

# **Female Integration in the Military: A Wicked Problem**

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

**Kathryn Leigh Ward**

Spring 2022

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

Travis Elliott, Department of Engineering and Society

## Introduction

The U.S military has fighter jets that are exclusively designed for the safety of the 50<sup>th</sup> percentile male. Should a pilot have to eject, they are inviting a high level of G force to be applied directly vertically along their spine. The vertical force is not strong enough to seriously injure the 50<sup>th</sup> percentile male, but smaller aviators, most often female, are at an extremely high risk of life threatening or paralyzing injury – because the seat was designed to clear the male pilot from the plane without injuring him (Salzar, 2009). Naval aviation traces its roots back to World War I, when Glenn Curtiss proved that aircraft could successfully take off from large seabound vessels, creating the mobile air defense base, and the modern aircraft carrier (*Naval History and Heritage Command*). Thus, Naval aviation, along with nearly all military installments, came to fruition before females were allowed into the military. The design of the military is disproportionately based around men: the ejection seat in all current fighter jets is simply one example of several that show military equipment and structure still revolves around an entirely male military, as women were only allowed in the service relatively recently when compared to the history of the military as a whole.

However, fixing and adapting technology to accommodate diversity within a fighting force presents issues that society, in general, does not have to take into account: the military faces a looming problem of expanding technology for the safety of their female personnel without sacrificing their ability to carry out the defense of the country. Where society can shift technology only with the constraints of business models and profit, military shifts are generally slower, as it is unpractical to shift technology to favor diversity over a sound defense system. The military remains predominantly male, currently at 85.6% (*America's Promise Alliance*) – and women make up a tiny 8.4% of pilots (*America's Promise Alliance*). Because of the height

and weight restrictions placed on pilots due to ejection seat safety, it is harder for smaller service members – most often female – to get clearance to fly: but shifting the technology to accommodate less than 10% of the force appears to be a waste of money and further, a possibly dangerous breach in fighting capability. The issue itself is a wicked problem – a wicked problem is defined by an issue, usually conservational or political, where the solution is hard to define, as it is dependent on the issue itself (Seager, 201). Integration of females into the military depends on the military adjusting to better accommodating them, which is unnecessary and dangerous in an overwhelmingly male organization: the cyclical nature of solving this integration issue makes it wicked.

### **Supportive Background Information**

Women have been officially in the military for years – ever since 1948, when President Harry S. Truman signed the Women’s Armed Services Integration Act (Gorbulja-Maldonado, 2020). Even before that, women in America have been serving in limited and often hidden roles since the founding of the country: women like Margaret Corbin disguised themselves to effectively fight in the front lines of the Revolutionary War. And yet, 73 years after the military became ‘integrated,’ the number of women hovers at around sixteen percent (Insinna, 2021). There are sociotechnical systems at play that effectively bar the military from achieving full integration: uniforms, barracks, and even obstacle courses are built so that they are navigable for the 50<sup>th</sup> percentile male. Because of the historic and continuing technical design of the military, the societal issue of integrating women remains a difficult, nearly insolvable issue.

Women have been flying planes and been in the military for years, and yet, the number of female fighter pilots across the military has remained largely stagnant. Planes and cockpits designed in the 1960s for the 50<sup>th</sup> percentile male have never been redesigned, and they come

with height and weight requirements that are extremely restrictive to the female population, especially within the military. The minimum weight of a fighter pilot in the U.S. Navy is 160 pounds, and to fit the anthropometric standards of the aviation community, women must be five feet, nine inches: a height only reached by approximately ten percent of the female population (Alyson, 2020). Visibility of female fighter pilots is extremely low, due partially to the restrictions placed on size, and due partially to the fact that women have not been fully integrated into the fighter fleet the way they have been in both cargo and rotary wing platforms. Societal issues within the military are also obstacles to full integration, and the issues emerge within a community that prides itself on being extremely masculine: there were 998 cases of sexual assault in the United States Marine Corps in 2017 (Snow, 2019). The submarine fleet within the U.S. Navy is not tangibly integrated to women, as fast attack submarines quite literally do not allow women to deploy onboard due to the lack of female bathrooms built into the submarine (Faram, 2019). Every integration issue in the military arises independently, but all stem from a long-term male fighting force that only recently has transitioned to accommodate both genders. The issues, independently, combine to contribute to the overarching wicked problem of female integration in the armed forces.

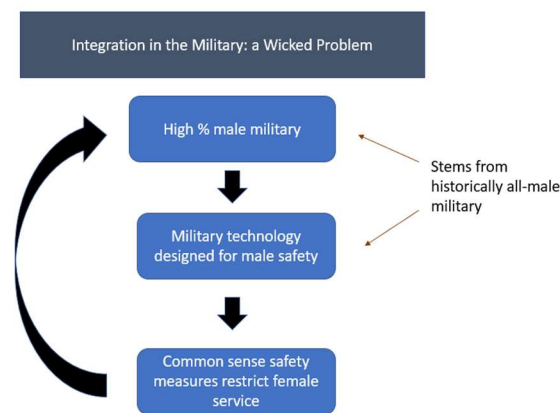
### **Wicked Problem Framing**

Wicked problem framing attempts to create solutions to the problem based of the perceived insolvable nature – common resolutions include shifting or decreasing the stakeholders, or increasing the scope of the population involved in solving the issue (Roberts, 2000). Critics of wicked problem framing are quick to claim that none of the aforementioned resolutions do much to help issues defined as wicked: instead, they present imperfect solutions that are incompatible with the nature of the issue itself, and therefore only small improvements

are realistic in practice (Termeer, 2019). However, small improvements, especially within wicked problems with a cyclical nature, are unobjectively better than no improvement: as small improvements are made, the cycle becomes closer and closer to being broken (Asdal 2007). When regarding female integration into the military as a wicked problem, increasing the scope of the issue to analyze when female integration is advantageous and when it is most hazardous makes the solution easier to arrive at for each military community.

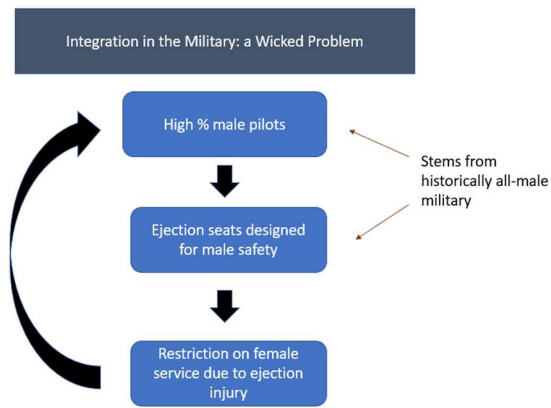
## Results and Discussion

An overview of the wicked problem when applied to female integration in the military is depicted below in Figure 1:

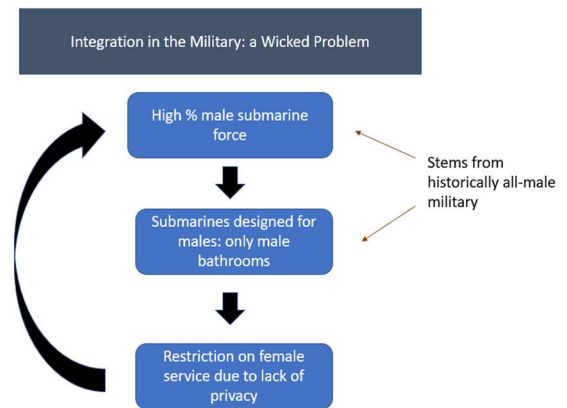


**Figure 1.** Integration in the military.

As shown in Figure 1, the design of technology is catered toward a predominately male military, which cyclically makes it more difficult for females to serve in all capacities, driving the number of females service members down. Figure 1 represents an abstract overview of the armed forces, but the chart can be modified to fit specific instances of low female participation institutions within the military, as shown in Figures 2 and 3.



**Figure 2.** Integration in the pilot platform.



**Figure 3.** Integration in the submarine platform.

## Ejection Seats

Figure 2 depicts two separate case studies in which the military has both newly developed and outdated technology that keeps its institutions largely unintegrated. The first case study is within the various air warfare aspects of the Department of Defense: the Air Force, Navy, Coast Guard, Marine Corps and Army all have their own separate departments for aircraft – the aircraft that require ejection seats (fighter planes, or F-#) have heavy restrictions based on the G forces on the body of the pilot necessary to clear the plane. The minimum weight for a fighter pilot is 160 pounds due to the designed force of ejection; the issue is furthered by necessary military constraints of height-weight that promote physical fitness of service members. Men can be five foot even and weight 160 pounds by the anthropometric standards, but women must be five foot nine to qualify at the same weight. The ejection seat was not designed to barr women from entering the military: it was designed by the required constraint to clear the average pilot from the cockpit without damaging their spine. However, the currently used Martin-Baker US16 seat goes off designs dating back to the sixties (Dario, 2020), and even large male pilots face a one in

three chance of spinal injury upon ejection, making pilots say that ejection is ‘a punishment in itself’ (Dario, 2020).

The process of diversifying the technology of the ejection seat would require a solution that does not, in any way, endanger the previous safety of the average jet pilot. The seat cannot be redesigned to only accommodate the smaller female pilot – thus, the resultant shift in technology would have to be constrained to become adjustable to the pilot. The U.S. Navy currently has 530 active fighter jets, each worth upwards of fifty million dollars (Roblin, 2021). The pure engineering feat of replacing each ejection seat within *active duty* (not including training aircraft) Naval aviation would require a draining weight on taxpayers, as well as the systematic removal of jets from the fighting force to be brought to any new standards – a process that would take years just for the Navy. Thus, the diversification of the Navy’s fighter jets is a wicked problem: the planes that are currently in use cannot be taken out of service, as that would decrease the readiness of the U.S. military against all enemies, foreign or domestic. Additionally, with the low percentage of current female pilots, it would be solving an issue that is not an actual threat to pilot safety.

### **The Submarine Fleet**

The first nuclear powered submarine was introduced to the U.S. Navy in 1995 – well after women were allowed to join the military (*Nuclear Powered Ships*). However, the reason nuclear powered submarines are so lethal is because they can stay submerged for months on end: the only reason current U.S. submarines need to surface is because of the constraints presented by the crew itself (food, water, waste management). Submarines are essentially small tubes, with cramped sleeping quarters and little to no privacy, with sailors living as well as they can among the military equipment. Such an environment presents common sense challenges in integration

women into the submarine fleet: until 2010, they were not allowed in the fleet at all, due to a lack of separate female bathroom facilities or sleeping quarters (Faram, 2019). Further, the original round of integration only included the larger Ohio-class ballistic missile submarines (Smith, 2020), as they had more available space to build separate female facilities. Enlisted female sailors were not allowed onto the ballistic missile submarines until 2016, as it is harder to build private enlisted racks, where officer privacy is already maintained due to separate, private quarters – though the Navy circumvents this simple technical explanation by claiming a ‘top-down integration process’ (Smith, 2020).

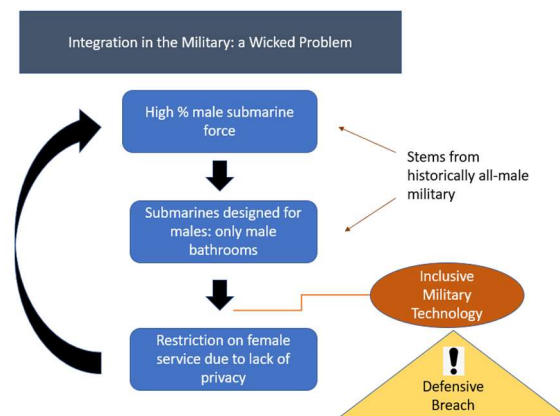
The Navy plans to fully diversify the submarine fleet, to include fast attack submarines, by an unspecified date: unspecified largely because the interest from women in the ‘silent service’ of submarines does not meet requirements to fully integrate the force. When taking into consideration that serving on a submarine constitutes being underwater in a small metal tube with a predominately male crew for months, the socio-technical effects of the wicked problem come into light: to fix the issue, the military would not only have to fully and tangibly integrate the submarines themselves, but find a way to make the personnel about half female to make it a worthwhile endeavour for female sailors. Such a technological shift would not only take submarines out of an active fighting force, but also require redesignating the already small female population of the submariners onto one vessel to get to the level of integration required to drive up interest. In essence, fully diversifying the fleet would first require doing the opposite, an act that would easily be criticized and would likely never be put into effect.

### **The Diversity Trade-Off**

As seen in the case studies of the aviation force and submarine force, diversity in the military is not as simple as diversity in the civilian world. Modifying technology so that the



military can adequately mirror the diversity of society is unfortunately a feat that can only be made at the expense of the readiness of the organization itself: an expense that the U.S. cannot afford in any short amount of time. Female integration is a cyclical and therefore wicked problem in the military, and the possible solution of shifting technology is show in Figure 4 below.



**Figure 4.** Inclusive military technology and its potential threat to national defense.

With inclusive measures in the military comes a severe warning: a lack of readiness in the defense of the nation. The best example of a ‘defense breach’ – a specific lack of readiness due to attempted military diversity – can be seen in the special operations branch of the armed forces. The Navy sea, air and land teams (SEALs) are the least diverse institution within the U.S. Navy, standing at exactly 0% female. However, the SEALs have no specific technology or anthropometric standard that disallows females from joining. Instead, it is the steadfast rigorous training and physical requirements of their training program, basic underwater demolition school (BUDS) along with their intense physical screener that has not permitted any diversity when it comes to gender. Members of the SEAL teams must be able to do ten pull-ups, with fifteen to twenty deemed competitive: a task that is tremendously more difficult for the physiological makeup of the female body (Stew, 2020). There have been women that have qualified to attempt

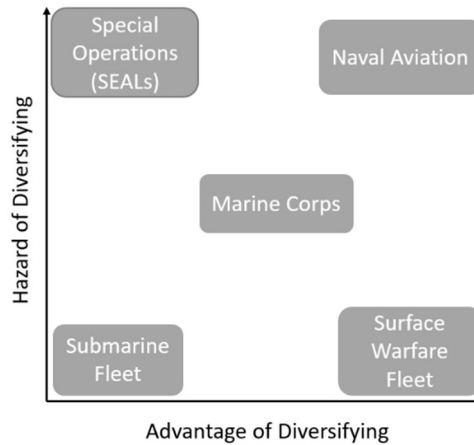
and become a Navy SEAL, but none have survived the infamous BUDs course, where they would have to keep up with the fittest men in the service.

Figure 4 shows how the cycle of female integration can be broken by utilizing inclusive technology – more specifically, inclusive technology refers to broader sociotechnical systems. However, the Navy SEALs illustrate the warning attached to the inclusive technology – if the SEALs were to lower their physical standards to diversify the teams, the effectiveness of the fighting force would fall at expense of the inclusion of women. While the argument can be made that diversity strengthens the armed forces as it should be a representation of American society, diversifying the most elite special operations team just for the name of inclusivity is inherently a bad idea. The warning can be applied to every smaller inclusivity issue within the military, such as the aforementioned submarine and aviation force: however, the defense breach is relative to the force itself.

### **Solving the Issue: Case-by-Case**

The military is often criticized for always being the last part of society to adapt to forward momentum in diversity: however, this criticism stems from the lack of understanding that the military is completely separate from society. When considering solving the wicked problem of female integration, the military must consider two crucial variables: how hazardous it is to diversify the institution, and how advantageous it is. The two factors are shown in Figure 5, with various institutions of the U.S. Navy analyzed. The surface warfare fleet has already been practically integrated, with no obstacles in the way of female service: the integration makes sense, as the ships did not have to be modified to accommodate women, and with no physical requirements in driving a ship, there is extremely low hazard in diversifying the fleet. The advantages are extremely high, as a diverse surface warfare fleet represents society, gives

women places in the military that are inclusive, and opens the largest officer installment of the U.S. Navy to college educated women, which make up sixty percent of current college enrollment (West, 2021).



**Figure 5.** Hazards versus advantages of diversifying military communities.

On the opposite of surface warfare lies submarine warfare: while the hazard of diversifying submarines is comparatively low, the advantage is low enough that it has stopped integration: women are not interested in serving on submarines. Taking on the challenges of integration would be futile if it did not result in higher female participation. Though the challenge could be viewed as sociotechnical, the issue cannot be resolved through the expansion of technology itself.

The rest of the chart includes installments of the U.S. Navy with higher hazards in integration their respective fighting force. The Marine Corps is the world's most lethal ground force, with rigorous physical requirements: but it is not as specialized as the SEALs, and the Corps has modified its requirements to allow female leadership and service. The advantages of the diversity are balanced, with not many women fit to serve in the intense environment: but this is reflected through the mere 8% of women in the Corps (Trotta, 2021). Traditionally, Naval

aviation's only obstacle to female pilots is ejection seats: but ejection seats are the core to safety in the cockpit. Changing the design could be potentially disastrous for current pilots, and doing so deteriorates the readiness of defense by taking aircraft out of active duty. A diverse flying force could be advantageous to the Navy, but the trade off for diversity is extremely high.

The wicked problem must be analyzed and solved on a case-by-case basis to balance the trade off between diversity and fighting effectiveness. SEAL teams do not need to prioritize diversity, but Naval aviation should take steps to better integrate women into the force over time. The solution to a high hazard, high advantage case such as aviation lies within designing and testing technology such as ejection seats and then building it into already advancing technology. The F-35 Lightning II is the newest installment of fighter jet in the military, and should a new ejection seat have existed, it could have been built into the aircraft. Small steps over time in the development of inclusive military technology is the best way to mitigate hazards to readiness while also striving to break the cyclical, wicked problem of military integration.

## **Conclusion**

Female integration remains a wicked problem as it is cyclical and by definition, reliant on itself. Further, incorporating more inclusive military technology can present hazards to a fighting force that do not have to be accounted for in society. To best attempt and fix the wicked problem, the military must first assess which institutions would benefit from diversity instead of just blind integration, and then assess the hazards and how to mitigate them.

## References

- Naval Aviation*. Naval History and Heritage Command. Retrieved from <https://www.history.navy.mil/browse-by-topic/communities/naval-aviation0.html>.
- Nuclear Powered Ships*. World Nuclear Association. Retrieved from <https://world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships.aspx#:~:text=The%20first%20nuclear%2Dpowered%20submarine,submerged%20for%20weeks%20on%20end>.
- U.S. Military Demographics*. (2010, January). America's Promise Alliance. Retrieved from americaspromise.com.
- Alyson, Jennifer. (08 January 2020). Air Force Fighter Pilot Qualifications. *Chron*. Retrieved from <https://work.chron.com/air-force-fighter-pilot-qualifications-8456.html>.
- Asdal, Kristin, et al. (2007). *Technoscience: The Politics of Interventions*. Unipub Norway: Oslo Academic Press.
- Faram, Mark (17 Jul 2019). What's next for the female enlisted submariners. *Navy Times*. Retrieved from [https://www.google.com/search?q=apa+non+scientific+article+citation&source=lnms&tbm=isch&sa=X&ved=2ahUKewjtupnqytX3AhX3lnIEHXl6DzsQ\\_AUoAXoECAEQAw&biw=1280&bih=601&dpr=1.5#imgrc=vZCT\\_YZV04V6vM](https://www.google.com/search?q=apa+non+scientific+article+citation&source=lnms&tbm=isch&sa=X&ved=2ahUKewjtupnqytX3AhX3lnIEHXl6DzsQ_AUoAXoECAEQAw&biw=1280&bih=601&dpr=1.5#imgrc=vZCT_YZV04V6vM)
- Gorbulja-Maldonado, A. (2020). 'We can do it!' The history of women in military service. *American Legion*. Retrieved from <https://www.legion.org/womenveterans/248582/%E2%80%98we-can-do-it-history-women-military-service>.
- Insinna, Valerie. (19 August 2021). To get more female pilots, the Air Force is changing the way it designs weapons. *Air Force Times*. Retrieved from <https://www.airforcetimes.com/news/your-air-force/2020/08/19/to-get-more-female-pilots-the-air-force-is-changing-the-way-it-designs-weapons/>.
- Leone, Dario (2020). *Former Ejection Seat Maintainer explains why "Ejection is a Punishment" for Military Pilots*. The Aviation Geek Club, Virginia Polytechnic Institute and State University. Retrieved from <https://theaviationgeekclub.com/former-ejection-seat-maintainer-explains-why-ejection-is-a-punishment-for-military-pilots/#:~:text='Ejection%20is%20a%20punishment%20in,because%20it's%20THE%20final%20action>.
- McCullough, Amy. (01 November 2020). Erasing Artificial Barriers. *Air Force Magazine*. Retrieved from <https://www.airforcemag.com/article/erasing-artificial-barriers/>.
- Roberts, Nancy. (2000). Wicked Problems and Network Approaches to Resolution. *Internal Public Management Review*. 1(1): 1-19.

- Roblin, Sebastien (31 Jul 2021). F-35A Jet Prices to Rise, But It's Sustainment Costs That Could Bleed Air Force Budget Dry. *Forbes Magazine*. Retrieved from <https://www.forbes.com/sites/sebastienroblin/2021/07/31/f-35a-jet-price-to-rise-but-its-sustainment-costs-that-could-bleed-air-force-budget-dry/?sh=ecf4d6d32dfe>.
- Salzar, R. (2009). Ejection Injury to the Spine in Small Aviators: Sled Tests of Manikins vs. Post Mortem Specimens. *University of Virginia Center for Applied Biomechanics*.
- Seager, Thomas, et al. (15 September 2011). Sustainable Engineering Science for Resolving Wicked Problems. *Springer Science and Business*. 25(1): 467-484.
- Smith, Stew (20 May 2020). How Tough is the Navy Seal Fitness Test? *Military.com*. Retrieved from <https://www.military.com/military-fitness/navy-special-operations/navy-seal-fitness-test>.
- Snow, Shawn. (2 May 2019). Sexual assault reports across the Corps up 20 percent. *Marine Times*. Retrieved from <https://www.marinecorpstimes.com/news/your-marine-corps/2019/05/02/sexual-assault-reports-across-the-corps-up-20-percent>.
- Stoner, Cameron (25 Jun 2021). Women in Submarines: Ten Years Later. *America's Navy*. Retrieved from <https://www.navy.mil/Press-Office/News-Stories/Article/2671640/women-in-submarines-10-years-later/>.
- Termeer, Catrien, et al. (17 May 2019). A critical assessment of the wicked problem concept: relevance and usefulness for policy science and practice. *Policy and Society*. 38(2): 167-179.
- Trotta, Daniel (26 Apr 2021). Breaking a Barrier, Women become U.S. Marines after Surviving the 'Crucible.' *Reuters*. Retrieved from <https://www.reuters.com/world/us/breaking-barrier-women-become-us-marines-after-surviving-crucible-2021-04-26/#:~:text=The%20Marine%20Corps%20has%20consistently,2020%20General%20Accounting%20Office%20report>.
- West, Charlotte (27 Oct 2021). An unnoticed result of the decline of men in college: It's harder for women to get in. *The Hechinger Report*. Retrieved from <https://hechingerreport.org/an-unnoticed-result-of-the-decline-of-men-in-college-its-harder-for-women-to-get-in>.