

Safety learnings from normal work in future systems?

Autonomous ship research – high on technology, low on Human Factors

Published research on autonomous ships 2018 – 2022

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HUMANE

a human perspective
on autonomous
shipping

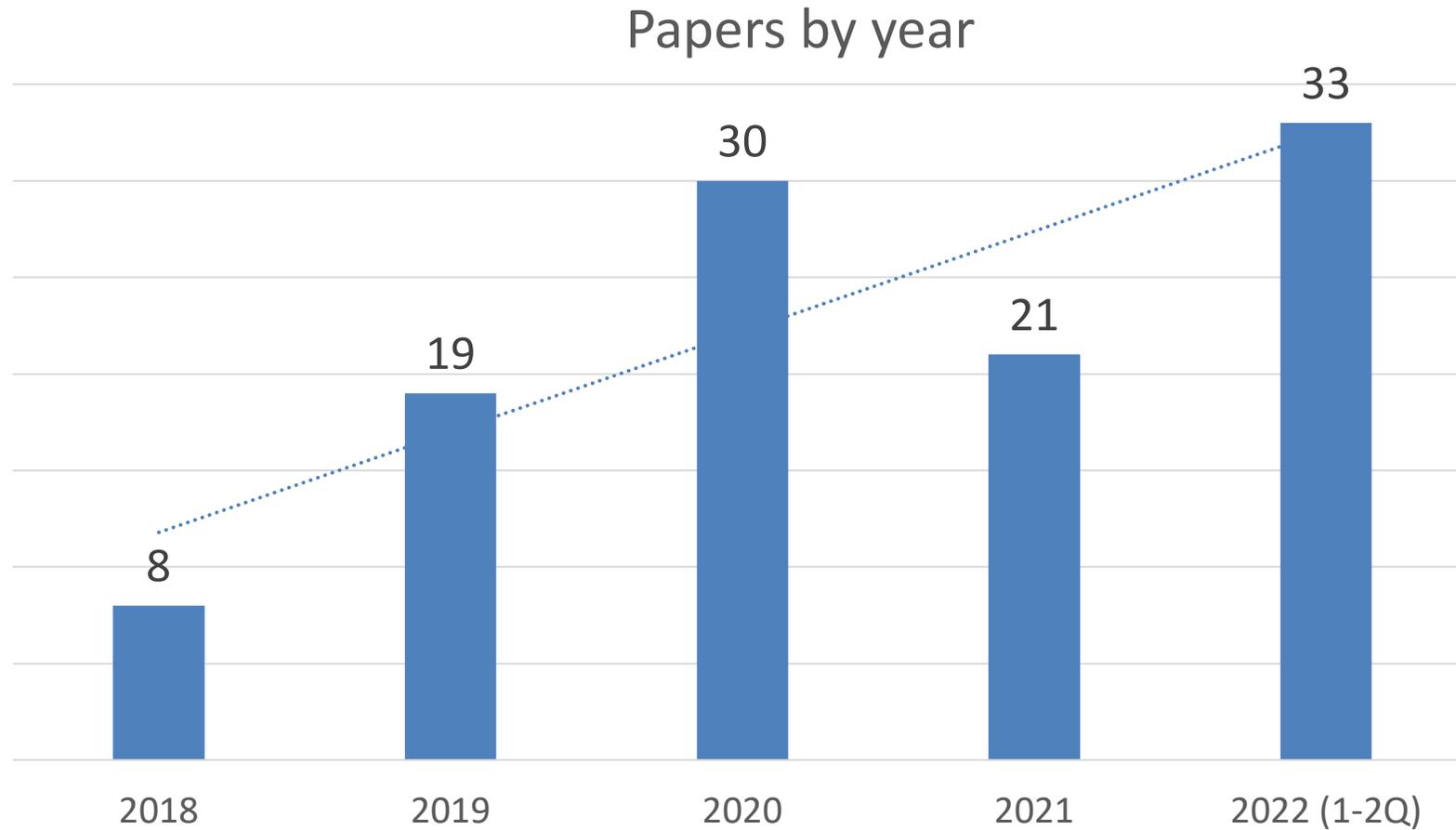


The project is financed by  The Research Council of Norway

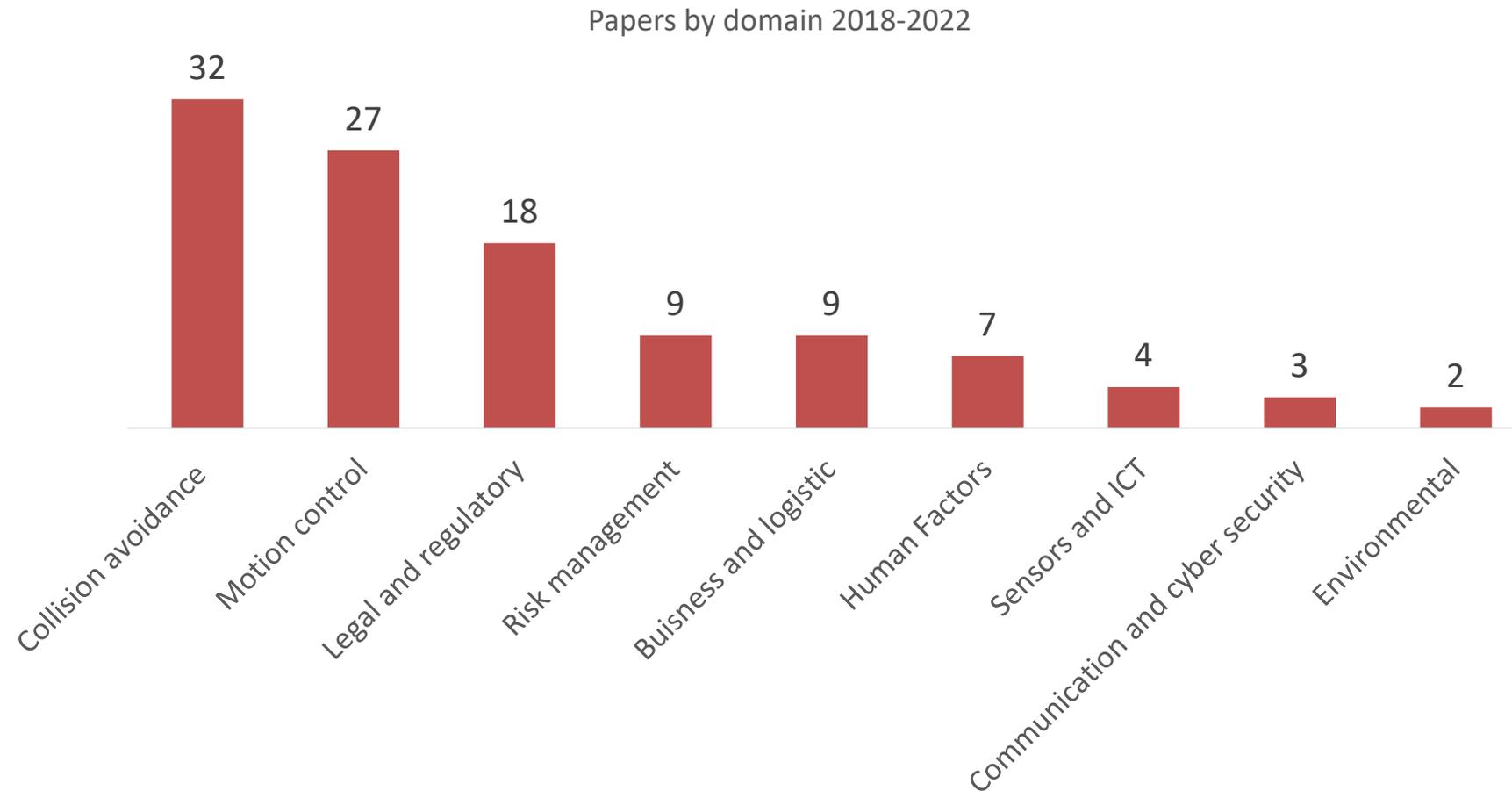
111 Research papers on “autonomous ships” found for the period 2018 to 1st half of 2022 (July)

111 articles have been reviewed. The collection method was “Snowball sampling,” an unstructured nonprobability sampling technique where references in, or references to existing articles are used based on a NTNU library database search using the search string “autonomous ships”.

111 research papers found for 2018 to 1st half of 2022



Research domains represented in the 111 papers



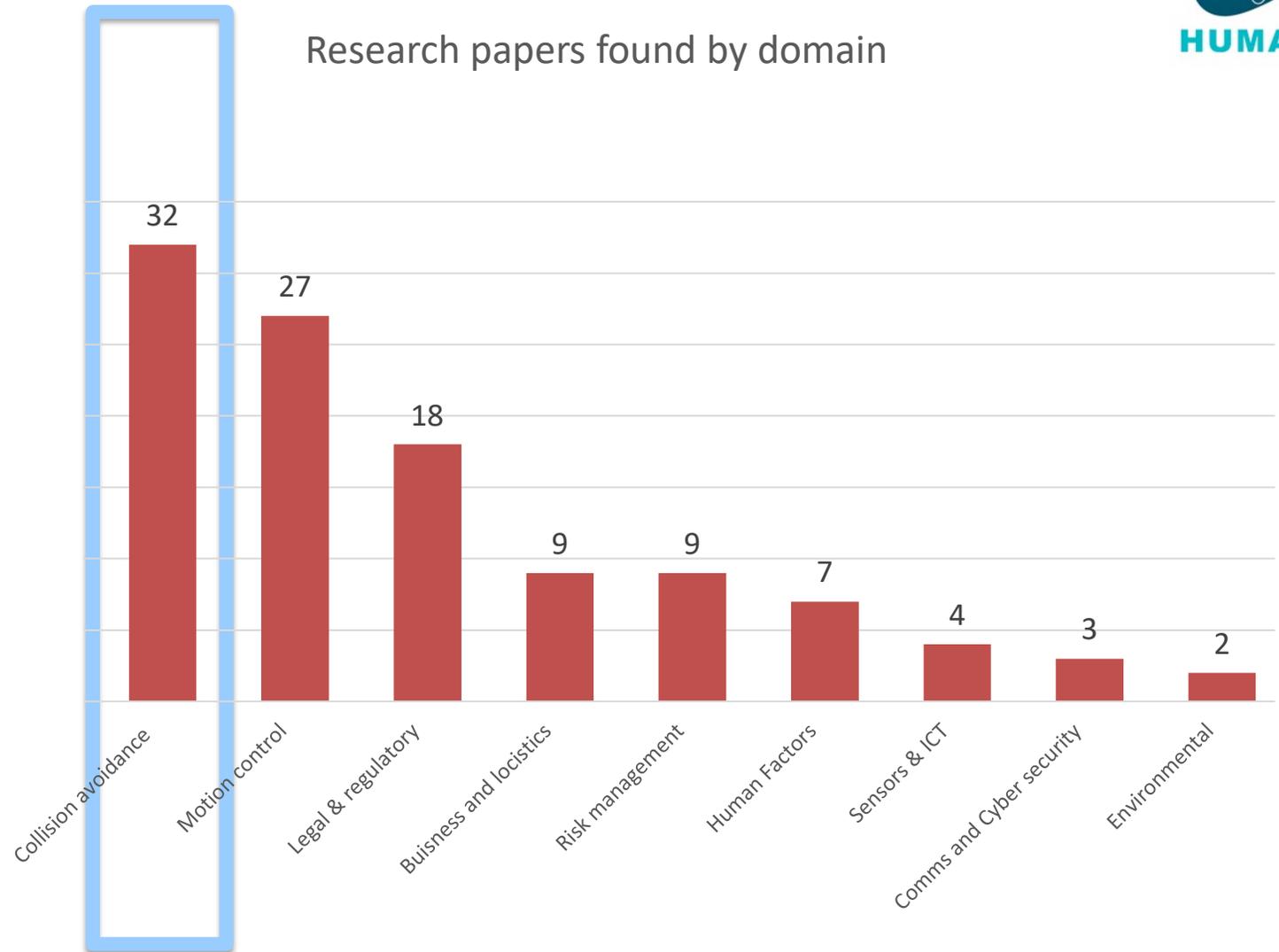
Collision avoidance

The ability of automatically avoiding to collide with known or unknown static or dynamic objects, e.g. shore, buoys and other ships.

- Long term collision avoidance: Route planning, or weather routing.
- Path planning (Local)
- Reactive collision avoidance (dynamic)

Two-ship encounters vs. Multi-ship encounters

Data: own sensors, AIS, Route exchange



Motion control

Path planning is classified into three stages:

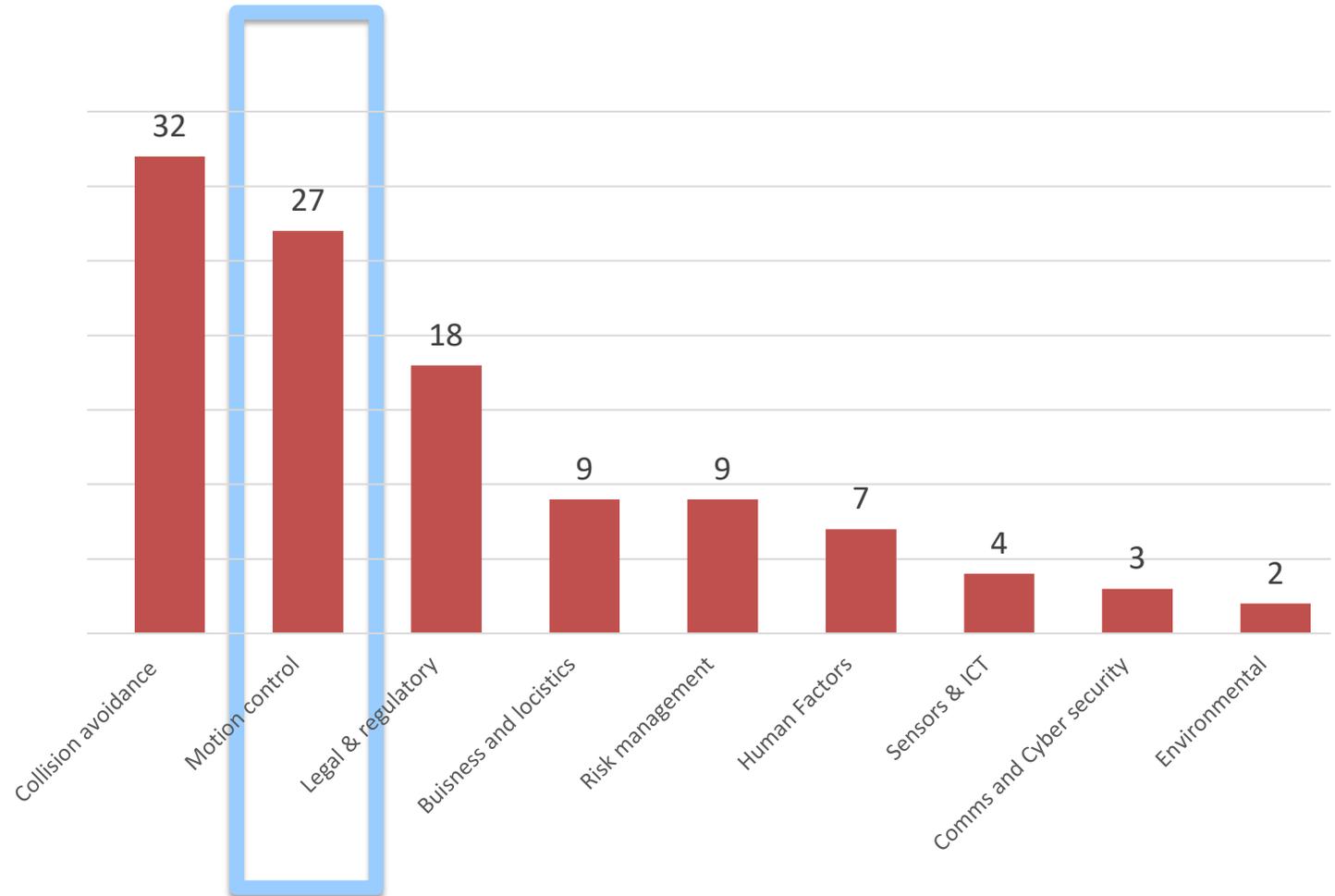
- route planning
- trajectory planning
- motion planning.

Problems

- Large mass
- Poor rudder response
- Poor turning performance
- Wind, wave and current effects
- Ship–ship and ship-bank effects

Tracking, Berthing, Dynamic positioning,

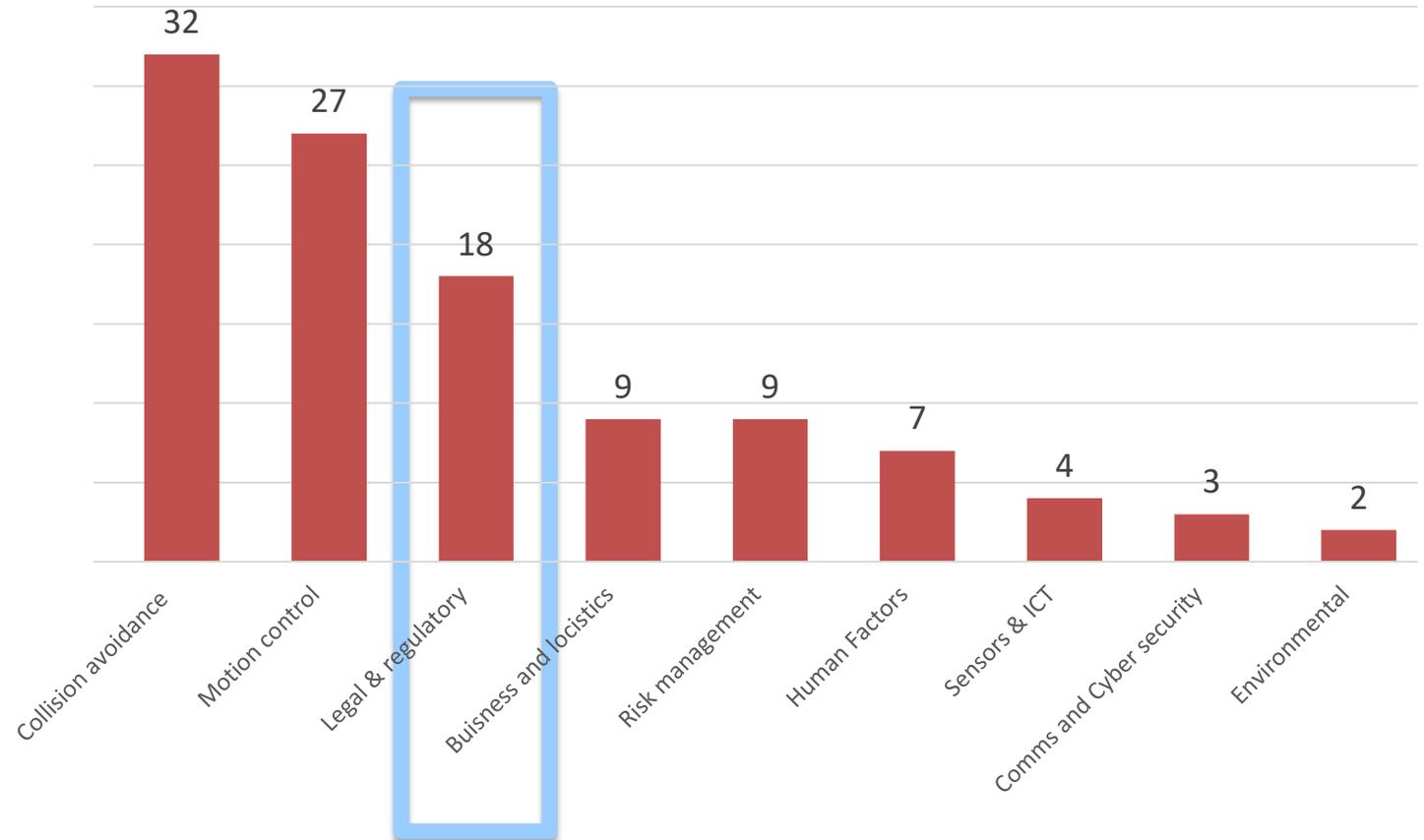
Research papers found by domain



Legal and regulatory

Research papers found by domain

- Laws and regulation preventing MASS
- IMO's regulatory scoping exercise (RSE) 2018-2021.
- Functional and operational requirements of the remote-control station/centre and the possible designation of a remote operator as seafarer.
- Carriage of goods, definitions, flag states?
- Qualitative vs quantitative COLREGs
- Inland waterways
- Remote operators
- SOLAS
- Insurance



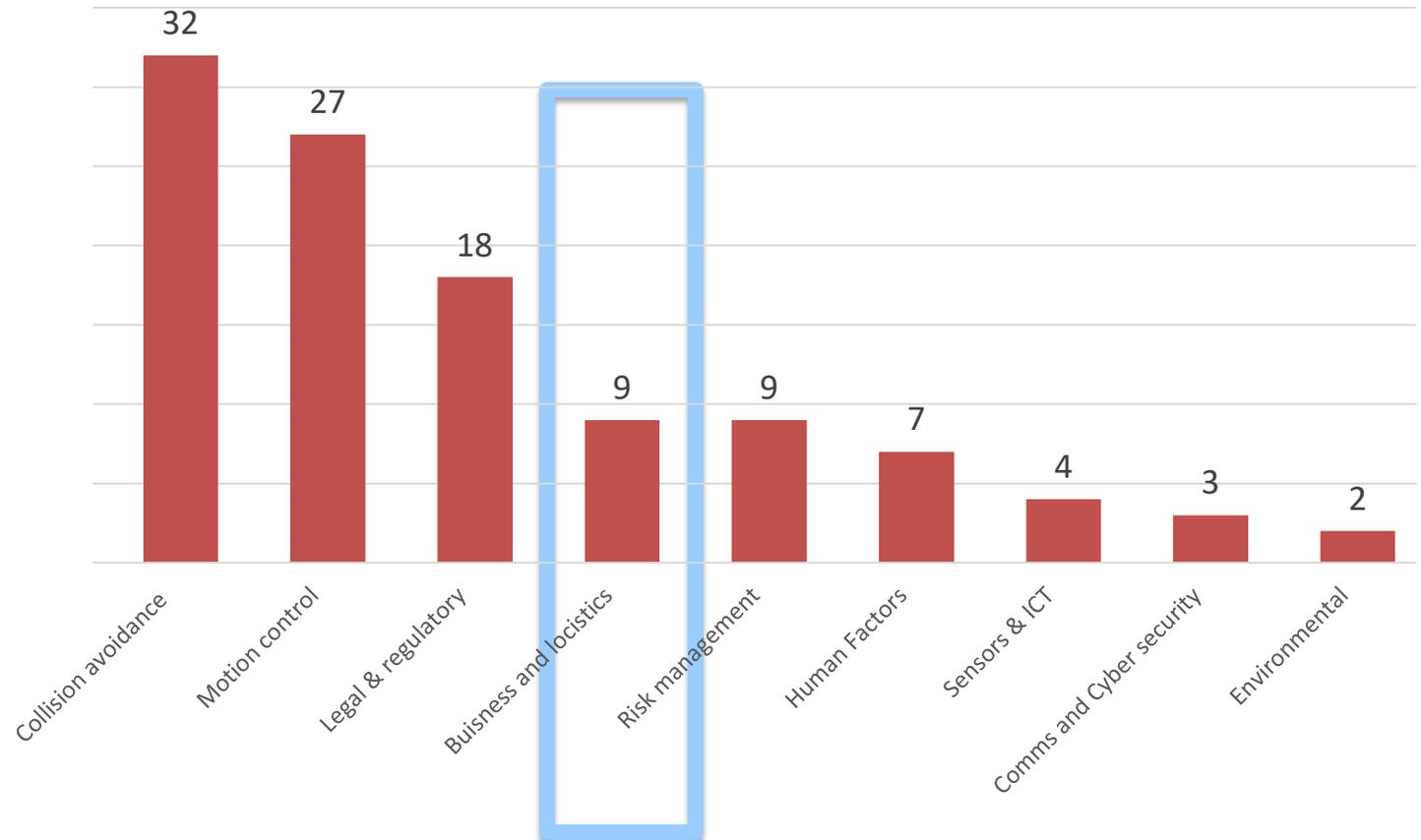
Research papers found by domain

Risk management

A MASS should be at least as safe as any conventional ship.

Studies of **ship risk models** for ship-ship collision, ship-structure collision, and groundings.

Proposed new framework for the identification of factors that influence the navigational risk of remotely controlled MASS with or without crew on board.



Business and logistics

Research papers found by domain

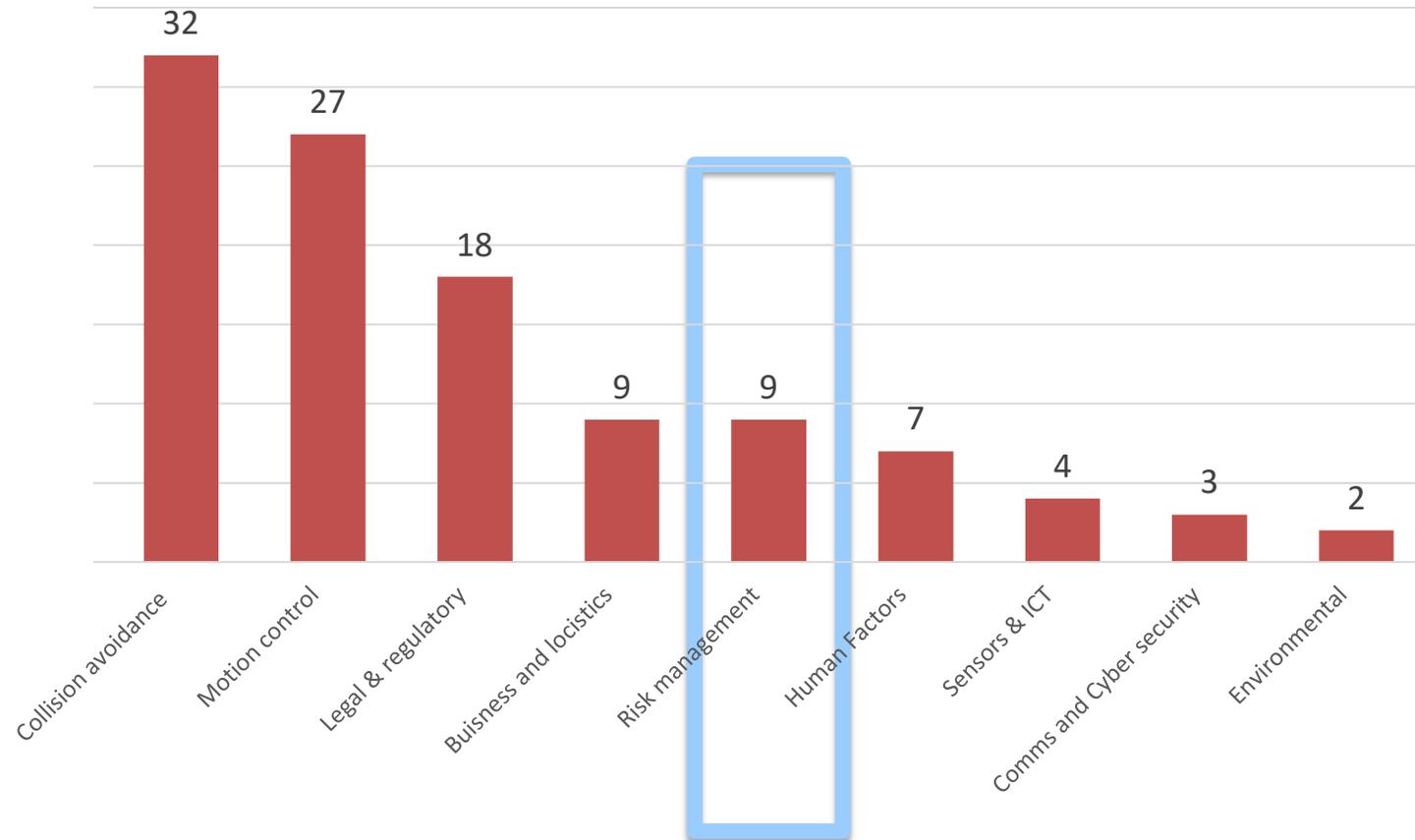
Successful tests with commercial unmanned cargo ships are currently unavailable.

Literature review on the issues facing by the **short sea shipping** industry, and developed a model to explore the potential savings of removing crew and use of autonomous technologies

Need for research about MASS transportation and logistics

In-depth cost and benefit estimation of autonomous ship technology

The Arctic case



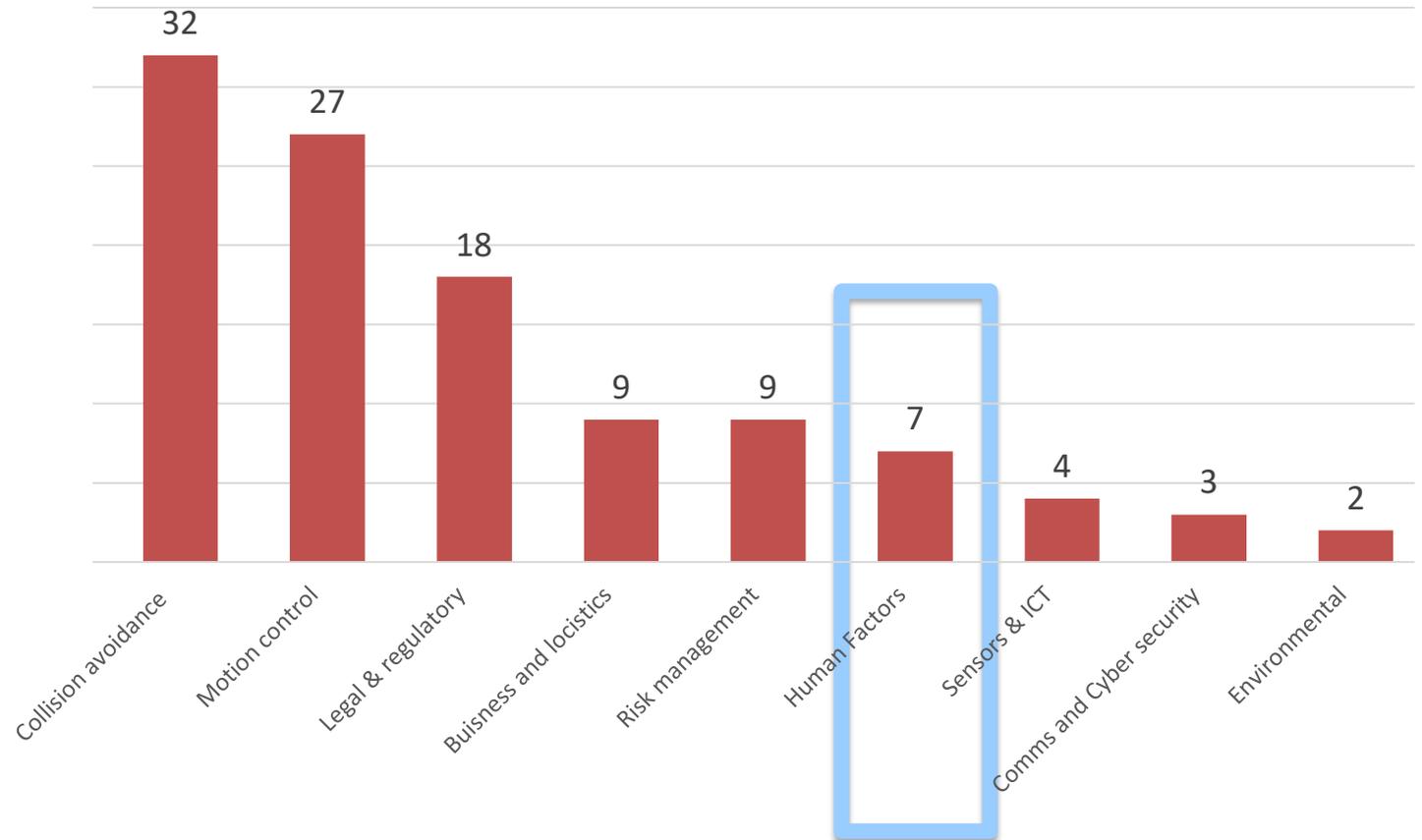
Human Factors

Research papers found by domain

Humans will remain in the remote control centers and automation has the potential of creating accidents in itself, e.g. through transitions between automatic and manual control and the human having to rapidly assess the situation and make the right decisions.

Human-In-The-Loop (HITL) vs Human-Out-Of-The-Loop (HOOTL).

Human-AI interaction in autonomous ship systems.



Sensors and ICT

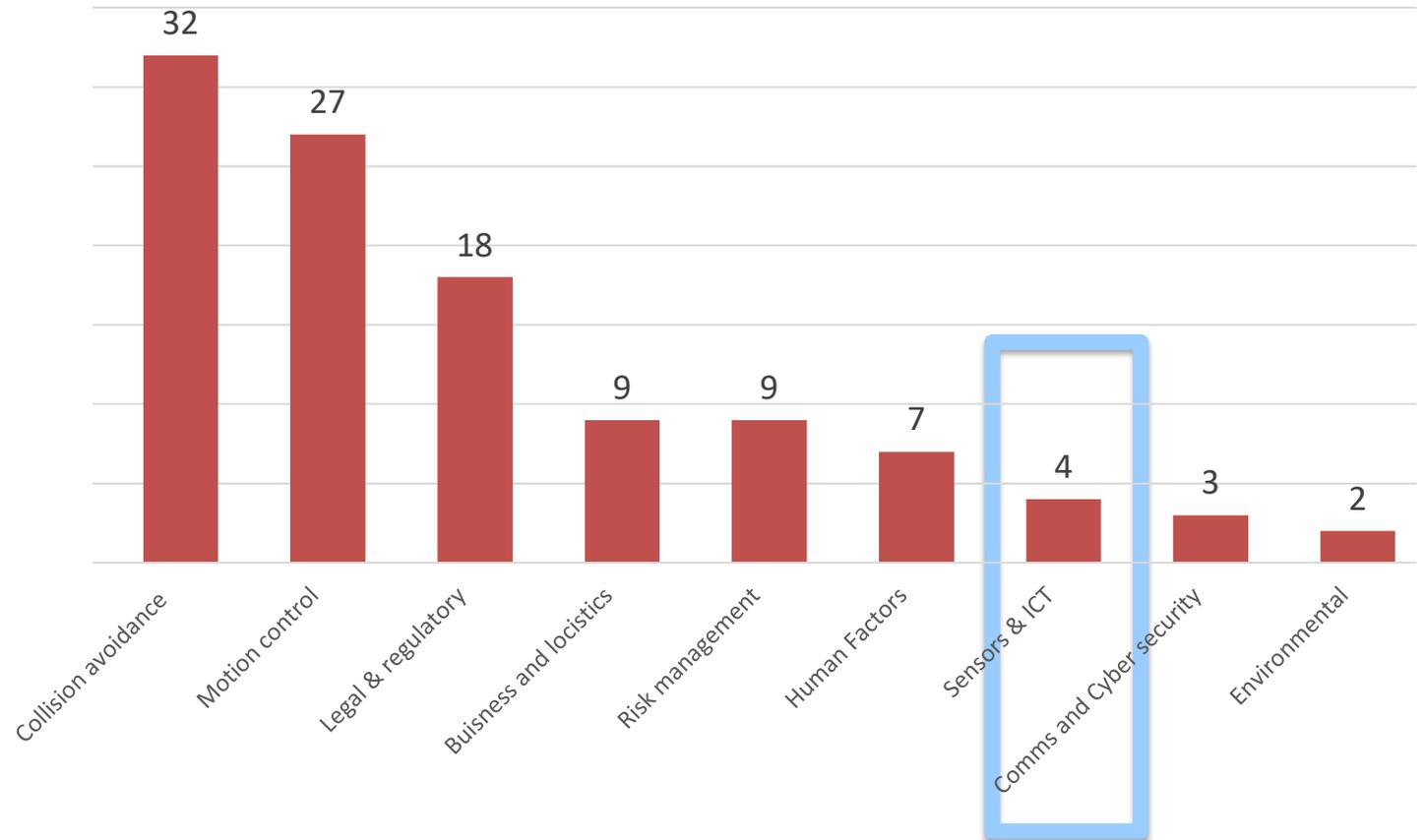
Research papers found by domain

Sensor fusion plays a key part in MASS

Hyper-connectivity and Super-intelligence technology of the 4th Industrial Revolution

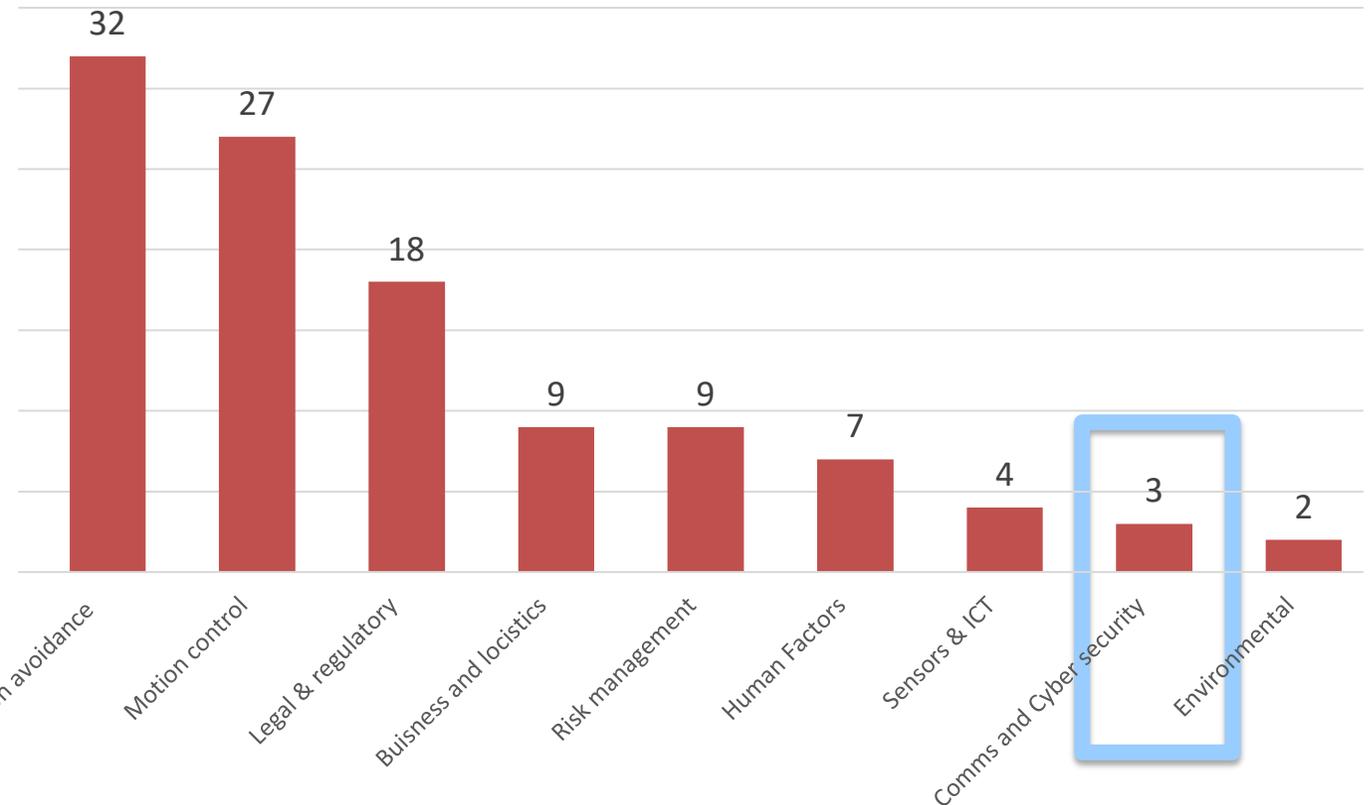
Smart Autonomous Ship and Shore Architecture

Multi sensor fusion.



Communication and cyber security

Research papers found by domain



Attacks on the shore control centre have the highest potential safety implications and can be of high interest to terrorists.

Malware installation on the collision avoidance system and the situation awareness system have also significant safety implications as well.

Public Key Infrastructure (PKI) system could provide security barriers to mitigate relevant cyber threats and possible consequences of unwanted events.

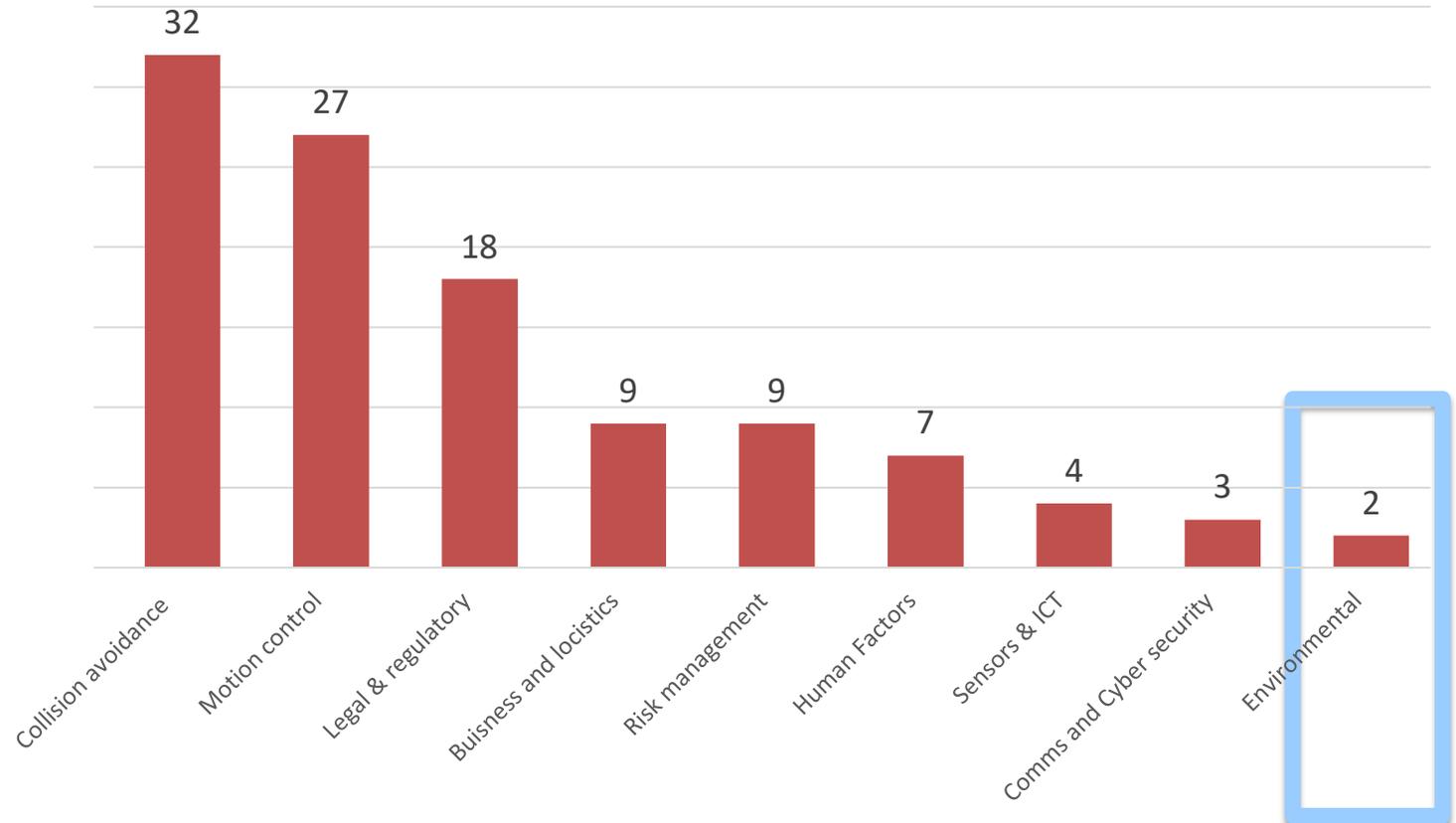
Cyber-Preliminary Hazard Analysis method

Environmental

Research papers found by domain

Reduction of pollution by vessels:

- Pollution by dumping, which represents approximately 10% of the pollution of the marine environment (20% of the total plastics in the maritime environment).
- Deliberate discharges of oil, such as tank cleaning operations.
- With 100 % MASS: Decreased emissions by more than 45% 2050 compared to 2020



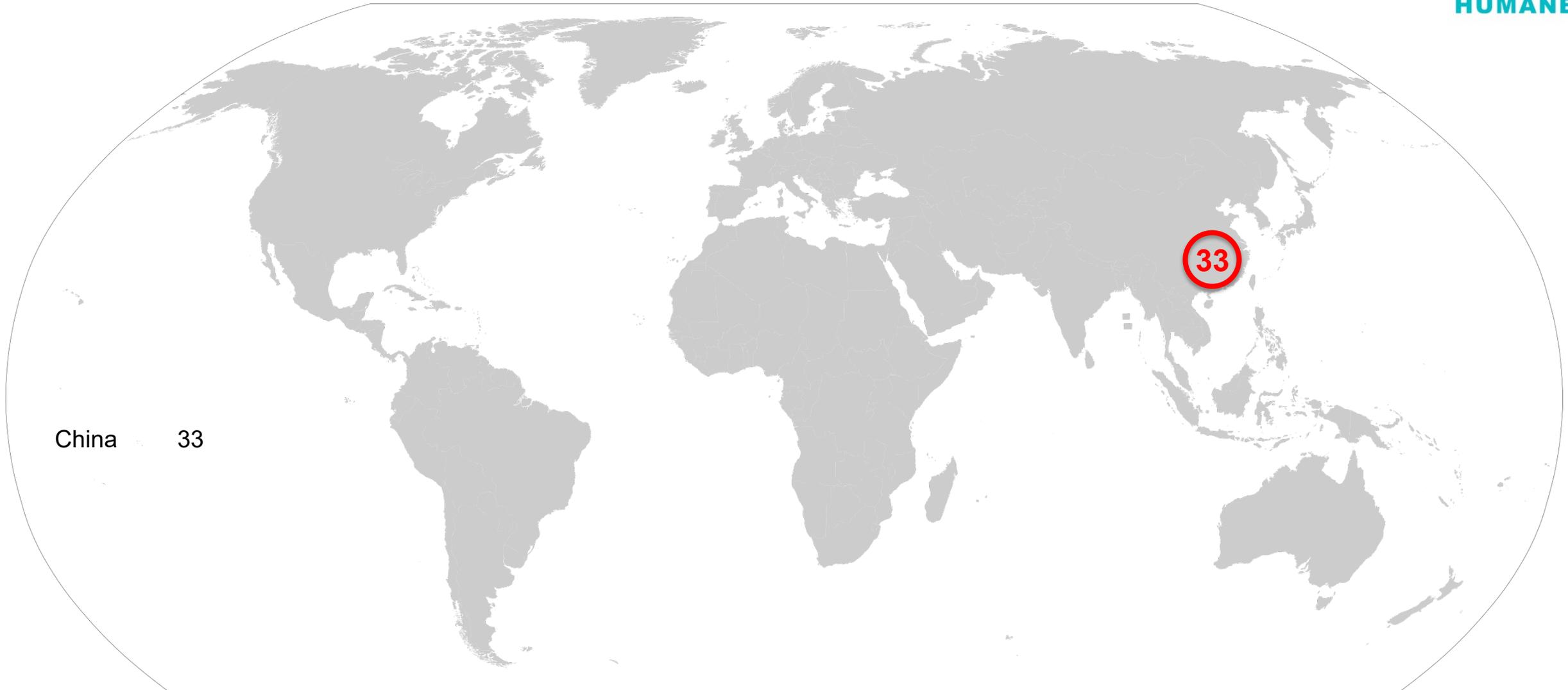
Which countries are represented in the 111 papers?

The 111 papers were written by authors from institutions in 25 different nations.

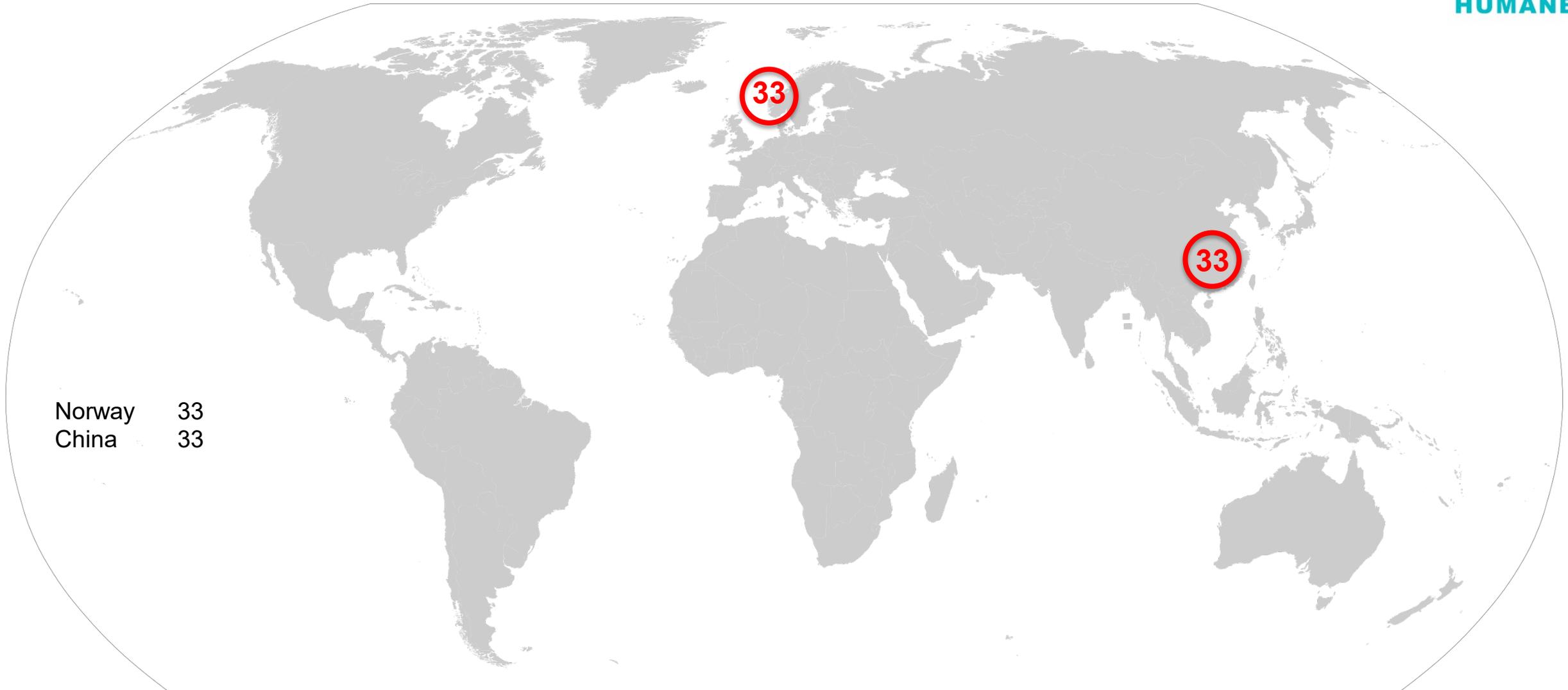
Most papers were written by a group of authors. This meant that some papers became designated to several countries depending on the nationality of the institution the authors had used as their affiliation in the author list.

Viewed this way the 111 papers contained 140 national contributions.

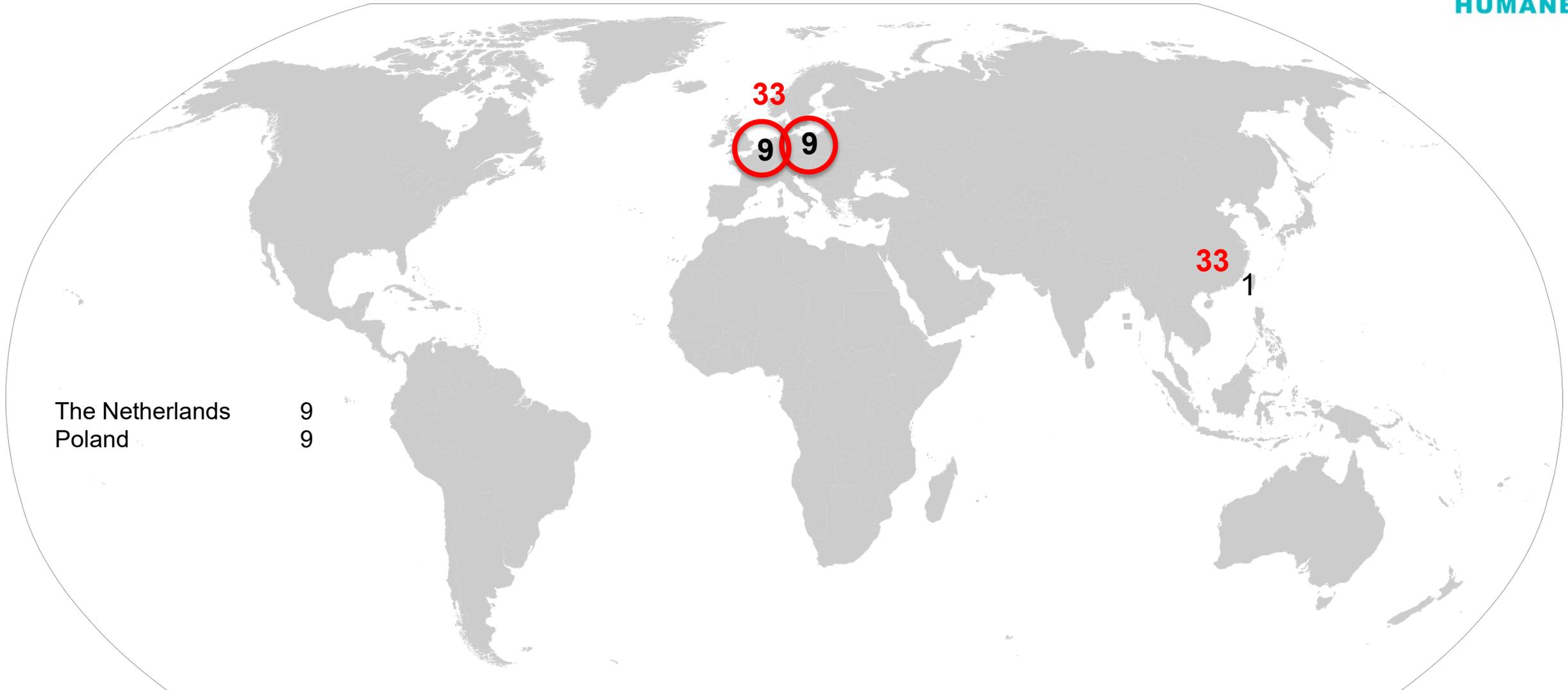
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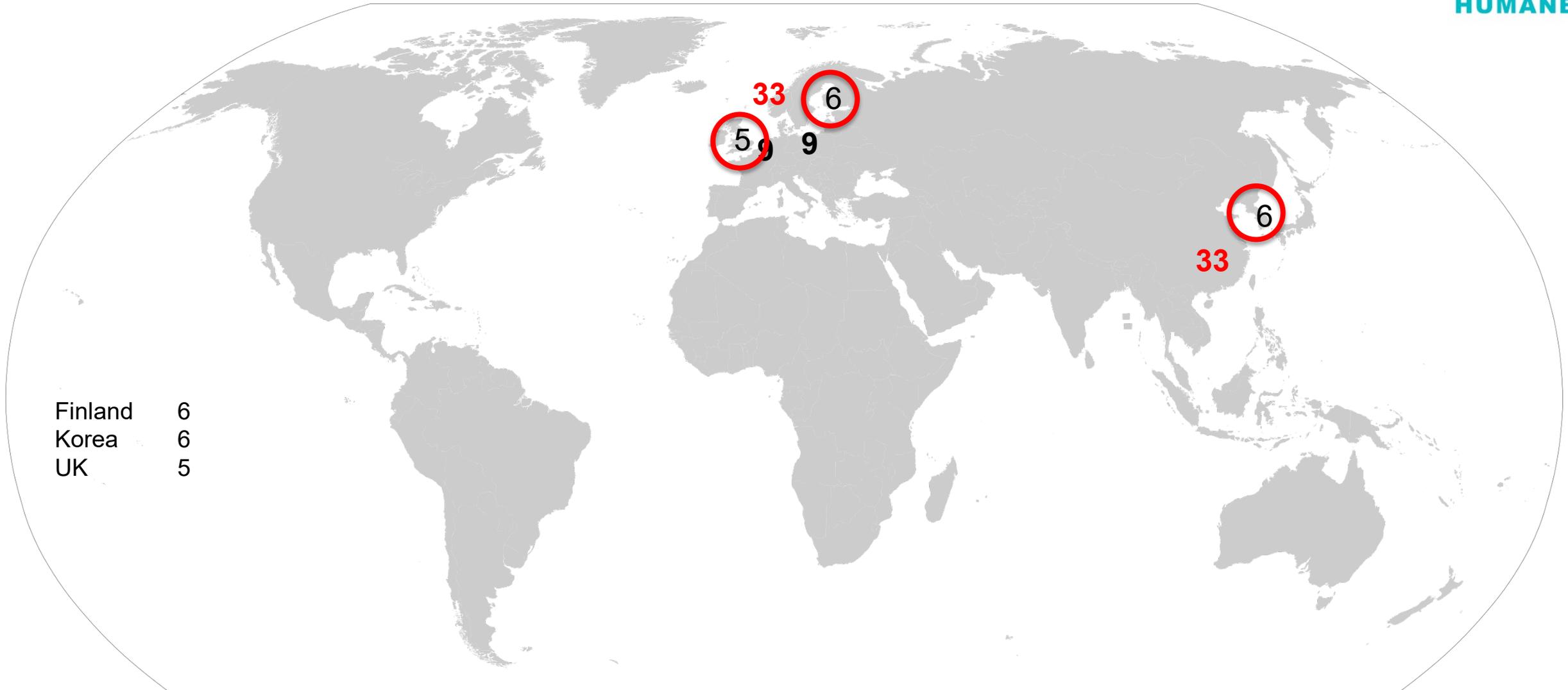
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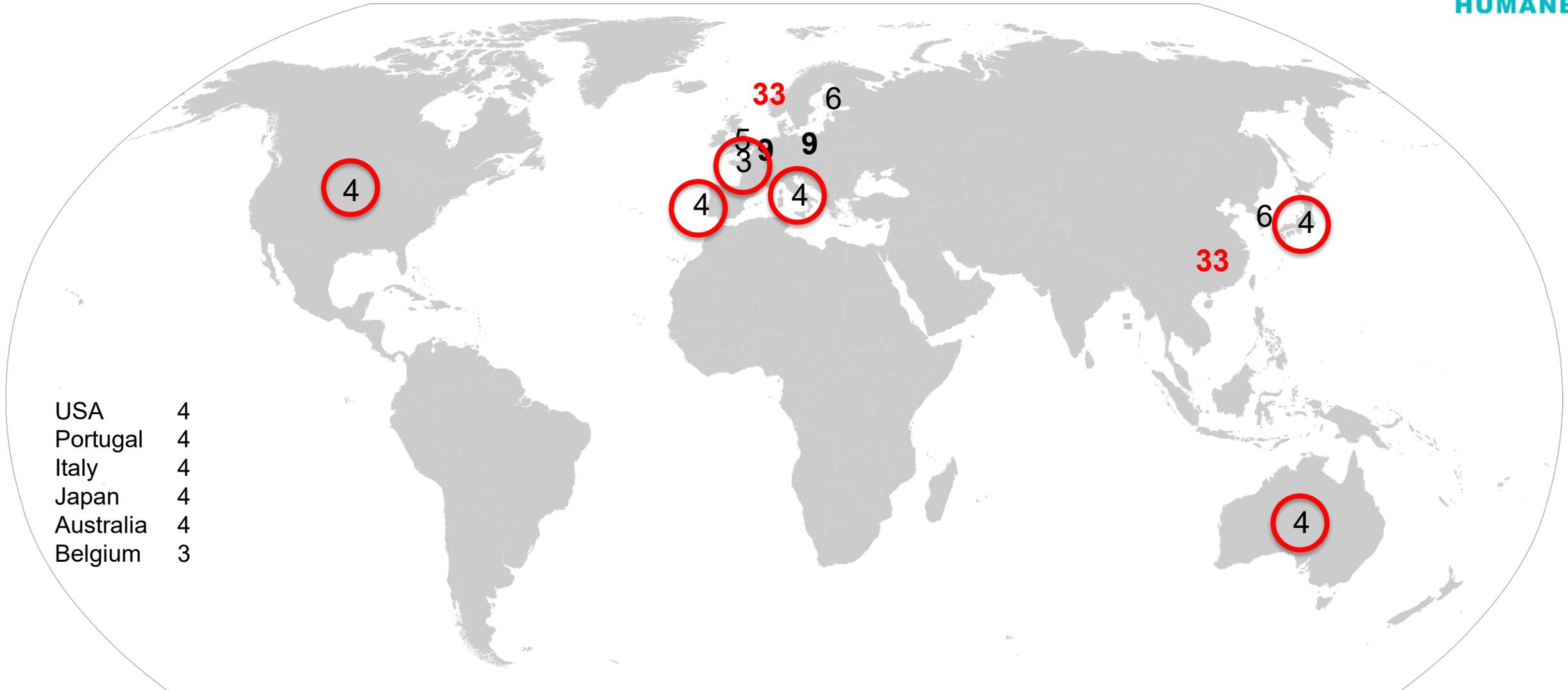


Which countries are represented in the 111 papers



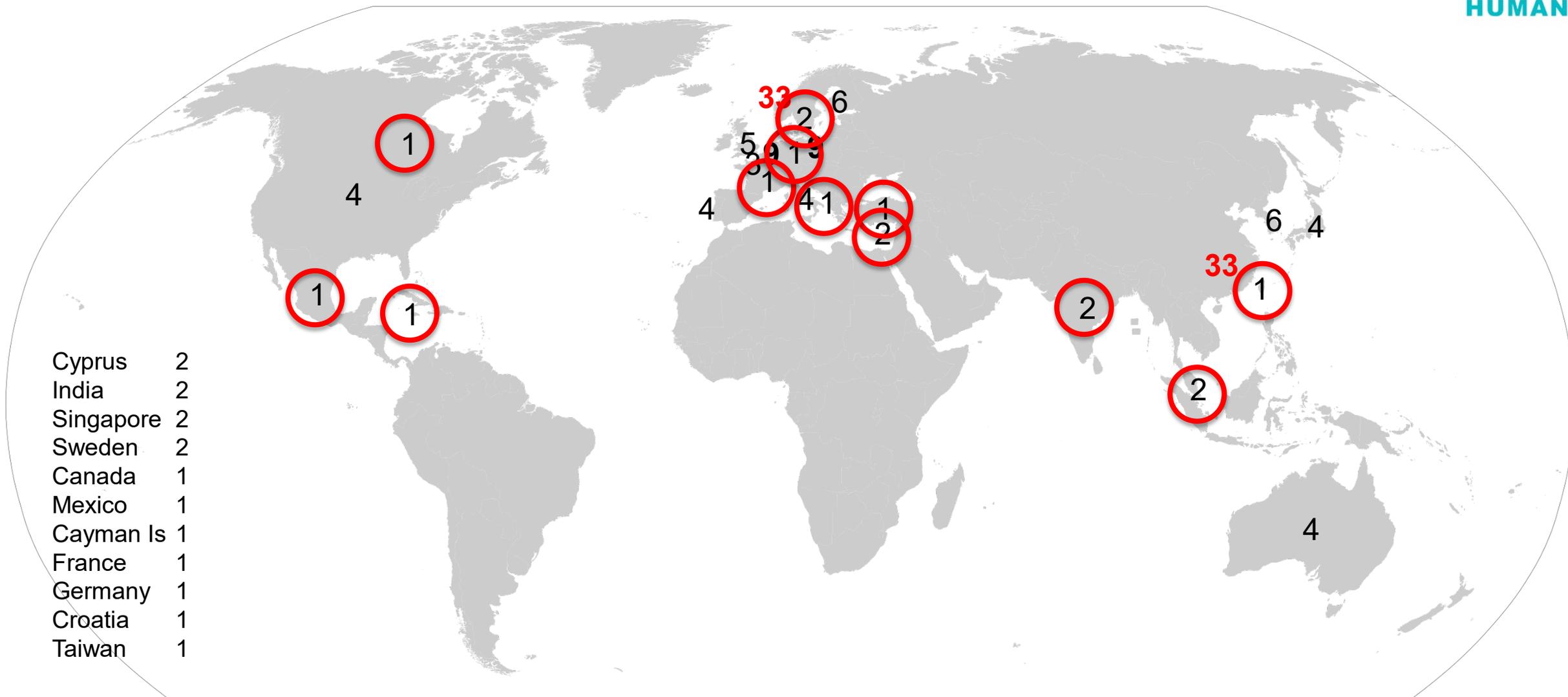
Finland 6
Korea 5
UK 33

Which countries are represented in the 111 papers

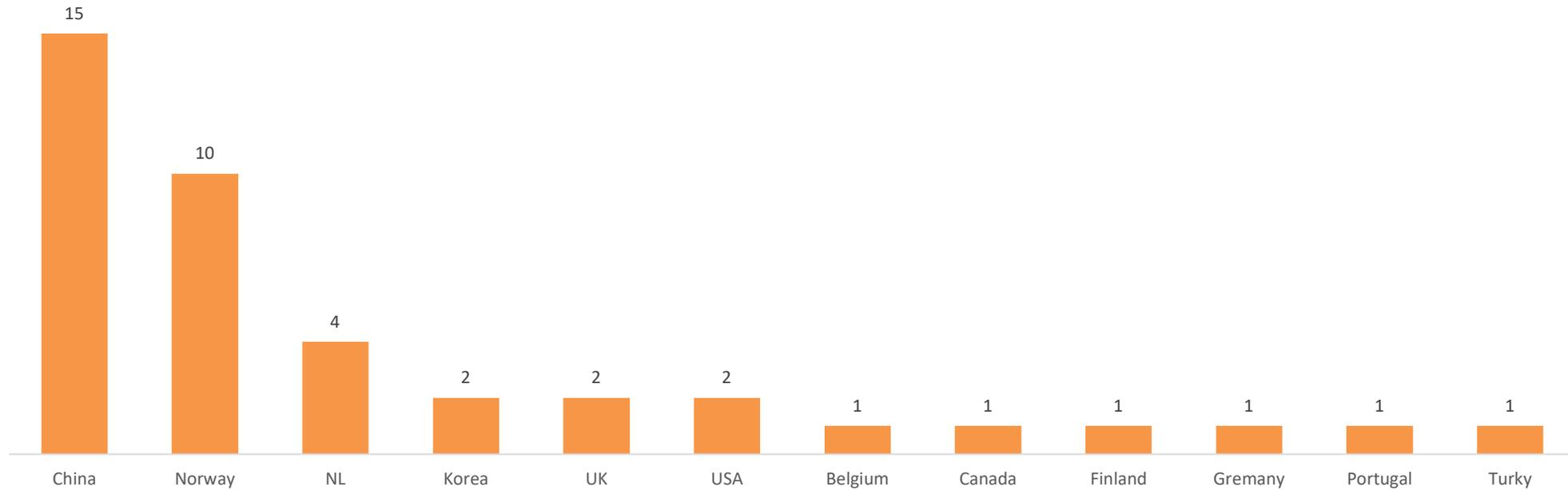


USA	4
Portugal	4
Italy	4
Japan	4
Australia	4
Belgium	3

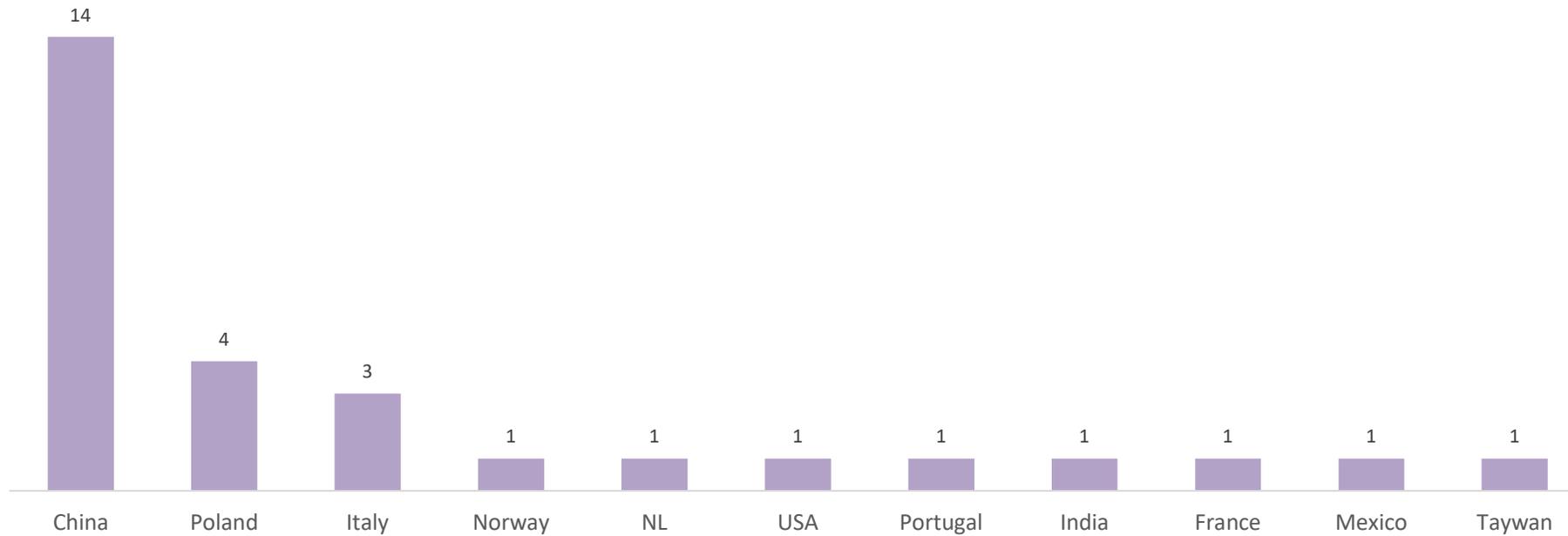
Which countries are represented in the 111 papers



Where is research on **collision avoidance** conducted? Number of authors from each nation

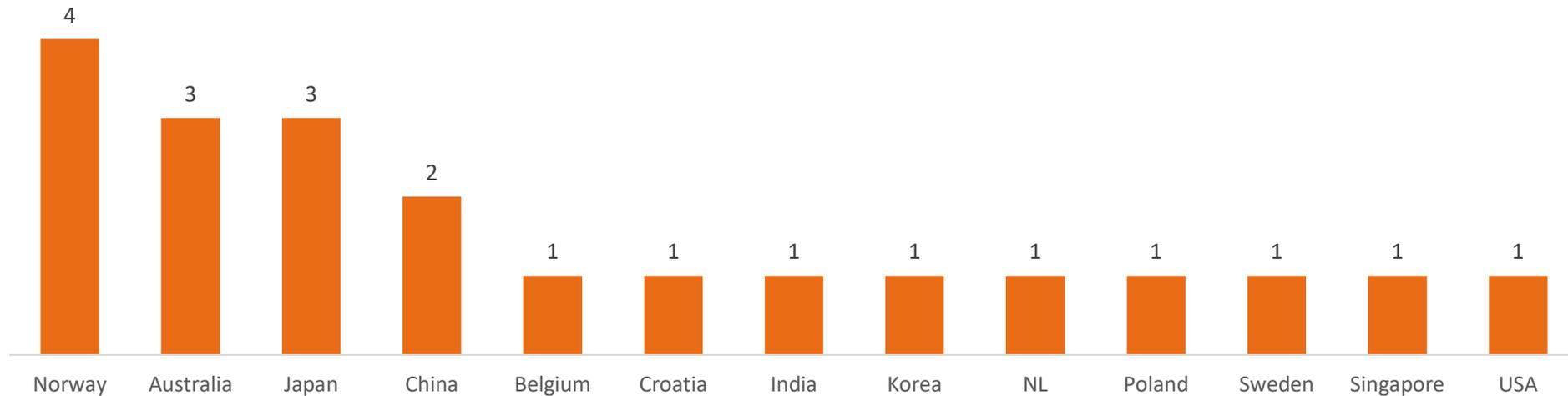


Where is research on **motion control** conducted? Number of authors from each nation



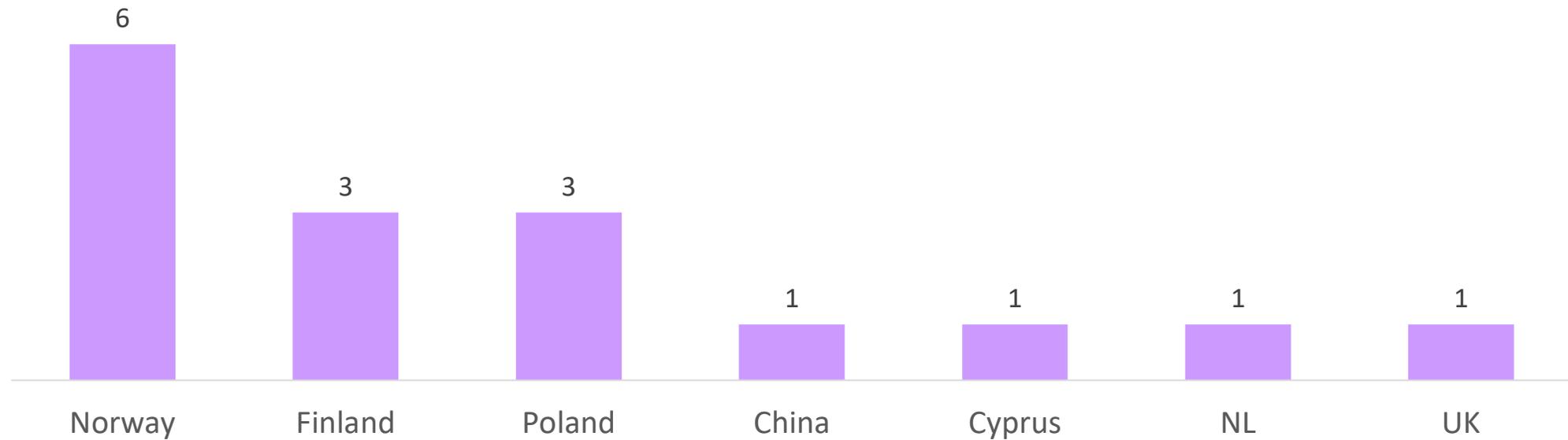
Where is research on **legal and regulatory** aspects of autonomous ships conducted?

Number of authors from each nation



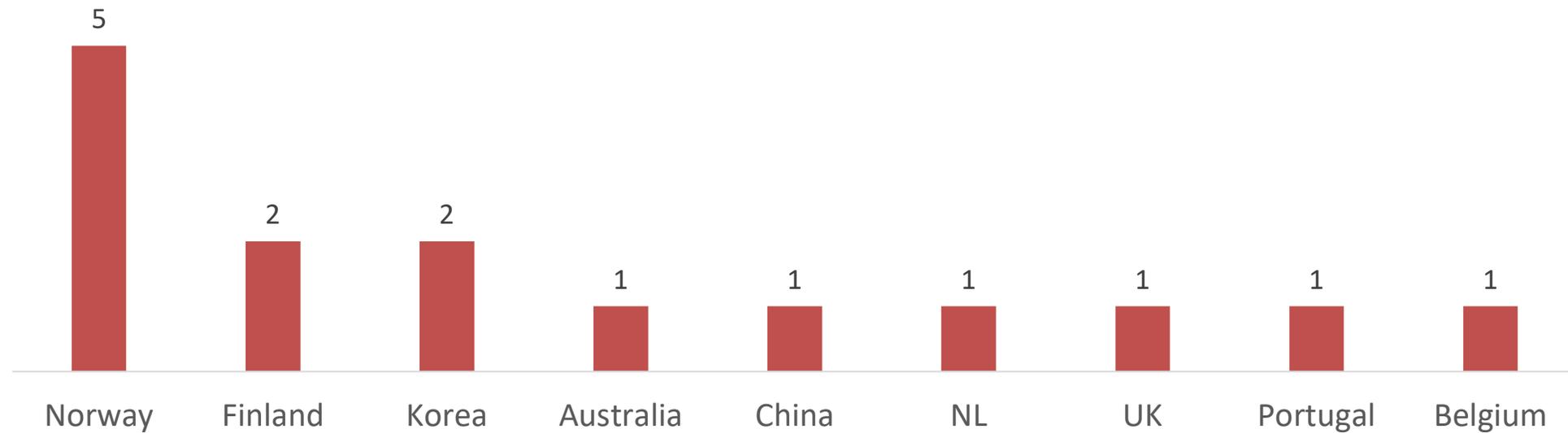
Where is research on **risk management** aspects of autonomous ships conducted?

Number of authors from each nation



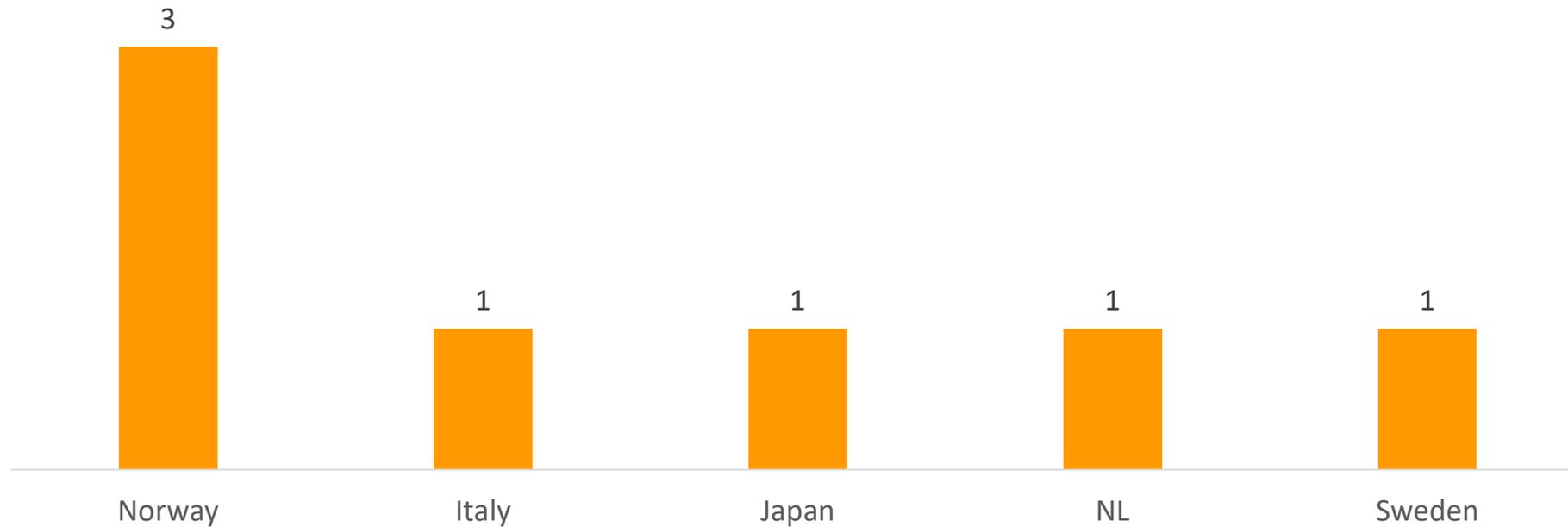
Where is research on **business and logistics** aspects of autonomous ships conducted?

Number of authors from each nation



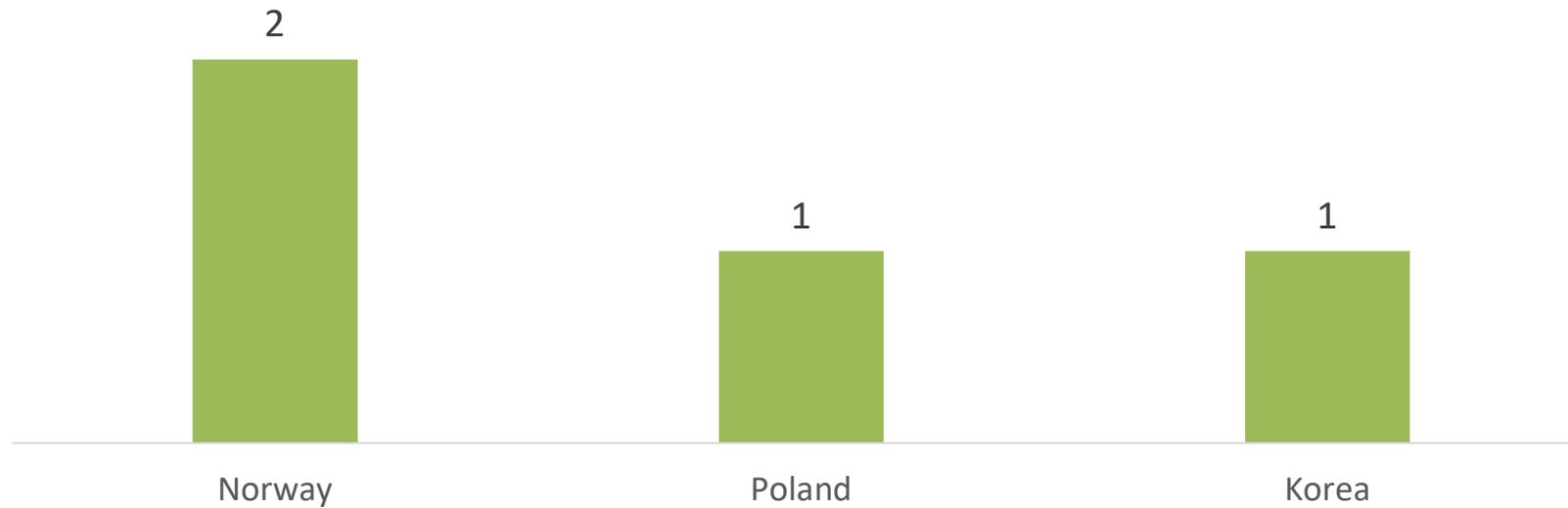
Where is research on **Human Factors** aspects of autonomous ships conducted?

Number of authors from each nation



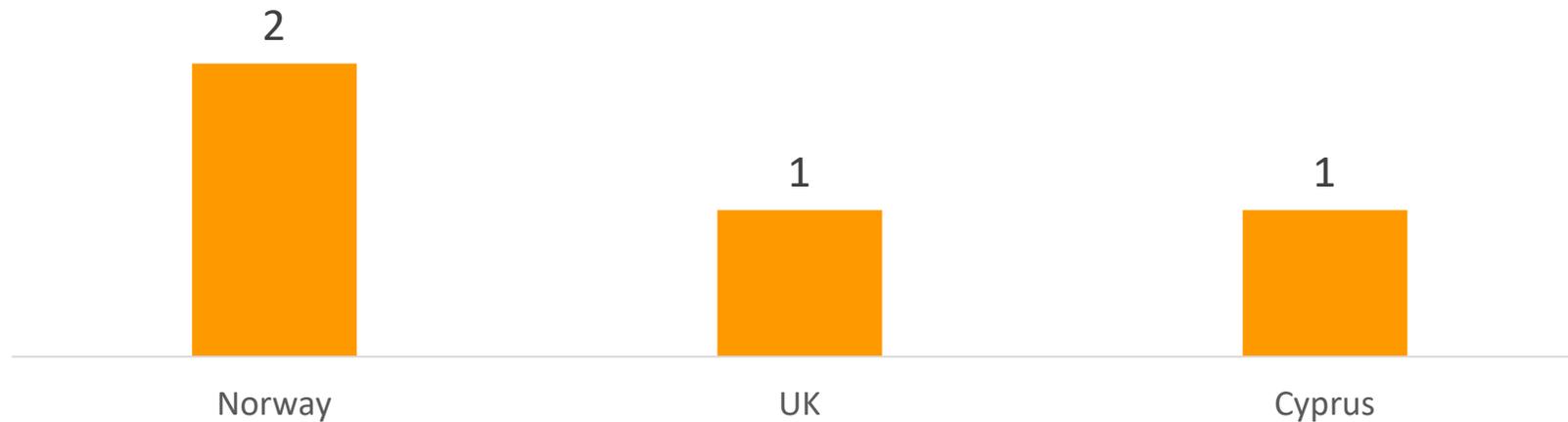
Where is research on **Sensor and ICT** aspects of autonomous ships conducted?

Number of authors from each nation



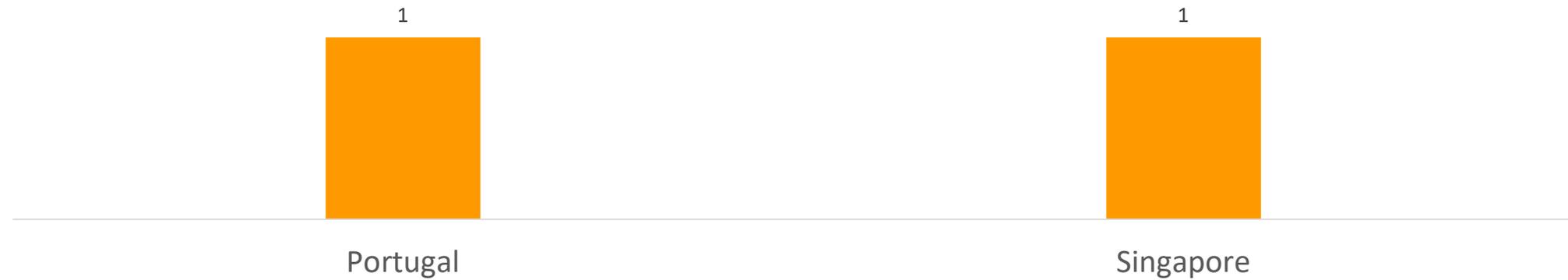
Where is research on **communication and cyber security** aspects of autonomous ships conducted?

Number of authors from each nation



Where is research on **environmental** aspects of autonomous ships conducted?

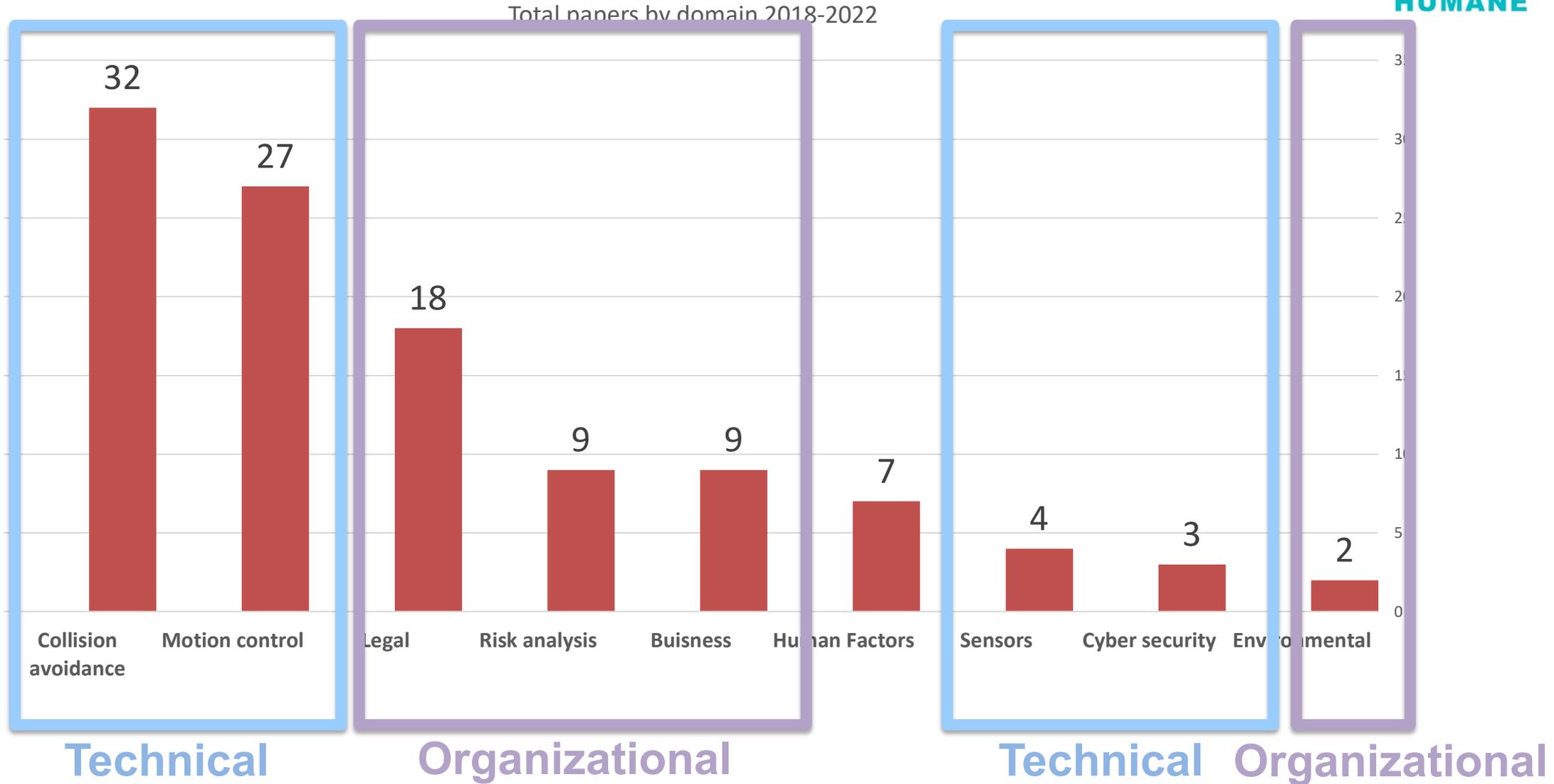
Number of authors from each nation



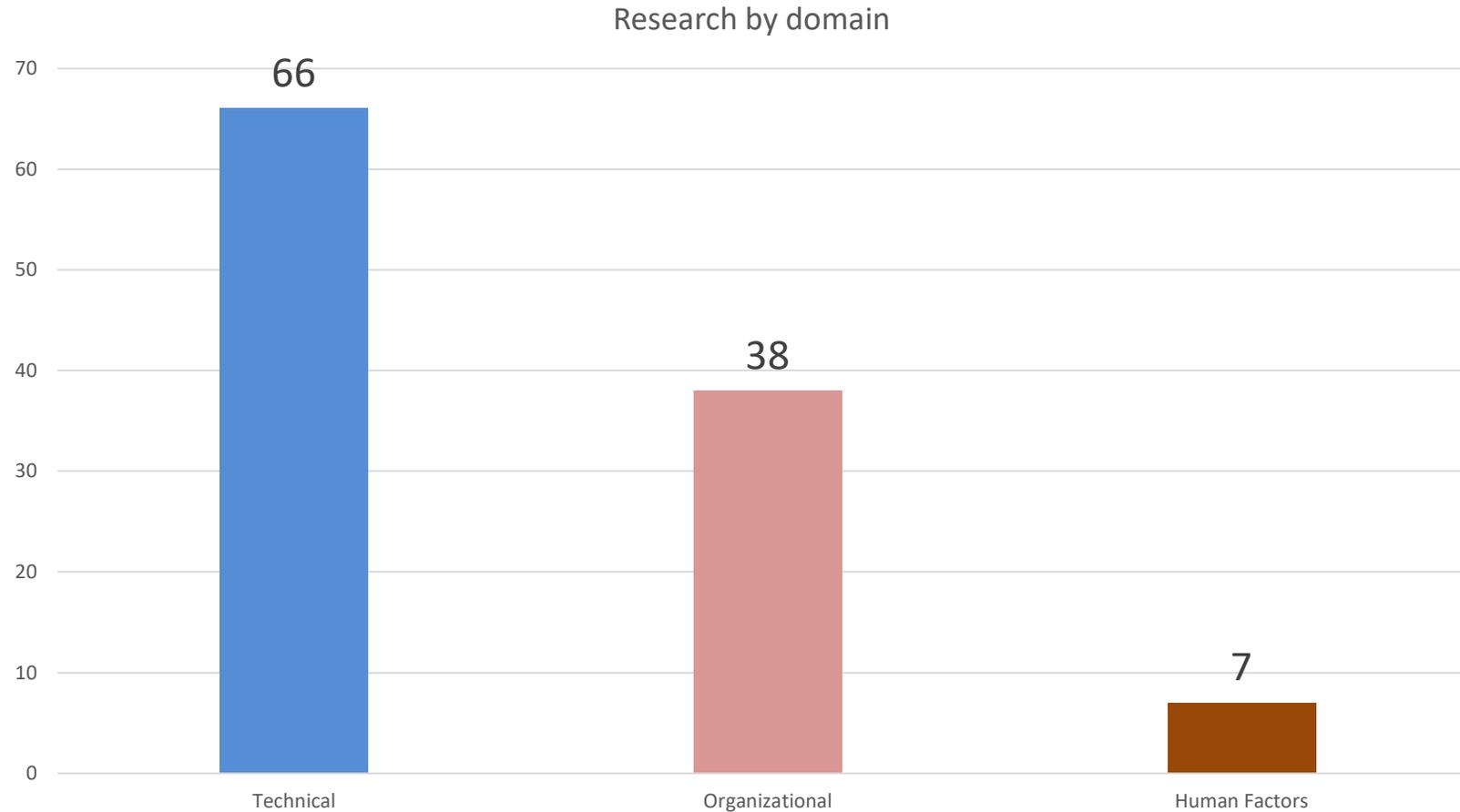
Merging domains to general research areas



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Research by domains (total 111 papers)



Conclusion

Although many publications point to the human operator as a final safety barrier, only 7 of the 111 found research publications contained studies of Human Factors related issues.

From this the conclusion points to a need of HF research in the autonomous ship domain.