Industrial Software:
Business Value, Agility & Resilience

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Ringvorlesung TU Dresden WS 2014/2015
Montag, 26. Januar 2015

V1.7 /18.01.2015

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- Dipl. El. Ing. ETH Zurich (1970)
- Ph.D. Technical Sciences ETH Zurich (1974)
- Management Consultant: «Very Large Software Systems»
- EC Expert (Evaluator & Reviewer): «Safety-Critical Systems»
- TUD: «Future-Proof Software Systems» (WS13/14, WS14/15)

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Line of Thought

Context: A world of software

⇩

Vision: Future-Proof Software-Systems

⇩

Strategy: Managed Evolution

⇩

Implementation: Industrial Software

⇩

Foundation: Architecture Principles

⇩

Aging: Architecture Erosion & Technical Debt

http://www.wissenswertes.biz

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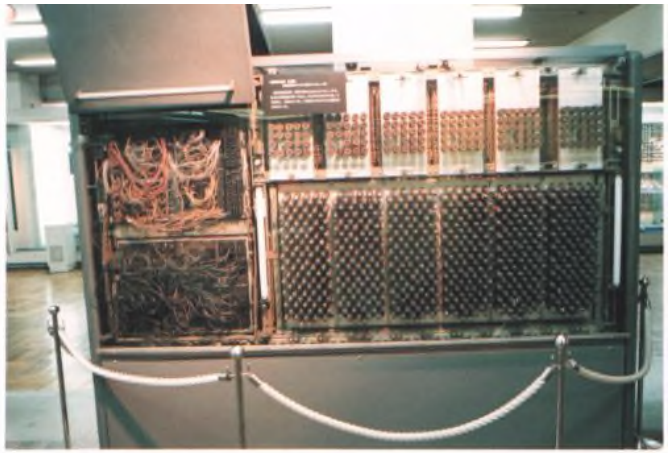
Industrial Software: Business Value, Agility & Resilience

UNIVAC 120 (1953)



http://web.kyoto-inet.or.jp/people/s-oga/oldcom/index.html

Decimal storage: 120 digits
„Program“: Wired Panel

+ 60 years

CRAY Titan (2013)

http://www.eweek.com/servers/slideshows

Data storage: 710 Terabytes RAM
30 Petabytes Disk
Computing Power: 17,59 Petaflops

http://www.motorbase.com/picture/by-id/437941611

Land Rover 1953: SLOCs = 0
(SLOC = Source Lines of Code)

http://myauto24.blogspot.ch/2013/

Mercedes S-Class 2013: SLOCs ≈100 Million

❶ Software has evolved from a system *building block*

to a major *industrial asset*

with a large financial *investment*

and tremendous impact on the *business opportunities*

❷ Many software modules have a long life span.

They need to be maintained and evolved over many years/decades

Therefore: Our software needs to be **future-proof**

(Definition follows later)

UNIVAC 120 (1953)

CRAY Titan (2013)

http://web.kyoto-inet.or.jp/people/s-oga/oldcom/index.html

https://www.mercedes-benz.com/en/mercedes-benz/innovation

http://www.motorbase.com/picture/by-id/437941611

http://myauto24.blogspot.ch/2013/

> 2015: 80% der technischen Innovation

= Software

Land Rover 1968: SLOCs ~0

Mercedes S-Class 2013: SLOCs ~100 Million

(SLOC = Source Lines of Code)

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Software-Systems: **Impact Factors**

„The three devils of systems engineering are:

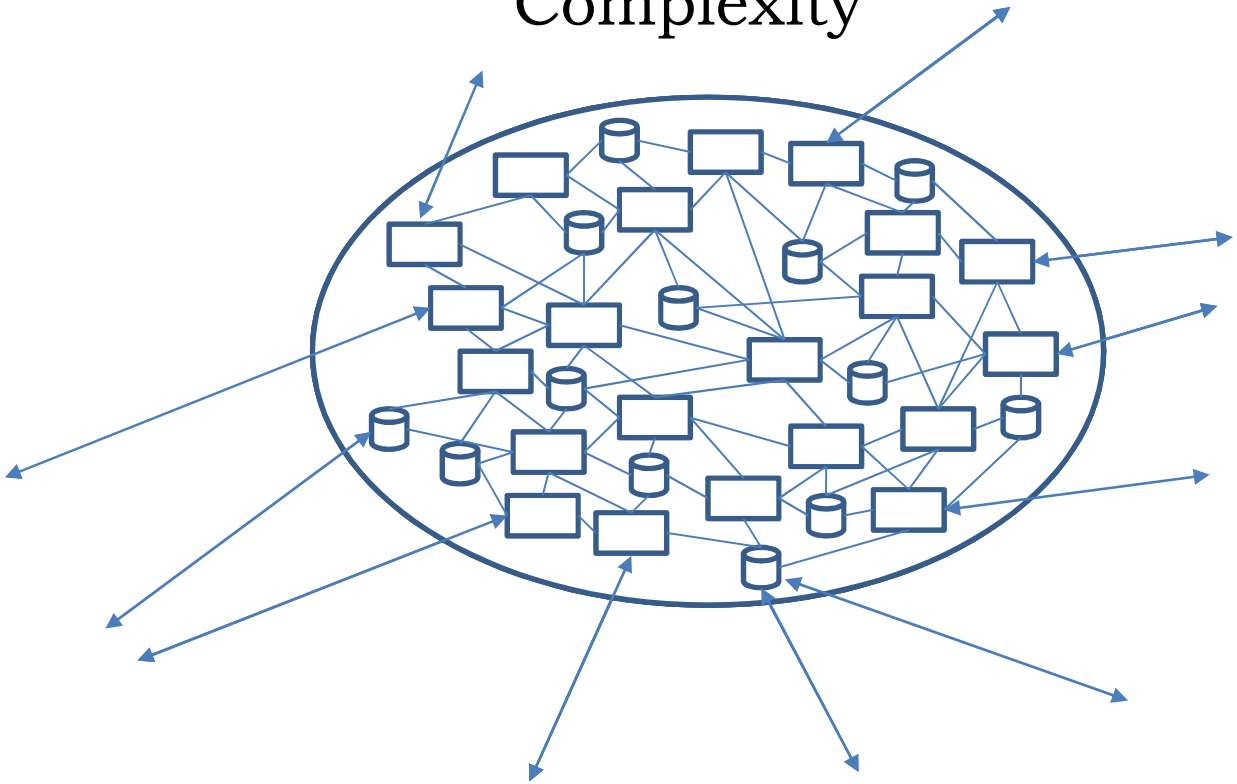
- Complexity,
- Change,
- Uncertainty"

Anonymous

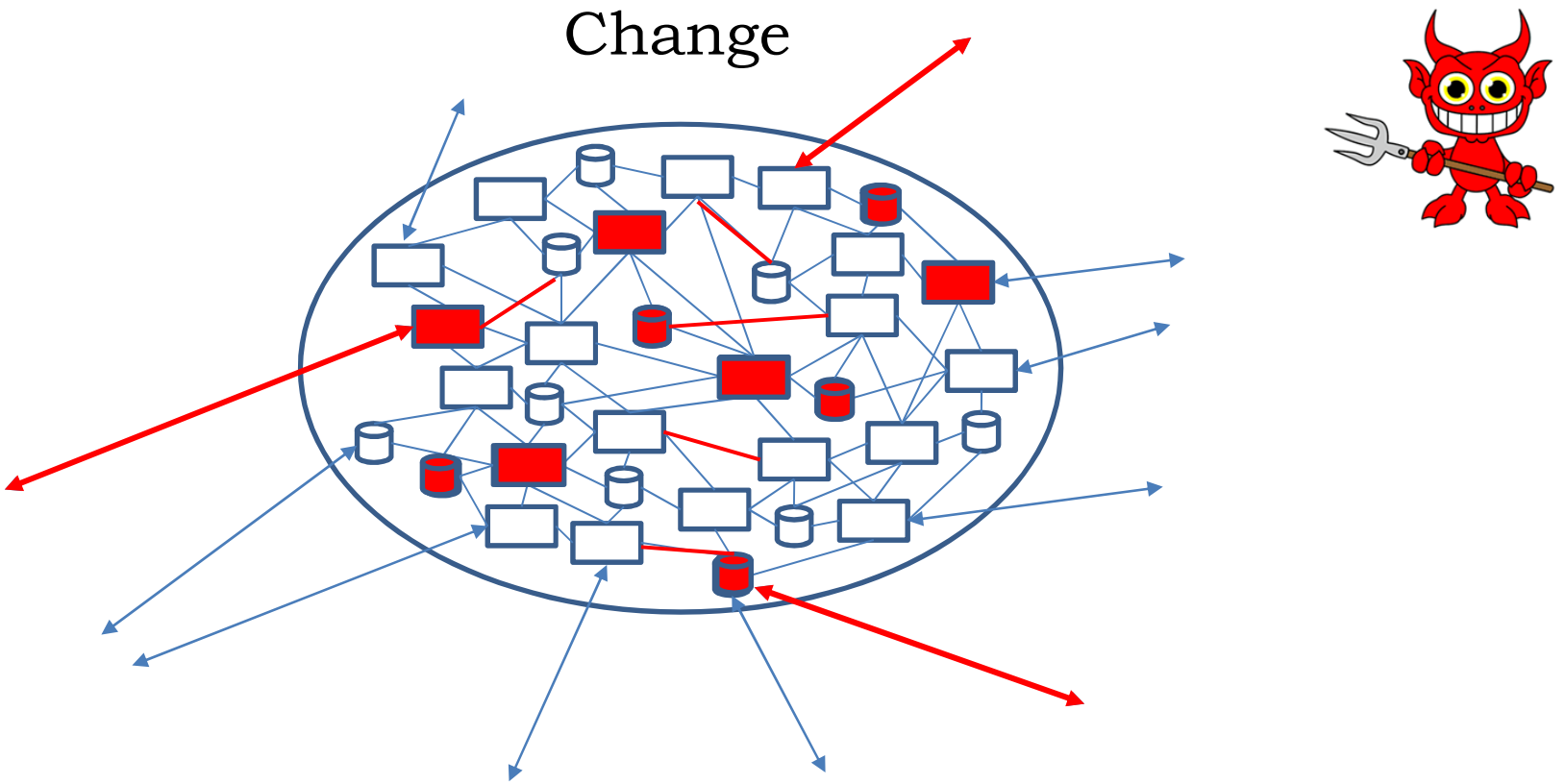
What do they do to our software?

How can we fight them?

Complexity

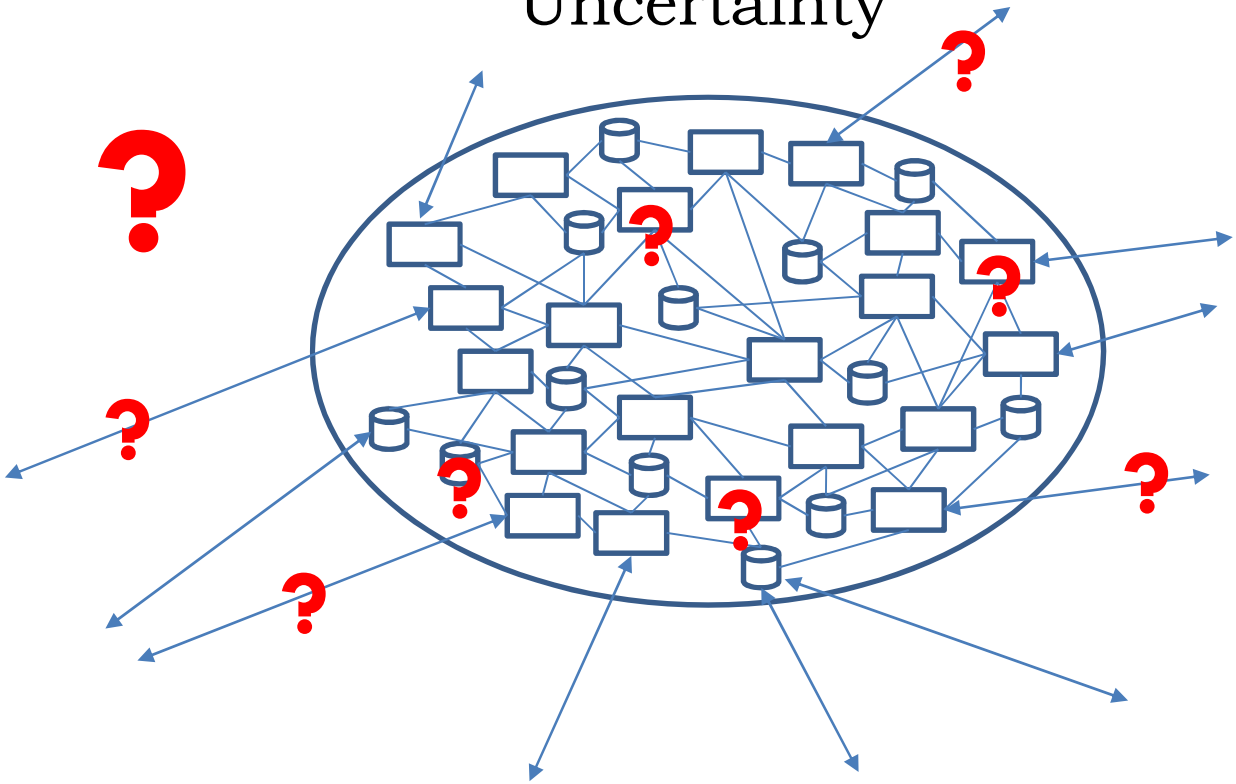


"**Complexity** is that property of an IT-system which makes it difficult to formulate its overall behaviour, even when given complete information about its parts and their relationships"



"Continuous – sometimes disruptive – **change** force relentless adaptation of the system to new requirements, to changes in the environment and to technological progress"

Uncertainty



"**Uncertainty** – both during development and during operation – forces weakly founded decisions with possibly far-reaching consequences"

How can we successfully fight them?

Complexity

Change

Uncertainty

… by using principles, methods, metrics, strategies and processes for **future-proof software-systems**

Vision: Future-Proof Software-Systems

Definition:

A future-proof software-system is a structure

that enables the management

of complexity, change and uncertainty

with the least effort, with acceptable risk and with specified quality properties

http://juliecoleman.org

Vision: Future-Proof Software-Systems

Activity: Steering the development & evolution
→ **Strategy**

Parts of the system and their relationssships
→ **Architecture**

Definition:

A future-proof software-system is a structure

that enables the management

of complexity, change and uncertainty

with the least effort, with acceptable risk and with specified quality properties

Best value for the parameters 'money' and 'time-to-market'
→ **Agility**

Acceptable probability for undesired effects and consequences
→ **Resilience**

Assuring the desired non-functional properties
→ **„Fit for Purpose"**

Future-Proof Software-Systems: **Primary Characteristics**

Business Value

Definition:

A future-proof software-system is a structure

that enables the management

of complexity, change and uncertainty

with the least effort, with acceptable risk and with specified quality properties

Agility

Resilience

Domain-specific **Quality Properties**

What are the characteristics of Future-Proof Software-Systems?

Primary Characteristics:

- Business Value
- Agility
- Resilience

«continuous improvement»

Secondary Characteristics:

- Non-functional properties:
  - Reusability
  - Hardware Resource Consumption
  - Adherence to industry-standards
  - etc.

«as good as necessary»

Business Value

http://blog.enfocussolutions.com

Metric: **NPV** (Net Present Value)

Business Value (of a software development) =

The opportunity to gain an **advantage** for the business

- Financial advantage (earnings), but also:
- Competitive advantage (innovative functionality),
- Compliance to laws and regulations,
- Process improvements, etc.

Business Value = Net Present Value (**NPV**)

http://www.eco-way.ch/?p=10846

Investment:
- 860‘000.- €

NPV = +165‘000 €

Earnings:	Year1	Year2	Year3	Year5	Year6
	240‘000 €	270‘000 €	230‘000 €	280‘000 €	300‘000 €
8 %/year:	$(1+0.8)^{-1}$	$(1+0.8)^{-2}$	$(1+0.8)^{-3}$	$(1+0.8)^{-4}$	$(1+0.8)^{-5}$
	1.08	**1.17**	**1.26**	**1.36**	**1.47**
	+ 222‘000 €	+ 230‘000 €	+ 182‘000 €	+ 205‘000 €	+ 186‘000 €

+ 1‘025‘000 €

Agility

Metric: **Size²/(TtM*DeVC)**

http://giaonthemove.com

Agility =

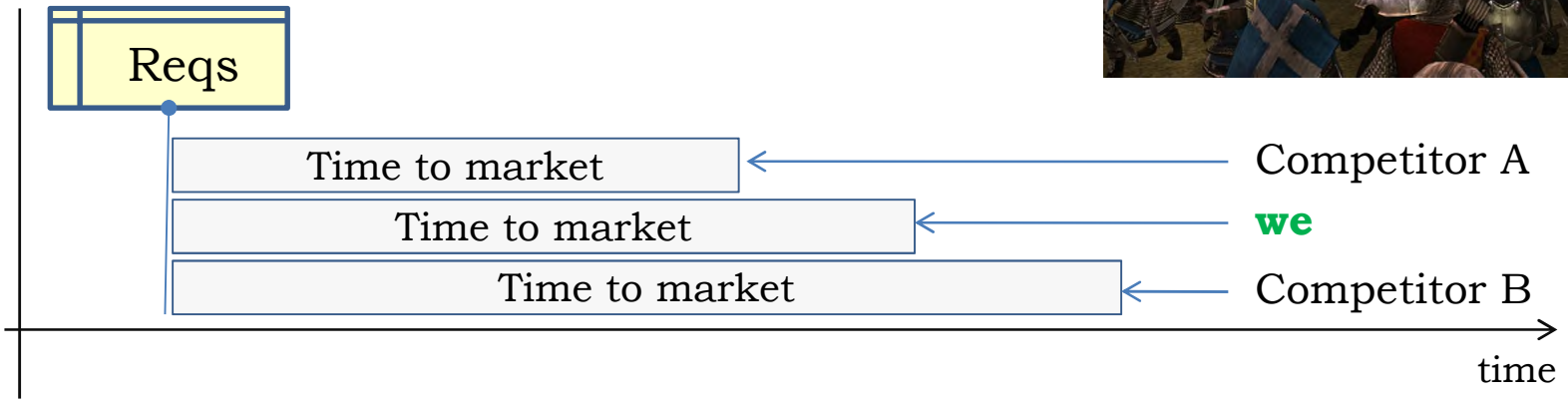
The **capability** to develop new functionality with a

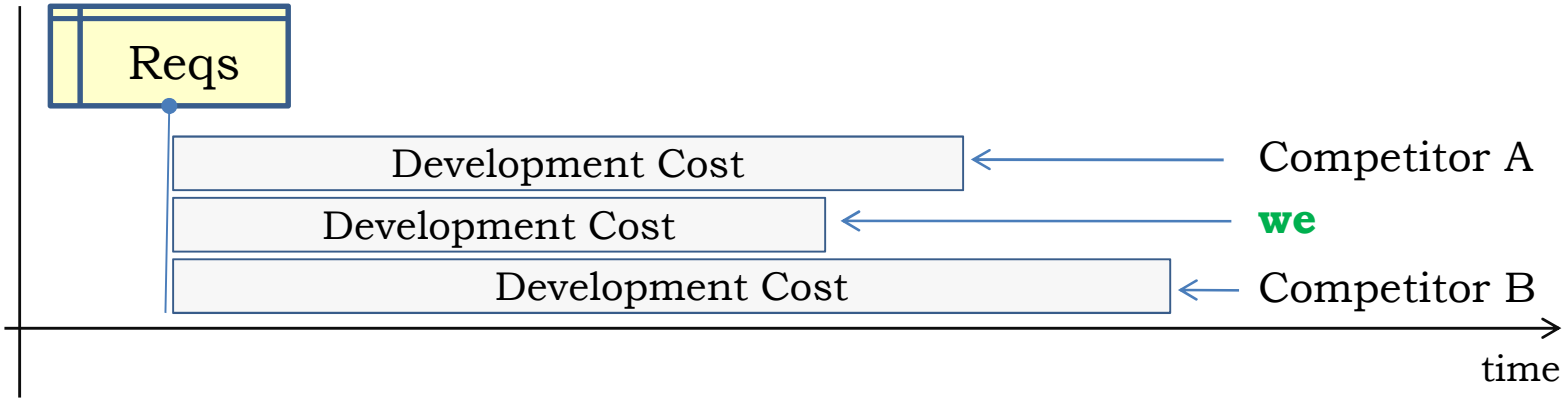
- short time-to-market
- reasonable development cost

Important note: This capability is a property of an *organization*!

Agility

Why is **agility** so important?



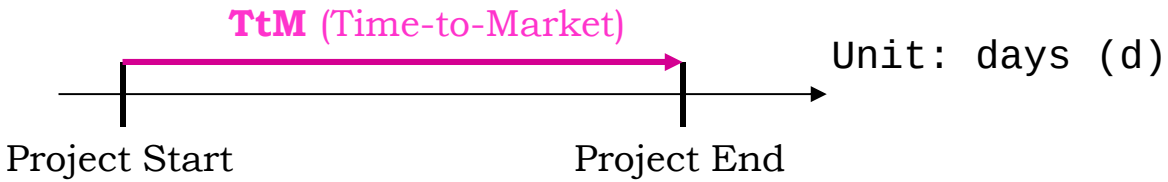


Agility

Agility Metric:

Amount of functionality:
Functional Size

Size Unit: #UCP or #FP



$$\text{Agility} = \frac{(\sum \text{Size}_i)^2}{\sum \text{TtM}_i * \sum \text{DevC}_i}$$

Unit: #UCP/(days*k€)

Resilience

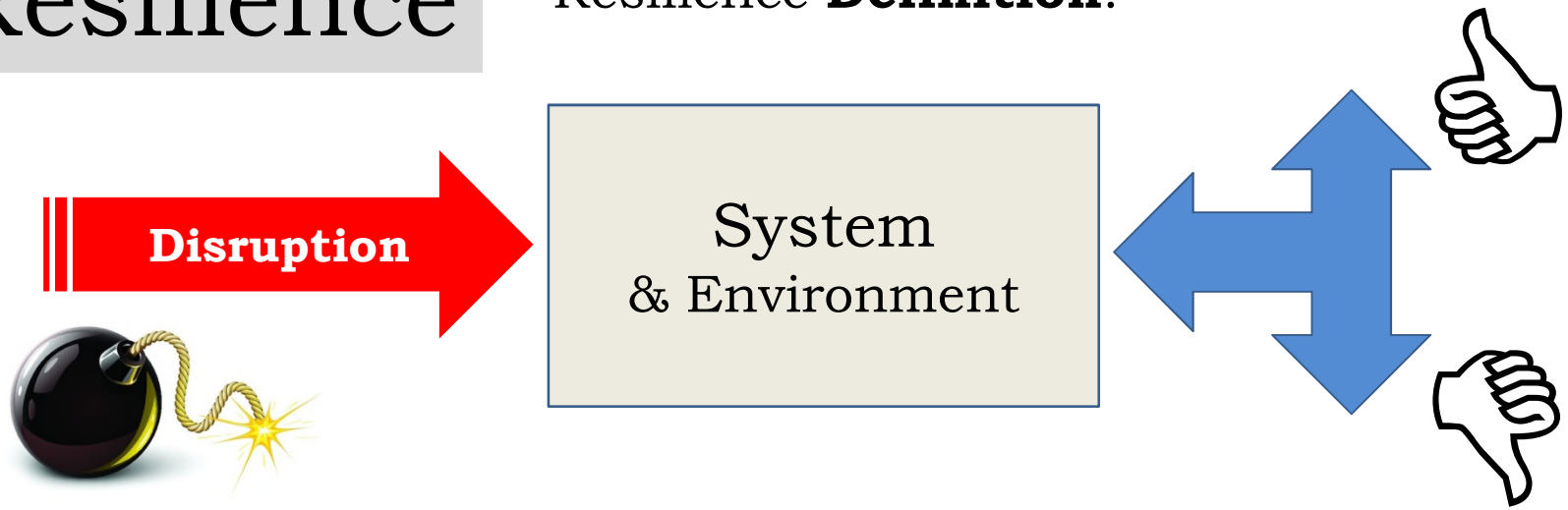
Why *resilience* as a primary characteristic of future-proof software-systems?

⇒ The world has become a dangerous place for software

http://bookroar.blogspot.ch/2012/05/most-dangerous-snakes-in-world.html

Resilience

Resilience **Definition**:

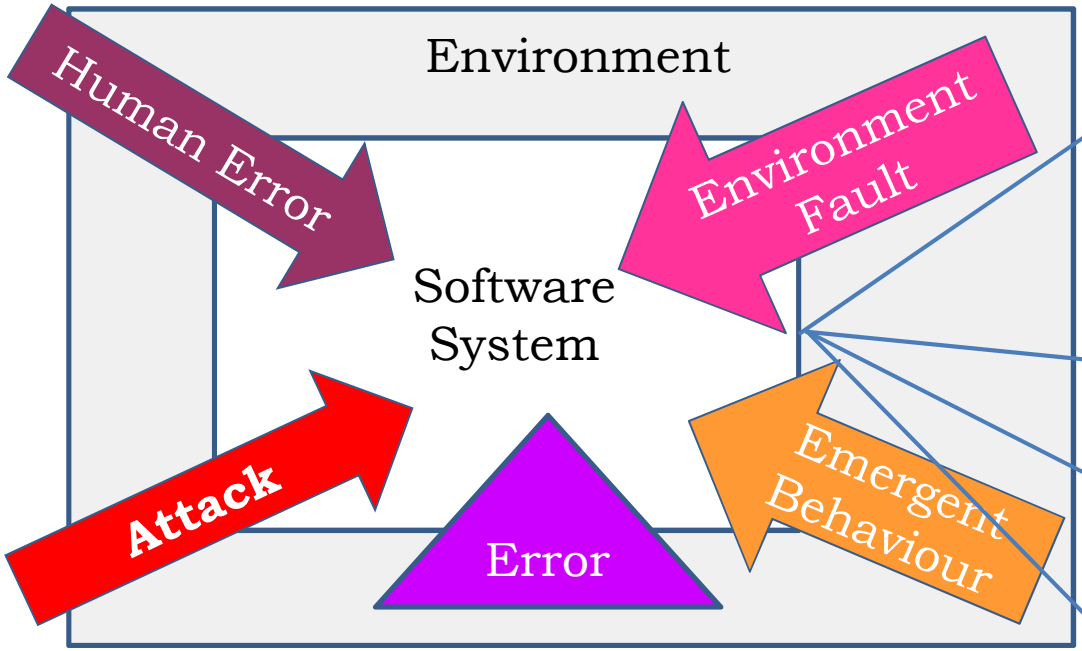


Resilience is the *capability* of a system with specific characteristics before, during and after a *disruption* to *absorb* the disruption, *recover* to an acceptable level of performance, and *sustain* that level for an acceptable period of time

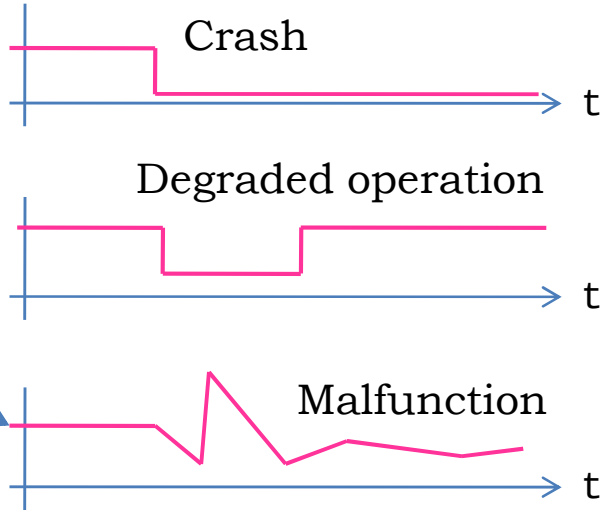
- *Before* – Allows anticipation and corrective action to be considered
- *During* – How the system survives the impact of the disruption
- *After* – How the system recovers from the disruption

http://www.incose.org/practice/techactivities/wg/rswg/

Resilience



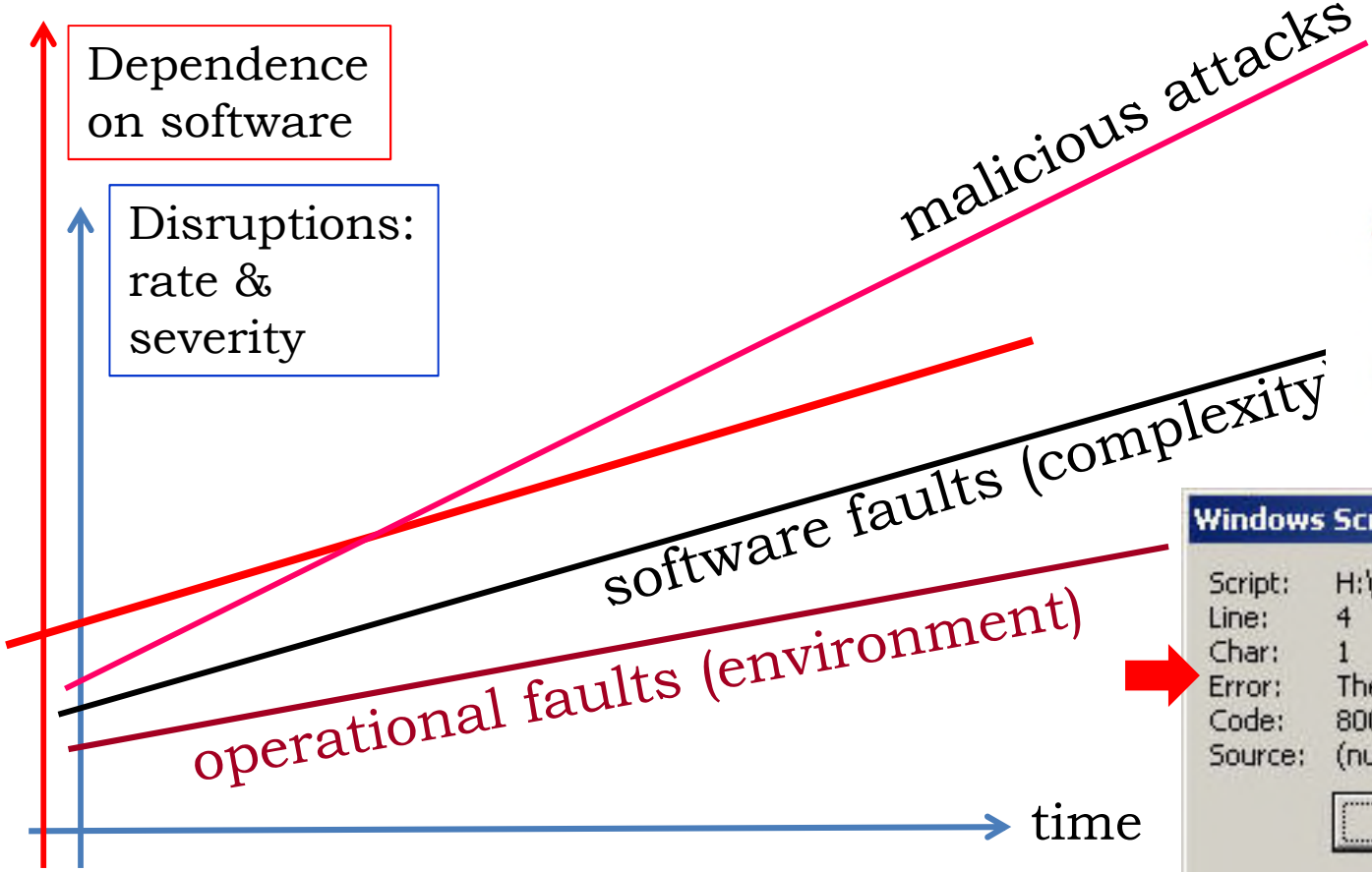
https://soundcloud.com

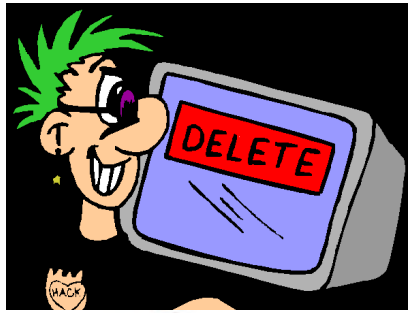


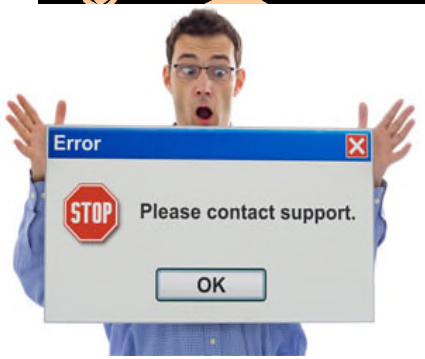
http://kanto.stripes.com

Resilience

Why is **resilience** so important?







http://blog.qatestlab.com

http://www.computerperformance.co.uk

Resilience

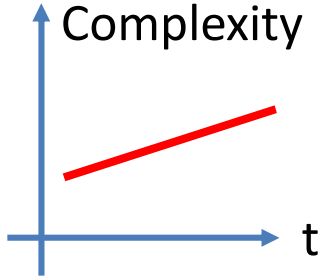
< 2010 → > 2010

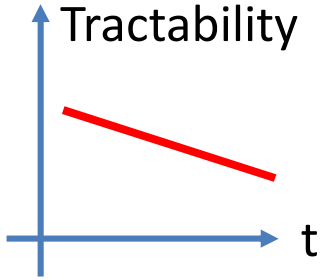
Disruptive Incidents
1. Xxx
2. Yyy
3. Zzz

System

Safety Case

predict





Resilient System

adjust

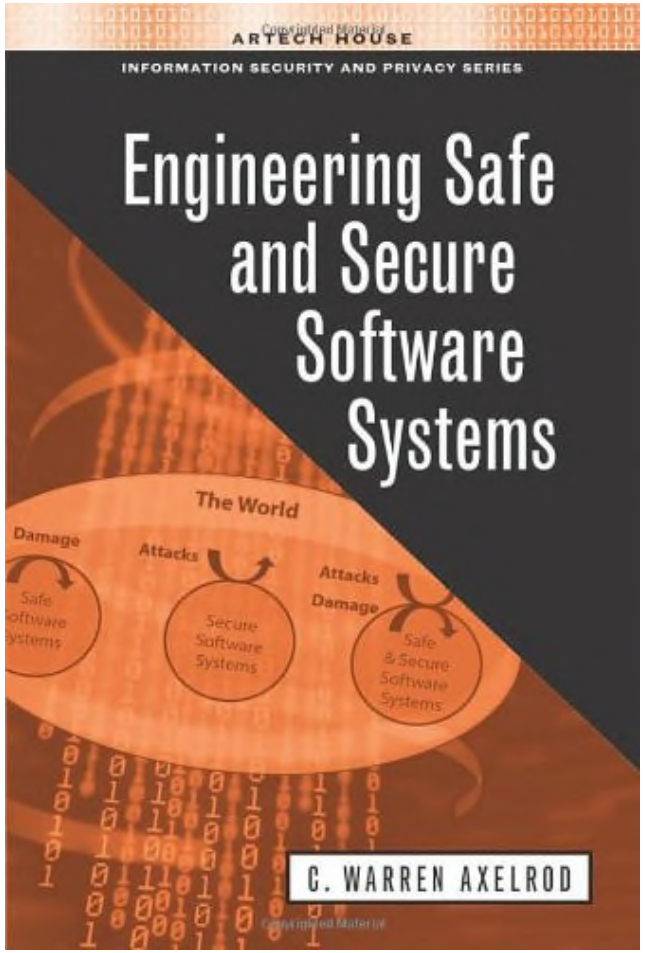
Resilience

«While the general concept of safety and reliability is understood by most parties, the specialty of software safety and reliability is not»

(Debra S. Hermann)

http://www.motivationalmemo.com

Pflicht-lektüre!



C. Warren Axelrod, 2013
ISBN 978-1-60807-472-3

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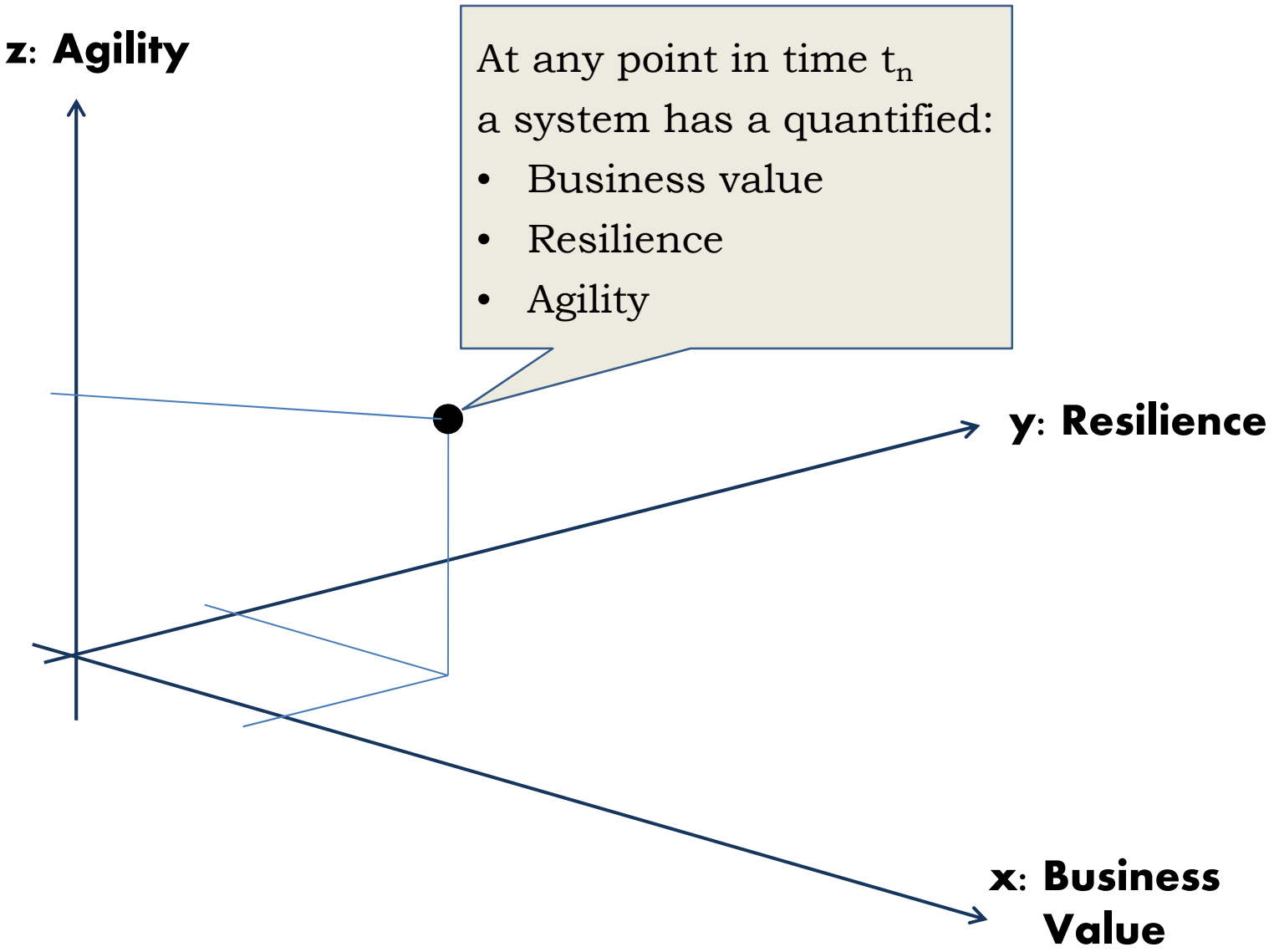
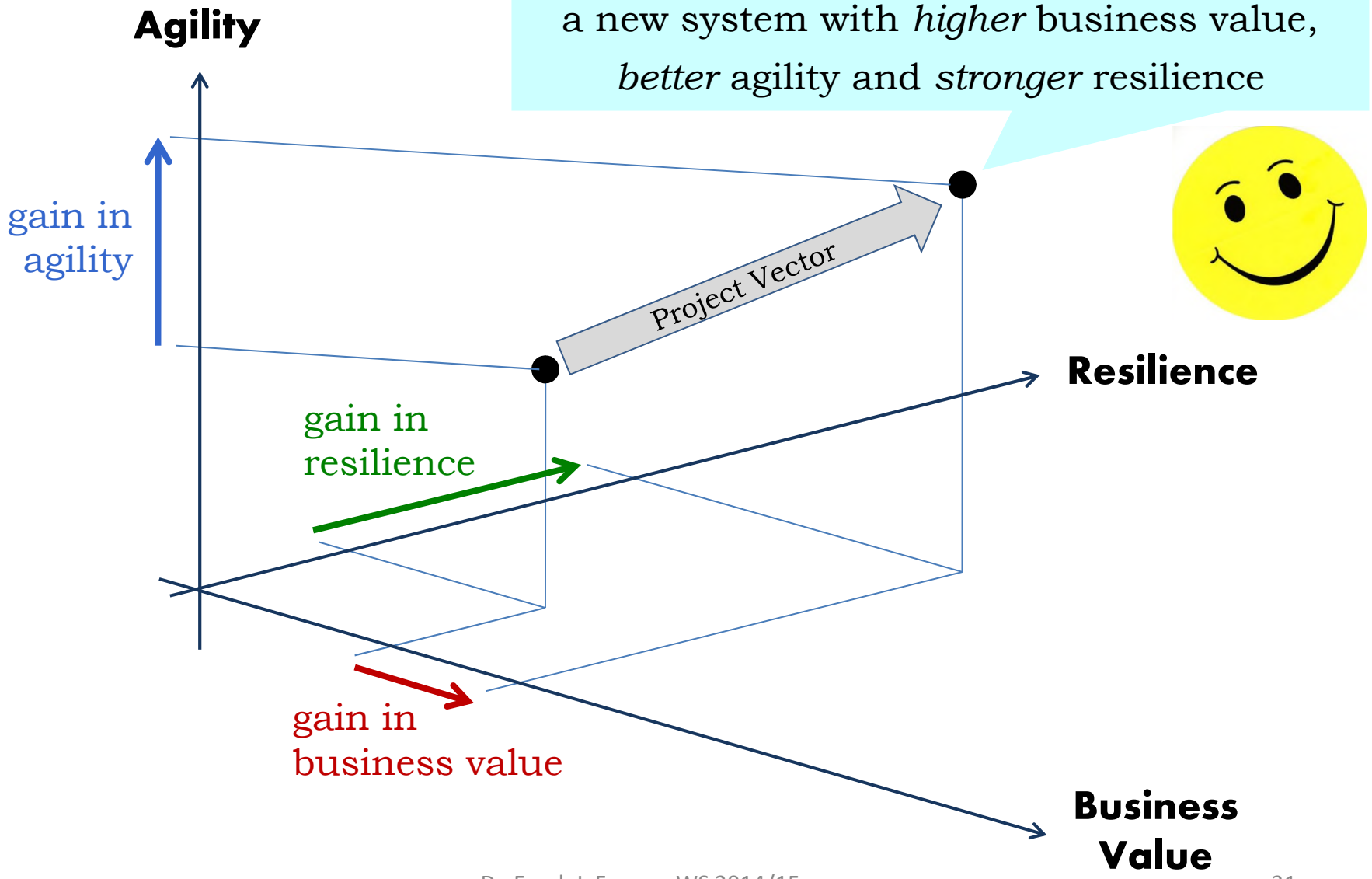
http://www.wissenswertes.biz

Future-Proof Software-Systems: **Managed Evolution** Coordinate System

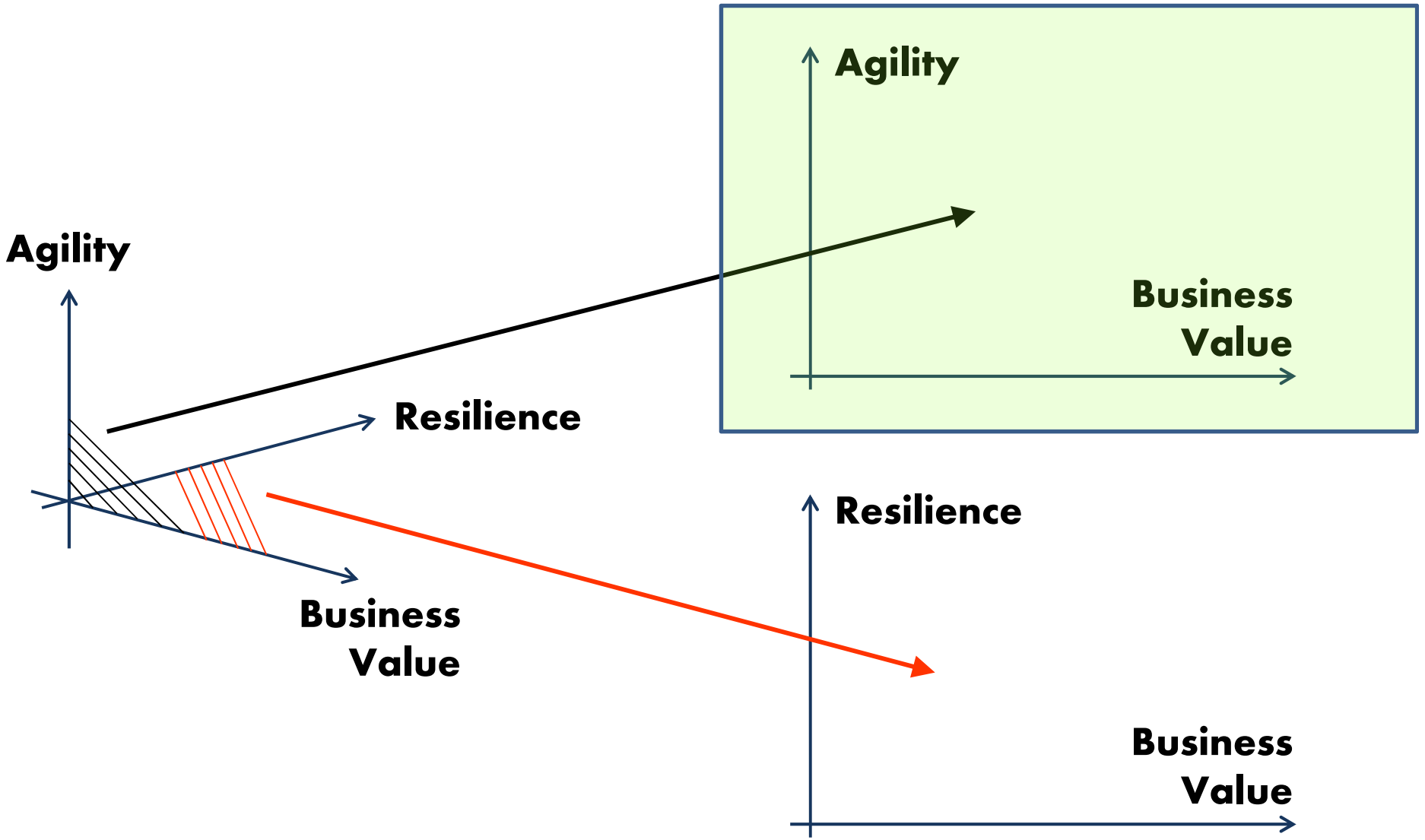


The project has transformed the system into a new system with *higher* business value, *better* agility and *stronger* resilience

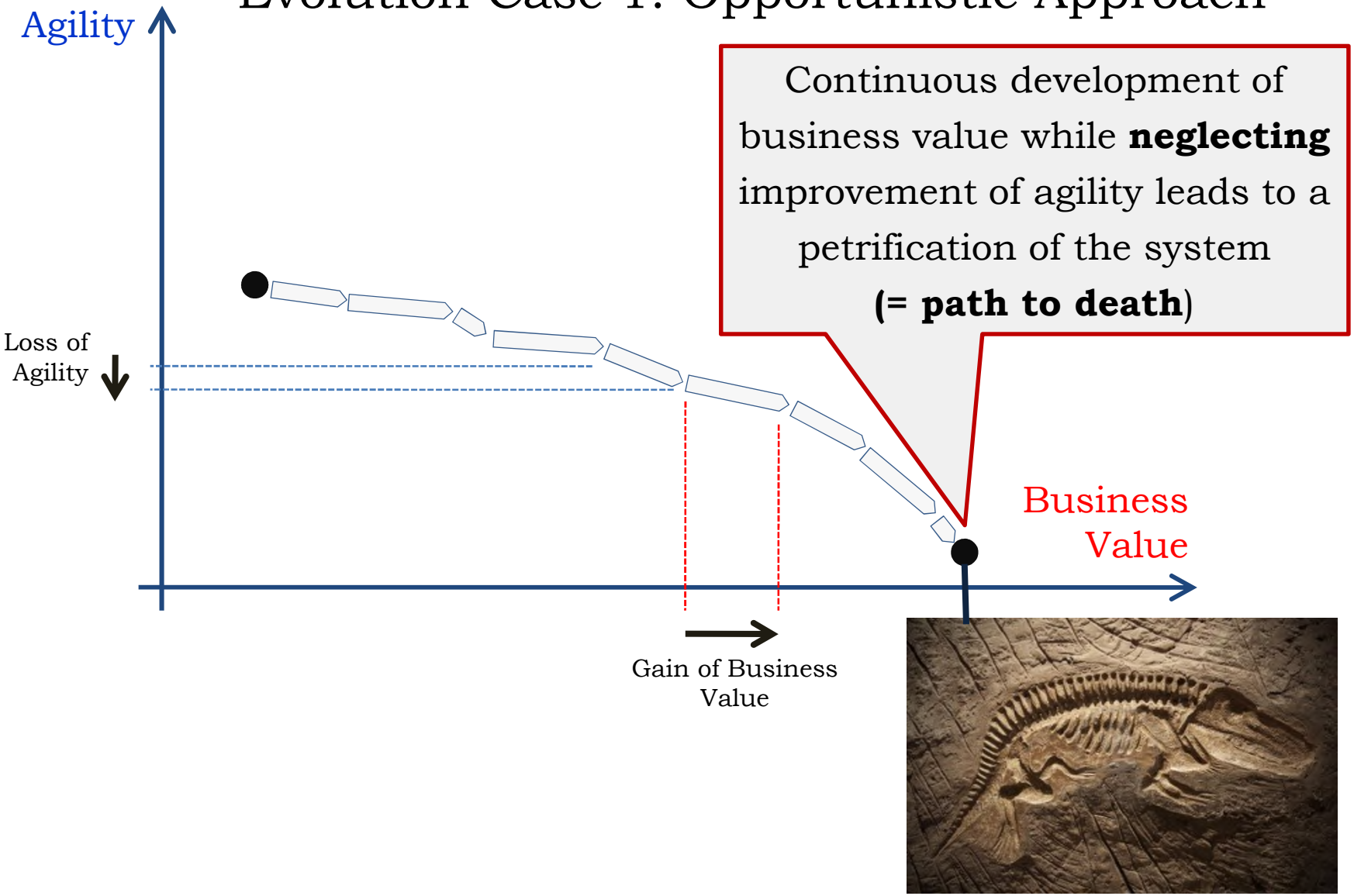


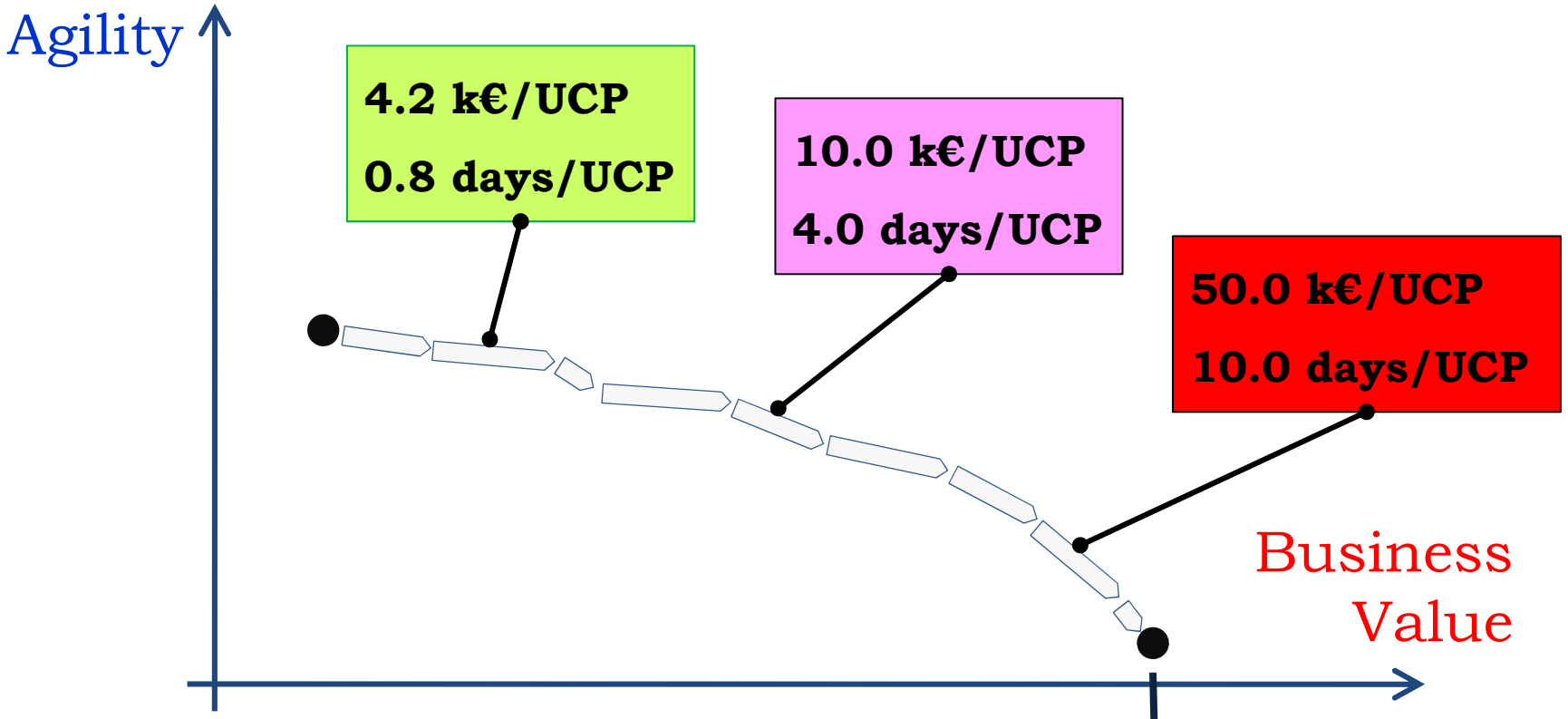
The project has transformed the system into a new system with *higher* business value, *lower* agility and sligthly *weaker* resilience

Industrial Software: Business Value, Agility & Resilience



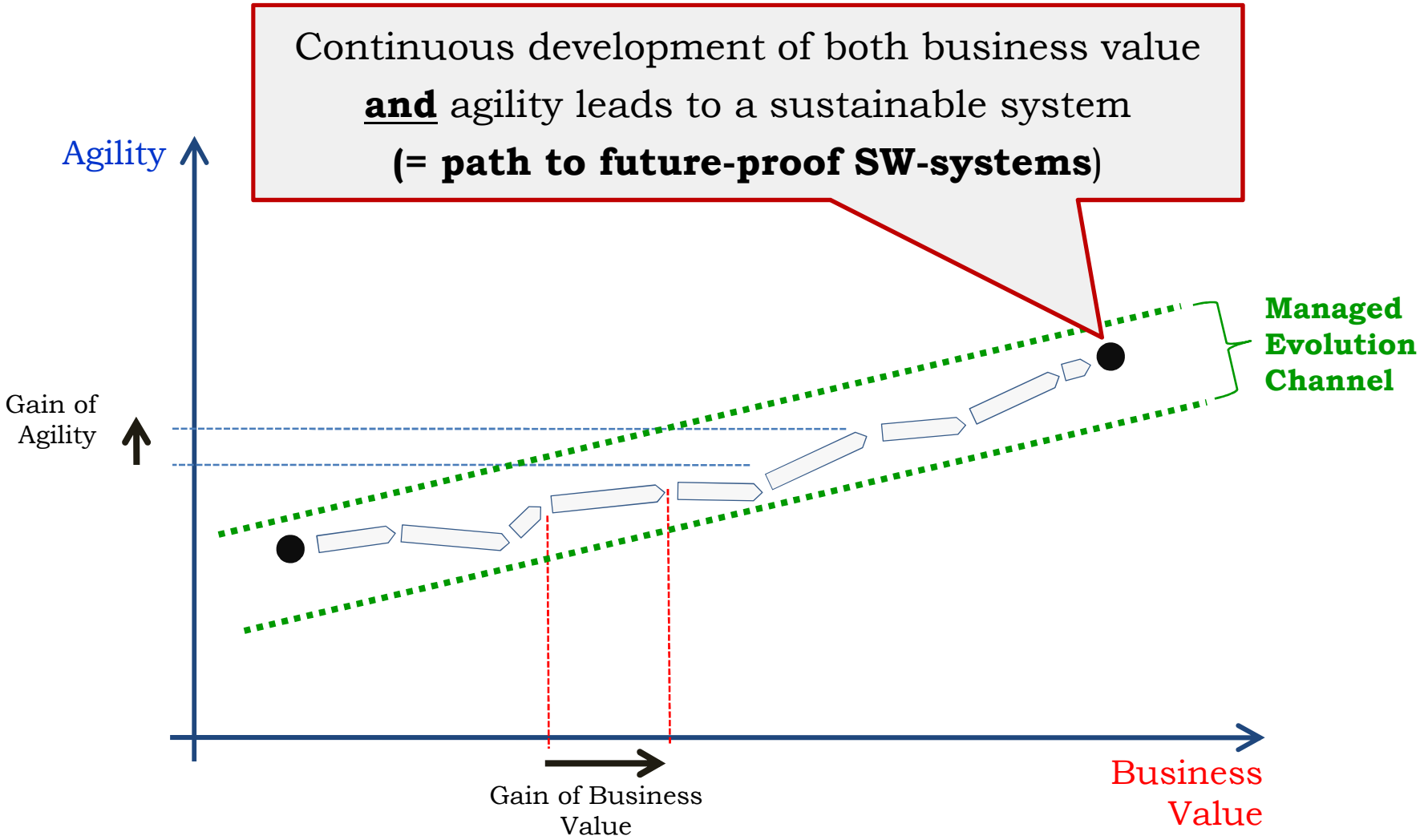
Evolution Case 1: Opportunistic Approach



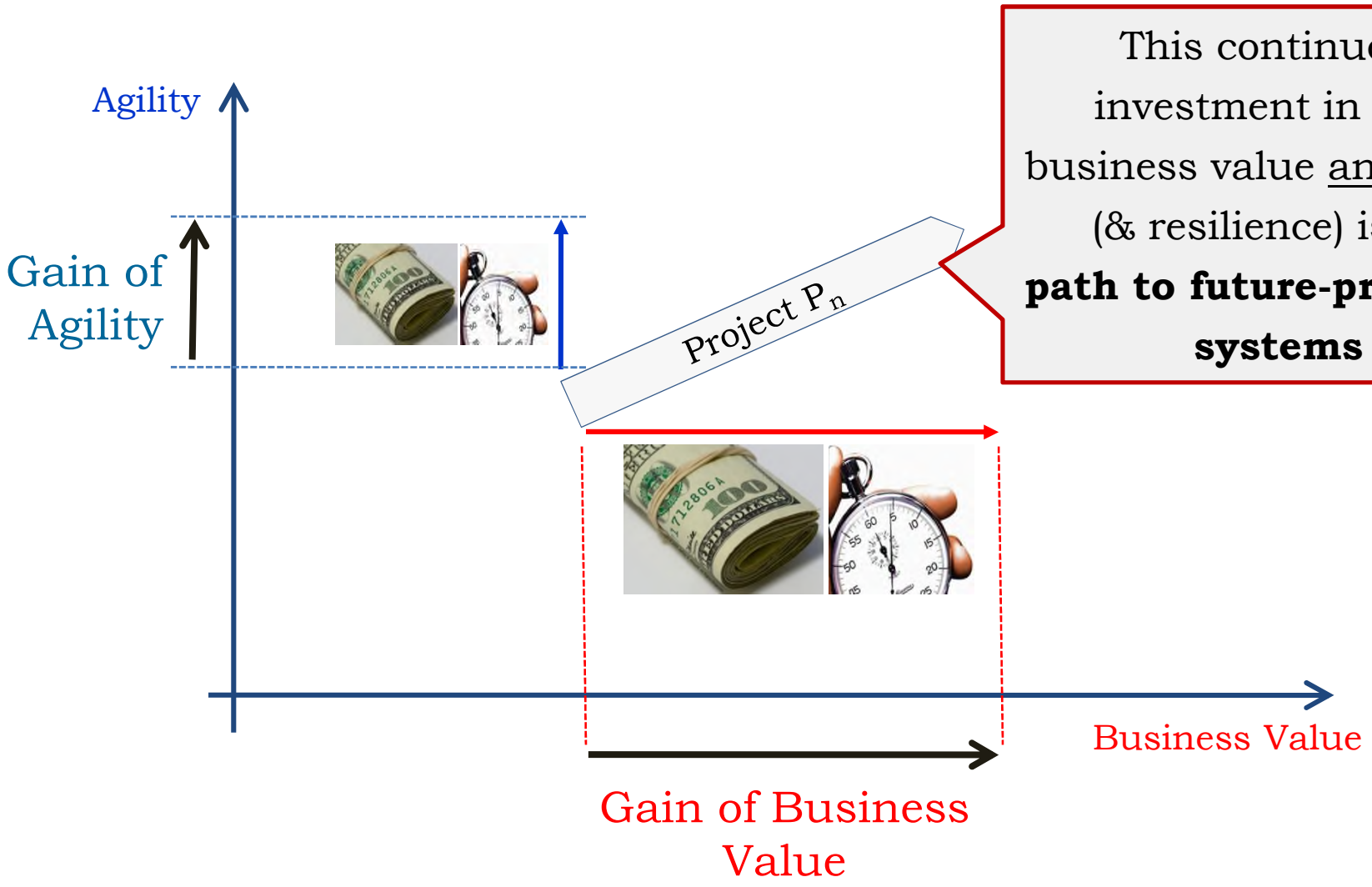


Trajectory Case 1:
Opportunistic Evolution

Evolution Case 2: Managed Evolution



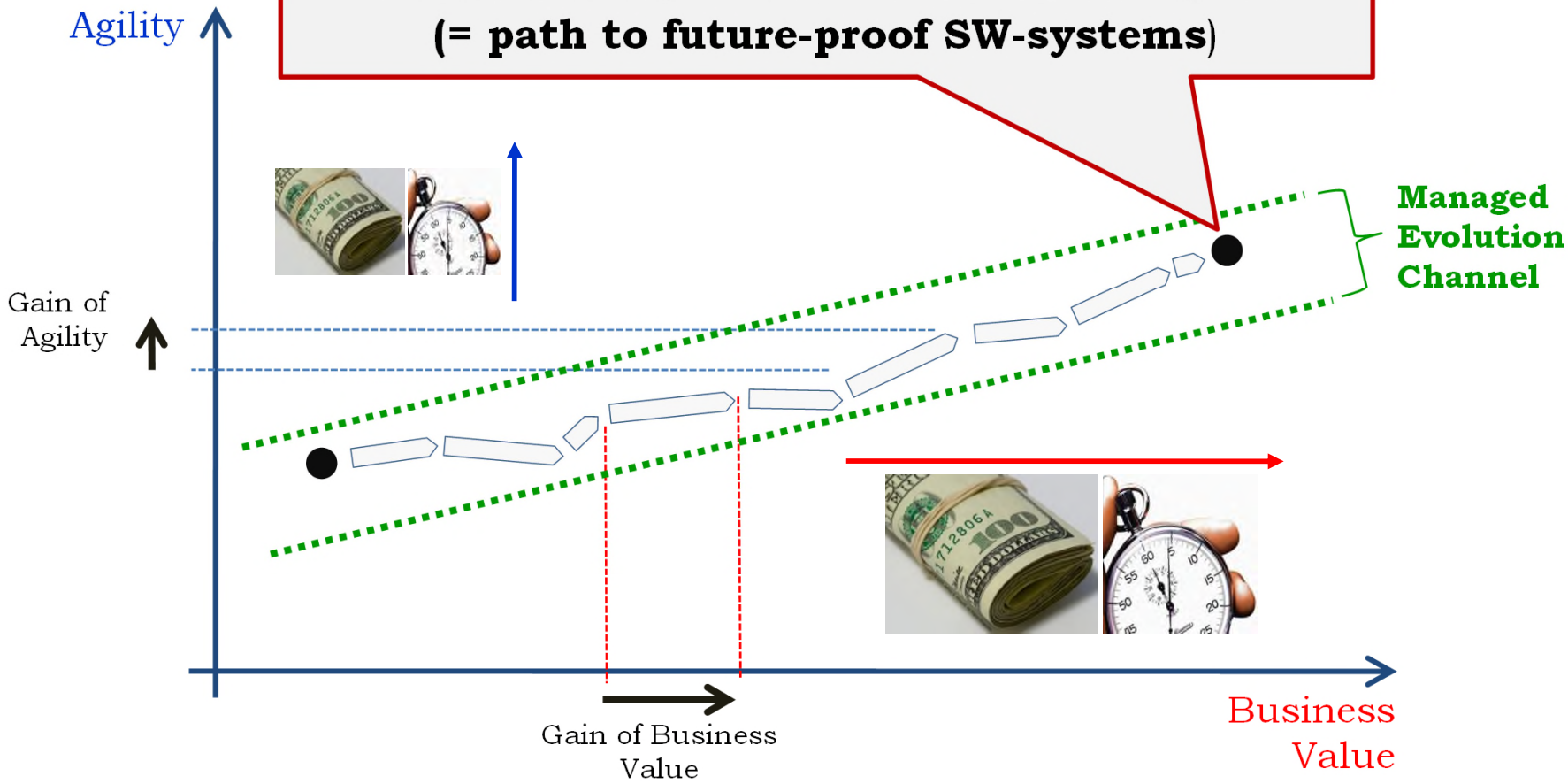
Evolution Case 2: Managed Evolution



This continuous investment in both business value and agility (& resilience) is the **path to future-proof SW-systems**

Evolution Case 2: Managed Evolution

Only continuous development of both business value **and** agility leads to a sustainable system
(= path to future-proof SW-systems)



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http://www.wissenswertes.biz

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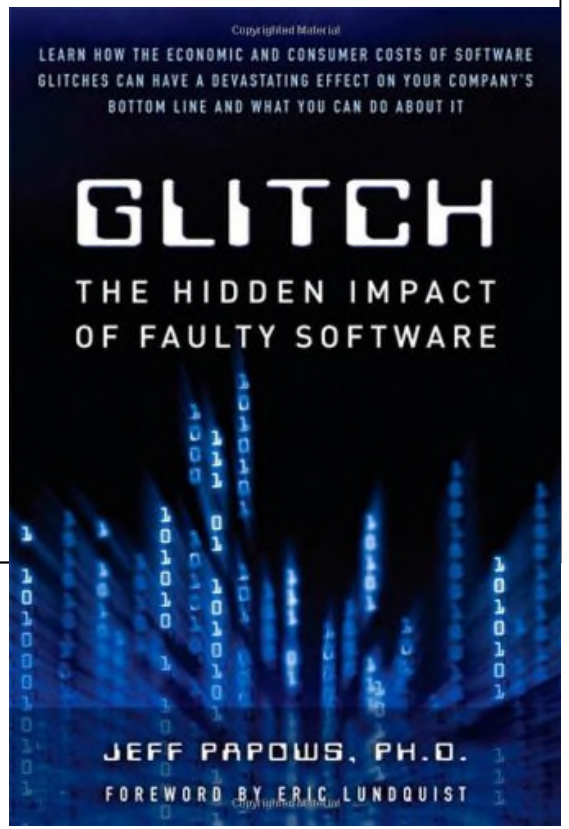
Aging: Architecture Erosion & Technical Debt

Software – especially *faulty* software – has an enormous impact on people and society:

- Functionality in all areas of life and work
- Tremendous business opportunities
- Risks in safety-critical systems
- Legal & regulatory consequences
- Product liability
- etc.



Jeffrey Papows, 2010
ISBN 978-0-132-16063-6

http://www.motivationalmemo.com

Pflicht-lektüre!

Software must be specified, developed, maintained and evolved according to *industrial methods and processes*

⇒ **Industrial Software**

Industrial Software:

7 laws

1. Clear business – IT alignment
2. Architecture-centric
3. Strategy-controlled (Evolution, Reuse, Product Lines, …)
4. Unambiguous specification of requirements (functionality and non-functional properties)
5. Powerful, accepted, enforced development process
6. Modelled (~ formal)
7. Metrics √

Industrial Software: Business Value, Agility & Resilience

A future-proof software-system is a structure that enables the management of complexity, change and uncertainty with the least effort, with acceptable risk and with specified quality properties

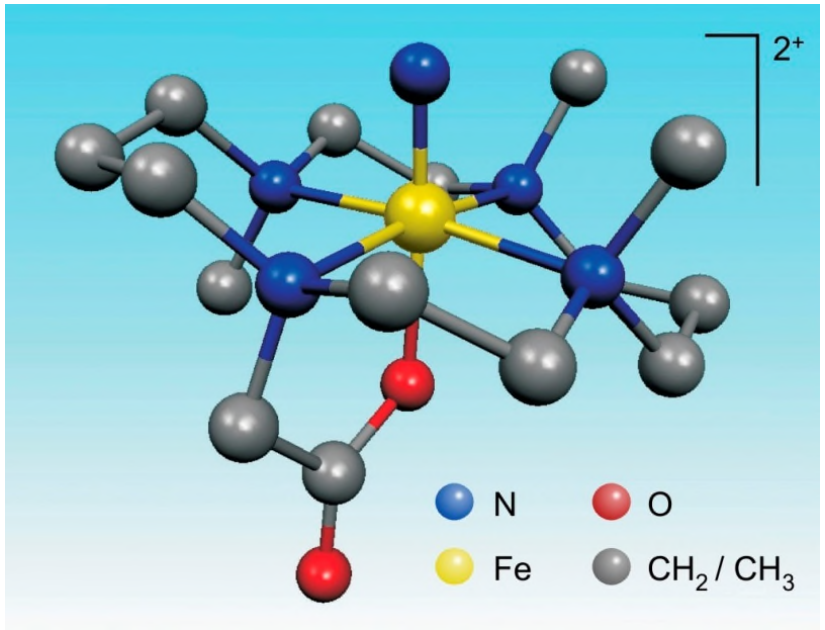
http://www.0lll.com/architecture-exhibitions/?gal=24

http://www.asisbiz.com/index.html

Which structure is easier to expand and evolve?
Which structure has the better properties, e.g. quality of life?
Which structure is future-proof?

Why is structure important?

What determines structure?



http://www.news.wisc.edu/newsphotos/ironVI.html

The tower of babel by Pieter Bruegel the Elder (1563)

Structure is the basis for ordered, managed evolution

Architecture !

Architecture Definition:

The fundamental *organization* of a system embodied in its *components*, their *relationships* to each other and to the environment, and the *principles* guiding its design and evolution

[IEEE-SA Standards Board, Standard IEEE 1471-2000]

www.rfc123.com

Architecture Importance:

The architecture of a system determines:

- The success of coping with complexity
- The effort for extensions
- Many non-functional quality properties (Safety, security, …)
- The probability of system development failures
- The viability of compromises
- Early (and dependable) stakeholder commitments

Line of Thought

http://www.wissenswertes.biz

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1843 – today:

Software engineering matured from a „black art“
(mastered by few, experienced, talented individuals only)
to an accepted engineering discipline

www.123rf.com/photo_9353072

http://wordpress.com

Today - future:

Software engineering progresses to a mature, industrial production – based on formal, proven and validated principles and processes

Architecture Principles

Architecture Principles:

Fundamental insights – formulated as rules – how a good software-system should be built

Architecture Principles:

→ highly valuable architecture knowledge in proven & easily accessible form

→ teachable & enforcable

→ the foundation for the design, implementation and evolution of future-proof software systems

Example: Architecture Principle A2

A2

Architecture Principle A2:

Partitioning, Encapsulation & Coupling

1. Partition the functionality and data into encapsulation units according to their coherence and cohesion (thus minimizing dependencies)
2. Isolate the encapsulation units by strictly hiding any internal details. Allow access to functionality and data only through stable, well specified interfaces governed by contracts
3. Minimize the impact of dependencies between the encapsulation units by using adequate coupling mechanisms

Justification: These 3 principles minimize the number and the impact of dependencies. The resulting system therefore offers the least resistance to change, because any change affects the smallest possible number of system elements. A low resistance to change corresponds to high agility.

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http://www.wissenswertes.biz

Architecture Erosion

http://thoreau.colonial.net/Students/EricksonHoyt/erosion

Architecture Erosion:

Any IT-architecture is continuously *degenerating* due to many factors:

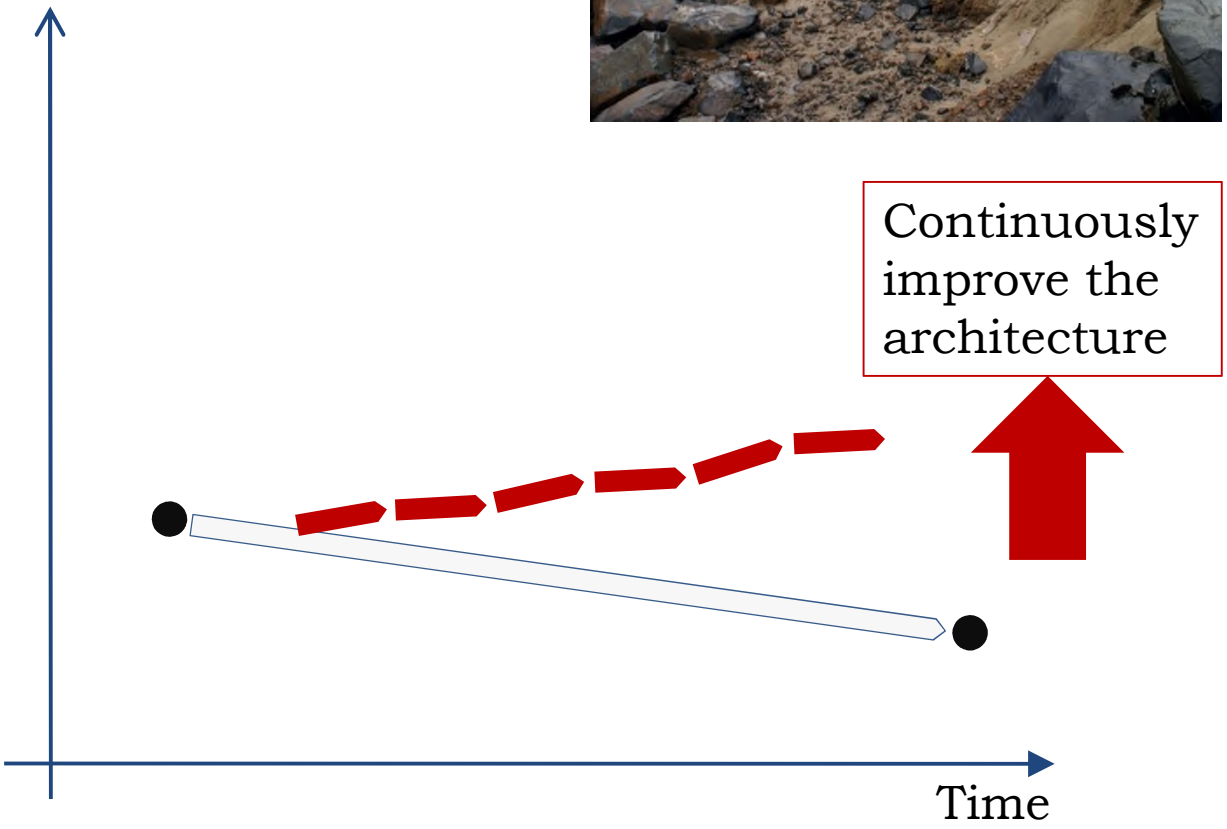
- SW Paradigm changes (e.g. SOA)
- New laws & regulations
- New standards (e.g. interoperability)
- Accumulation of mistakes + shortcuts (e.g. breaking partitions)
- Sloppy system extensions
- Introduction of new architecture principles

… and some more

Architecture Erosion

Degeneration of Quality Properties:

- Business Value
- Agility
- Resilience
- Std Conformance
- Reusability
- etc.



Technical Debt

Technical Debt:

Technical Debt is the accumulation of violations of best practices in a software system:

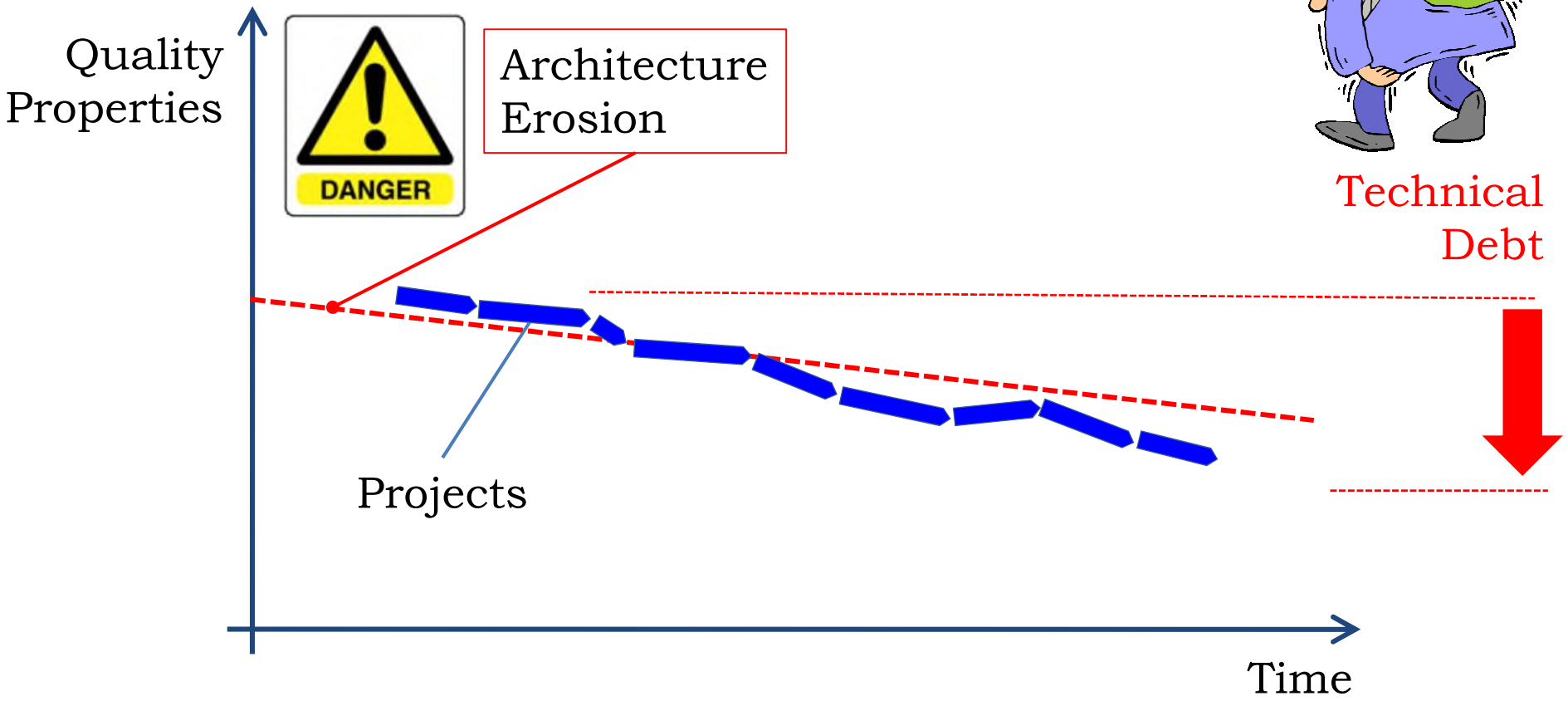
- Architecture Erosion
- Disruptive technology
- Dead code (missed explementations)
- Redundancy (code and data)
- Progress in software-engineering (e.g. programming languages)
- Careless or skipped upgrades
- Management mistakes (time-to-market over SW-engineering)

… and some more

Technical Debt

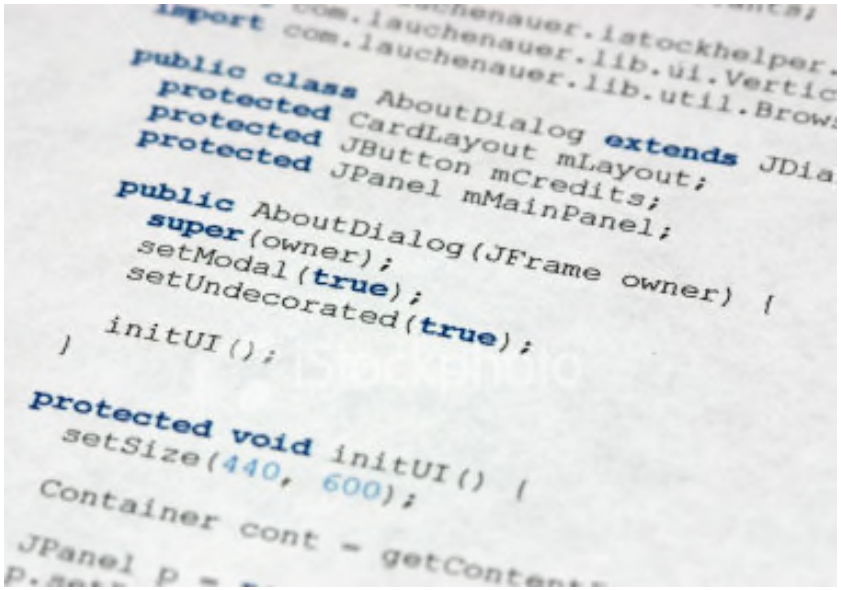
Technical Debt

Technical Debt



Technical Debt

http://dandev91.wordpress.com/



Cost of one source line of embedded systems code:

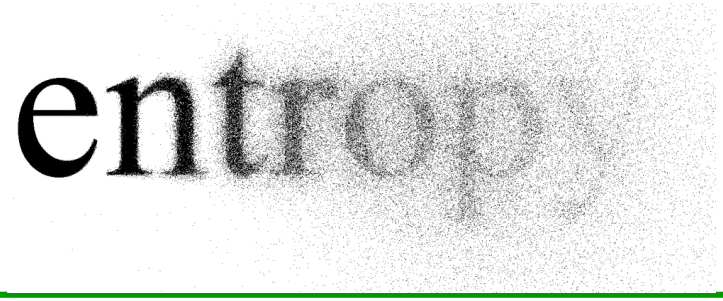
€ 15.00 ... € 40.00

Average Technical Debt in each source line of embedded systems code:

€ 2.70

[Deloitte Consulting LLP: Tech Trends 2014]

Conclusions



http://larvalsubjects.wordpress.com

The force of entropy means that *disorder* is the only thing that happens automatically and by itself.

If you want to create a completely *ad-hoc IT architecture*, you do not have to lift a finger.

It will happen *automatically* as a result of day-to-day IT activity.

Richard Hubert: **Convergent Architecture**, 2002. ISBN 978-0-471-10560-2

Conclusions

Architecture Principles

Agility
Resilience

Gain of Agility & Resilience

Managed Evolution Channel

Project modifying the system

Gain of Business Value

Business Value

Conclusions

Architecture Principles

Agility
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Business Value

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