

The University of Akron

IdeaExchange@UAkron

---

Williams Honors College, Honors Research  
Projects

The Dr. Gary B. and Pamela S. Williams Honors  
College

---

Spring 2023

## Sustainability and Biomimicry

Tabitha Cooper  
tkc25@uakron.edu

Follow this and additional works at: [https://ideaexchange.uakron.edu/honors\\_research\\_projects](https://ideaexchange.uakron.edu/honors_research_projects)



Part of the [Integrative Biology Commons](#)

Please take a moment to share how this work helps you [through this survey](#). Your feedback will be important as we plan further development of our repository.

---

### Recommended Citation

Cooper, Tabitha, "Sustainability and Biomimicry" (2023). *Williams Honors College, Honors Research Projects*. 1654.

[https://ideaexchange.uakron.edu/honors\\_research\\_projects/1654](https://ideaexchange.uakron.edu/honors_research_projects/1654)

This Dissertation/Thesis is brought to you for free and open access by The Dr. Gary B. and Pamela S. Williams Honors College at IdeaExchange@UAkron, the institutional repository of The University of Akron in Akron, Ohio, USA. It has been accepted for inclusion in Williams Honors College, Honors Research Projects by an authorized administrator of IdeaExchange@UAkron. For more information, please contact [mjon@uakron.edu](mailto:mjon@uakron.edu), [uapress@uakron.edu](mailto:uapress@uakron.edu).

# **Sustainability and Biomimicry**

Tabitha Cooper

University of Akron

Spring 2023

## **Abstract**

Standardization of business management systems is a vital part of the economic climate, as it allows for fair play between all competitors and encourages growth. The International Organization of Standardization (ISO) independently provides hundreds of standards ranging through dozens of different fields, providing standards applying to topics from quality management to material composition. Not much is readily available on the topics of ISO 9001, which outlines quality management systems (QMS) ISO 14001, which details environmental management systems (EMS), and their relation to ISO 18457, which explains what composes a biomimetic material or product. A literature review was conducted to gather more information on the contents of all three standards and how they relate to one another, with a greater focus on application in the Aerospace industry. It was found that application of ISO 9001 and ISO 14001 act as both a method for environmental protection and economic benefit when applied, as ISO 9001 enforces continuous improvement of quality and ISO 14001 requires more efficient, waste-reducing practices which can make an excellent impression for investors (Johnstone & Hallberg, 2020).

*Keywords:* Aerospace, biomimetics, sustainability, QMS, EMS

## **Introduction**

In recent years, there has been a growing focus on practicing sustainable business practices, limiting human impact on the environment through pollution and using resources faster than they can be replaced (MDPI, 2021). With the rise of global warming, overfishing, and pollution, most businesses will need access to resources that will assist them in altering their methods of production to better suit the new social, political, and ecological climate. The United States Environmental Protection Agency (EPA) defines sustainability as utilizing natural resources in a method conducive to coexisting with nature (EPA, 2022).

The International Organization of Standardization (ISO) is an independent, non-governmental organization located in Geneva, Switzerland which produces standards for subjects such as management, material components, sales, and more. (ISO, 2023b). Companies interact with the ISO to provide credibility to their business practices, such as proper waste disposal and quality material production, and to hold each other accountable for violating these regulations, creating an even playing field for all involved. Each standard is numbered. This paper will focus on ISO 9001 and ISO 14001.

What is ISO 9001 and ISO 14001? Both act as guidelines focusing on quality and environmental consciousness. ISO 9001 outlines the concept of a Quality Management System (QMS), which encourages organization, efficiency, and improvement to methods of production and management (ASQ, 2018). The standard requires any company utilizing it to set specific, achievable goals to improve both the product created and services provided by the company (ASQ, 2018). ISO 14001 applies to Environmental Management Systems, which similarly offer concepts of organization, efficiency, and improvement, but through the lens of sustainability by focusing more on reducing waste, rather than creating different products (Alfredo & Nurcahyo, 2018). While the standard provided is identical, regardless of the industry, the application of the standard is left to the leadership of the company to determine the goals and how to work to achieve them (Martins & Fonseca, 2018). Independent auditors are used to annually check progress and ensure the goals set and are being followed. Each standard can be hundreds of pages long, outlining what constitutes reasonable goals, both for achievability and progress toward greater quality or reduced environmental impact.

According to a 2021 ISO survey, ISO 9001 is the most widespread certification with 1,077,884 certifications worldwide, spanning 1,463,153 sites (ISO, 2023a). ISO 14001 is the second most used, but only makes up less than half of ISO 9001's numbers at 420,433 certifications at 618,384 sites (ISO, 2023a). Even when ISO 14001 was initially released, the enthusiasm for its use was far lesser than that of ISO 9001, implying that there was less focus on the environmental impact of business practices (Bellesi et al., 2005).

Biomimetics is the practice of utilizing concepts from biological systems to provide innovative solutions to human problems that often can improve sustainability at the same time (Biomimicry Institute, 2023). ISO 18457 is another standard, shorter than most, that outlines the definition of a biomimetic material and its applicability to the concept of sustainability (ISO, 2016). ISO 18457 complements ISO 9001 by demonstrating how utilizing biological principles can lead to a better-quality material or system, as well as working with ISO 14001 by showing how to create reusable, multifunctional products to reduce waste and cost (ISO, 2016).

Aerospace is a growing industry across the globe. For example, Boeing, a major aerospace manufacturer, saw a 35.06% increase in revenue from 2021 to 2022 (Macrotrends, 2022). However, little is known about the role of ISO and certain standards, such as ISO 14001, which experienced revisions in 2015. Less than 20,00 companies in the aerospace industry are currently following ISO 14001, a meager number compared to the number of certifications in industries such as chemicals or plastics (Advanced Conversion Technology, 2022).

This paper will compare ISO 9001 and ISO 14001 and provide an overview of the importance of their use for industries in general and aerospace in particular. Finally, a brief overview of ISO 18457 will be provided to suggest how it can be used to bolster both standards and the aerospace industry.

## **Methods**

This paper used a literature review to study the applications of ISO 9001 and ISO 14001 to reveal how biomimicry could be applied to efforts to improve sustainability in implementing ISO 14001. This was accomplished through digital collection of scholarly resources including

academic reviews of standards, case studies of implementation, and published analyses of benefits some companies experienced in utilizing each standard. Greater focus will be placed on ISO 18457 and ISO 14001, as for these standards, the most information is accessible.

## **Results**

A total of 10 scholarly articles pertaining to ISO 9001 and ISO 14001, 6 of which were case studies, were found and reviewed for ISO 9001 and ISO 14001. I also gathered information from other sources, including the ISO website and other publicly available sources.

ISO 9001 outlines the requirements of a QMS. A QMS is a method of managing purchases, manufacturing, and sales to act as a method to consistently meet and surpass customer expectations (Alfredo & Nurcahyo, 2018). ISO 14001 alternatively focuses on sustainable environmental management system (EMS) while providing an economic incentive for businesses who utilize it (Alfredo & Nurcahyo, 2018). An EMS is intended to formalize procedures to better reduce environmental impacts (Manurung & Rachmat, 2019).

While standards provide detailed instructions about the conduct of companies that use them, certification is required to check compliance and results. While the ISO provides the standards, independent auditors review changes made by the company to ensure they are keeping to the commitment they made, acting as supervisors and reporting improper implementation to both the ISO and management (Heras-Saizarbitoria et al., 2013). Certification (of any standard) is a rigorous process and many auditors are not fully aware of the scope of the company's commitment to environmental change which can cause improper implementation (Heras-Saizarbitoria et al., 2013). However, certification is expensive and highly valued, providing independent evidence of compliance that can be evaluated by other interested parties and stakeholder (e.g., customers) acts as the only current method of oversight after the ISO's involvement has concluded. Several auditing methods exist, such as the Building Research Establishment's Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED), which are both utilized to assess the life cycle of a product or project from start to finish, leading to lessened environmental impact due to the reduced waste

and use of limited resources such as fossil fuels (Brem et al., 2020). These tests provide one possible method of ensuring compliance with ISO 14001, due to their relation to environmental consciousness and sustainable business practices. BREEAM and LEED were used by Brem et al. (2020) to demonstrate the effectiveness of ISO 14001 implementation through measurable scores, rather than qualitative discussion .

Auditing of ISO standards is what allows them to maintain their effectiveness despite being a voluntary method of regulation. Brogi and Menichini demonstrate this by comparing ISO 14001 certified companies to those without based on the European Eco-Innovation Scoreboard interactive tool (ECO-IS), a method of scoring environmental consciousness (Brogi & Menichini, 2019). Scores from the ECO-IS tool were used to create a Spearman rank correlation between the proportion of ISO 14001 certified companies and the score they achieved (Brogi & Menichini, 2019). They found that, while ISO 14001 is a useful tool regardless of regulation when applied, ISO 14001 is far more effective when outside auditing makes sure that the goals set by the company are being followed strictly, rather than haphazardly (Brogi & Menichini, 2019).

ISO 14001 is currently the only auditable standard in the ISO with a focus on waste management and environmental impact (Alfredo & Nurcahyo, 2018). However, ISO 14001 is not the only standard that interacts with more sustainable production. ISO 18457 lays out what defines a biomimetic material (ISO, 2016). A major focus is put on defining the aspects, features, and traits of a biomimetic material or product, such as multifunctionality, hierarchical structures, and reusability (ISO 2016). A biomimetic material is defined by having one or more of these traits, resulting from a use or mimicry of biological systems (ISO, 2016). Several of the traits provided involve the concept of reusing and maintaining current materials in circulation, rather than producing new materials and disposing of the old (ISO, 2016). This concept is known as circular economy, where machinery, products, and materials are kept in circulation as long as feasible to reduce waste (Rodrigues et al., 2022).

For example, by far the most famous example of biomimicry is Velcro (Library of Congress, 2019). Velcro was based off the concept of burrs sticking to other surfaces to be transported elsewhere, while still retaining this ability after each use. This is possible because of the hooked barbs on the surface of the burr, which cling to anything that has a fibrous texture, such as fur, hair, or clothing (Library of Congress, 2019). Despite environmental consciousness not being a major factor in its creation, the concept of a reusable adhesive is in it of itself an environmentally friendly product since it reduces overall waste and potentially toxic chemicals from being introduced to humans and the world (ISO, 2016). As Velcro itself is made of plastic, it is still not an entirely sustainable solution but provides a steppingstone for new innovation due to reducing the amount of non-reusable plastic adhesives being used.

While subjection to additional standards on a company may seem to counter performance or growth, many small to medium companies adopt ISO 14001 for economic purposes, seeing customer appeal as a major factor (Johnstone & Hallberg, 2020). Kaur et al. references the concepts of cost reduction, improved access to international markets which may require certifications to conduct business, and even improved staff morale due to implementing more environmentally friendly methods of production (2021). Other major motivating factors include many larger companies requiring their business partners to use ISO 14001 and other standards, as they can pass any potential savings along to create a lower cost, environmentally friendly product (Johnstone & Hallberg, 2020).

These concepts can be broken down into three sectors: financial, societal, and environmental benefits. These three sectors are known as a “triple bottom line”, or 3BL, and outline the potential benefits of environmental conservation (Gopalakrishnan et al., 2012). Gopalakrishnan reviews the EMS decisions of British Aerospace systems (BAe) to better demonstrate how the ISO 14001 standard is implemented (2012). BAe outlines their goals as such: using environmentally friendly machinery, following the United Kingdom’s Ministry of Defense’s environmental policy, and assessing the life-cycle of their products from creation to disposal, using environmental auditing as explained above (Gopalakrishnan et al., 2012).



While ISO 9001 and ISO 14001 act as useful tools for any industry, some industries utilize other standardization methods. For example, the Aerospace industry utilizes the Society of Automotive Engineers (SAE) standard of AS9100. AS9100 is based on ISO 9001, using the quality management guidelines while altering and adding to them to better suit the Aerospace field, as the methods of production and required materials to create and maintain airplanes, rockets, and more are very different from an industry producing plastics for use on the ground (SAE, 2016). ISO 14001 and ISO 18457 have yet to be transferred into SAE standards. However, with a growing interest in environmentally conscious business practices as green energy becomes more prevalent, it is likely that the Aerospace industry will have to put a greater emphasis on environmental protection. As aviation is currently the highest carbon-emission form of transport for passengers and freight, more pressure is likely to be put on production of more efficient, environmentally friendly alternatives (EEA, 2023).

Of course, standards such as those discussed also have weaknesses. For example, keeping standards consistent with one another across hundreds of different industries can be challenging and lead to splits such as ISO 9001 and AS9100, where both are extremely similar in concept with very minor changes. Auditing is also not a foolproof method of regulation, since auditors can occasionally miss things they are unaware of (Heras-Saizarbitoria et al., 2013). As Martins and Fonseca explain, groups such as the European Union use greater governmental oversight to ensure the proper usage of environmental management systems (2018). As these methods are still voluntary, this provides a level of oversight that the ISO cannot achieve due to being unaffiliated with any governmental organization (Martins & Fonseca, 2018).

## **Discussion**

All four standards (ISO 9001, ISO 14001, ISO 18457, AS9100) mentioned act as an impressive tool for preservation and reparations of the current ecological climate, working to continually improve current methods of production in both matters of quality and environmental consciousness (Johnstone & Hallberg, 2020). As all three ISO standards apply to any industry, they are more likely to spread and become more prevalent in business culture, as

the good press, increased efficiency, and less waste provide tempting benefits (Johnstone & Hallberg, 2020).

The case studies reviewed suggest that ISO 14001 is an important steppingstone to a greater environmental focus in all industries, as well as continuous growth in both quality and sustainability. However, the implementation of ISO 14001 standards remains slow, partly due to how each implementation must be created and maintained by the company themselves, rather than any organization in charge of oversight (Heras-Saizarbitoria et al., 2013). Improvements could be made to how reporting and auditing is performed, using methods such as LEED and BREEAM to better assess 'success' of an EMS in a piecewise manner (Brem et al., 2020).

On the topic of where ISO standards should be applied, Aerospace only makes up 1,189 ISO 9001 certifications and 341 ISO 14001 certifications across the globe (ISO, 2023a). This is a miniscule proportion compared to industries such as plastics, which has 19,153 ISO 14001 certifications alone (ISO, 2023a). As a growing industry, especially as space transport becomes of greater focus in the public eye, the Aerospace industry has a responsibility to lead by example in sustainable, unique, and biomimetic business practices.

### Citations

- Advanced Conversion Technology. (2022, August 25). HOW DOES A COMPANY ACHIEVE AS9100 CERTIFICATION? Advanced Conversion Technology. Retrieved April 10, 2023, from <https://www.actpower.com/educational/as9100d-certification/#:~:text=According%20to%20OASIS%2C%20the%20Online,AS9100%20certification%20in%20the%20world.>
- Alfredo, E. I., & Nurcahyo, R. (2018). The Impact of ISO 9001, ISO 14001, and OHSAS 18001 Certification on Manufacturing Industry Operational Performance. Proceedings of the International Conference on Industrial Engineering and Operations Management.

- ASQ. (2018, September 14). What is ISO 9001:2015 – Quality Management Systems? ASQ. Retrieved April 6, 2023, from <https://asq.org/quality-resources/iso-9001>
- Bellesi, F., Lehrer, D., & Tal, A. (2005). Comparative advantage: the impact of ISO 14001 environmental certification on exports. *Environmental Science & Technology*, 39(7), 1943–1953. <https://doi.org/10.1021/es0497983>
- Biomimicry Institute. (2023, February 21). What is Biomimicry? Biomimicry Institute. Retrieved April 6, 2023, from <https://biomimicry.org/what-is-biomimicry/>
- Brem, A., Cusack, D. Ó., Adrita, M. M., O’Sullivan, D. T., & Bruton, K. (2020). How DO companies certified to ISO 50001 and ISO 14001 perform in LEED and BREEAM assessments? *Energy Efficiency*, 13(4), 751–766. <https://doi.org/10.1007/s12053-020-09864-6>
- Brogi, S., & Menichini, T. (2019). Do the ISO 14001 Environmental Management Systems influence eco-innovation performance? evidences from the EU context. *European Journal of Sustainable Development*, 8(4), 292. <https://doi.org/10.14207/ejsd.2019.v8n4p292>
- EEA. (2023, February 9). Rail and waterborne - best for low-carbon motorized transport. European Environment Agency. Retrieved April 9, 2023, from <https://www.eea.europa.eu/publications/rail-and-waterborne-transport>
- EPA. (2022, November 14). Learn About Sustainability. EPA. Retrieved April 7, 2023, from <https://www.epa.gov/sustainability/learn-about-sustainability#what>
- Gopalakrishnan, K., Yusuf, Y. Y., Musa, A., Abubakar, T., & Ambursa, H. M. (2012). Sustainable Supply Chain Management: A case study of british aerospace (BAE) systems. *International Journal of Production Economics*, 140(1), 193–203. <https://doi.org/10.1016/j.ijpe.2012.01.003>
- Heras-Saizarbitoria, I., Dogui, K., & Boiral, O. (2013). Shedding light on ISO 14001 certification audits. *Journal of Cleaner Production*, 51, 88–98. <https://doi.org/10.1016/j.jclepro.2013.01.040>
- International Organization of Standards. (2023, January 24 a). ISO Survey 2021 Results. Geneva; <https://www.iso.org/committee/54998.html?t=KomURwikWDLiuB1P1c7SjLMLEAgXOA7emZHKGWyn8f3KQUTU3m287NxnPA3Dluxm&view=documents#section-isodocuments-top>.
- International Organization of Standards. (2023, April 3 a). About Us. ISO. Retrieved April 16, 2023, from <https://www.iso.org/about-us.html>
- International Organization of Standards. (2016, September 15). Biomimetics — Biomimetic materials, structures and components. Geneva; International Organization of Standards.
- Johnstone, L., & Hallberg, P. (2020). ISO 14001 adoption and environmental performance in small to Medium Sized Enterprises. *Journal of Environmental Management*, 266. <https://doi.org/10.1016/j.jenvman.2020.110592>
- Kaur, J., Kochhar, T. S., Ganguli, S., S, S. R. (2021). Evolution of management system certification: An overview. *Innovations in Information and Communication Technology Series*, 82–92. [https://doi.org/10.46532/978-81-950008-7-6\\_008](https://doi.org/10.46532/978-81-950008-7-6_008)

- Boeing revenue 2010-2022: BA. Macrotrends. (2022, December 31). Retrieved April 16, 2023, from <https://www.macrotrends.net/stocks/charts/BA/boeing/revenue>
- Manurung, D. T., & Rachmat, R. A. H. (2019). ISO 14001 implementation impact and financial performance on Corporate Social Responsibility disclosure. *Jurnal Manajemen*, 23(2), 207. <https://doi.org/10.24912/jm.v23i2.473>
- Martins, F., & Fonseca, L. (2018). Comparison between eco-management and audit scheme and ISO 14001:2015. *Energy Procedia*, 153, 450–454. <https://doi.org/10.1016/j.egypro.2018.10.023>
- MDPI. (2021). Sustainability. Sustainability | Statistics. Retrieved April 16, 2023, from <https://www.mdpi.com/journal/sustainability/stats>
- Rodrigues Dias, V. M., Jugend, D., de Camargo Fiorini, P., Razzino, C. do, & Paula Pinheiro, M. A. (2022). Possibilities for applying the circular economy in the aerospace industry: Practices, opportunities and challenges. *Journal of Air Transport Management*, 102. <https://doi.org/10.1016/j.jairtraman.2022.102227>
- SAE. (2016, September 20). AS9100D: Quality Management Systems - requirements for aviation, space, and defense organizations. SAE International. Retrieved April 10, 2023, from <https://www.sae.org/standards/content/as9100d/>
- Science Reference Section. (2019, November 19). Who came up with the idea for Velcro? The Library of Congress. Retrieved April 10, 2023, from <https://www.loc.gov/everyday-mysteries/technology/item/who-came-up-with-the-idea-for-velcro/#:~:text=The%20invention%20of%20Velcro%20is,Harvey%20Halvorsen%20of%20Wisconsin%20Dept.>