Applied Research & Technology Transfer at Fraunhofer IESE:

Benefits to Industry

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Motivation (1/3)

- **Most businesses (products & services) depend heavily on "quality" software – both to**
  - **optimize existing products & services (e.g., automobiles, telecommunication)**
  - **develop new products & services (e.g., e-business, ambient systems)**
- **Software quality (Q) depends on quality development processes (P)**

$$Q == f(P)$$

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Motivation (2/3)

- **Software Engineering (as a discipline) aims at optimizing software development processes to quality goals (Q) in a given context (Context) and with some level of variance (<var>)**

$$Q \overset{<var>}{==} f\ (P,\ Context)$$

e.g., Defect Freeness == f (Inpection, <Experience, ...>)

- **Special considerations in software**
  - **process-product relationships in a "design" domain such as software development are non-deterministic and must be determined empirically!**

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Motivation (3/3)

- Objectives of Academia
  - empirically investigate process-product relationships for innovative processes!
  - problem: What Q and Context to focus on?

$$Q == f(P, Context)$$

- Objectives of Industry
  - empirically optimize processes for given quality goals and contexts!
  - problem: What processes to focus on?

$$Q == f(P, Context)$$

Motivates Mutual Collaboration Interests!

Technology Transfer Problems in Industry

Typical Technology Transfer Problems

- New processes rejected by project personnel
  - considered not well adapted to needs
  - not convinced of being beneficial
- New processes not “lived” under project pressure
  - not convinced enough of benefits to take risk
  - not supported by project management
- Past project experiences not reused in new projects
  - no demonstrated evidence of benefits
  - “religious” beliefs win

Root Causes (1/2)

- **Inappropriate transfer of new software development processes**
  - **transfer of "un-tested" processes (instead transfer of "competences")**
    - **a process P is a competence if and only if one understands Q == f (P, Context) for all relevant Contexts**
  - **"train and go" approach is insufficient**
    - **leads to inappropriate application (faking) without "off-line empirical studies" for motivation (e.g., Ada/OO experience)**
    - **leads to "return to the old process" under project pressure without "off-line empirical studies" for risk mitigation (e.g., inspection experience)**
    - **leads to sub-optimal effects without "on-line empirical studies" for optimization (e.g., inspection experience)**

$$Q \overset{???}{==} f(P, ???)$$

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Root Causes (2/2)

- **Underestimation of individual motivation**
  - **processes (and as a result products) are only as good as they are adhered to**
  - **adherence –under project pressure – requires evidence that the potential of something "new" is greater than "the experienced potential of the old"**

This is one of the major reasons for the unusally huge gap in software engineering between state-of-the-art and -practice!

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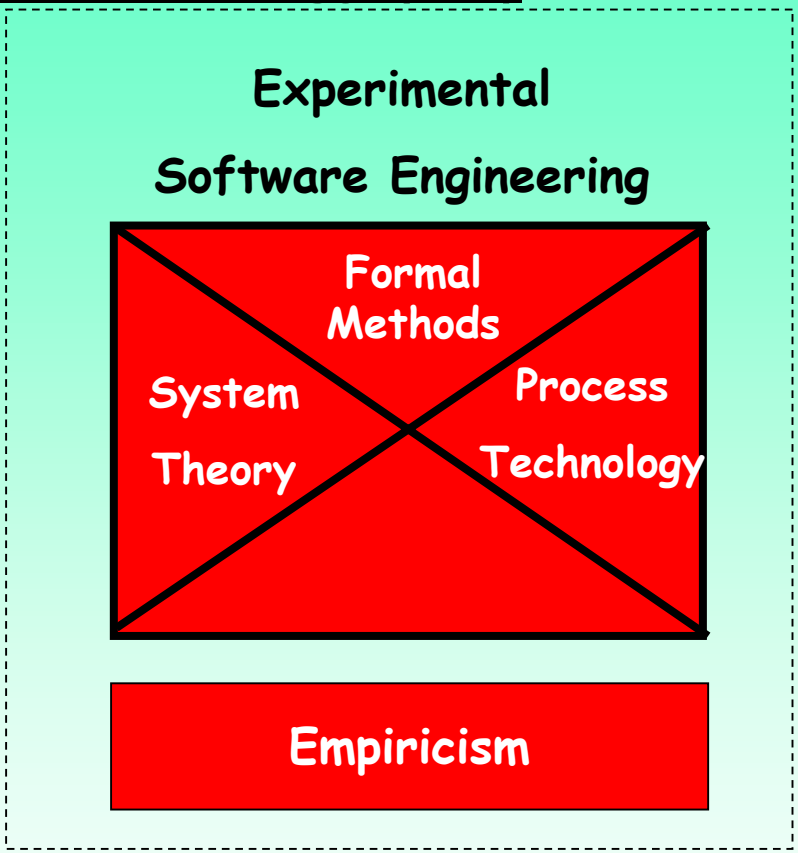
Solution Strategy (1/2)



- **Software Engineering comprises**
  - **(formal) methods** (e.g., modeling techniques, description languages)
  - **system technology** (e.g., architecture, modularization, OO, product lines)
  - **process technology** (e.g., life-cyle models, processes, management, measurement, organization, planning QS)
  - **empiricism** (e.g., empirical studies, experience capture, experience reuse)

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Solution Strategy (2/2)

- Cooperation between Academia & Industry
- Why should companies cooperate with external R&D organizations?
  - external competence & experience about "candidate new processes"
  - external competence & experience about "empirical study performance"
- Possible joint activities
  - off-line empirical studies ranging
    - from University laboratory studies (e.g., potential of a testing strategy)
    - to joint "trial engineering experiments" (e.g., study of a new design approach)
  - establishment of "measurement" infrastructure for online empirical studies in a company (e.g., measurement tools)
  - data analysis, interpretation & modeling to establish initial baselines & continuously optimize
  - build "Best practice" databases (experience bases) for new processes
  - education & training

Fraunhofer IESE (1/6)

- **Fraunhofer Gesellschaft e.V.**
  - **largest applied research organization in Europe**
  - **57 institutes, 12000 scientists**
  - **domains range from materials, production technology to information & communication technology and life sciences**
  - **funding scheme: 1/3 base funding from government**
  - **considered preferred research & technology partner for industry**
  - **technology transfer accelerator between academia & industry**

Fraunhofer IESE (2/6)

- **Fraunhofer IESE (Kaiserslautern, Germany: 150 FTEs & US: 20 FTEs)**
  - **applied research in the areas of**
    - **software/systems engineering**
      - **requirements & usability engineering**
      - **component-based software engineering**
      - **software product line engineering**
    - **project & quality management**
      - **project & subcontract management**
      - **measurement (based on GQM)**
      - **process modeling & documentation (collaboration with Dr. Bill Riddle)**
      - **security evaluation & engineering**
      - **experimentation**
    - **competence management**
      - **experience management (based on EF)**
      - **e-learning & coaching**

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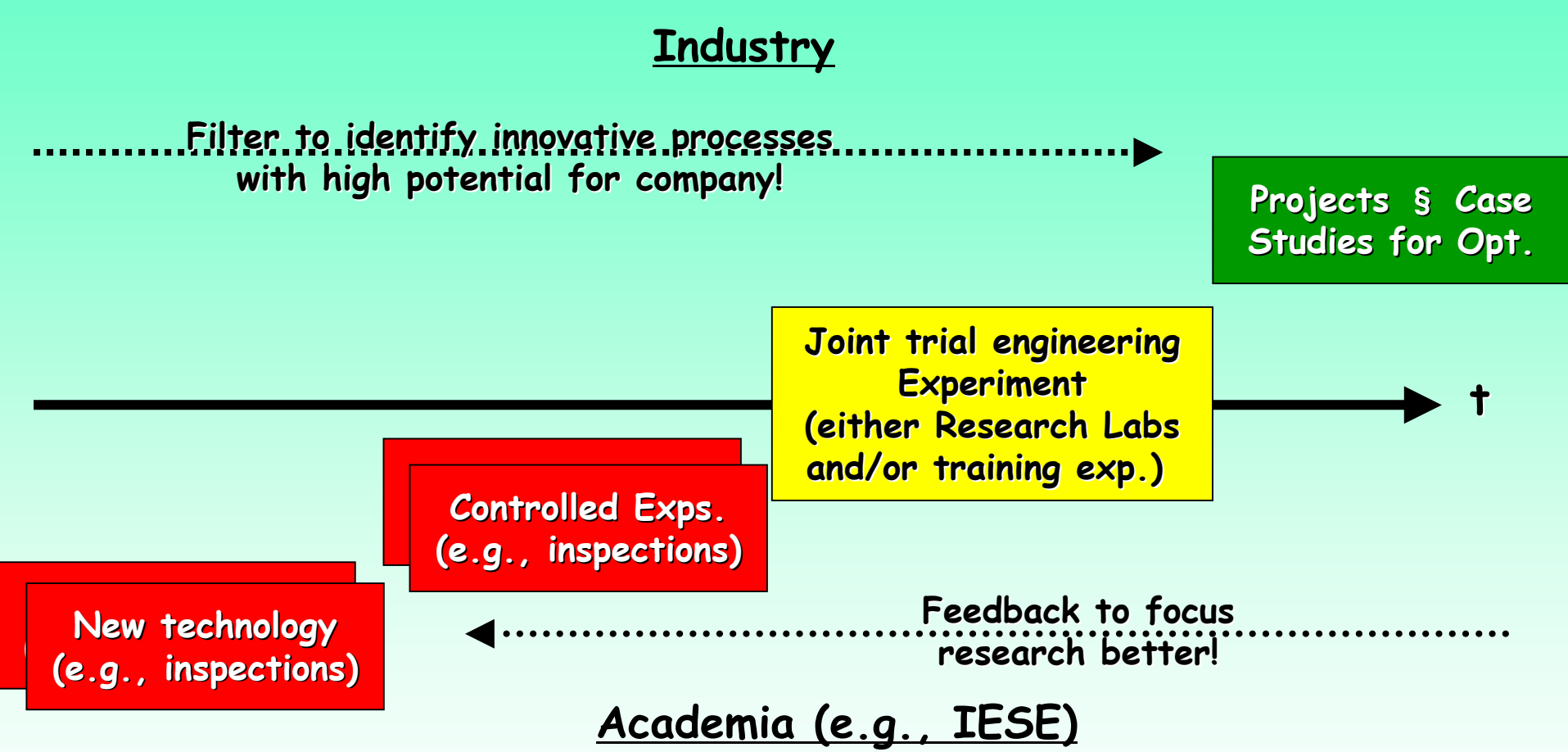
Fraunhofer IESE (3/6)

- Fraunhofer IESE (Germany: 150 FTEs & US: 25 FTEs)
  - cooperative projects with industry
    - tech transfer
    - contract research (Joint Research Labs)
    - consulting/assessing/training/….
    - expert assistance (e.g., for subcontract or acquisition mgt)
    - extended workbench activities applying new processes (e.g., inspection, usability testing)
  - industry projects with companies in several sectors
    - reliable embedded systems (e.g., automotive, aerospace, mechanical engineering, defense, …)
    - secure telecom systems (e.g., network providers & applications)
    - flexible banks, insurance, trade systems
    - software companies

Fraunhofer IESE (4/6) – Empirical Transfer Paradigm



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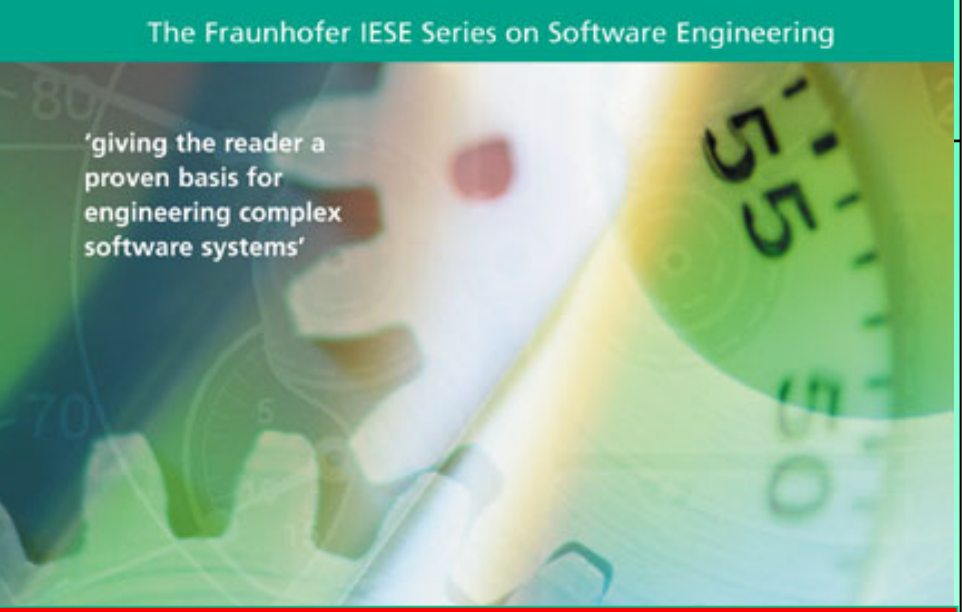
Fraunhofer IESE (5/6) – Experience Base (for Benchmarking)

- Fraunhofer IESE's main capital is its internal experience base capturing "Best Practice Evidence"
  - IESE experience base
  - book (Endres/Rombach, Addison, 2003)
  - externally available portals (e.g., www.visek.de)
- There exists more knowledge than we typically recognize
  - mostly in terms of "context-specific empirical observations"
  - rarely in terms of empirical "laws"
  - almost none in the form of "theories"
- More studies need to be done
  - repeat (with variation) to tailor to company needs
  - generalize to transfer across company boundaries



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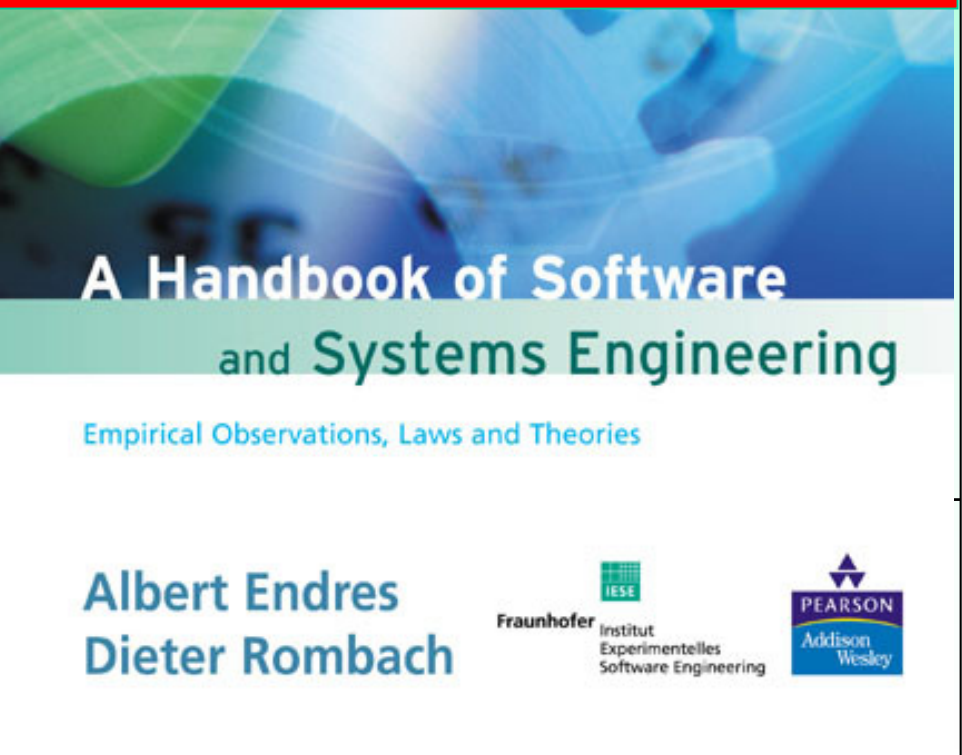

Fraunhofer IESE Series

Editorial Board includes
- Dave Parnas
- Dieter Rombach
- Ian Sommerville
- Marv Zelkowitz

Handbook capturing existing body of knowledge

Students can learn about existing body of knowledge

Practitioners can avoid negligance of due dilligance

Additions are welcome for next edition of book

Industrial Success Stories (1/5)

- Allianz, Germany (inspections)
- Bosch, Germany (product lines, inspections)
- Market Maker, Germany (product lines)
- …..

Financed by companies!

- Fraunhofer IESE SME Research Lab
  - currently being built up
  - supports cluster of regional SMEs
  - one technology per cluster (e.g., testing)

Co-financed by state government!

NO sustained transfer success story (ROI) exists without appropriate support via continuous empirical studies!

Industrial Success Stories (2/5) - Allianz, Germany

- Domain
  - information systems (Insurance products)
- Transferred processes
  - requirements inspection based on PB-reading
- Expected effects
  - reduction of development time (by reduction of rework)
- Actual effects
  - 90% of all requirements defects (after 3 Iterations) are being caught
  - development time (- 30%)
- Empirical studies
  - off-line
    - evaluation of inspections based on sound reading techniques (to motivate trial)
  - on-line
    - training experiment with inspections (to motivate process adherence)
    - continuous case studies to optimize effects (of non-slippage of inspections from 30% to 90%)

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Industrial Success Stories (3/5) - Bosch, Germany

- Domain
  - embedded software (car controls, e.g., fuel injection or body electronics)
- Transferred processes
  - inspections based on PB-Reading
  - product Line engineering (current activity)
- Expected effects
  - better process control
  - reduced rework
  - increased quality (certifiable)
  - reduced cost via reuse

Industrial Success Stories (4/5) - Bosch, Germany

- **Actual effects**
  - **much better process control (e.g., project halts when too many problems are identified**
  - **reduction of rework (-80%)**
  - **Increased quality (no defects in final testing stages)**
  - **high reuse potential based on "trial SPL experiments" estimated (-50% via reduction of 15 existing into 2 new product lines)**
- **Empirical studies**
  - **off-line**
    - **evaluation of inspections based on sound reading techniques (to motivate trial) & joint SPL trial engineering experiment (ongoing)**
  - **on-line**
    - **training experiment with inspections (to motivate process adherence)**
    - **continuous case studies to optimize effects (of non-slippage of inspections from 30% to 80%)**

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Industrial Success Stories (5/5) – Market Maker, Germany

- **Domain**
  - **stock market software**
- **Transferred processes**
  - **software product line development (PuLSE)**
- **Expected effects**
  - **reduction of cycle time to adjust to customer needs**
- **Actual effects**
  - **cycle time reduction (-50%)**
  - **larger market share in Germany & Europe (No. 1 in Germany)**
  - **listed by SEI as success story in "SPL Hall of Fame"**
- **Empirical studies**
  - **baseline study regarding development effort & time**
  - **joint trial engineering experiment by reverse engineering existing systems using PuLSE**
  - **on-line case studies monitoring development efforts in new environment**

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Key Lessons Learnt

- No sustained improvement through software engineering processes without empirical evidence!
- Academia can highlight potential of new innovative software engineering processes via empirical studies
  - the more they know about "industrial contexts", the higher the credibility of empirical study results will be
- Academia (Fh IESE) & Industry can perform joint trail engineering experiments to establish business case
- Industry has to customize and optimize high potential processes to its own goals and contexts
  - on-line customization & optimization in-house
- Technology transfer benefits by
  - faster transfer (-50% in company comparison)
  - higher adoption rate (100% of all processes that underwent joint trial engineering experiments were adopted)
  - Sustainability/ROI (possible only based on empirical studies)

Potential Collaborations

- Academia & industry in Japan could/should
  - transfer promising infra-structure for empirical studies (e.g., measurement tool) to industry
  - establish joint research labs (to investigate specific processes for a specific industry firm)
  - create national or sector-specific experience exchange forum(s)
  - create national or sector-specific portal(s) on software engineering experience (best practices)
- International collaboration in the EASE project could include
  - exchange experience with leading "empirically based" software engineering competence centers (e.g., FC-MD/Basili, IESE/Rombach, NICTA/Jeffery, USC/Boehm)
  - collaboration on EASE project
  - collaboration on joint research labs with Japanese industry (based on partner competences)

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