Industry-academia collaborations in Software Engineering: 20+ Years of Experience from 50+ international projects


Canada


Turkey


UK

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VIRAL

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Outline

- **Background**
  - Background of the speaker… Principal Investigator (PI)
  - (Reminder) What is Software Engineering (SE) and SE research?
  - Our research philosophy and approach
- **Experience in industry-academia collaborations (IAC)**
- **Challenges, best practices, and collaboration models for IAC**

My background (international experience)

Work experience:
Associate Professor, Queen's University Belfast, UK, 2019-
Associate Professor, Wageningen University, Netherlands, 2017-2019
Associate Professor, Hacettepe University, Ankara, Turkey, 2015-2017
Associate Professor, University of Calgary, Canada, 2006-2014
CEO and Managing Consultant, Bahar Software Engineering Consulting, since 2001-
Software Engineer, Offshore office of Corsha Software Inc., Quebec, Canada, based in: Tehran, Iran, 1998-2001

Education:
PhD in Software Engineering, Carleton University, Ottawa, Canada, 2006
MSc in Computer Engineering, University of Waterloo, Canada, 2003
BSc in Software Engineering, Sharif University of Technology, Tehran, Iran, 2000

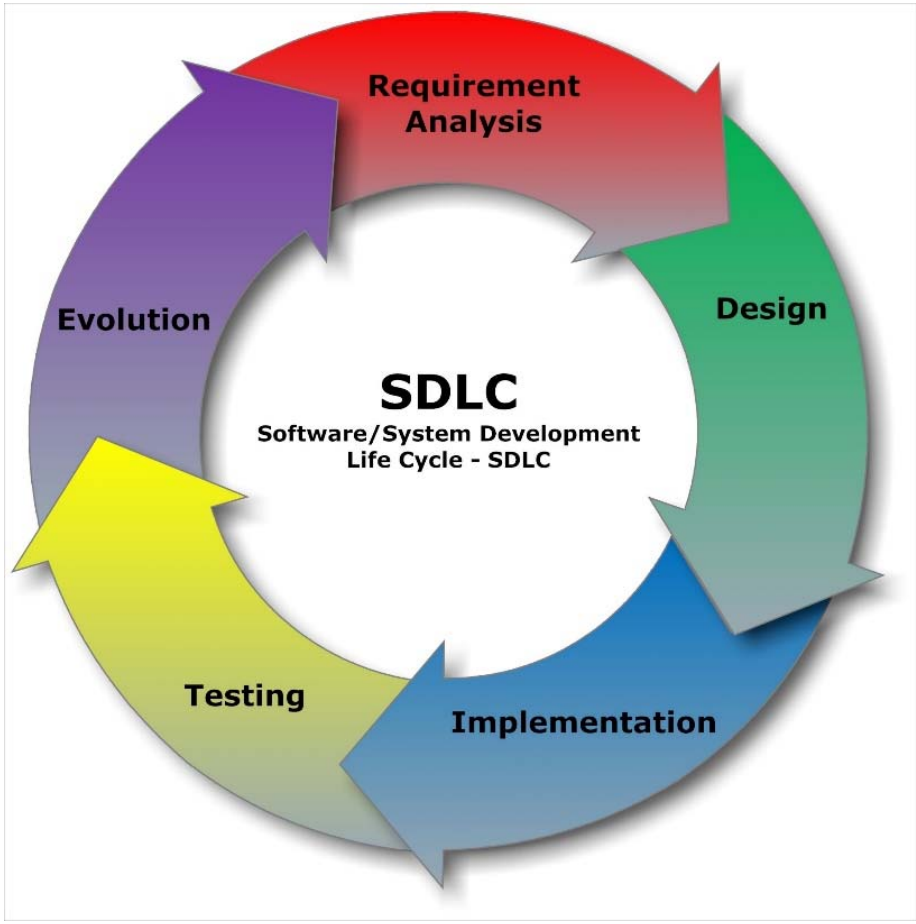
Acknowledgement

- I would like to thank all my collaborators since 2001 … (both in industry and academia)

… and many others…

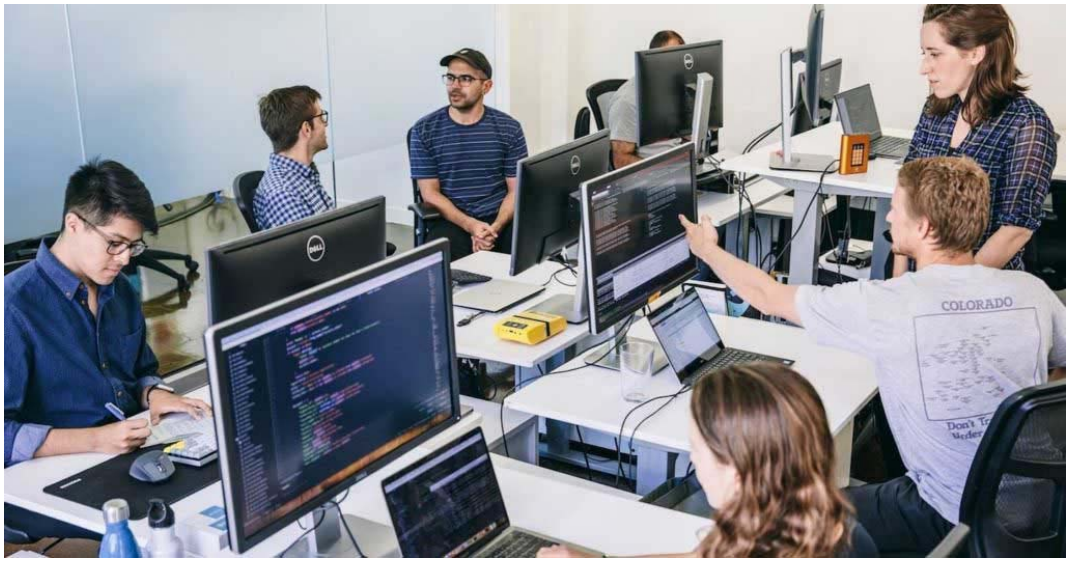
(Reminder) What is Software Engineering?

- **Software engineering is the systematic application of engineering approaches to the development of software.**
- **Software Development Life Cycle (SDLC): Phases and knowledge areas:**
  - Requirements engineering
  - Software design
  - Implementation
    (coding, programming)
  - Software testing and QA
  - Software maintenance
    and evolution
  - Software project management
  - Software process
  - …



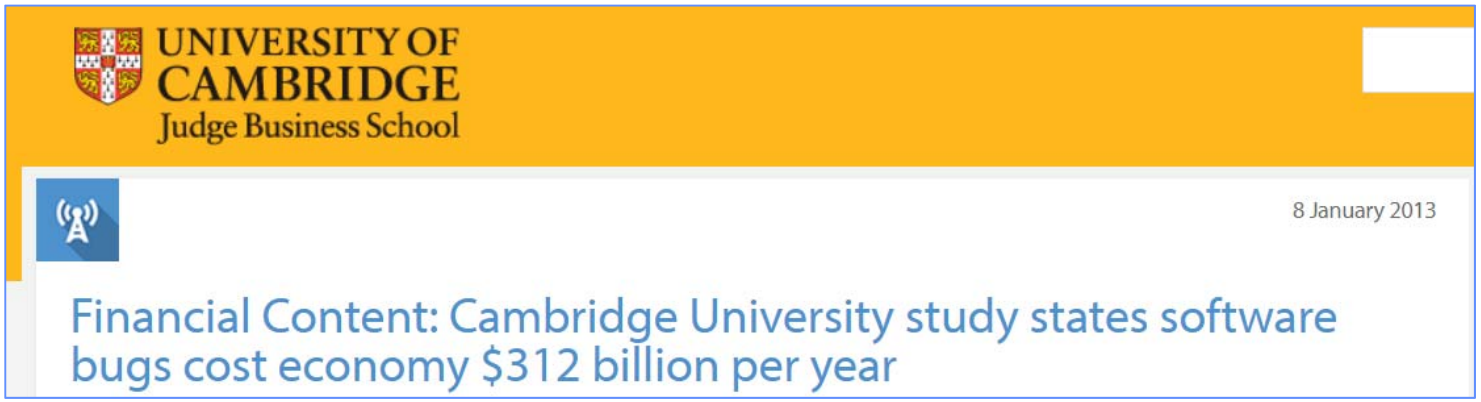
Software Engineering (SE): Example Research Questions

- How can we manage software requirements in an effective and efficient manner?
- How can we design software systems in an effective and efficient manner?
- How can we implement software in an effective and efficient manner? (such as OO concepts)
- How can we test a given software system in an effective and efficient manner?
- How can we maintain (evolve) a given software system in an effective and efficient manner?
- Howe should we manage a software project in an effective and efficient manner?



(Many!) Motivations for applied SE research…

- Did you know that the **global cost** of **detecting** and **fixing software defects** has risen to **$312 billion annually?**



insight.jbs.cam.ac.uk/2013/financial-content-cambridge-university-study-states-software-bugs-cost-economy-312-billion-per-year

- **Thus, we really need effective and efficient Software Engineering practices…**

Goal of software engineering (SE) research

- **What we, SE researchers, do:**

Train young researchers in SE

1-Characterize / formalize software engineering practices, challenges, etc.

SE researcher

2-Develop approaches to help engineers develop, and test software in an effective and efficient manner

Software companies and engineers

Engineer and release software

Software

Software to be used by

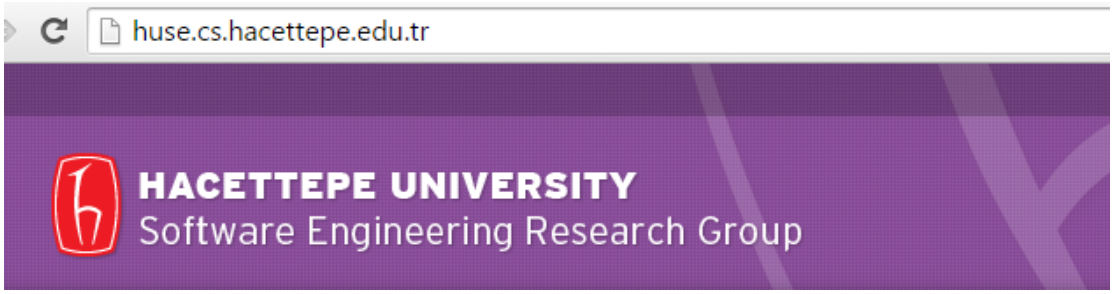
Clients (customers) using software systems

Solicit requirements / needs

Publish papers

Hacettepe University Software Engineering (HUSE) (2015-2017)

- Founded and led by myself
- 3 faculty members
- 20+ graduate students
- 10+ industry partners



Research in University of Calgary, Canada (2006-2014)

- Established and led the Software Quality Engineering Research Group (SoftQual)
- www.softqual.ucalgary.ca

- Research team:
  - 2 Post-doctoral fellows
  - 3 PhD students
  - 9 MSc students
  - 30+ undergraduate research students

- Almost all our projects were applied R&D projects in collaboration with the industry.

- More than 10 industrial partners such as IBM
- More than $1.3 Million CND in funding in 6 years

- Output:
  - More than 30 journal papers and 45 conference papers
  - Several software tools
  - One start-up firm and one commercialized software product

Optimal Pipeline

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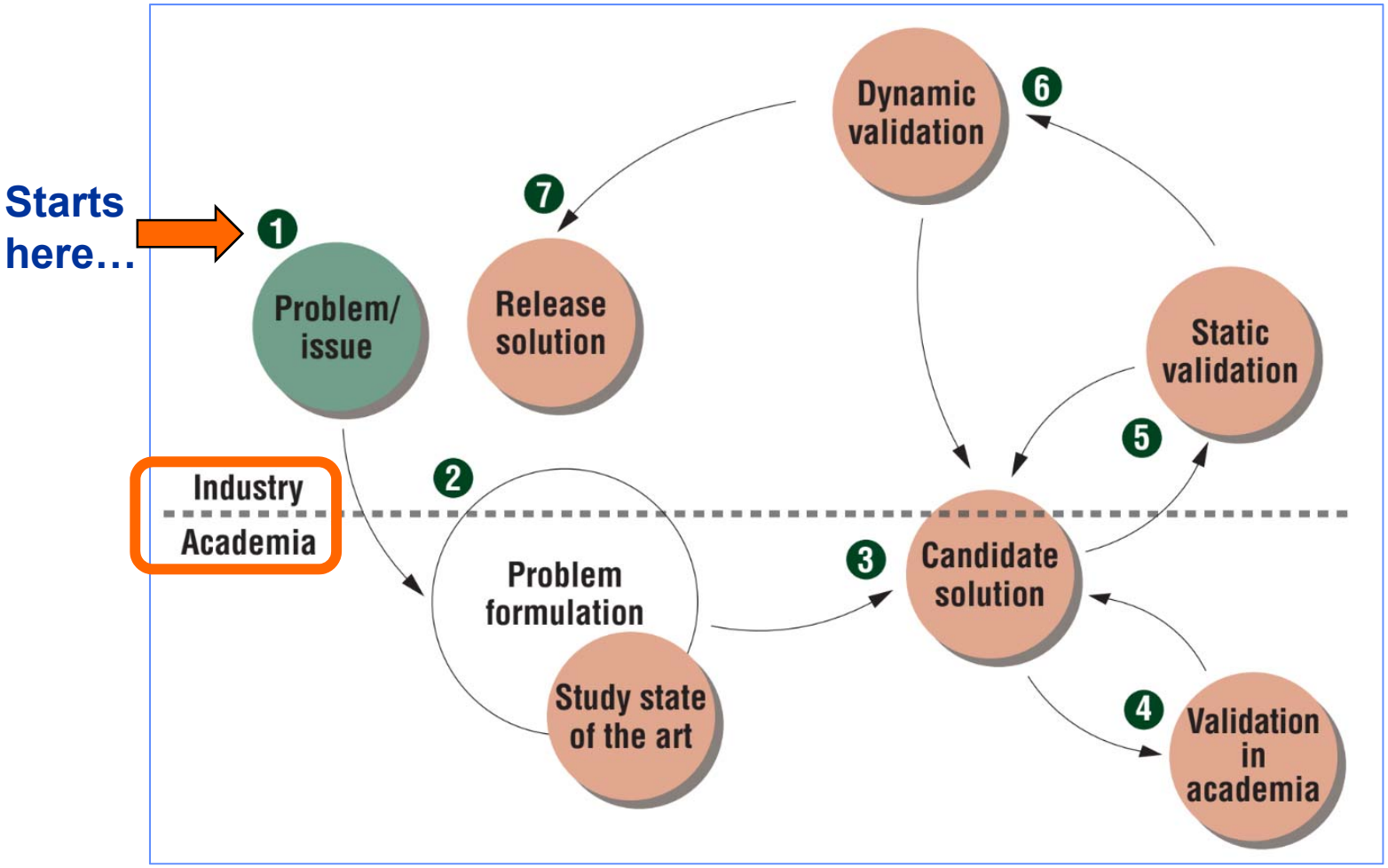
Our research goal and philosophy

- **Goal: To help software companies and engineers "engineer" (develop, test and maintain) large-scale software systems in an effective and efficient manner**



Gorschek et al., "A Model for Technology Transfer in Practice", IEEE Software, vol. 23, pp. 88-95, 2006

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Research Projects in the UK, EU and Turkey

- **Research Project: XANDAR: X-by-Construction Design framework for Engineering Autonomous & Distributed Real-time Embedded Software Systems (2020-2024)**
  - Eight (8) partners from across Europe, including five industry and three academic partners – Project will start in November 2020
  - Budget: €5 million Euros

- **Research Project: TESTOMAT (The Next Level of Test Automation)**
  - Industry partners: Two large companies, project funded by the EU
  - Budget: €21 million Euros
  - www.testomatproject.eu (2018-2020)

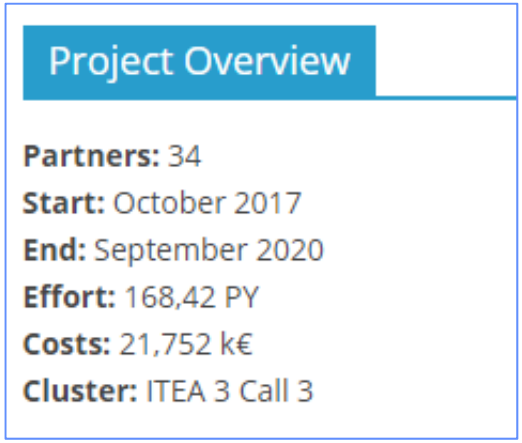
- **Research Project: Multi-objective regression test selection (2016- 2017)**
  - Industry partner: An aviation contractor (anonymous)
- **Research Project: Improving test automation practices**
  - **Industry partner: HAVELSAN A.Ş. (*Hava Elektronik Sanayi*, Aviation Electronics Industries),** (2015-2017)

- **Research Project: Automated testing of law-management software suite**
  - **Industry partner: Innova IT Solutions, Ankara, Turkey** (2016-2017)

- **Research Project : Approach and tool-set for automated inspection of software design documents** (2016)
  - Industry partner: Turkish Aerospace Industries, Inc. (TAI)

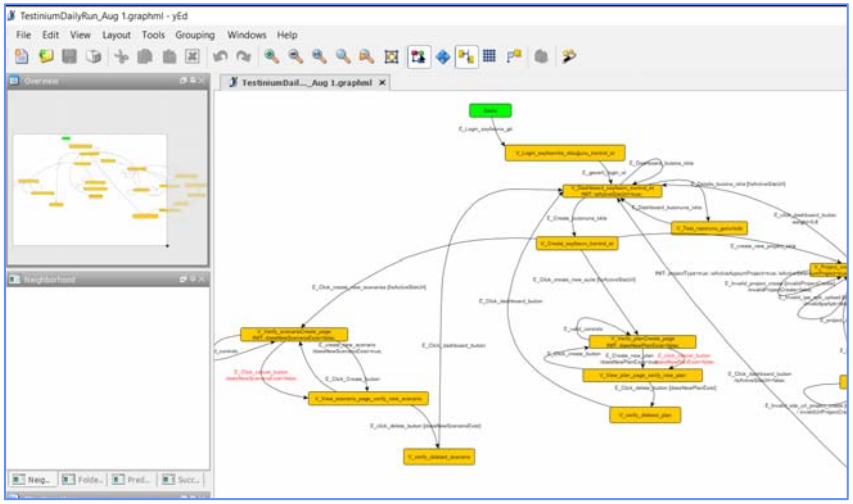
The TESTOMAT project: The Next Level of Test Automation

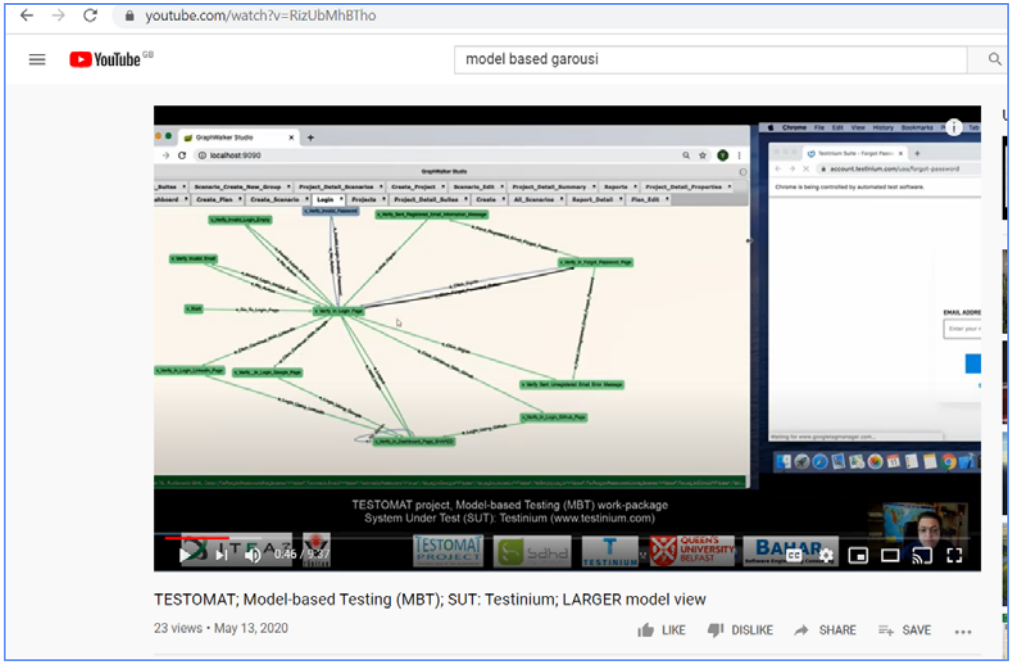
- Topics:
  - Model-based testing
  - Visualization of test results
  - Test prioritization and selection
  - Improving the quality of automated test-code
- Project is funded by the ITEA3 program and the government of the six countries involved in the project
  - *"ITEA is a transnational and industry-driven R&D&I programme in the domain of software innovation [in Europe]"*
- **www.testomatproject.eu**



The TESTOMAT project

- **Benefit:**
  - Automating both the test-case design and test-case execution
  - Testing almost all possible paths (would be impossible to do in manual testing)
- **Let's see the video below":**
  - www.youtube.com/watch?v=RizUbMhBTho





The TESTOMAT project

- **Several papers are in the pipeline:**

Model-based testing in practice: An experience report from the banking domain

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Kuveyt Türk R&D Center
Kocaeli, Turkey
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***Abstract*— Model-driven software engineering has become more popular in recent years. Due to the high number and diversity of users, new testing approaches are necessary to reduce the occurrence of faults and ensure higher quality in industrial applications. The objective of this paper is to evaluate the use of Model-Based Testing (MBT) practices in the development and exeuction of automated test suites to verify and validate internet-banking solutions in the context of a large banking institution in Turkey.**

***Keywords*— Model-based testing, graphwalker, internet banking, expereine report, industrial case study**

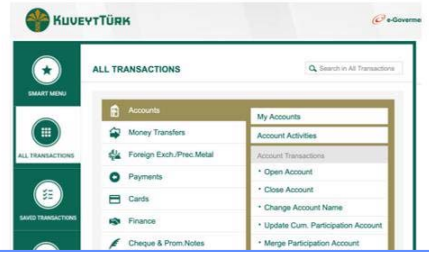

Figure 2-A view from the physical test setup and hardware

Pragmatic model-based testing: Experience from the web applications domain

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Queen's University Belfast

Alper Buğra Keleş, Yunus Balaman, Zeynep Özdemir Güler
Saha Information Technologies A.Ş.

Andrea Arcuri
Kristiania University College

Abstract: In the context of a large software testing company, we have deployed the model-based testing (MBT) approach to take the company's test automation practices to the next level. We have chosen, from a set of MBT tools, an open-source tool named *GraphWalker*, and have pragmatically used MBT for end-to-end test automation of several systems. The MBT approach has provided various tangible and

[4]. Several papers on MBT have been published in IEEE Software in the past, e.g., [5]. However, many studies report that: "*most developers [still] don't view MBT as a mainstream [testing] approach*" [5].

Projects in Canada

- Project 1: Decision-support for deciding “when to automate testing” and “what (test cases) to automate” **2010-2012**
  - Industry partner: Pason Systems Corporation, Calgary, Canada

- Project 2: Optimizing amount and level of software documentation **2009-2012**
  - Industry partner: NovAtel Inc., Calgary, Canada

- Project 3: Development and assessment of effective test automation infrastructure **2008-2011**
  - Industry partner: MR Control Systems International, Calgary, Canada

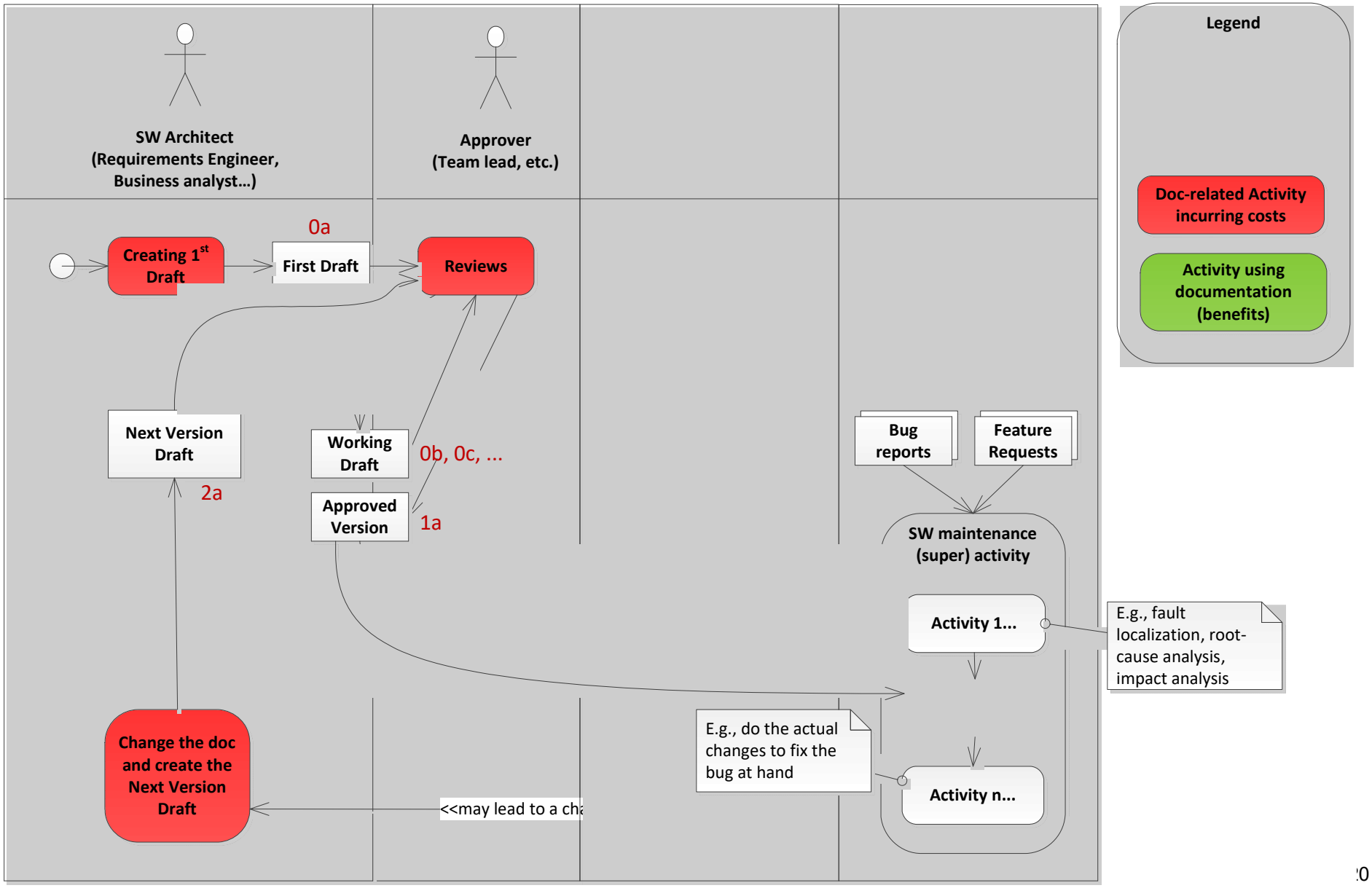
- Project 4: Development and assessment of effective automated “environment configuration” testing infrastructure **2007-2009**
  - Industry partner: Alberta Energy Resources Conservation Board (ERCB), Calgary, Canada
  - Challenge: The cost of manual “environment configuration” testing was very high. Need for test automation

Research project #2: Summary

- **Industry partner:**
  - NovAtel Inc., Calgary, Canada, a global leader in GPS and GNSS software and systems (embedded software with C/C++ code inside)
  - The company had CMMI Level-3 certification
- **Clients:**
  - Military, agriculture, ….
- **Challenge:**
  - Huge amounts of effort (cost $$$) were spent for developing and maintaining software documentation in the last several years
    - ☞Reminder: According to the literature and various empirical studies, software maintenance typically consumes 40 to 80% of software project costs.
- **Solution:**
  - A systematic approach for reducing cost of software documentation was developed and deployed in the industrial context

How did we systematically optimize cost of software documentation?

For requirements and design documents

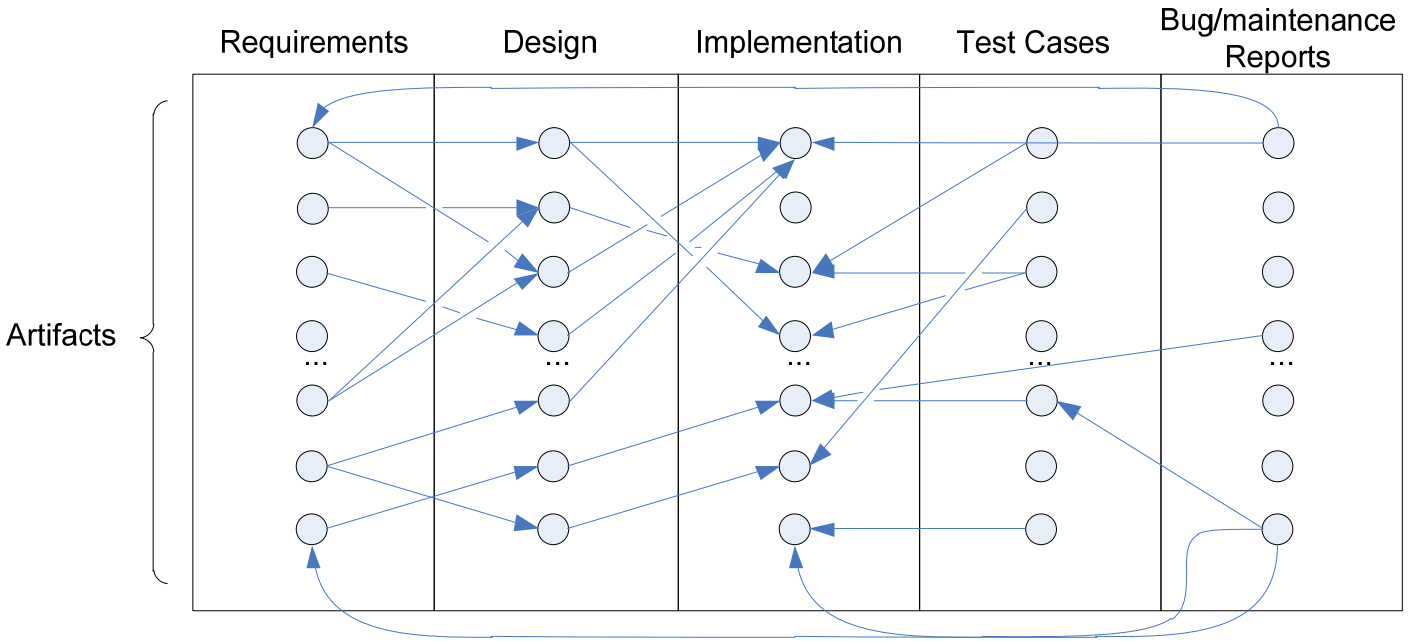


Cost Metrics

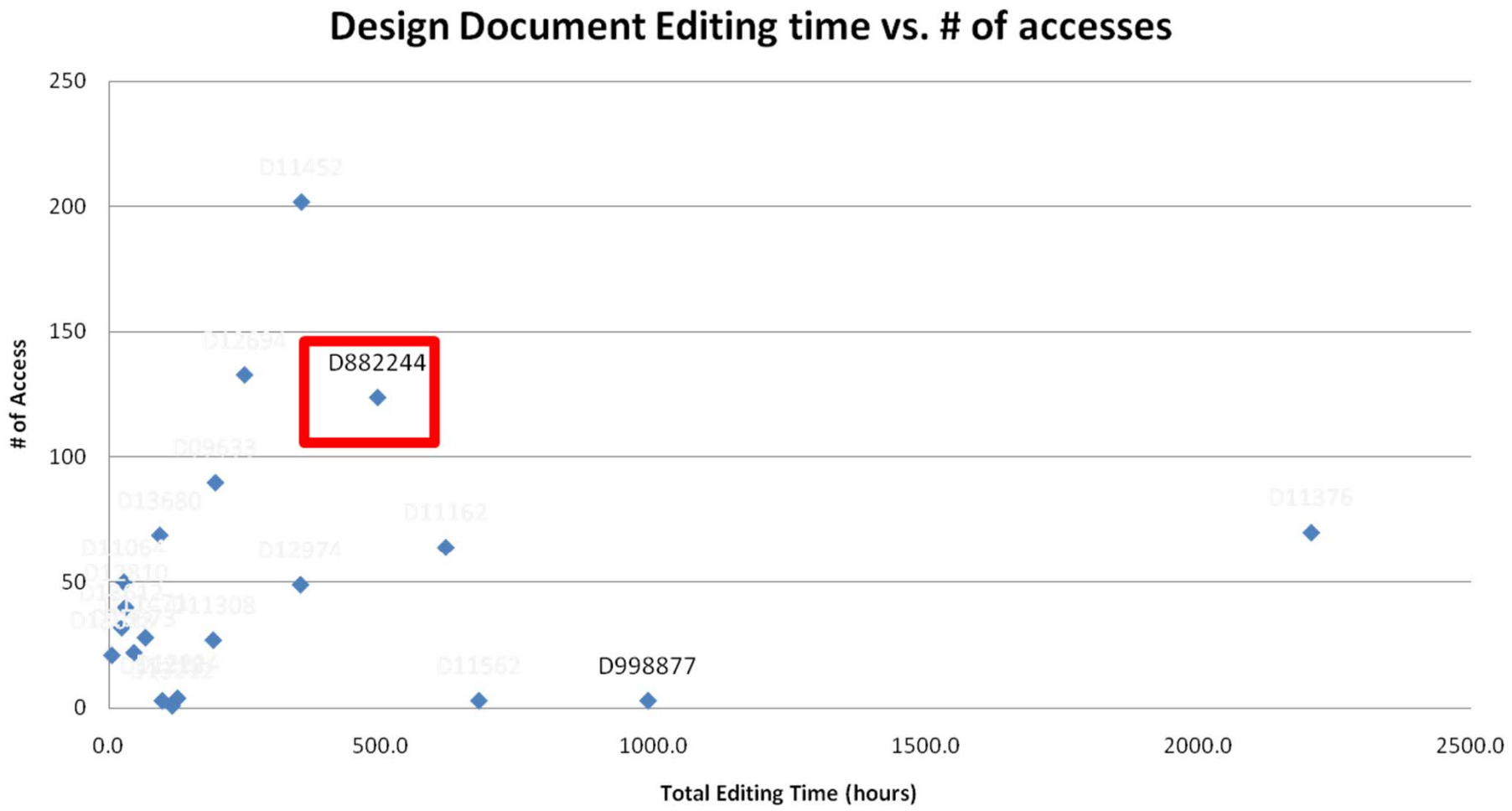
Benefit Metrics

- Initial cost
  - Number of minutes
  - Number of words in the file
- Maintenance cost
  - The above
  - + Amount of change from each version to the next
  - …

- Benefit (usage) during development cycle
- Benefit (usage) after the development: during maintenance
  - Which sections of a certain documentation are used?
  - How much help a certain documentation artifact has made for a task at hand?



How can we systematically optimize cost of software documentation?



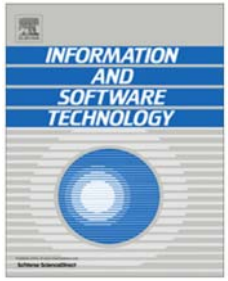
Projects in Canada

- **Industry partner:**
  - NovAtel Inc., Calgary, Canada
- **Solution:**
  - A systematic approach for optimizing cost of software documentation was developed and released to the industrial context.
- **More details in the following articles:**

Usage and usefulness of technical software documentation: An industrial case study

Golara Garousi [a,b], Vahid Garousi-Yusifoğlu [c,b,*], Guenther Ruhe [b,d], Junji Zhi [e], Mahmoud Moussavi [b], Brian Smith [f]

[a] geoLOGIC Systems Ltd., Calgary, Alberta, Canada
[b] Department of Electrical and Computer Engineering, Schulich School of Engineering, University of Calgary, Alberta, Canada
[c] System and Software Quality Engineering Research Group (SySoQual), Department of Software Engineering, Atilim University, İncek, Ankara, Turkey
[d] Department of Computer Science, University of Calgary, Calgary, Alberta, Canada
[e] Department of Computer Science, University of Toronto, Toronto, Ontario, Canada
[f] NovAtel Inc., Calgary, Alberta, Canada



Cost, benefits and quality of software development documentation: A systematic mapping

Junji Zhi [a], Vahid Garousi-Yusifoğlu [b,c,*], Bo Sun [d,e], Golara Garousi [c,f], Shawn Shahnewaz [c], Guenther Ruhe [c,d]

[a] Department of Computer Science, University of Toronto, Ontario, Canada
[b] System and Software Quality Engineering Research Group (SySoQual), Department of Software Engineering, Atilim University, İncek, Ankara, Turkey
[c] Department of Electrical and Computer Engineering, University of Calgary, Alberta, Canada
[d] Department of Computer Science, University of Calgary, Alberta, Canada
[e] iSolutions Inc., Calgary, Alberta, Canada
[f] geoLOGIC Systems Ltd., Calgary, Alberta, Canada

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Challenges and best practices

- **Synthesized the findings of 33 primary studies**

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journal homepage: www.elsevier.com/locate/infsof

Challenges and best practices in industry-academia collaborations in software engineering: A systematic literature review

Vahid Garousi[a,b,*], Kai Petersen[c], Baris Ozkan[d]

[a] Software Engineering Research Group, Department of Computer Engineering, Hacettepe University, Ankara, Turkey
[b] Maral Software Engineering Consulting Corporation, Calgary, Canada
[c] Department of Software Engineering, School of Engineering, Blekinge Institute of Technology, Sweden
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Agile Collaborative Research:

Action Principles for Industry-Academia Collaboration

Anna B. Sandberg, Ericsson

Lars Pareto and Thomas Arts, Chalmers University of Technology

Action Research as a Model for Industry-Academia Collaboration in the Software Engineering Context

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The 4+1 View Model of Industry–Academia Collaboration

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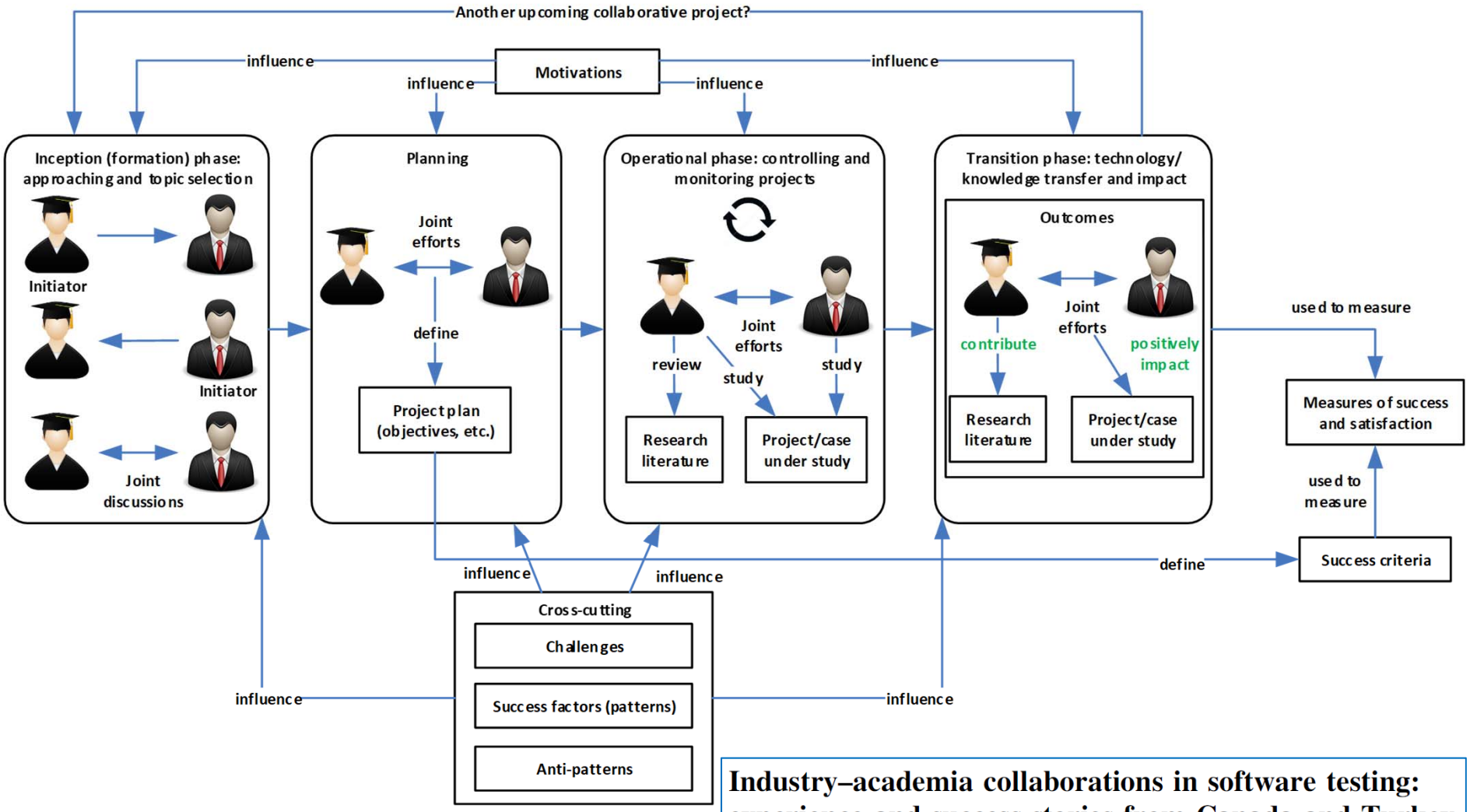
Data from: 33 “primary” studies… Three of them:

A typical simplified process for industry-academia collaborations



Industry–academia collaborations in software testing: experience and success stories from Canada and Turkey

Vahid Garousi[1,2] · Matt M. Eskandar[3] · Kadir Herkiloğlu[4]

Challenges and best practices

Challenges	Best practices (success patterns)
1. Lack of research relevance 2. Research method related 3. Lack of training, experience, and skills 4. Lack or drop of interest / commitment 5. Mismatch between industry and academia 6. Communication-related issues 7. Human and organizational factors 8. Management-related issues 9. Resource-related issues 10. Contractual, and privacy concerns	1. Knowledge management (communication, terminology, transfer, training and skills) 2. Ensure engagement and manage commitment 3. Consider and understand industry's needs, challenges, goals and problems 4. Ensure giving explicit industry benefits and solve the right problem 5. Have mutual respect, understanding and appreciation 6. Be Agile 7. Work in (as) a team and involving the "right" practitioners 8. Consider and manage risks and limitations 9. Researcher's on-site presence and access 10. Follow a proper research/data collection method 11. Manage funding/recruiting/partnerships and contracting privacy 12. Understand the context, constraints and language 13. Efficient research project management 14. Conduct measurement/ assessment 15. Test pilot solutions before using them in industry 16. Provide tool support for solutions

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[b] Maral Software Engineering Consulting Corporation, Calgary, Canada
[c] Department of Software Engineering, School of Engineering, Blekinge Institute of Technology, Sweden
[d] Department of Information Systems Engineering, Atilim University, Ankara, Turkey

Another work

2016 IEEE International Conference on Software Testing, Verification and Validation

Selecting the right topics for industry-academia collaborations in software testing: an experience report

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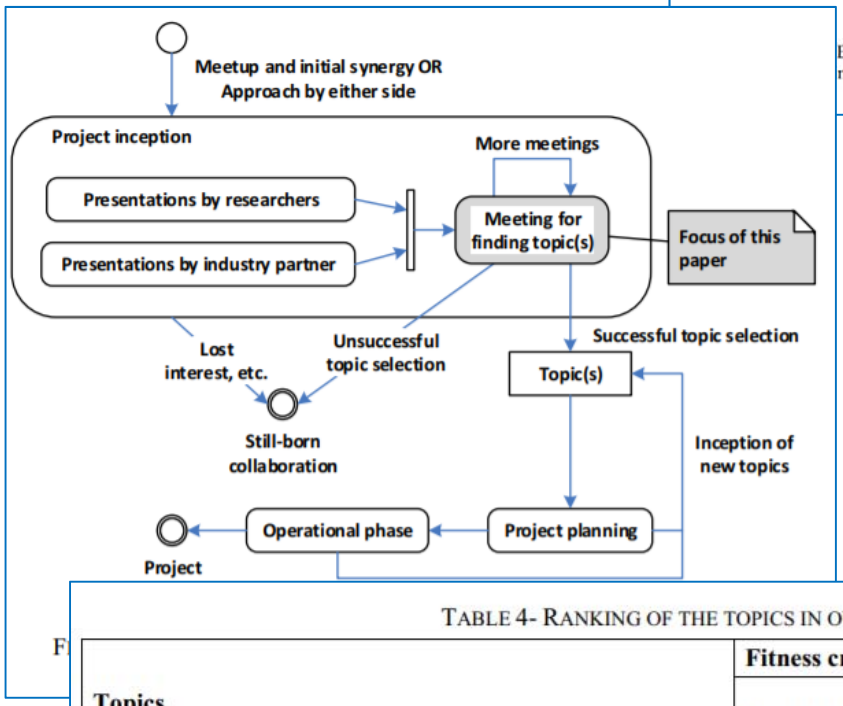

TABLE 4- RANKING OF THE TOPICS IN OUR CASE BASED ON THE CRITERIA DEFINED BY MISIRLI ET AL. [1]

Topics	Fitness criteria for topics (1: Low, 2: Medium, 3: High)				
	Concreteness	Suitability for experimentation	Relevance to research community	Prior domain experience of researchers	Average
Need for more test automation for test group X	3	3	2	3	2.75
Need for more test automation for test group Y	3	3	2	3	2.75
Need for more test automation for test group Z	3	3	2	3	2.75
Assessing and improving an in-house test automation framework for test group Q	3	3	2	3	2.75
Establishing a systematic, effective and efficient GQM-based measurement program for the testing department	2	2	3	2	2.25
Assessment and improvement of test process maturity using TMMI and TPI-Next	3	2	2	2	2.25
Bi-directional knowledge transfer (in software testing) from/to international organizations in the aviation industry	2	N/A	N/A	2	2

Outline

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  - Of the speaker, and his research teams in the past
  - Our research philosophy and approach
- **Success stories of industry-academia collaborations**
  - Projects in Canada
  - Projects in Turkey
  - Challenges, best practices, and collaboration models

Questions and answers