b/COMAC_B-001A_May_2017.jpg

15. Hitchcock, Jeff (2017). 737 MAX 9 first flight on April 13, 2017. [Photograph] https://upload.wikimedia.org/wikipedia/commons/4/46/Boeing%2C_N7379E%2C_Boeing_737-9_MAX_%28cropped%29.jpg

16. Alexander-93 (2023). Audi A4 B9 in Stuttgart-Vaihingen. [Photograph] https://upload.wikimedia.org/wikipedia/commons/7/75/Audi_A4_B9_sedans_%28FL%29_1X7A6816.jpg

17. Migl, Alexander (2022). Mercedes-Benz_W206 in Filderstadt. [Photograph] https://upload.wikimedia.org/wikipedia/commons/b/be/Mercedes-Benz_W206_IMG_6380.jpg

18. Migl, Alexander (2019). BMW G20 in Frankfurt am Main. [Photograph] https://upload.wikimedia.org/wikipedia/commons/8/8d/BMW_G20_IMG_0167.jpg

19. Migl, Alexander (2021). Genesis_G70 at IAA 2021. [Photograph] https://upload.wikimedia.org/wikipedia/commons/c/cd/Genesis_G70_IAA_2021_1X7A0227.jpg

20. Cleynen, Oliver (2011). Main landing gear of a Boeing 747-8F prototype. [Photograph]

https://upload.wikimedia.org/wikipedia/commons/0/0a/Main_landing_gear_of_747-8F.jpg

21. Aircraft Recognition Guide. Lockheed-Martin YF-22 & F-22 Raptor. [Photograph] https://www.aircraftrecognitionguide.com/lockheed-martin-f-22

22. Pierce, Steve (2015). 29 Inch Tires. [Photograph] https://www.supercub.org/forum/attachment.php?attachmentid=19318&d=1426035536

23. Timdorr (2017). After 5 months of repair work, old finally meets new. (2012 S85 and late-2016 P90D) [Photograph] https://i.redd.it/lgr8f2t18ely.jpg

24. Yann (2011). Taj Mahal, Agra, India. [Photograph] https://upload.wikimedia.org/wikipedia/commons/1/1d/Taj_Mahal_%28Edited%29.jpeg

25. Westend61. Closeup of fire buttons and warning lights on control console in cockpit of contemporary airplane. [Photograph] https://www.westend61.de/en/imageView/ADSF09172/closeup-of-fire-buttons-and-warning-lights-on-control-console-in-cockpit-of-contemporary-airplane

26. Karnozov, Vladimir (2018). The CRAIC CR929 forward fuselage mockup makes its first appearance at a Zhuhai air show. [Photograph] https://www.ainonline.com/aviation-news/air-transport/2018-11-06/cr929-mockup-unveiled-airshow-china-2018

27. Milstein, Jeffery (2005-2019). Aircraft: The Jet as Art. [Photograph]

http://www.jeffreymilstein.com/portfolios/aircraft/

28. Slattery, Chad. THE RUTAN BOOMERANG. [Photograph] https://aerocrafted.com/blogs/edc-tools/the-rutan-boomerang

29. Naddsy (2007). The flight deck of the Airbus A380. [Photograph] https://upload.wikimedia.org/wikipedia/commons/a/a4/Airbus_A380_cockpit.jpg

30. Altair78 (2011). JAL Boeing 747-400 flight deck. [Photograph] https://upload.wikimedia.org/wikipedia/commons/9/94/JAL_Boeing_747-400_flight_deck.jpg

31. Bowen, Paul (2020) Beautifully restored "razorback" Republic P-47 Thunderbolts owned by The Fighter Collection (foreground) and the Planes of Fame Air Museum fly together. [Photograph] https://www.historynet.com/p47-thunderbolt/

32. Master Sgt. William Greer, U.S. Air Force (2011). An A-10 Thunderbolt II, assigned to the 74th Fighter Squadron, Moody Air Force Base, GA, returns to mission after receiving fuel from a KC-135 Stratotanker, 340th Expeditionary Air Refueling Squadron, over the skies of Afghanistan in support of Operation Enduring Freedom, May 8, 2011. [Photograph] https://upload.wikimedia.org/wikipedia/commons/8/80/Fairchild_Republic_A-10_Thunderbolt_II_-_32156159151.jpg

33. pjs2005 (2016). ANA Boeing 787. [Photograph]

https://upload.wikimedia.org/wikipedia/commons/4/4e/Boeing_787_N1015B_ANA_Airlines_%2827611880663%29_%28cropped%29.jpg

34. van der Schaaf, Gerald. Airbus A350 XWB file photo. [Photograph]
https://aviation-safety.net/database/types/Airbus-A350/specs

35. Linkor Digital. Tails of Airline Companies. [Photograph]
https://dribbble.com/shots/2317879-Tails-of-Airline-Companies?utm_source=Pinterest_Shot&utm_campaign=spacebase&utm_content=Tails+of+Airline+Companies&utm_medium=Social_Share

36. NASA/ Tschida, Tom (2000) NASA's B377SGT Super Guppy Turbine cargo aircraft touches down at Edwards Air Force Base, Calif. on June 11, 2000 to deliver the latest version of the X-38 flight test vehicle to NASA's Dryden Flight Research Center. [Photograph]
https://en.wikipedia.org/wiki/Aero_Spacelines_Super_Guppy#/media/File:Super_Guppy_N941_NASA_landing_(crop).jpg

37. Salard, Eric (2015). MSN 24310 LN 778 B747-409LCF BOEING / ATLAS AIR PAE BOEING AIRPORT EX CHINA AIRLINES AS B-162 AND B-18272 / STORED 12/2004 TO 02/2007. [Photograph]

https://upload.wikimedia.org/wikipedia/commons/a/a6/Boeing%2C_N780BA%2C_B747-409%28LCF%29_Dreamlifter_-_PAE_%2819833251496%29.jpg

38. Julien.jeany (2018). Maiden flight of the "Beluga XL" on 2018, July 19th at around 10:31am. [Photograph] https://upload.wikimedia.org/wikipedia/commons/7/72/%22Beluga_XL%22_A330-743L_%28cropped%29.jpg

39. Cassandra (2017). Quick Flights for Large Groups and Freight on the ATR42. [Photograph] https://blog.jettly.com/quick-flights-for-large-groups-and-freight-on-the-atr42/