



Modelling Cook-Off

IMEMG EWG Computer Modelling

» IMEMTS, October 2019



Modelling Cook-Off

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Introduction / Motivation

Group Members, Group Tasks

Benchmarking Codes and Models

Examples discussed during EWG Meetings

Review of Computer Models

AOP-39 protocol and availability of computer models

Conclusions

EWG Participants

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	Victor Benito Martin	EXPAL
	Pablo Bernardez Gonzales	EXPAL
	Victor Bjorkgren	Saab Dynamics
	Pierre Brunet	NEXTER
	Ron Holland	BAE Systems Land
	Daniel Lewis	AWE
	Paul Locking	BAE Systems Land
	Didier Picart	CAE
	Michel Vives	MBDA-F
	Eric Winkler	Saab Dynamics

Motivation

Numerical simulation is helpful to:

- test solutions during the design of new systems
- respond quickly to questions (waiting experiments)
- reduce testing
- provide answers in the demonstrations delivered to customers

The group reviews and discusses:

- availability
- applicability
- capability

of existing models.

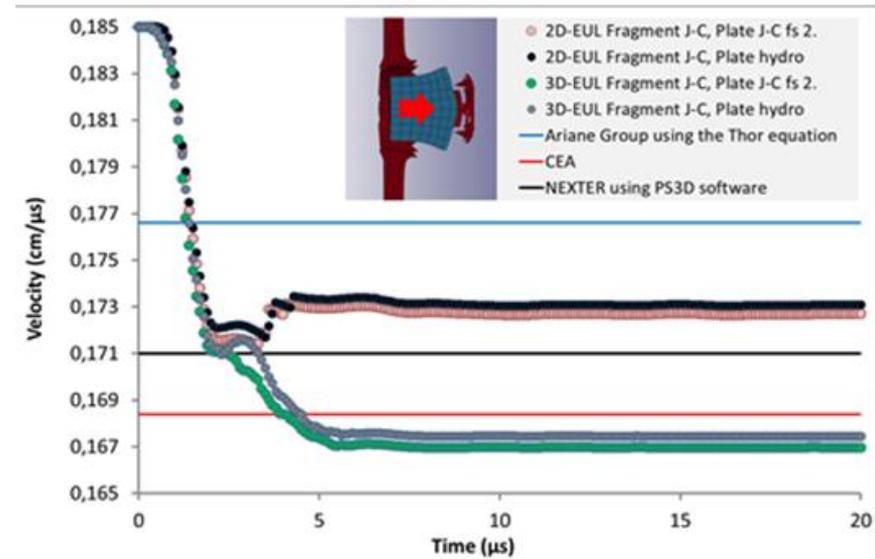
To give confidence on the numerical results to the users/customers, the tool (models, codes...) must be validated. Experiments are needed to assess such models.

BENCHMARKING CODES AND MODELS

A recent example discussed during EWG CM meetings

Fragment impact → **Experiment needed to improve our numerical results!**

- Several computer modelling tools are broadly available
- Results can be compared to analytical models
- The results tend to depend sensitively on parameters of the material model (that are to be determined from experiments)
- Material parameters tend to depend on material processing (i.e., in general, $Cu \neq Cu$)



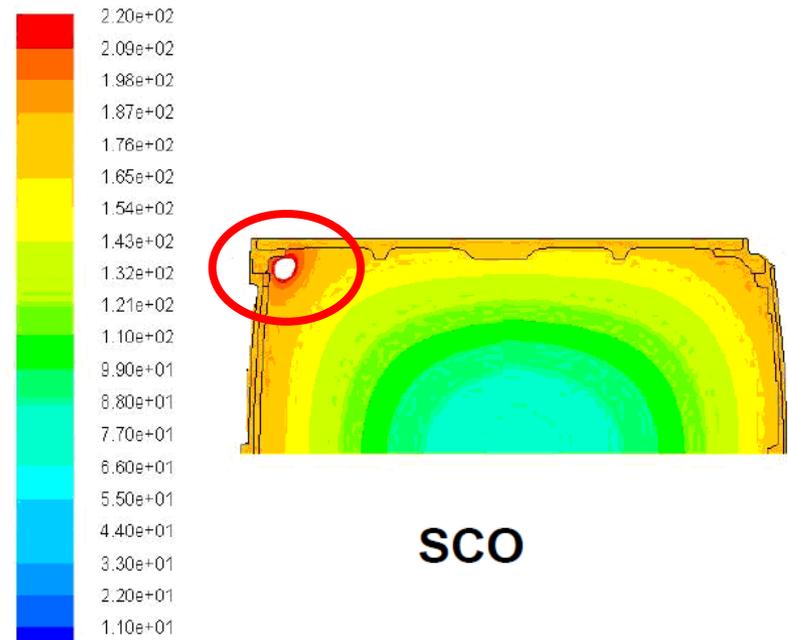
Impact of a STANAG light fragment on an aluminum plate. Different models give close but different results. (Thanks to P. Brunet, Ariane Group, FR)

BENCHMARKING CODES AND MODELS

A recent example discussed during EWG CM meetings

Slow Cook-Off (SCO) → **Experiment needed to improve our numerical results!**

- In testing and simulation, small scale is much easier and cheaper than AUR (full scale all up round)
- The relation of small scale vs. AUR is only known from experience while there are no rigorous formulae or methods
- Certain effects (e.g., hot spots in SCO simulations) can only be reproduced in AUR simulations



SCO

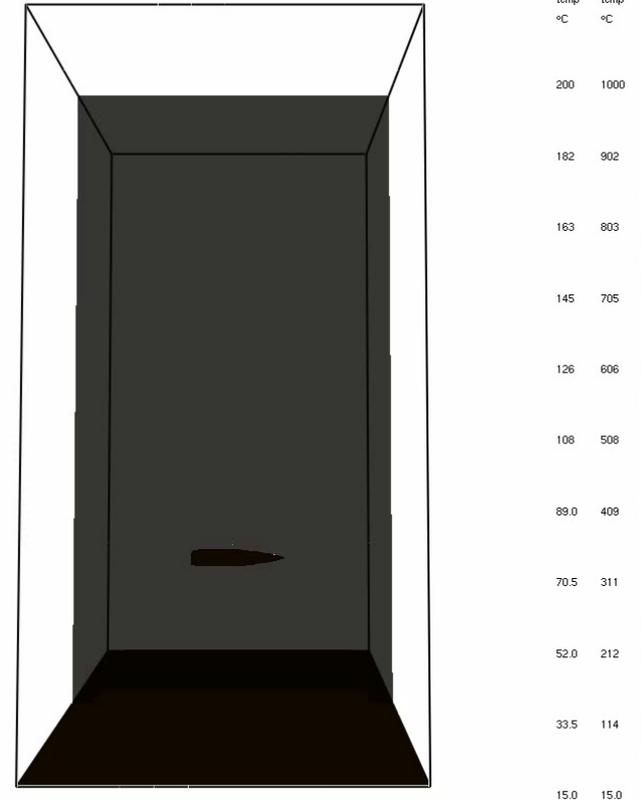
SCO Simulation (thanks to V. B. Martin and P. B. Gonzalez, EXPAL, ES)

BENCHMARKING CODES AND MODELS

A recent example discussed during EWG CM meetings

Slow Cook-Off (SCO) → **Experiment needed to improve our numerical results!**

- Simulations of a reactive flow around and heat flux into munition
- The simulation gives a qualitative understanding of important processes
- The quantitative results depend on choice of turbulence model, mesh resolution and combustion model



Time: 0.2

(Thanks to P. Locking, BAE, UK)

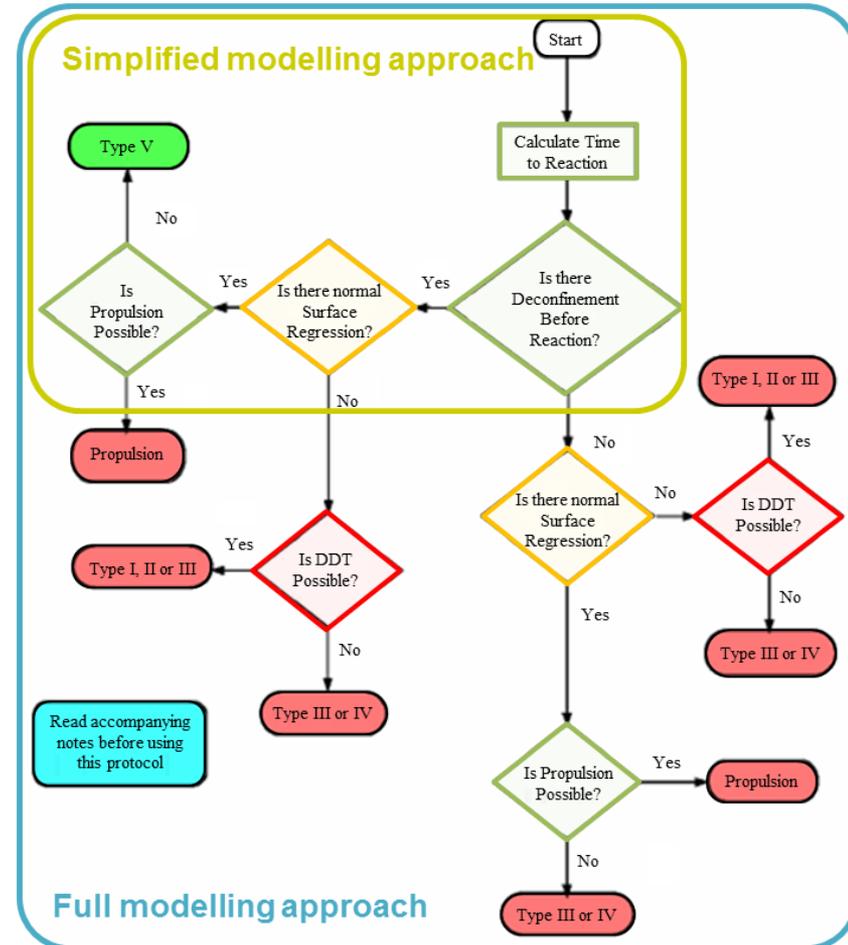
BENCHMARKING CODES AND MODELS

- **For given boundary conditions, computer modelling allows to precisely calculate the physical environment of energetic materials in space and time**
 - heat
 - pressure
 - mechanical stress/strain
- **Models for reaction thresholds are available**
 - allows to predict time and position of ignition
- **It is very hard to predict what exactly happens after ignition**
 - slow burning, deflagration or detonation
 - violence of the reaction

Review of Computer models

A method has been proposed based on AOP-39 flowcharts: Some comments

- **Deconfinement** (pressure release) is the most important stage to be answered
- **DDT** still hardly tractable
- **Sub-detonative** response types II-IV are hard to distinguish (fragmentation of casing and violence without detonation)
- **Possible propulsion:** the location of ignition versus position of vents (e.g., nozzles, openings) is needed



green: models available, orange: depends on the case, red: fundamental research

Conclusions

- European manufacturers share data and information in the IMEMG EWG „Computer Modelling“.
- Today, computer models as part of the design process can predict ignition time and location quite precisely.
- Processes after ignition are still very challenging to predict. There are no generally accepted models for such predictions.
- Currently, there is no systematic collection of experimental data to assess such models.
- A collection of benchmark experiments –agreed to by the community– is the aim of our EWG.

Please send us any unclassified experiment!

<https://imemg.org/contact/>

Thank you for your attention!