

# Key Insights and Findings from the STAMP Workshops at MIT

(2012 - 2024)



**Lt.-Col. Guilherme Moreira, PhD**  
**Brazilian Air Force FAB & ITA (Brazil)**  
moreira@ita.br  
gui.moreira@gmail.com



**Dr. Carlos Lahoz**  
**Univ. Vale do Paraiba & ITA (Brazil)**  
lahoz@ita.br  
carloslahoz@univap.br

# Remarks

The results presented were based on the works available on the [PSAS](#) website.

It is believed that several works related to STAMP are not yet included on the website.

One of the goals of this initiative is to make an exhaustive survey of publications related to STAMP.

# Introduction

Since its inception, the STAMP Workshop at MIT has provided a collaborative forum for **researchers, practitioners, regulators, and industry leaders** to share advancements, challenges, and lessons learned in applying STAMP-based methodologies.

This work aims to synthesize the key trends, innovations, and lessons learned from years of STAMP workshops.

Also, highlight improvements in how the STPA is applied, its integration with emerging technologies, and the adoption of STAMP in various industries.

# Workshop participants

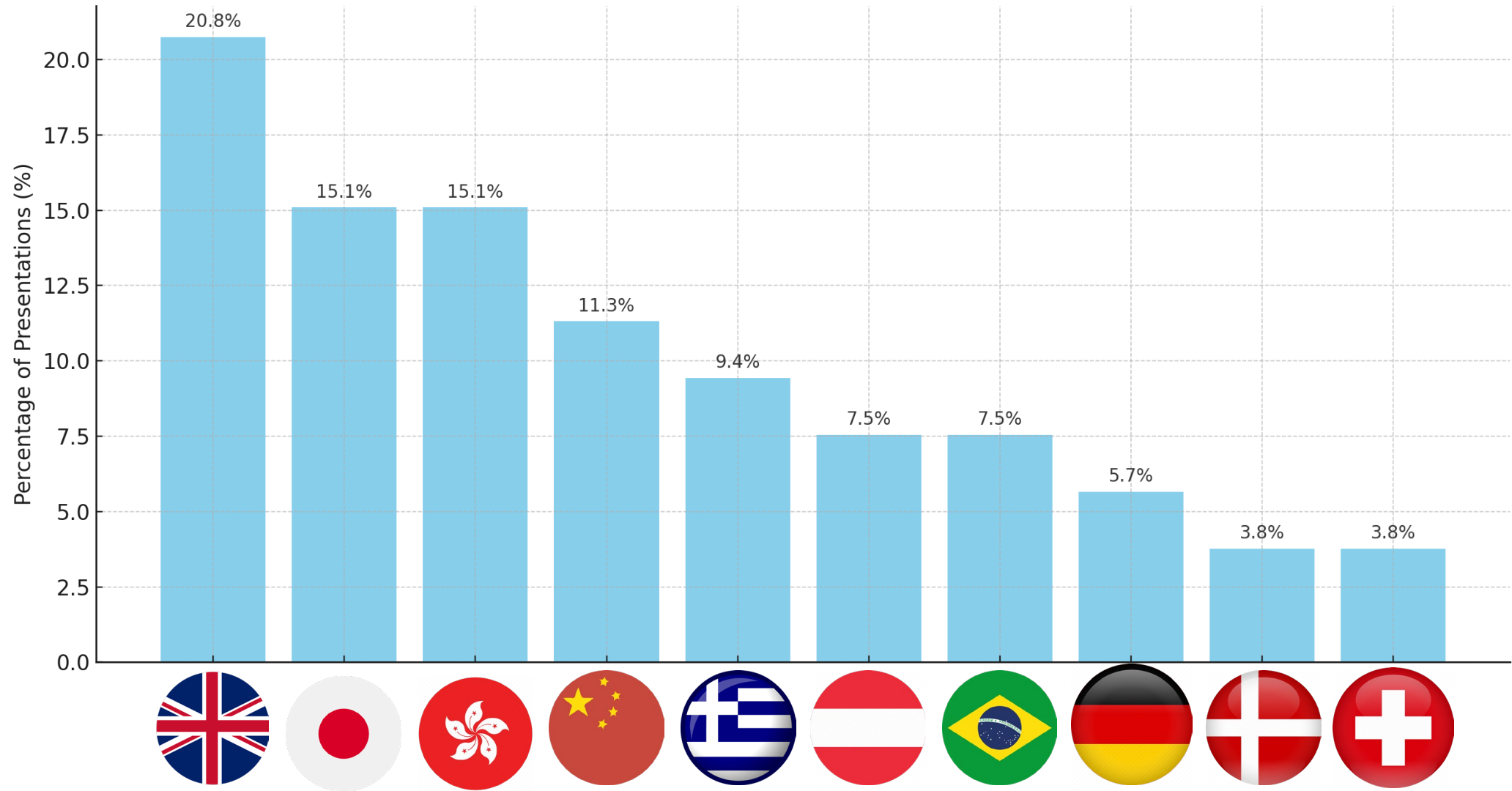
The 2012 STAMP Workshop at MIT brought together a small community of system safety researchers, primarily from aerospace and academia (countries from the first edition: US, Switzerland, Greece, Netherlands, Ireland, China, German and Japan)

By 2024, the workshop presentations included participants from the **United States, Europe, Asia, and South America**, highlighting STAMP's expanding international footprint.

Over this twelve years of STAMP Workshop participants from **97 countries attended**.

# Workshop Evolution (2012-2024)

Main contributing countries to STAMP Workshops' presentations (excluding USA)



# Workshop representatives

Representatives from a wide range of industries :

- Aviation (Boeing, Embraer)
- Automotive (General Motors, Ford, Volvo, Mercedes-Benz)
- Healthcare (Memorial Sloan Kettering Cancer Center, UC San Diego Health, VCU)
- Defense (e.g., U.S. Air Force, L3Harris)
- Maritime (e.g., L3Harris MAPPS, Norwegian Univ Science and Technology)
- Nuclear power (e.g., U.S. Nuclear Regulatory Commission),
- Software/IT (e.g., Google, Akamai)

# Workshop tutorials

- Over the years, the STAMP Workshop has also emphasized knowledge dissemination through tutorials.
- A significant portion of the **presentations** - **65** in total from 2012 to 2024 - were dedicated to introducing, demonstrating, or elaborating on STAMP, STPA, and CAST methods, a unique opportunity for attendees to training.
- These tutorials have played a vital role in expanding the adoption of these methods across various industries and domains, highlighting their versatility and practicality.
- **48 countries** have been represented in the Workshops' presentations and **97 countries** attendees.

# Workshop emerging trends

Over time, participants introduced novel tools, automated analysis techniques, and integrations of STAMP with other frameworks - such as Model-Based Systems Engineering (**MBSE**), ISO standards (e.g., ISO **26262** and ISO **21448** in automotive), and sector-specific safety standards in aviation and healthcare.

By 2024, the workshop's content increasingly addressed emerging trends: **AI safety, machine learning-driven control systems, autonomous vehicles,** and **cybersecurity-threat** modeling using STPA-Sec.

# Advancements in STPA

From 2012 onward, the wide applicability of STPA was a central theme. Initially applied to conceptual aerospace systems and automotive features, STPA's methodological refinements broadened its applicability.

## Refinements in Methodology

Early tutorials (**2012–2016**) focused on **basic STPA steps**; by **2020–2024**, participants demonstrated sophisticated extensions, such as **scenario generation techniques** to identify subtle system interactions and advanced integration with architectural modeling tools.

# Integration with Technologies

## AI and Autonomous Systems

By 2024, multiple presentations highlighted the application of **STPA to machine learning-based flight controls, autonomous marine navigation, and data-driven decision-making systems.**

For example, the U.S. Air Force and MIT collaborated on analyzing autonomous aircraft systems before flight testing. In healthcare, researchers applied STPA to identify hazards in data-driven treatment protocols and augmented reality tools for surgical procedures.

# Integration with Technologies

## Cybersecurity

As there is increasing awareness that safety and security are intertwined, workshop participants introduced **STPA-Sec**, which applies systems-theoretic principles to identify vulnerabilities in avionics, automotive software, and IoT devices.

**Cyber-risk modeling sessions** discussed how STPA's control structure analysis could capture not just physical hazards but also malicious cyber threats.

# Tools and techniques

## Modern Tools and Techniques

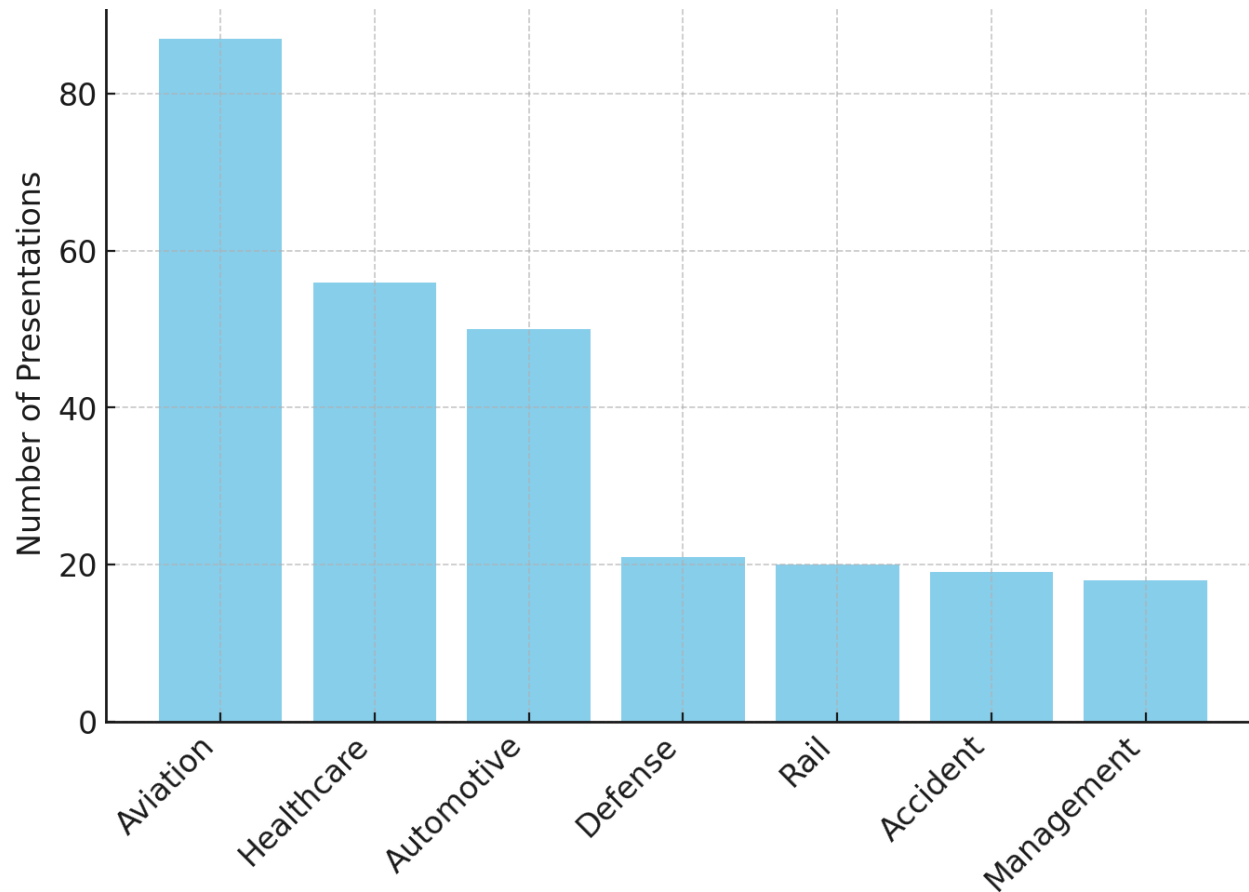
New tools, including STPA automation platforms, emerged to streamline STPA execution, facilitate large-scale analyses, and reduce manual effort.

The 2024 workshop featured multiple tool demonstrations from European and American developers, enabling more efficient hazard analysis across industries.

Examples: **STPAmaster Lite, MicroSTAMP, VisualPro STPA, STPA Tool (MIT), XSTAMP, STPA-SysML, STPA Pro, STPA GPT**, etc.

# Real Case Studies

Case studies illustrated the real-world impacts of STAMP-based methods year after year. The Figure below shows the case studies presented over the years, separated by industry area.



# Yearly contributions

It's important to highlights the yearly contributions of top organizations to the STAMP Workshops, and the significant involvement of industry leaders such as **Boeing**, **General Motors**, **Embraer**, and **Google**, alongside governmental and academic entities like the **U.S. Air Force**, Brazilian Aeronautics Institute of Technology **ITA**, and **Lawrence Livermore National Laboratory**.

The consistent presence of these organizations reflects the growing collaboration between academia and industry in advancing STAMP methodologies.

# Challenges and Future Directions

Despite significant progress, recurring challenges emerged:

- **Cultural and Organizational Hurdles**

Industries with long-standing safety cultures (e.g., nuclear, aviation) often faced resistance when introducing a new methodology. Many presentations emphasized the **need for training, organizational buy-in, and leadership support.**

In the 2024 workshops, discussions focused on how to communicate STPA's benefits to decision-makers and **integrate STAMP-based methods into existing safety management processes.**

# Challenges and Future Directions

## Scalability and Complexity

As systems grew more complex, participants grappled with **how to scale STPA effectively.**

Ongoing research involves automating parts of STPA, **integrating it with MBSE frameworks,** and **developing guidance for analyzing extremely large-scale systems,** such as entire healthcare ecosystems or interconnected urban infrastructures.

# Challenges and Future Directions

## Standardization and Regulatory Acceptance

While progress occurred - **SAE** and **ISO** initiatives recognized STPA - there remain difficulties in standardizing STAMP-based analyses.

More research is needed to bridge the gap between STPA outputs and traditional compliance-driven verification.

Participants envisioned a future where STPA is fully harmonized with certification standards, making it easier for regulators to accept STAMP-based outputs as evidence of thorough safety analyses.

# Challenges and Future Directions

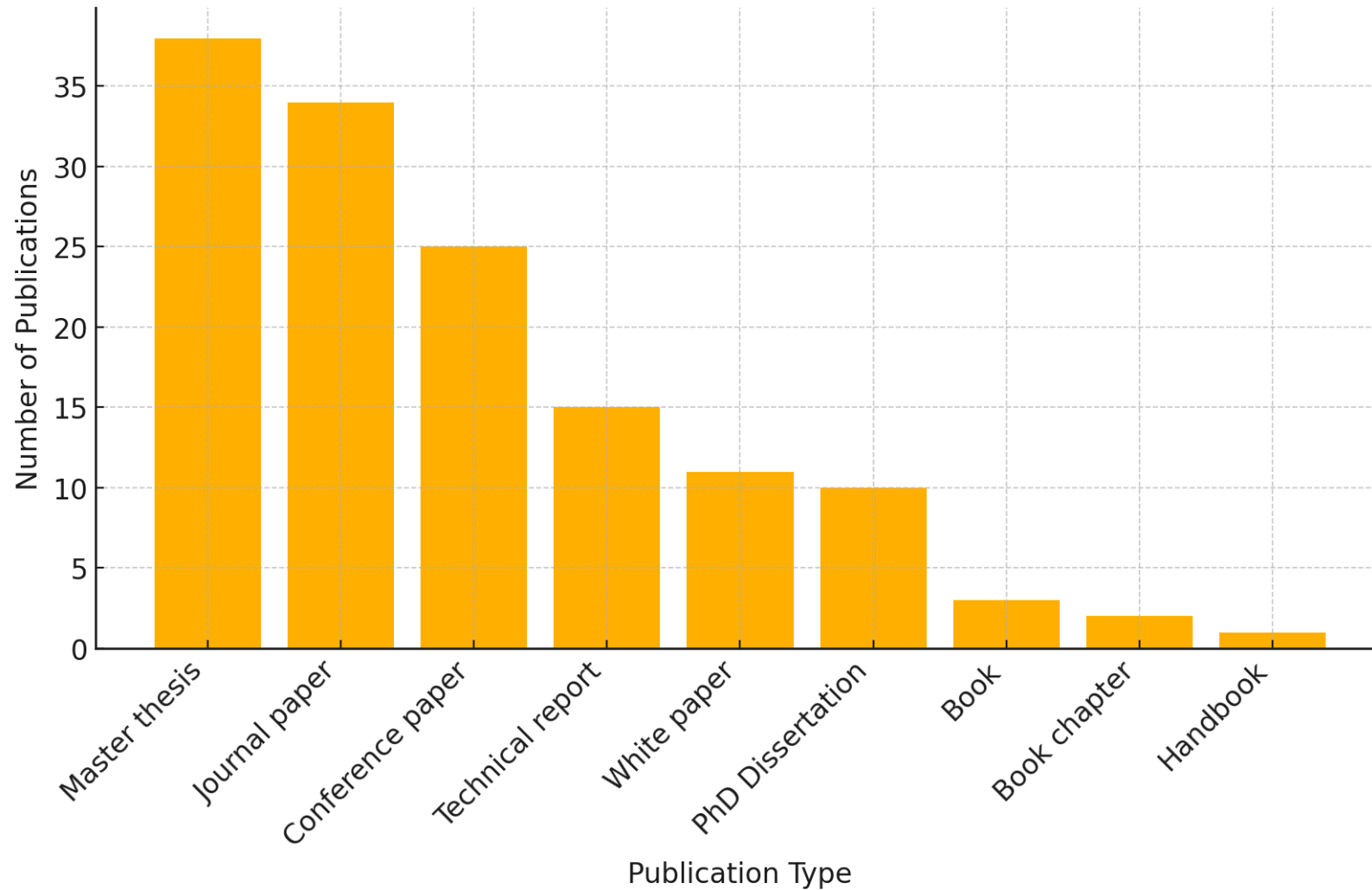
## Integration with AI and Emerging Domains

As autonomous systems proliferate, the workshop community recognized the need for tailored STPA approaches.

Future research must refine techniques that **handle complex AI systems with non-deterministic behaviors, dynamic control loops, and opaque decision-making processes.**

Presenters speculated on the role of STAMP in addressing societal-level challenges, such as **climate adaptation strategies, smart city safety management, and large-scale infrastructural resilience.**

# Next step: publications survey

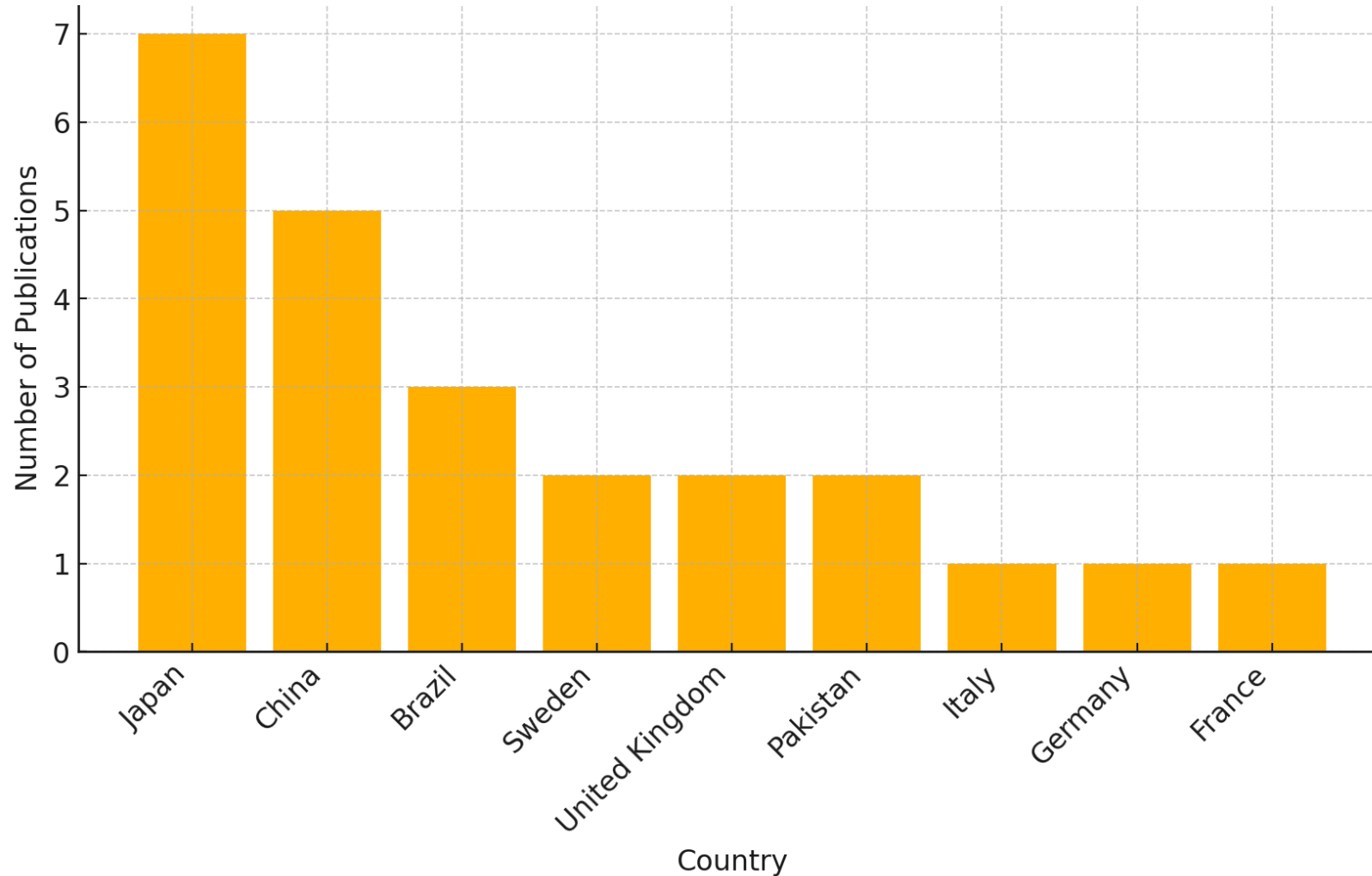


# Next step: publications survey



# Next step: publications survey

Main publishing countries (excluding USA)



# Thank you!



**Lt.-Col. Guilherme Moreira, PhD**  
**Brazilian Air Force FAB & ITA (Brazil)**

**moreira@ita.br**

**gui.moreira@gmail.com**



LinkedIn



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**carloslahoz@univap.br**



LinkedIn