Assoc. Prof. Dr. Harald Störrle
Danmarks Tekniske Universitet (DTU)
COMPUTE Software Group

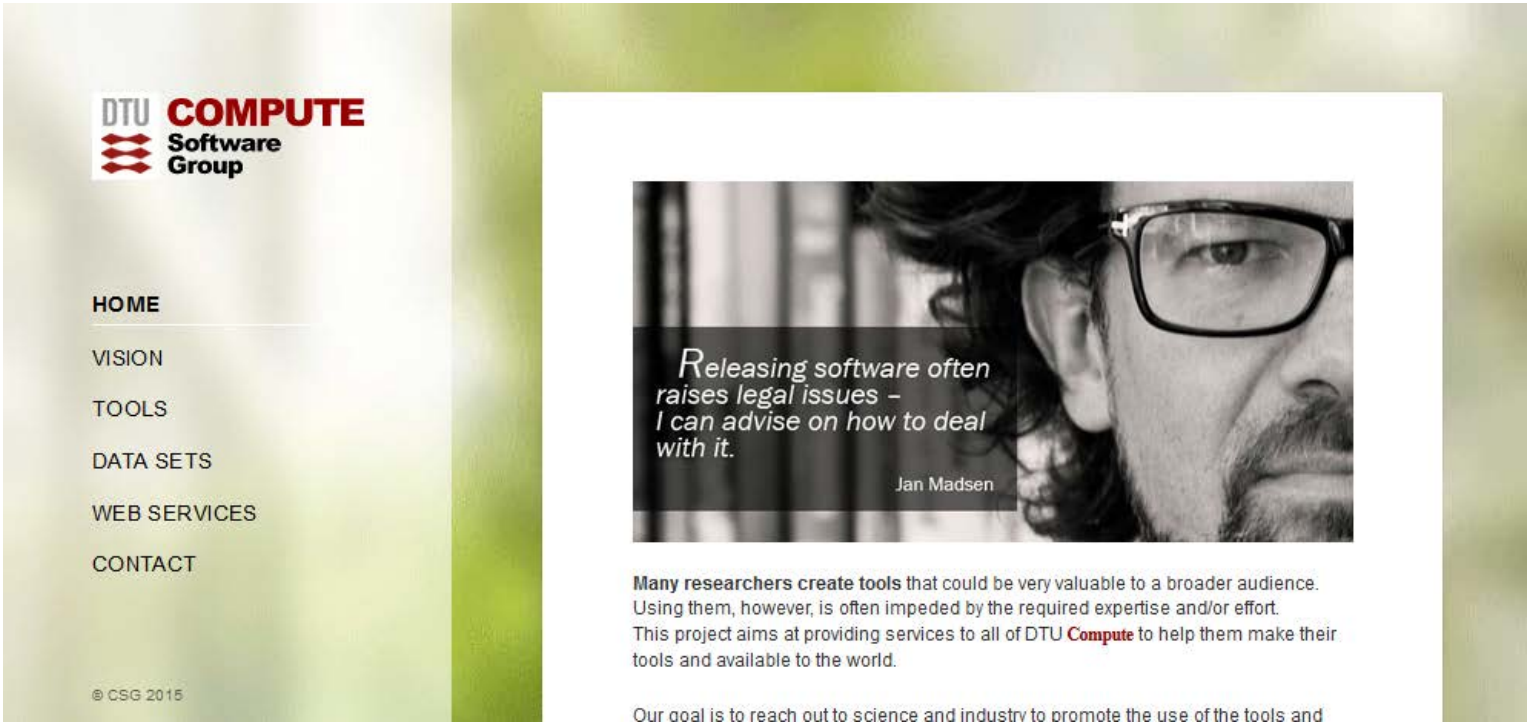
Requirements Engineering Tools

Academic and Industrial Perspectives

Lund University, 21.4.2015

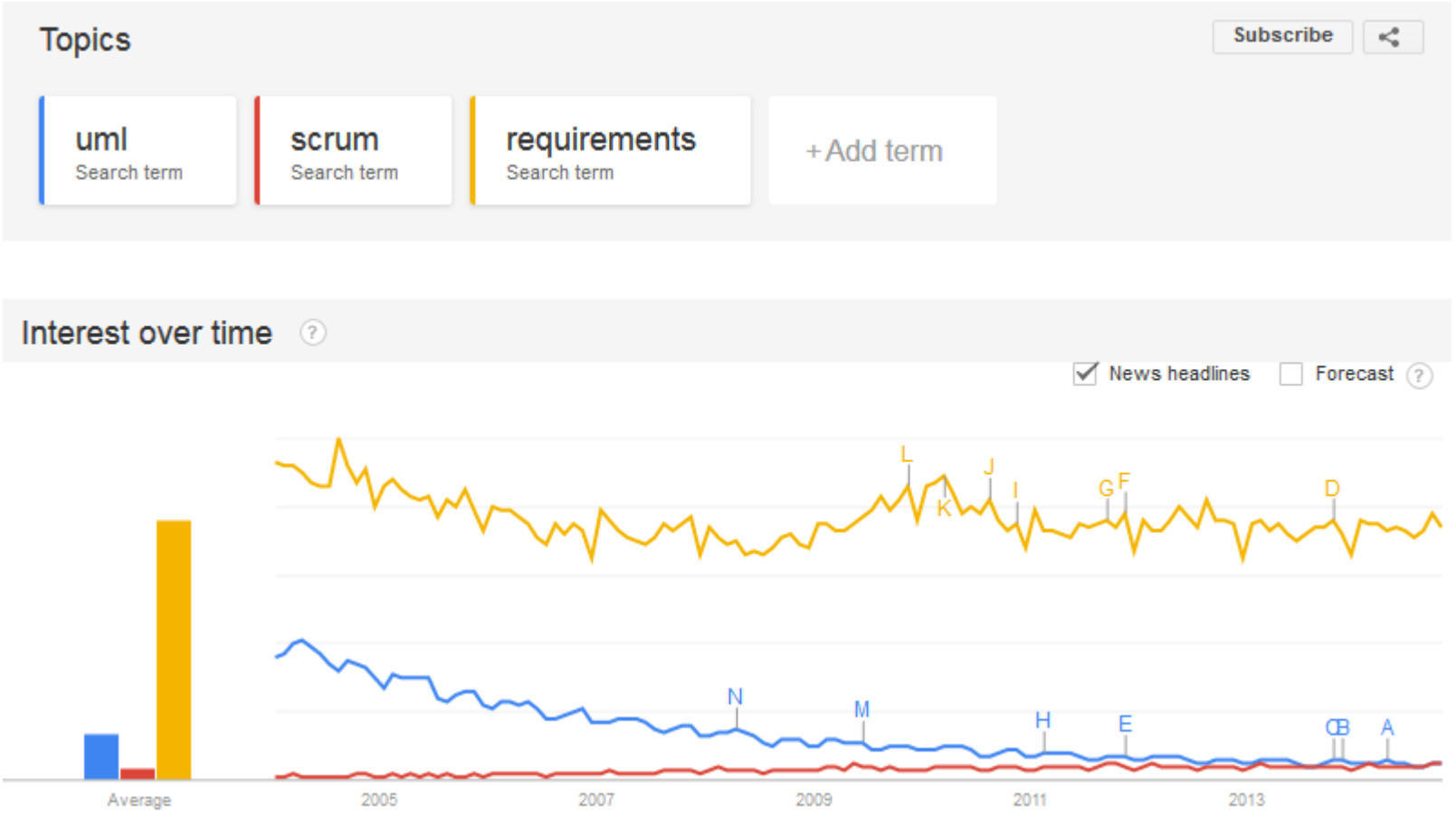
COMPUTE Software Group

- **Many researchers create tools that have tremendous value and potential way beyond their initial setting.**
  - Spreading and maintaining these tools is difficult and time consuming.
  - The CSG aims at providing services to all of DTU Compute to help them improve their tools and make them available to the world.
  - See csg.compute.dtu.dk for more.

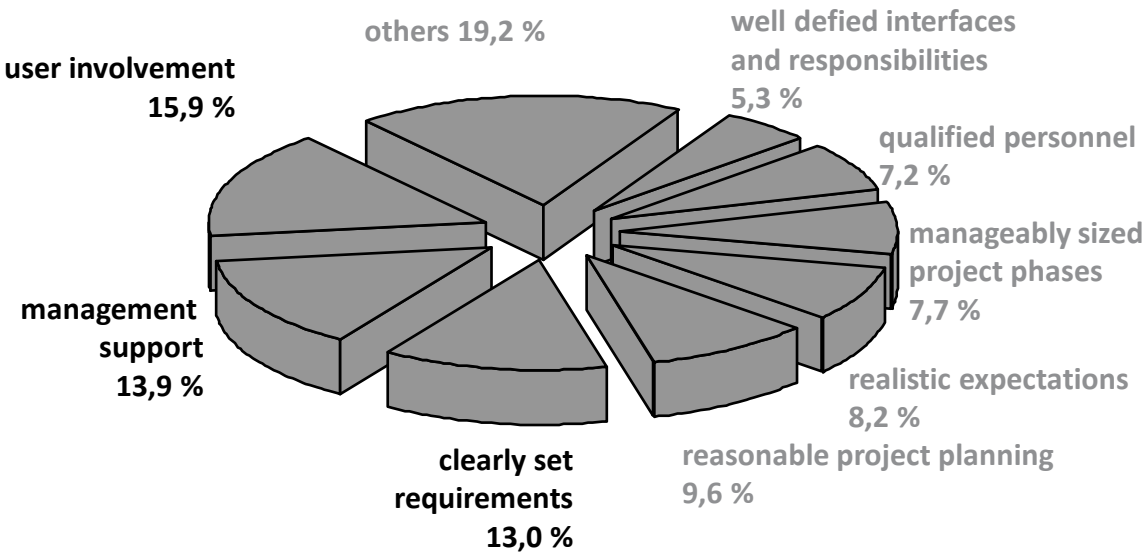


RE – a relevant topic?

- **Let‘s have a quick look at Google Trends for a first impression.**

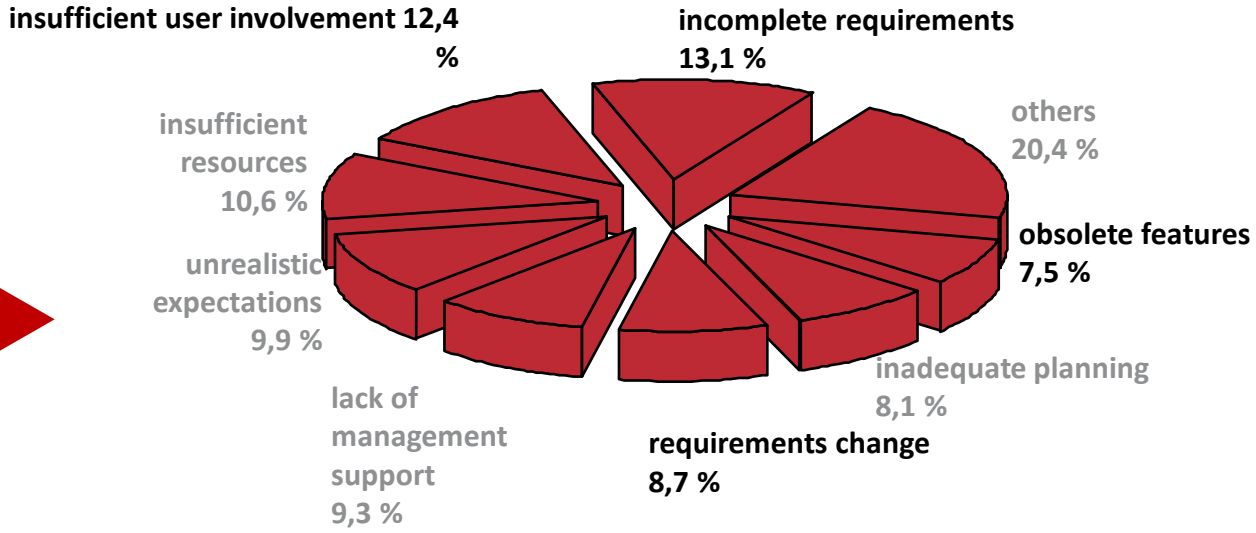


Requirements are a key factor



reasons for success

reasons for failure



[Standish Group & Scientific American]

More (reliable) sources

- **Requirements Engineering (or the lack thereof) is still the single most important reason for poor software quality**
  - Lutz [1993] showed that 60% of errors in critical systems were the results of requirements errors.
  - Espiti [1996] conducted a survey of European companies and found that more than 60% of them considered requirements engineering problems as very significant.
  - Hall et al. [2002] carried out a case study of 12 companies at different CMM levels. They discovered that, out of a total of 268 development problems cited, almost 50% (128) were requirements problems."

- *„Nonetheless, requirements engineering is still performed in an intuitive and chaotic way."*

Sommerville, I., Ransom, J.: An Empirical Study of Industrial Requirements Engineering Process Assessment and Improvement. ACM Transactions on Software Engineering and Methodology 14(1), 85–117 (2005)

RE in the age of Agile

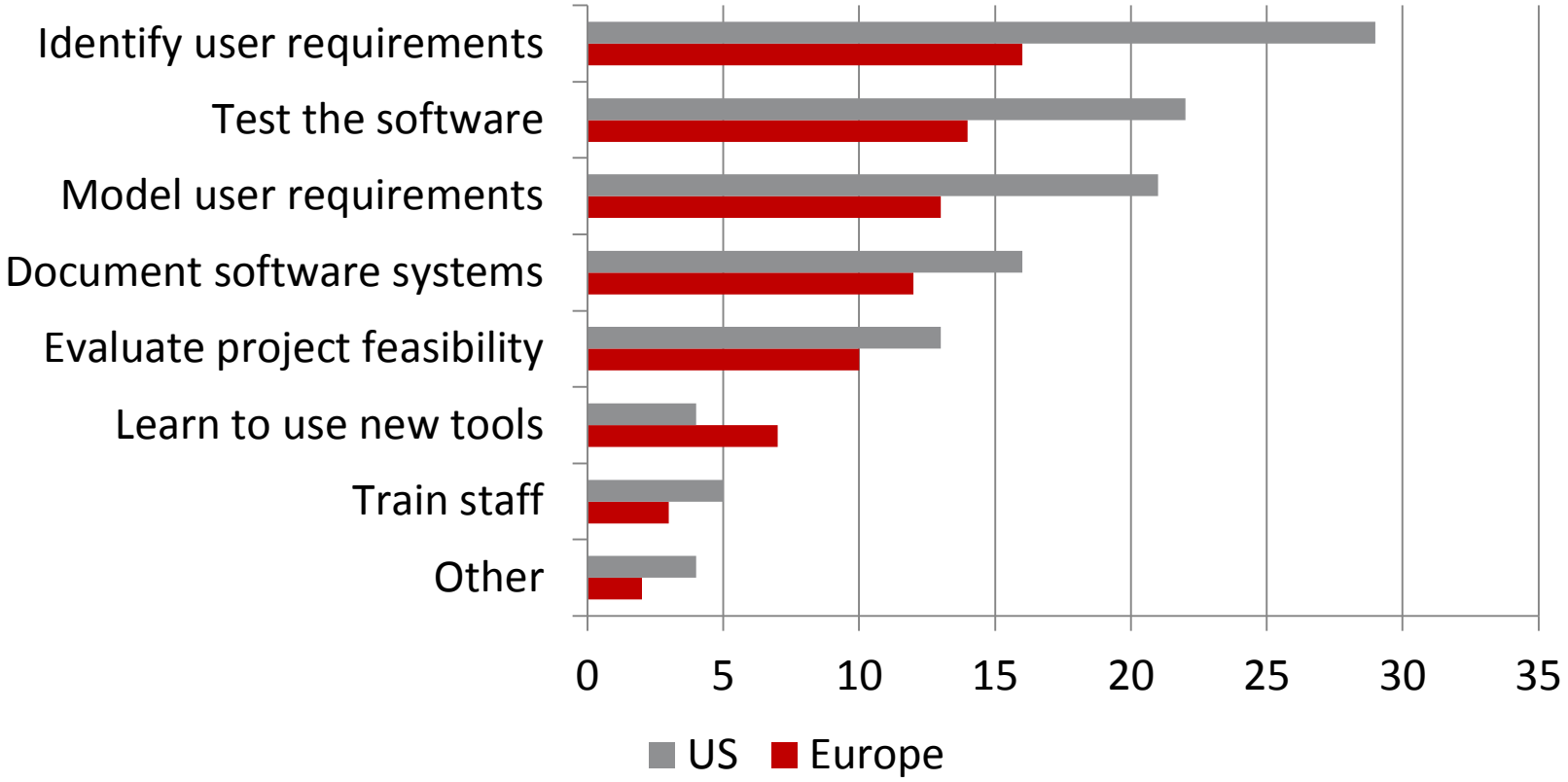
- **Classic RE approaches are often associated to sequential development processes (“waterfall”), and sometimes frowned upon proponents of lightweight (“agile”) methods.**

- **It is important to acknowledge, however, that the majority of concerns and techniques re-popularized in “agile” contexts are indeed concerned with requirements.**
  - Test first
  - User stories
  - Customer on-site
  - Incremental releases
  - Backlog/grooming
  - Kanban-stages/buckets

Assoc. Prof. Dr. Harald Störrle
Danmarks Tekniske Universitet (DTU)
COMPUTE Software Group

Industrial Perspective on RE Tools

Tool Usage in RE

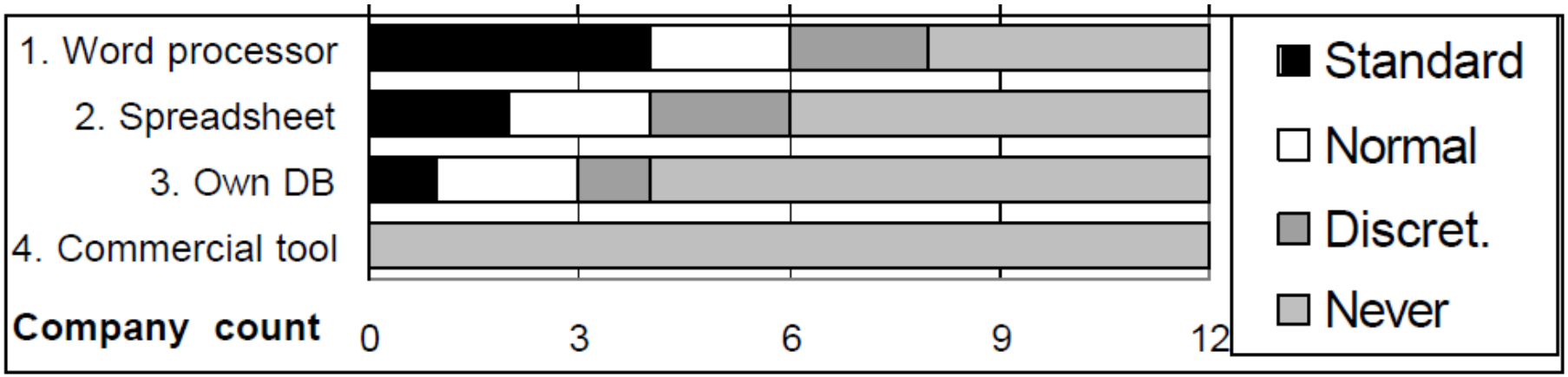


"I hate to be a cynic, but there are hardly any worthwhile tools. The overhead in learning to use them is too great for the payoff."

Luisa Mich, Mariangela Franch, Pierluigi Novi Inverardi: **Market research for requirements analysis using linguistic tools** Requirements Eng (2004) 9: 40–56, Springer

Tools

Do you use any tool supporting requirements analysis and top-level design?	How many employees and consultants are there in your company?				
	1–5	6–20	21–50	51–100	More than 100
Yes	16%	18%	33%	33%	51%
No	84%	82%	67%	67%	49%

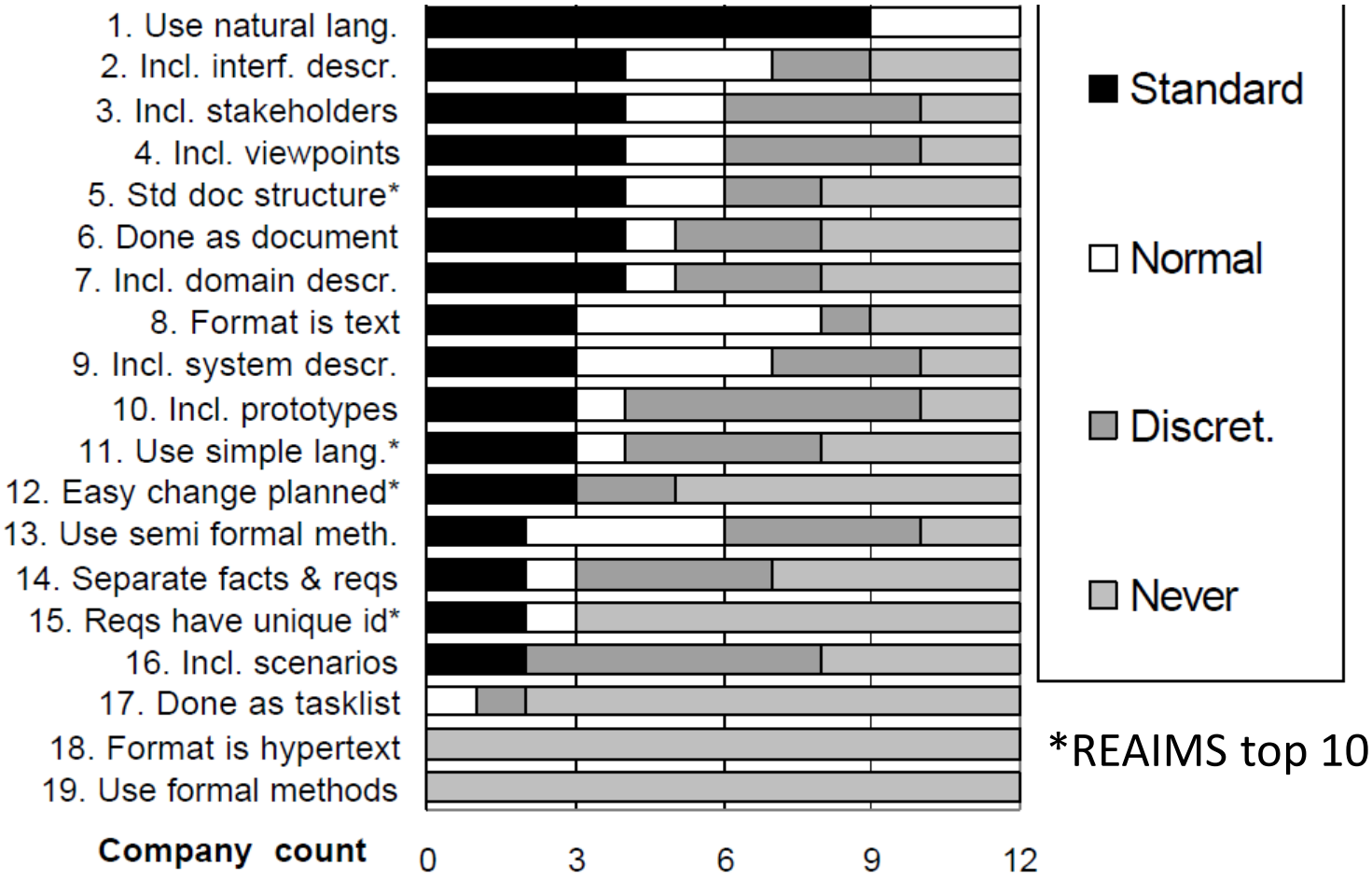


Luisa Mich, Mariangela Franch, Pierluigi Novi Inverardi: **Market research for requirements analysis using linguistic tools** Requirements Eng (2004) 9: 40–56, Springer

State of RE in Practice is Poor

"There is a lot of information available on solid RE practices but anecdotal evidence still indicates poor practices."

U. Nikula, J. Sajaniemi, H. Kälviäinen: A State-of-the-Practice Survey on Requirements Engineering in Small- and Medium-Sized Enterprises. Telecom Business Research Center Lappeenranta, Research Report 1, 2000



*REAIMS top 10

Improving RE Process Maturity is easy

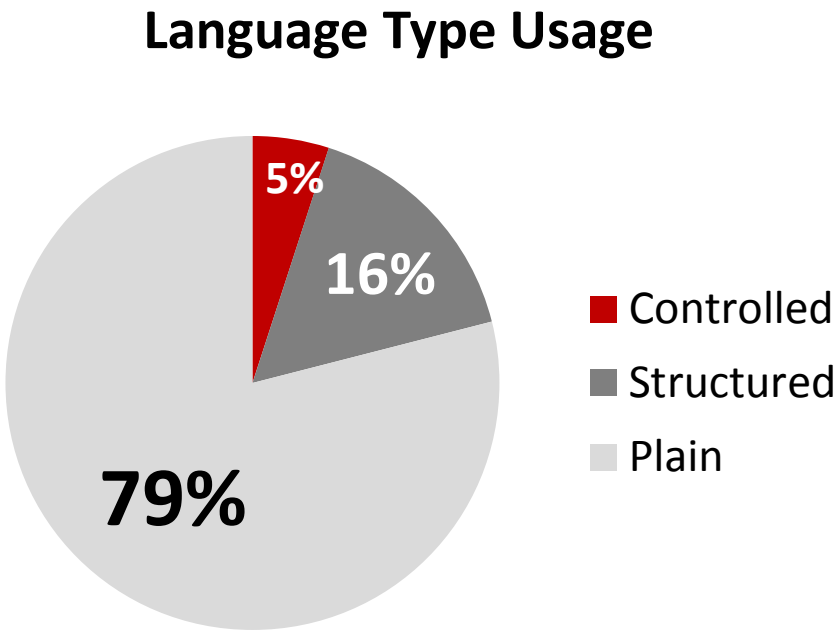
- Here are some examples of the practices by maturity level defined by the REAIMS RE process maturity framework.

- Basic
  - 3.1 Define a standard document structure
  - 4.3 Identify and consult system stakeholders
  - 6.2 Use language simply, consistently and concisely
  - 8.2 Organize formal requirements inspections
- Intermediate
  - 4.10 Prototype poorly understood requirements
  - 9.6 Define change management policies
- Advanced
  - 10.6 Specify systems using formal specifications
  - 10.8 Collect incident experience

[Ian Sommerville, Pete Sawyer: *Requirements Engineering: A Good Practice Guide*. Wiley, 1997]

Prose for Requirements Engineering

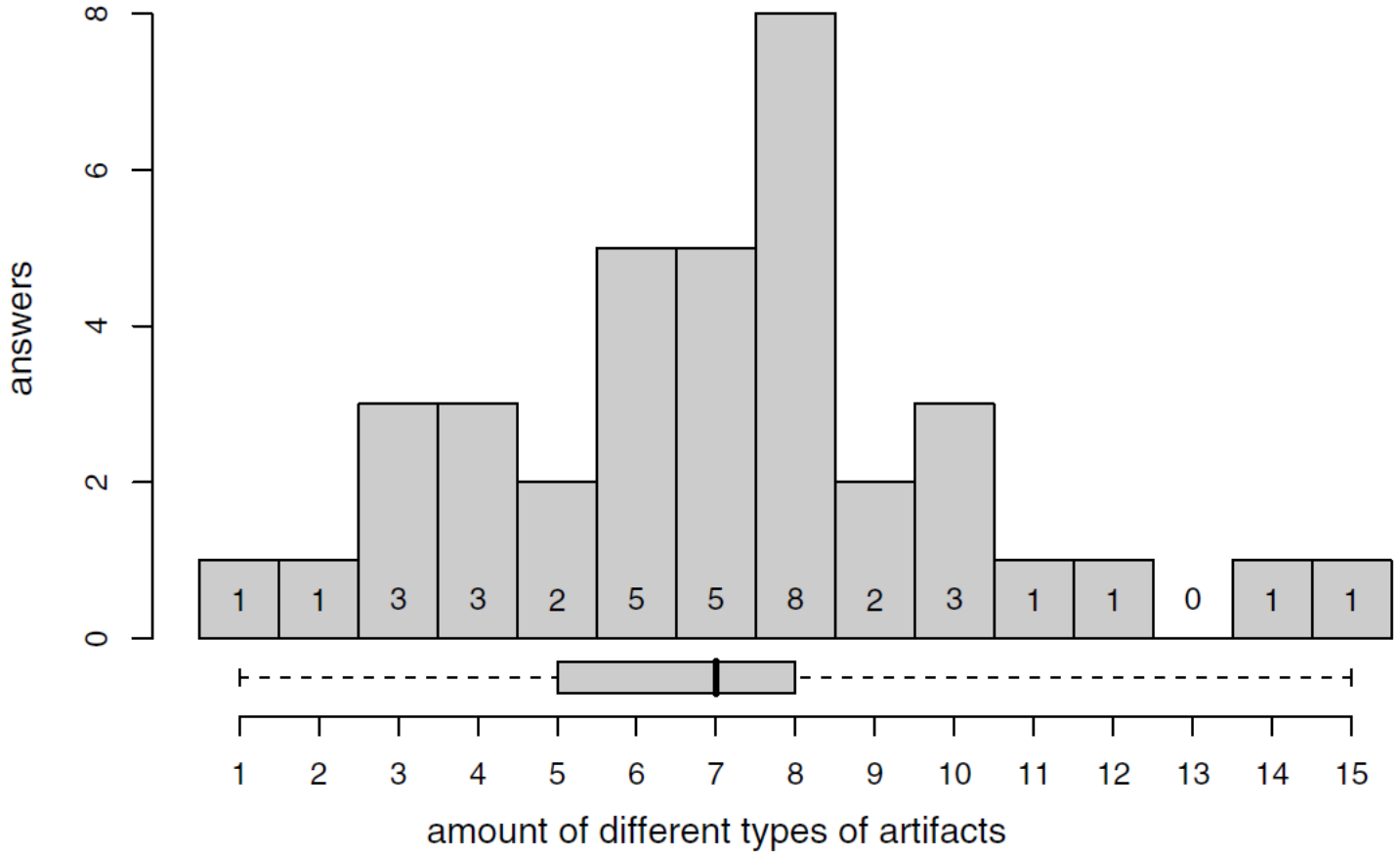
- **Alternatives exist, that can (mostly) replace NL, as various case studies have demonstrated.**



- **Natural Language Processing (NLP) and Information Retrieval (IR) technology can do amazing things:**
  - generating sequence diagrams from natural language use case descriptions;
  - generating class diagrams from NL requirements specifications.
- **However, if the performance is less than perfect, using tools is often worse than not using them.**

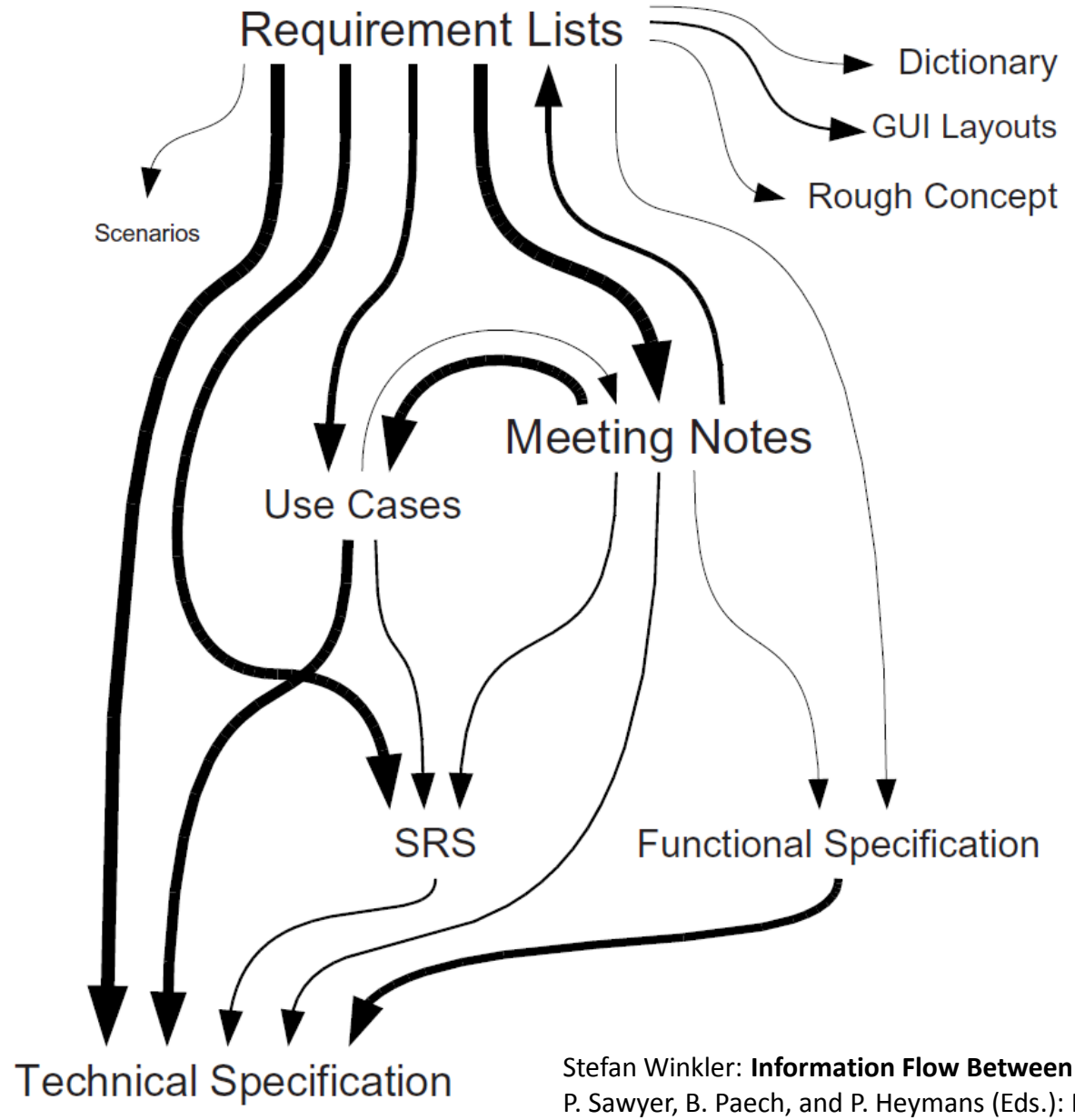
Concurrent Requirements Stores

- **In typical industrial settings, five to eight different media are used to store requirements.**



Stefan Winkler: **Information Flow Between Requirement Artifacts. Results of an Empirical Study**
P. Sawyer, B. Paech, and P. Heymans (Eds.): REFSQ 2007, LNCS 4542, pp. 232–246, Springer, 2007

Requirements Flow



Stefan Winkler: **Information Flow Between Requirement Artifacts. Results of an Empirical Study**
P. Sawyer, B. Paech, and P. Heymans (Eds.): REFSQ 2007, LNCS 4542, pp. 232–246, Springer, 2007

Industrial Perspective

- **Plain text prevails as the major RE "formalism".**
- **Existing tools are expensive and poor.**
  - They are used out of despair or regulatory torture.
  - Problems include ease of use, cost, and lack og (obvious) benefit.
- **Many long standing problems are still open.**
  - Transition to design phase, tracing
  - Integration in "lightweight" approaches
  - Team collaboration, version control
  - Effort/Cost estimation
  - Requirements validation
- **Academia is sitting in an ivory tower.**

Assoc. Prof. Dr. Harald Störrle
Danmarks Tekniske Universitet (DTU)
COMPUTE Software Group

Academic Perspective on RE Tools

Should Academia Create Tools?

- **Should we as scientists really create tools?**
  - After all, we're academics, and our job is research and teaching, and creating products is really the job of industry, isn't it?
  - Also, we don't have the resources to create tools with the degree of polishing required.

- **I believe that there are just three ways we as academics can impact the industrial practice of software development.**
  - Educate students better – but we're doing that already as best as we can.
  - Conduct targeted research through industrial co-operations.
  - Create and publish tools that address practical needs.

- **Actually, tools are instrumental to SE research.**
  - Conceptual research without validation is not any longer *de rigeur*.
  - Tools are essential for running case studies.
  - Tools that implement novel concepts are **embodied hypotheses**.

Academia Perspective on RE Tools

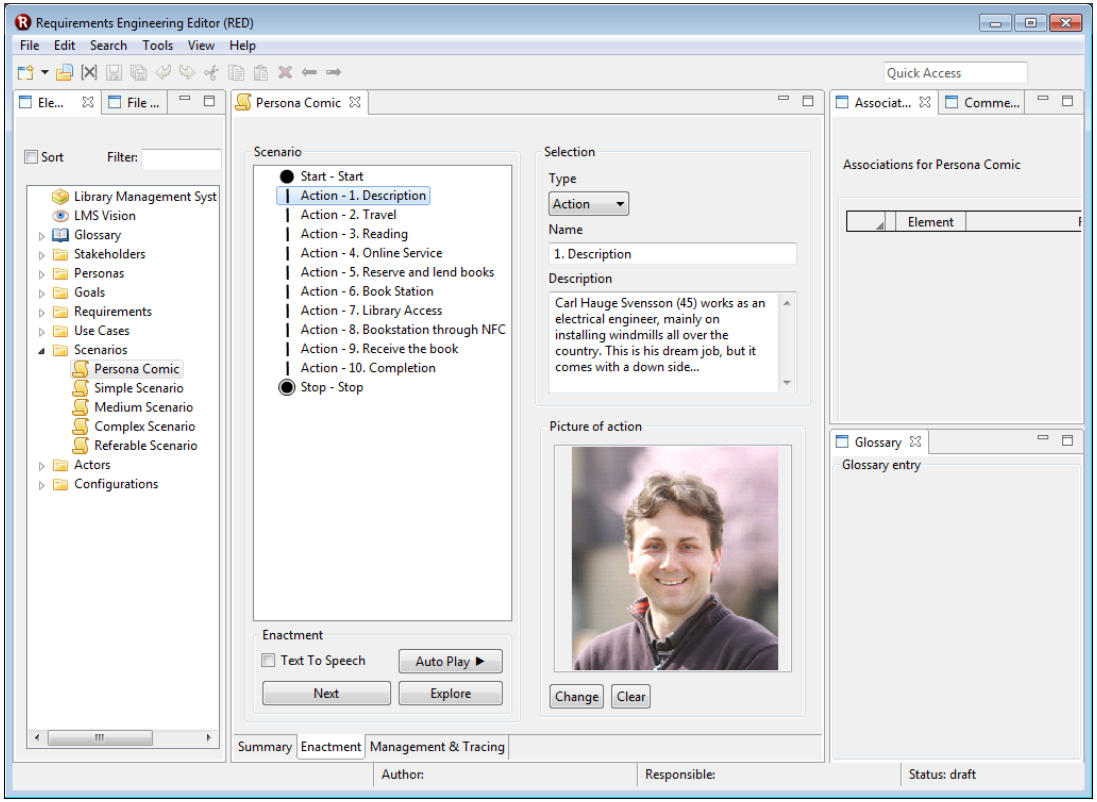
- **Academia cannot hope to create "a better DOORS".**
  - We should not attempt to, either—we should leap-jump industry.

- **There are many clever ideas & algorithms. Here are just few examples:**
  - Natural Language processing (checking of style/grammar, document outline)
  - Scenario enactment for validation
  - Effort estimation based on Function Points
  - Model Version Control to support group collaboration
  - Trace-preserving transition to design
- **These contributions are used neither in industry nor commercial tools.**

- **In order to achieve any kind of adoption, academic ideas will have to satisfy three conditions.**
  - They must be nicely wrapped – people are spoilt rotten by visual bling.
  - They must provide overkill benefit – acceptance must be a no-brainer.
  - They must address bread and butter features – no matter how booooring.
  - Advanced features must be fully automatic – no training/knowledge needed.

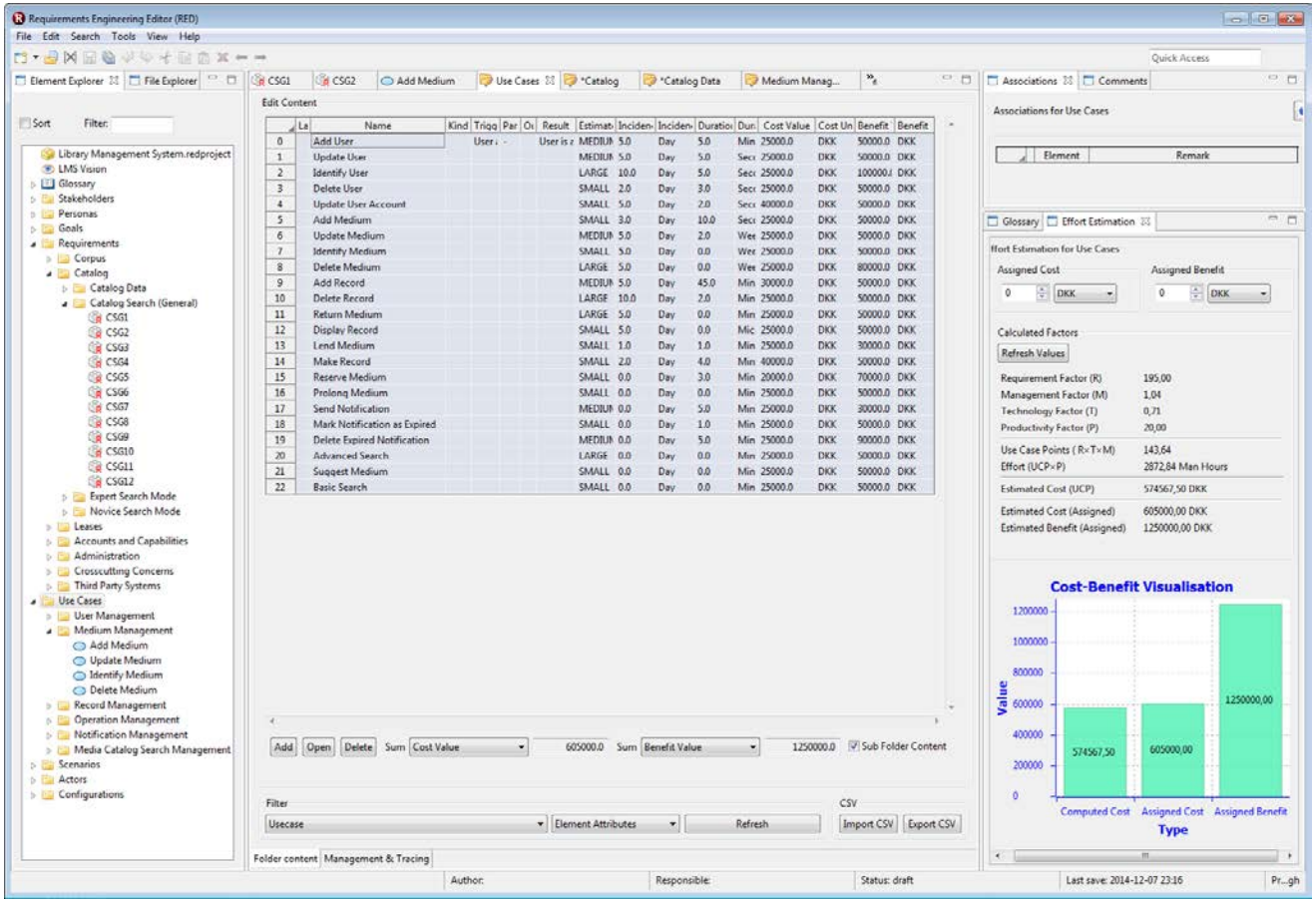
Enactment

- **Scenarios for Use Cases and Persona descriptions can validated through enactment.**
  - With a formal scenario structure, text to speech processing can create an interesting effect.
  - Enactment can be done without tool support, as a “design game”.



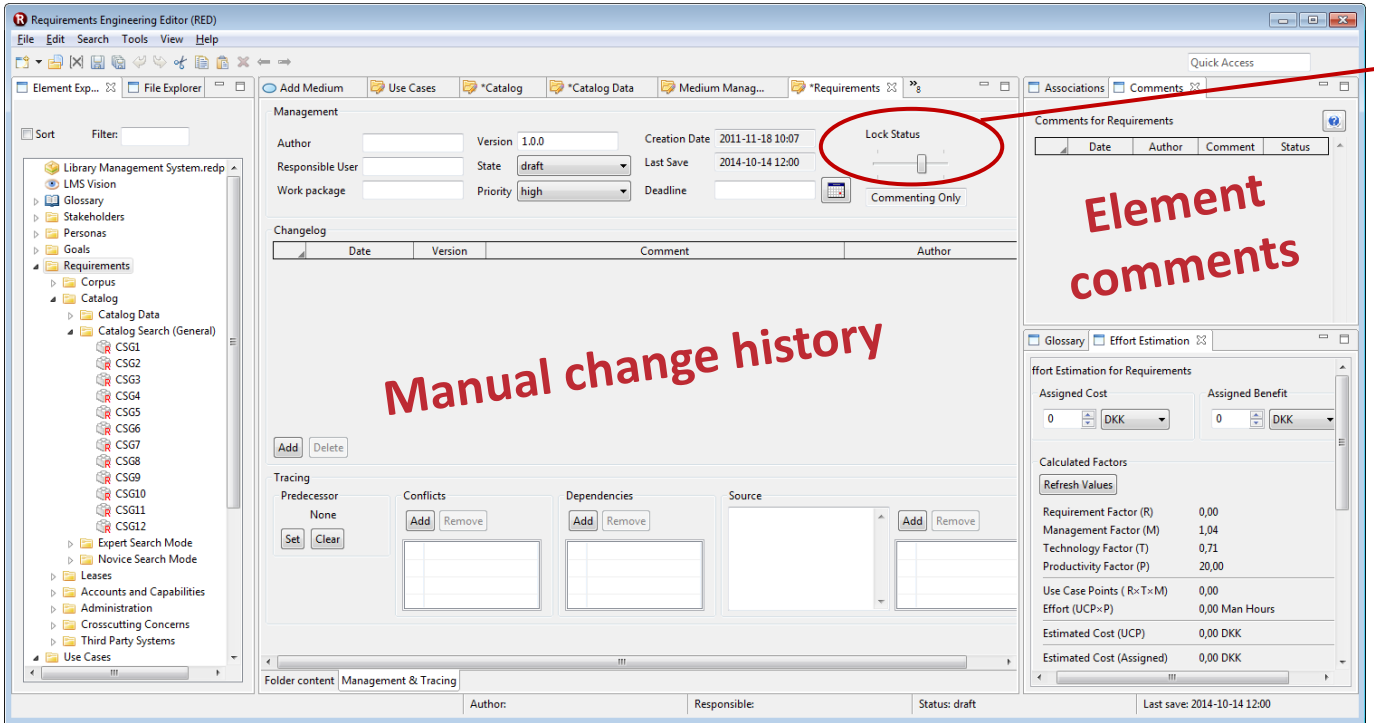
Function Point Estimation

- **Function Point Analysis (FPA) allows cost estimation of use cases.**
  - FPA is not routinely used in practice, despite solid evidence in their favor.
  - There is very little literature linking them to RE.
  - The topic is usually not taught in academic courses, and the tools don't support it.



Design Inspections

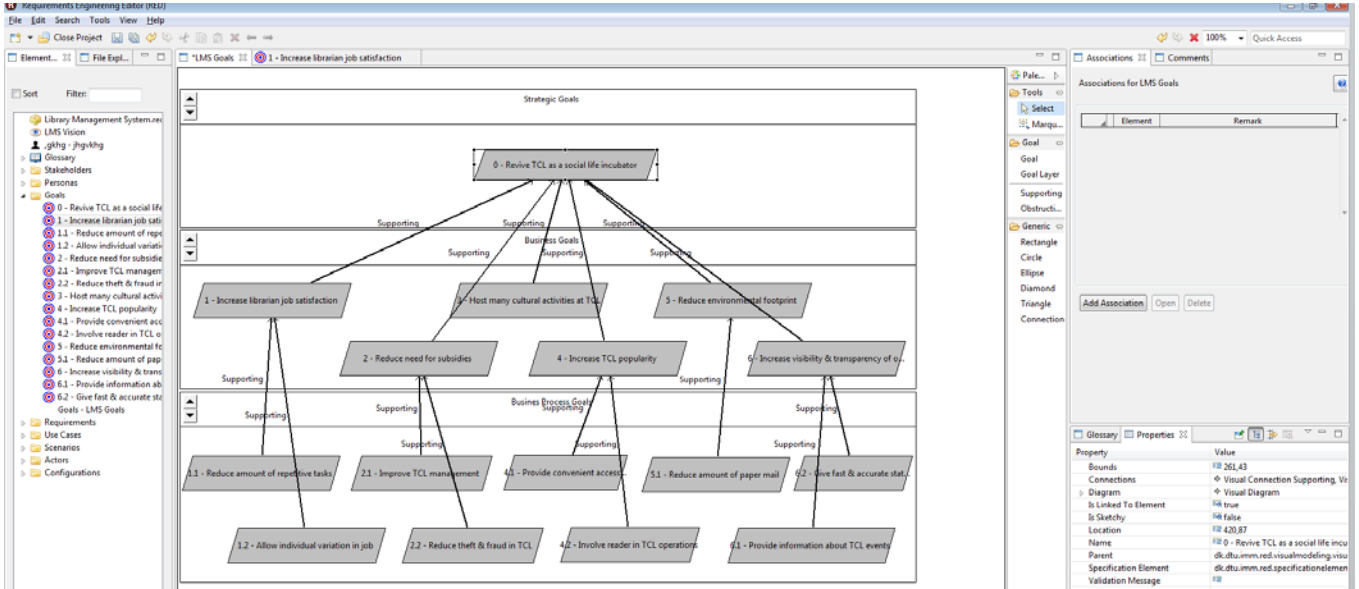
- **Inspections are a rather old QA technique that is particularly suitable for early phases.**
  - There is solid evidence to support the cost-effectiveness of code inspections.
  - There is very little literature on or guidelines for the application of inspections to requirements, or analysis-level models.
  - The topic is usually not taught in academic courses, and the tools don't support it.



Visual Editors

- **Many people like to complement their textual requirements by some visualization, with the aim to**
  - provide better overview (over a set of goals and their relationships, say);
  - illustrate their otherwise dreary and boring texts; or
  - provide an alternative view to better explain what they mean.

- **Observe that these drawings have a different status than both UML diagrams and fully informal doodles.**



Group Collaboration

- **Requirements specification is typically a team activity**
  - Classical problems of distribution/replication, locking/version control arise.

- **Unfortunately, existing tools do not fit the case of RE very well.**
  - Collaborative editing in Word, Google Docs, CMS, and Wikis support prose-like textual data spread out over a number of files.
  - Collaborative programming projects use VCS's like CVS, Continuous, SVN, GIT, etc. for many small text files in a fairly static overall structure.
  - In collaborative modeling, a single large DB (e.g., XMI-file) is created that captures a graph-like structure.

- **Requirements have unique characteristics, though:**
  - More than one person, but not that many either.
  - Requirements exhibit characteristics of text and graphs.
  - Conventional VC methods for code are not suitable

Collaboration Support in RED

- **The collaboration support in RED is made up of two feature sets.**
  - On the Client, RED offers multi-file projects with diff/merge by files/element.
  - On the Server, RED offers a visual version history that focuses on major development activities rather than (small) individual commits of data files.

Context & Challenges				Realization & Examples			
Case	**Files**	**Data**	**Users**	**Diff**	**Merge**	**Lock**	**Example**
Coding	10^k	Text	10^k	**`diff`**	**`patch`**	File	CVS, SVN, GIT, Continuous, …
Editing	1 (k?)	Text + Mark-Up	1…k	Highlighting	?	File	GoogleDocs, Wiki, Word,
Modeling	1	Graph-like	1…k	Highlighting, Delta	global	Element	MagicDraw, VP, Rational Rose
Requirements Engineering	1…k	=Editing	1..k	per File	?	File	DOORS
	1?	=Modeling		=modeling			RequisitePro
	1…k	Editing + Modeling		Per File	per File/ Element	File	RED

where *k* is a small constant (maybe around 3…8)

Trace-respecting A/D-Transition

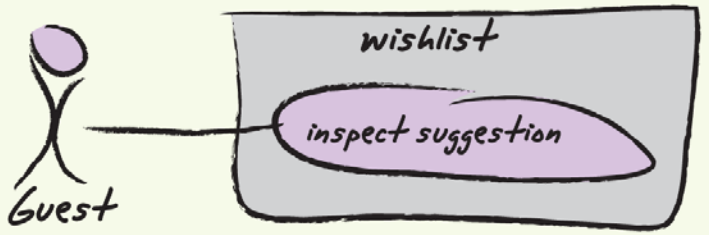
- **Translating a (big) textual requirements specification into a design model is difficult.**
  - The translation as such is difficult and requires guidance and expertise.
  - There are bound to be many decisions, some are genuine design decisions, others result from weaknesses of the specification (ambiguity, omissions, …)
  - Domain experts and clients typically do not understand the design level language (e.g., UML), so they cannot validate the translation outcome.
  - Trace links must be established manually.

- **Idea: Translating individual requirement is much easier.**
  - Each requirement is translated into a small model fragment (lenient syntax).
  - The translation as such uncovers errors by change-of-perspective.
  - The resulting fragments are then woven automatically.
  - Weaving diagnostics and manual inspection of the result uncover errors.
  - Traces are generated automatically.

Individual Translation

Requirement MLC9a
Guest readers may inspect suggestions in the wishlist system.

Fragment MLC9a-UC

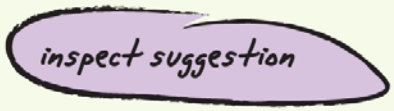


Requirement MLC9b
Guest readers may inspect suggestions.

Fragment MLC9b-UC

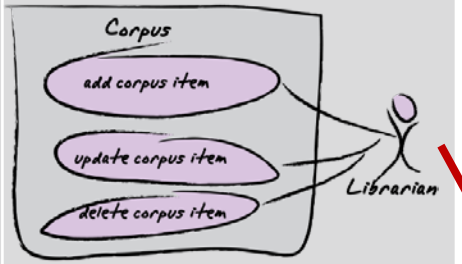
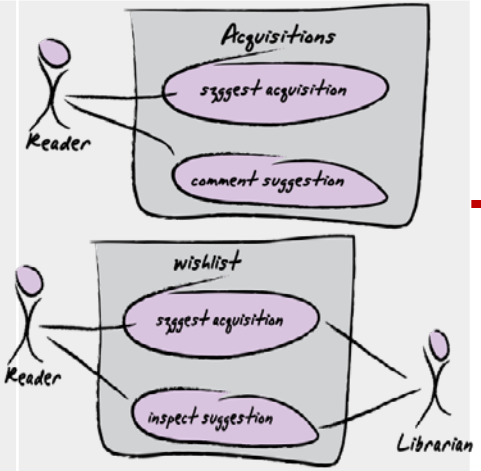
Requirement MLC9c
Book suggestions may be inspected.

Fragment MLC9c-UC

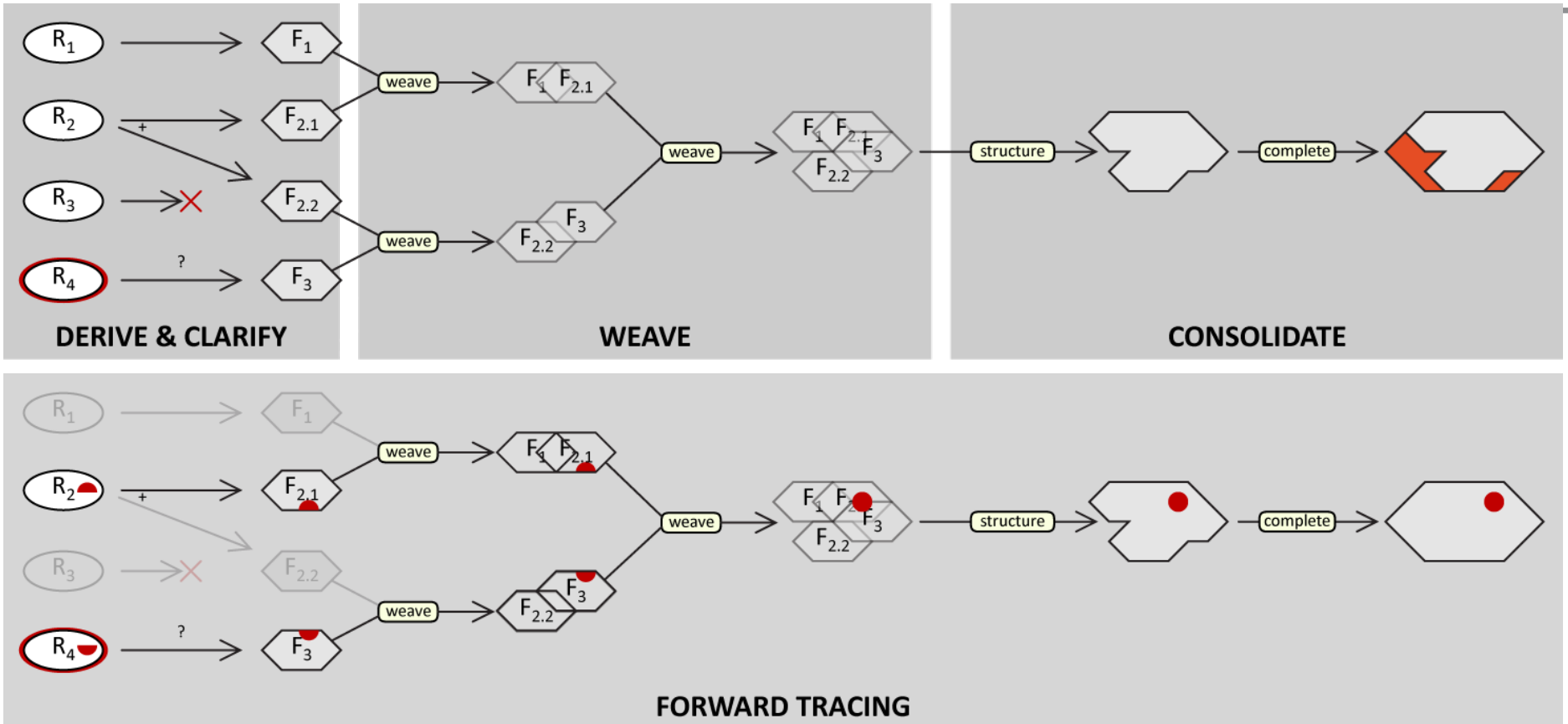


Weaving Model Fragments

- **Here is an excerpt from the LMS requirements specification, and how the features described may be captured as models.**

ID	Requirement	Model Fragment
MLC 2	Librarians may add, update, and delete corpus items manually.	
MLC 4	Librarians and Readers may post and inspect media they think should be acquired by the library to a public "wish list" indicating the status of the wish and the originator.	
MLC 10	A librarian can do all a reader can do; a reader can do all a guest reader can do.	

Weaving Fragments Establishes Traces



Assoc. Prof. Dr. Harald Störrle
Danmarks Tekniske Universitet (DTU)
COMPUTE Software Group

The Requirements Editor RED

The Requirements Editor RED

- **RED is a stand-alone tool for requirements engineering**
  - RED is based on Eclipse RCP, and was developed mostly by students as their final thesis project (MSc, some BSc) plus some paid hands.
  - Development has started in September 2011, a major re-engineering took place in 2013. Currently (04/15), we are preparing version 3.0.

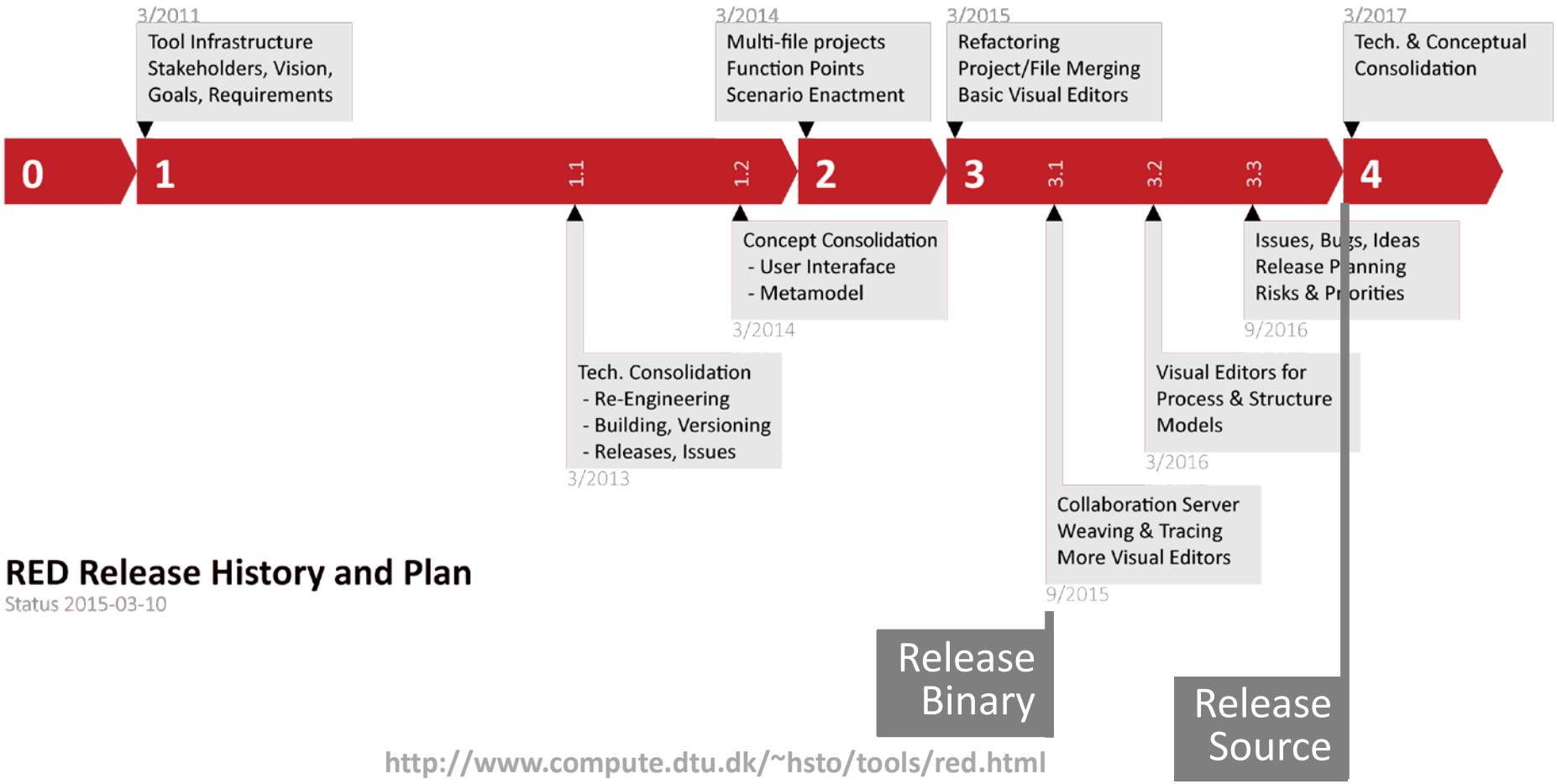
- **RED is intended as a tool to support teaching**
  - We aspire to maximize conceptual clarity and coherence, while offering a comprehensive and practical toolbox with some cutting-edge features.
  - The tool aspires to be conceptually consistent, in itself (UI, meta-model) and with regards to the course material (slides, case studies, samples, guidelines).

- **Development goes on, a first public release is scheduled for 09/15.**
  - RED now consists of over 1,860/650 classes (hand-written/generated) and over 114,000 Lines of Code (Java).
  - The last major components (Collaboration Server) are close to completion.
  - The main focus has shifted to quality rather than adding new features.
  - One of the next steps is Bootstrapping, i.e. documenting RED in RED.

RED Features

- **Features in RED 3.0 (3/2015)**
  - Goals, stakeholders, visions
  - Textual & multimedia requirements
  - Informal requirements, assumptions
  - Use cases, test cases
  - External document integration
  - Personas, storyboards
  - Scenarios, enactment, Text2Speech
  - Use case points effort estimation
  - Cost/benefit annotation & analysis
  - Full cross-referencing glossary
  - UML Model Fragments
  - Browsing, searching, and sorting
  - Reporting, exporting, importing
  - Multi-file projects, Merging
  - Inspection support, locking
  - Traceability, manual change history
  - Visual modeling (Use Cases, Goals)
  - Model fragments weaving
- **3.1 (9/2015)**
  - Online collaboration server
  - Dynamic web service extensions
  - More visual modeling (all of UML)
  - Dynamic view filtering
- **3.2 (3/2016)**
  - Quantitative risk management
  - Features, Issues, Bugs
  - Releases, release planning
  - AHP prioritization
- **Future Work (Options)**
  - More file formats (ReqIF, XLSX,…)
  - CNL/Pattern checker
  - semi-automatic text-to-model translation
  - formal methods for checking
  - Mobile elicitation device

Release Plan



http://www.compute.dtu.dk/~hsto/tools/red.html

https://hsto@bitbucket.org/hsto/red.git

Assoc. Prof. Dr. Harald Störrle
Danmarks Tekniske Universitet (DTU)
COMPUTE Software Group

Conclusion

Academic Tool Development

- **Developing practical tools is possible.**
- **Developing practical tools is not easy.**
  - Considerable effort and time for polishing is needed – it's a long shot.
  - But IT is a people industry – and we have the most valuable resource.
- **Developing practical tools is useful.**
  - Such a tool can serve as a proof-of-concept platform for individual ideas, it can be the basis for case studies, provide students with a realistic project environment...
- **Creating large scale software is the topic of Software Engineering.**
  - First we should get it right ourselves. Then, we should help scientists outside of SE to get their large scale developments right.
  - That is the aspiration of the COMPUTE Software Group.
- **Therefore, in SE, developing tools should be accepted as a scientific contribution per se – not just for proof-of-concept.**

Upcoming Elections for ACM Europe Council

The ACM Europe Council aims to increase the level and visibility of ACM activities across Europe, e.g.

- fostering the visibility and relevance of ACM in Europe, and
- encouraging greater participation of Europeans in all dimensions of ACM.

Vote for me to represent Germany & Scandinavia!

Prof. Dr. Harald Störrle
Software Engineering Section
Informatics and Mathematical Modelling
Technical University of Denmark

Matematiktorvet
Building 303b, Room 056
DK-2800 Kgs. Lyngby

Tel 0045 4525 3757
EMail hsto@dtu.dk
Web www.compute.dtu.dk/~hsto

acm Europe

http://europe.acm.org/