

***Soldier Systems Technology Roadmap
Weapons: Lethal and Non-Lethal Workshop***

Weapon Effects Characterization



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Biokinetics**

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Toronto, Ont.**



**Government
of Canada**

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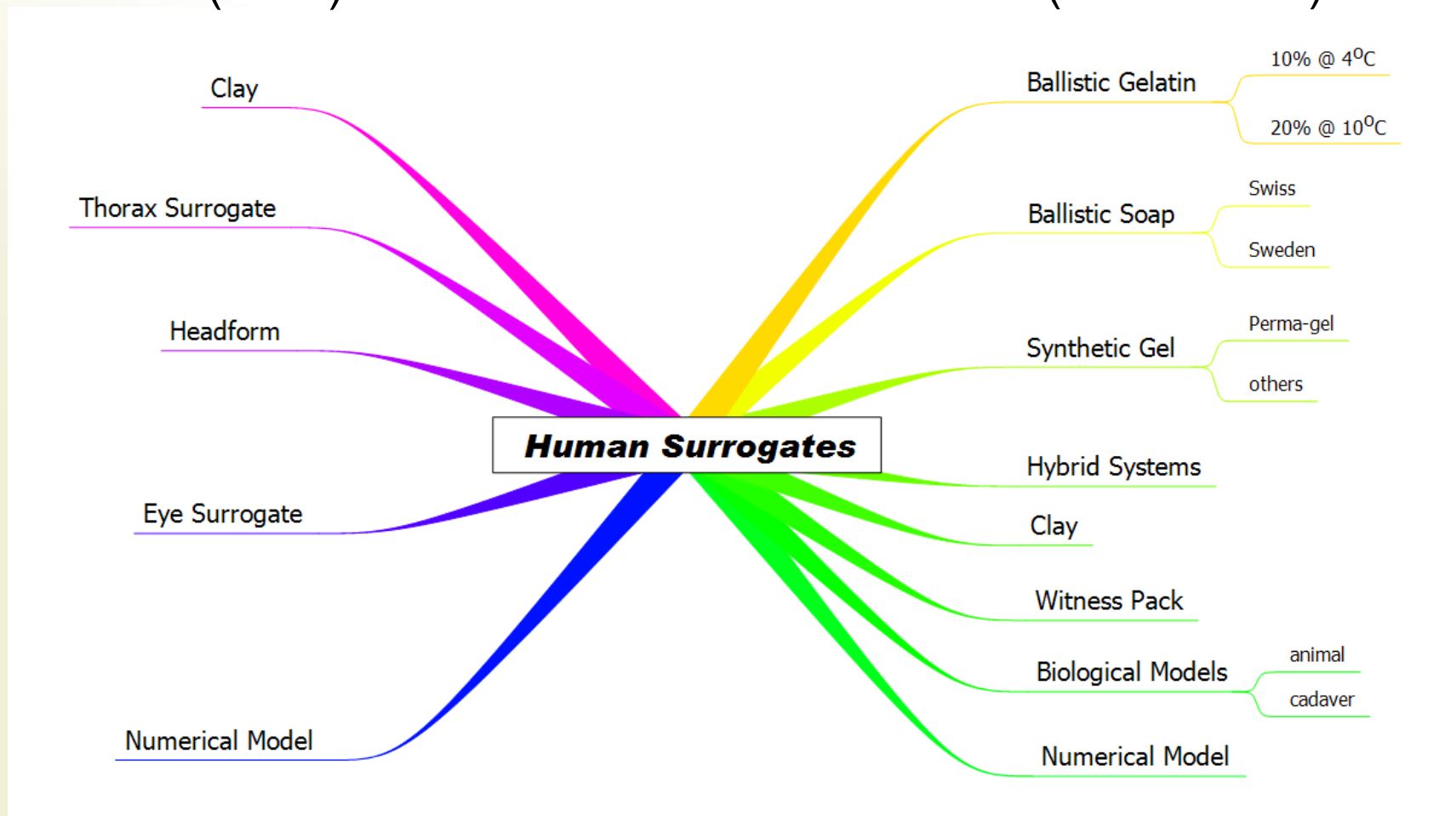
KEY FACTORS

- What are the optimal terminal effects for the soldier's weapon ?
- What are the techniques available to measure these terminal effects?
- What are the advantages & limitations of these techniques?
- Is there an accepted standard?
- Which technique should be considered?
- Can it be improved?

WEAPON EFFECTS CHARACTERIZATION

Non Penetrating Effects (NLW)

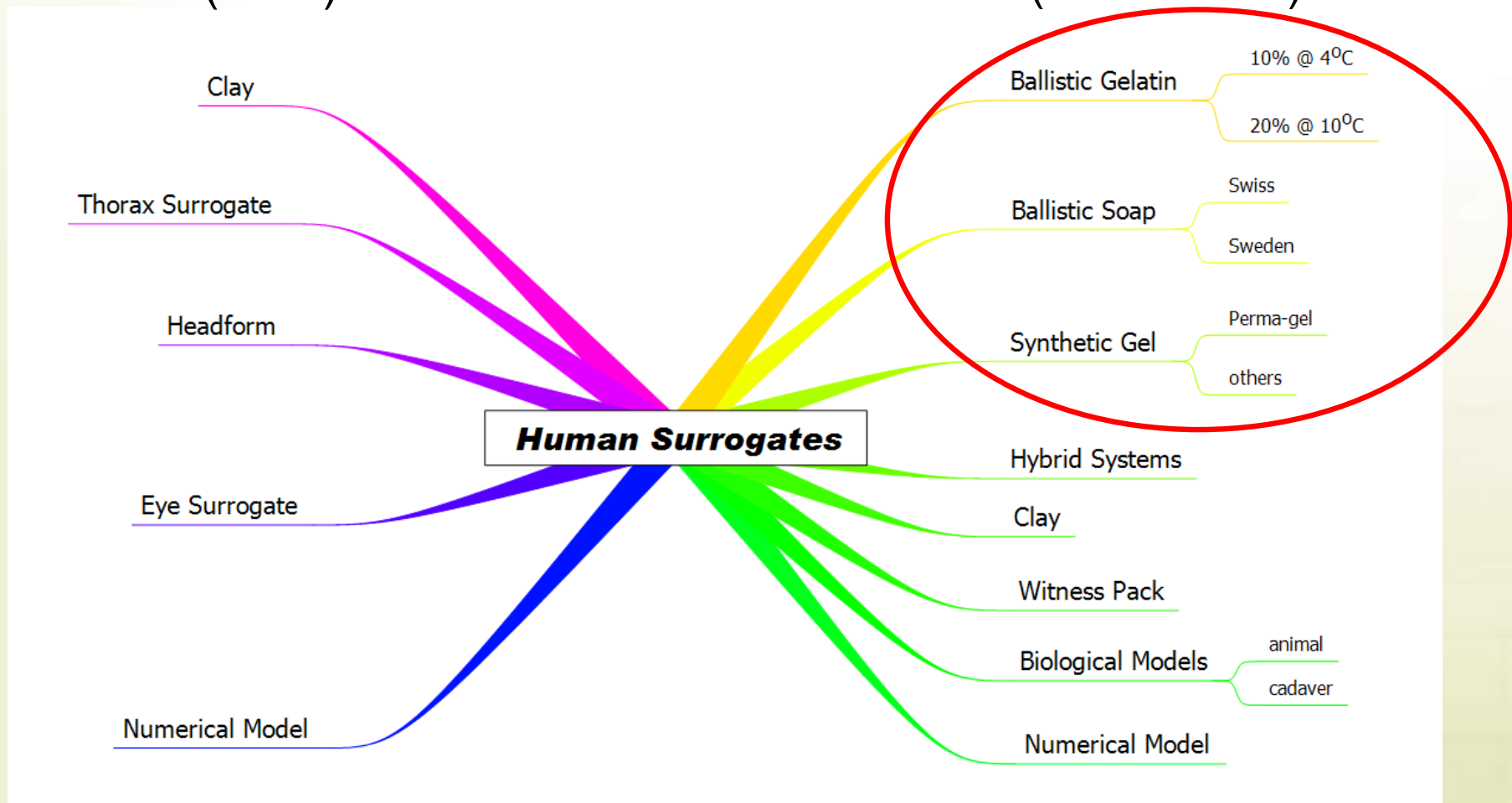
Penetrating Effects (Small Arms)



WEAPON EFFECTS CHARACTERIZATION

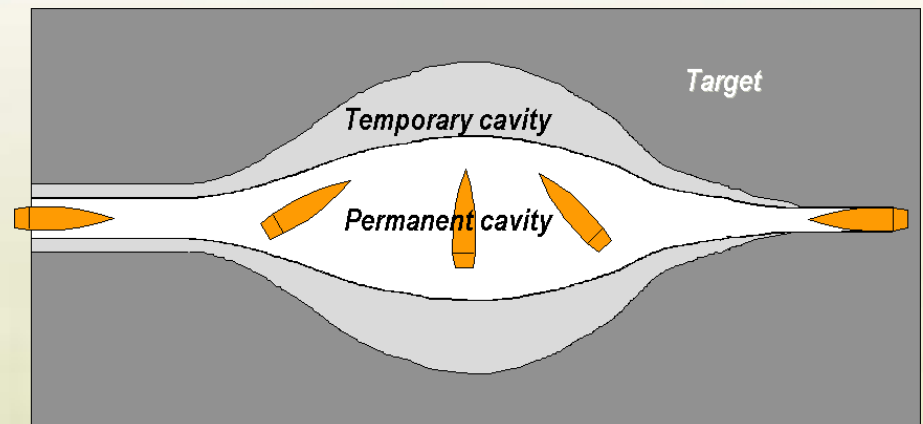
Non Penetrating Effects (NLW)

Penetrating Effects (Small Arms)



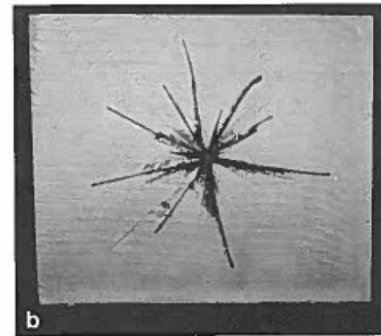
PROJECTILE BEHAVIOR ASSESSMENT

- Dynamic
 - energy dumped in the simulant (tissue damage measurement)
 - high speed cameras or flash X-ray
 - expensive
- Static
 - direct measurement of simulant damage and projectile state
 - after the event
 - still photography

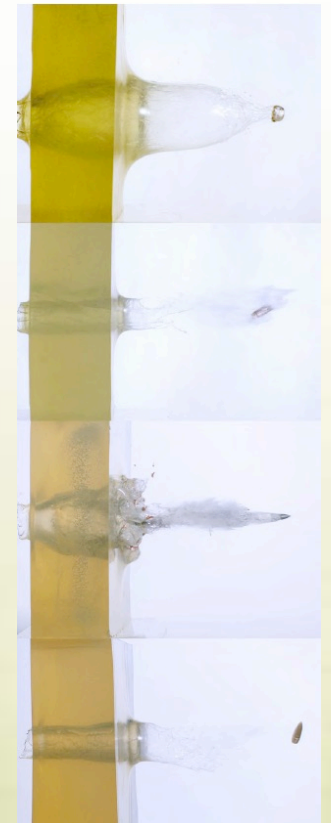
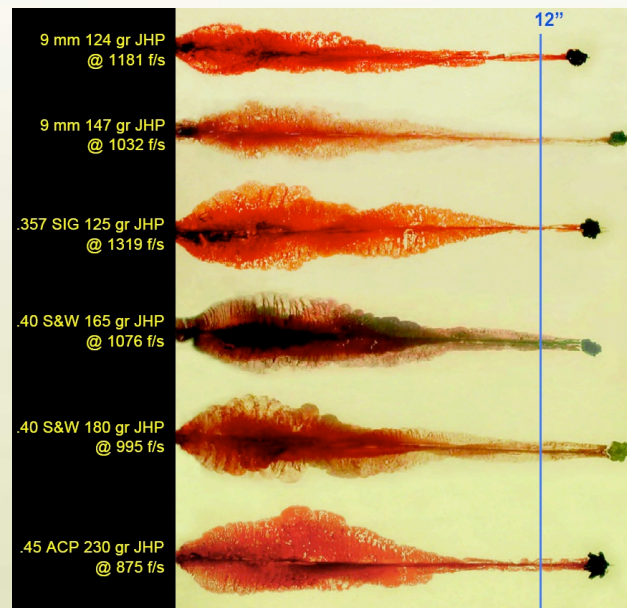


BALLISTIC GELATIN

- living muscle tissue
- homogenous
- permanent vs. temporary cavity
- static vs. dynamic
- limited shelf life
- extensively used
- Fackler 10% @ 4°C vs. NATO 20% @ 10°C

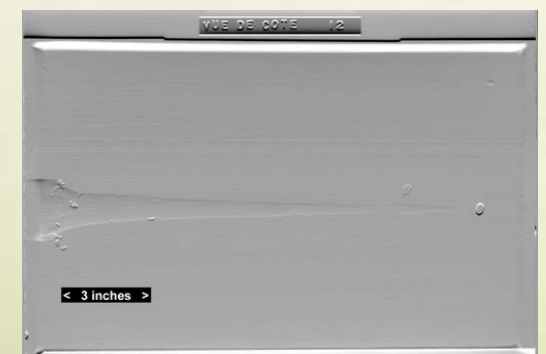
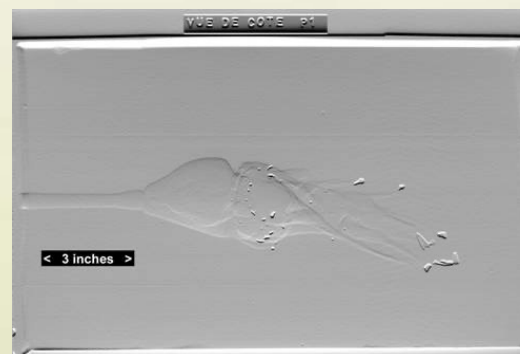
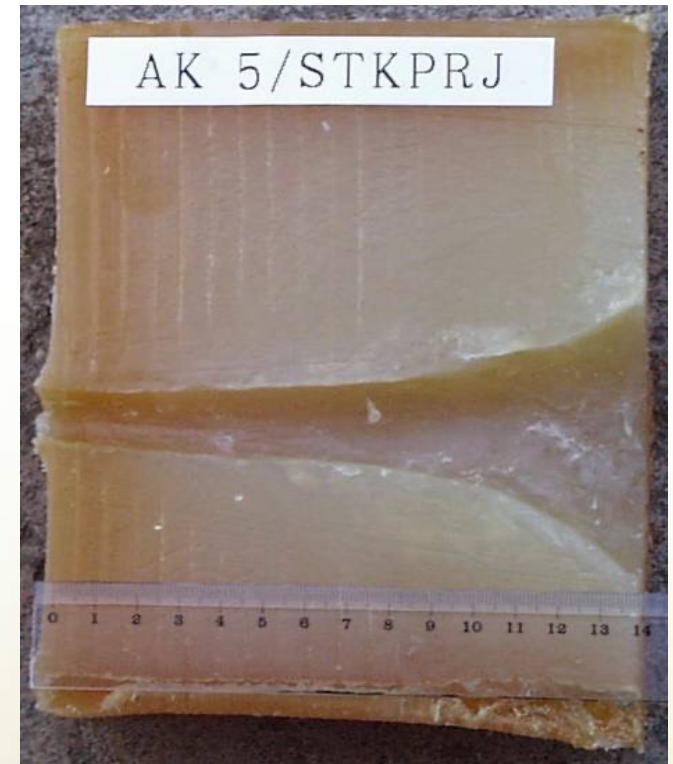


Gel block slice to evaluate total crack length



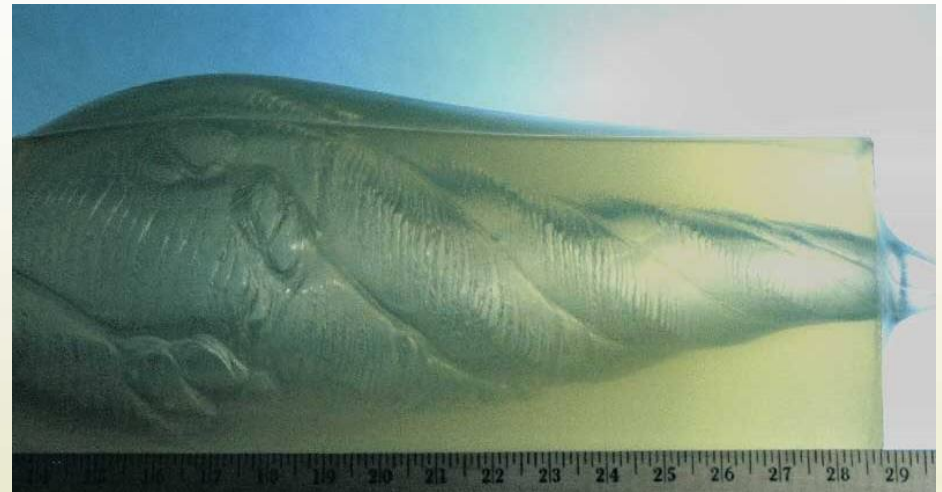
BALLISTIC SOAP

- living muscle tissue
- homogenous
- energy dumped
- permanent cavity
- static only
- long shelf life
- room temperature
- expensive material
- non elastic
- accurate



SYNTHETIC GELS

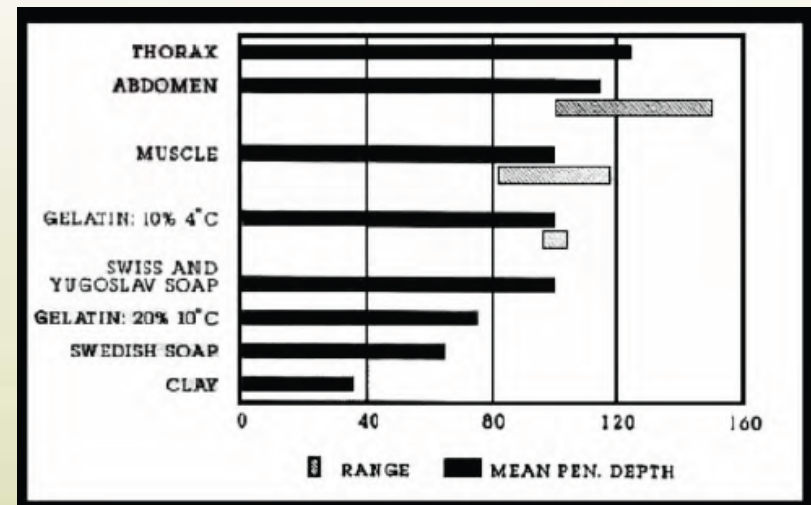
- living muscle tissue
- homogenous
- permanent vs. temporary cavity
- static vs. dynamic
- room temperature
- reusable
- cost ?
- validation?



SUMMARY

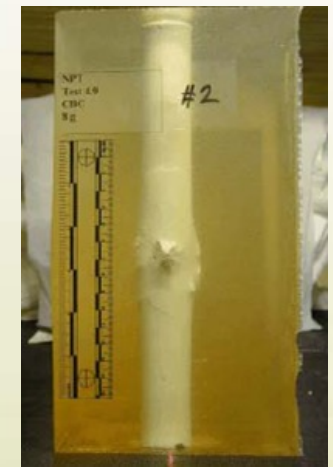
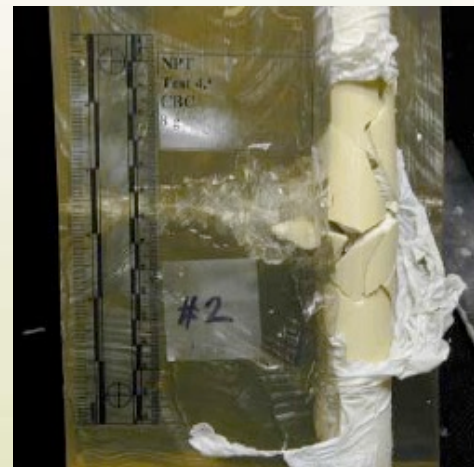
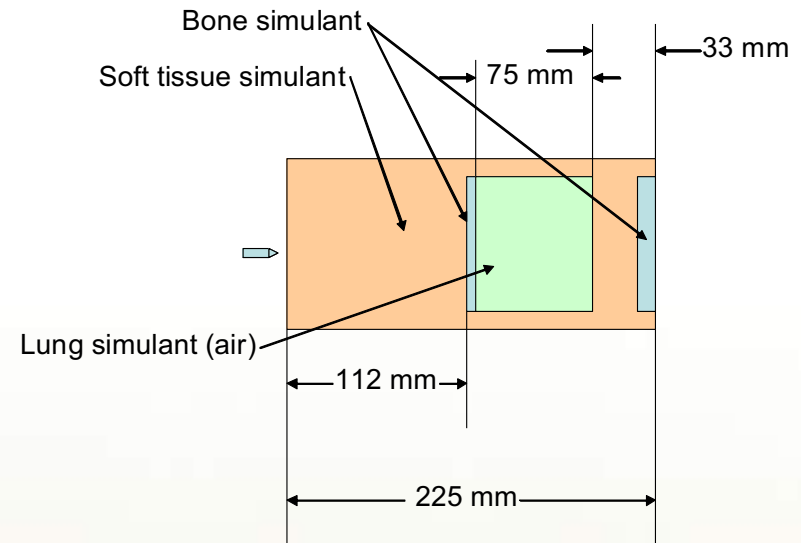
Characteristics	Soap	Gelatine	Perma-gel
Handling	Green	Red	Green
Acquisition	Red	Green	Green
Temporary cavity measurement	Green	Red	Red
Permanent cavity measurement	Red	Yellow	Yellow
Biofidelity	Red	Green	?
Projectile's dynamic behavior	Red	Yellow	Green
Measuring energy deposit	Green	Red	Red
Reuse	Green	Red	Green

- all represent living muscle tissue ?
 - similar density
 - isotropic
 - homogenous
- but ...
- human body is not homogenous
 - nor isotropic

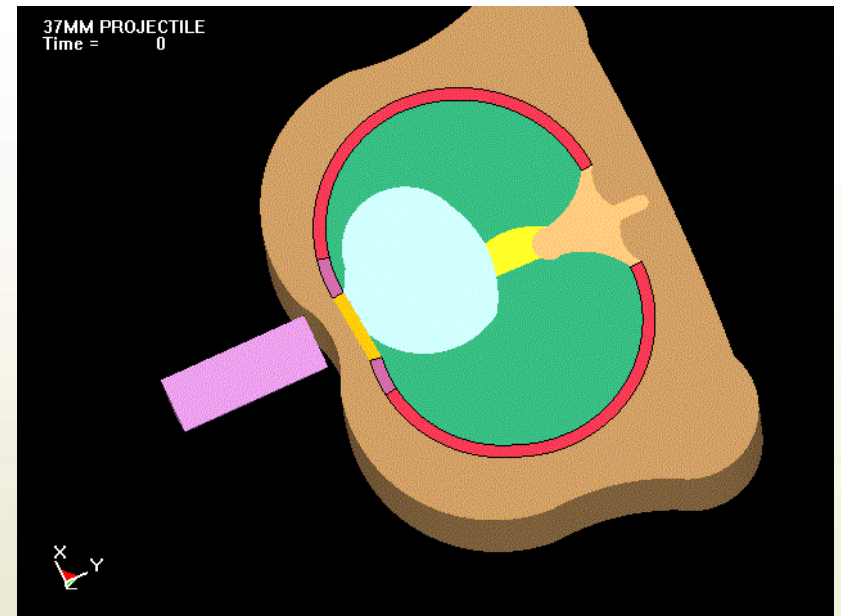
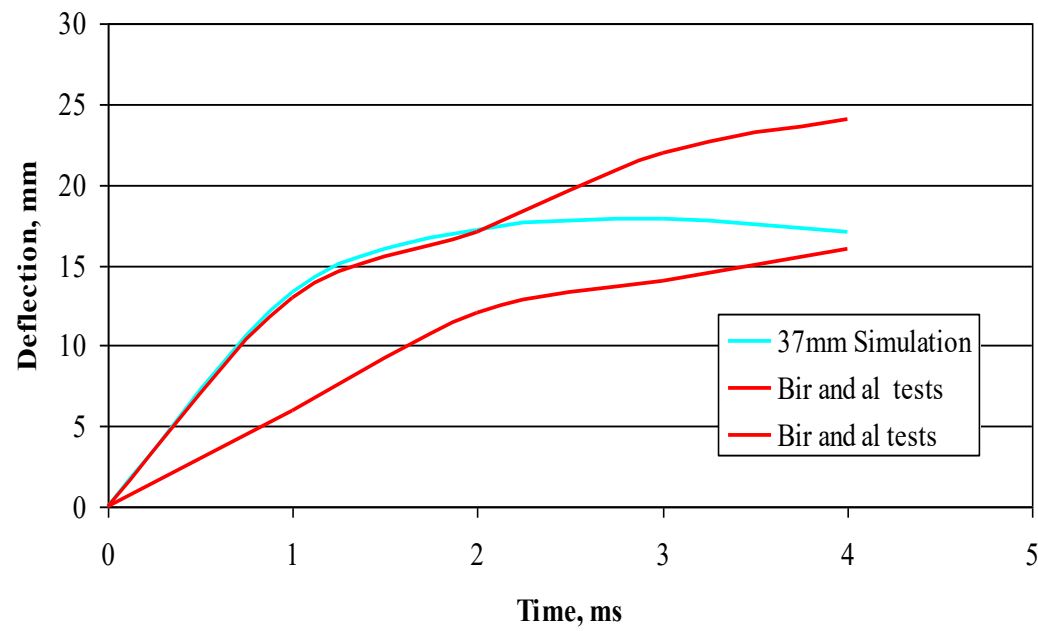


ALTERNATIVES

- hybrid surrogates
 - living muscle tissue
 - bones
- biological surrogates
 - animal (swine, sheep,...)
 - live
 - dead
 - cadavers



NUMERICAL MODELING



NUMERICAL MODELING

- help understanding of the phenomena that are difficult to examine using experimental methods
- optimization of experimental trials
- save time and money
- fast trade up analysis for acquisition or design systems (parametric studies)
- need to model each projectile
- proper validation remains the main challenge
 - adequate fracture model ?

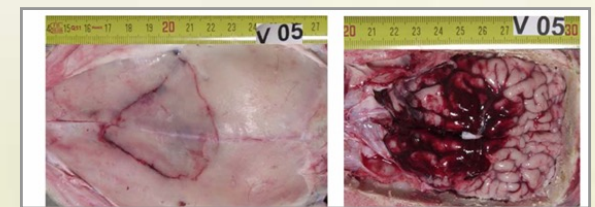
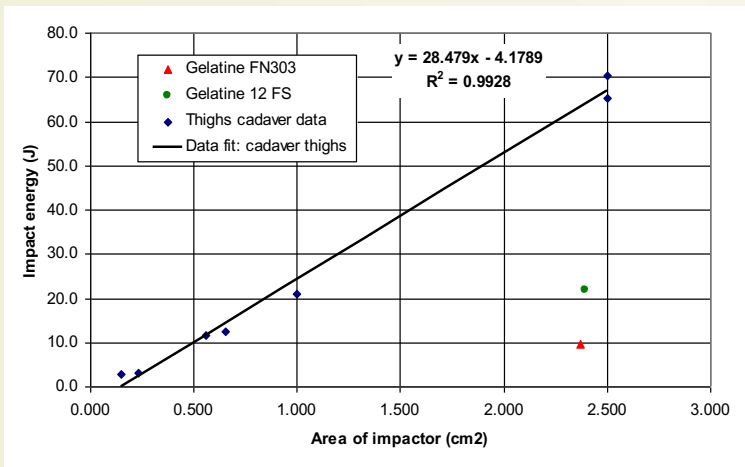
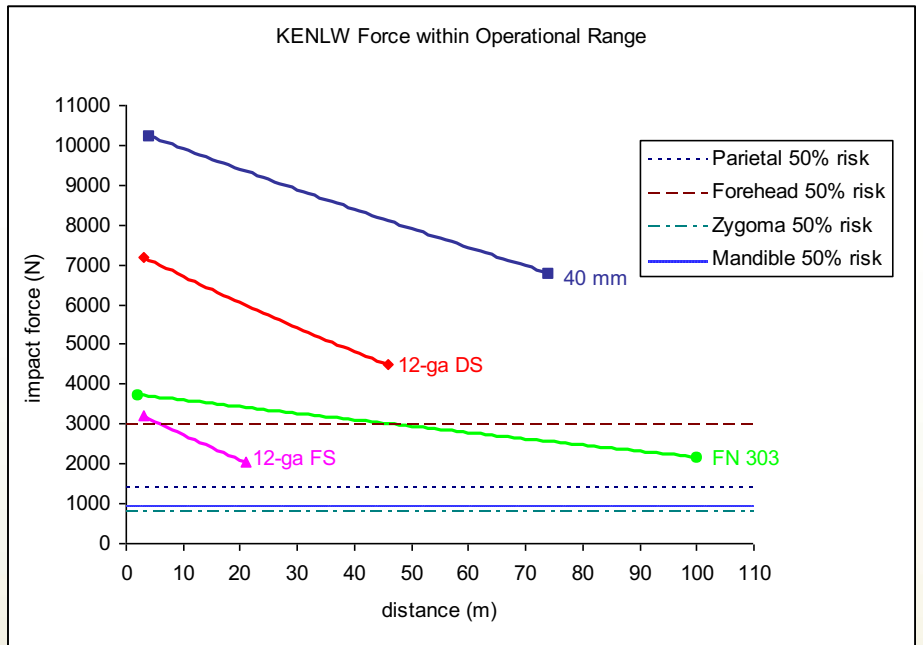
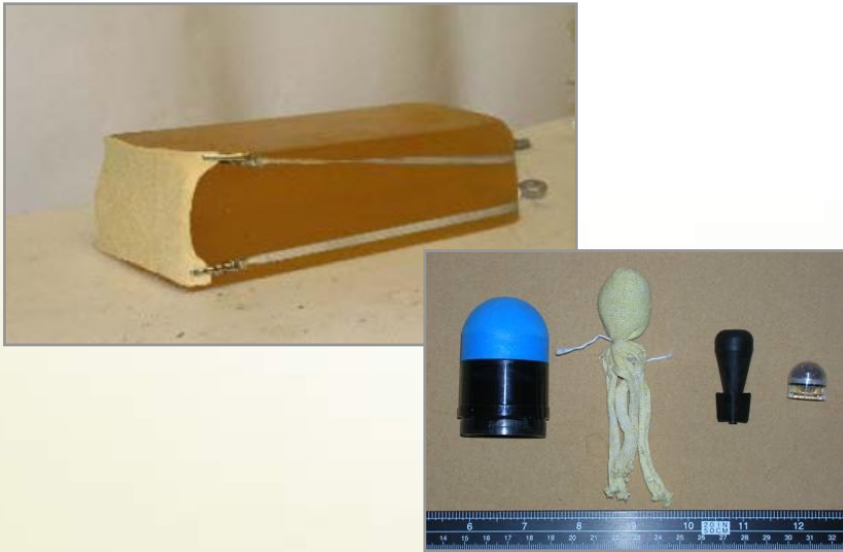
NON PENETRATING EFFECTS

BLUNT IMPACT - NLW

- velocity-range data, impact force measurement
- penetrating limit assessment (safety)
- head, thorax and eye injury assessment



BLUNT IMPACT - NLW



CONCLUSIONS

- weapon effects characterization is essential for future weapon development
- no single surrogate for the different effects
- for penetrating effects, no consensus on best approach
- hybrid surrogate more suitable ?
- more R&D and collaboration required

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