FABER Project

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What It Offers to Engineering Companies

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FABER

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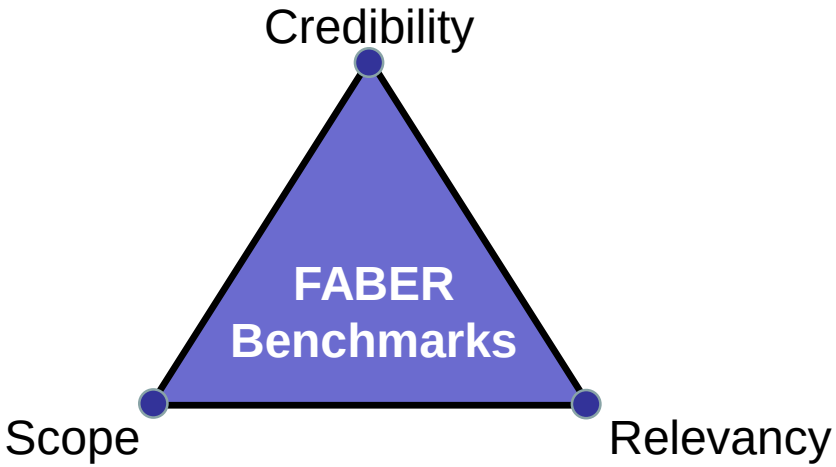
FAtigue BEnchmark Repository

Benchmark

Benchmarking is used to **measure performance of evaluated prediction methods** using a specific indicator (relative error between predicted and experimental fatigue lives) resulting in a **metric of performance that is then compared to others**.

What FABER offers to Engineering Companies

- Benchmarks to evaluate and improve fatigue procedures either implemented in own in-house solvers or in those bought



- **Scope:** Assembled in a scope the company would never be able to reach
- **Credibility:** Agreed on by an international community of fatigue researchers
- **Relevancy:** Free of ballast or harmful items, which could damage the output quality

Why Fatigue Solver Users Need Benchmarks

- The user is the only person responsible for obtained results

WARRANTY DENIAL

  - Typical clause in End Users License Agreement (EULA) signed during the purchase
  - Removes any responsibility for obtained results from the SW developer
  - Necessary due to the need to treat the user's bad practice
  - It anyhow pardons also any shortcomings in SW developing

- If no further responsibility is asked from SW developers, all benchmarking of the software within company's common practice should be covered by it

Warranty denial vs Advertisement

- *„MSC Fatigue enables durability engineers to quickly and accurately predict how long products will last under any combination of time-dependent or frequency-dependent loading conditions.“*

  MSCsoftware.com (2018). MSC Fatigue: FE Based Durability Solution. [online] Available at: http://www.mscsoftware.com/product/msc-fatigue [Accessed August 30, 2018]

- *“Do I need to be a fatigue expert?*
  No, you can leave that to us. There are factors which cannot be ignored if results are to be trusted. However, because fe-safe is technically advanced, it is configured to take into account many variables which will affect the accuracy of your results automatically.”

  3ds.com. (2018). FE-SAFE – SIMULIATM 3D Software – Dassault Systèmes®. [online] Available at: https://www.3ds.com/products-services/simulia/products/fe-safe/ [Accessed August 30, 2018].

Responsibility? Multiaxial fatigue solutions:

Fatigue solvers

Methods	Fe-Safe	MSC.Fatigue	Femfat	FEARCE	nCode DesignLife	LMS Virtual. Lab Durability	WinLife	eFatigue	Code Aster	PragTic	FatLab	Mean relative error [%]	St. deviation of relative error [%]
	Commercial							Non-commercial				Test set 407 exps.	
Dang Van (1973)	X	X		X	X	X	X	X	X	X		-0.1	12.2
Findley (1957)							X	X		X	X	8.7	15.2
McDiarmid (1991)		X		X	X					X		-6.2	12.0
Sines (1959)								X		X		-4.3	17.9
Matake (1977)									X	X		6.4	15.8
Other solution									X	X	X		

Academic benchmarks

Ref..	Year	Sets	Items	Method:	C&S	Crossland	Dang Van	Findley	Fogue	Goncalves	L&M	L&Z	Matake	McDiarmid	Papadopoulos	Papuga PC	Robert	Sines	Susmel
				Year of publication:	2001	1956	1973	1957	1987	2005	2005	1989	1977	1991	1994	2008	1988	1959	2001
[8]	1997	4	43			X							X	X	X			X	
[9]	1999	1	2			X	X												
[10]	2000	?	179									A			X				
[11]	2001	3	30		A			X					X	X					
[12]	2002	52	447												X				A
[13]	2003	3	38			X	X								X				
[14]	2005	4	41			X				A					X				
[15]	2006	1	8				X	X				X			X				
[16]	2007	16	125		X									X					
[17]	2008	4	43			X							X		X				
[18]	2009	40	320			X							X		X				X
[19]	2010	13	131			X	X								X	X			
[20]	2010	6	66			X								X				X	
[4]	2011	49	407		X*	X*	X*	X*	X*	X*	X*	X*	X*	X*	X*	A*	X*	X*	X*
[21]	2011	8	52		A	X*	X*	X*	X*	X*		X*	X*	X*	X*		X*	X*	
[22]	2013	8	62			X												X	
[23]	2014	2	4			X		X										X	
[24]	2014	18	58		A	X				X					X				
[25]	2014	3	?				X	X						X	X				
[26]	2015	25	269					X										X	
[27]	2015	7	26										X		X				
				Number of occurrences	2	13	7	7	2	3	1	3	7	7	14	1	2	7	2
				Mean relative error [%]	-4.8	-8.0	-0.1	8.7	2.4	0.7	-1.2	0.0	6.4	-6.2	-4.6	-0.5	4.7	-4.3	1.7
				St. dev. of rel. error [%]	8.7	11.3	12.2	15.2	10.8	10.9	12.1	8.8	15.8	12.0	10.3	6.1	9.9	17.9	8.4

- The orange rectangle below shows the summary of relative errors in fatigue strength estimation on a biggest ever published benchmark set (the error should be zero for perfect results)
- It proves that most of tested prediction methods yield better results than any of those implemented in commercial fatigue solvers
- Why their use is not abandoned?
- See more: https://c.csm.cz/files/Bulletin_01_2019.pdf, pp. 18-42

Benchmarking of commercial software?

- Example:

> *"Except as specifically permitted in this Agreement, Customer agrees not to: (a) … (e) provide, disclose or transmit any results of tests or benchmarks related to any DS Offering to any third party,…"*
>
> DASSAULT SYSTEMES. (2018). Customer License and online service agreement. [v. 11.2], DASSAULT SYSTEMES.

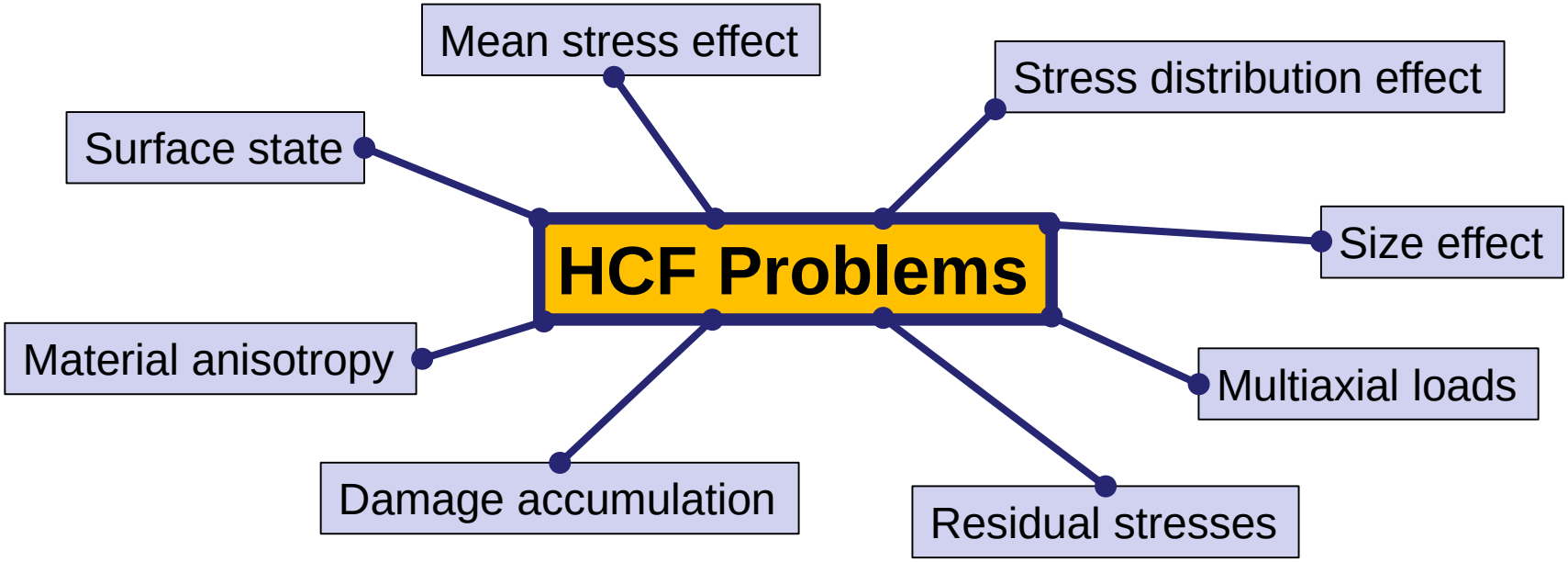
- This means, that every customer is left alone, without any legal chance to understand better the offer on the market
- This is acceptable (though costly) only for large companies with own experimental base usable for own benchmarking
- There is no reason, why fatigue solver developers should change anything, unless the users start to claim the change

Market doesn’t favor the best but the cheapest

1. Engineering companies wanted to cut their costs for fatigue analyses.
2. They started to buy fatigue solvers, which can be developed cheaply, without the need to support own research.
3. The money paid for fatigue solvers enabled developers to develop solvers, but there was little real research underlying them.
4. Solver developers became aware that they cannot substitute research, so they avoided providing a warranty.
5. Academia lost interest in what was implemented in fatigue solvers (no more money, no research).
6. Nobody has been taking care of the core methods in fatigue solvers. They are generally considered or assumed to be good enough (whatever this means).

FABER Project - Goals I

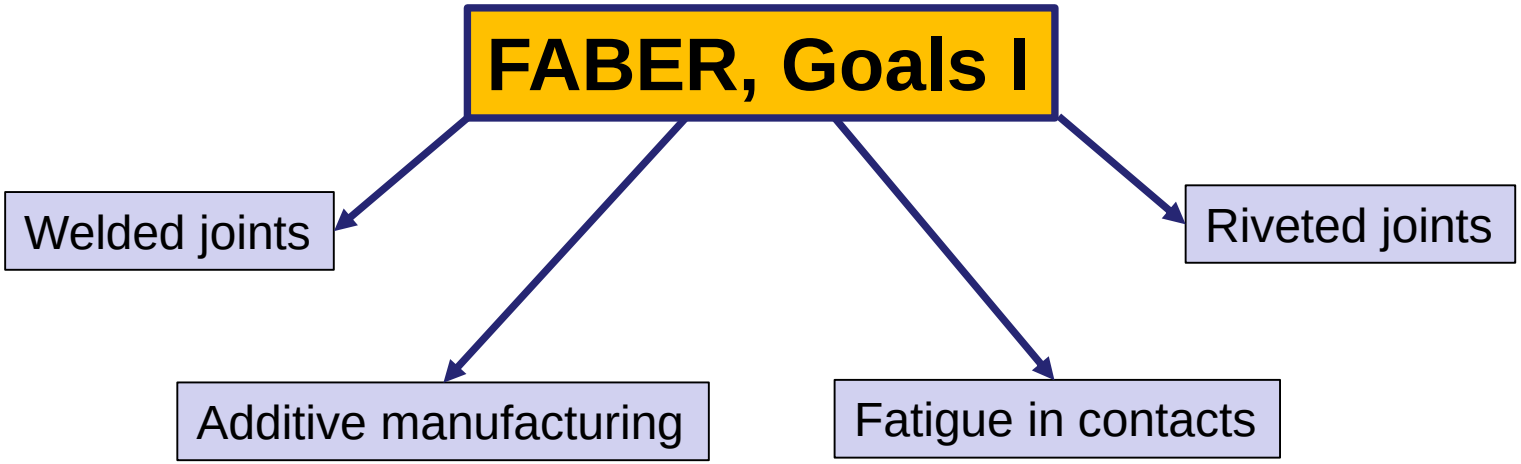
- To establish benchmark sets for testing quality of **High-Cycle Fatigue prediction methods** in these categories:



- These categories
  - **Affect the basic prediction quality**
  - Conditions of dedicated experiments are **still simple enough to monitor**
  - Prediction reasonably simple to perform automated large-scale evaluation

FABER Project - Goals II

- **Prepare basis for future benchmarks** on compound problems:



- Fatigue processes in these domains are more complicated than those in Goals I, various issues interact
- Within FABER, only these activities targeted:
  - Monitoring of optimum data sources
  - Applicable experiments to be defined
  - Definition of experimental data record

How to reach those goals

- To disperse the demanding task to more cooperating people/institutions
- To create a broad network
- Some momentum to start with it sought:
  - COST Projects
  - First project from September 2019 call
    - 4-years project planned
    - Failed while attaining 40 points from 50
    - No fatigue solver developer was invited in the first round

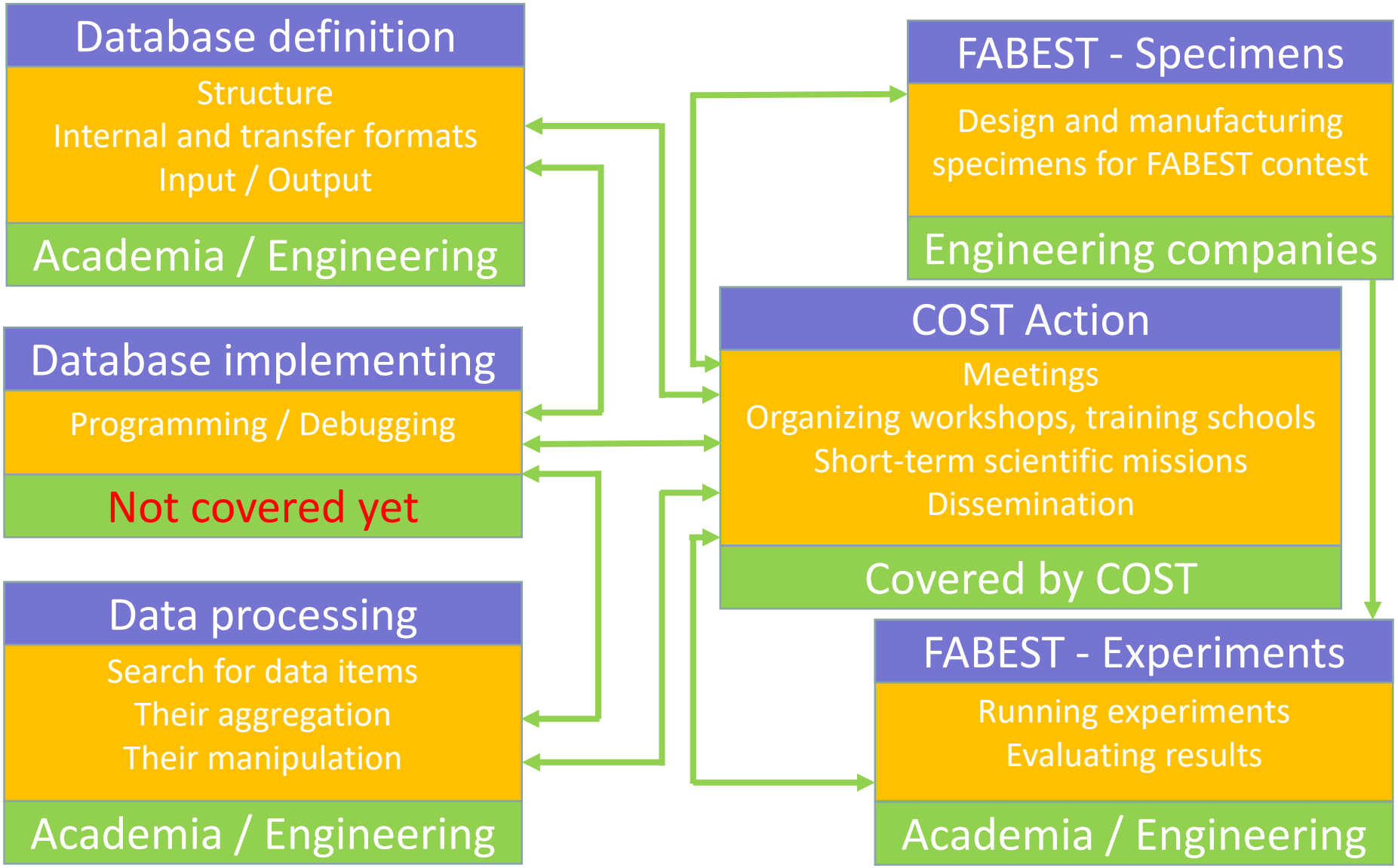
COST Actions

- Focused on European countries and immediate neighbors, but no problem with getting worldwide
- If funded, the funds can be used **only for costs of**:
  - Meetings
  - Organizing workshops, training schools
  - Short-term scientific missions
  - Dissemination
- There are **no funds at all for research or experimenting** itself

Concept of implementation

- The current consortium partners dispose of three different database systems to preserve experimental fatigue data – they should be compared, and **either new solution proposed and built, or some of those solutions adopted**
- Format of an experimental setup record should be checked and redefined, if necessary, for all focused domains in Goals I section
- Participants select their focused areas, look for potential data sources and aggregate data from them. Systems for evaluating data quality and for data inputs checking is developed
- Individual workgroups discuss those rules and decide on selecting of evaluated data sets or their removing
- Benchmark established in Goal I categories and they are tested on available prediction methods, results published
- FABEST – Worldwide contest on best fatigue prediction in selected categories: **experiments to feed the predictions to be run** before the contest, those to show results after the call is closed, contest is monitored and results published

Funding


Database definition
Structure
Internal and transfer formats
Input / Output
Academia / Engineering
Database implementing
Programming / Debugging
Not covered yet
Data processing
Search for data items
Their aggregation
Their manipulation
Academia / Engineering
FABEST - Specimens
Design and manufacturing specimens for FABEST contest
Engineering companies
COST Action
Meetings
Organizing workshops, training schools
Short-term scientific missions
Dissemination
Covered by COST
FABEST - Experiments
Running experiments
Evaluating results
Academia / Engineering

What FABER needs from engineering companies

- **Financial involvement to support implementation of the database** of experimental results used for data aggregation and for benchmark(s) assembly
  - Set to 1,000 EUR per year
  - It can be replaced by alternative means
    - Manufacturing samples for FABEST contest
    - Prizes for FABEST winners
    - Providing access to own company experimental data of interest
    - Running the experiments
- Inviting other interested companies to FABER
- Reporting about FABER goals and activities in journals, on conferences
- Checking on own SW, that the final benchmarks can be processed
- Proposals on FABEST contest topics
- Reminding the fatigue solver developers, that the current status quo must end