How to improve the representation of women in STEM

A case study from Aerospace and Defense Industry

IBM

The 2030 Agenda put forward by the United Nations General Assembly (UNGA) proposed 17 Sustainable Development Goals[1] for achieving a better future by fostering equality, economic growth, and innovation.

In its economic and social dimensions, this document acknowledges that gender parity is an important step for achieving sustainable development, while recognizing that "gender inequality remains a key challenge"[2] and that empowering women and girls by allowing them to contribute fully to the industry without being hindered by gender inequalities to contribute and achieve all the goals and targets proposed.

Working towards achieving these goals is of great importance for potentiating sustainable economic growth (Goal 8) and reducing all form of inequalities (Goal 10) while acknowledging the role of gender equality (Goal 5) and innovation (Goal 9) to create a sustainable future.

Today, increasing attention is being paid to the level of female representation in STEM (science, technology, engineering, and mathematics). However, women, especially as inventors, continue to be underrepresented in STEM fields, leading to missed opportunities for innovation in numerous sectors.

Closing the gender gap is vitally important in the areas of patenting and inventorship, where generating innovation and gaining ownership over it helps companies to create better and more efficient products and services that set them apart from competitors.

This is particularly relevant in the Aerospace and Defense (A&D) industry, where sustained innovation is one of the main drivers of competition and a means to stay relevant in the global market.

Gender diversity is also one of the 15 sustainable development goals supported by the International Civil Aviation Organization (ICAO). In fact, it was the main focus area of the first "Global Aviation Gender Summit" where participants advocated for the aviation industry to demonstrate strong commitments towards gender equality. [3]

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The Role of Diversity and Inclusion in the A&D Industry

Companies in the A&D industry rely on a culture of innovation as a means to thrive in a fast-moving landscape. For "an industry that depends on innovation," it becomes essential to foster the potential of Diversity and Inclusion (D&I) to expand on inventorship. [4]

There is increasing recognition of the business case for D&I. Studies have shown that companies with a more diverse leadership team and workforce are not just more innovative and profitable, but they also tend to have better employee engagement and retention. [5] It has been shown that in general, companies with diverse teams are more likely to outperform the competition. [6]

To capture growth opportunities and prepare for the future, A&D firms must focus on building a strong governance strategy based on D&I. [7]

A diverse team has more opportunities to respond to, and become aware of, broader segments of the market. In a historically male-dominated industry, team diversity brings a broader collection of experiences, viewpoints, and backgrounds, which results in better decision-making. [8]

Therefore, diverse groups are better positioned to offer multi-dimensional and creative solutions that produce more robust strategies – ultimately leading to comprehensive and innovative products and services for the A&D industry.

Case study: Women Inventorship in the A&D Industry

IVADO, IBM, LGS, an IBM company and MakilaAI partnered once again to analyze the inclusion of women in innovation and patenting, this time focusing on companies in the Aerospace & Defense industry.

To conduct this research, the team examined seven leading A&D companies: Boeing, Airbus, Lockheed Martin, Mitsubishi, Bombardier, De Havilland, and General Electric, and assessed how they positioned themselves in terms of female inventorship. To this end, we collected the companies' published patents between March 1890 and December 2022 and conducted descriptive and predictive analysis of their female participation in innovation. We also relied on public data from these companies' annual Environmental, Social and Governance (ESG) reports.

To assess the evolution and role of female inventorship, we evaluated multiple factors, including processing times, gender composition of the inventorship, and average female participation in patents both overall and by classification sections. Significant observations included:

- On average, women were more represented in complementary areas of innovation in each company. When analyzing the companies' percentage of patents in each of the Cooperative Patent Classification (CPC) sections, we observed that the average proportion of females is not similarly distributed across sections, and that those sections with larger average female representation were not the sections where the company published the most patents (their main innovation drivers).

For example, approximately 43 percent of Airbus' published patents were classified in the section of "Performing Operations and Transporting." However, the largest average proportion of female participation in this company was recorded in the sections of "Human Necessities" and "Chemistry, Metallurgy" – two sections that, combined, represented just 2.9 percent of the total number of patents published by the company.

- Although multiple efforts have been undertaken to improve the participation of women in STEM, and despite an incremental increase in the number of female inventors, the average participation of women in patents for these companies, combined, has grown less than 10 percent since the 1980s. This demonstrates that the rate at which the proportion of women in patents is growing is slow and largely insufficient.

The team estimated that if current trends were to continue, the year for reaching gender parity, for all these companies combined, would not be before 2396. In other words, women in innovation would need to wait hundreds of years before experiencing parity.

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Three Factors Hindering Gender Parity in Patenting in A&D

Gender-based patenting disparities are not simply a pipeline problem, but something more structural and systemic. They are driven and affected by many factors, including longstanding structural barriers, socioeconomic and technological transformation, as well as economic shocks[8].

To illuminate key aspects of underlying and emerging trends impacting the trajectory of gender parity, here are three important factors hindering companies from reaching gender parity in patenting:

1. A perception of male dominance in the industry

Women may face bias and stereotypes in the workplace that limit their opportunities for patenting. Decisions about whom to include in research teams are affected by preconceived notions and stereotypes regarding gender. Women may be perceived as less competent or less innovative than their male counterparts, which can impact their ability to obtain patents. Women may also be affected by differing rates of self-nomination and self-promotion, whereas men may be more willing to request that their names be added as co-inventors on patent applications. [9]

## 2. Lack of female role models in the industry

The lack of representation and diversity can create a sense of exclusion and make it difficult for women to envision themselves as leaders in the A&D industry. A BCG study suggests that in 2018, women held no more than a quarter of executive level roles and made up only 22% of the entire A&D workforce. This underrepresentation highlights the lack of female role models in both leadership roles and the overall workforce.[9]

One of the main reasons for this discrepancy is the historical discrimination and exclusion of women from STEM fields. For many years, women were not encouraged or allowed to pursue careers in these fields, which led to a shortage of women in these industries. Another reason is the lack of visibility of women in leadership positions in aerospace. Women who do manage to break through the barriers and succeed in the industry may not receive the same recognition or opportunities for advancement as their male counterparts.

3. Women have fewer opportunities for peer-to-peer mentorship than men

Many patenting opportunities and research projects may be filled by an informal network, rather than through formal interviews or competitions. These self-perpetuating social hierarchies can entrench gender discrimination practices.

Women may be excluded from mentorship opportunities due to the artefacts of established networks, rather than any lack of education or merit. These networks may have been created and sustained over time by individuals who are already part of the industry, and they may not always be inclusive of women or other underrepresented groups. Another factor that may catalyze this disparity is the "likeability penalty" that women can face in the workplace. Research has shown that women who are perceived as competent and assertive are often penalized socially and viewed as less likable than their male counterparts with the same attributes. This can make it more difficult for women to find mentors who are willing to invest in their development. [10]
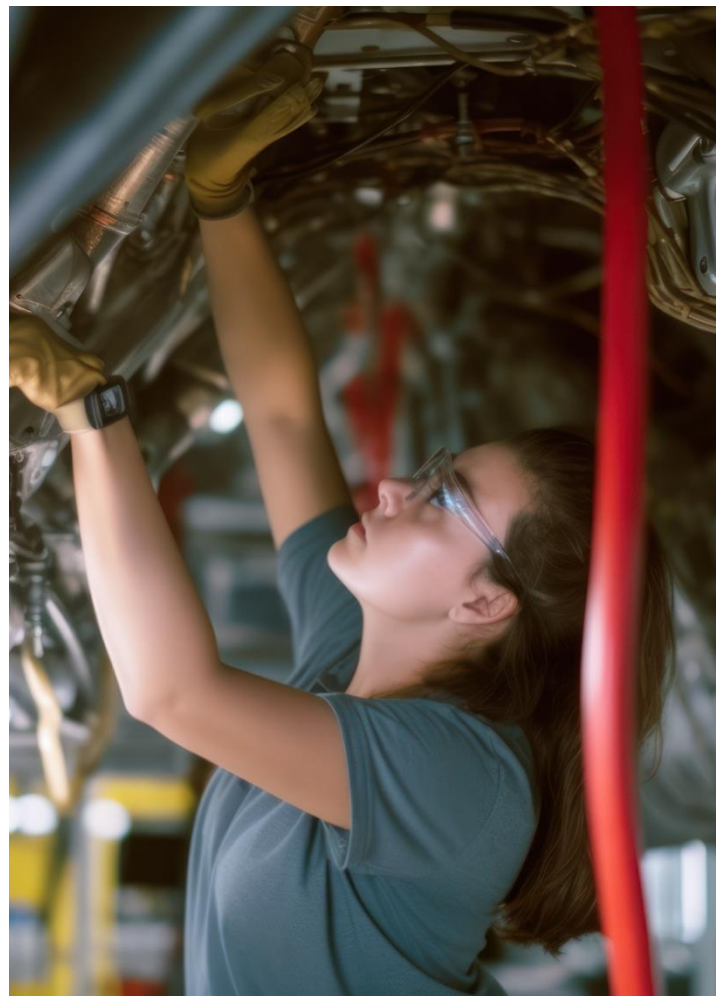
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How A&D Companies are Fostering Gender Equality in the Workplace

From the latest D&I reports produced by these seven companies, we can see that multiple initiatives have been executed to improve female representation in the workforce. Ranging from better hiring practices to community investments, these efforts show that companies have recognized the need for creating an inclusive and safe workplace where diversity can thrive.

Examples of the initiatives include:

- "Seek, Speak & Listen (SS&L)" are habits launched by Boeing to be embedded into their daily work rhythms to empower their teams to speak up, share ideas and include all perspectives.[11] Another example is the four-pillar strategy from Bombardier based on "Lead, Recruit, Develop and Include" to promote better governance in their D&I program. [12]
- To foster better hiring practices, companies have increased female representation "in part to strengthen the equity in the selection process" by offering training to their hiring managers. An example of this is the Bias Mitigation Training for hiring managers implemented at Boeing. [13]
- Employee-led initiatives such as the Employees Resource Groups (ERGs) and Business Resource Groups (BRGs) play an important role in promoting diversity inside companies by fostering a sense of community and serving as a forum to share experiences within the organizations.[14]

Some examples of ERGs supporting female innovation are the Women Innovative Network (WIN) at Airbus, [15] as well as the Women Impact Network (WIN) and the Women and Allies in STEM (WAIS) groups from Lockheed and Martin, with a mission to "inspire the next generation of engineers and scientists" by providing support to female engineers that join the company. [16]

- Other initiatives focus on external collaborations with universities. One such collaboration between Bombardier's Women in Engineering affinity group and Concordia University supports the Women in Engineering – Career Launch Experience by adding mentorship and professional development to female engineers and computer scientists. [17] General Electric offers a similar example of collaboration through their Women's Network partnering with the Society of Women Engineers (SWE) to fund scholarships and offer awards to current or future female students of STEM in U.S. accredited universities.

Through this program, female students become part of GE's network, gaining access to professional activities, internships, and employment opportunities in the company. [18]

Table 1 shows that most companies have seen a modest increase in their female workforce composition in recent years. While some progress has been made in terms of female representation, many of these companies recognize it is still not enough.

Company Name	2016	2017	2018	2019	2020	2021
Boeing	–	–	–	–	22.9%(US)	23.2%(US)
General Electric	–	–	–	21.8%	21.9%	22.3%
Airbus	–	17.5%	17.7%	18%	18%	19%
Lockheed Martin	23%	23%	22.6%	23%	23.2%	23.2%
Bombardier	–	19%	19%	18%	20.4%	20.2%
Mitsubishi Heavy Industries	9.9%	10.2%	9.8%	10.1%	101%	12.5%

Table 1: Reported Workforce Composition Among Examined Companies

How IBM is Helping to Increase STEM Awareness and Close the Gender Gap

According to the 2022 Environmental, Social and Governance (ESG) Report, [19] IBM is actively focusing a culture of conscious inclusion and active allyship. During the past 10 years, IBM launched and enhanced innovative social programs to promote equality and diversity and to address complex societal challenges by utilizing IBM technologies.

IBM prioritizes the education and skills of women in STEM, not only to close the gender gap, but also to turn sustainability social ambition into real action.

The following programs are designed to increase STEM awareness for women and girls and to create an equitable and balanced environment for women to fully participate in all STEM technologies and opportunities.

STEM For Girls
STEM for Girls, which launched in India in 2019, is designed to foster a robust STEM ecosystem that encourages critical thinking, problem solving, and innovation among the upcoming generation of women in India. Through mentorship and project-based learning pathways, middle school and high school young women are exposed to different careers in STEM.

P-TECH
In 2011, IBM co-created P-TECH, an innovative high school model that integrates post-secondary pathways and workplace experiences to prepare for professional life. Today, it has grown into a successful, free, global model that includes mentoring, career exploration, and access to IBM SkillsBuild. Additionally, these programs offer specific benefits for women aimed at boosting women's presence in STEM fields.

IBM SkillsBuild
This free education program provides valuable skills and career opportunities in technology to traditionally underrepresented communities. In addition to workplace skills, the program offers over 1,000 courses in 20 different languages on topics such as cybersecurity, data analysis, cloud computing and many other technical disciplines. Learners around the world are predominately high school and university students, faculty, or adult learners. The program includes an online platform that is complemented by customized, practical learning experiences delivered in collaboration with a global network of partners.

HBCU Cybersecurity Leadership Centers
IBM is collaborating with over 20 historically black colleges and universities (HBCUs) to create IBM Cybersecurity Leadership Centers that will advance STEM-based opportunities for students. Through this collaboration, faculty and students at participating schools will have access to coursework, lectures, immersive training experiences, certifications, IBM Cloud®-hosted software, and professional development resources, all at no cost to them.

With these educational programs, IBM is committed to providing educational programs aimed at training 30 million individuals by 2030, with a focus on individuals. Since 2021, over 7 million learners have enrolled in free IBM courses through our combined education initiatives in 2022, IBM contributed over $435 million in combined cash, technology, and services toward education. Furthermore, these investments have acted as a catalyst for innovation and collective advancements to support female leadership and promote gender equality, thus strengthening equitable and inclusive access to numerous educational and professional opportunities in the aerospace industry.

These programs can help pave the way for women and girls to participate in innovation more fully, not only in the A&D industry but in all STEM-related domains.

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Recommendations for the A&D Industry

Overcoming existing barriers for women in the A&D Industry needs to be addressed. Below we outline some of the actions A&D companies can implement to empower women in the industry.

1. Provide detailed reports about the effectiveness and the progress made towards diversity and inclusion efforts.
2. Partner with organizations that comply with gender-parity indexes that include innovation in patents.
3. Promote and ensure that women are participating in key areas of innovation inside the company.
4. Ensure a gender-diverse pool of candidates when recruiting for a job position.
5. Potentiate women's leadership by providing training and mentoring programs.
6. Conduct workforce surveys to measure female engagement and satisfaction.
7. Support women and girls' STEM education to expand the talent pool.
8. Partner with and sponsor organizations that promote STEM programs for girls and women.
9. Support reading clubs for women inventors to systematically share current, past, or relevant third-party research areas to foster networking.
10. Sponsor women mentorship programs for inventors.
11. Increase awareness and training on Inclusive Leadership.
12. Invest in systematic unconscious bias trainings.
13. Sponsor leadership programs for women.
14. Battle harmful stereotypes.

Conclusion

The underlying reasons that keep women away from STEM industries and companies are multi-faceted, ranging from historical and cultural reasons to unconsciously internalized biases.

In our study, we found that even though female inventorship has increased over time, its growth is still insufficient. We outlined some of the factors holding women back and recommended some actions for the industry to consider. The IBM-launched programs could help to leverage a new workforce era with a keen awareness of STEM technologies for women and girls.

We acknowledge that Aerospace and Defense is historically a male-dominated industry, giving it a lower starting point in terms of gender diversity. Other barriers include an aging workforce and a declining appeal towards the industry versus other STEM-centered career paths, like Technology.

Nevertheless, most companies in this report have taken first steps towards a more inclusive and diverse workforce and are transparent about their social, diversity and inclusion endeavors as evidenced by their public reports outlining their sustainability efforts. Still, more needs to be done to foster female inclusion in the industry and in innovation.

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