

# FABER Project

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## What It Offers to Engineering Sector

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# FABER

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# FAtigue BEnchmark Repository

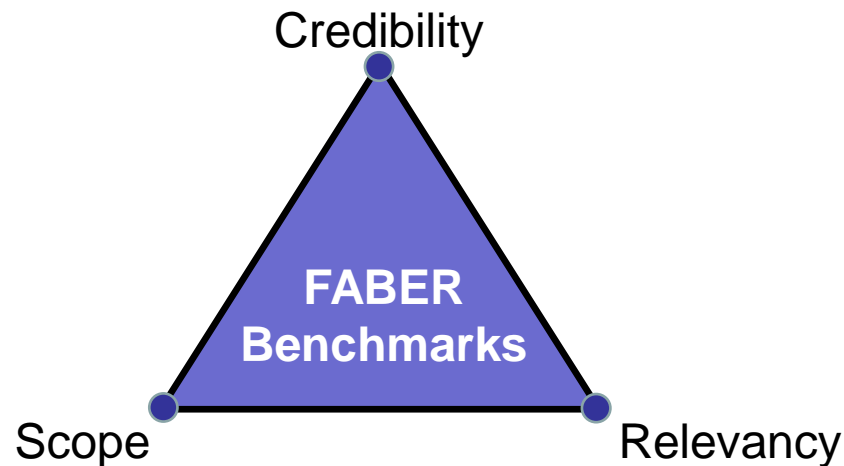
## Benchmark

Benchmarking is used to **measure performance of evaluated fatigue 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

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



- **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

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- 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 funded solely by the company itself

# Warranty denial vs Advertisement

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- *„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	Commercial							Non-commercial			Test set 407 exps.			
	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 [%]
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	X		-4.3	17.9
Matake (1977)										X	X	X	6.4	15.8
Other solution									X	X	X			

- 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)

Academic benchmarks

Ref.	Year	Sets	Items	Method:																
				C&S	Crossland	Dang Van	Findley	Fogge	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						X	X	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						
[16]	2007	16	125	X									X							
[17]	2008	4	43		X							X	X	X						
[18]	2009	40	320		X							X	X	X				X		
[19]	2010	13	131		X	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*	X*	X*	X*		
[22]	2013	8	62		X									X						
[23]	2014	2	4		X		X							X						
[24]	2014	18	58	A	X				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		

- 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](https://c.csm.cz/files/Bulletin_01_2019.pdf), pp. 18-42

# Benchmarking of commercial software?

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- 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

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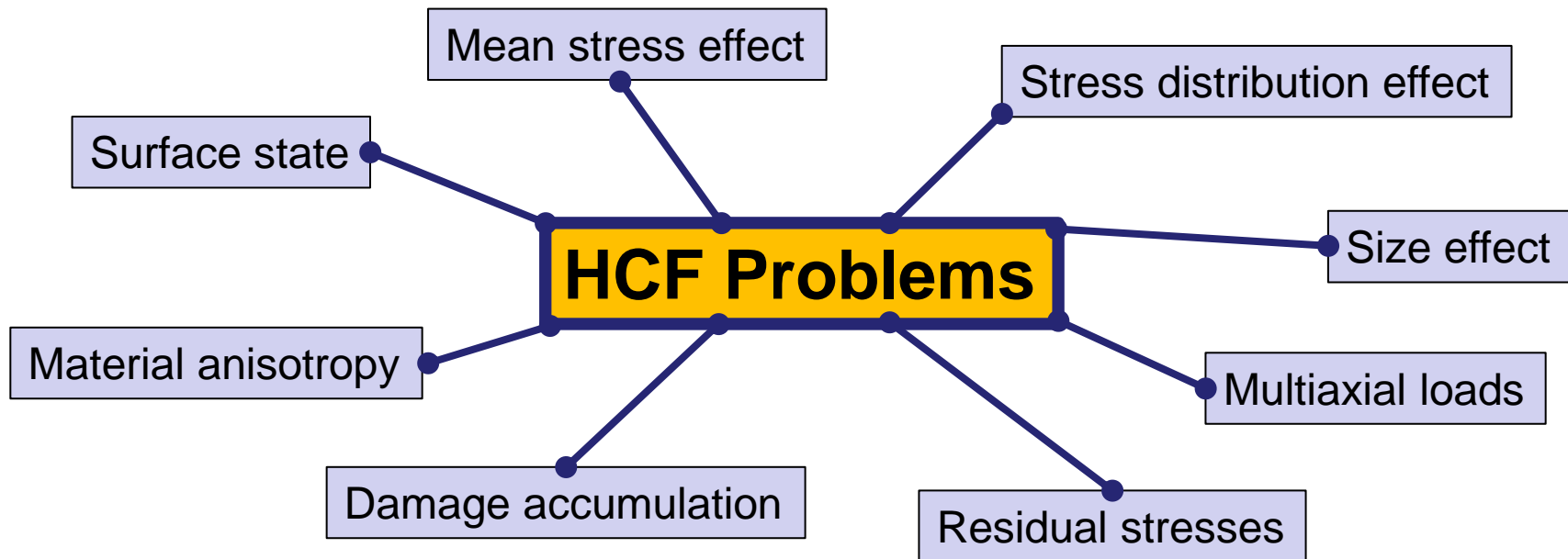
1. Engineering companies wanted to cut their costs for fatigue analyses.
2. They started to buy fatigue solvers, which can be developed relatively cheaply, without the need to support own research.
3. The money paid for fatigue solvers enabled developers to develop solvers, but there was little real 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

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

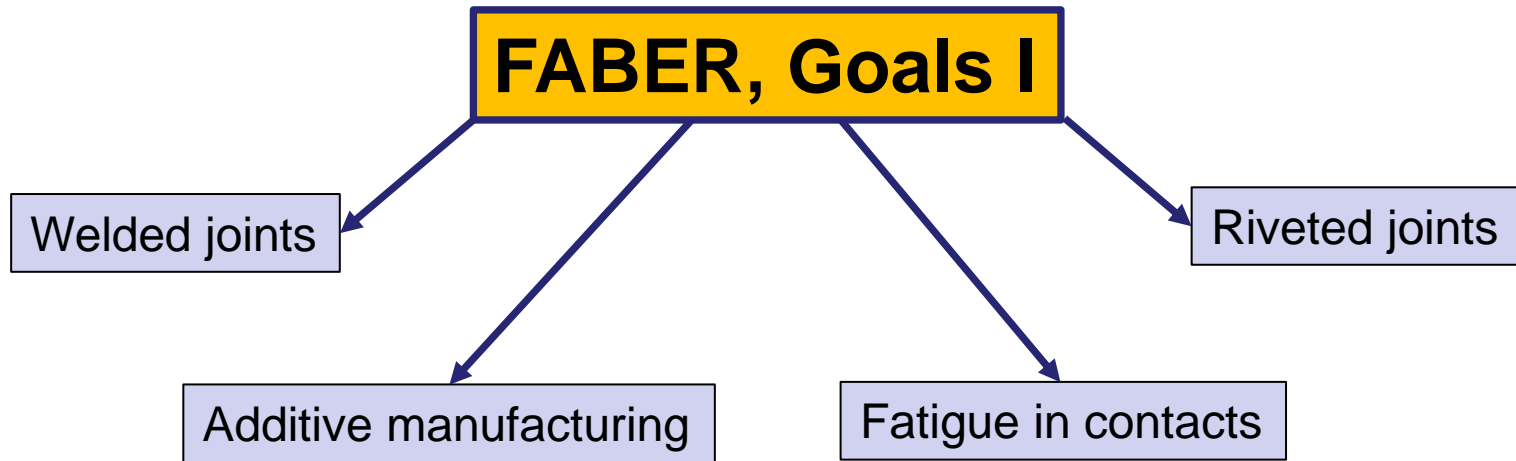


- These categories
  - **Affect the basic prediction quality**
  - Conditions of dedicated experiments are **still simple enough to monitor**
  - Prediction reasonably simple to perform automated large-scale evaluation

# FABER Project - Goals II

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- 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

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- 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
  - Also second project (October 2020) failed to reach funding
  - Third version of the project currently under preparation to meet the deadline on October 29, 2021.

# COST Actions

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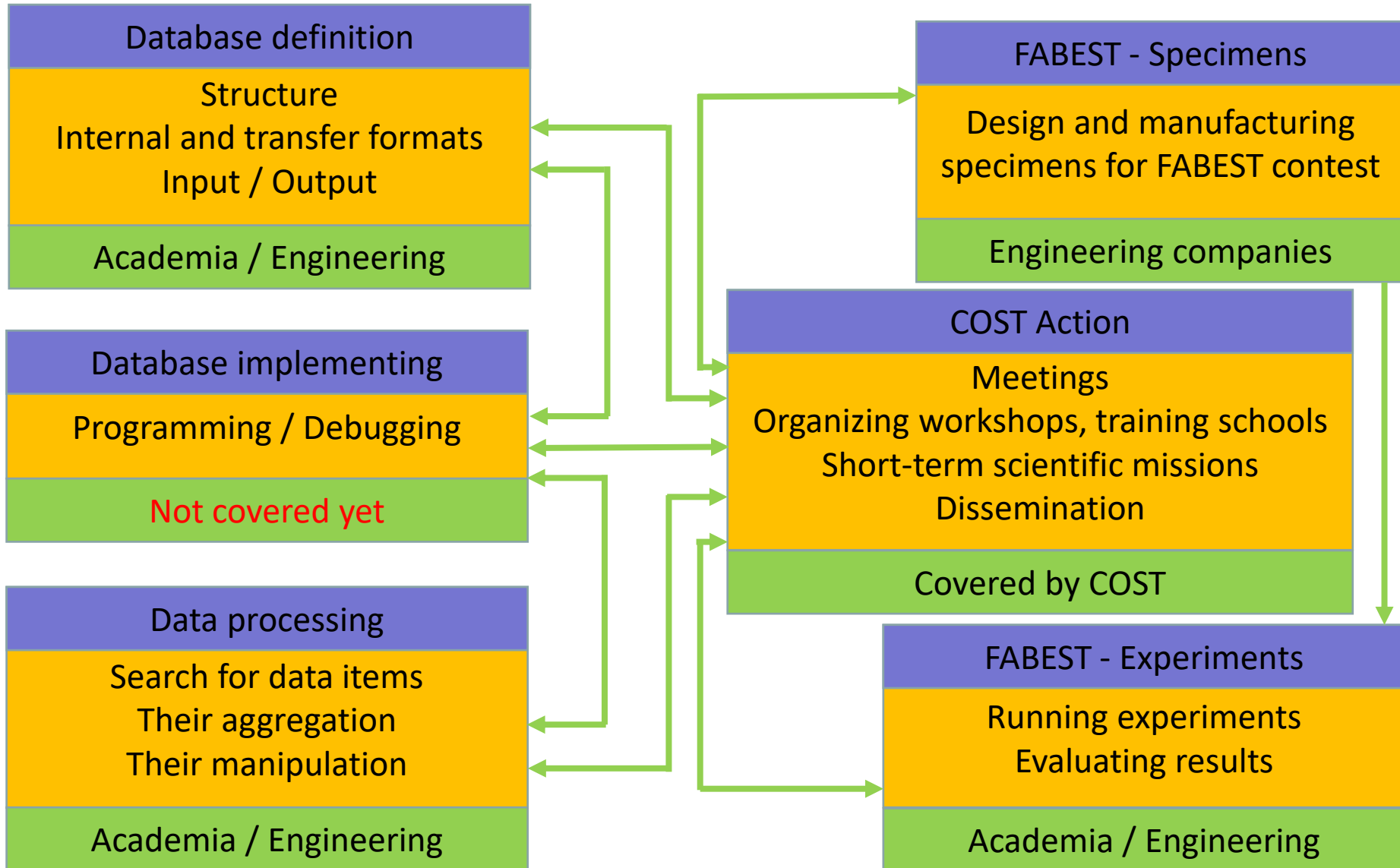
- Focused on European countries and immediate neighbors, but no problem with getting worldwide
- If funded, the funds can be used **only for costs of:**
  - Meetings
  - Organizing workshops, training schools
  - Short-term scientific missions
  - Dissemination
- There are **no funds at all for research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

# Concept of implementation

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- 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 of partial tasks



# What FABER needs from engineering companies

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- **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

# FABEST

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## ■ Original concept:

- Worldwide challenge organized by FABER on best fatigue prediction in selected categories
- Experiments to feed the predictions to be run before the contest
- The experiments results of which are to be predicted will be run after the call is closed
- Contest is monitored and results published

## ■ FABEST#0:

- In January 2021, I proposed wide cooperation of research teams on testing 1.4 ton of 42CrMo4+QT from a single heat I purchased
- Members finance the manufacturing and testing by themselves
- Results are shared and published by the originators
- Within 2021, these domains are focused – size effect, frequency effect, mean stress effect, roughness effect and semi-product homogeneity/anisotropy evaluated
- 15 institutions joined the project
- **We are jointly building the base, on which FABEST challenge could be run in 2022!!!**