



26th annual **INCOSE**
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Edinburgh, UK
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An Initial Bibliometric Analysis and Mapping of Systems Engineering Research

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Content Outline



- Introduction and Aim
- Research in Systems Engineering
- Research Methodology
- The Journal of the International Council on Systems Engineering
- Research Results:
 - Bibliometric Analysis
 - Systematic Mapping
- Conclusions

Introduction

- Systems Engineering is a young and growing discipline
- Systems engineering has to continue growing:
 - Develop tools
 - Develop supporting theories (research)
- Systems engineering research is not easy



Research in Systems Engineering



- Research:
 - Aims to understand, explain and predict phenomena
 - Produce knowledge manifested in scientific literature
- No accepted general research theory for systems engineering
 - Immaturity and lack of established proofing methods
 - Research often takes place in the real world with real-world problems
 - Similar to business research

Research Questions



- Is the field of systems engineering research growing?
- Where is systems engineering research being performed?
 - Geographical distribution
 - Disciplines
 - Sectors
- Who are the leading researchers in systems engineering?
- Which are the key research papers in the systems engineering?
- Which are the most important research topics?

Research Methodology



- **Scientometrics (Bibliometrics)**
 - Describe development of a research field
 - Applied to a specific journal or set of journals
 - Explore performance and impact of a research field through citation and content analysis :
 - The Number of Papers
 - The Number of Authors and Co-authors
 - Institutions and Affiliations
 - The Number of Citations
- **Keyword Parsing**
 - Occurrence of keywords in abstracts
 - Identify focus areas of research

The Journal of INCOSE

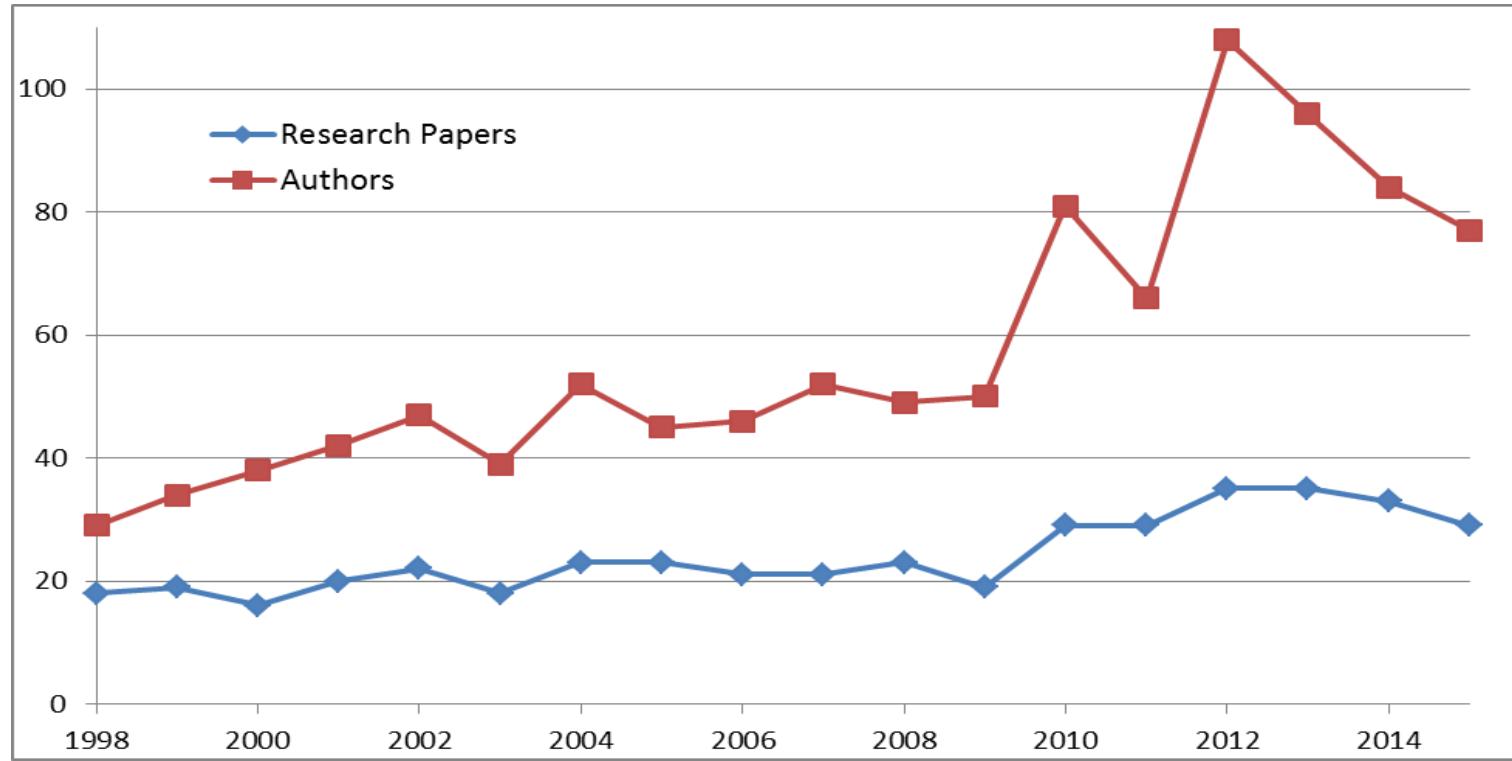


- Journal of the International Council on Systems Engineering
- Stated Journal Aim:
 - Development of systems engineering knowledge
 - Integration and dissemination of systems engineering knowledge
 - Establishment of standards
 - Improve the professional status of systems engineering
- Scimago H-Index – 33
- Impact Factor – 0.956
- First published in 1998, four issues per year

Data Capture

- 467 articles from 1998 to 2015 in 72 issues
- 433 without erratum, correspondences and editorials
- Data Captured:
 - Perusing each paper:
 - Title, Year, Volume, Issue
 - Authors
 - Author Discipline
 - Author Affiliation
 - Author Country
 - Harzing's “Publish or Perish” tool:
 - Number of Citations
 - Keyword Parsing:
 - Common Keywords
 - Number of References

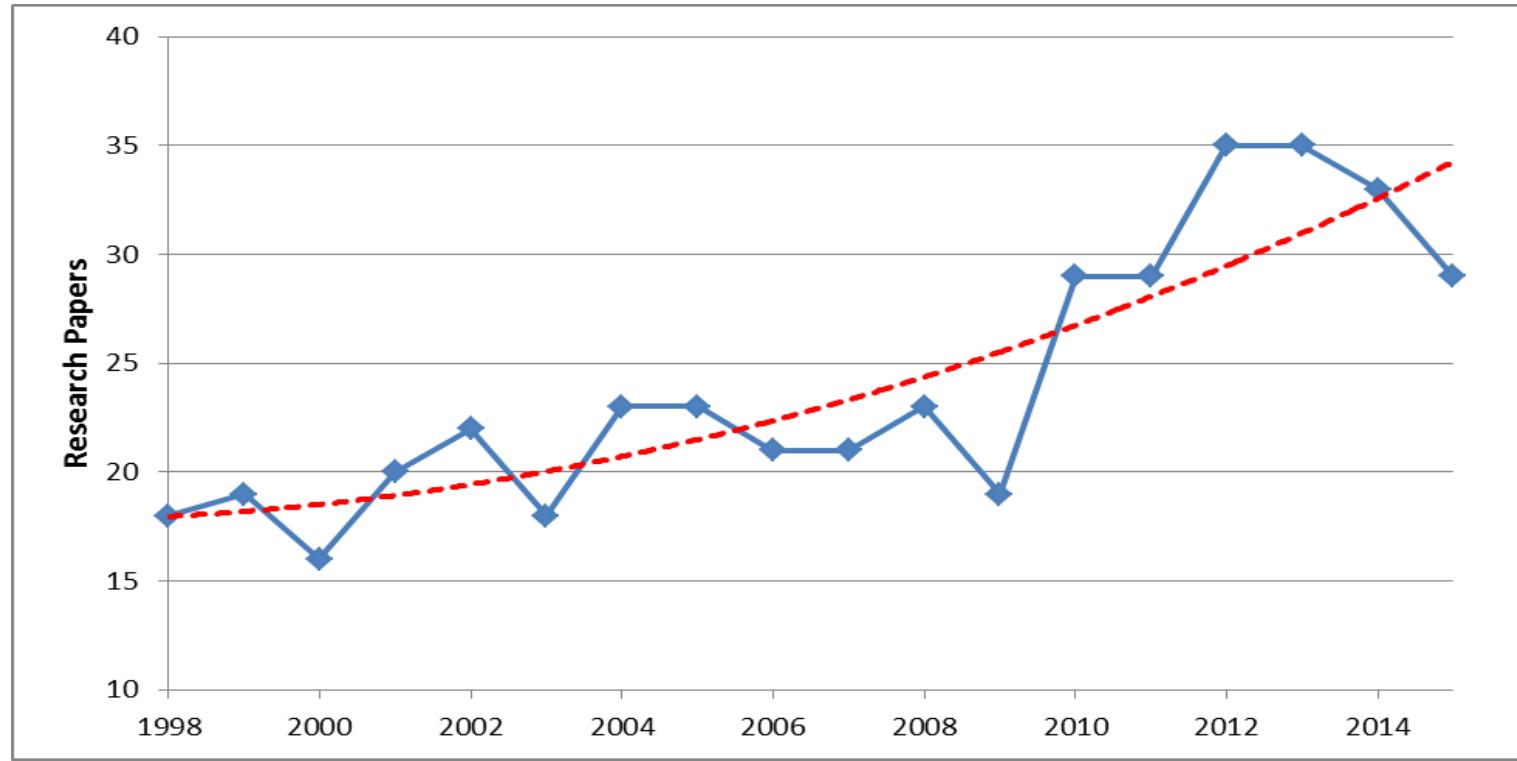
Number of Papers and Authors per Year



Number of Authors per Paper



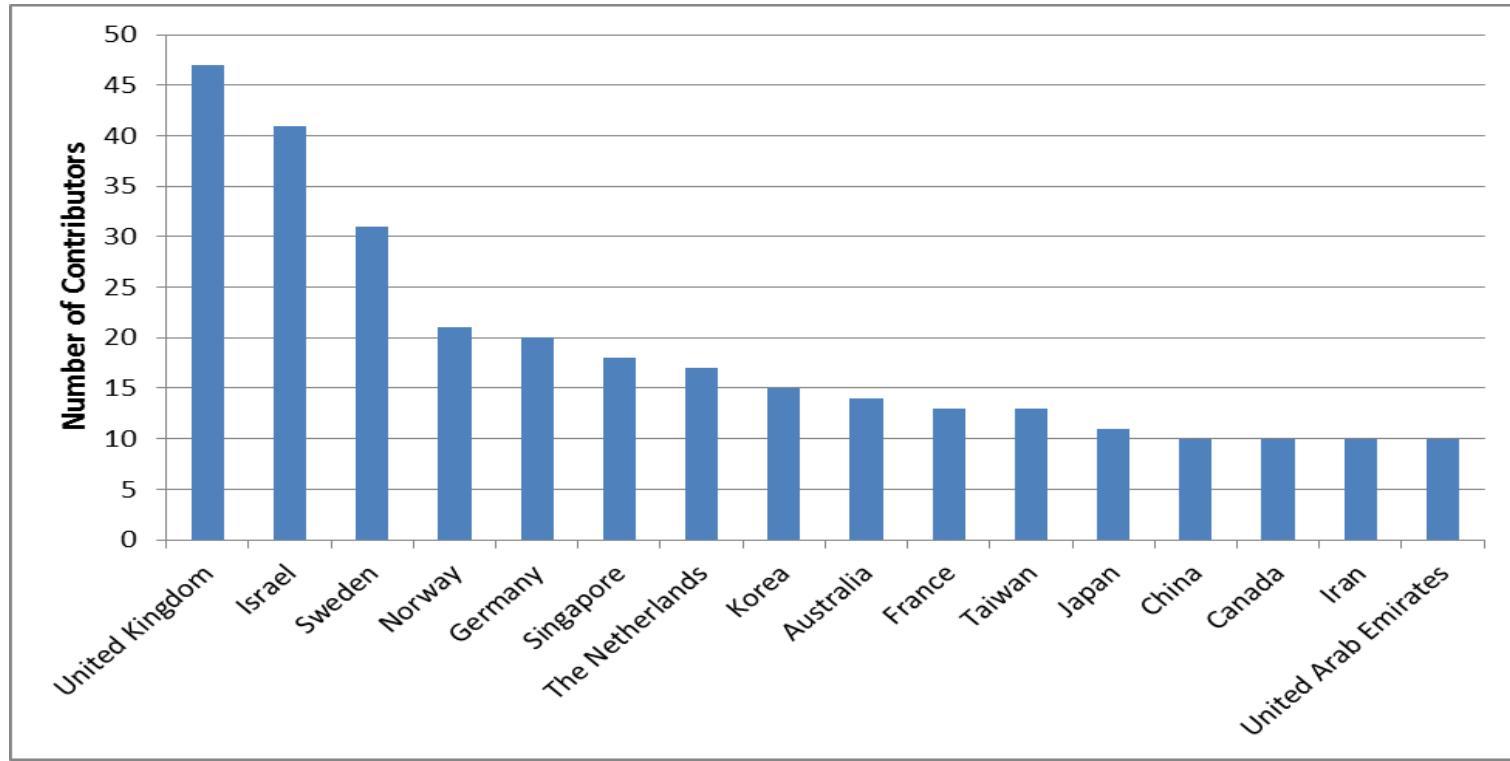
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Number of Authors per Country



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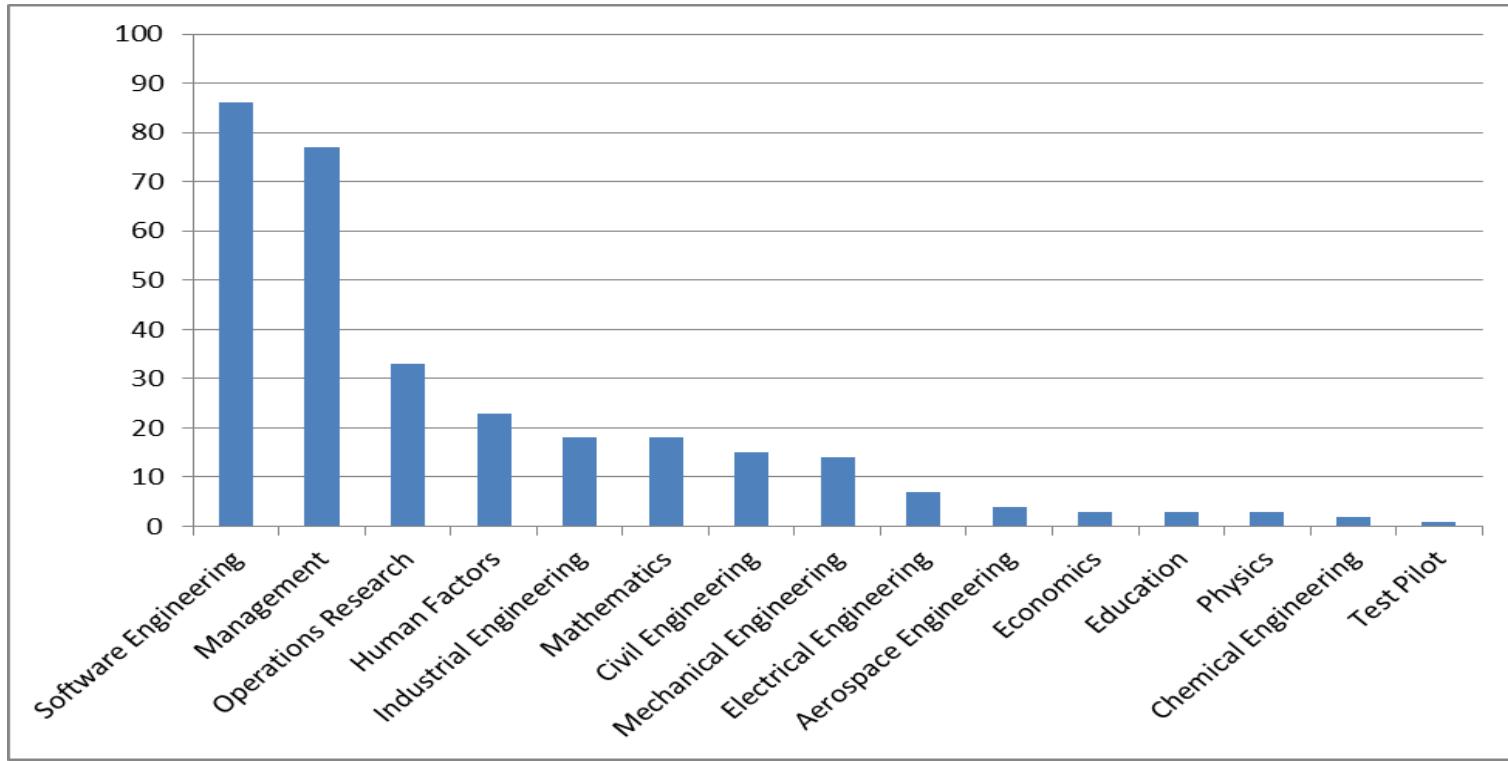
USA = 69%

Disciplines of Contributing Authors

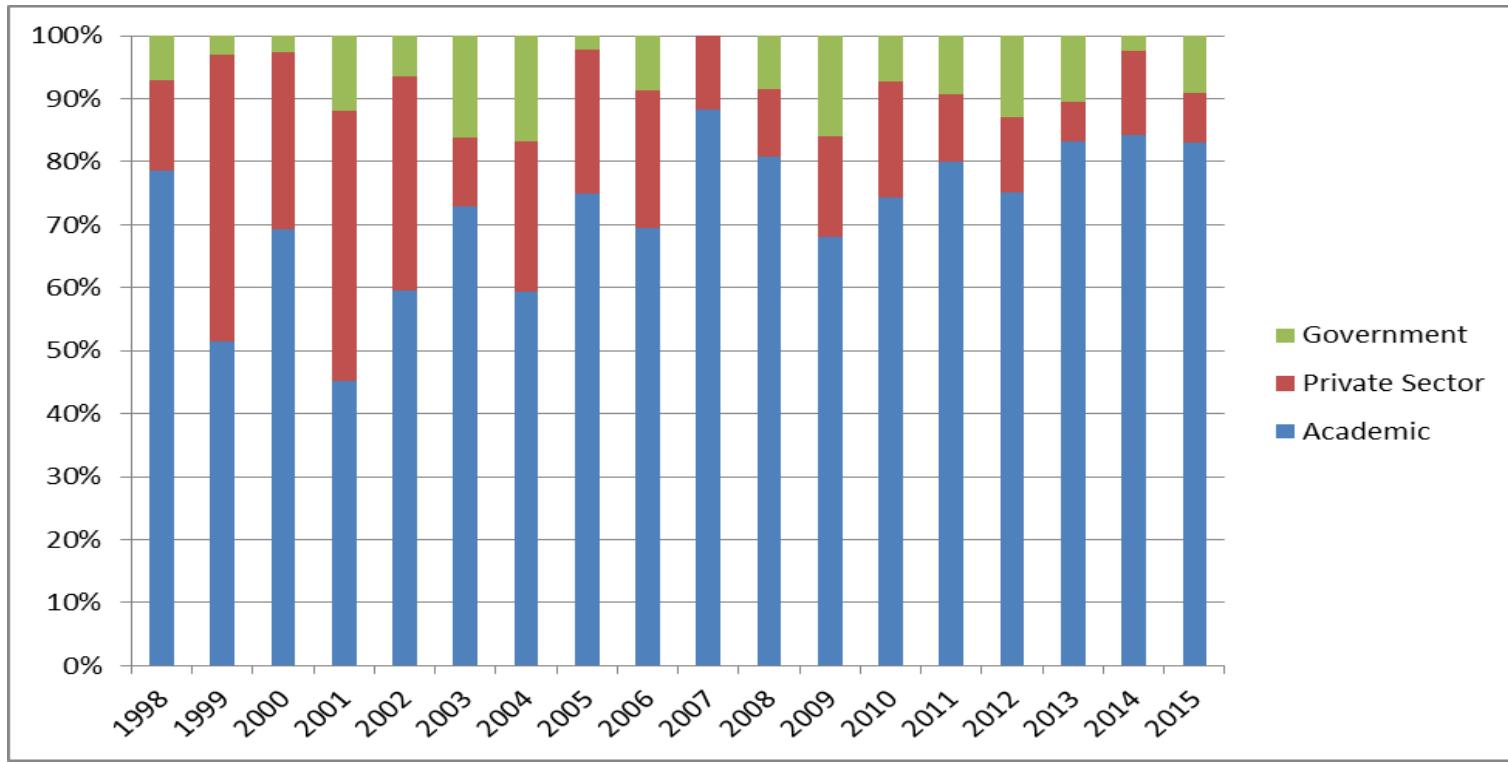


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SE = 70%



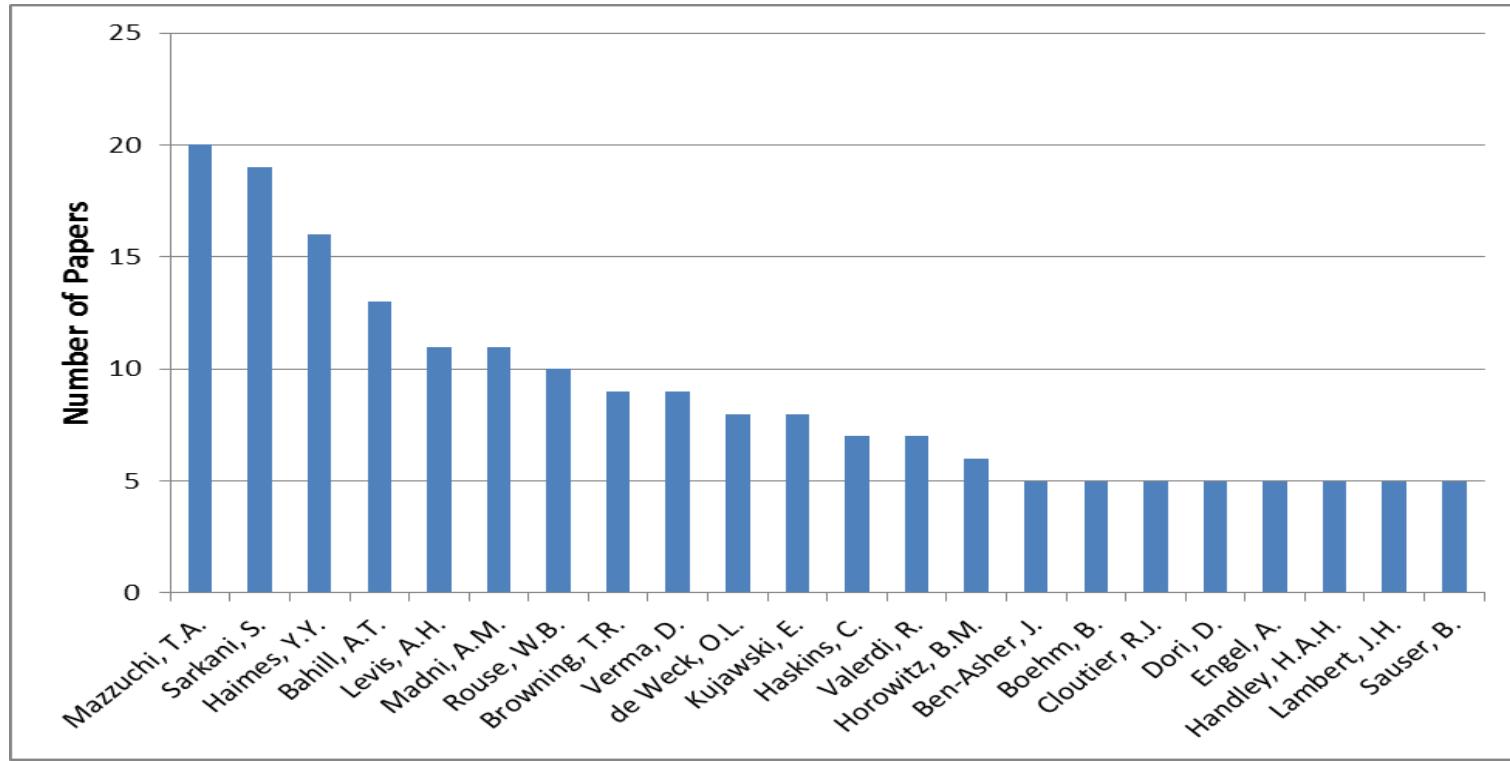
Sectors for Research



Papers for Top Researchers



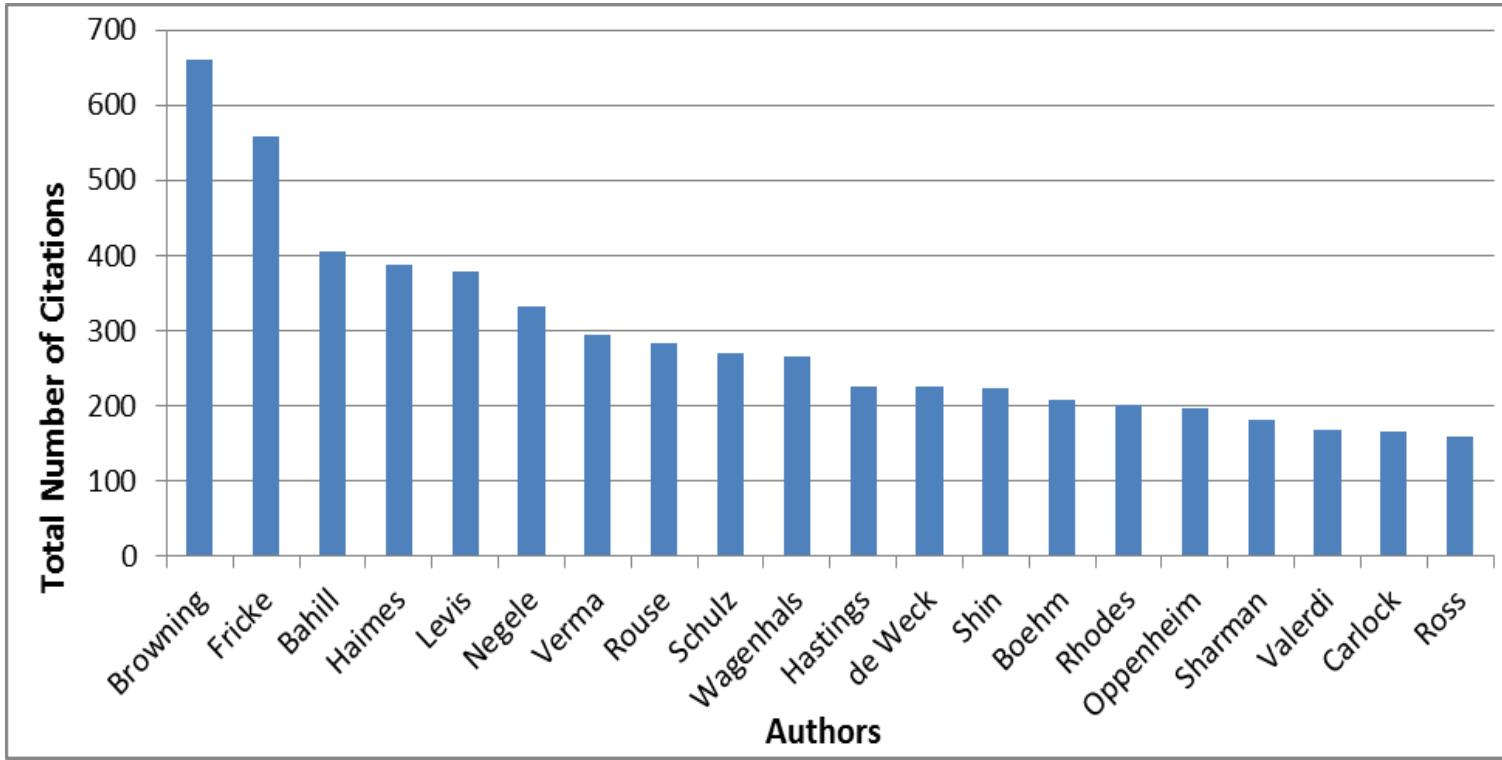
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Citations for the top Researchers



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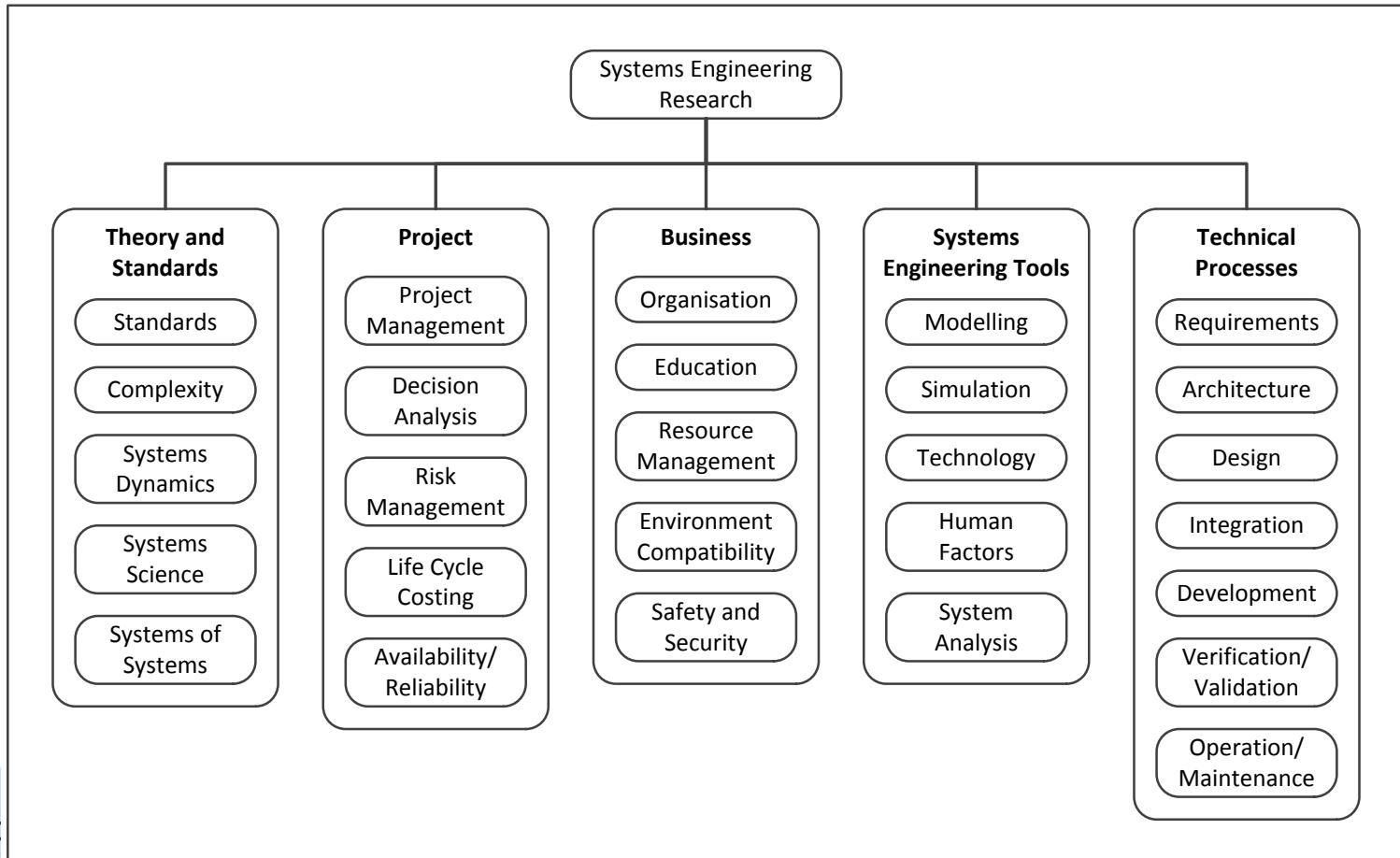


Top Papers



Citations	Title	Authors	Year
227	Design for changeability: Principles to enable changes in systems throughout their entire lifecycle	Fricke, Schulz	2005
185	Key concepts in modeling product development processes	Browning, Fricke, Negele	2006
181	Characterizing complex product architectures	Sharman, Yassine	2004
166	System of systems enterprise systems engineering for information-intensive organizations	Carlock, Fenton	2001
158	Defining changeability: Reconciling flexibility, adaptability, scalability, modifiability, and robustness for maintaining system lifecycle value	Ross, Rhodes, Hastings	2008
147	Some future trends and implications for systems and software engineering processes	Boehm	2006
139	Lean product development flow	Oppenheim	2004
127	C4ISR architectures: I. Developing a process for C4ISR architecture design	Levis, Wagenhals	2000
124	Process integration using the design structure matrix	Browning	2002
114	C4ISR architectures: II. A structured analysis approach for architecture design	Wagenhals, Shin, Kim, Levis	2000

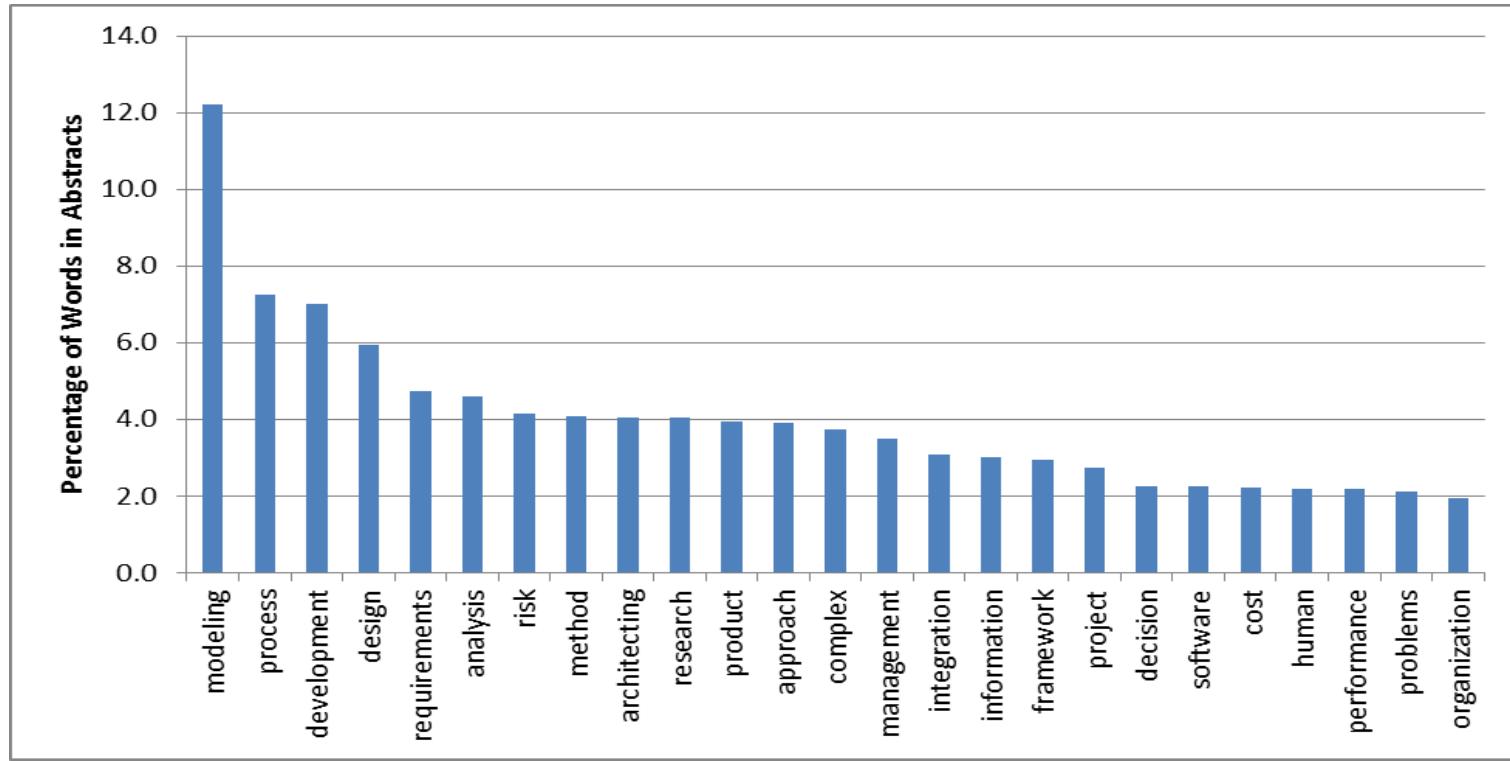
SE Research Framework



Keyword Mapping



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Other Results

- Research collaboration:
 - 63% within academia
 - 27% between academia, industry and/or government
- 14 497 references in all journals, only 955 are from prior Systems Engineering papers (6,6%)
- Low frequency keywords from parsing:
 - System Dynamics
 - Systems Science
 - Simulation

Conclusions (1)



- Research in systems engineering is difficult
- Number of authors per paper is steadily increasing
- Academia dominates systems engineering research
- Collaboration between academia, industry and government is low
- Academic researchers must collaborate with practitioners:
 - Not only support students from industry or government
 - Test theories in the real world
 - Incorporate feedback

Conclusions (2)



- Research is dominated by the USA
- High presence of western and English speaking countries
- Research framework for systems engineering, derived from INCOSE and keyword parsing
- Results compare well to bibliometric research and systematic mapping on the field of System of Systems research

Conclusions (3)



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Future work

- Identify other SE publications (journals and conferences)
- Identify research frameworks, methods and tools for SE
- Identify major contributors
- Identify how major research outcomes are applied
- Propose SE research guidelines



Questions ?