

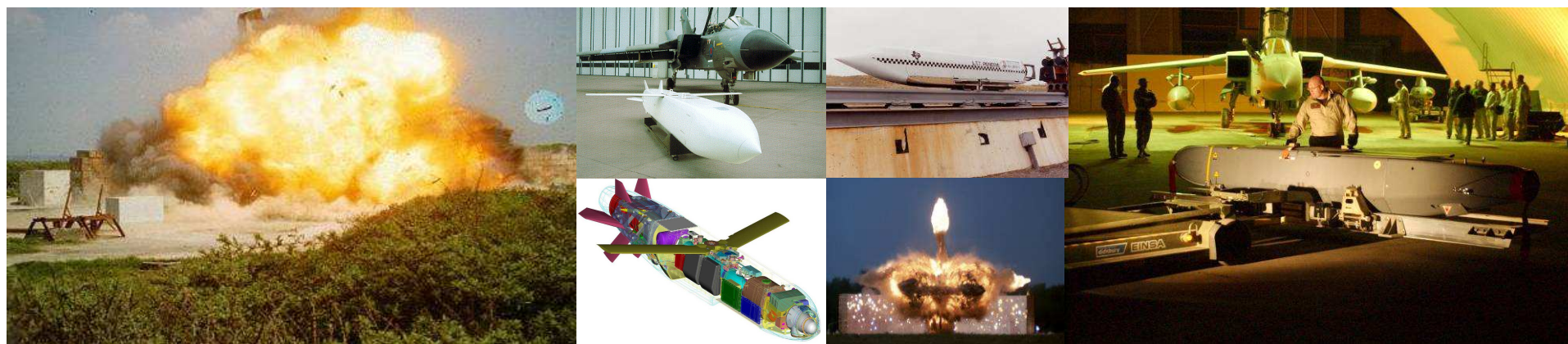
Storm Shadow: Achievement of an IM Compliant Lethal Package

Insensitive Munitions & Energetic Materials Technology Symposium

28 April, 2006

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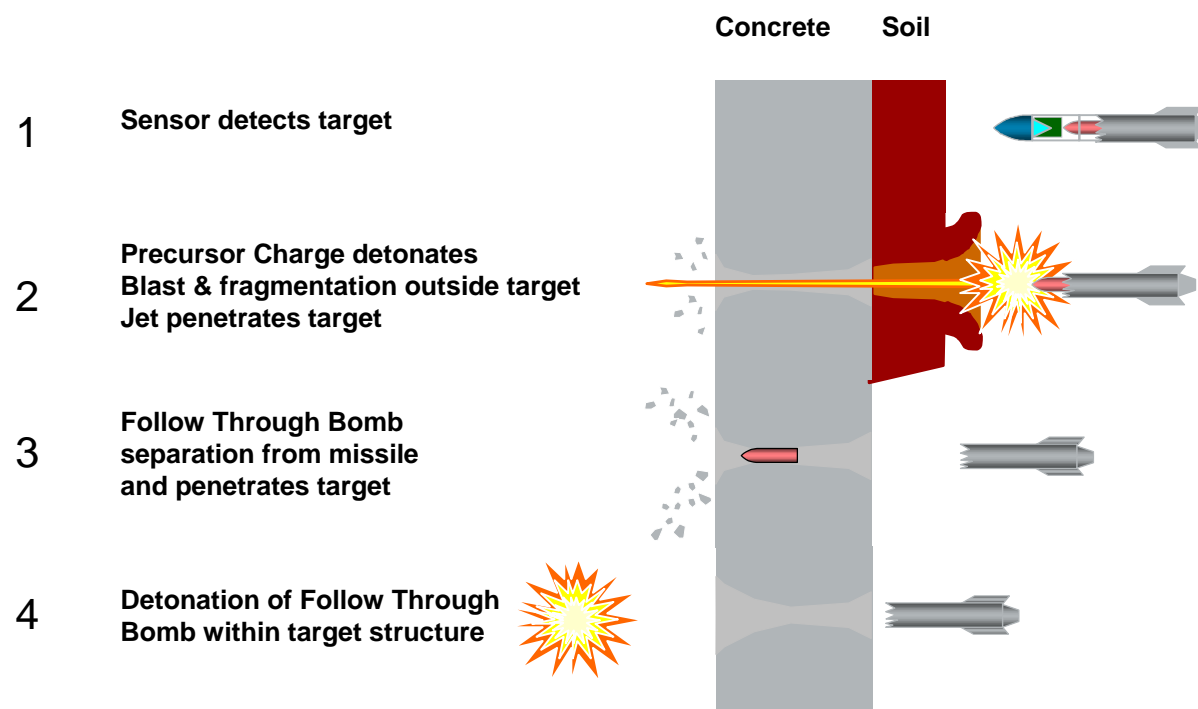
Introduction

- Air-launched, long-range cruise missile
- Attack of high value, hardened targets
- BROACH multiple warhead system
(**B**omb, **R**oyal **O**rdnance, **A**ugmenting **C**harge)
 - Precursor Charge (PC) pre-damages the target structure
 - Follow-Through Bomb (FTB) perforates the target and detonates within it
- The design of an effective Lethal Package inevitably conflicts with IM compliance

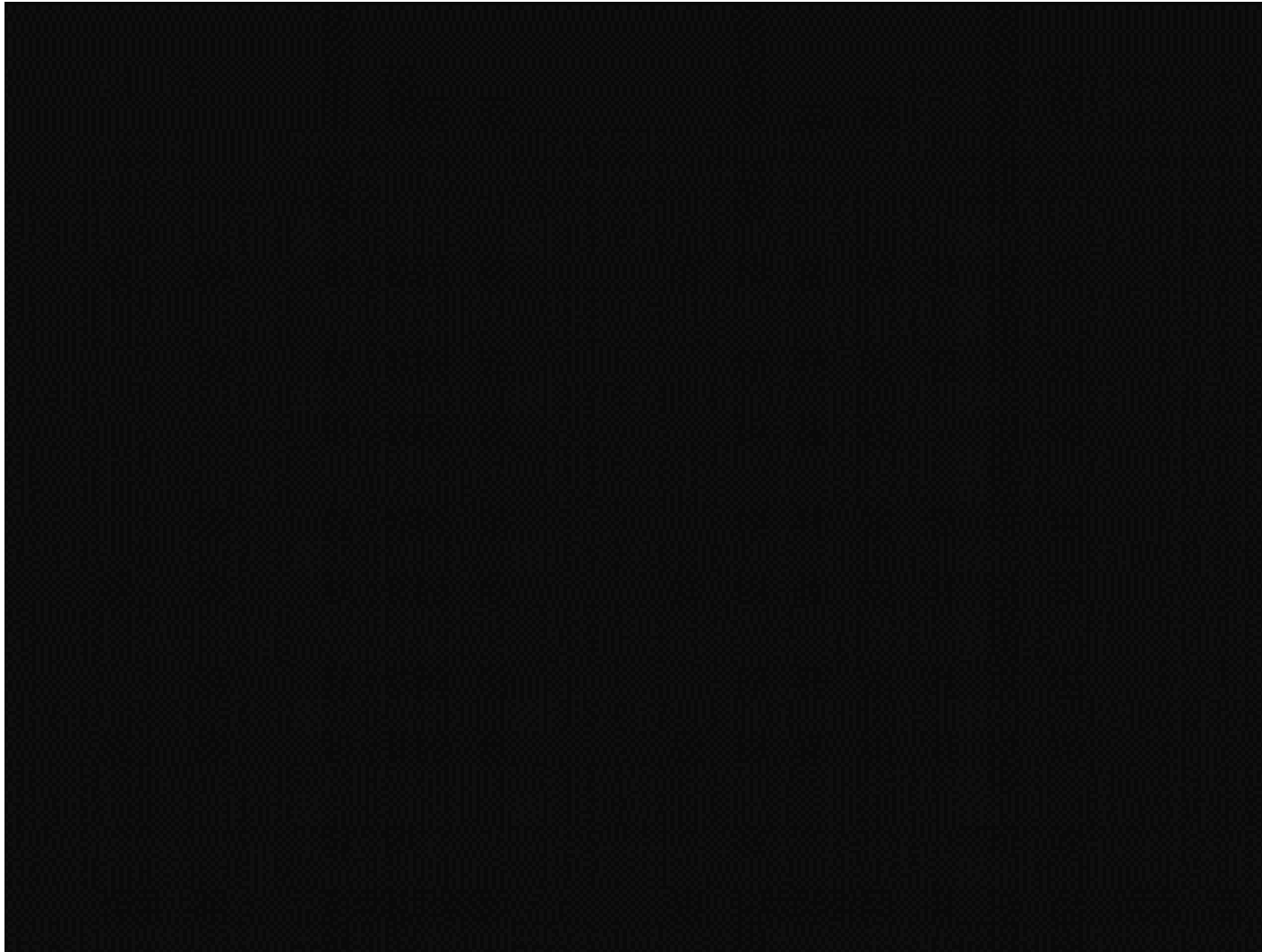


BROACH Concept

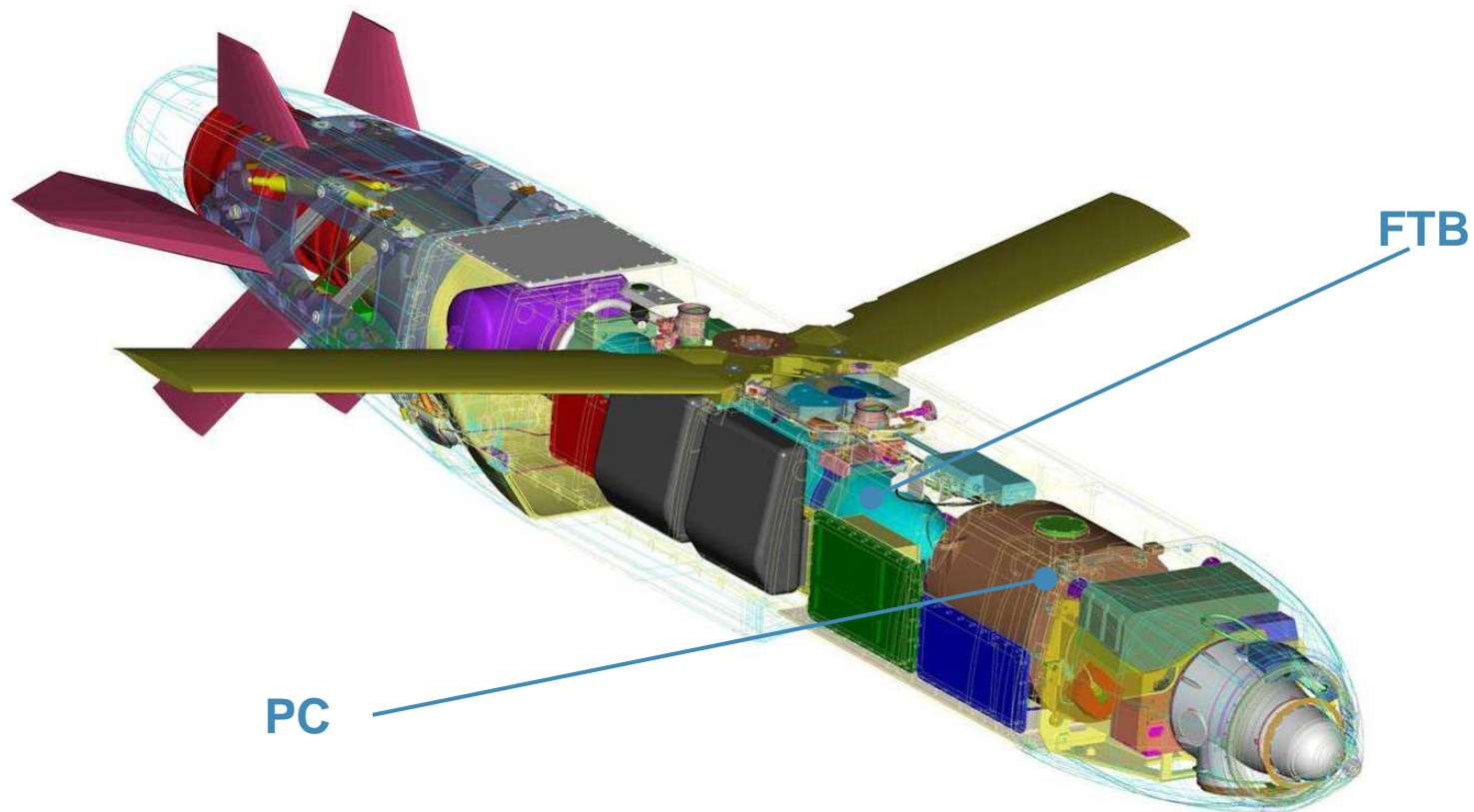
BROACH SEQUENCE OF OPERATION



BROACH Concept



Missile components



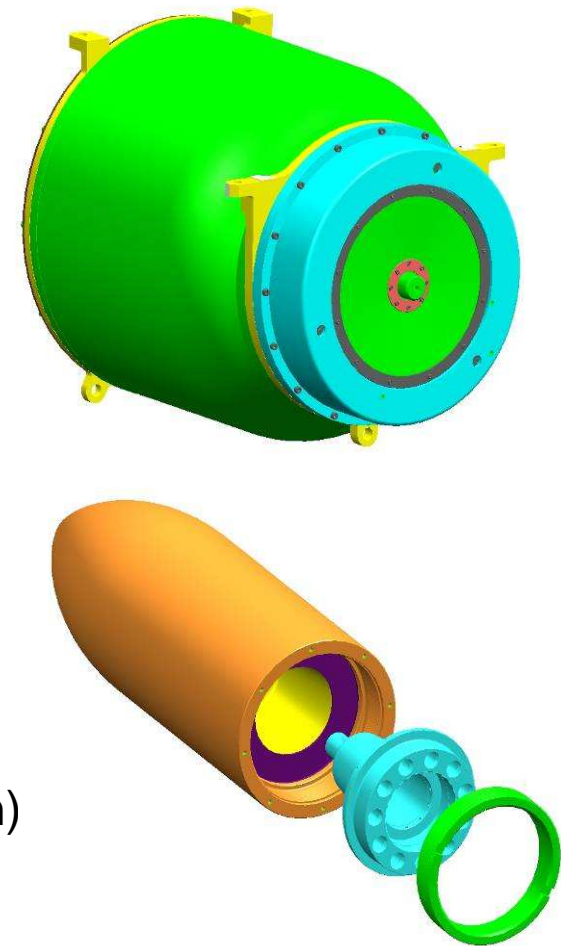
Requirements

- Functional requirement
 - Target penetration
 - Reliable detonation
 - Range of target constructions
 - Range of impact conditions:
 - Velocity, impact angle, incidence angle (AOA)
- IM Requirement
 - Ordnance Board Proceeding 42657

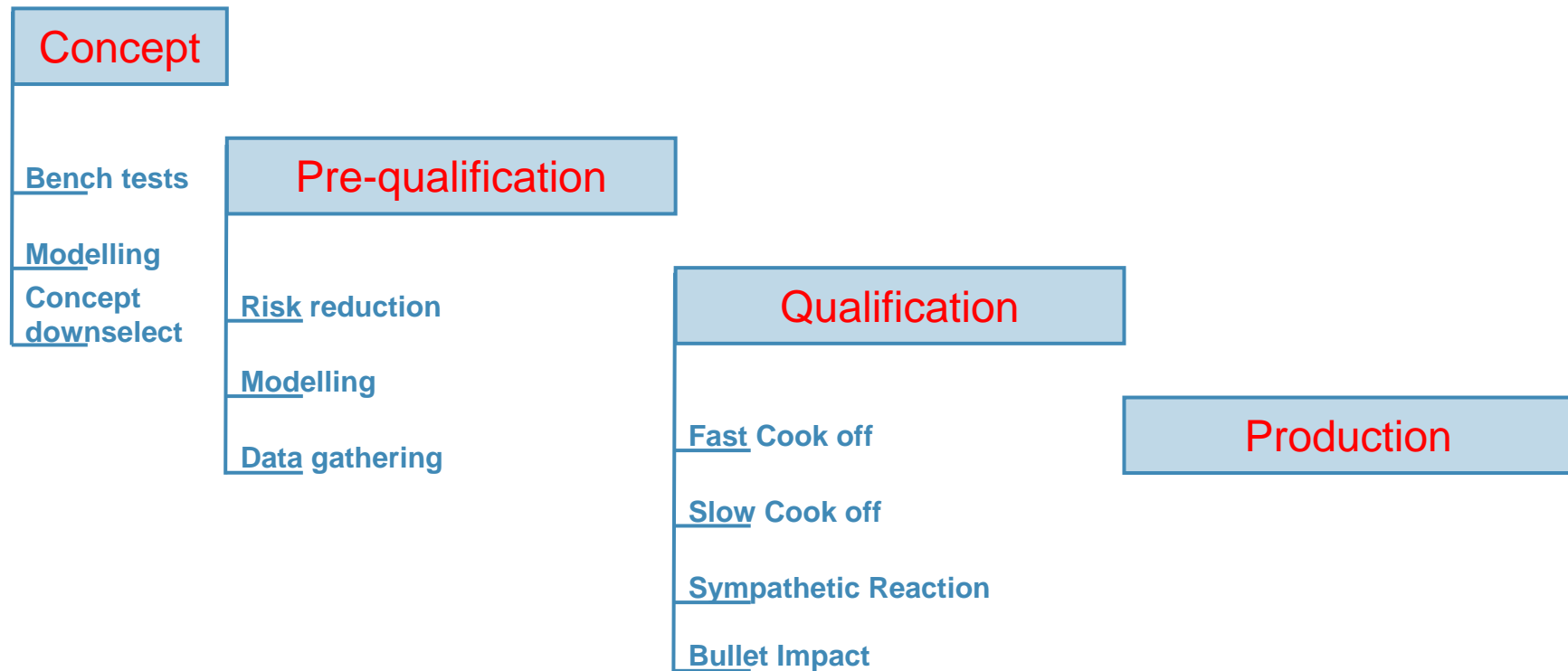
Threat	Required reaction
Fast Cook-off (FCO)	Type V
Slow Cook-off (SCO)	Type V
Bullet Impact (BI)	Type V
Sympathetic Reaction (SR)	Type III

LP Functional Design

- PC
 - High performance explosive (brisant)
 - Optimised shaped charge
 - Airframe & forebody integration
- FTB perforation
 - High strength
 - High mass (KE)
 - Minimised cross section
 - Airframe integration
- FTB behind target effect
 - High performance explosive (blast / fragmentation)
 - Fragmenting case
 - Fuze reliability

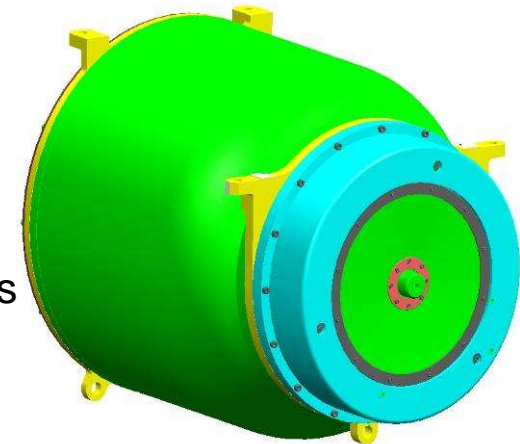


IM development programme



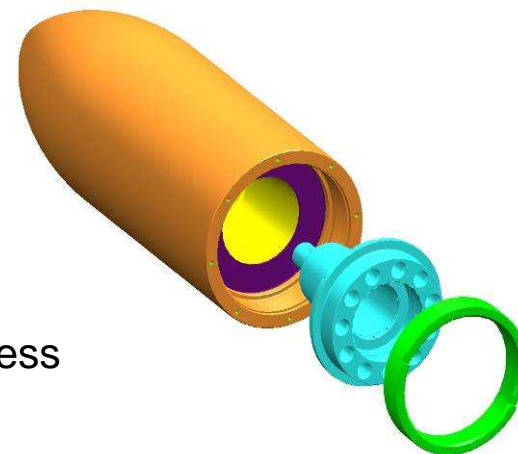
PC IM Design

- Trade-offs
 - Performance of explosive conflicts with insensitiveness
- Energetic materials
 - Cast PBX material main filling – no DDT, low explosiveness
 - Proven insensitive booster pellet and pyro cord compositions
- Venting
 - Closure fixings designed to detach as temperature increases beyond environmental limits
 - Steel & aluminium case construction
- Thermal management
 - Body lined with insulating material
 - Thermal modelling conducted to build confidence before trials



FTB IM Design

- Trade-offs
 - High strength and mass conflict with need for venting
 - Small cross section means large aspect ratio
 - Performance of explosive conflicts with insensitiveness
- Energetic materials
 - Cast PBX material main filling – no DDT, low explosiveness
 - Proven insensitive booster pellet composition
 - EMTAP fast heating tube tests conducted to aid selection
- Venting
 - Vent holes incorporated in rear closure for main fill and boosters
- Thermal management
 - Body lined with insulating material
 - Controlled ignition site position – supported by modelling



PC Bullet impact



PC Bullet impact



Fast Cook Off



Sympathetic Reaction



Sympathetic Reaction



Qualification trial results

Threat	Acceptable reaction	Result
Fast Cook-off (FCO)	Type V	Type V
Slow Cook-off (SCO)	Type V	Type V
Bullet Impact (BI)	Type V	Type V
Sympathetic Reaction (SR)	Type III	Type IV

Fragment impact assessment – type V

Operational Effectiveness



Summary

- Full compliance with IM requirements was achieved
 - FCO, SCO, SR and BI demonstrated
 - Assessment conducted on Fragment Impact threat
- Performance requirements not compromised
 - Despite functional requirements acting against IM compliance
- In service with UK MoD
 - First IM compliant system of its size
 - Proven effective in Operation Telic

