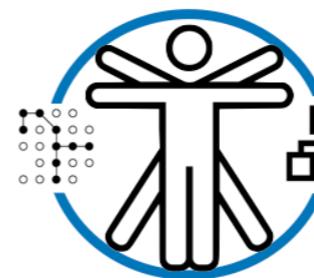


In Quest of Requirements Engineering Research that Industry needs

CibSE WER 2018
Bogotá, Colombia

Daniel Méndez
Technical University of Munich, Germany

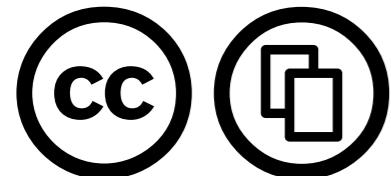


evidence-based
Human-Centred Software Engineering

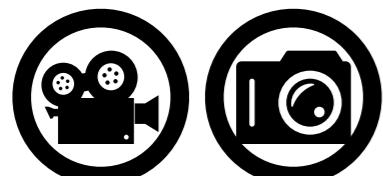


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The Year 1977

Guest Editorial

Reflections on Requirements

INTRODUCTION

MAN is a social animal. Man also is a tool-user. Computer systems are social tools. Computer systems are man-users. Ponder that. Then proceed.

This is a Special Issue of the IEEE TRANSACTIONS ON SOFTWARE ENGINEERING. But it is not merely a Special Issue, it is a *special* Special Issue. It addresses the most special of all issues in our field—how can man master his use of computers rather than being mastered by them? This should be our highest concern, but as yet it has not been directly addressed in the pell-mell burgeoning of our technology-oriented understanding of computers and their uses.

THE THESIS

Some may say this is too grand sounding. Some may say, "My interest in computers is only to compute numbers. My computer is not social at all. It is not even a system. I just write programs." But do not fool yourself. That simply is not so. Even the most mundane use of a computer is part of a system, and even the simplest such system does involve man, somehow.

The reason is quite simple. Every computer use is a tool use. And, as tools, computers process only one kind of thing—numbers (or bits). Numbers are abstract creations of man. Numbers represent, to man, information—every time—they never are mere numbers, but always have a meaning, an interpretation. Either man or (via his programming of a machine to act as his surrogate) another machine always interprets those numbers. So always there is a system. And always there is man either in that system, or at its boundary. So it is a social system.

Every use of a computer is intended to serve some purpose, and we intend that that purpose be established by man. We intend that the computer be *required* to perform certain functions in order that some higher purpose of man be served. We do not want the man to be subservient to the machine. Nor do we want the purpose of man to be subverted or compromised. We want to *require* the machine to conform to the man, not the other way around, and with no back talk either. But both our individual and collective experience has shown this is seldom the case. We tussle with our machines as though doing battle with some devil with a will of its own. We are baffled by the untoward consequences of our sorcerer's apprentice gone wild.

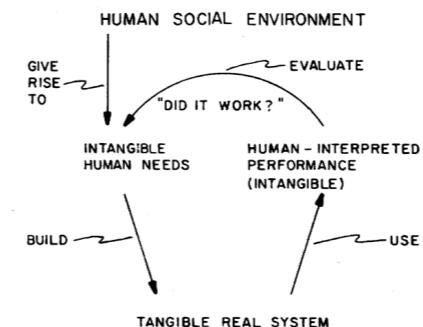


Fig. 1. Reflection.

tools we sense some insidious presence actively working against us, making *us* the one who is required to succumb, even if only a little.

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The reason again is quite simple, but this time extraordinarily difficult to cope with. There is *indeed* another will doing battle with our own, a black-hearted genie of our own making that *does* in fact impose its will on us. Our senses do not deceive us. There *is* a demon in the bottle. And its will is just as willful and strong as our own—for the demon is *us*.

The opposing will in our systems is our own will itself, reflected back to us, as in a distorting mirror, by the imperfections of our system technology. What starts out as valid desire is turned around and thrown back at us as erratic, miscreant system behavior. Every time we make a move, the demon makes a counter move. There is no escape, just as there is no escape from the wild distortions of our image in a fun-house mirror. But this is no fun-house mirror. This is man-moving, society-transforming system technology. Why does it act like a mirror? Fig. 1 shows the reason.

In every case of computer use, some human needs arise out of the human social environment. These needs are intangible, but nonetheless very real. They stem from real, willful desires to somehow have things be different. In every case, in one way or another, some form of system technology is used to build a tangible, real system intended to satisfy those needs. The system is put to use and yields tangible behavior—mechanisms move, numbers are printed, and so forth.

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TANGI

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The reason again is quite simple. It is ordinarily difficult to cope with a situation in which we are doing battle with our own, internal forces, making that *does* in fact impossible. We are not deceived by the situation; we are not deceived us. There is a force that is as strong as we are, and is just as willful and strong as we are.

The opposing will in our system is reflected back to us, as in a mirror. The inflections of our system tell us that our desire is turned around and reflected back to us, as in a miscreant system behavior.

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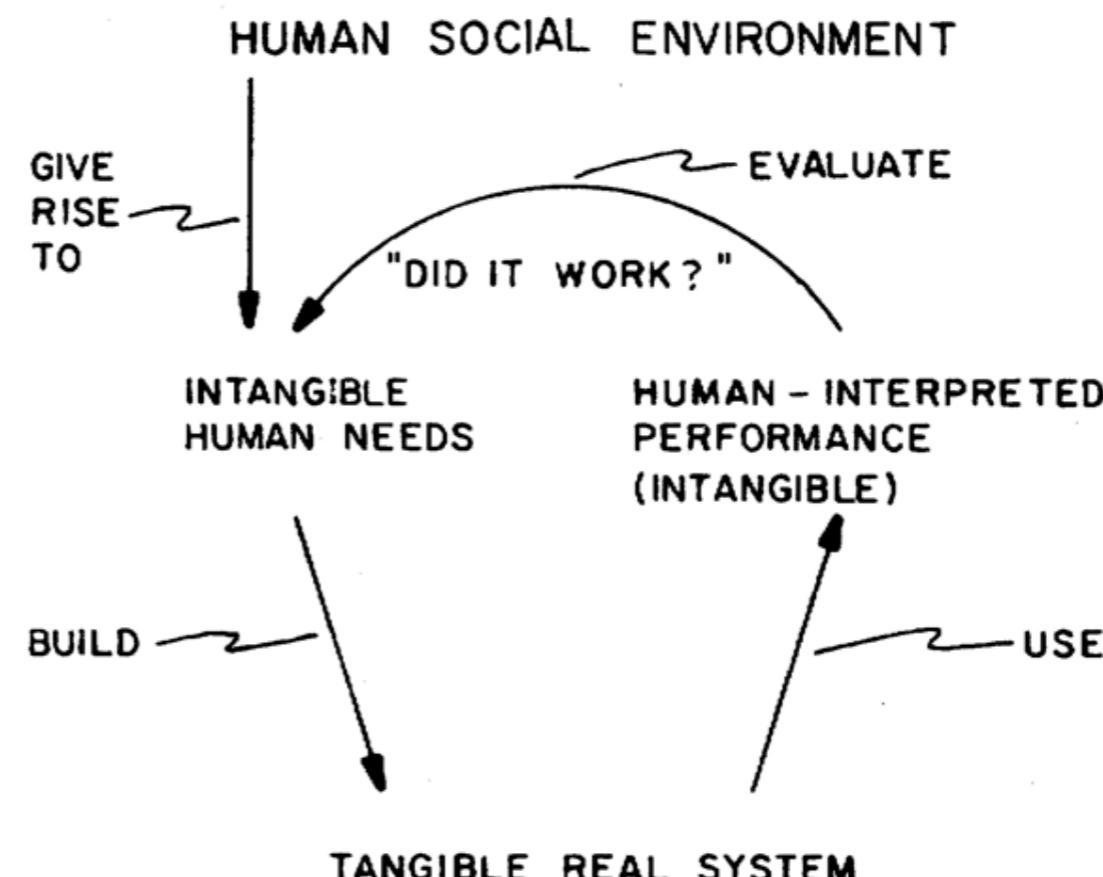


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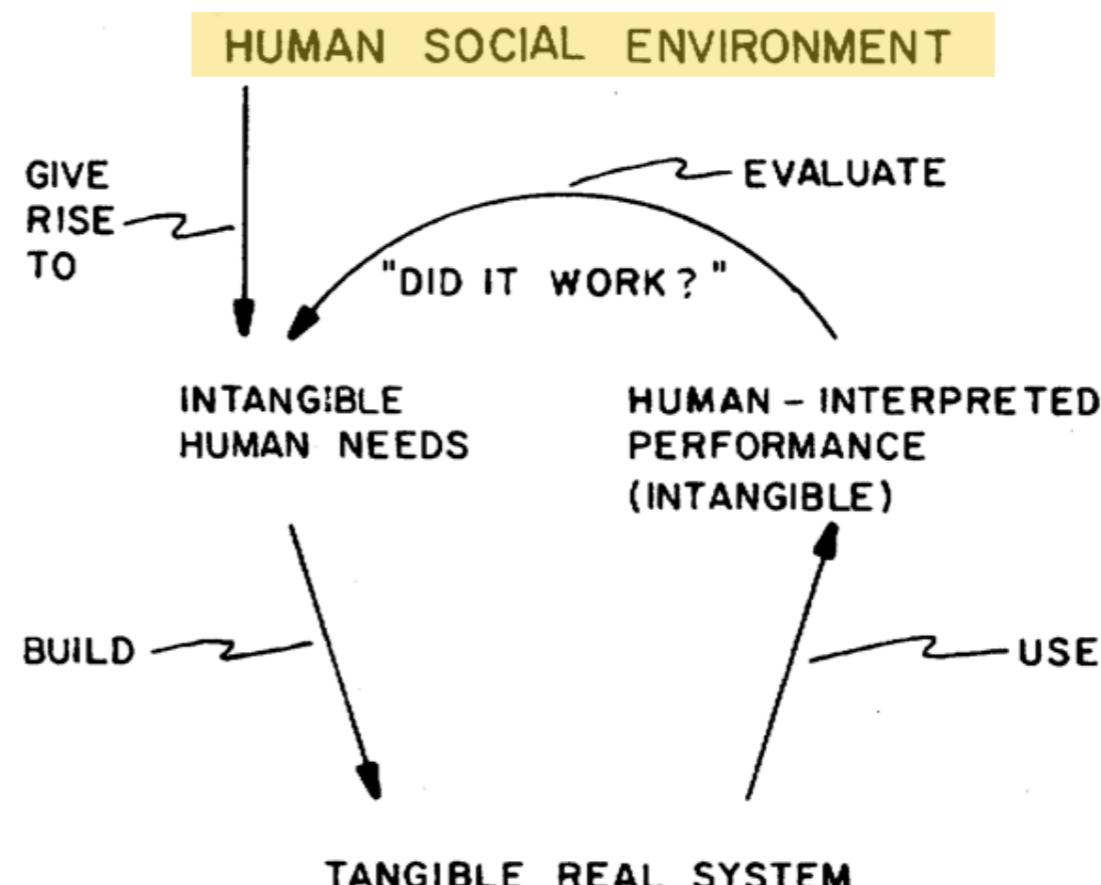


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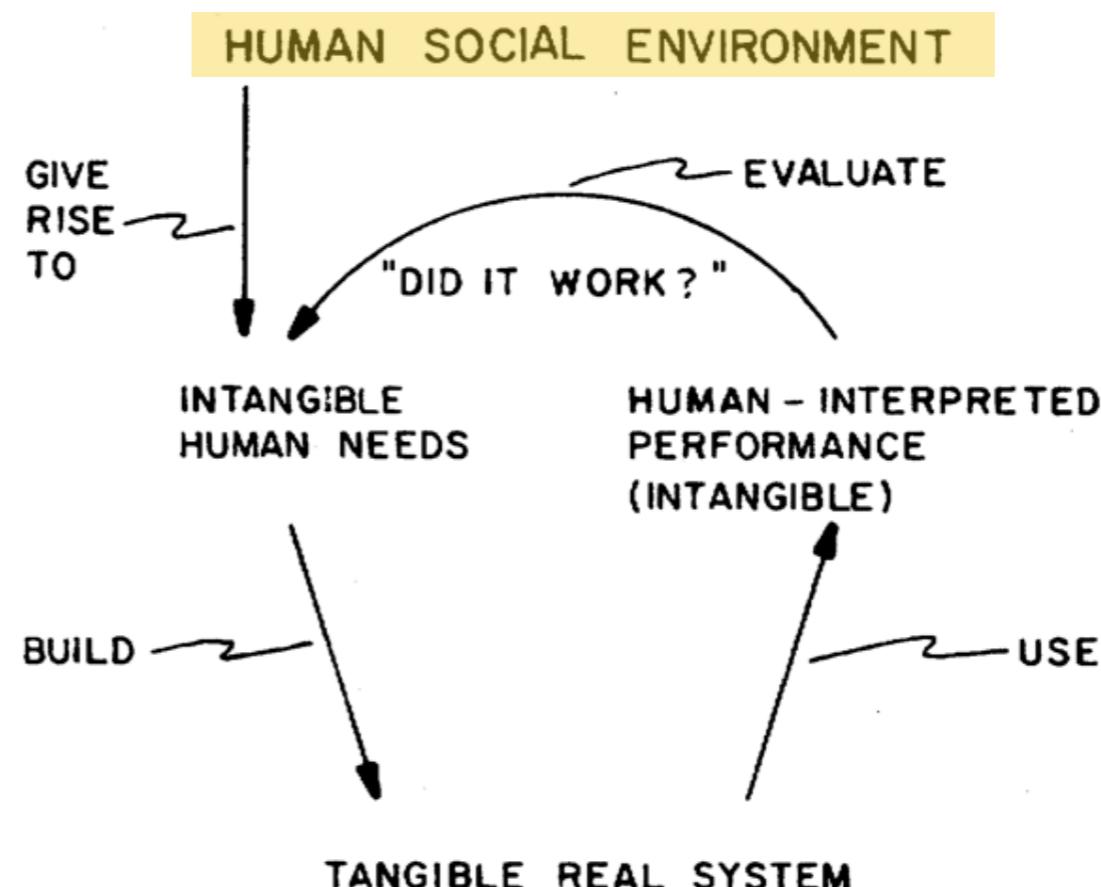


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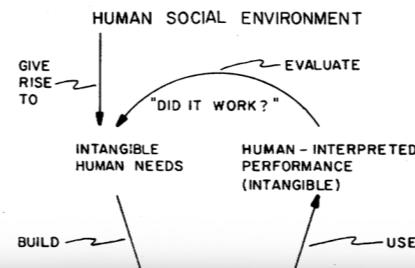
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Today

Germany Seeks Toll Collect Compensation

The German government announced Thursday it would seek almost €4.5 billion in compensation from the companies it contracted to build a high-tech highway toll system for heavy trucks.

Originally scheduled to launch in August 2003, the satellite system designed by automaker DaimlerChrysler and telecommunications giant Deutsche Telekom failed and is currently being replaced by a less-sophisticated system.

The system has been plagued with technical troubles -- including problems with the 3,000 roadside terminals for payment, the 150 control bridges and the electronic devices truck drivers must install in their rigs in order to operate within Germany. In addition to the 2003 failure, Toll Collect failed to meet a second deadline last year and has now proposed a simpler system that is planned to go into operation in January 2005.

Siren police I a 'debacle'



US Army's Future Combat Systems Program Formally Terminated

Tran

Robe

30 Million German Bank Cards Almost Fixed

2010 Date Problem Still Exists For Cards Used Outside of
Germany

Robert Charette



As I mentioned a few days ago, some 2010 date problems hit various electronic systems and devices in different parts of the world on New Years Day. One Risk Factor reader noted that Germany likely experienced the greatest date-related problem because software in a security microchip used in 30 million German bank cards was unable to recognize the date 2010.

BBC abandons £100m failure

James Purnell, BBC's director of strategy and digital, "The BBC has scrapped a £99m digital project", says a spokesperson

The BBC has scrapped a £99m digital project, says a spokesperson. The director general said it was "not worth the money".

The Director General

Government to downsize Canada.ca project

...the IT initiative, says a spokesperson

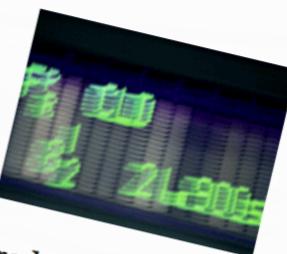
...the IT initiative, says a spokesperson

£100m digital project

London Stock Exchange Suffers 4 Hour Outage

Rob

Traders disgusted - again



age suffered yet another technical problem today. This

e suspended for some 4 hours.

try at the London Telegraph, trading was halted a few minutes earlier at 0800 London time. The market then reopened at 0845, according to reports.

SN Airways) London

continued into today.

for occurring, BA

re the day began. It also

v with hand luggage. I

programme for

urgently" dismantled.

ned

[EHR]

Health,

In 2016 alone ...



548 publicly reported failures

\$ 1.1 trillion impact in assets

4.4 billion people affected

(Amounts to over 50% of world's population)

“The serious problems that have happened with software have to do with requirements, not coding errors.”

— Nancy Leveson

33%

... of errors happen in RE.

36%

... of errors in RE lead to project failure.

Why do we still have so many problems?



1977

Today



1977



Today





1977



Today



Yet, many of our contributions

- ▶ pretend to be universal,
- ▶ address problems not well understood, and / or
- ▶ remain unknown.

There is a gap between research and practice

Key question

How can we foster research that
industry needs?

Key question

How can we foster research that industry needs?



This is a recognised problem



In Quest for RE Research that Industry Needs

- ▶ Turn RE into a theory-centric discipline
... to eradicate the many Leprechauns we still have.
- ▶ Understand practitioners' problems
... to foster problem-driven research.
- ▶ Engage in academia-industry collaborations
... to analyse problems in their natural environment and frame our work.



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Goal-oriented Requirements Engineering

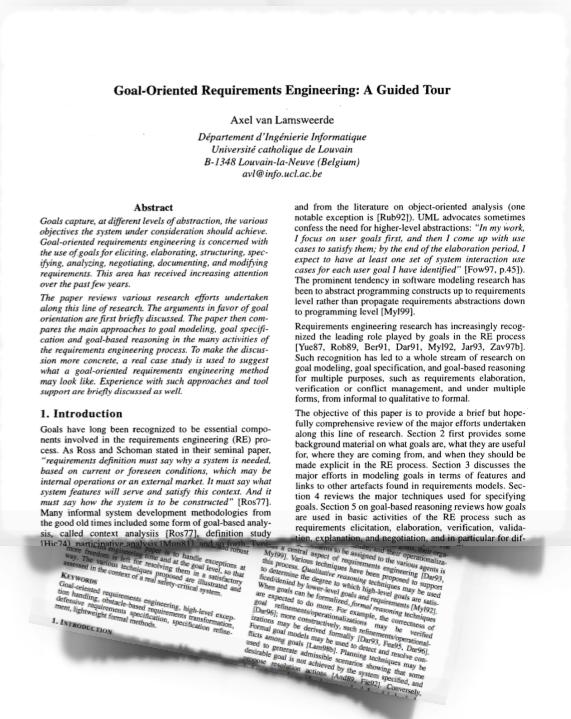
(Example to be taken with a grain of salt)

Goal-oriented Requirements Engineering

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Papers published [1]:

966



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Papers cited at least 3 times:

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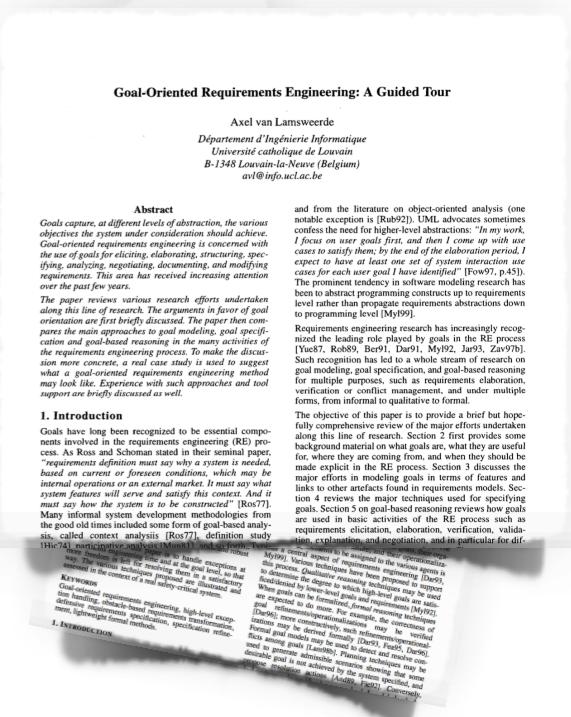
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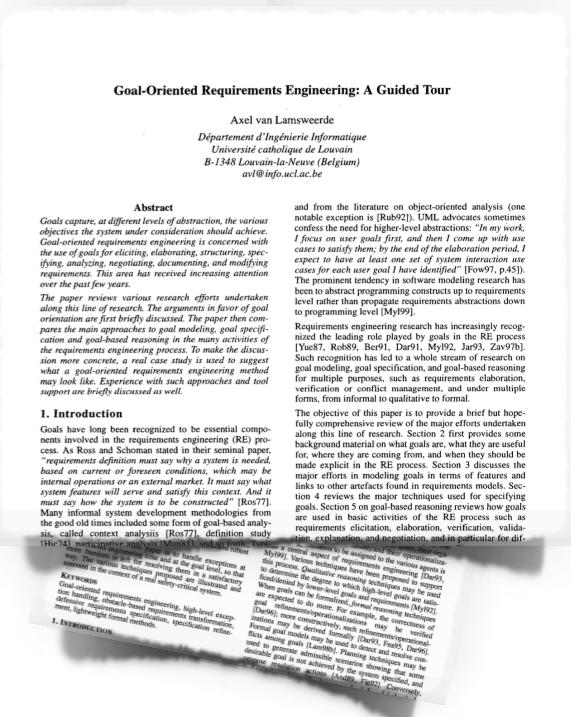
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Actual in-vivo case studies [2]:

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[1] Horkoff et al. Goal-Oriented Requirements Engineering: A Systematic Literature Map, 2016

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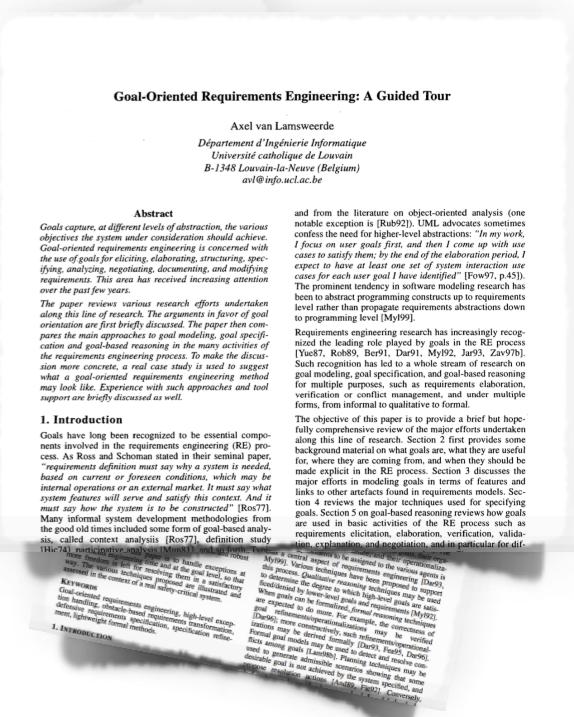
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Practitioners actually using GORE [3]: ~ 5%
(among 228 companies surveyed)



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Goal-oriented Requirements Engineering

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For comparison:

Icelanders believing in elves [1]: 54%

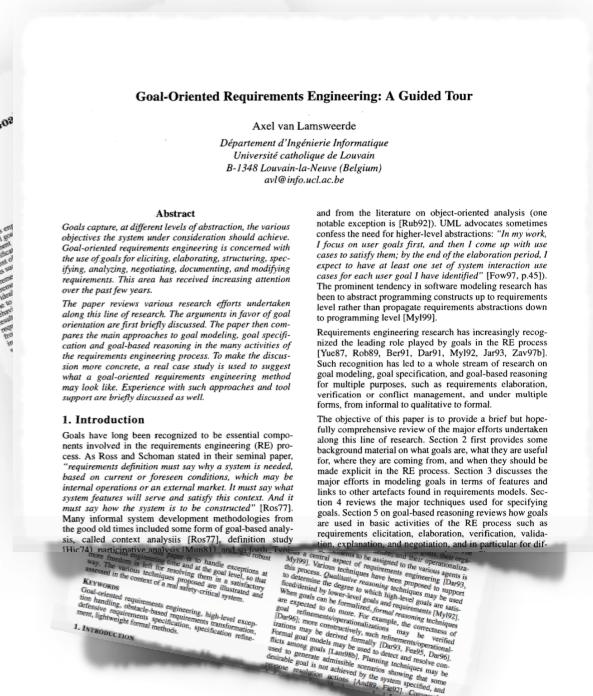
[1] <https://www.nationalgeographic.com/travel/destinations/europe/iceland/believes-elves-exist-mythology/>

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Current state of evidence in RE is weak

“[...] judging a theory by assessing the number, faith, and vocal energy of its supporters [...] basic political credo of contemporary religious maniacs”

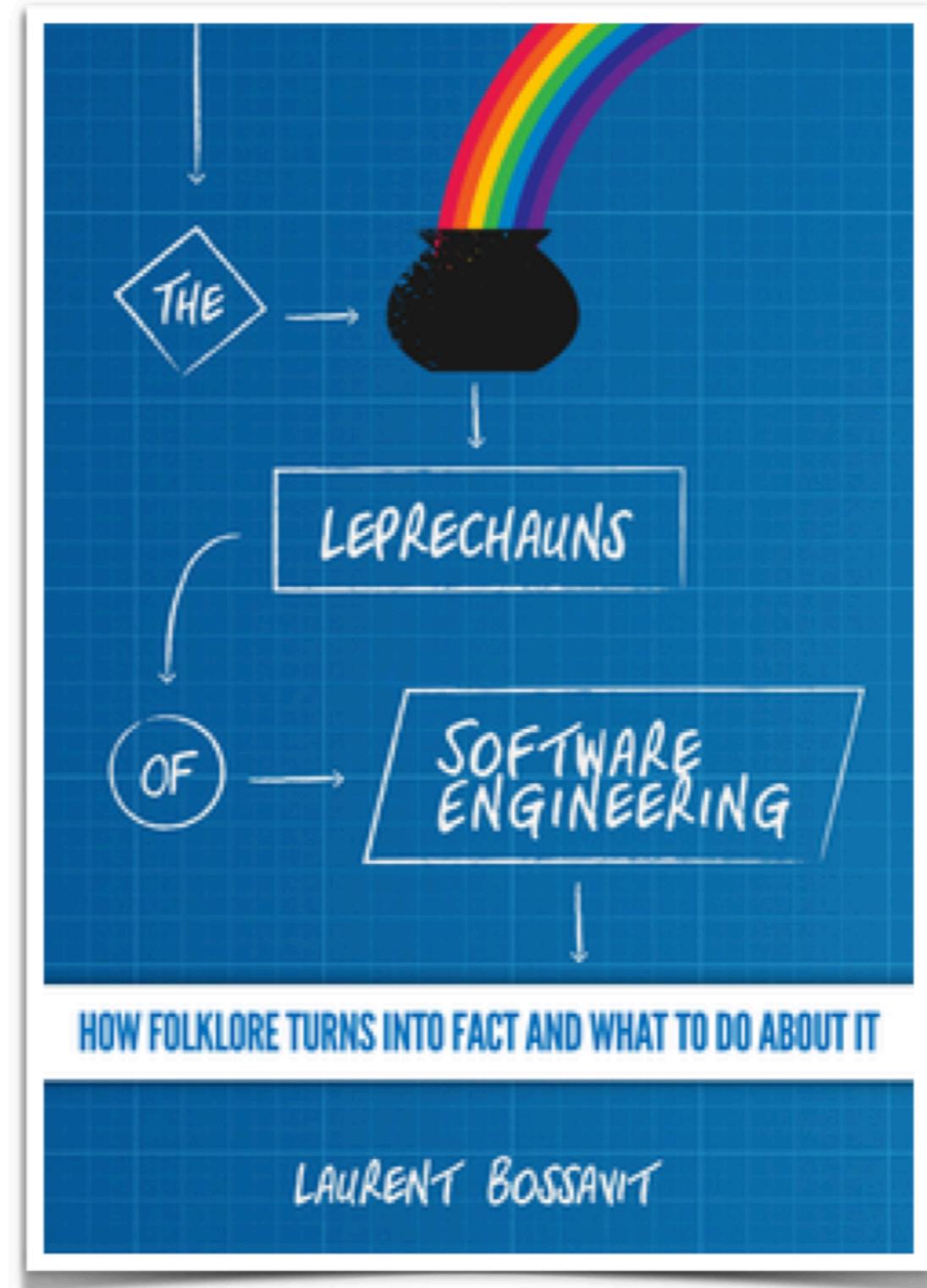
— Imre Lakatos, 1970

* Addressing the situation in the quantum mechanics research community, an analogy

RE largely dominated by conventional wisdom

Reasons are manifold:

- Lack of empirical awareness
- Neglecting particularities of practical contexts
- Neglecting relation to existing evidence
- Treating claims by authorities as facts
- ...
- Lack of data



Consequences

RE largely dominated by conventional wisdom

Reasons are manifold:

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- ...
- Lack of data

The diagram illustrates the concept of 'How Folklore Turns into Fact'. It features a rainbow above a pot of gold, which is connected by arrows to the words 'LEPRECHAUNS' and 'SOFTWARE ENGINEERING'. Below these boxes is the subtitle 'HOW FOLKLORE TURNS INTO FACT AND WHAT TO DO ABOUT IT'. At the bottom, the author's name 'LAURENT BOSSAVIT' is visible.



- » Practical relevance and impact?
- » Potential for transfer into practice and adoption?

Key Take-Away

We^{*}need to change from...

- conventional wisdom
- universal solutions

...to...

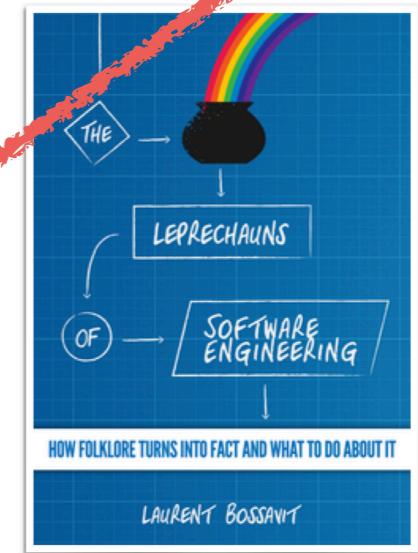
- evidence-based, theory-centric
- context-sensitive

...Requirements Engineering research

RE largely dominated by conventional wisdom

Reasons are manifold:

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*** Everyone's responsibility:**

We as authors, reviewers, organisers, and educators.



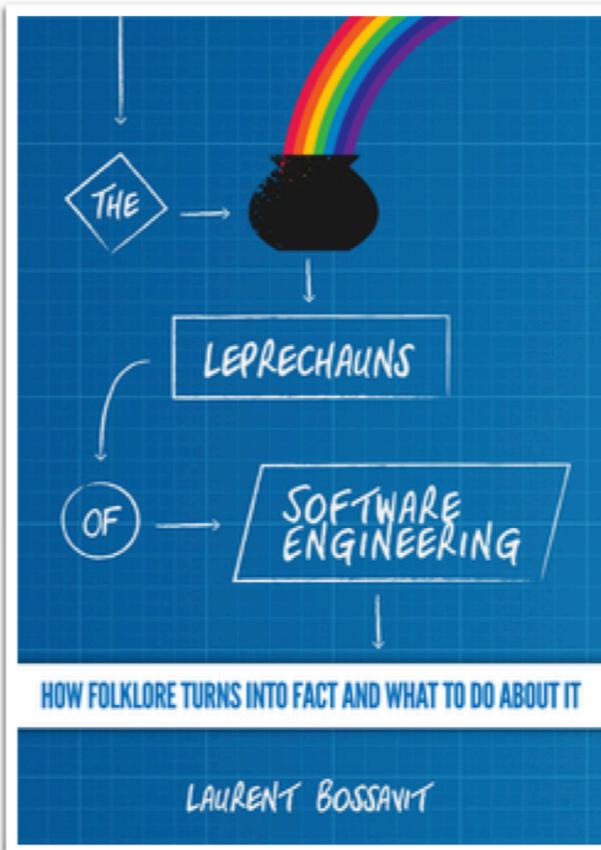
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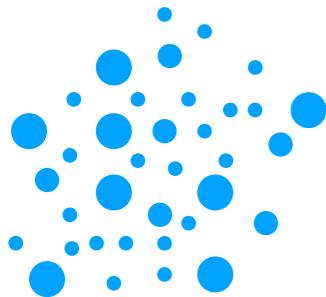
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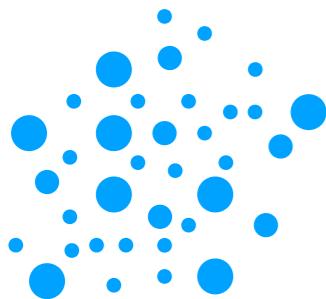
Naming the Pain in Requirements Engineering

NaPiRE

www.re-survey.org

Goals

- ▶ First theory on industrial practices and problems in Requirements Engineering
- ▶ Open Data Foundation for problem-driven research



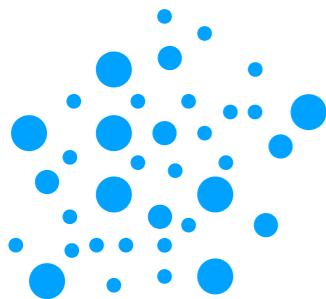
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www.re-survey.org

2011/12
1 country,
2 researchers

- ▶ Bi-yearly replicated,
globally distributed family of surveys
- ▶ Collaborative design, analysis
and synthesis



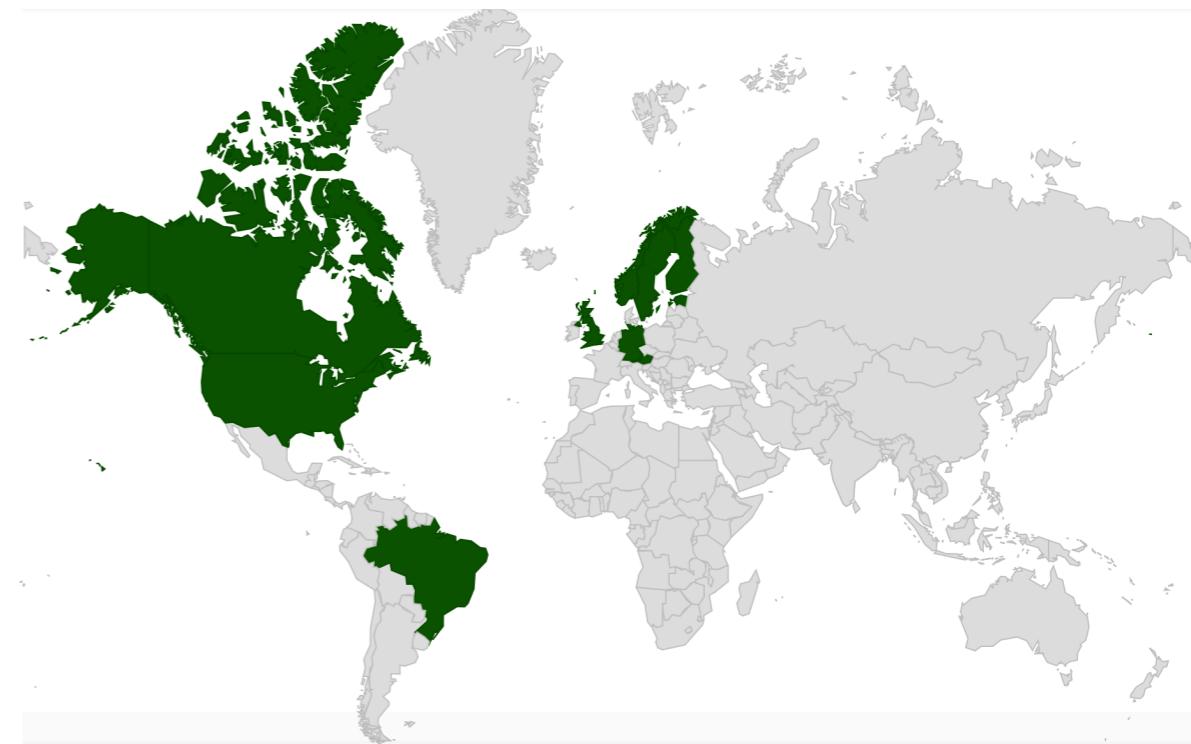


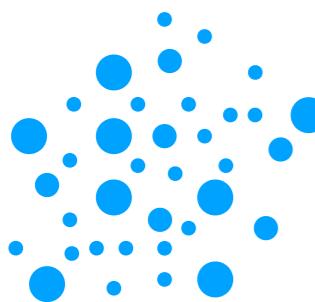
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www.re-survey.org

2014/15
10 countries
23 researchers

- ▶ Bi-yearly replicated,
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Naming the Pain in Requirements Engineering NaPiRE

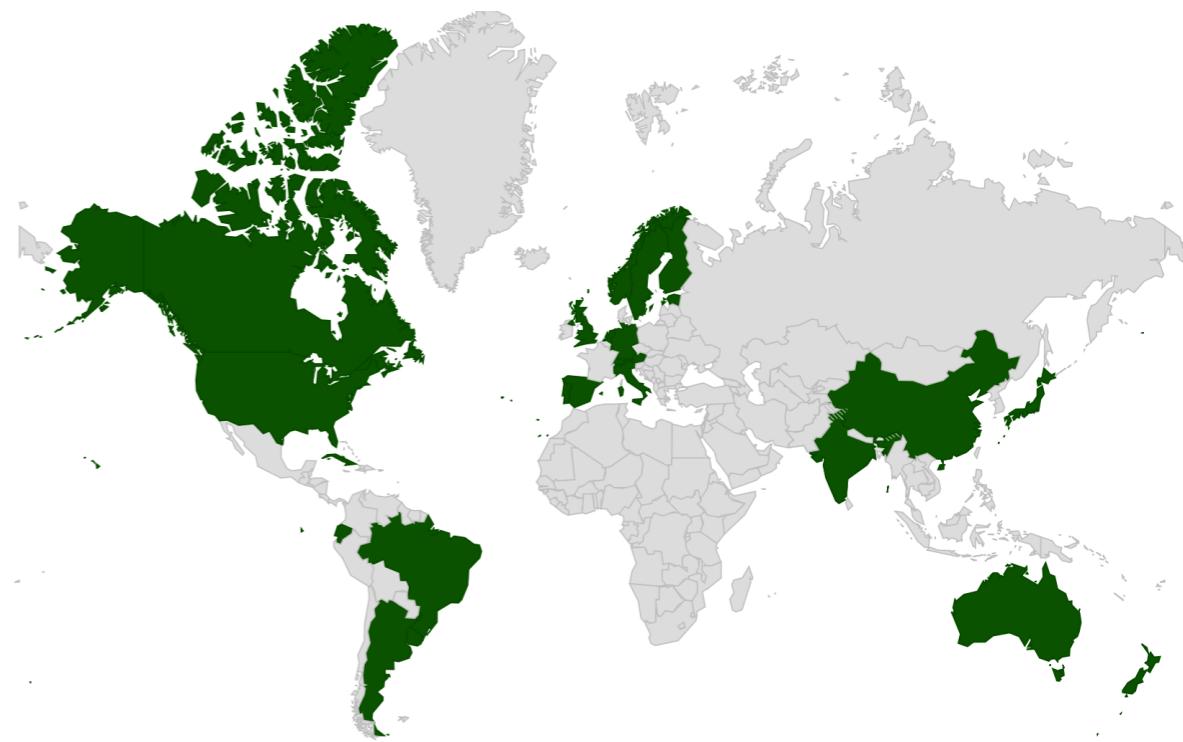
www.re-survey.org

2017/18

25 countries

61 researchers from 53 institutions

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- ▶ Collaborative design, analysis
and synthesis

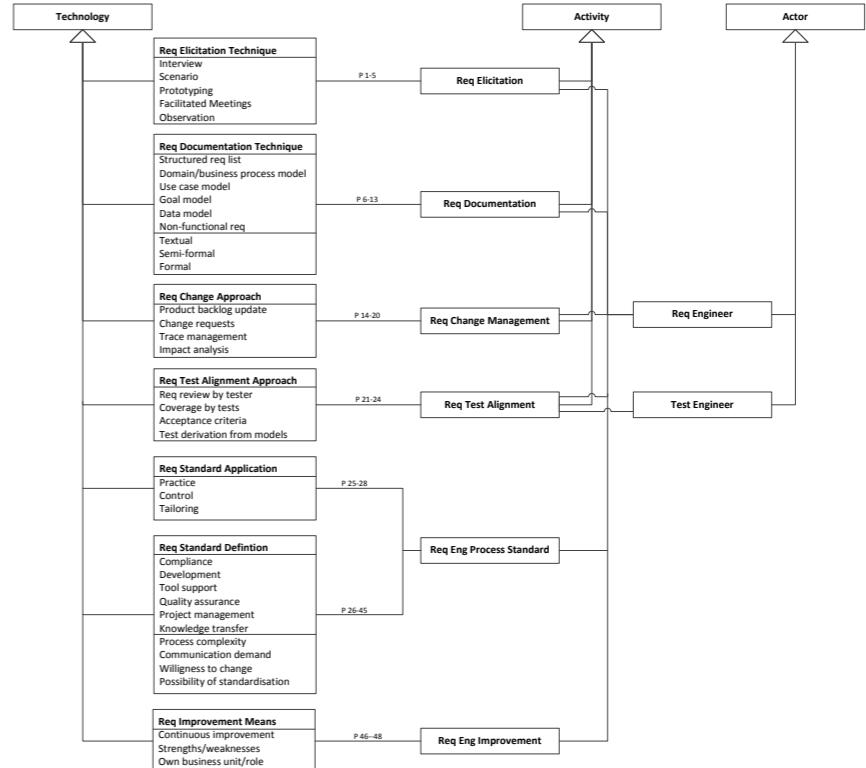


Results from NaPiRE 2015/16

- ▶ 10 countries, 228 companies

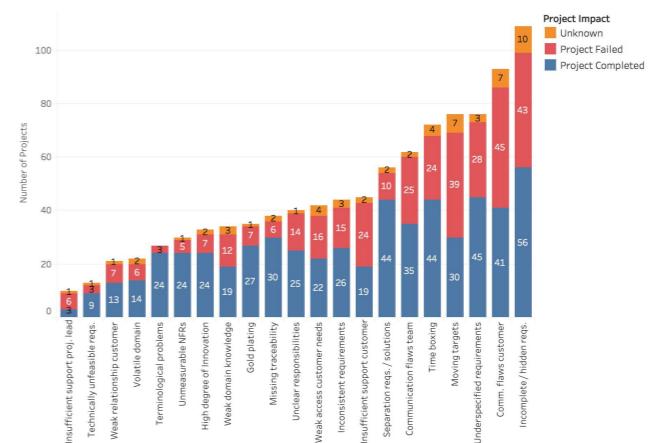
Status quo in practices used

- ▶ Requirements Elicitation
- ▶ Requirements Documentation
- ▶ Requirements Change and Alignment
- ▶ Requirements Engineering Standards
- ▶ Requirements Engineering Improvement



Problems in RE

- ▶ Problems and criticality
- ▶ Causes
- ▶ Effects

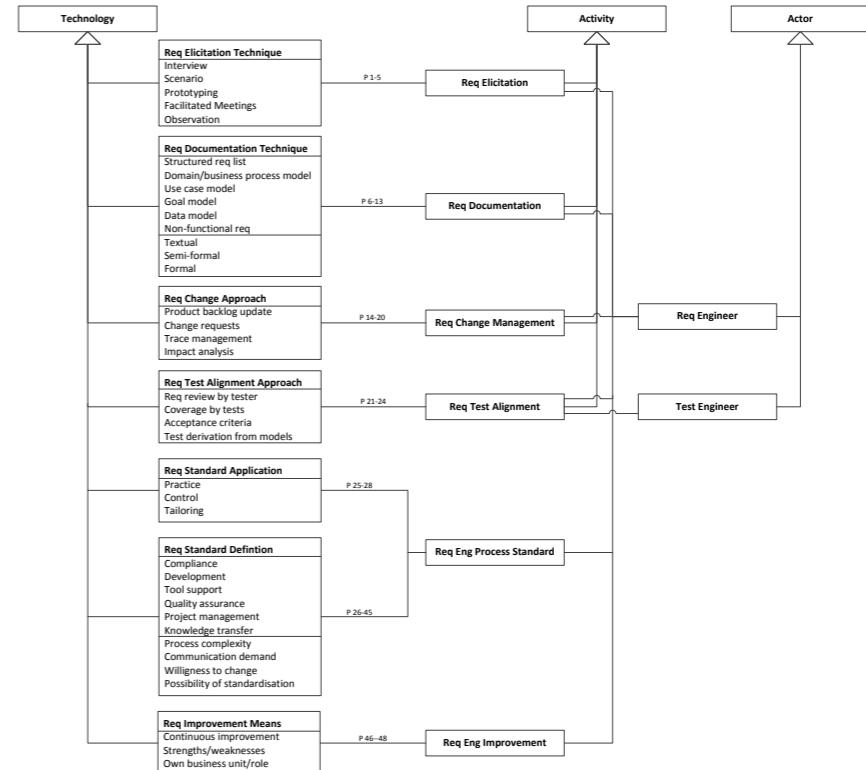


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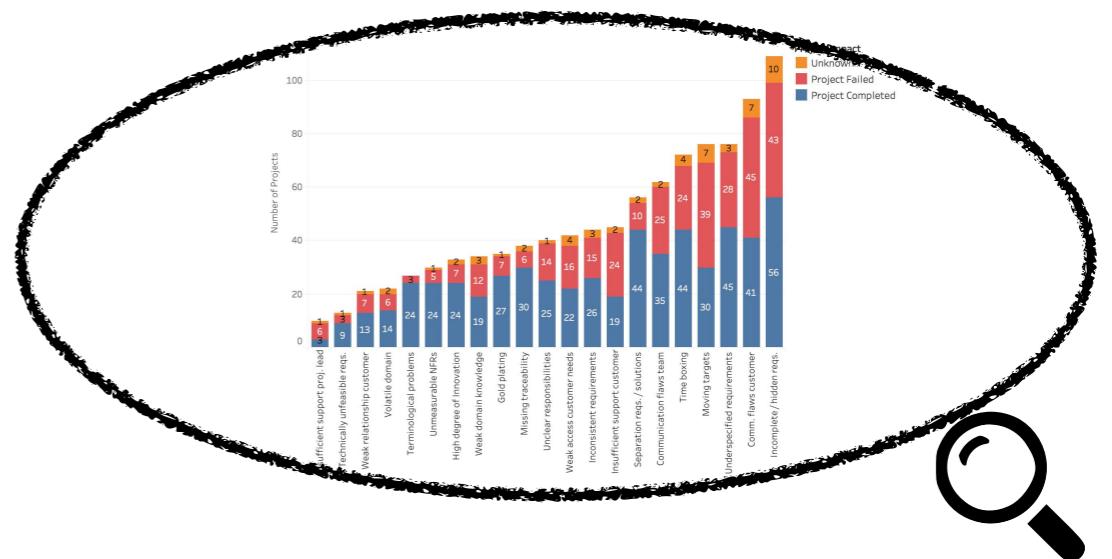
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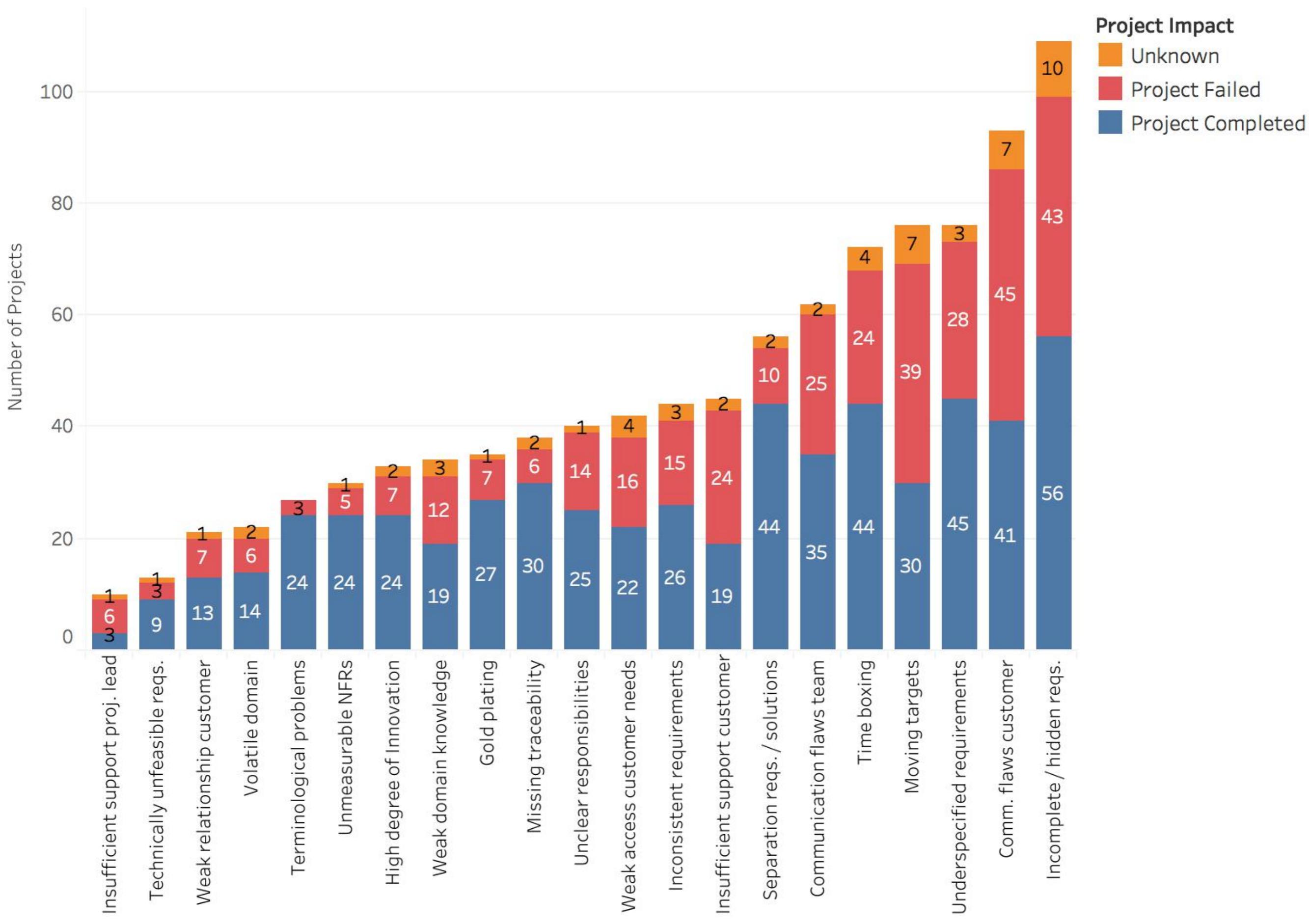
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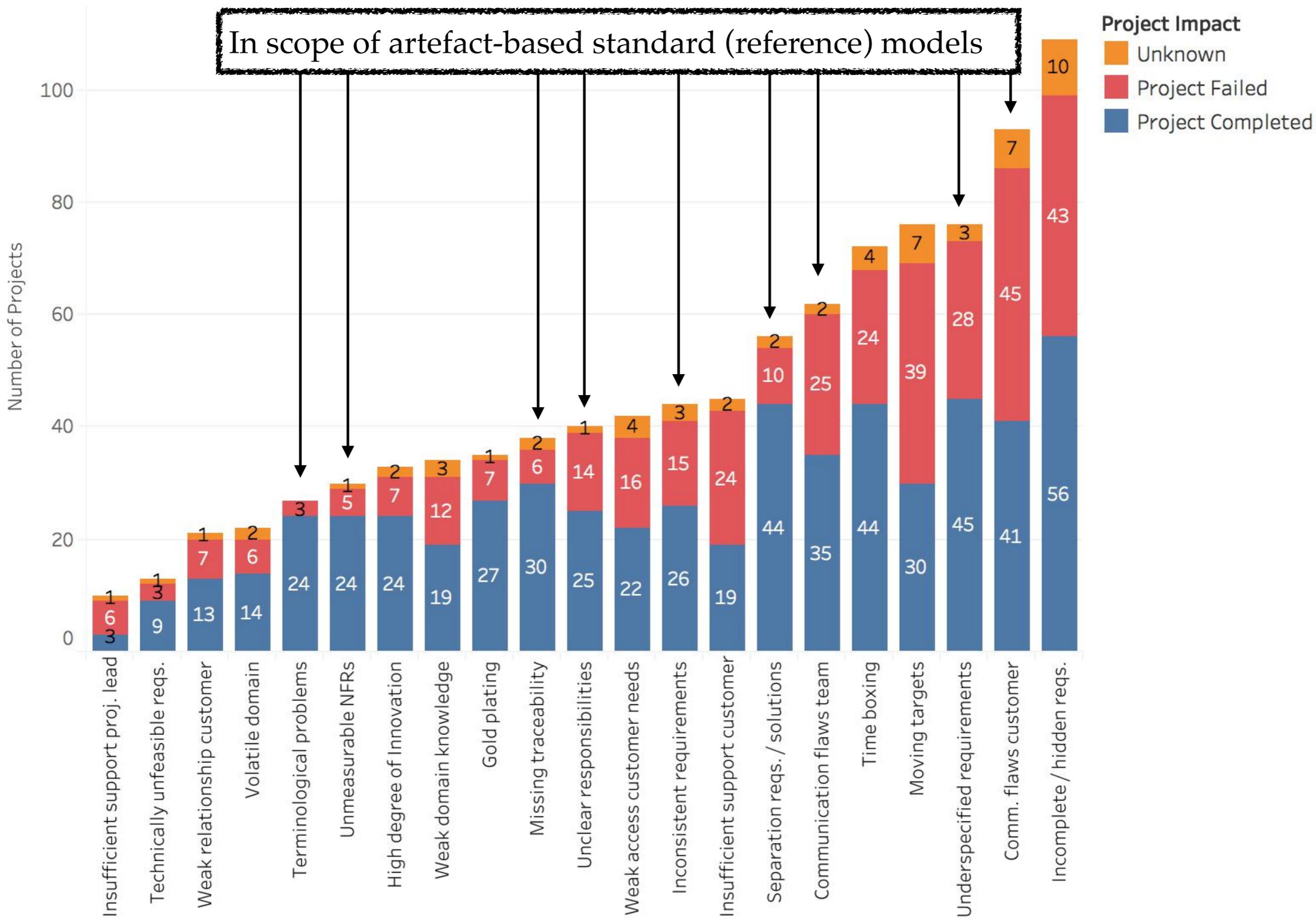
Problems in RE

- ▶ Problems and criticality
- ▶ Causes
- ▶ Effects





In scope of artefact-based standard (reference) models



In scope of artefact-based standard (reference) models

Project Impact

- Unknown
- Project Failed
- Project Completed

Number of Projects

100

80

60

40

20

0

Insufficient support proj. lead

Technically unfeasible reqs.

Weak relationship customer

Volatile domain

Terminological problems

Unmeasurable NFRs

High degree of Innovation

Weak domain knowledge

Gold plating

Missing traceability

Unclear responsibilities

Weak access customer needs

Inconsistent requirements

Insufficient support customer

Separation reqs. / solutions

Communication flaws team

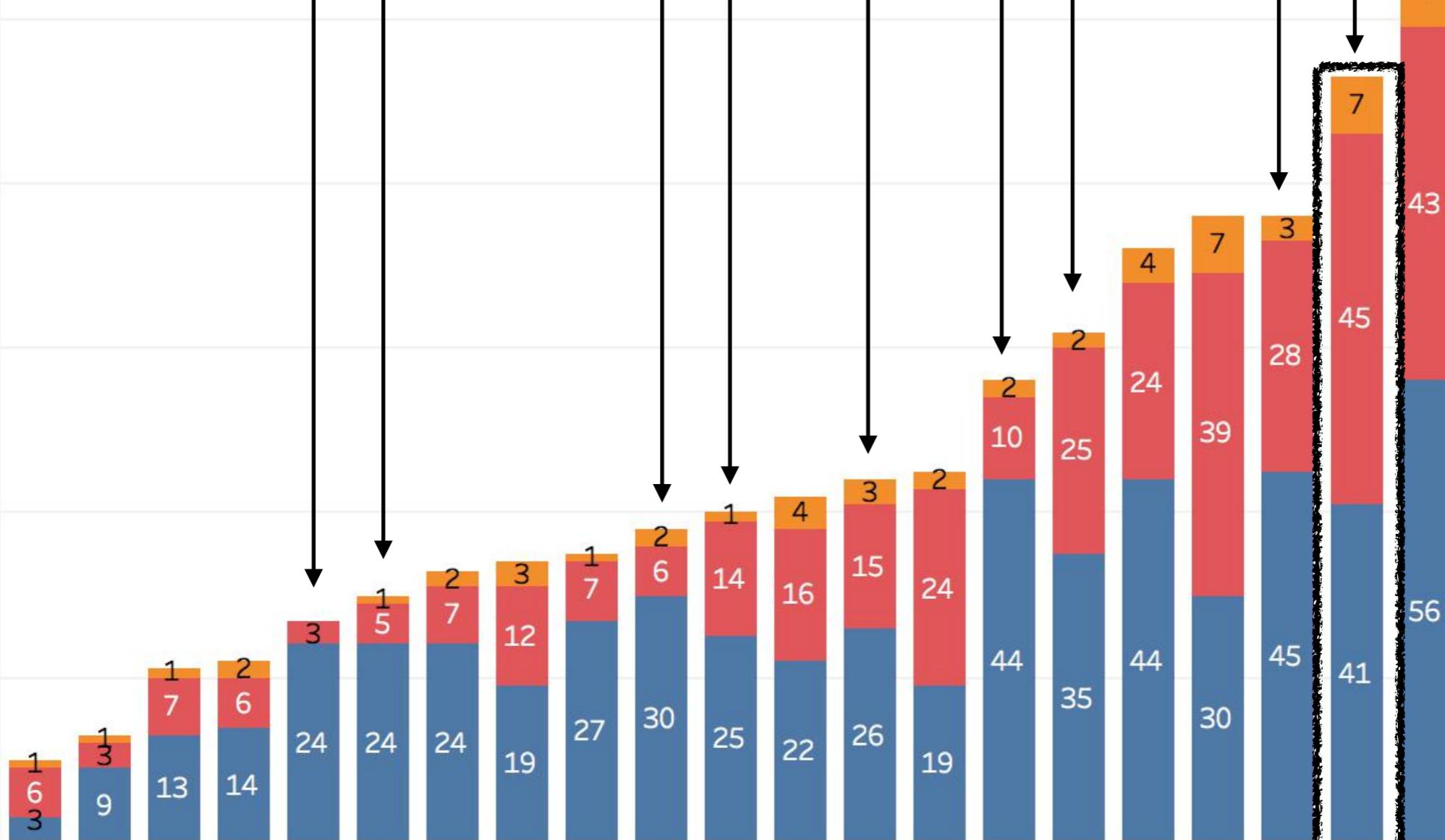
Time boxing

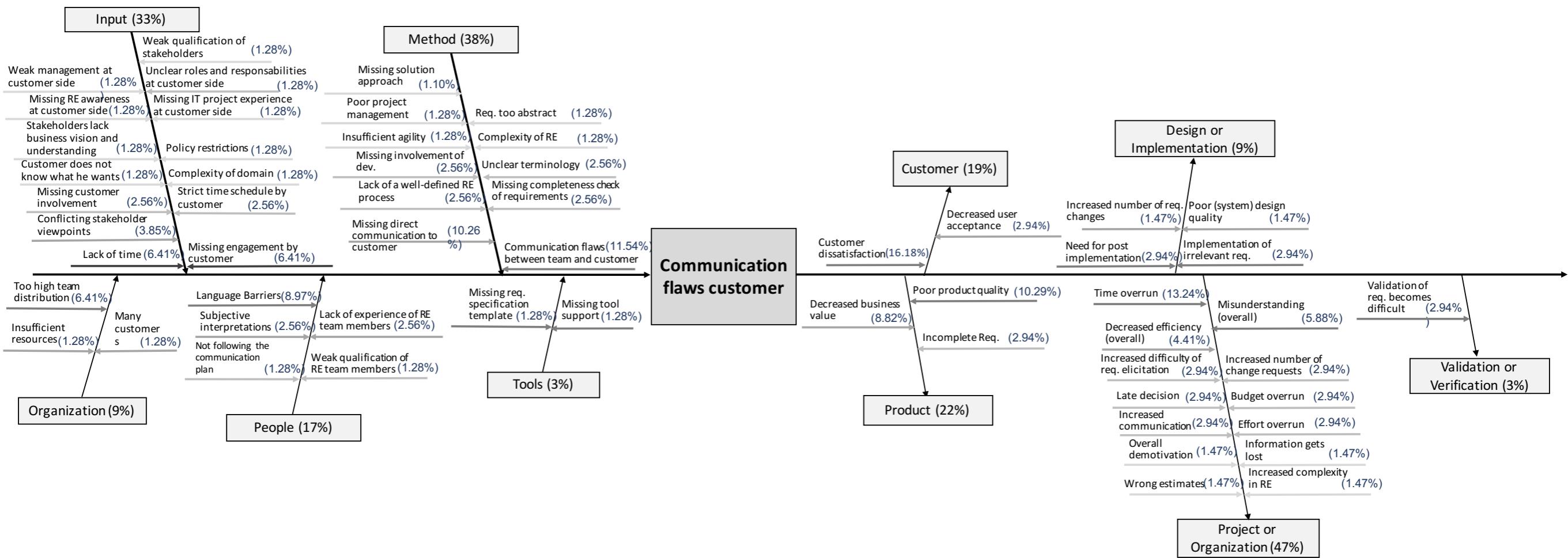
Moving targets

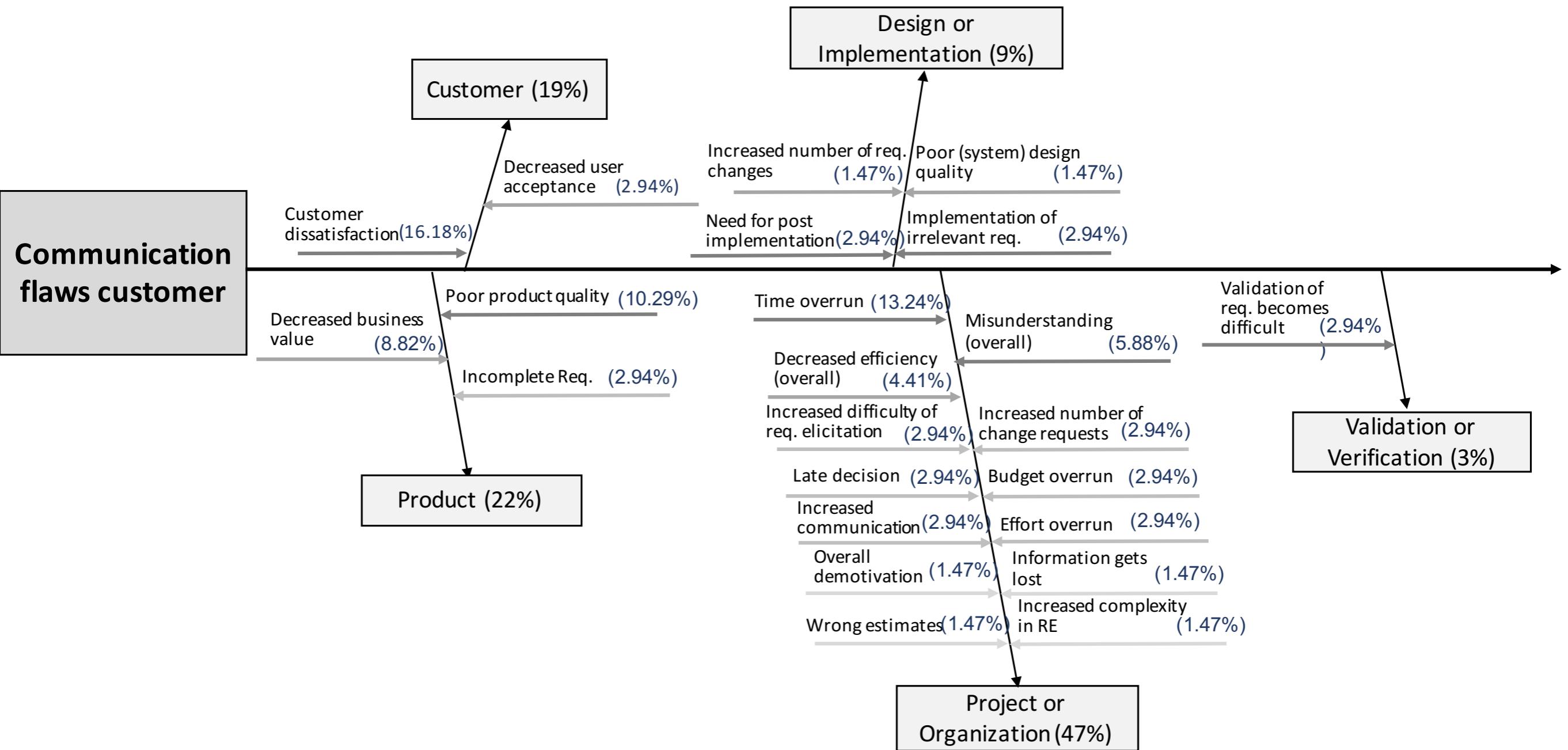
Underspecified requirements

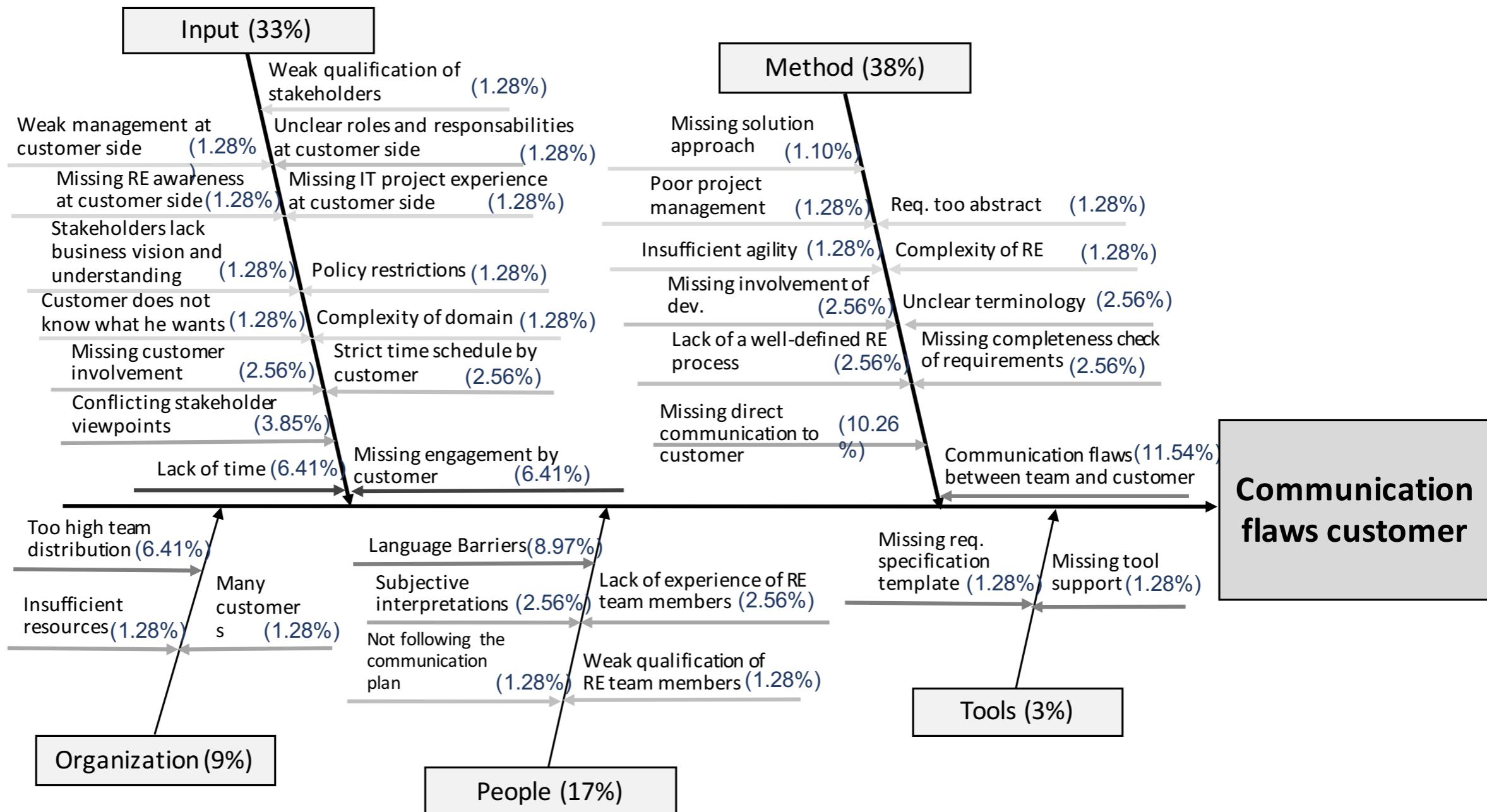
Comm. flaws customer

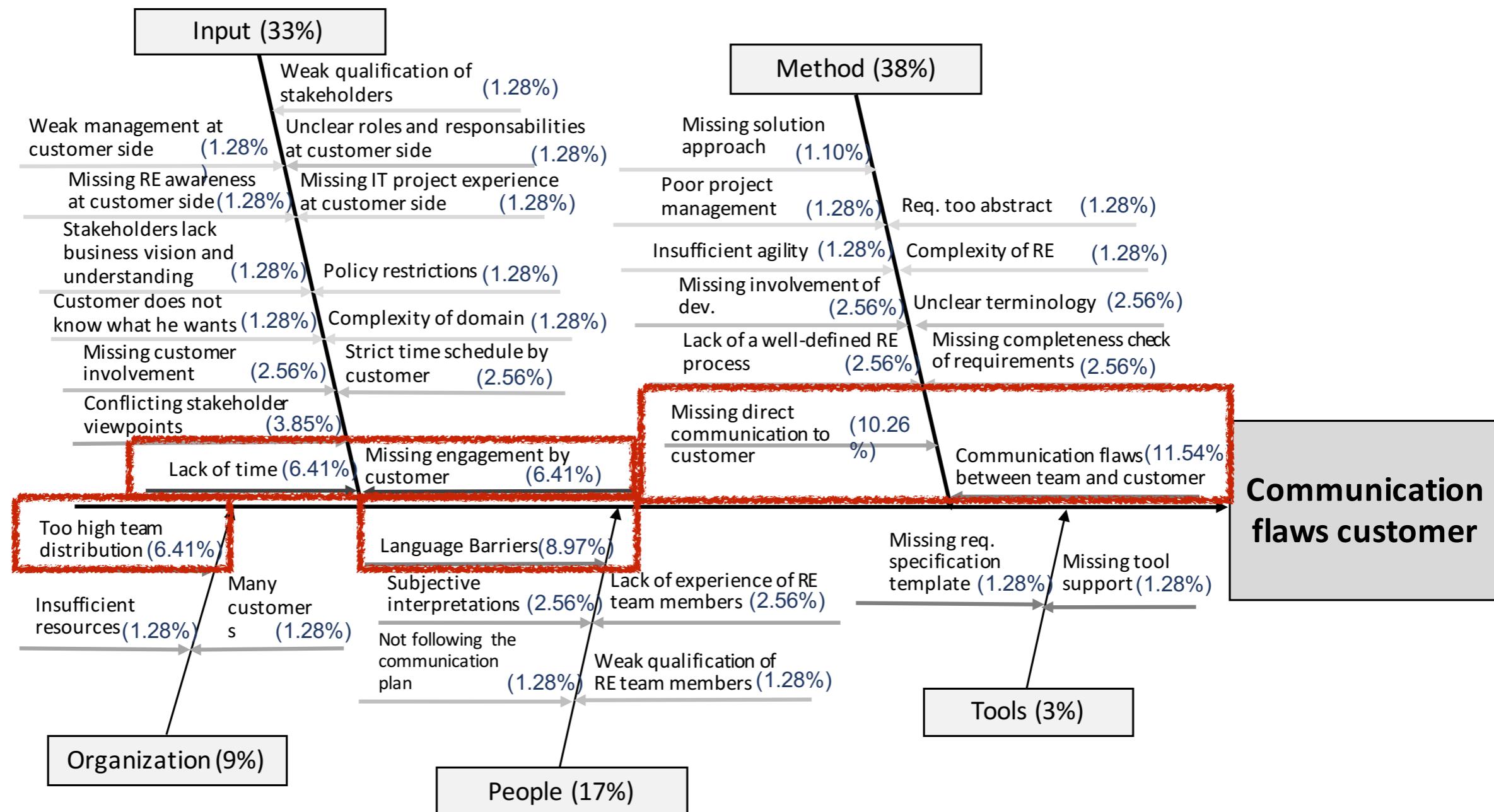
Incomplete / hidden reqs.



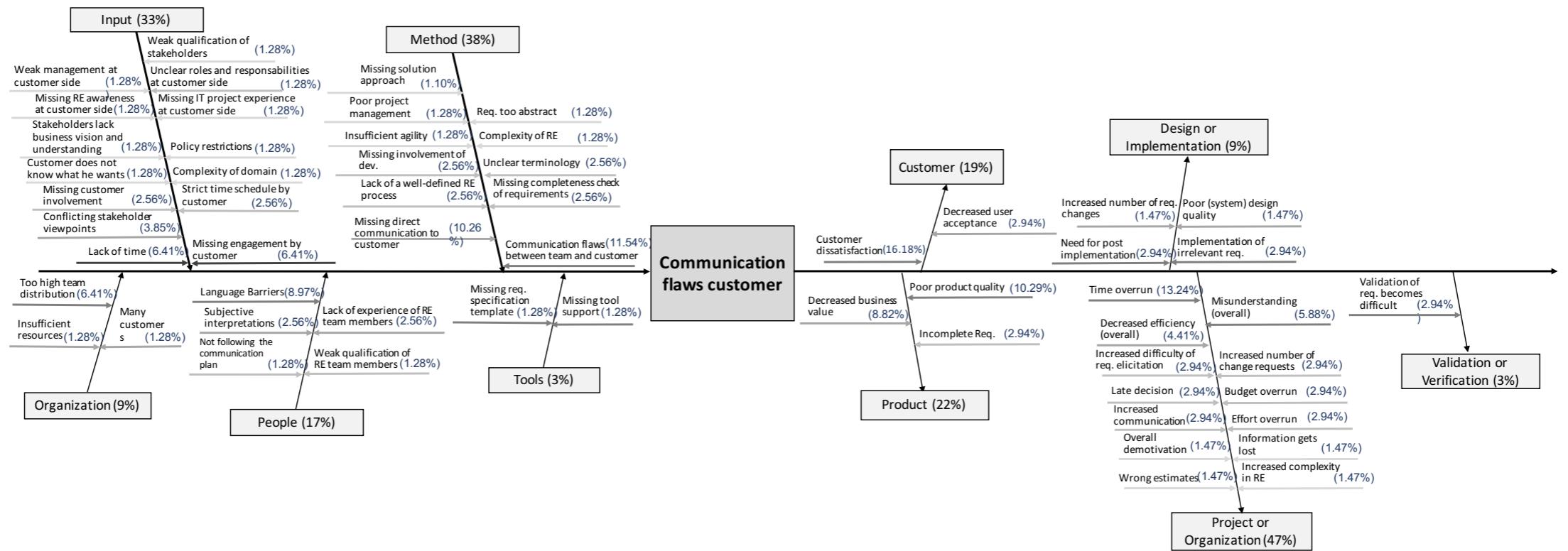








Causes rather not due to missing guidance via reference models, but due to organisational and even social issues.



Do teams applying agile practices avoid these issues?

Do teams applying agile practices avoid these issues?

	Small companies (1-50)	Medium companies (51-250)	Large companies (> 251)
#1 Problem	Incomplete/hidden requirements	Communication flaws customer	Incomplete/hidden requirements
#2 Problem	Communication flaws customer	Incomplete/hidden requirements	Moving targets
#3 Problem	Underspecified requirements	Communication flaws project team	Communication flaws customer
#4 Problem	Communication flaws project team	Separation reqs. / solutions	Time boxing
#5 Problem	Time boxing	Weak access customer needs	Underspecified requirements

Do teams applying agile practices avoid these issues?

No.

	Small companies (1-50)	Medium companies (51-250)	Large companies (> 251)
#1 Problem	Incomplete/hidden requirements	Communication flaws customer	Incomplete/hidden requirements
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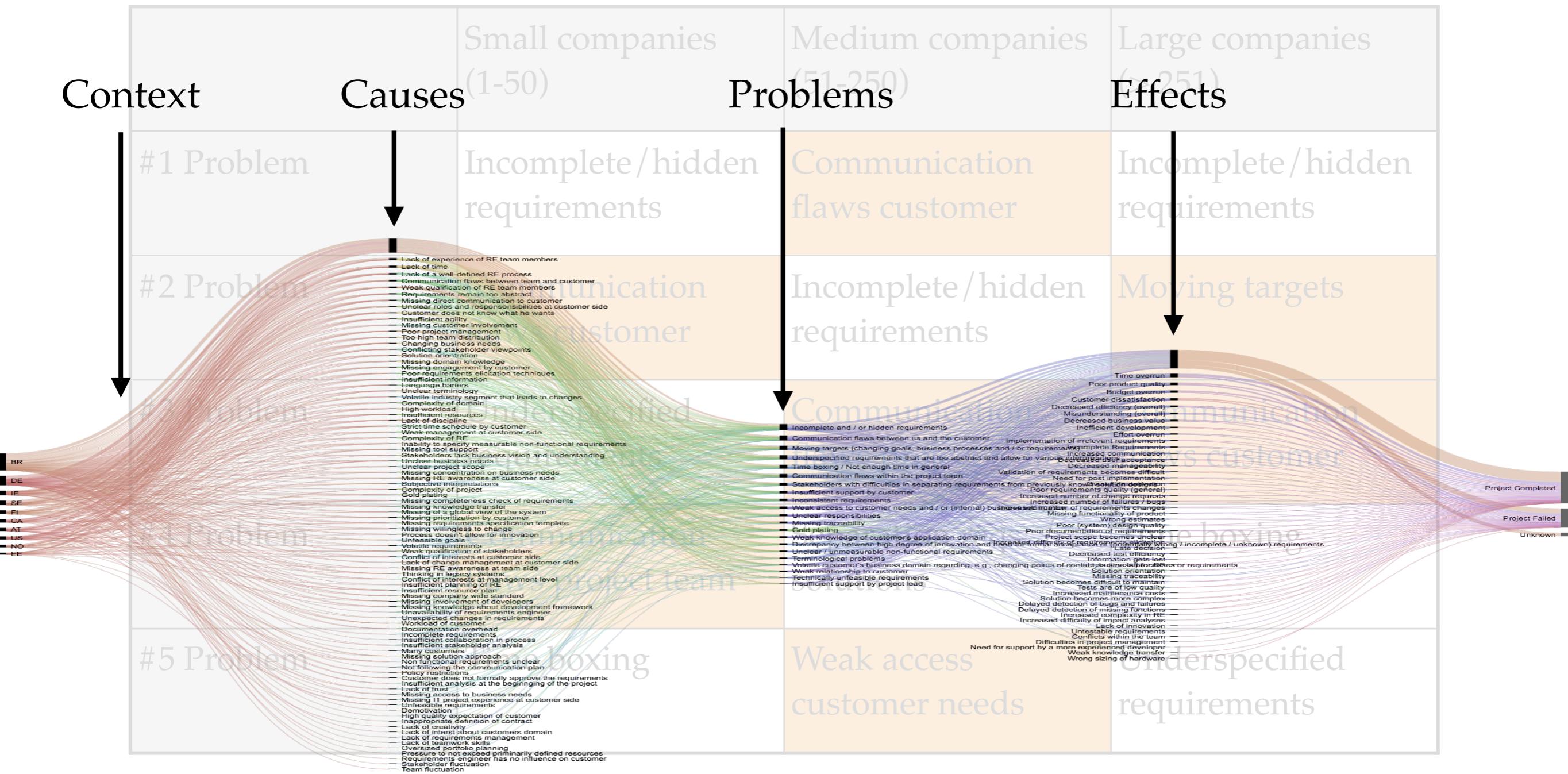
Not at all.

	Small companies (1-50)	Medium companies (51-250)	Large companies (> 251)
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“Insufficient RE” is too manifold to be avoided via universal solutions

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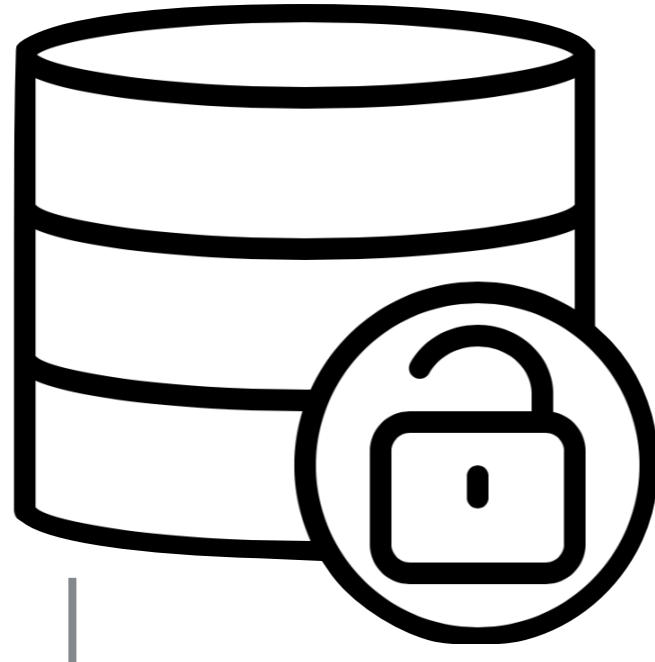
“Insufficient RE” is too manifold to be avoided via universal solutions



How can you make use of this initiative?

How can you make use of this initiative?

- ▶ Make use of the NaPiRE results and data



supports



Problem-driven research

- Increase flexibility in process
- Increase syntactic quality in RE artefacts
- Support precise terminology and communication
- Support consistency and traceability
- Support testability of requirements
- Make explicit particularities of application domain
- Increase semantic quality of RE artefacts
(reflecting, e.g., incomplete/hidden requirements)

Open data repository

www.re-survey.org

Phenomena and measurements

ID	Node	New (Description)	Dimension (JM)	Dimension (DM)	Dimension (HF, not counting)	Dimension	Measurability	Actionability
M15	Failed_Acceptance		SW project	Engineering and QA	SW process phase	SW project	PAR Not measurable	No
M16	Missing_Infrastructure		SW project	SW project	SW project	SW project	PAR Not measurable	PAR No
M17	Increased_effort_in_testing		Engineering and QA	Engineering and QA	SW process phase	Engineering	INF Measurable on activities	No
M18	Increased_effort_in_reviews		Engineering and QA	Engineering and QA	RE	RE	INF Measurable on activities	No
M19	Inconsistent_Object_Models		Engineering and QA	Engineering and QA	RE	RE	Measurable on artefacts	Yes
M20	Too_complex_solutions		Engineering and QA	Engineering and QA	SW process phase	Engineering	Not Measurable	No
M21	Wrong_design_decisions		Engineering and QA	Engineering and QA	SW process phase	Engineering	Not Measurable	PAR No
M22	Wrong_Implementation		Engineering and QA	Engineering and QA	SW process phase	Engineering	PAR Measurable on artefacts	Yes
M23	Incomplete_Implementation		Engineering and QA	Engineering and QA	SW process phase	Engineering	PAR Measurable on artefacts	Yes
M24	Bugs_and_defects		Engineering and QA	Engineering and QA	SW project	Engineering	INF Measurable on artefacts	PAR No
M25	Increased_discussions	Increased_Di	SW project	Engineering and QA	SW process phase	Engineering	INF Measurable on activities	PAR No
M26	Stripping_features		Engineering and QA	Engineering and QA	SW project	Engineering	Measurable on artefacts	PAR No
M27	Throw-away_prototypes		Engineering and QA	Engineering and QA	SW project	Engineering	PAR Not measurable	No
M28	Weak_relationship_between_customer_and_project_lead		SW project	SW project	Socio economic context	SW project	PAR Not measurable	PAR No
M29	Time_overrun		SW project	SW project	SW project	SW project	INF Measurable on activities	No
M30	Cost_overrun		SW project	SW project	SW project	SW project	PAR Measurable on both	No
M31	Additional_iterations		Engineering and QA	SW project	SW process phase	SW project	INF Measurable on activities	No
M33	Stagnating_progress		Engineering and QA	SW project	SW project	SW project	INF Measurable on activities	No
M34	Rework_and_refactoring		Engineering and QA	Engineering and QA	SW project	Engineering	INF Measurable on activities	No
M35	Missing_transparency		Engineering and QA	SW project	Socio economic context	SW project	PAR Not measurable	PAR No
M36	Unavailability_of_customer		SW project	SI				
M37	Customer_dissatisfaction		Company	SI				
M38	Missing_user_involvement		SW project	RI				
M39	Missing_Traceability		SW project	SI				
M40	No_further_improvement_after_acceptance		Company	SI				
R01	Implicit_Reqs_not_made_explicit		RE	RI				
R02	Too_much_abstraction_from_solution_level		RE	RI				
R03	Missing_abstraction_from_solution_level		RE	RI				
R04	Unmeasurable_reqs.		RE	RI				
R05	Missing_understand_and_unclear_terminology		Company	RI				
R06	No_validation		RE	RI				
R07	No_traceability		Engineering and QA	RI				
R08	Obsolete_Requirements		RE	RI				
R09	Uncertainty_in_RE		RE	RI				
R10	No_RE_explicitly_planned(in_tendering)		RE	SI				
R11	Weak_communication		SW project	SI				
R12	Frequent_changes		SW project	SI				

RE improvement goals

- Increase flexibility in process
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How can you contribute to such initiatives?

How can you contribute to such initiatives?

- ▶ Join existing initiatives, e.g.



Naming the Pain in Requirements Engineering
NaPiRE

- ▶ Understanding practitioners' problems



- ▶ Understanding relevance of available RE Research and topics of interest to practitioners

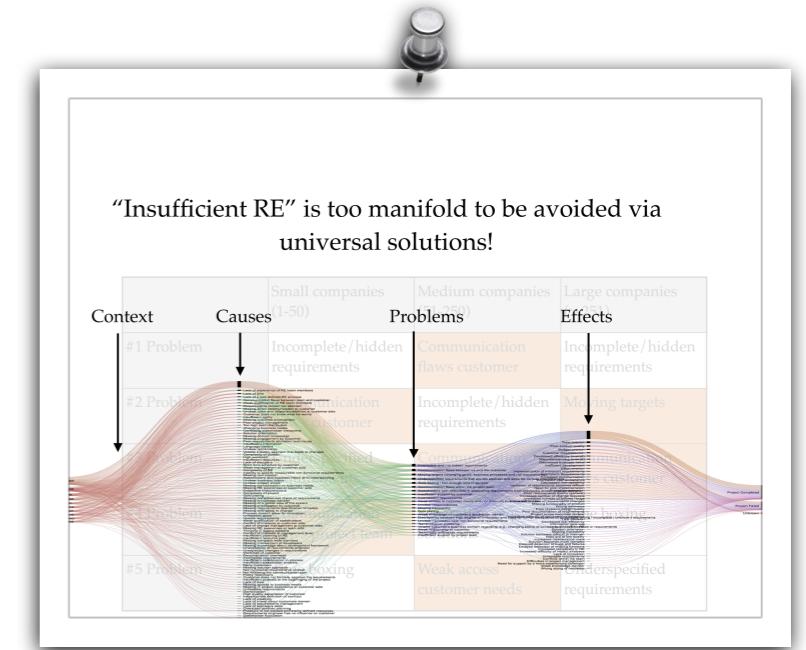
- ▶ Kick off new community initiatives
- ▶ Share your own empirical data

Key Take-Away

Only a shared understanding of

- RE practices and problems
- context factors

supports problem-driven research



Joint open data initiatives are key in our community to:

- » strengthen shared body of knowledge
- » establish common references for evaluation research



In Quest for RE Research that Industry Needs

- ▶ Turn RE into a theory-centric discipline
... to eradicate the many Leprechauns we still have.
- ▶ Understand practitioners' problems
... to foster problem-driven research.
- ▶ **Engage in academia-industry collaborations**
... to analyse problems in their natural environment and frame our work.

Academia-Industry collaborations

- Academia-Industry collaborations can form a great environment to frame research that cannot otherwise be conducted in the lab
- ... but what are the success factors?

Academia-Industry collaborations

- Academia-Industry collaborations can form a great environment to frame research that cannot otherwise be conducted in the lab

... but what are the success factors?

A research area of its own



KNORR-BREMSE



CONSULTING.TECHNOLOGY.OUTSOURCING



SPARCED LABS *

DAIMLER

WACKER

SIEMENS

Deutsche Post The Deutsche Post logo, featuring the company name in a black sans-serif font next to a stylized orange post horn icon.



...T...Systems...

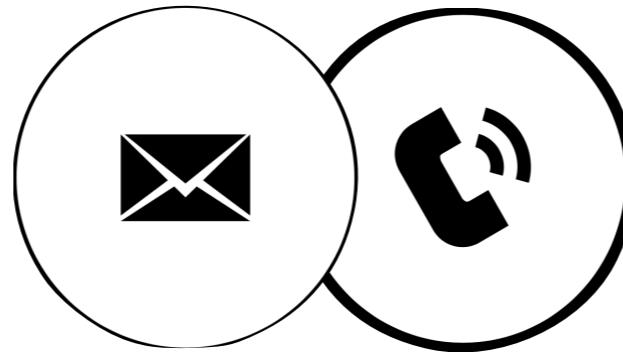
Qualicen



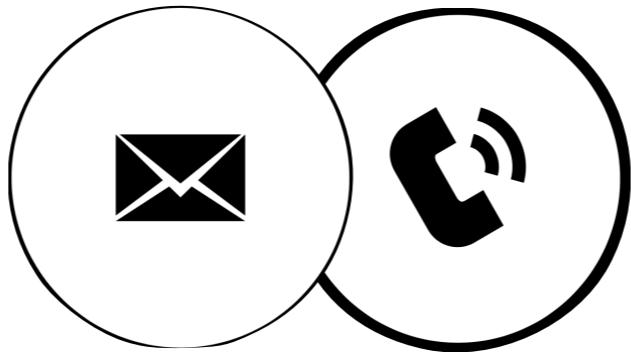
Lufthansa

.msg

MaibornWolff The MaibornWolff logo, featuring the company name in a black sans-serif font next to a teal square containing the word "etal" in white.



1. How do you remember our research collaboration?
2. Which effects did our work have in the long-run?
3. If you could name one important factor for academia-industry collaborations, which would it be?



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Success factors for collaborations with industry

(Least common denominator of practitioners' voices)

1. Shared long-term vision and project goals
2. Common problem- and domain-understanding
3. Proper project organisation
 - ▶ Manageable-sized sub-problems
 - ▶ Minimal-invasive solutions
 - ▶ Regular on-site work and meetings
 - ▶ Fast feedback loops
4. Proper mindset and principles

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"Academic mindset with a 'Free-as-a-bird'-mentality."

main-understanding

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"Pragmatism [...] free of idealism when solving industry problems."

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3. Proper project organization

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"Pragmatism [...] free of idealism when solving industry problems."

Partner with academic background

Partner with no academic background

4. Proper mindset and principles



Key Take-Away

- Academia-Industry collaborations can form a great environment to frame research that cannot otherwise be conducted in the lab

“Academic mindset with a ‘Free-as-a-bird’-mentality.”

- ... but there is a fine line between applied research and (cheap) consultancy

“Pragmatism [...] free of idealism when solving industry problems.”

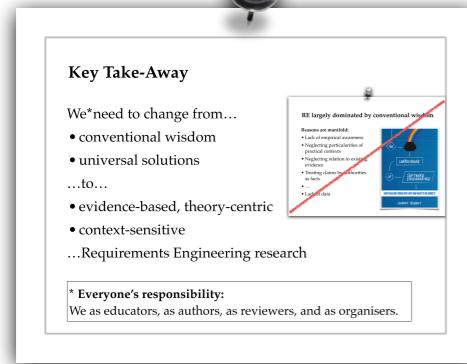


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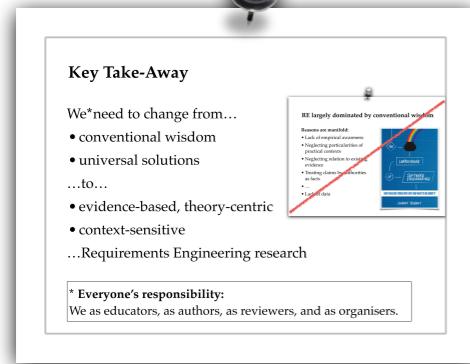
In Quest for RE Research that Industry Needs



► Change from conventional wisdom
to theory-centric, context-sensitive RE



In Quest for RE Research that Industry Needs

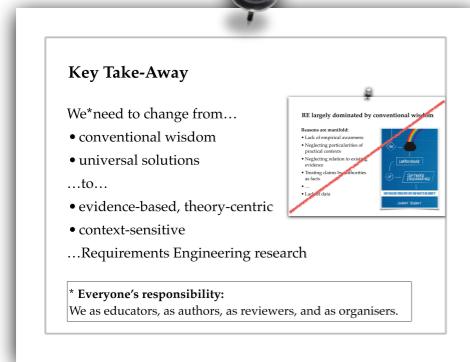


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► Unlock our data to support a shared
understanding on practical problems

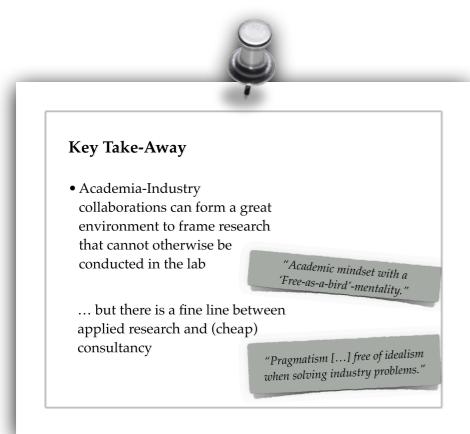
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▶ Engage in academia-industry collaborations to frame our research while preserving our academic integrity

In Quest for RE Research that Industry Needs



LAST BUT NOT LEAST

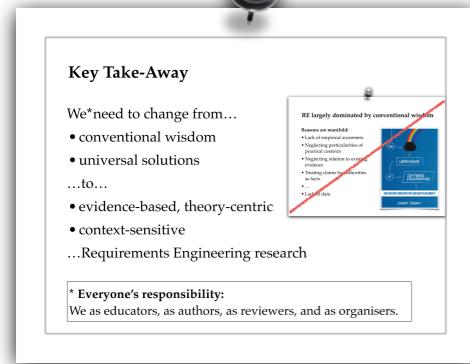
1 For a successful dissemination of RE research into practice, it still needs “two to tango”[1]

2 Even though sometimes people want to make you believe that industry needs are the sole measure of success, they are clearly not.

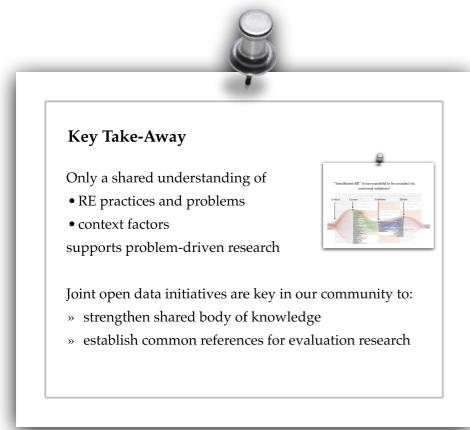
[1] Runesen, P. It Takes Two to Tango -- An Experience Report on Industry -- Academia Collaboration, 2012



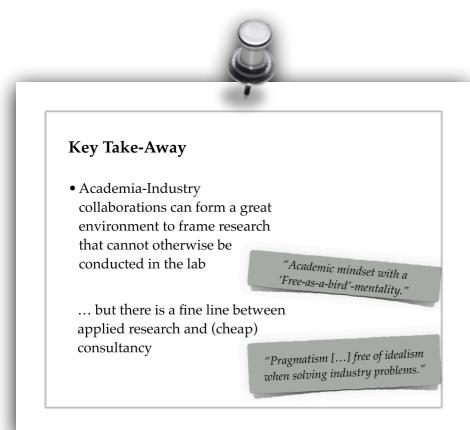
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Thank you!