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155 MM X 52 CAL ADVANCED TOWED ARTILLERY GUN SYSTEM (ATAGS)

Technology Focus focuses on the technological achievements in the organization covering the products, processes and technologies.

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From the Desk of Guest Editor

Armament Research & Development Establishment (ARDE), Pune is one of the premier laboratories established under the DRDO, with a task to achieve the self-sufficiency in the vital field of armament technologies. The capability of ARDE embraces the whole gamut of research, development, prototyping, test & evaluation and Transfer of Technologies (ToT) activities for diverse armaments. ARDE has acquired core competence in the area of Artillery Guns & Ammunition, Infantry Weapons & Ammunitions, Pinaka Rocket & Launchers, Warhead Technologies for various missile systems, Air Delivered Munitions, Tank Ammunitions & Warheads, Armament Fuzes, Mines and Munitions, Internal & External Ballistics, etc. ARDE has attained remarkable expertise in establishing test, evaluation & trial methodologies for various armment stores during different development stages.

In 1944, Joseph Stalin said "Artillery is the god of war". There have been extensive advancements in defence technology since then; however, artillery systems have not lost the relevance by any factor and means. Artillery gun is the most effective and reliable method of delivery in all kinds of battlefield, because of its ability to concentrate sustained fire in varied terrain and harsh weather. It has the capability to perform in defencive as well as offensive roles. It has proven to be war winning assets and Armed Forces have been striving to retain the most powerful gun in their inventory to maintain higher force multiplier. Due to its significant features like cost-effectiveness, accuracy & rate of fire, the requirement of advanced artillery gun systems, to replace the existing 105 mm, 130 mm, and 155 mm FH77B 39 calibre gun systems was the need of Indian Artillery since long back.

It is evident that the future battlefield scenario will be dominated by the technological advancement in the areas of weapons and ammunition system. Foreseeing the futuristic requirements, a project for design and development of 155 mm x 52 calibre Advanced Towed Artillery Gun Systems (ATAGS) was sanctioned to ARDE in 2012. ATAGS has been envisaged with high degree of excellence in terms of higher range, best-in-class accuracy and consistency, all electric drives for exceedingly reliable gun operations, superior rate of fire, higher mobility and all weather & terrain deployability. The design and development of ATAGS was executed by ARDE as the nodal laboratory and IRDE, VRDE, CAIR, DEAL, DMRL, and PXE were the partners to provide solution in the respective specialist areas. Various Defence Public Sector Undertakings (DPSUs) along with two main development partners, viz. Tata Advanced Systems Limited and Bharat Forge Limited are associated with ATAGS realisation.

ATAGS was first publicly showcased at 68th Republic Day Parade on 26 January 2017. Also, ATAGS has become the first indigenous gun to participate in 21-gun salute alongside the British origin 25 pounder as part of 76th Independence Day celebrations at Red Fort on 15 August 2022.

The present issue of *Technology Focus* highlights the comprehensive overviews of various technologies developed and incorporated in 155 mm x 52 calibre ATAGS.

A. Raju

Outstanding Scientist & Director, ARDE

155 MM X 52 CAL ADVANCED TOWED ARTILLERY GUN SYSTEM

Artillery is a class of heavy military weapon systems responsible for engagement of targets at longer ranges. Usually, artillery weapons function on battery concept. A battery consists of 6 to 8 guns under command of a battery command post from where all guns receive firing data in terms of projectile type, quantity of propellant, and laying angles. Role of an artillery weapon depends on four basic artillery missions. Firstly, direct support mission, which includes all fires delivery in proximity to and in support of front line Infantry. Secondly, counter-battery fire, where all fires are directed towards enemy artillery including enemy artillery battery positions, observation posts and ammunition dumps. Third, interdiction/harassing fire, which is meant to deny enemy access to a particular area or route. In this, the firing is done in a sustained manner so that own infantry and mechanised forces are able to move swiftly under the cover of artillery shells. The fourth mission is to provide deep engagements into enemy territory beyond the main battle area. In this, the targets of engagement may be non-artillery targets.

The tactical employment of artillery system is based on location and selection of targets to be engaged and thereon, selection of weapons system and allocation of ammunition is decided. In other words, the desired target effect dictates the selection of artillery.

There are two primary target effect: destruction and neutralisation. Destruction means complete extermination of the target. Destruction usually comes at a cost, as more ammunition will be required to fire or precision ammunition would be vital. On the other hand, neutralisation is only a temporary effect. However, when properly coordinated and synchronised with other arms, neutralisation can be as effective as destruction. For an instance, artillery would neutralise enemy artillery until infantry or mechanised elements have advanced completely. Thus, the enemy artillery would be neutralised and eliminated from a critical phase without actually causing destruction.

Despite of the fact that there have been significant advancements in non-conventional technologies and advanced weapon system, a conventional artillery gun system is still a vital component of all armies to fulfil both defensive and offensive roles as elaborated above. Artillery gun is the most effective and reliable weapon system especially for neutralisation, because of its ability to perform sustained firing for longer durations as compared to other weapon systems.

Artillery Gun System

Artillery gun systems are primarily used for indirect fire and can be mounted on different platforms. Each type of platform is applicable specific to terrains and employment areas and gives an optimum performance in terms of mobility, fire power, and protection along with logistics requirements. Artillery guns are the backbone of any army which function to fulfil the military doctrine of country including defence, offence, destruction, and neutralisation.

Type of Artillery Gun Systems

Artillery gun systems are broadly classified in three categories:

- Towed Artillery Gun: The towed gun system is one of the major systems in most of the artillery of different countries. More than 46 countries are using the towed artillery guns. The study shows the maximum number of guns in the world armies are in this category (> 70%) in 46 countries of the world. Hence the development of the towed artillery gun always set the trend in the development of other types of platform.
- Self-Propelled Artillery Gun: Mobility of track or wheeled gun platform with different calibre is provided depending upon the terrain conditions and operational employment. The system may

be incorporated with mechanised forces with matching mobility and manoeuvrability. Few countries have already employed the SP guns in its inventory including India named K9 Vajra.

- Mounted Gun System: Mounted Gun System are the other type of artillery gun system in which a gun is mounted on a vehicle or a platform such as tank, armoured vehicle or helicopter. These guns are designed to provide mobile and flexible fire power, allowing the operators to engage targets while on the move to achieve shoot and scoot capabilities.

Advanced Towed Artillery Gun System

Indian artillery initiated a major drive somewhere in the year 2000 towards modernisation and rationalisation of various artillery equipment under employment and fleet reorganisation around 155 mm x 52 Calibre gun systems. In connection with this, an ambitious Field Artillery Rationalisation Plan (FARP) was formulated by Indian Army. Under FARP, procurement of total 1580 nos. of 155 mm x 52 Calibre Towed Artillery Gun Systems was envisaged along with additional numbers of self-propelled (Tracked/ Wheeled) Guns, Mounted Gun Systems and Ultra Light Howitzers. The Indian artillery witnessed no induction of new gun systems subsequent to induction of 155 mm x 39 Calibre Bofors FH-77B howitzers in 1986-87.

To meet FARP requirements, ARDE initiated feasibility study and other pre-project activities for design and development of 155 mm x 52 Cal Towed Artillery Gun System in year 2009. In September 2012, a mission mode project titled 'Design and Development of 155 mm x 52 Cal (ATAGS)' was sanctioned to ARDE as nodal DRDO laboratory. The other participating laboratories including IRDE, VRDE, CAIR, DEAL, and PXE were given sub-projects to provide solution in the respective specialist domains. The development of ATAGS was carried out indigenously with two development partners namely, Tata Advanced Systems Limited (TASL) and Bharat Forge Limited (BFL). During the development phase itself, Artillery Directorate appointed and positioned at ARDE, a Weapon Design and Development Team (WDDT) consisting of a Program Co-ordinator (Rank Col), two Project Managers (Rank Lt Col), and supporting staff for close co-ordination, support, and monitoring of project progress.

With the tireless effort of all stakeholder, as mention above, 155 mm x 52 Cal (ATAGS) culminated into an indigenously developed Artillery Gun System with approximately 85 per cent IC. Operationally and technologically, ATAGS has been designed to achieve superiority in fire power in terms of range, accuracy, & consistency, and rate of fire. Sustainability of fire, Multiple Rounds Simultaneous Impact (MRSI) fire, tow-ability, higher mobility, communication, day & night sighting, deploy-ability and maintainability are some of its salient features. The system is compatible to ACCCS-Shakti command and control network of Indian artillery. The gun is compatible to fire existing in-service ammunitions. It is configured based on the existing operational aspects being practiced by Indian artillery, reducing the training and logistic burden. ATAGS provide means of achieving Indian artillery's short and long term objectives including the development of advanced technologies.

Most of the advanced technologies developed, have been tested initially in the stand alone mode and there-after incorporated into the ATAGS. These include higher pressure, higher chamber volume gun barrel and breech mechanism, compact Recoil system, efficient Muzzle Brake, light-weight structures, All electric drives for gun laying and ammunition handling mechanisms, console-based gun automation and control, SDR-based advanced communication, simultaneous voice and data communication, fire control computer, integrated sighting system including day camera, thermal imaging & Laser Range Finder (LRF), Higher mobility in cross country, high power compact auxiliary power unit and walking beam suspension for negotiating with highly undulated terrains and mountain roads.

The system is configured with 'All Electric Drive' to ensure maintenance free and reliable field operations. The automation ensures automatic operation of

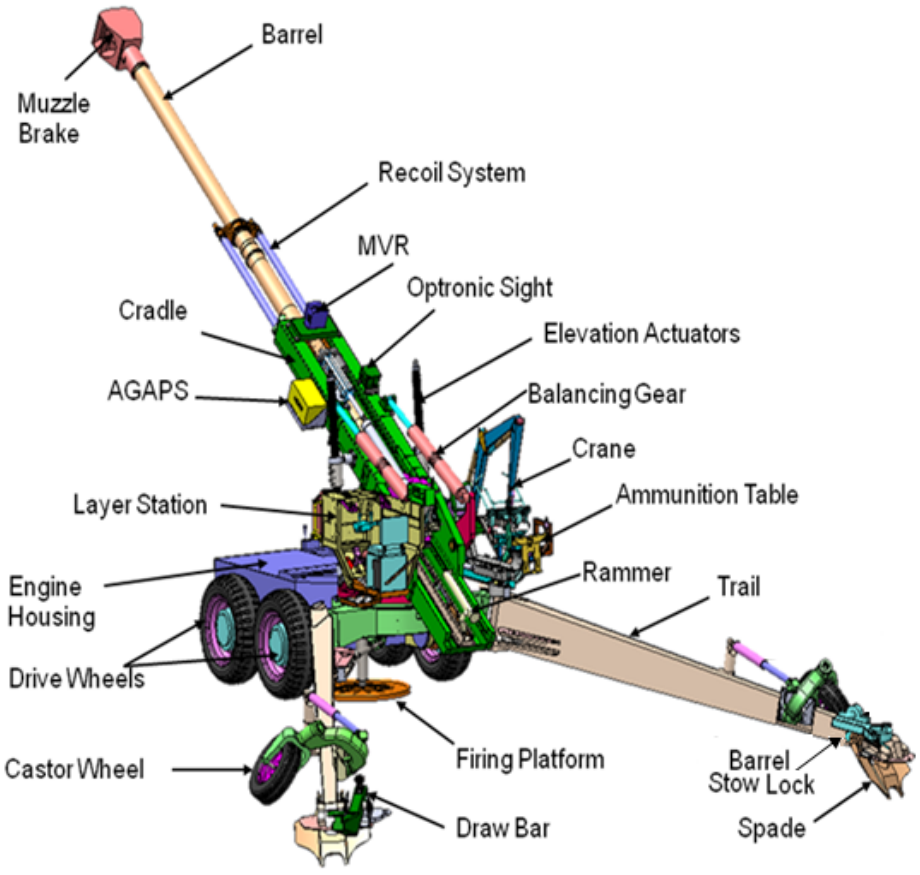
laying, shell and charge loading, ramming and gun deployment. The automation also facilitates higher rate of fire, fast coming in-to/out of action in the day/night war scenario. It is equipped with integrated fire control system consisting of inertial land navigation-based Automatic Gun Alignment and Positioning System (AGAPS), Muzzle Velocity Radar (MVR), and ballistic computer to carryout online computations. Thermal Imager (TI) is incorporated to impart direct firing capability during night.

The gun system is configured to work in battery concept in which a Battery Command Post commands and controls a battery of six to eight guns over radio and line. The system has been configured to be integrated with higher echelons as per Artilery Combat Command and Conbel System Shakti network protocols.

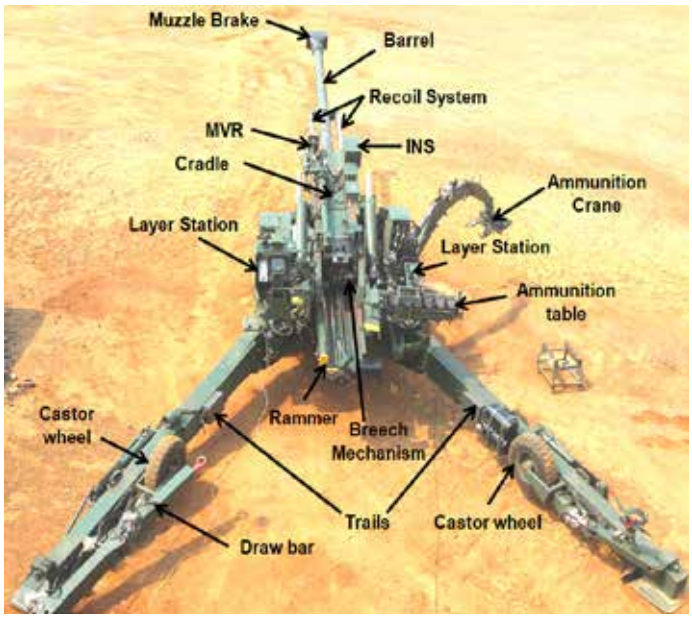
ATAGS delivers 10 high explosive shells on the target in a very short span of 2.5 minutes as intense rate of fire and 5 rounds in 60 sec as burst rate of fire. The exceeding range of 35 km for Boat Tail round and 45 km for base bleed round can give a longer standoff distance and greater edge over the adversary.

During technical trials at Pokhram Field Firing Range, PFFR Pokhran, ATAGS achieved the milestone of attaining highest ever range of 38.5 km and 48 km with in-service ERFB Boat Tail and ERFB Base Bleed ammunitions, respectively as compared to 30 km and 40 km being achieved by the contemporary artillery guns worldwide.

ATAGS has successfully completed winter and summer PSQR validation trials conducted by users along with Maintainability Evaluation Trials (MET), DGQA evaluation and EMI/EMC evaluation. Licence Agreement-Transfer of Technology (LA-ToT) for the entire system has also been concluded and two development partners, TASL and BFL have been nominated as production agencies. Defence



ATAGS Conceptualised



ATAGS Realised

Acquisition Council (DAC) has already accorded Acceptance of Necessity (AoN) for 307 nos. of ATAGS for procurement by Indian Army. Therefore, it is absolutely appropriate to mention that ATAGS, in full sense, commensurate with the idea and effectiveness of both 'Make in India' and 'Atmanirbhar Bharat' initiatives of Government of India.

Salient Features of ATAGS:

- Highest range (45+ km) with ERFB-BB shell.
- Higher accuracy & consistency, best in the class worldwide.
- Higher rate of fire for burst, intense and sustained.
- Gun-barrel with improved material properties in terms of strength and fracture toughness.
- High efficiency Muzzle Brake (>35 %) and highly reliable hydro-pneumatic recoil system.
- All `Electric Servo' Drives for laying, breech, ramming, and crane operation
- Automatic Gun Alignment and Positioning System (AGAPS) integrated as servo loop feedback for precise gun position and orientation.
- Advanced optronics sight for direct firing at target up to 1.5 km, during both day & night.
- Four wheel configuration and higher capacity 'Auxiliary Power Unit' for better mobility in SP mode.
- Front towing arrangement with castor wheel steer-ability reducing turning circle diameter significantly.
- Compact gun configuration with backpack arrangement for lower Turning Circle Diameter (TCD).
- Improved wireless communication with Software Defined Radio (SDR).
- Fully compatible with ACCCS-SHAKTI.
- Fully autonomous capability with on board FCS.
- Completely silent operations with all drives on battery backup.
- Faster coming into and out of action for quick response in firing readiness.

System Description and Technology Established

ATAGS comprises of two major sub-assemblies upper carriage and under carriage. Upper carriage has ordinance assembly (gun-barrel, breech and muzzle brake), recoil system, cradle, saddle, elevating & traversing mechanism, layer station, loader station and Ammunition Handling System (AHS). The undercarriage consists of structural, automotive, and auxiliary systems. Under carriage structural system is majority an assembly of chassis, trails, draw bar, engine housing, walking beam and spades. Automotive system consists of 'Auxiliary Power Unit' to provide traction for Self-propulsion capability. It includes diesel engine, hydraulic pumps, hydraulic motors, main wheels, and steerable castor wheels.

The auxiliary system provides capability for gun deployment using hydraulic power. It includes various actuation mechanisms for deployment of central firing platform, trails, and castor wheels. A slew ring bearing acts as an interface between upper carriage and lower carriage. Various subsystems of ATAGS and technology developed are:

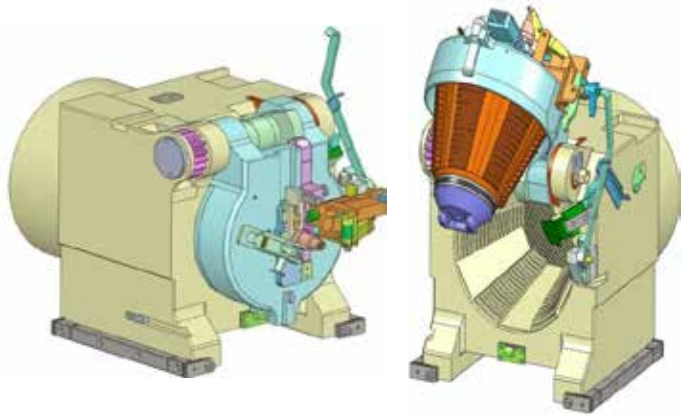
- Ordnance: It consists of a barrel, breech mechanism and a muzzle brake. Gun Barrel is a 155 mm x 52 Calibre auto-frettaged barrel

Manufacturing of Gun Barrel

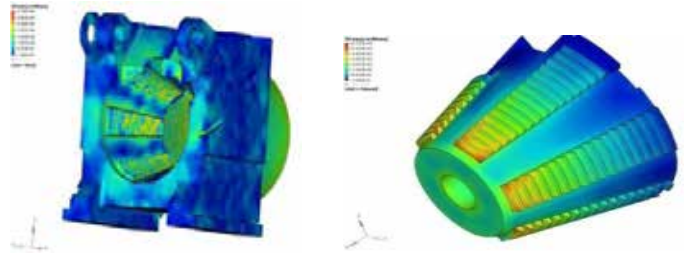
First Firing of ATAGS Barrel at P_2 Pressure at PXE, Balasore

capable of withstanding high chamber pressure corresponding to BMCS zone 7. It is having a nominal chamber volume of 25 litres which accommodates seven modules of Bi-Modular Charge System (BMCS). Barrel is manufactured using Full Length Differential Autofrettage (FLDA) technology and high grade ESR steel having fracture toughness up to 165 MPa√m. The barrel is proven at P2 pressure (1.2 times service pressure) before fitments on the gun.

Breech mechanism closes the combustion chamber of the barrel during firing and opens it for loading of the shell and the charge after each firing. It also seals the chamber to prevent leakage of the powder gases during firing. Design and development of breech mechanism has been done to withstand proof pressure (P2 pressure). It has used stepped and taper thread screw type breech technology with ability provide the rearward two stage obturation by using specially designed and developed Nitrile Butadiene Rubber (NBR) elastomeric obturating pad.



CAD Model: Breech Mech

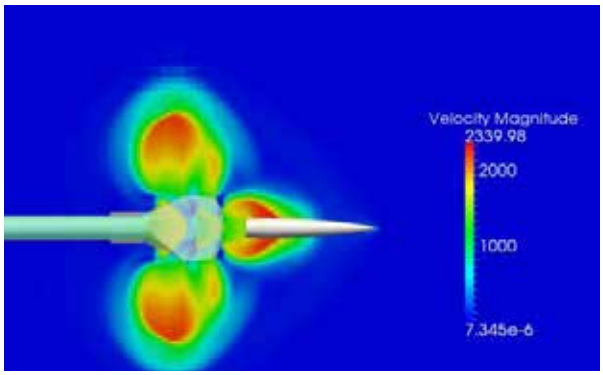


FEA of Breech Mech

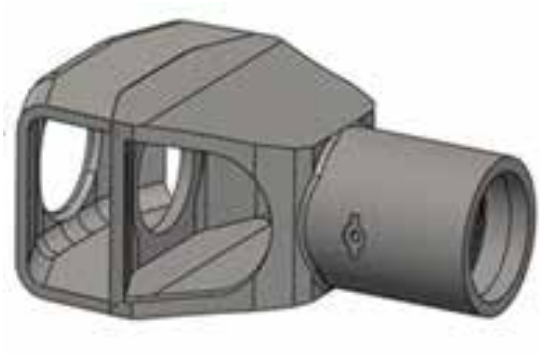
Breech Mechanism Hardware

Breech Mech Proof

The breech mechanism is opened and closed with the help of a Breech Operating Device (BOD). The BOD consists of a recoiling and the non-recoiling parts. The recoiling parts of the breech operating mechanism consist of a pinion, rack, springs, and a spring buffer. The entire assembly of the recoiling parts is mounted on the breech ring. The non-recoiling parts consist of an electric motor, a fail safe electromagnetic brake, an electric actuator and a dog clutch.



CFD Analysis of Double Baffle Muzzle Brake

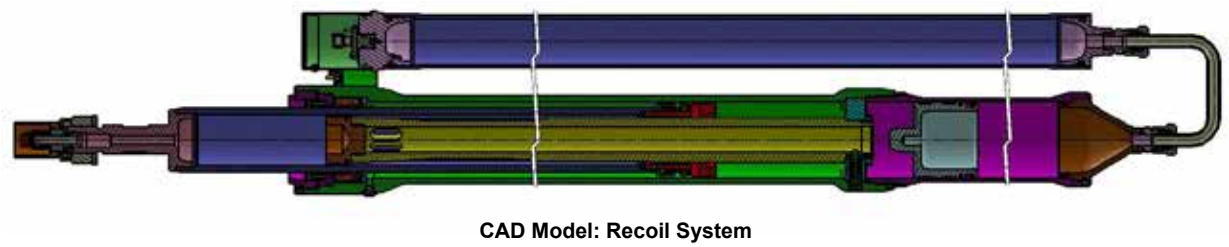


CAD Model: Muzzle Brake

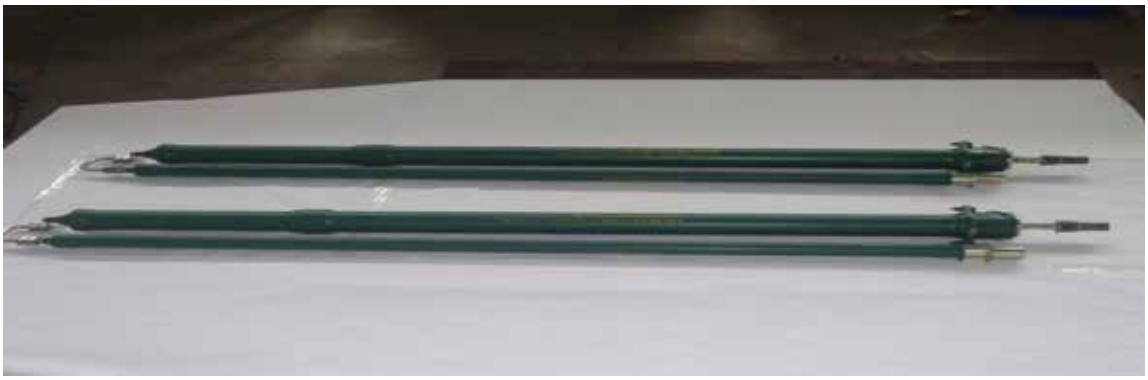
Muzzle Brake Hardware

ATAGS is having a double baffle Muzzle Brake with a muzzle brake efficiency of 35 per cent When the gun is fired, the gases moving behind the projectile strike the muzzle brakes baffles exerting a force acting in a forward direction. This action reduces the backward momentum of the recoil mass thus reducing the recoil energy. Muzzle brake has been designed to withstand proof pressure (P2 pressure). It uses double-baffle technology and it is fabricated out of ESR steel plates. The design of the muzzle brake was initially validated using CFD simulations. The deflection angles and contours of the discharge areas of the muzzle brake are specifically designed to achieve higher braking efficiency. Surface treatment and higher hardness is incorporated to avoid gas erosion and achieve longer life.

- Recoil System: ATAGS is equipped with a hydro pneumatic recoil system. The role of recoil system is to hold the gun in battery position when not firing, dissipate the energy of firing impulse, stop recoiling mass within specified distance and bring the gun back to battery position. The recoil system consists of two identical units symmetrically positioned with respect to the barrel. The recoil system technology has been developed which uses a specially designed control rod to control the discharge of recoil fluid so that maximum trunnion pull (recoil force) and counter recoil velocity at the run out position are maintained within an acceptable limit. The efficient design of recoil



CAD Model: Recoil System



Recoil System Assembly

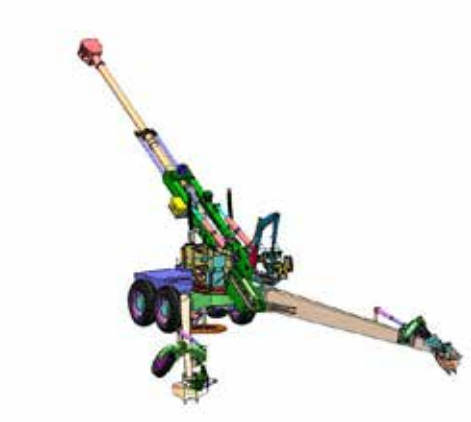
Static Testing of Recoil System

Pressure Testing of Recoil System

Recoil System Hardware Components

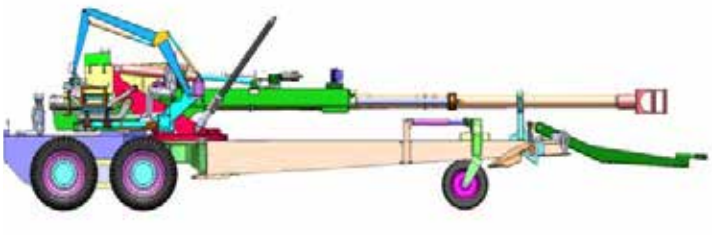
system is very much essential for a gun system as it would decide the effective trunnion pull, stability of gun and the gross weight of the gun system. CFD and MBD simulation technologies were used for initial design validation. Further, the design and reliability of functioning were validated by carrying at least 100 cycles of continuous recoil and run out cycles. The testing of recoil system was carried out on a specially designed static and hydraulic test bench, simulating the dynamic conditions.

- Gun Structural System: Gun Structural System contributes to nearly 70 per cent of the weight of the integrated gun which provide strength and rigidity to the gun during firing as well as it provides the platform for mounting of the armament system, automation & system, propulsion and drive system, communication & sighting system. The gun structural system has been configured and designed to provide three modes of operations namely Towed, Self-propelled (SP) and Deployed/ Firing Modes. The gun structure is divided into two



CAD Model of ATAGS in Deployed Mode

ATAGS in Deployed Mode (Ready for Firing)

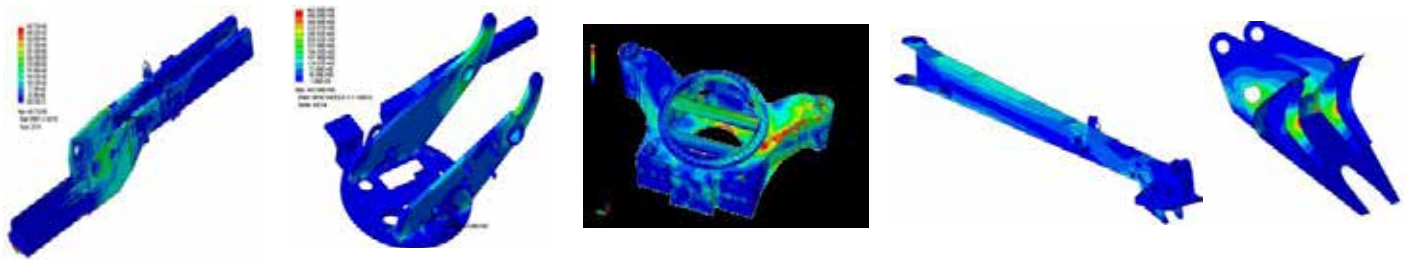


CAD Model of ATAGS in SP Mode

ATAGS in SP Mode during Firing Trials

CAD Model of ATAGS in Towed Mode

ATAGS in Towed Mode



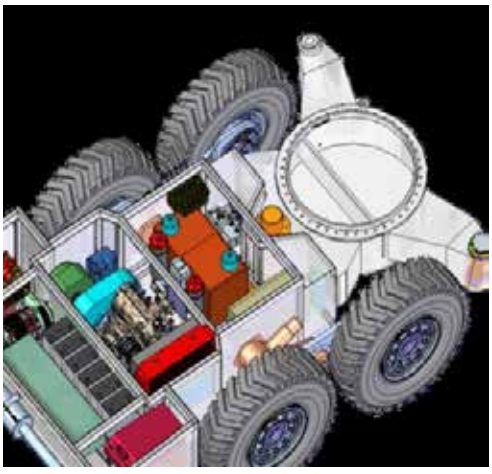
FEA Analysis of Critical Systems

Upper Structure Assy & Testing

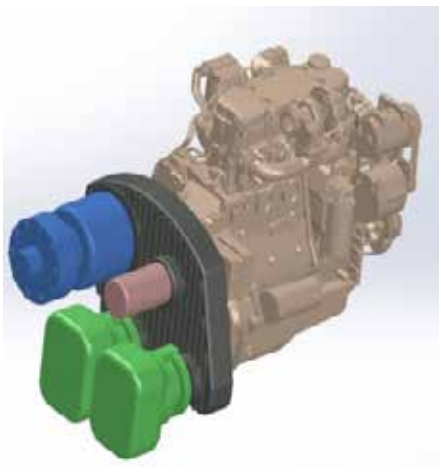
Under Carriage Assy & Testing

major sub-systems namely the supper structure and under carriage. Further the supper structure consists of critical precision assemblies like cradle, saddle, balancing gear, trunnions, layer's station, loader's station. The structural elements for the under carriage consists of slew ring bearing, Chassis, Trails (LH & RH), central firing platform, engine housing, towing mechanism, spades and draw bar. The efficacy of the design has been validated by conducting static load tests, brake efficacy test, pull back test and finally validating the gun carriage proof at P1 pressure (1.15 times service pressure) by conducting dynamic firing.

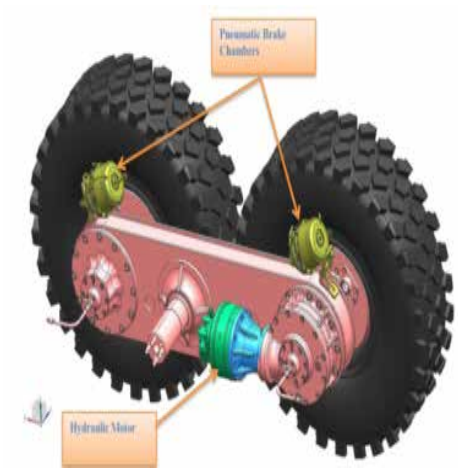
- Automotive System: ATAGS has self propulsion capability which has been achieved through an Auxiliary Power Unit (APU) consisting of automotive system, hydraulic transmission, and actuation mechanisms. It was imperative for ATAGS to adopt a new strategy for automotive system for enhancing the mobility, deployability, and powering the complete drive system including the gun automation. A compact high efficiency customised 110 kW Diesel Engine fitting to the



Engine Housing Assembly



Power Take-Off Unit



Walking Beam Assembly

110 kW Engine

Automotive Testing on Test Rig

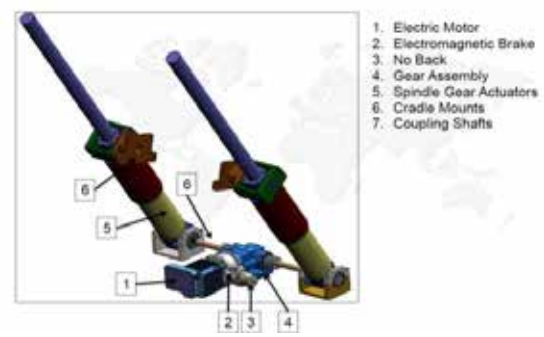
Walking Beam Suspension Assembly

stringent emission norms have been successfully realised. This is followed by a compact, high rigidity Power Take Off (PTO) for wheel traction, functioning of 12 kW alternator, charging of battery bank, and power the hydraulic drive for auxiliary operations such as cooling system and gun deployment. The unique technology incorporated in ATAGS automotive system is the use of walking beam suspension as against the conventional hydro gas suspension as well as independent drive to all four wheels.

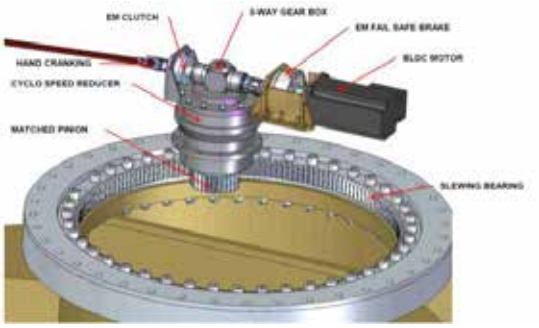
- Gun Automation: Gun automation is considered as the backbone of all futuristic gun system which aims to harness the controller, drives, actuator, sensors and GUI/MMI technologies. ATAGS has been provided with numerous automation for various gun operations including gun deployment, laying, ammunition handling and firing. ATAGS is the only artillery gun in the world in which all the mechanisms of upper structure are automated using all electric drives.

The electric gun laying mechanism which consists mainly of BLDC motors, EM brakes, Gear boxes, cyclo-speed reducers, EM clutches and battery bank as power source. The elevation is achieved using ball screw based elevating actuator (LH/RH) which is powered though electric motor. The gun is also equipped with pneumatic equilibrates which helps in reduction of the effort during elevation of the gun for both powered and manual modes. The traversing of gun is achieved through a pinion which is interfaced with slew ring bearing. To achieve desired accuracy of positioning and laying, the Gun is integrated with an Automatic Gun Alignment and Positioning System (AGAPS). The AGAPS acts as a feedback sensor for servo loop and orients the very accurately. The gun is provided with two levels of redundancy for laying which includes joystick and manual mode in case of servo drive failure.

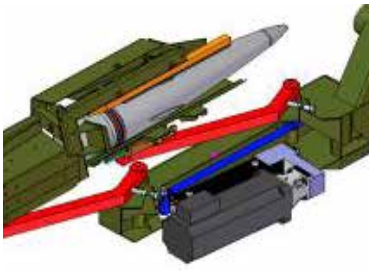
The Ammunition Handling System (AHS) of the gun consists of ammunition crane, loading table, loading pendulum, rocker arm, rammer, and primer loading mechanism. Ammunition handling crane is electrically operated and used to transfer O3 shells from the shell dump to the loading table. Loading table consists of six shell holders which are connected to each other at both sides through links, pin, and rollers. Loading table transfers one shell at a time on the loading tray. Loading pendulum mechanism helps loading tray to receive a shell from loading table one at time and aligns it with the cradle. Rocker arm mechanism helps to align the loading tray with the axis of barrel by providing swivelling motion to the loading tray. Rammer mechanism rams the shell and places the charge into the barrel chamber. Primer loading mechanism consists of an electric actuator and sensors. The entire primer feeding mechanism is mounted on a frame, the base of which is bolted to the cradle. The complete AHS operations are also powered though all electric means.



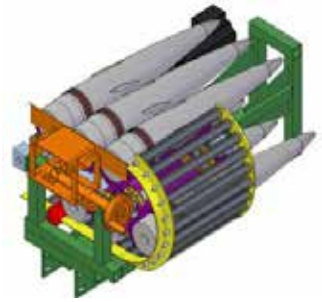
Elevation Mechanism: Ball Screw Actuator



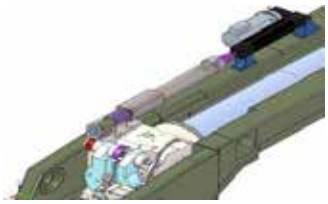
Traverse Mechanism: Gear Box



Pendulum Mechanism



Ammunition Carousel



Breech Opening Device

Ammunition Replenishing Crane

Loading and Ramming Mechanism

Operators Console

Three Way Gearbox

EM Fail Safe Brake

Power Drives

MVR & AGAPS

Table Top Testing

Electrically Operated Mechanisms for Upper Structure

As all the mechanism of upper structure is powered electrically through battery bank, it provides the capability to carry out necessary mission even in case of APU failure. The technology for gun automation with all electric drives along with development of software, GUI, and sensor-based interlocks have been established in the gun which makes ATAGS first of its kind of an artillery gun.

- Sighting System: ATAGS is designed to engage the target in both direct and indirect fire modes. For these requirements, the gun is equipped with various sighting systems. The primary role of these sighting systems is to enable the crew of the ATAGS to carry out day & night surveillance and provide static target engagement capability.

In direct fire mode, the gun can engage a target up to a range of 1.5 km. Instruments Research & Development Establishment (IRDE), Dehradun in association with a private industry designed and developed optronics sight as the main sight for direct fire role. Optronic sight consists of day camera, TI and Laser Range Finder (LRF). It has identification range upto 2 km and detection range up to 10 km. The optronic sight has been designed, developed, and integrated through indigenous sources.

In case of failure of optronic sight or electrical power, direct firing can be performed using Day

Optronic Sight

Dial Sight

Day Telescope

Muzzle Bore Sight

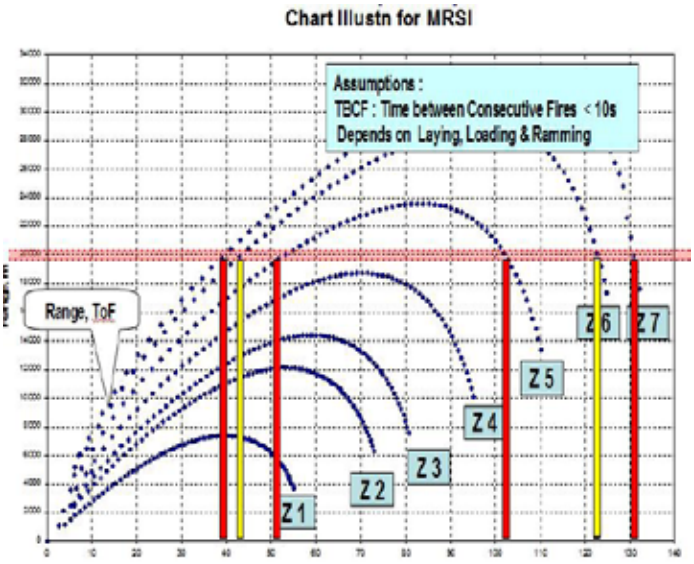
Telescope as a back-up sight. In case of failure of AGAPS or power failure, the gun is provided with a dial sight for indirect fire as a backup sight. The dial sight and telescope are back-up sights which are entirely opto-mechanical in design, as both are required for redundancy in case of power failure or any situations where gun is required to function in manual mode.

- Advanced Communication and Fire Control System: The role of communication system is to provide line and radio communication between gun and Battery Command Post (BCP). For this, ATAGS is equipped with a Voice and Data Communication Unit (VDCU) to facilitate the simultaneous voice and data communication between gun and the BCP. To facilitate the radio communication, the gun is having a SDR. The entire communication system of the gun has been configured to meet the requirement of ACCCS-Shakti protocols. Centre for Artificial Intelligence & Robotics (CAIR), Bengaluru and Defence Electronics Application Laboratory (DEAL), Dehradun are partner laboratories for design and development of ATAGS communication system. All the hardware and software have been designed and developed through indigenous sources. The complete fire control software for ATAGS including Trajectory Computation Module (TCM) has been designed, developed, and implemented to the tactical computer of the gun. This feature enables ATAGS to perform in autonomous mode in which gun is able to compute and execute the complete firing mission independently.
- Ballistic Solutions: For achieving various firing parameters such as maximum & minimum range, accuracy & consistency, direct firing capability and autonomous mode of operation, ballistics plays the most significant role. Initially, detailed internal ballistic studies were carried out using various simulation tools, with an aim to arrive at the optimum system configuration to achieve the highest range in the world. Internal ballistics solution outcome established the gun barrel chamber capacity, service pressure, and expected muzzle velocity. To establish firing parameters for ATAGS, numerous firing trials were carried out for finalisation of various gun and ammunition parameters including Muzzle Velocity (MV),

VDCU and Tactical Computer

Integration and Testing of Communication System

Software Defined Radios

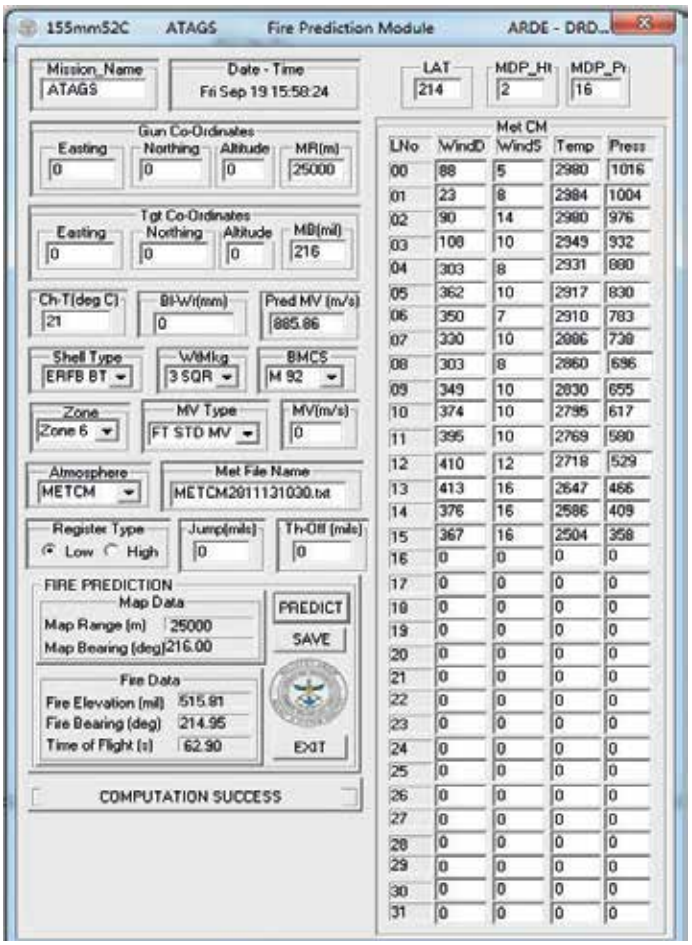


MRSI Simulation

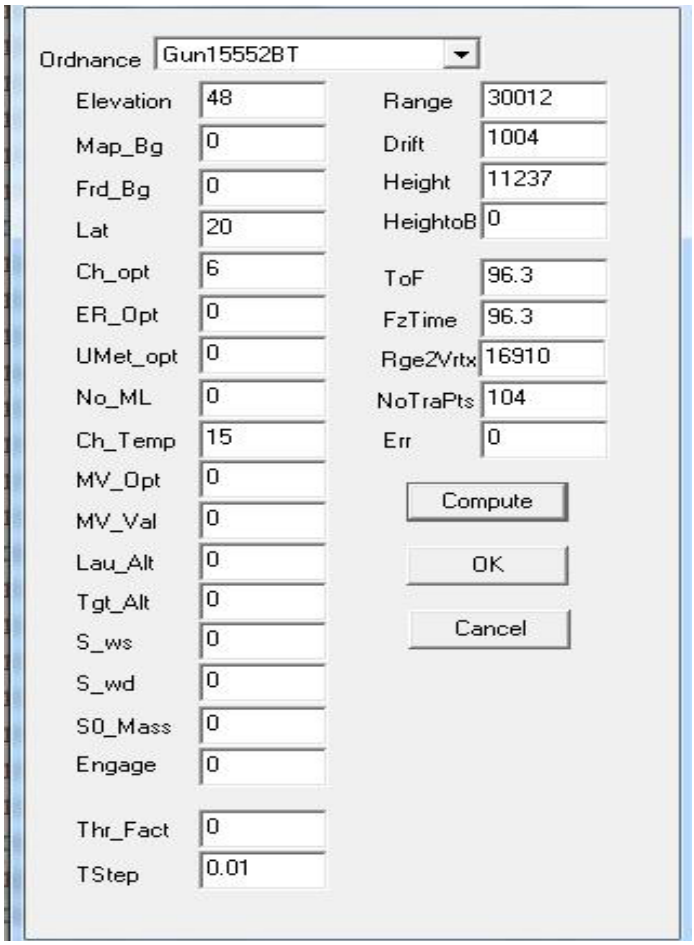
Zone 6	TABLE F(i)							M1 BB
MV 879 m/s	Sea Level							HE
	Basic Data and correction to Bearing							
1	2	3	4	5	6	7	8	9
Range	Firing Table Elevation	Fuze setting for Graze Burst	Correction to fuze settings to change Height of Burst Down by 10m	Effect on Range for increase of 1mil in Firing Table Elevation	Fork	Time of Flight	Correction to bearing for Drift	Correction to bearing for 1 Knot Cross Wind
(X)	(AE)	(FS)	(Δ_cFS/10mV_0)	(ΔEFX÷1milA_E)	(f)	(t)	(Δ_cAng/A_E)	(Δ_cAg/1ktW_x)
(m)	(mil)	(m)	(m)	(m)	(mil)	(s)	(mil left)	(mil)
100	0.6	0	0	162	0.0	0.1	0.2	0.0
200	1.2	0	0	160	0.0	0.2	0.3	0.0
300	1.9	0	0	159	0.0	0.4	0.5	0.0
400	2.5	0	0	158	0.0	0.5	0.6	0.0
500	3.1	0	0	157	0.0	0.6	0.7	0.0
600	3.7	0	0	156	0.1	0.7	0.9	0.0
700	4.4	0	0	154	0.1	0.8	1.0	0.0

Firing Tables

Ballistic Performance Evaluation



Fire Prediction Module



STM DII Verifier

temperature coefficients, gun jump & throw-off, range, accuracy and consistency. Thereafter, prediction and validation of complete ballistics solution carried out by firing BMCS Zone 1 to 7, bagged charges, in-service ERFB-BT, ERFB-BB shells, proof shots, and other in-service ammunition

- Fixed Firing Stand: For conduct of proof trials for ATAGS ordnance (barrel, breech mechanism and

FFS Configuration

FFS Ready for FAT

Installation on Grouting Platform at PXE, Balasore

Instrumented Setup for Firing on FFS

Firing on FFS at Different Angles of Elevation

muzzle brake) and recoil system, development of Fixed Firing Stand (FFS) 'ANGAD' was carried out. The FFS 'Angad' is a unique facility created in the country to conduct dynamic proof of ordnance, recoil system, propellant proof and recovery proof. The FFS has been installed and commissioned at Proof & Experimental Establishment (PXE), Balasore.

Futuristic Artillery Technologies System

The futuristic artillery will have technologies related to the following areas:

- Fuel cell as a power source for electric drive-based transmission for Self-propelled mobility as well as for various gun operations.
- Artificial intelligence and machine learning based fire control system and real time structural health monitoring system.
- Adaptive recoil system comprising of both Magneto Rheological (MR) fluid and Soft recoil system to reduce firing load and consequently, reduce the system structural weight.
- Laser-based ignition system to eliminate primer and improve reliability of fire.
- Solid Fuel Ram Jet projectile with precision control and guidance for enhanced range and accuracy.
- Advanced fault diagnostic tools to have higher level of maintainability and availability.
- Virtual reality-based training simulators for effective training of crew.
- Advanced simulated testing platforms to minimise trial and evaluation cost and logistics during development.
- Drone-based observation post for accurate acquisition of fall of shot data.
- Application of robotics for reducing manpower/ fatigue and a remote platform operated across wide terrain in real time.

ATAGS being showcased at 68th Republic Day Parade on 26 January 2017

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