TEST AND EVALUATION OF THE 40MM CASED TELESCOPED WEAPON SYSTEM
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Summary

> CTA INTERNATIONAL and QINETIQ
> 40 mm Cased Telescoped Weapon System
> Barrel heating and cook-off test and evaluation
> Point detonating performance trial at long range
> Over water recovery and CT scans for safety assessment
CTA INTERNATIONAL

> CTA INTERNATIONAL is a joint venture 50 % Bae Systems (UK)
  50 % Nexter Systems (France)
> Based in Bourges (France)
> Turnover 2018 : ~60 M€
> Order book 2018 : ~200 M€
  > UK programs (AJAX & WARRIOR) : 515 CT-Cannons
  > FR program (JAGUAR) : 300 CTAS
> 80 permanent employees (25 % british – 75% French)
  > + sub-contractors

> Production
  > 275 CTC cannons delivered on 01/01/19
  > About 100,000 ammunition TP-T, APFSDS-T & G PR-PD-T delivered (serial and pre-serial production)
CTAI AND QINETIQ

CTAS QUALIFICATION

> UK MOD & FR DGA joint qualification
> 7 trial centers
  > QinetiQ (3 locations)
  > Bae Systems (2 locations)
  > DGA (3 locations)
  > Nexter Munitions (2 locations)
  > Nexter Systems
  > CTAI
  > MIRA

> Trials
  > Over 70 natures of trials totalling over 150 trials
  > 10,000 rounds fired
  > 5 cannons

> Evaluations
  > To justify read across between ammunition qualified
  > To explain methodology for measures or data processing
  > To state on compliance using several trials data
CTA International and QinetiQ

- ~150 trials performed over the last 8 years
- ~2500 ammunition fired
- For development work and also official UK / French qualification programmes
- Expertise includes:
  - Chemical and physical analysis of High Explosive (HE) filling prior to and following firings including nuclear magnetic resonance (NMR), Fourier Transform Infrared (FTIR) and Scanning Electron Microscope (SEM) techniques
  - Analysis of plastic components subjected to extremes of heat and cold combined with vibration
  - Barrel bore size measurements and straightness analysis using bore size and laser straightness measuring heads
  - Dynamic Finite Element Analysis (FEA) modelling of HE filling during the projectile launch process taking into account both the axial acceleration and spin encountered
  - CT scanning both prior to and following soft recovery techniques to determine the reliability and performance of individual components within the projectile fuze system as well as condition of the HE filling and projectile body
Overview

- Provides world class expertise in advice, services, test and evaluation and innovative based products and operates in primarily in the defence security and aerospace markets
- Employs over 6000 people
- Manages and operates extensive test and evaluation capabilities for air, land and sea target systems throughout the UK and world
- The QinetiQ Long Term Partnering Agreement (LTPA) provides the UK’s largest independent test and evaluation service to assess the performance of weapons, ordnance and munitions which includes:-
  - Munition Performance to ensure the systems capability requirements are met
  - Munition environmental assessments to check performance following exposure to a range of chemically and mechanically induced environments experienced during long service life
  - Ordnance performance tests to ensure that the performance requirements are met
  - Terminal effects assessing the projectiles and warheads against a range of known survivability targets
LTPA Site Map highlighting trial sites used for CTAI ammunition testing
40 MM CASED TELESCOPED WEAPON SYSTEM
40 mm Cased telescoped weapon system

40 mm Cased telescoped cannon

> Light, low intrusion Cannon to be integrated in a turret.

> Effectiveness:
  > Against armoured vehicles (with armour piercing fin stabilized ammunition),
  > Against infantry or facilities (with general purpose explosive ammunition).

> Maximum range 3 km.

> Large set of ammunition:
  > APFSDS-T: perforation
  > TP-T: practice and perforation
  > GPR-PD-T: High explosive, point detonating
  > GPR-AB-T: High explosive, airburst
  > TP-RR-T: Practice, reduced range
  > KE-AB: Anti-air airburst
Cased telescoped ammunition concept

- The projectile is telescoped inside the cartridge case and surrounded by propellant. Compared to a conventional cartridge the overall round volume is reduced, especially the length.

- The functioning of the case telescoped munition is classic except that the projectile is not engaged into the barrel before firing.
  - It is introduced into a rotating chamber physically separated from the Barrel.
40 MM CASED TELESCOPED WEAPON SYSTEM

Cannon “Push through” concept

- The reduced length of the round allows it to be fed into the chamber perpendicular to the barrel axis.
- The chamber makes a 90° turn to fire the ammunition.
- After the fire, the chamber rotates again 90°; the subsequent ammunition is introduced in the chamber which ejects the empty case.
- One complete cycle of the Cannon constitutes a rotation of the chamber of 180° (i.e. half a turn).
40 MM C A S E D  T E L E S C O P E D  W E A P O N  S Y S T E M

Video of CT cannon firing in burst mode
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Purpose

> Part of cannon and ammunition full qualification with multiple purpose:
  > Give evidence of cannon performance by firing the whole content of ammo of the vehicle
  > Give evidence that the barrel is not exhibiting any permanent damage after this scenario
  > Give evidence that there is no risk of cook-off at the end of the firing sequence
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Check barrel wear with bore inspection (endoscopy)
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Check barrel straightness by laser measurement
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Firing of 3x53 rounds, 1 round / 10s, 10 min to reload
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Check accuracy on target during firing
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Record temperature of the barrel & the breech during all firing and 30 min after the end of firing

Record temperature of the barrel & the breech during all firing and 30 min after the end of firing.
Steps of the trial and evaluation

- Load in chamber an instrumented ammunition (for temperature measurements)
- Measure temperature in the propellant and HE during 30 min after the end of firing

Sensor at the location of the primer
Sensor in the location of the propellant near the case tube
Sensor in the location of the fuze
Sensor in the front of the projectile body
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Check barrel wear with bore inspection (endoscopy)
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

- Check barrel straightness by laser measurement
BARREL HEATING AND COOK-OFF TEST AND EVALUATION

Steps of the trial and evaluation

> Process ammunition temperature data to assess probability of cook-off within the whole range of temperatures of firing (cannon and ammunition)
POINT DETONATING PERFORMANCE TRIAL AT LONG RANGE
QINETIQ TRIALS

Typical high speed video captured during CTAI trials
POINT DETONATING PERFORMANCE AT LONG RANGE

Purpose and general description

> Context

  > Part of the GPR-AB-T ammunition internal qualification
  > Planned in full qualification in extreme distances of the requirement
  > Purpose: assess the limit distance of PD functioning against 2 natures of targets
    > Distance between muzzle and target 1750 – 2500 m
    > Size of target: 8m x 6m, nature of targets: 3mm & 4 mm Aluminium – 2017A
POINT DETONATING PERFORMANCE AT LONG RANGE

Challenges

> Allowing for the change in target distances ranging from 1750m to 2500m to determine the design limitations of the ammunition

> Providing additional protection to the range fairway and the target construction area during wet conditions on a site which is classified as a site of significant scientific interest (SSSi).

> Constructing a large 8m wide x 6m high aluminium target which would cope with windy conditions

> Making the target frame construction so that damage caused during the trial could be repaired and also the target material thicknesses changed from 4mm to 3mm thick when required

> Determination of the target impact to detonation time for each round fired
POINT DETONATING PERFORMANCE AT LONG RANGE

Solutions

> Using M110 mobile Howitzer chassis fitted with an adaptor plate to suit both the cannon and slave gun. This ensured that the target would remain in the same position while the gun moved forwards or backwards according to the required range.

> Hiring of specialist matting to prevent damage to SSSI fairway but also to prevent machinery from becoming bogged down at the target area during maintenance.
POINT DETONATING PERFORMANCE AT LONG RANGE

Trial setup

- M110 Howitzer chassis fitted with the CTAI slave gun with F432 vehicle behind containing the instrumentation and gun crew
Solutions

- Use of a high speed phantom camera located in front of the target fitted with an infrared filter to determine the target strike positions and make aim point adjustments where necessary.

- Using two phantom cameras perpendicular with the target face capturing 30,000 frames per second enabled the target impact to detonation time to be determined.
POINT DETONATING PERFORMANCE AT LONG RANGE

Trial setup

Target built using 2m wide timber frames which were bolted together and then the aluminium plates fitted. This allowed panels or frames to be changed during the trial using a remote working platform.
POINT DETONATING PERFORMANCE AT LONG RANGE

Solutions

> Steel plates behind target ensured that live rounds were destroyed on impact

> Example below shows round passing through hole in target where sheet had been blown off and resulting in round point detonation on steel plates behind
Solutions

> Images showing target prior to firing and after trial
POINT DETONATING PERFORMANCE AT LONG RANGE

Trial setup

> Round M40 after impact with Aluminium plate
OVER WATER RECOVERY AND CT SCANS FOR SAFETY ASSESSMENT
OVER WATER RECOVERY AND CT SCANNING

Purpose and general description

> To demonstrate safety of the rounds,
> In accordance with STANAG 4224
  > Firings in overpressure,
  > HE filled rounds
  > Fitted with inert fuzes
> Part of development, internal qualification, and full qualification
OVER WATER RECOVERY AND CT SCANNING

Challenges

> Firing relatively small projectiles approximately 4km from the gun at high tide and recovering these using tracked vehicles when tide recedes

> Ensuring that projectiles do not become damaged when landing in the water especially if the water depth becomes too shallow

> In windy conditions the projectiles can skip when the sea becomes rough after which they are unlikely to be recovered

> In the summer months, increased seaweed growth can result in projectiles becoming hidden

> Recovery of projectiles must happen on the same day of firing otherwise the incoming tide will cover the projectiles

> Recovery period will be limited in time before the incoming tide returns
OVER WATER RECOVERY AND CT SCANNING

Trial Instrumentation

> Internal ballistics measurements inside the cartridge case are completed using drilled ammunition while the firing chamber and muzzle are fitted with kistler pressure gauges.
OVER WATER RECOVERY AND CT SCANNING

Trial Instrumentation

> High speed Phantom cameras are used to check the early flight characteristics of the rounds approximately 10m from the muzzle

> SIR2 cameras are also used to capture a detailed image of the projectile after muzzle exit
OVER WATER RECOVERY AND CT SCANNING

OWR solutions

- The projectiles are fired with a live high explosive filling in their shell body but with an inert fuze preventing the ammunition from functioning upon impact with the water.

- A total of 38 OWR trials have now been completed, all firing from the same firing position at the same elevation and direction.
OVER WATER RECOVERY AND CT SCANNING

OWR solutions

- The firings will take place on a specific date when the high tide times are most suitable for recovery, the typical depth of water at high tide can be approximately 4m deep although this can quickly reduce so there is only typically a 2 hour firing slot.

- Tracking radar behind weapon tracks the distance from the gun to the impact position with the water.

- An additional blighter radar is also positioned further down the estuary closer to the impact positions to provide additional data.
OVER WATER RECOVERY AND CT SCANNING

OWR solutions

- The impact positions recorded from the blighter radar are then converted into global positioning system coordinates which are then loaded onto a portable GPS receiver.
- This allows the recovery team to drive to the impact position of the round which travelled the shortest distance.
- When completing OWR trials, the ammunition will typically be conditioned to the temperature extremes of +63ºC or -46ºC and when recovered the hot conditioned rounds will typically impact the water approximately 150m further than the cold conditioned rounds.

![Image showing typical distance between cold and hot rounds 100m]
OVER WATER RECOVERY AND CT SCANNING

OWR solutions

- Recovery of the projectiles on sea at low tide using Lance tracked vehicles
- Projectile recovery rate remains high but has dramatically improved recently by using new radar systems and GPS.
- From the last four OWR trials completed, a total of 104 rounds were fired and 101 rounds were recovered
OVER WATER RECOVERY AND CT SCANNING

Post recovery inspections

Projectile examination and measurement: check relative movements between parts.
OVER WATER RECOVERY AND CT SCANNING

Steps of the trial

> Sectioning after firing if required
OVER WATER RECOVERY AND CT SCANNING

CT Scanning

> CT scans of ammunition showing an example of conventional X-Ray
OVER WATER RECOVERY AND CT SCANNING

CT Scans of complete cartridge prior to being fired
OVER WATER RECOVERY AND CT SCANNING

Steps of the trial

> CT scans of ammunition before and after firing
OVER WATER RECOVERY AND CT SCANS

Steps of the trial

> CT scans of projectiles after firing
OVER WATER RECOVERY AND CT SCANNING

3D Animation of CT scan
OVER WATER RECOVERY AND CT SCANNING

CT Scanning facility in explosive licensed building at the Environmental test Centre