

# 25mm Ammunition Development

From idea to prototype

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# History

- JSF development traject
  - NL partnering in JSF-development
  - JSTAB – visit partner countries (2003)
    - Check for (new) technologies
      - Lower the costs
      - Weight reduction
    - Proposal TNO: **gun ammunition development**
      - In close co-operation with operational user and ammunition manufacturer
      - JSTAB voting (2004)
        - Ranking #1 of all ideas



# TNO's proposal

## 25 mm gun ammunition development

### *Optimized Effectiveness*

- Maximum firepower for 25 mm gun
- Only one ammunition type needed for air-to-air and air-to-ground combat missions

### *Safe*

- No high explosives/detonator carried, resulting in less vulnerability of:
  - airplane itself
  - ground storage sites
  - aircraft carriers

### *Cost Effective*

- Only one round needed for combat and training (no environmental hazards)
- Only one ammunition type gives considerable logistic advantages
- Flexible and cheap development of projectile also for possible future requirements

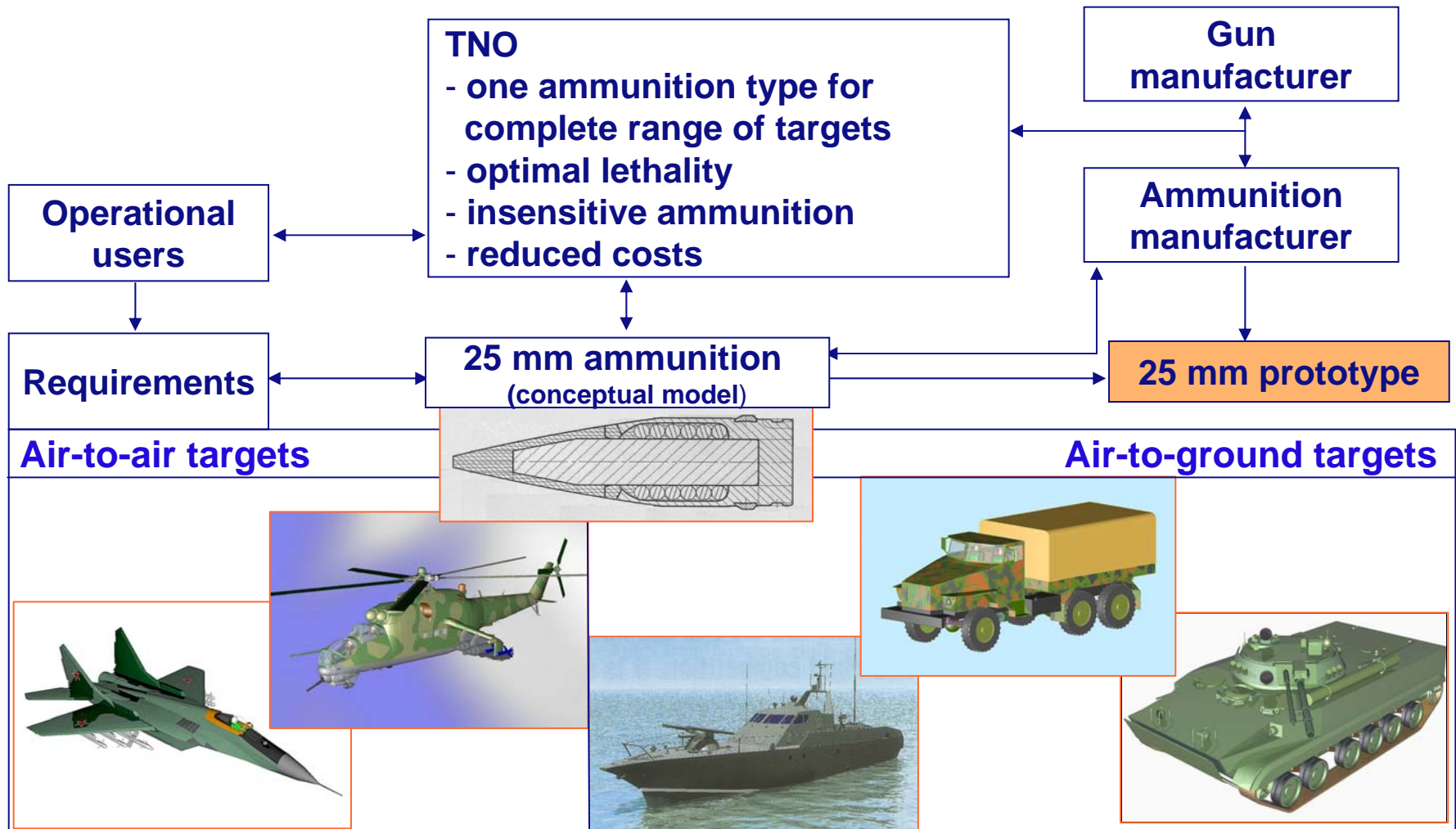


## TNO's 25 mm proposal (2)

- Lethality optimization together with the manufacturer (RWMS) and operational user (RNLAf) to develop the best 25 mm ammunition against selected targets
  - One round for the complete range of targets: as good as an AP, better than HE
  - FAP shows good performance to complete range of targets
  - Safe solution (no explosives, no DU)
  - Cost effective solution
- TNO has unique capability to optimize frangible ammunition with respect to lethality
- JSTAB Technology Readiness level:
  - Tools and experience: 9
  - Development of 25 mm round: 6
- Proposal started in 2004
  - Prefeasibility study
  - Design and realization of conceptual model(s)



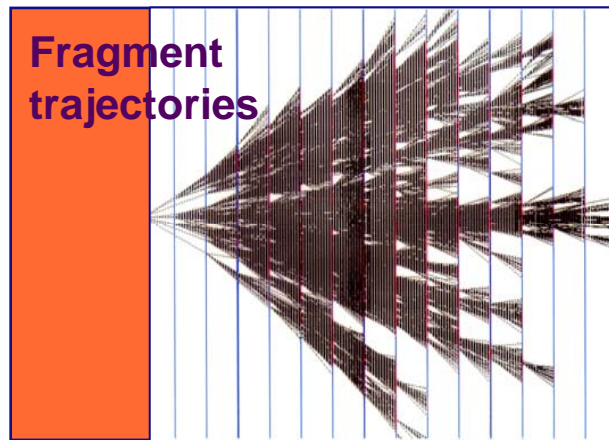
# Development of 25 mm ammunition



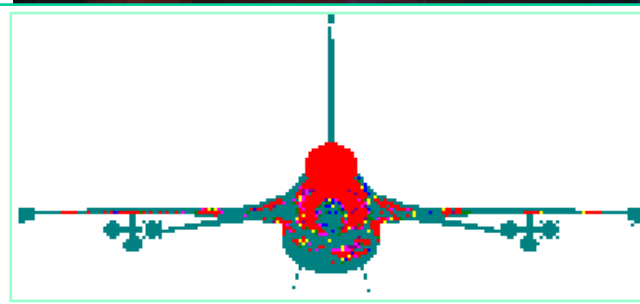
# Frangible ammunition

Based on many years of experience in performing firing trials and lethality simulations against air- and ground targets, TNO has a unique capability to evaluate and develop specific ammunitions, like frangible ammunition.

*Terminal ballistics*



*Lethality simulations*



# Effects of Frangible projectiles





# Experience of TNO with frangible projectiles

- TNO terminal ballistic model based on live firings against different plate arrays and combat targets:

Projectiles	Targets
<ul style="list-style-type: none"> <li>• <b>Frangible FSP's against:</b> (FSP = Fragment Simulating Projectile)</li> </ul>	<p>aluminum plate arrays</p>
<ul style="list-style-type: none"> <li>• <b>12.7 mm FAP against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays, urban targets, composite targets, ceramics</p>
<ul style="list-style-type: none"> <li>• <b>20 mm FAP against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays, truck</p>
<ul style="list-style-type: none"> <li>• <b>25 mm FAPDS against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays, helicopter, aircraft, IFV, urban targets</p>
<ul style="list-style-type: none"> <li>• <b>27 mm FAP against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays</p>
<ul style="list-style-type: none"> <li>• <b>30 mm FAPDS against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays</p>
<ul style="list-style-type: none"> <li>• <b>30 mm FMPDS (Goalkeeper) against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays, missiles</p>
<ul style="list-style-type: none"> <li>• <b>35 mm FAPDS against:</b></li> </ul>	<p>aluminum plate arrays, armored steel plate arrays, composite materials, urban targets, aircraft</p>



# Phase 1: Pre-feasibility study



- Paper study only;
  - The results are based on simulations only (no trials!!)
  - Projectile drawings/designs delivered by RWMS
  - Terminal ballistic - and lethality simulations performed by TNO
    - Based on real End-game scenario's
- TNO redesigned the projectiles by varying the penetrator mass and the number of included preformed fragments (total projectile mass constraints).
- Deliverable:
  - a paper study for preliminary 25 mm projectile designs with optimized capability in air-to-air and air-to-ground combat

# Phase 2: Effectiveness optimization

- Projectile optimization with respect to penetration and lethality
  - Penetration characteristics are determined with standard software; input data based on experiments with other caliber projectiles
  - Fragmentation characteristics are determined using TNO's Frangible Terminal Ballistic model:
    - ✘ makes fast, flexible, cheap projectile design changes possible
  - Simulation results have to be verified with trials is next step

- Air-to-ground:
  - aircraft velocities
  - dive angles
  - range

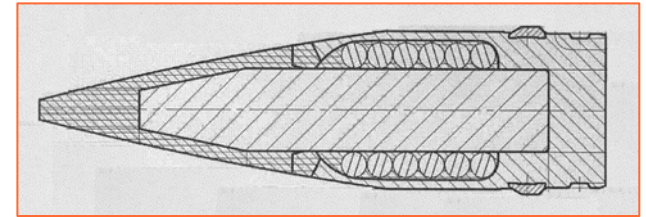


- Air-to-air:
  - Hind: air-to-ground scenario's are used
  - MiG-29



# Optimisation of conceptual design (I)

- Basic concept: frangible penetrator  
preformed fragments



FAP basic design was evaluated in Lockheed Martin 25mm trade study

Results:

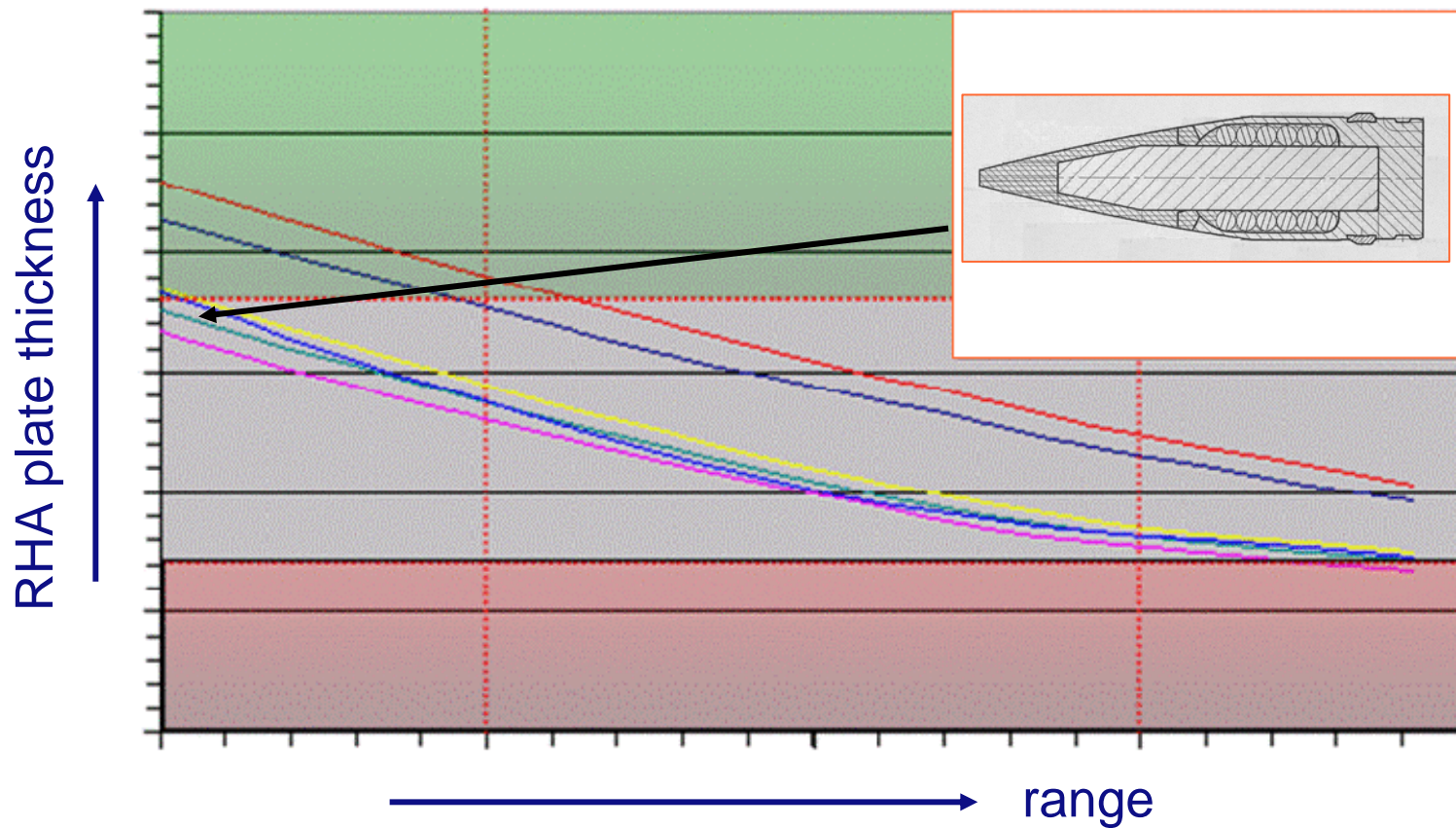
“If the partner countries want a general purpose round - this round is recommended against Air-to-Air and/or Air-to-Ground targets”

- Concept 3: heavier projectile  
heavier frangible penetrator  
no preformed fragments
- Concept 4: heavier projectile  
equal frangible penetrator mass  
more preformed fragments

# Optimisation of conceptual design (II)

## Penetration characteristics

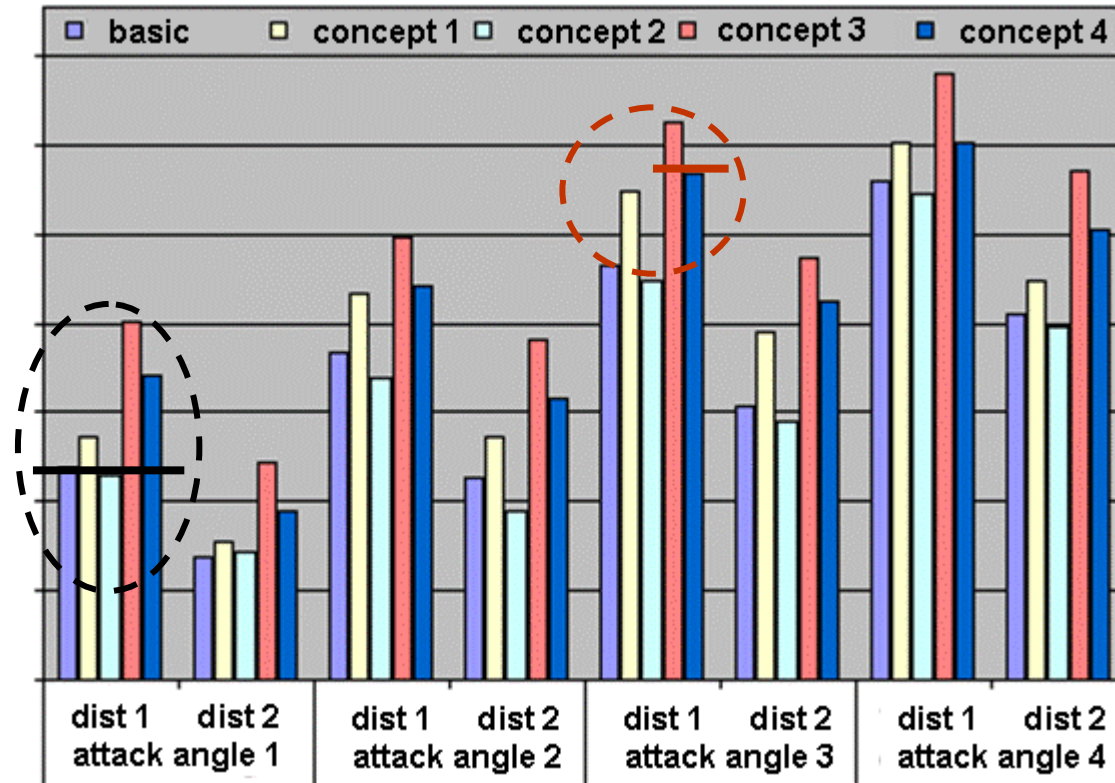
RHA plate thickness as a function of range



# Lethality results against the BMP-2



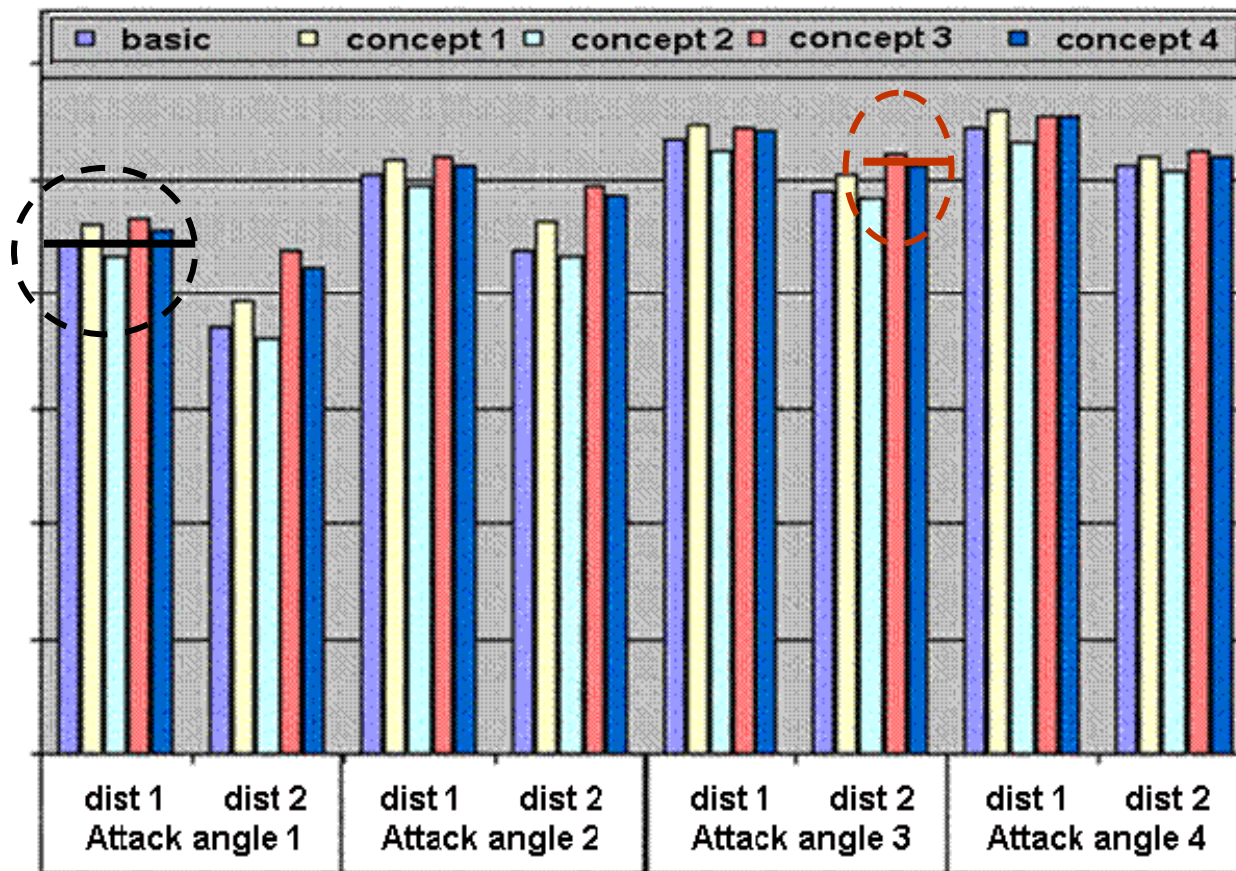
- The fragmentation and penetration characteristics are implemented in the lethality software
- The chart presents the average SSPK given a hit on the BMP-2
- The lethality results are presented for different Slant ranges as a function of dive angles





# Lethality results against the Ural4320

- The chart presents the average SSPK given a hit on the Ural4320 (loaded with ammunition boxes)



# Conclusions

- Air-to-Ground:
  - Base-line version can be improved
  - Low Drag versions improve lethality for longer ranges
  - Heavier penetrator improves lethality
  - Effect of preformed fragments is minor for selected targets
- Air-to-Air:
  - The specified combat ranges are too short to result in an extra advantage for Low Drag versions
  - The difference in lethality for all considered FAP types is minor
- The FAP base-line version (already recommended LM trade study) can be improved for Air-to-Ground missions without losing Air-to-Air capability
- The selected FAP “paper” prototypes are ready for manufacturing and further development





# Next phase of the 25 mm round development

- 25 mm FAP conceptual models
- Perform firing trials
  - Validation of terminal ballistic model
  - Validation of SSPK results
- Prototype of 25 mm FAP



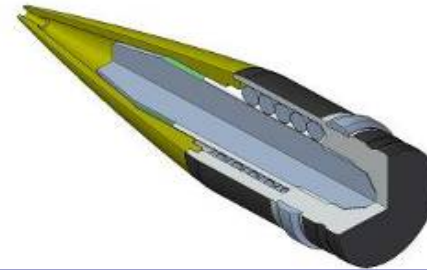
# Trials, November 2007

- In pre-feasibility phase;
  - Penetration characteristics are determined with standard software; input data based on experiments with other (caliber) projectiles
  - Fragmentation characteristics are determined using TNO's Frangible Terminal Ballistic model:
    - makes fast, flexible, cheap projectile design changes possible
  - Simulation results have to be verified in next phase with trials
- Range targets and impact velocities are selected to verify the fragmentation and penetration characteristics of the projectiles used in the pre-feasibility phase
- Conceptual designs are based on results of pre-feasibility phase



# Conceptual models selected

- Basic design):
  - frangible penetrator
  - preformed fragments

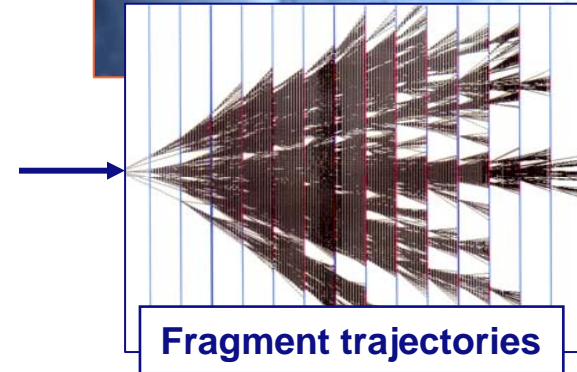
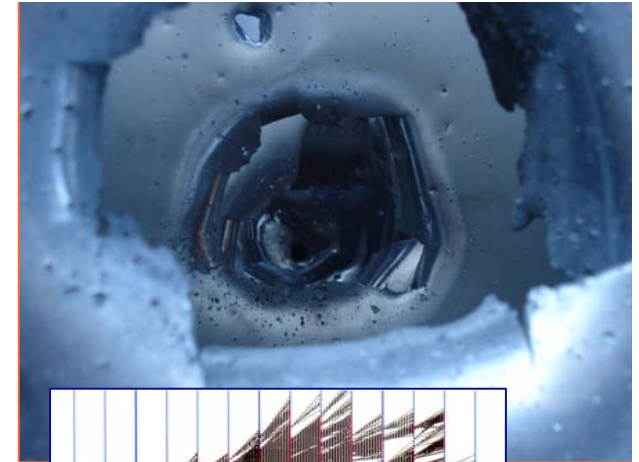


- Concept 1:
  - equal total mass
  - frangible penetrator
  - no preformed fragments
- Concept 3 :
  - heavier projectile
  - heavier frangible penetrator
  - no preformed fragments
  - material type X
  - Low Drag version

- Concept 5 :
- see concept 3
  - material type Y

# Trials

- Targets:
  - Monoblock (representing hard target)  
+ after armour effect
  - Range target (representing soft target)
  - Both short and long range



# Conclusions

- Trials:
  - Base-line version was skipped, based on expected penetration performance in combination with costs.
  - Normal mass FAP projectile performance slightly less than used input data in pre-feasibility study
  - Higher mass FAP projectile performance slightly better than used input data in pre-feasibility study
  - In general FAP material X penetrators will have better penetration capability compared to FAP material Y penetrator
- Simulations:
  - Both heavier projectiles fulfill the RNLAf requirements
  - FAP material X shows highest lethality against hard targets
  - FAP material Y shows highest lethality against soft targets



# Conclusions

- Difference between trial & simulation data is minor
- Study gives opportunity to determine design for 25mm prototype
- RWM-S has selected a design and manufactured a prototype.



