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Multiphysics Software: Comparing BEST-OF-CLASS approach against ALL-IN-STRATEGY

SUMMARY

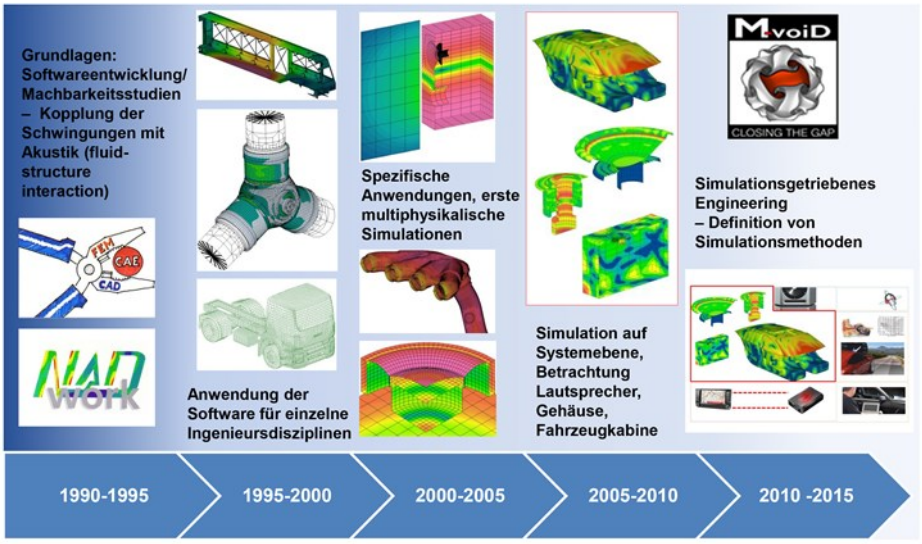
Nowadays there is a strong trend for multiphysics simulations being part of the standard development process in diverse industries. As there is no unique strategy on how to introduce multiphysics software and simulation processes into the product development cycle, this work compares the principal software approach of connecting different “best-of-class” software against introducing software packages that can combine different physical domains per se.

An overview of common industry solutions will be given for both strategies. Pro’s and Con’s will be listed for each of the two strategies. Technical details about the two strategies will not be given, but a general overview will show guidelines on the best fitting strategy for specific industrial applications. A general, yet of course not complete, list of existing tools will be presented as well. Additionally, general guidelines as a basis for a decision on what strategy path to walk will be outlined.

Finally, an outlook on the update strategy of this work will be discussed.

1. Introduction

Over the last 25 years the introduction of multiphysical simulations in diverse industries was a logical development due to the evolution of engineering analysis in virtual product development. In the 90's the focus was on single physics/discipline applications, while during the 2000's a trend towards system level and multiphysical simulations could be monitored (see Figure 1). Recently there is a move away from software/feature thinking towards a methods/process paradigm resulting in a new development approach called simulation driven engineering [1].



1. Evolution of engineering analysis over the last 25 years

As product development requires continuous improvement of the fidelity of simulation models, it was quite natural that for a vast majority of products different physical domains have to be taken into account for the analysis and improvement of product performance. A good example for such a product is an electrodynamic loudspeaker, where at least three different physical domains – electrical, mechanical and acoustical – have to be taken into account [2].

In fact, already in the early 1970's audio engineers have started to develop multiphysical simulation models with strong coupling between each physical domain [3]. While these pioneering models were based on lumped parameter models, during the 2000's a similar approach using matrix methods started [4], resulting in system level multidisciplinary simulation models for audio systems and their listening environment [5].

A very similar trend can be seen with a lot of other products, requiring the coupling of other, sometimes even significant more, physical domains as in a loudspeaker. Thus it is not surprising that all major vendors of CAE software have started to develop multiphysical products. This trend was also enforced due to a natural market adjustment, where "big players" acquired smaller market actors to diversify their product portfolio. These new acquisitions typically brought in expertise in new physical domains. E.g. some market leading vendors with a structural mechanics focus acquired fluid dynamics companies. Thus FSI (*F*luid *S*tructure *I*nteraction) is probably the best known multiphysics application today.

But, besides the general question (on engineering management level) of introducing a new technology into an engineering process, the big question now is: should a company adopt an "all-in" software package where all required physical domains are available, or go for a "best-of-class" solution, where software packages from different vendors are interacting by support from a middleware software package.

The aim of this paper is to support decision makers to find the best solution for their respective unique situation.

2. The basic difference between “all-in” and “best-of-class”

The software architecture between these two types is of essential difference, and thus the general “look and feel” and typical use scenario is of major difference. However, most important is to note that the originating business driver for software development is of significant difference, resulting in different types of products.

An “all-in” software package typically has been originally designed for multiphysical simulations as its prime application. Thus coupling of the various physics (with its most important physical effects and applications) is of crucial importance, while physical details in each domain are only secondary. Coupling of clearly more than two domains (typically three to five) is the strength of such software packages. These packages typically have a newer, fresher software design, and have a modern GUI and good interaction capabilities with horizontal software packages (e.g. in the field of system modelling).

Members of the “best-of-class” area are typically well established single physics packages (e.g. in structural mechanics or fluid dynamics) that are being connected by some kind of middleware software. The situation here is vice versa as with the prior, “all-in” software packages. Their strength is in high fidelity of each physical domain (including lots of physical “special” effects) with some limitations in coupling capabilities. Though software architecture is older, vast capabilities in its (single) physical domain is superior– at a great performance level.

2.1. Major pro’s and con’s of “all-in” and “best-of-class”

The previous statements already define the major pro’s and con’s. In Figure 2 you can find a quick summary.

	Pro	Con
“All-in”	Comprehensive coupling capabilities	Limited (single) physical capabilities
	Scales well with number of different physical domains	Coupling to other physical codes not well established
	Training on all physics from one source	Efficiency (accuracy/numerical) not superior for each single domain
	Single entry point for support / maintenance	Limitations in support for very complex multiphysics
“Best-of-class”	Superior (single) physical capabilities	Limited coupling capabilities
	Lots of different physical codes for potential coupling	More than two physical domains to couple is highly challenging
	Superior efficiency for each single domain	Training from different sources
	Support experts for each physical domain available	Multiple sources for support / maintenance

2. Major pro’s and con’s of “all-in” and “best-of-class”

2.2. Conclusions of major pro's and con's

As a general conclusion and guideline derived from the major pro's and con's we see different applications scenarios for "all-in" and "best-of-class" software packages. For concept, typically on system level, simulation models use of an "all-in" software package is advantageous, while for highly detailed (close to SOP) models "best-of-class" software is typically the better choice. Thus, it is not uncommon to use both types of software packages, but in different phases of the product development cycle.

3. An incomplete list of major tools

Explicit lists are always dangerous. They are never complete, and seem to be somehow arbitrary. The following list reflects major multiphysics software packages form our own point of view and market recognition. We know that once it is published it might already be incomplete. Anyways, despite all con's it is a helpful starting point for newbies in multiphysics and thus it is being published.

	URL	Type
3DS Multiphysics Simulation	http://www.3ds.com/products-services/3dexperience/multiphysics-simulation/	"all-in" + "best-of-class"
ACE+ Suite	https://www.esi-group.com/software-services/virtual-environment/cfd-multiphysics/ace-suite	"all-in"
ADINA Multiphysics	http://www.adina.com/multiphysics.shtml	"all-in"
Altair Smart Multiphysics	http://www.altairhyperworks.com/Solutions,1,20,Multiphysics.aspx	"best-of-class"
ANSYS Multiphysics	http://www.ansys.com/Products/Simulation+Technology/Systems+&+Multiphysics	"all-in"
COMSOL Multiphysics	http://www.comsol.com	"all-in"
Kratos Multi-Physics	http://www.cimne.com/kratos/default.asp Remark: open source	"all-in"
MpCCI	http://www.mpcci.de/mpcci-software.html Remark: Multiphysics Code Coupling Interface (middleware)	"best-of-class"
MSC Multiphysics	http://web.mscsoftware.com/solutions/Applications/Multiphysics.aspx	"all-in"
NX CAE	http://www.plm.automation.siemens.com/de_at/products/nx/9/for-simulation/nx-cae.shtml	"all-in"

3. An incomplete list of major tools (in alphabetical order)

4. Outlook

Within the author's work in the NAFEMS Multiphysics Working Group [6] the current topic will be further and constantly monitored and updated. Results of this ongoing work will be published regularly.

REFERENCES

[1] Alfred J. Svobodnik, “Vollständigkeit zählt”, in Automobil Konstruktion, Ausgabe Februar 2014 (in German)

[2] Alfred J. Svobodnik, “Multiphysical Simulation Methods for Loudspeakers - A (Never-)Ending Story?”, 136th AES Convention, Berlin, Germany, 2014

[3] R.E. Cooke, “Loudspeakers, An Anthology, Vol.1 – Vol.25 (1953-1977)”, AES Audio Engineering Society, New York, 1978

[4] Alfred J. Svobodnik, “Acoustic Matrix Methods for Woofers, Tweeters, Horns and Small Transducers”, 12th AES Regional Convention, Tokyo, Japan, 2005

[5] Alfred J. Svobodnik, “CAE as Key Technology for the Multidisciplinary Virtual Product Development of Automotive Audio Systems”, NAFEMS Seminar: „The Role of CAE in System Simulation“, Wiesbaden, Germany, 2011

[6] NAFEMS Multiphysics Working Group, http://www.nafems.org/about/tech/multiphysics