MSIAC
Supporting Munitions Safety





TEMPER Software from v1.0 to v2.0 (Toolbox of Engineering Models to Predict Explosive Reactions)



E. Lapébie – G. Baudin (FR/DGA/CEG)
P-F Péron (NATO/MSIAC)
F. Peugeot (NATO/NAMSA)




TEMPER Software from v1.0 to v2.0

Background

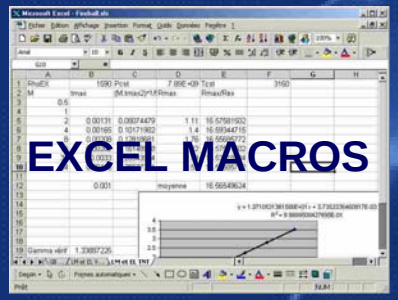
Features

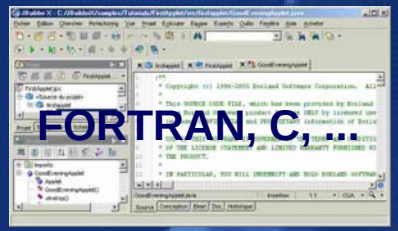
Highlights

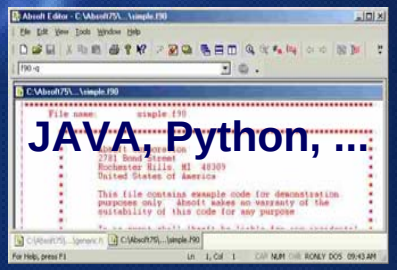
Conclusion

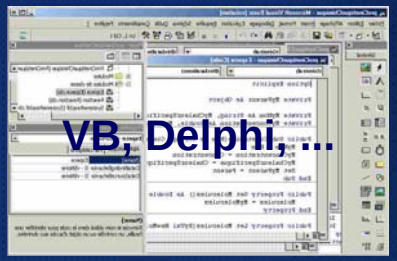
BACKGROUND : Modelling ...

- **EM experts, in many organizations, have in-house models, but ...**









- **NATO/MSIAC is promoting modelling as a major tool to improve munition IMness, in accordance with the new versions of safety-related STANAGS**

- **Why not sharing a common tool among MSIAC member nations ?**

BACKGROUND : Requirements

Flexible
to afford multiple implementers and therefore save time and money

Commented and Documented
to ensure timeliness
to ease further developments

Actively maintained
to ensure quality control

- Source code available
- Object oriented
- Users level | Developers level
- Users/Developers guide
- Models guide
- Implementation procedures
- Bugs report
- Request for enhancement
- FAQ – hot line

NEED FOR :

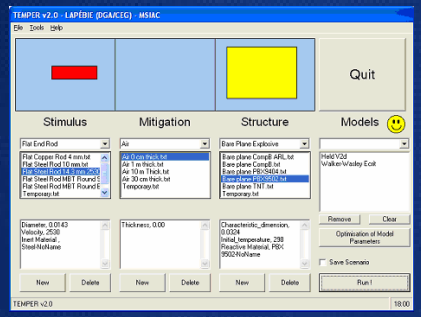
A focal point
(coherence & availability)
NATO / MSIAC

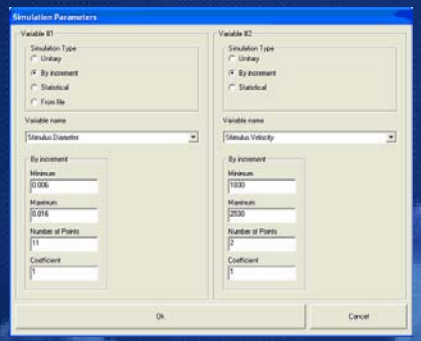
A code
(and a developer)
TEMPER / CEG /
(E. Lapébie)

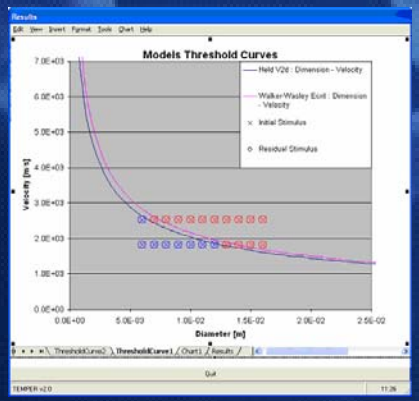
BACKGROUND : TEMPER v1.0

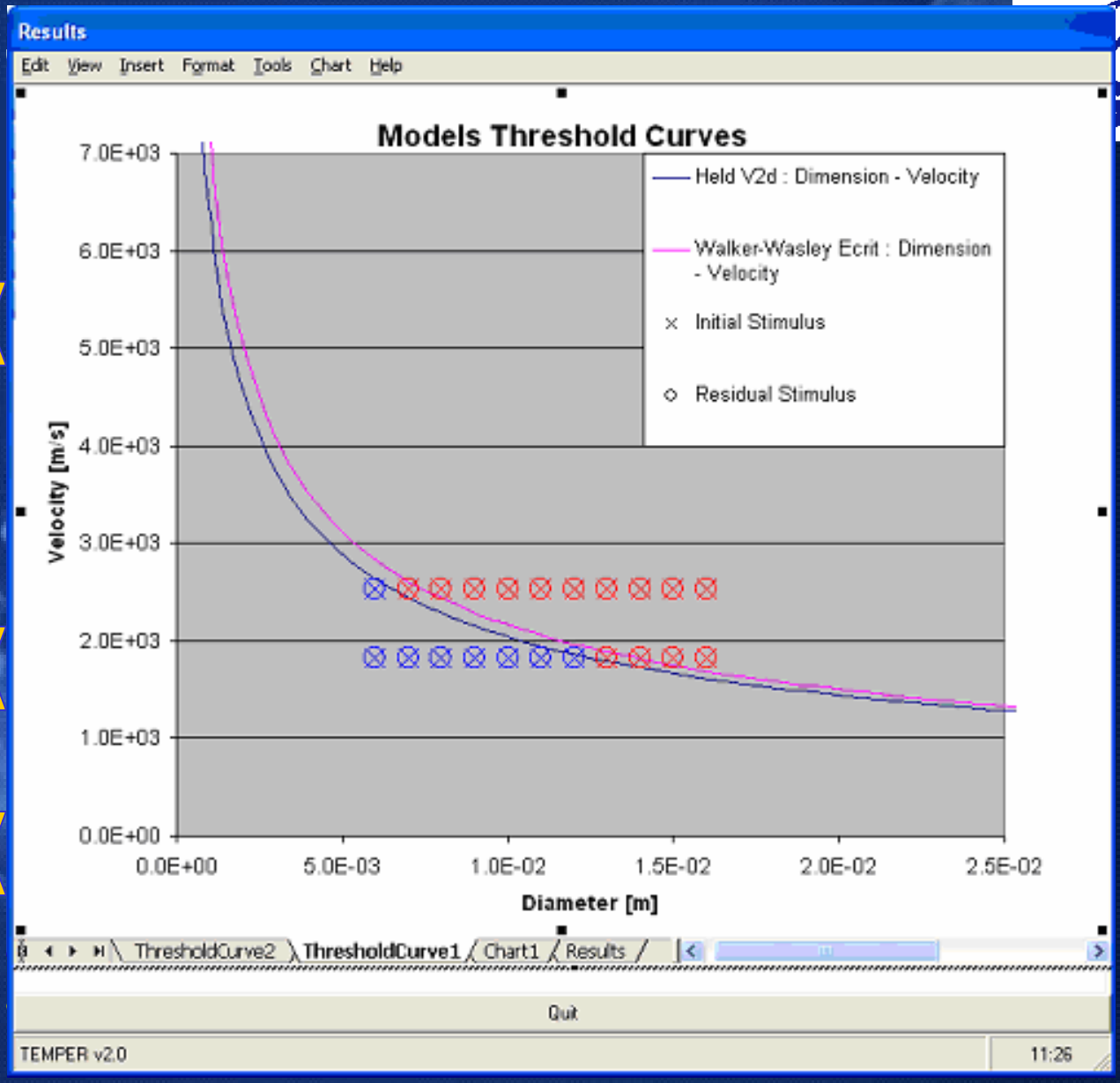
- TEMPER has been developed (VB 6.0) at CEG under FR/DGA contract 03.34.01, initially to share data and models between DGA centers involved in EM studies.
- TEMPER v1.0 has been made available to experts from MSIAC member nations since 2004 (FR) and 2005 (ENG). Its features have been presented at ESW 2006 and IMEMTS 2006.
- MSIAC manages an electronic TEMPER working group (TWG), with 21 registered users from 12 organizations and 7 countries (v1.0 figures).
- TEMPER v2.0 will be released in late October 2007 and provides many more built-in features than v1.0. Some of them will be detailed in the following slides.

FEATURES : TEMPER Basics





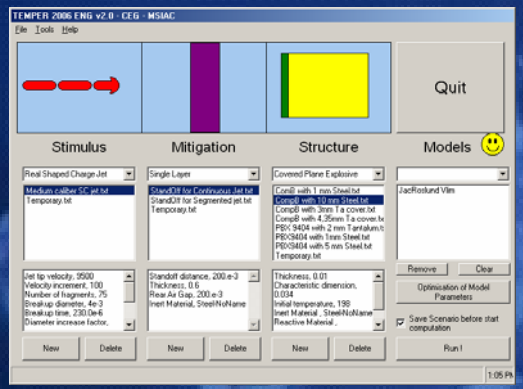




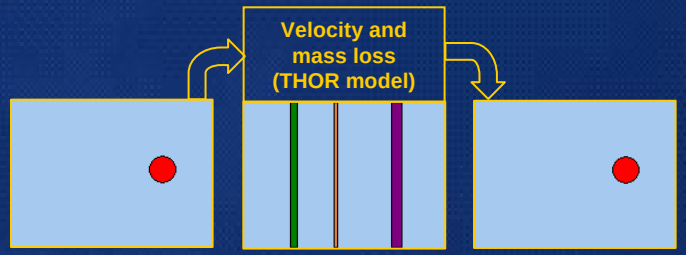
FEATURES : Simulation Logic

- **TEMPER decomposes munition aggression into the description of a Stimulus / a Mitigation / a Structure. The simulation then runs with one or more Model(s).**

- **The simulation logic relies on 2 steps :**



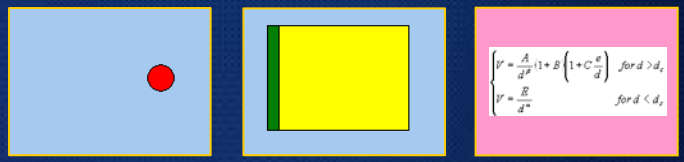
①



STIMULUS Spherical fragment | **MITIGATION** Spaced plates | **RESIDUAL STIMULUS** Spherical fragment

②

RESIDUAL STIMULUS Spherical fragment | **STRUCTURE** Covered E.M. | **MODEL** V_{lim} Jacobs-Roslund



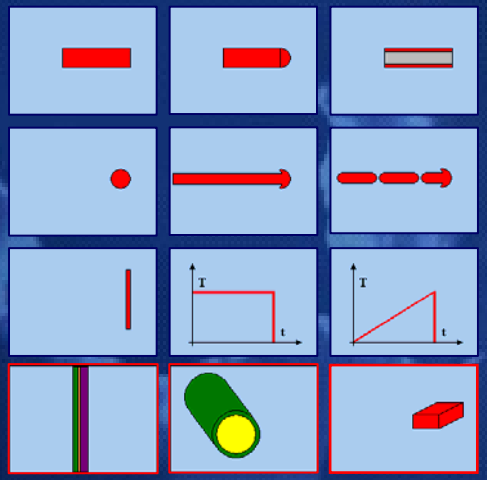
FEATURES : Roadmap to v2.0

- **Object-Orientation (strict requirement)**
- **Management of a Scenario (load / save simulations)**
- **Man-Machine Interface enhancements**
- **New objects and models:**
  - Peugeot SDT and BSDT
  - P^nTau
  - Extended Yactor model
  - New stimulus : parallelepiped fragment
  - One on One Warhead and SD approaches (MSIAC)
  - External 1D Hydrocode (GODLAG, developed by G. Baudin-CEG)
- **New simulation modes (1.from file, 2. Model fitting)**
- **Material Editor**
- **Better error handling and compatibility management**
- **Documentation upgrade (including online help)**

FEATURES : Objects and models

STIMULI

Flat end rod
Round end rod
Flat cookie-cutter
Spherical fragment
Simple shaped charge jet
Real shaped charge jet
Thin plate
Constant Temperature
Rising Temperature
Multilayer Impactor 1D
One on One Warhead
Parallelepiped Fragment



MITIGATIONS

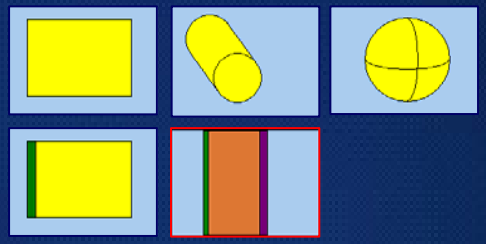
Air **[modified]**
Spaced plates
Single layer

MODELS

V^2d and u^2d (Held)
E_{crit} Walker - Wasley
E_{crit} James
Y (Yactor) **[modified]**
$V_{threshold}$ (Jacobs - Roslund)
$t_{cook-off}$ (Creighton - Victor)
E_{seuil} and BSDT (Peugeot)
Godlag 1D (Baudin)

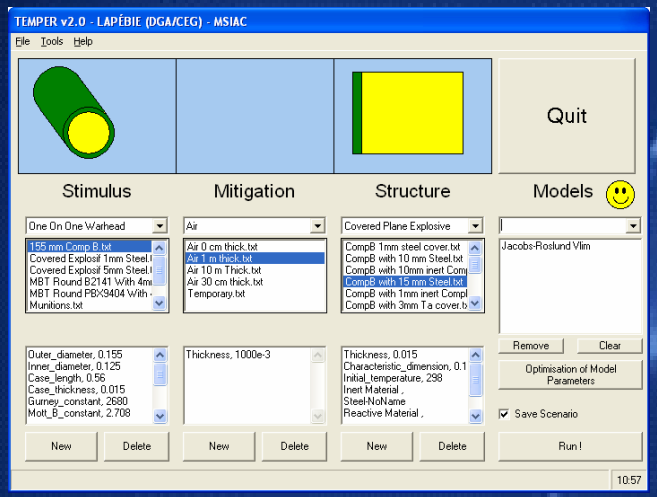
STRUCTURES

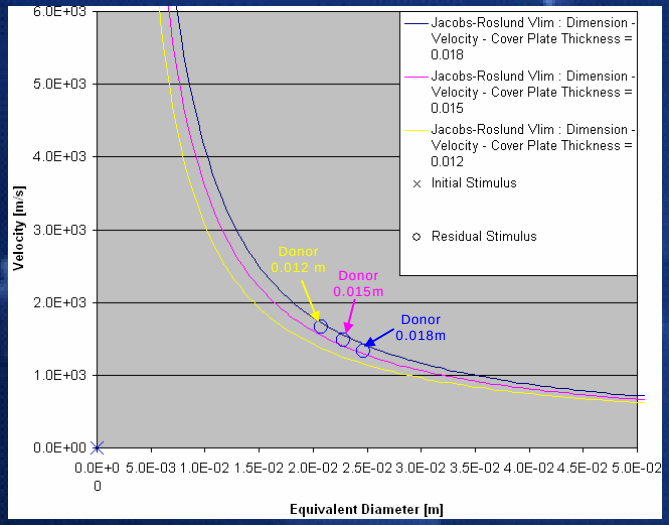
Bare plane explosive
Bare cylindrical explosive
Bare spherical explosive
Covered plane explosive
Multilayer Structure 1D



In RED:
New in v2.0

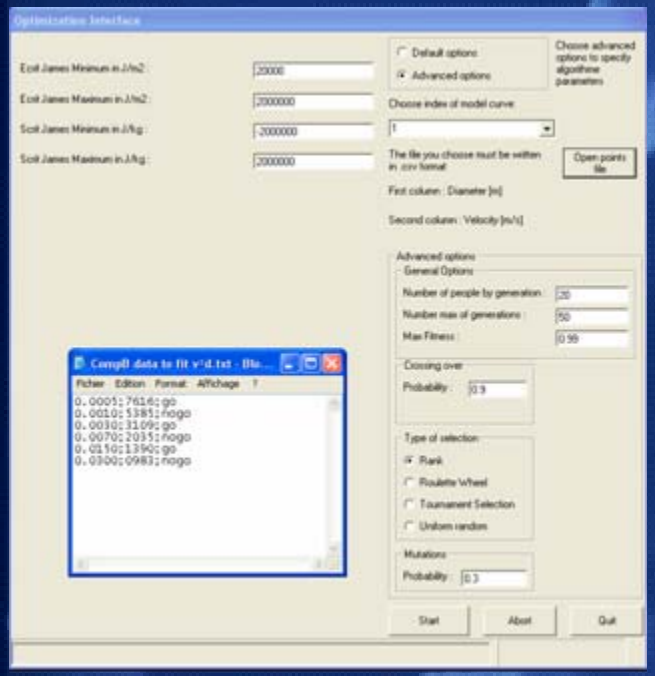
HIGHLIGHTS : One on One Warhead





- Developed by NATO/MSIAC (L. Nyogeri from DOSG, F. Peugeot, P-F Péron)
- Includes a new Stimulus “One on One Warhead” (corresponding Residual Stimulus = Parallelepiped Fragment)
- This first attempt to share the development of TEMPER among different organizations is successful …

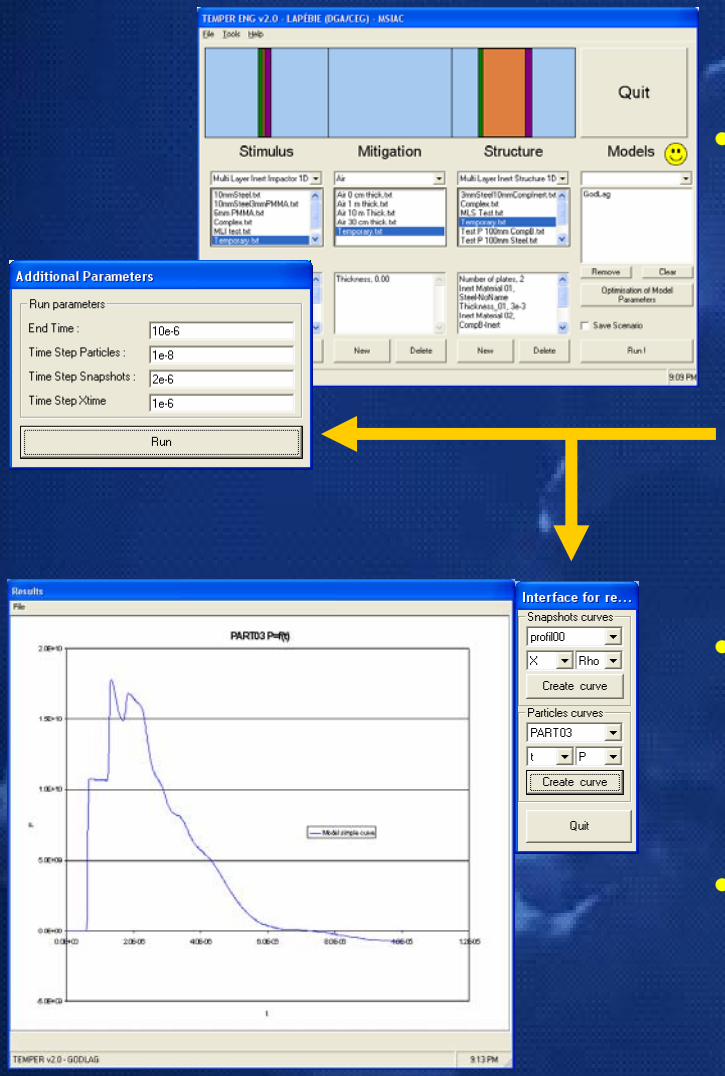
HIGHLIGHTS : Model fitting



Model fitting

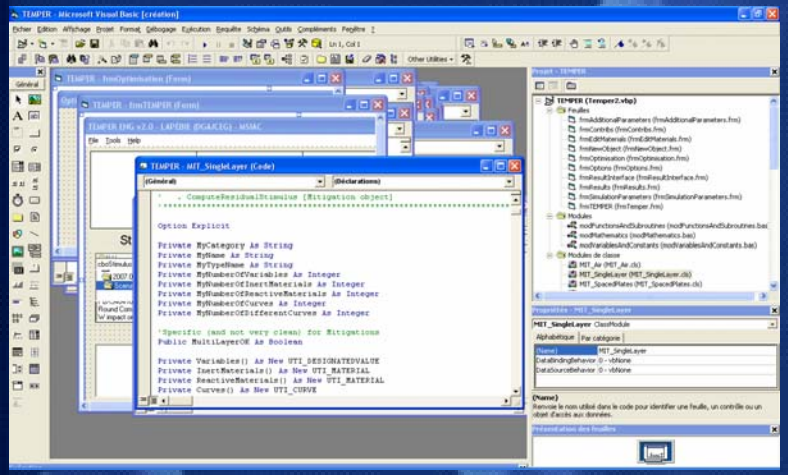
- Most analytical / empirical models only have a limited set of published parameters
- Many test results are available in the literature (MSIAC Fragment Impact Database for instance)
- Will it be possible to take benefit of these results to determine parameters for simple models ? YES !
- TEMPER v2.0 uses an implementation of genetic algorithms in order to fit model parameters.

HIGHLIGHTS : 1D Hydrocode



- **TEMPER v2.0 includes GODLAG, a 1D hydrocode for inert materials provided by G. Baudin (CEG)**
  - GODLAG adds its own interface for specific parameters and post-processing, but is fully embedded in TEMPER (seen as a model)
  - For the sake of simplicity, virtual sensors are added only at layers interface
- **Next version (GOLIATH):**
  - reactive materials,
  - Possible choice of virtual sensors position
- **The real challenge is to keep it as simple as possible for the user (default / advanced options) !**

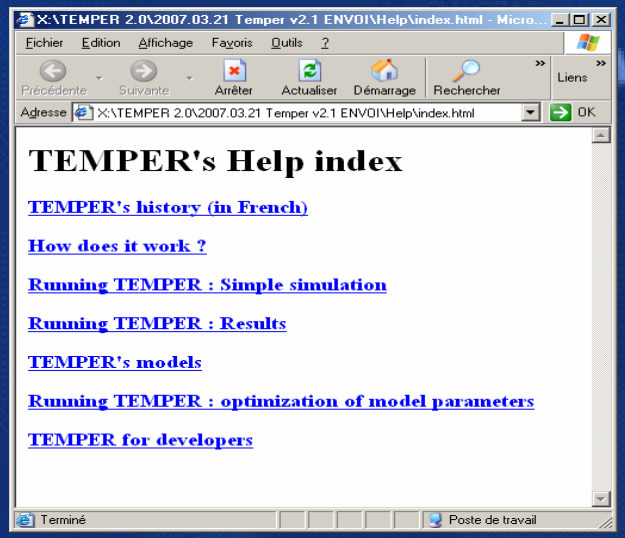
HIGHLIGHTS : Developer level



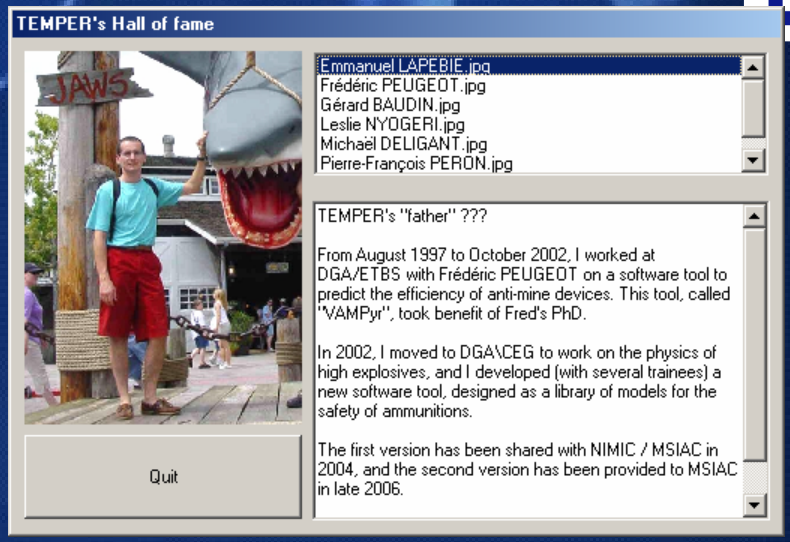
- **Source code for “contributors”**
  - Visual Basic 6.0
  - 23 000 lines of code (33% are comments)
- **Integration of new objects or models**
  - Simple object / model ~ 1 day of work
  - (Clever) cut & paste = 50% of the new code
- **Use of external EXE or DLL**
  - A solution for complex models (GODLAG)
  - Specific forms can be added to the GUI
- **Possible extensions**
  - Blast wave propagation
  - Classical penetration models
  - The only limit is our / your imagination !

HIGHLIGHTS : And Much More ...

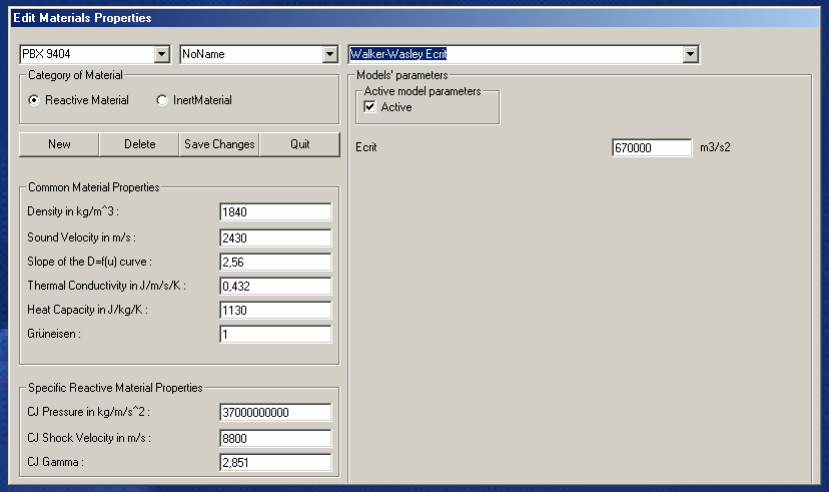
On-line help



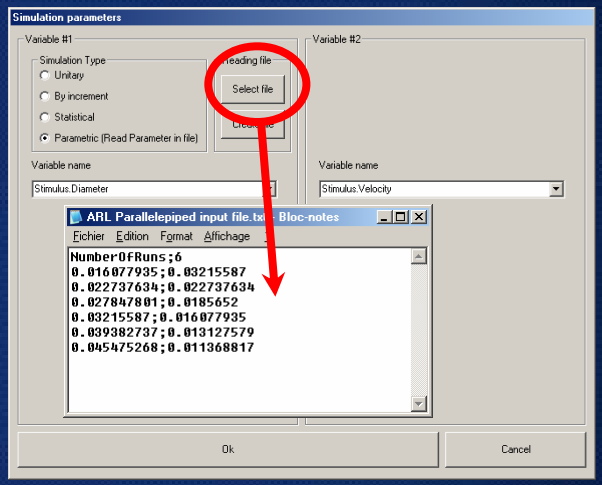
Contributors



Material Editor



Simulation from files



CONCLUSION : Availability

- **TEMPER is available for download from the MSIAC secure website**

Executable Code TEMPER version 2.0 For declared "Users Only"		Open Visual Basic 6.0 Source Code For declared "Possible Developers"	
English Version		English Version	
✓		✓	

- **Recent MSIAC reports :**
  - L137 : TEMPER v2.0 Tutorial (P.-F. Péron)
  - L138 : Implementation of a new Stimulus and Model in TEMPER v2.0 (P.-F. Péron)
  - L139 : TEMPER v2.0 – New Developments (E. Lapébie)

- **The ultimate goal of this project is to provide to the community a common tool that could become a reference in the S3 community.**

CONCLUSION : Next Version

- **Background work**
  - Cleanup of the code and addition of comments
  - Better error handling and compatibility management
- **New objects and models**
  - 1D GODLAG will be replaced by 1D GOLIATH (reactive)
  - New 1D conduction solver with multi-Arrhenius chemistry
  - Thermal stimuli and models
- **NATO / MSIAC**
  - Further work on SD (plate impact / fragment impact)
  - Training session on TEMPER v2.0
  - Implementation of new EM data
  - New reports on specific models
- **and more …**
  - It also depends on you !

CONCLUSION : MSIAC TWG

2005 (v1.0)	TEMPER e-Working Group (TWG)	10 members 9 organizations 6 nations
2006 (v1.0)	TEMPER e-Working Group (TWG)	21 members 12 organizations 7 nations
2007 (v2.0)	Come and join us (developers welcome !)	