

A detailed illustration of the Juno spacecraft in orbit around Jupiter. The spacecraft is a cube-shaped body with a large white circular antenna on one side and several long, rectangular solar panel arrays extending from it. Jupiter's massive, swirling cloud bands and the Great Red Spot are visible in the upper left background.

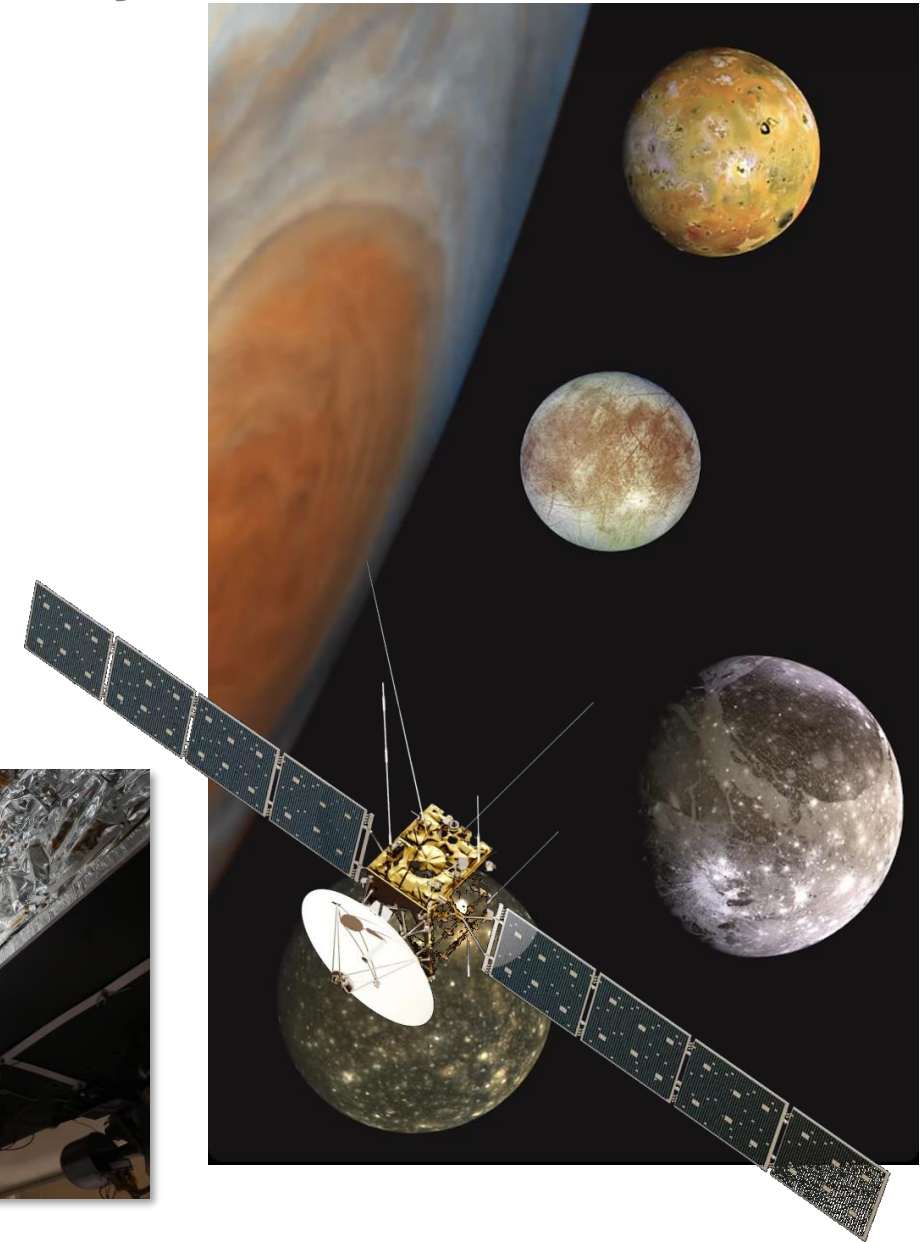
# INTERFACES OF KNOWLEDGE

AND THE ALIEN IN THE ROOM NEXT DOOR  
FRIEDRIKE WOLFF

# Contents: Alienation in research community itself

- Appreciating the increasing complexity of today's scientific world
- Lessons learned from 10 years in engineering for planetary research

Intra-disciplinary project work is very hard, even if you have a shared goal



# Certain field require more collaboration than others

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**Combined Measurement of the Higgs Boson Mass in  $pp$  Collisions at  $\sqrt{s} = 7$  and 8 TeV with the ATLAS and CMS Experiments**

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Hide

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25	0%	0%	0%	0%	0%	0%
26-50	3%	1%	0%	2%	1%	0%
51-100	1%	0%	0%	0%	1%	0%
101-500	1%	0%	0%	0%	1%	0%
500+	0%	0%	0%	0%	2%	0%

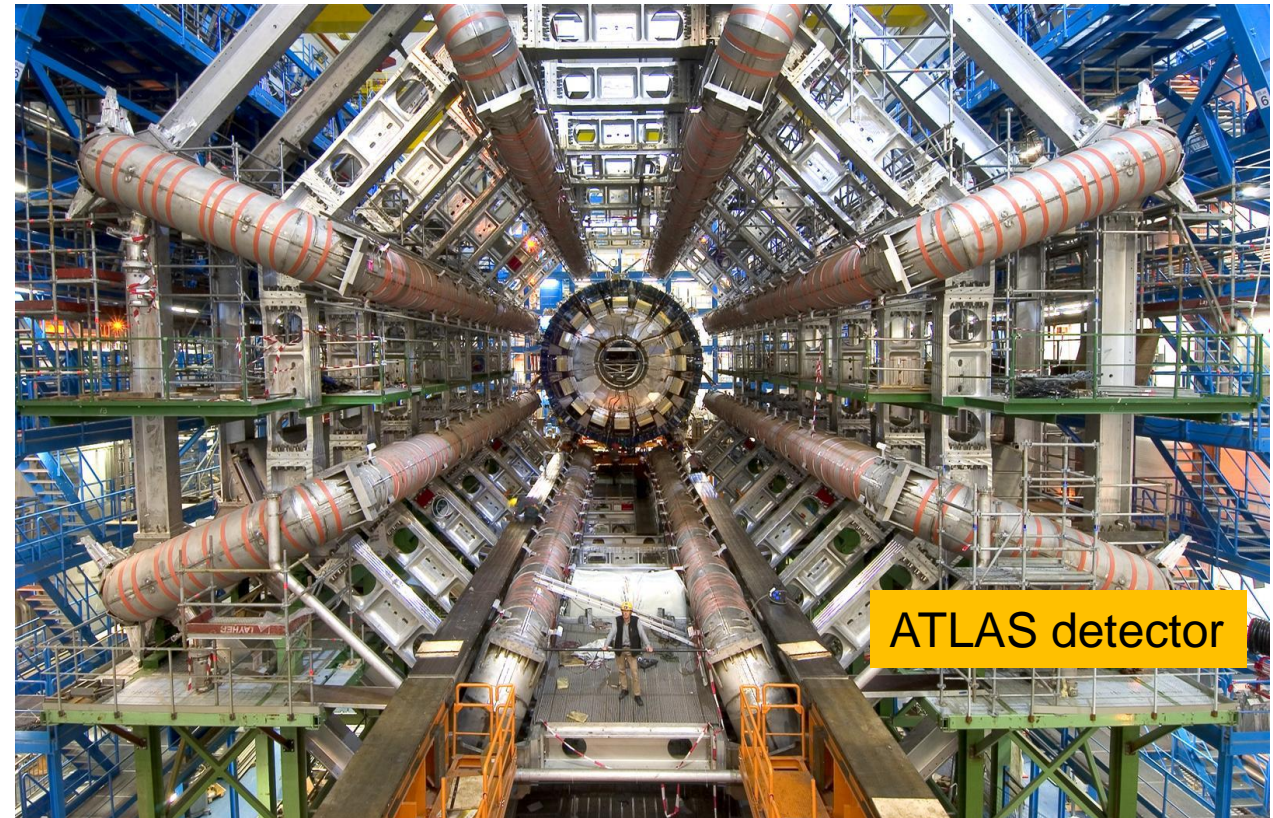
> 5000 authors

<https://www.nature.com/nature-index/news/paper-authorship-goes-hyper>



# „Big science“ as an extreme case study of interdisciplinary work

- Large scale organization
- Massive commitment of funds
- Complex technological systems
- **Large Hadron Collider**
  - 5,154 authors on Higgs Boson Paper
- **Human Genome Project**
  - 5 billion USD
- **James Webb Space Telescope**
  - 20,000 people over 20 years



ATLAS detector

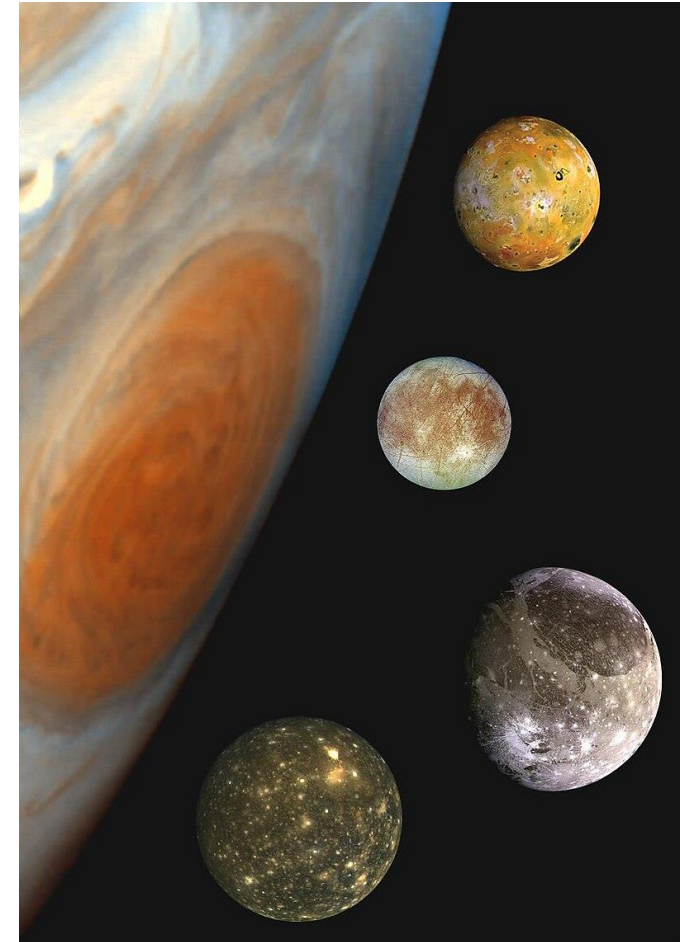
# Communication as a limiting factor

- The extend of the project is huge
- Projects beyond a certain scope or complexity necessitate more and more expertise that is more and more differentiated
- Progress is to some degree limited not by the lack of specialist knowledge but by the ability to communicate it

# Galileo Galilei

- In 1610, Galileo found the Jovian moons
  - On his own
  - Self-funded
  - Made the telescope himself
  - Results within 1 year

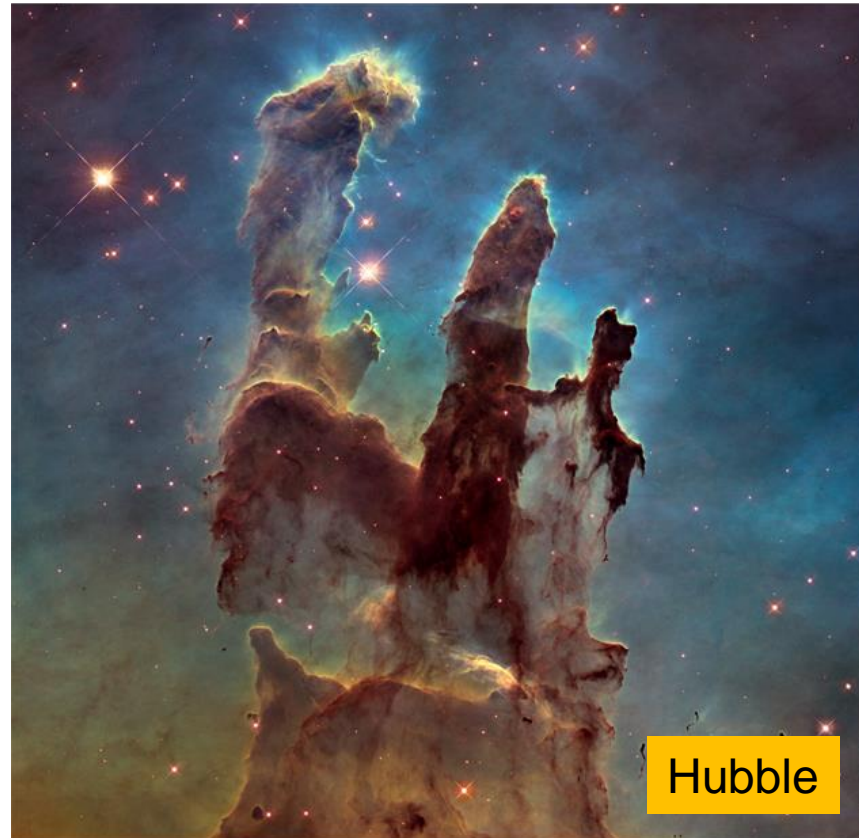
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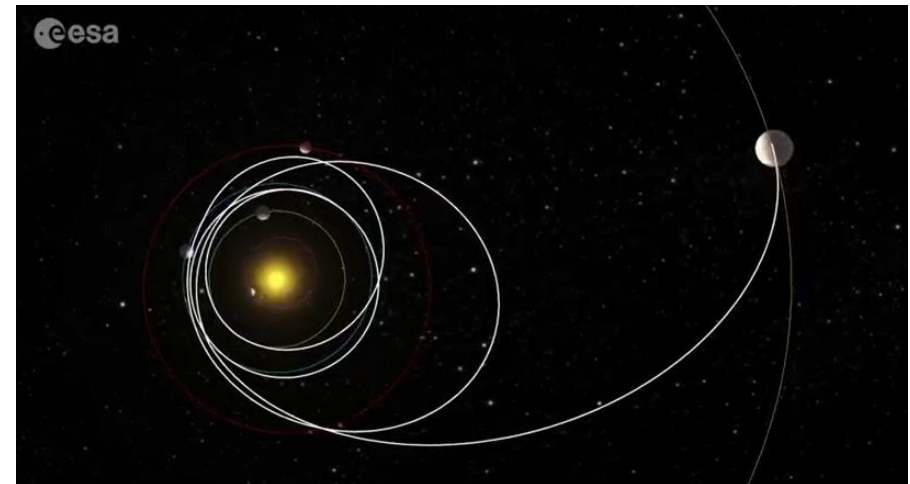
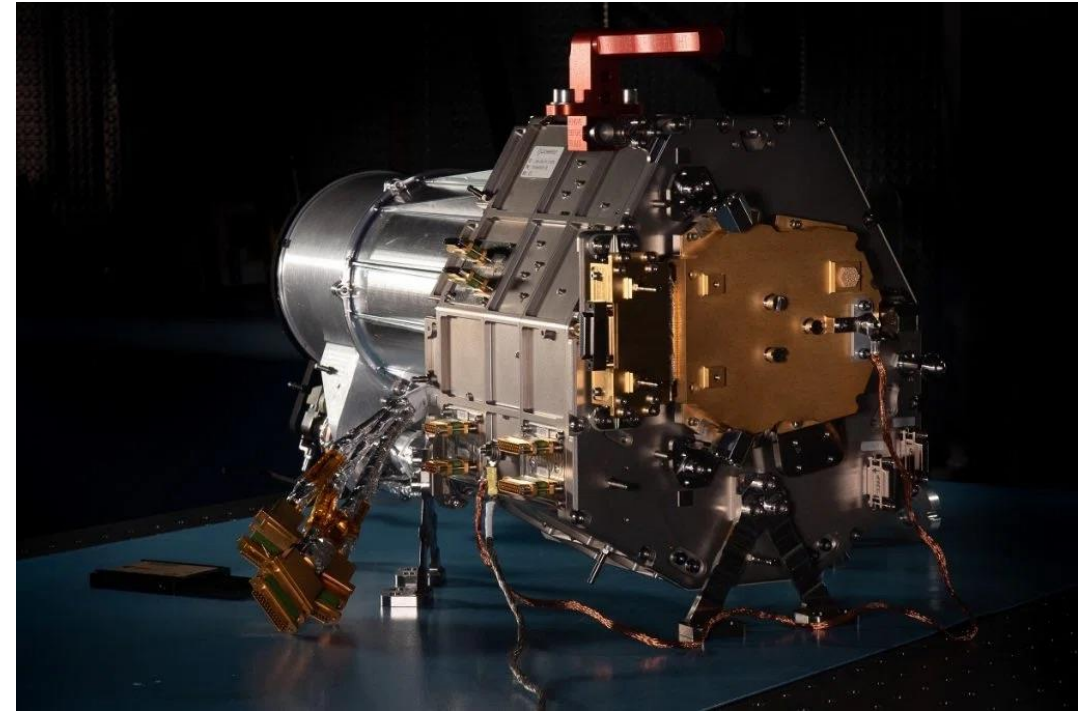
# The low hanging fruits are gone

- James Webb Space Telescope
  - 20,000 people
  - 20 years
  - 10 billion USD
  - 14 countries
  - 258 institutions



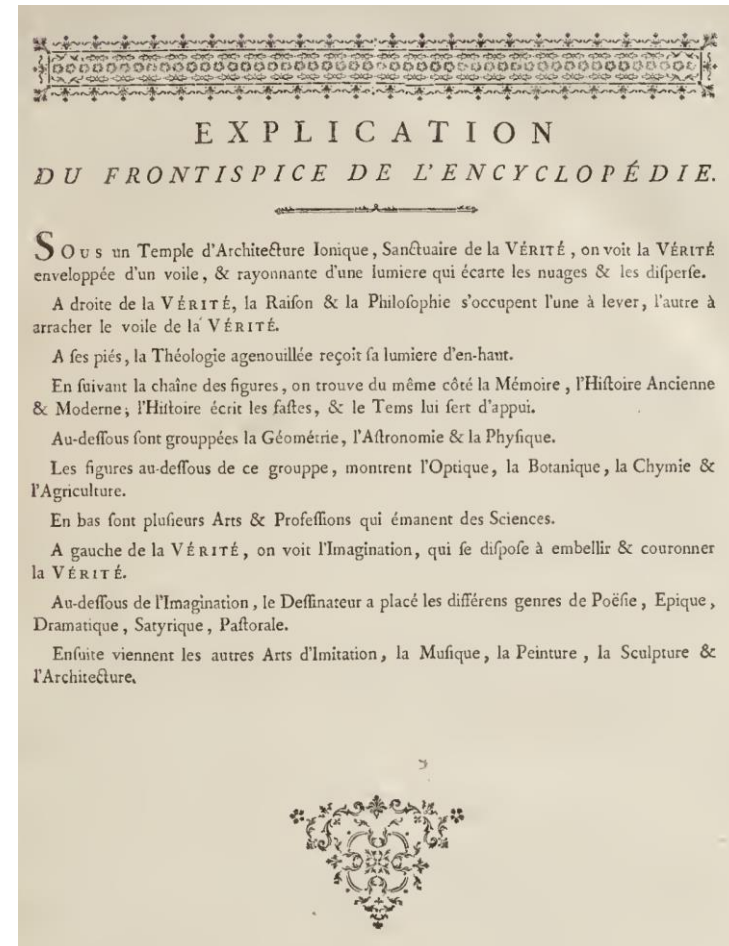
# Dealing with complexity

- The scale of research systems significantly shapes the research itself
- Complexity is never reduced, only transformed
- Interdisciplinarity becomes unbearable at decision points that
- In planetary research, there are hard deadlines
- I am astonished that anything in space works at all





# Interdisciplinarity used to be baseline



**Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers**  
Diderot & d'Alembert, 1751

# The burden of knowledge

- 90 million documents on scihub
- Growth rate of modern science is 3%
- Volume of publications doubles every 24 years
- In fields studying complex systems, the average number of authors increases

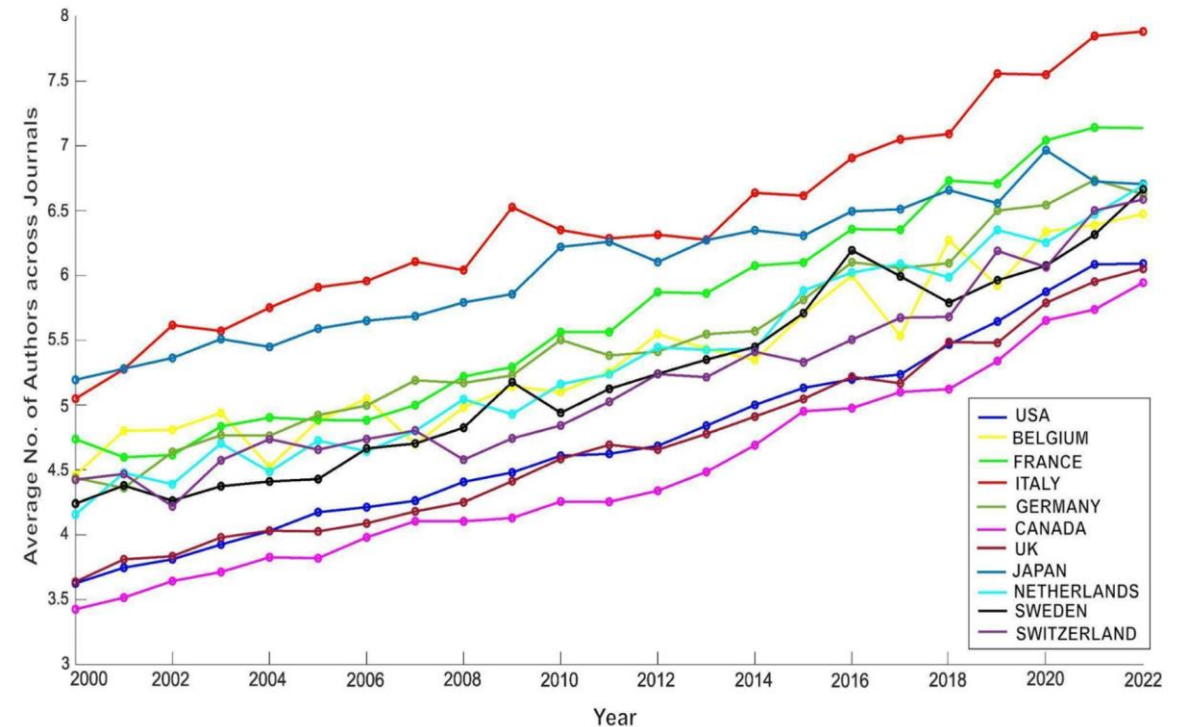


Fig. 1. Temporal trend of authorship in the field of Neuroscience for the eleven target countries from 2000 to 2022.

Average authorship in neuroscience  
+50% in 22 years

# Increasing specialization

- Navigating knowledge systems
- Pride in specialization works against us
- Everyone needs to have some understanding of the neighboring fields to the point that participation in discussion is possible

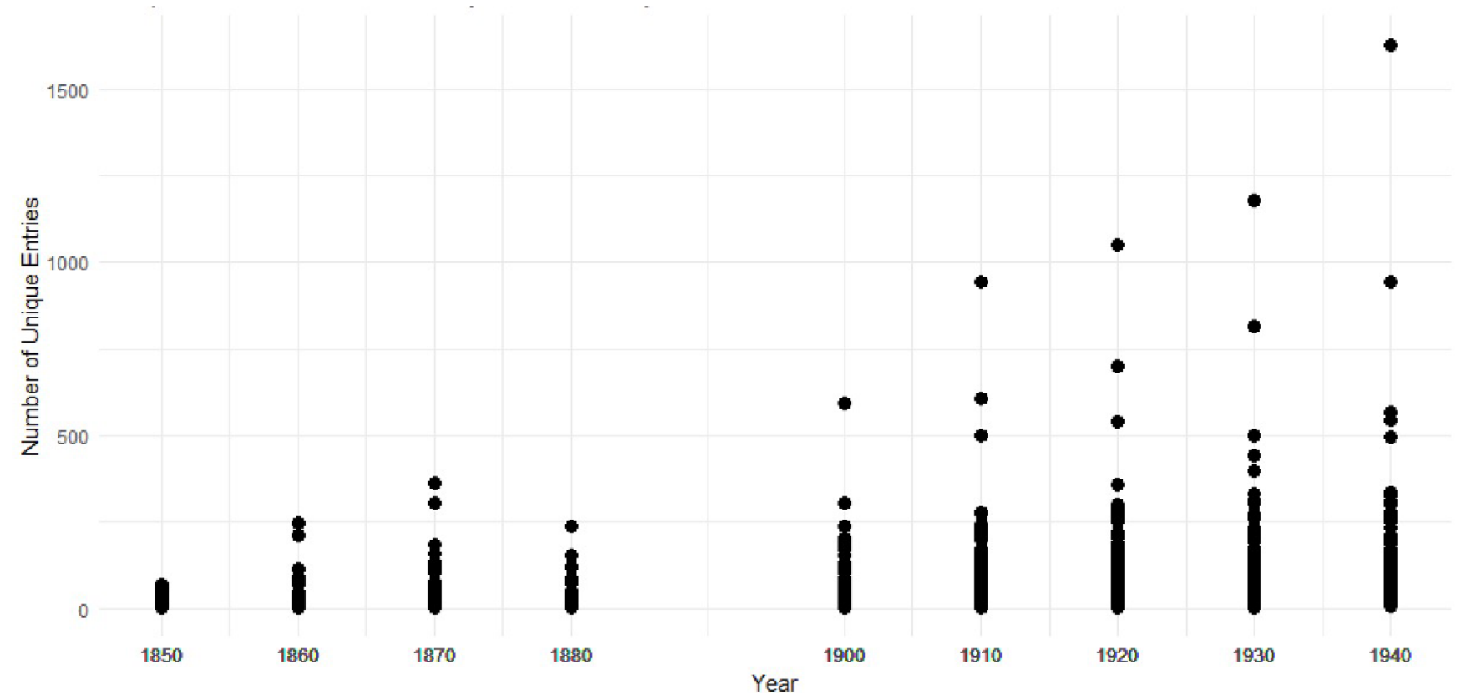
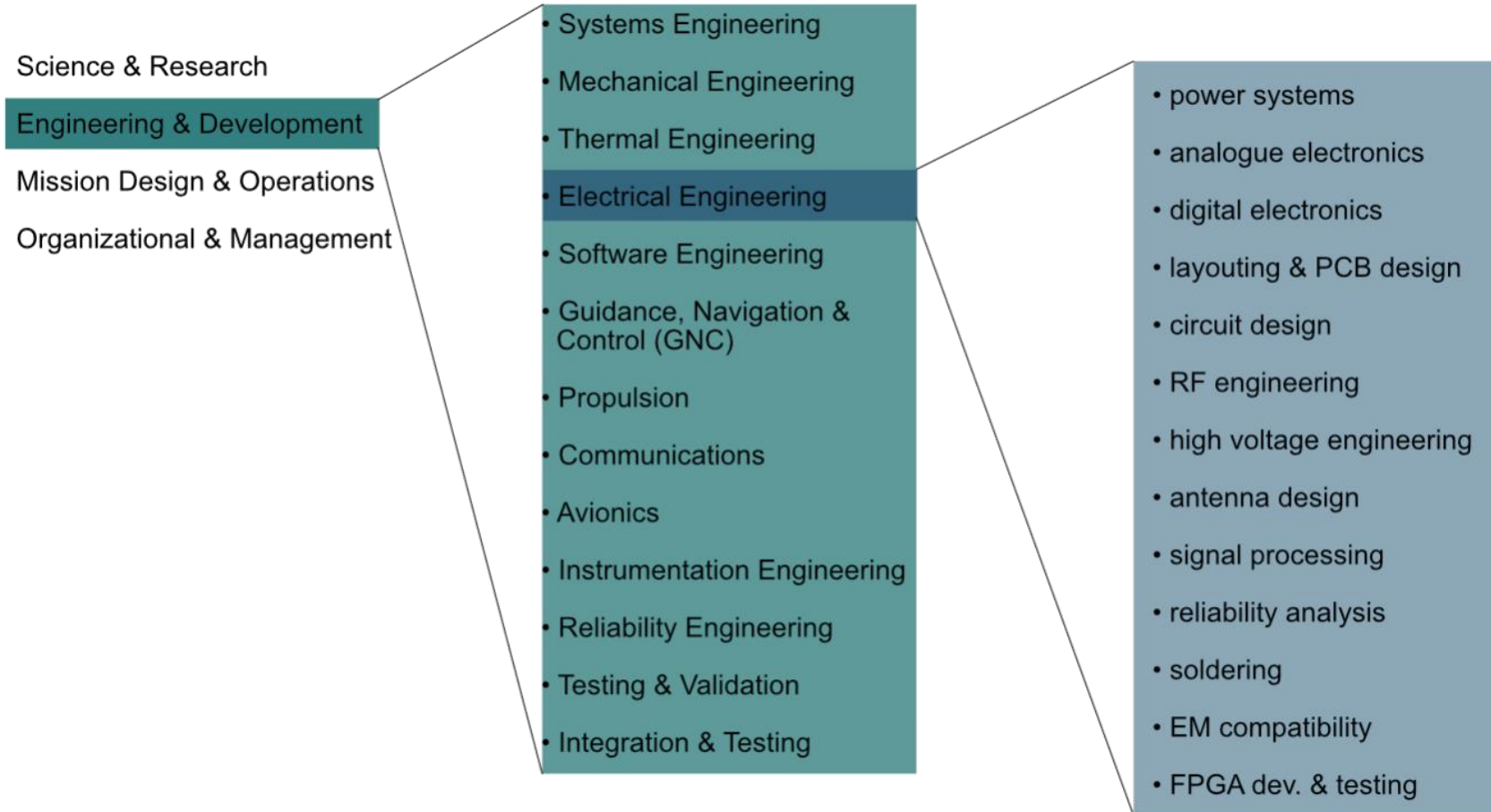


Figure 3: Number of unique words (minus articles, prepositions) used by census respondents in US cities to describe occupation; each dot is a US city. Data source: IPUMS (Integrated Public Use Microdata Series). This measure is independent of any classification system, and relies only on the respondent's direct answers, here in a one percent sample.

From 100 to 1700 in 90 years



# Flagship projects necessitate convergence of enormous expertise



- None of those people speak the same language → tower of babel feeling
- Many of these people follow logic that is conflicting by design

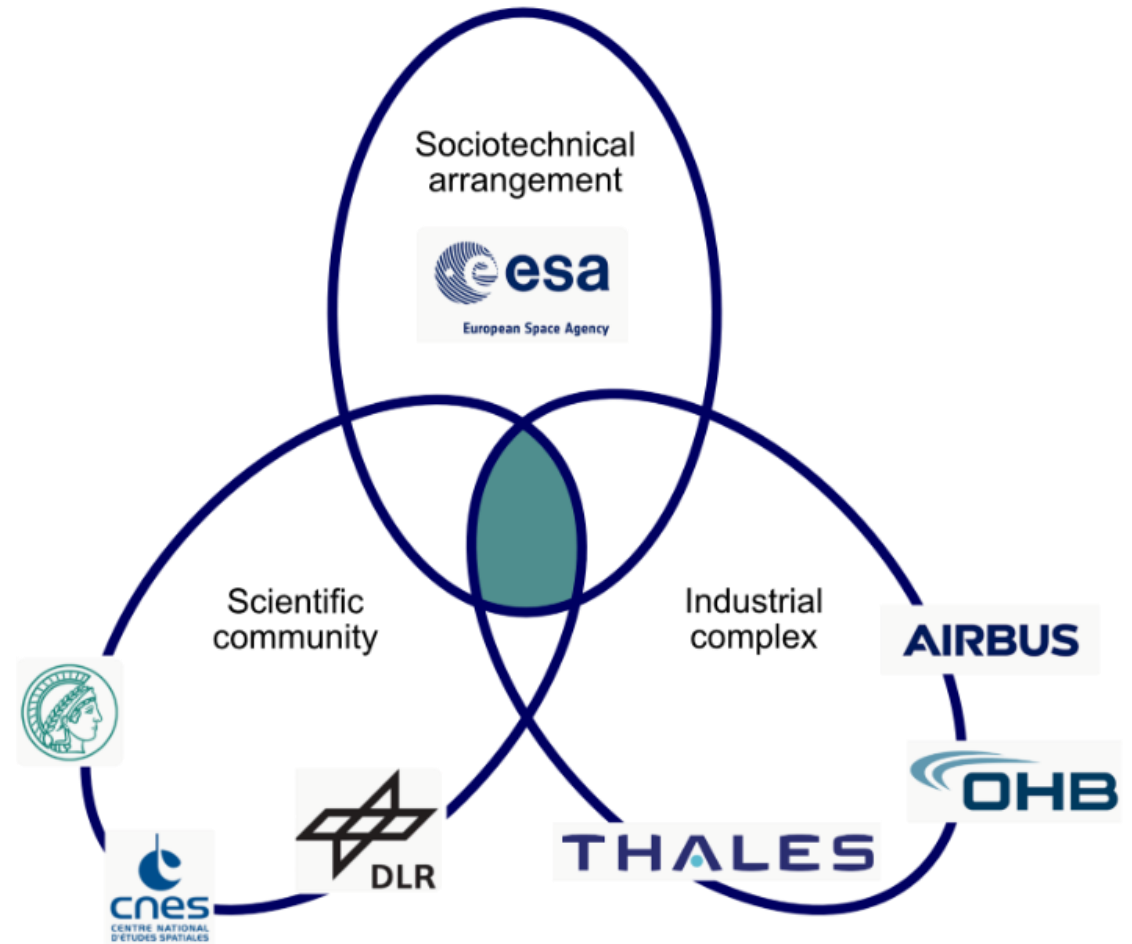
# JUICE – Jupiter and Icy Moon Explorer Mission

- No one can grasp the full extent of the project
- No one has full visibility
- No one has overall control
- Human implications
  - The system seems inefficient
  - Burocracy is suffocating
  - Frustration is very high



# There's more to it than science

- Scientists don't understand organizations
- Everyone hates politics
  - Is considered an illegitimate means
- Not everyone in a scientific project has scientific motivations (industry)
  - Economic incentives seen as morally corrupt





# Boundaries of knowledge

- Countries/Culture
- Fields of expertise
  - nothing is ever obvious
  - removing ambiguity
- Institution
- Age
  - Culture change
  - Changes in the field
  - → Information loss to retirement is 100%

# It's not (just) about information

- Diplomacy is important
  - Trustbuilding
  - common understanding
  - Negotiation
  - coalition building
  - Managing power dynamics



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26-50	3%	1%	0%	2%	1%	0%
51-100	1%	0%	0%	0%	1%	0%
101-500	1%	0%	0%	0%	1%	0%
500+	0%	0%	0%	0%	2%	0%

Analysis based on publications tracked by the Web of Science between 1980 and 2016.

Source: Vincent Larivière; Web of Science • Created with Datawrapper