Perspective on Naval Gun Systems

April 18, 2016

Rajesh Kohli
Addl. General Manager (Def. Engg, R&D, IPR)
BHEL Haridwar

Sept 30, 2015: Hon. RM dedicating INS Kochi to nation.
Commissioning of INS Kolkata

August 16, 2014

Hon’ble PM dedicating indigenously built INS Kolkata to Nation with BHEL’s manufactured SRGM 76/62
Agenda

- BHEL Corporate Profile
- BHEL Journey in Defence business
- Achievements in Key Areas of Naval Gun Systems
- BHEL Haridwar: A technology power house
- Way ahead: Upcoming Projects & new opportunities
- Challenges in Indigenization
### BHEL Corporate Profile

#### Single Source with Multiple Solutions for Infrastructure & Industrial Segments

<table>
<thead>
<tr>
<th>Power</th>
<th>Transmission</th>
<th>Transportation</th>
<th>Non Conventional Energy Source</th>
<th>Defence</th>
<th>Industrial Products &amp; Systems</th>
</tr>
</thead>
</table>
| - Contributes to around 80%\(^1\) of the total revenues  
- Proven capabilities to execute thermal power projects on EPC basis  
- 153 GW\(^2\) installed base of power plant equipment globally |
| - Offers wide range of transmission systems and products  
- Present in UHV, EHV, HVDC and GIS segments  
- Major orders received from MPPTCL, NTPC, TANTRANSCO, BIDCO, Discoms, etc |
| - Offers system range including traction machines, Electric Locomotive (AC/DC), Diesel Electric Shunting Locos, EMU Coaches and traction drive systems  
- BHELs’ IGBT propulsion equipment accounts for majority share of IGBT based locomotives in Indian Railways  
- > 70% of Indian Railways equipped with traction equipment built by BHEL |
| - Solar PV:  
- Offers EPC solutions from concept to commissioning for PV Power Plants  
- Capability to manufacture space grade solar panels and space grade batteries |
| - Water Management:  
- Offers turnkey solutions for industrial and power plant water systems |
| - Defence:  
- Contributing strategic equipments to Indian defence forces for over 20 years  
- Has MoU signed with Pipavav Defence and Offshore Engineering Company  
- Consortium with Hindustan Shipyard and Midhani for Indigenous Submarine Project |
| - Industrial Products & Systems:  
- Designs, manufactures and services various types of onshore rigs since 1975  
- Capability to manufacture onshore deep drilling rigs up to a depth of 9,000 meters  
- 86+ oil drilling rigs supplied |
| - Products:  
- Oil Rigs  
- Well Head & Xmas Trees  
- Fabricated Equipments & Boiler Feed Pumps  
- Compressors  
- AC Machines  
- Valves |

**Source:** Company data and filings.  
**Notes:**  
(1) For FY 2014  
(2) As of February 31, 2014. Domestic installed capacity of 142 GW. Rest is international.
BHEL’s operational Footprints in India

Source: Company data and Stock exchange filings.
Note: Map not marked to scale.
Global Presence

References in 76 countries and Offices in 8 countries across all six continents of the world

- First large turnkey project export by Indian co. – Libya (1977)
- Consistent Performance – 16,916 MW contracted
- Executing 24 Contracts in 16 Countries valued over US$ 2.5 bn
- Contracted Power Plant Equipment around 17,000 MW
- BHEL’s major contributions –
  - Bhutan (4,356 MW/ 98%)
  - Iraq (1,838 MW/ 14%)
  - Oman (1,124 MW/ 30%)
  - Libya (1,174 MW/ 15%)

Source: Company data and Stock exchange filings.
Note: Map not marked to scale.
**BHEL Corporate Profile**

**Continuous focus on R&D**

**High Spend on R&D (US$ mn)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Expenditure (US$ mn)</th>
<th>% of Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY10</td>
<td>$138</td>
<td>2.4%</td>
</tr>
<tr>
<td>FY11</td>
<td>$164</td>
<td>2.3%</td>
</tr>
<tr>
<td>FY12</td>
<td>$200</td>
<td>2.4%</td>
</tr>
<tr>
<td>FY13</td>
<td>$208</td>
<td>2.5%</td>
</tr>
<tr>
<td>FY14</td>
<td>$186</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

**Recent Product Development**

- Developing India’s first coal fired Advanced Ultra Supercritical (AUSC) power plant technology with NTPC and IGCAR
- Super critical boiler with an ability to switch 100% indigenous/imported coal
- Indigenously developed and commercialised Gas Insulated Switchgear (GIS) up to 400 kV
- 765 & 1200 KV UHVAC Transformer, Reactor developed.
- Transportation- Insulated-Gate Bipolar Transistor (IGBT) propulsion technology developed for Loco & ACEMU
- Sole supplier in world for 420 kN/320 kN porcelain insulators for ±800 kV HVDC lines
- Commissioning of 400kV Phase Shifting Transformers at Kothagudem
- STATCOM: Developed for Industrial and Grid Application
- 500 KW PCU for solar power generation

**Turnover from In-House Development (US$ mn)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Turnover (US$ mn)</th>
<th>% of Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY10</td>
<td>$1,121</td>
<td>19.7%</td>
</tr>
<tr>
<td>FY11</td>
<td>$1,302</td>
<td>18.0%</td>
</tr>
<tr>
<td>FY12</td>
<td>$1,639</td>
<td>19.9%</td>
</tr>
<tr>
<td>FY13</td>
<td>$1,841</td>
<td>19.2%</td>
</tr>
<tr>
<td>FY14</td>
<td>$1,352</td>
<td>20.1%</td>
</tr>
</tbody>
</table>

**Filing of Patents and Copy Rights (Total Filings: 3,487)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Filings</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY10</td>
<td>263</td>
</tr>
<tr>
<td>FY11</td>
<td>303</td>
</tr>
<tr>
<td>FY12</td>
<td>351</td>
</tr>
<tr>
<td>FY13</td>
<td>385</td>
</tr>
<tr>
<td>FY14</td>
<td>434</td>
</tr>
</tbody>
</table>
Awards & Recognition

- Awarded ‘Maharatna’ status in 2013
- Outstanding PSU of the year 2013
- Golden Peacock Award 2013
- National Intellectual Property Award 2014
- PSE Excellence Award 2014 for R&D - 2014
- WIPO Award for Innovative Enterprises 2014
- India Today Award 2015 for Best R&D and Innovation
- India Pride Award 2015-16
Centers of Excellence at Corp. R&D

Where Excellence Breeds

- Machine Dynamics
- Compressors & Pumps
- Intelligent Machines and Robotics
- Surface Engineering
- Permanent Magnet Machines
- Nano Technology
- Computational Fluid Dynamics
- Advance Transmission Systems
- Simulators

Bridging gap between generic competencies and industry applications
Welding Research Institute (WRI) at BHEL Trichy

- R&D in establishment and application of various welding processes
- Metallurgical investigations including Failure Analysis, Remnant Life Assessment
- Dissemination of knowledge in welding and allied areas
- Collaborative research in areas specific to any industry or a cluster of industries.
Centres of specialized research

1. Pollution Control Research Institute, Haridwar
   • Environmental Impact Assessment
   • Environmental Auditing
   • Establishment of Chemical Labs in Thermal Power Plants
   • Monitoring of source emission, workplace environment, ambient air quality, effluent, noise, solid & hazardous waste
   • Human Resource Development

2. Ceramic Technological Institute (CTI) at Bangalore

3. Centre for Electric Traction (CET) at Bhopal

4. Amorphous Silicon Solar Cell plant at Gurgaon
Technology Tie-up With World Leaders

USA
- GE
- Gas Turbines
- AC Variable Control Drives
- Combustion Engineering
- Steam generating equipment for industrial and utility purposes, & Coal Pulverisers
- Waste Heat Boilers
- Kjernek
- Christmas Trees & Well head Assemblies
- Mass & Sub-structures
- Promanexport
- Thermal, Hydro Sets & Motors

STOCK
- Geometric Feeders
- Air Preheaters
- Cathodic Protection System
- Valve & Controls
- Dresser Valve and Control Division
- Safety, Safety relief & Steel Valves
- Tuba Heat Transfer Corporation
- HP Feed water Heaters

AIR-PREHEATER CO. INC.
- Nuovo Pignone
- Centrifugal Compressors

ITALY

GERMANY
- Siemens
- Steam Turbines, Generators & Condensers
- SF-6 & Vacuum Circuit Breakers
- Electrical Motors
- Electronic Automation System for Steam Turbines and Generators
- Camshaft Controllers & Trunion Gearbox Support Unit
- Large Size Gas Turbines

FLÄKTE-DURR
- Moisture Separator Reheaters
- Dry Type Transformers

FRANCE
- Creusote Loire
- Castings & Forgings
- Alsthom Savoisienn
- France
- 400 kV Class Power Transformers & Shunt Reactors
- Neyric Creusote-Loire
- Pelton type Hydraulic Turbines

SWEDEN
- ABB
- High Voltage Direct Current Systems
- Fläkt IndustriAll
- Electrostatic Precipitators
- Tube Mills

SWITZERLAND

UK
- WEIR PUMPS LTD.
- Boiler Feed Pumps
- CW Pumps
- Condensate extraction pumps

CANADA
- ABB
- ASEA Brown Boveri
- Programmable Controllers
- Hitachi
- Reversible Pump Turbines
- Hitachi
- High Pressure Valves
- GE
- Francistype Hydro Turbines
BHEL Journey in defence business
BHEL is active in Defence since more than 2 decades.

Creation of dedicated manufacturing and testing facilities at major units to cater the needs of Strategic equipment

- Haridwar: Gun Systems
- Bangalore: Defence Simulators, Ship Automation IPMS
- Trichy: Testing infrastructure & Track for ARVs, ATVP
- Bhopal: Testing infrastructure for GCS for MBT Arjun
- Ranipet: Launchers

10 Units already involved in Defence Equipment Manufacturing

Supplying Castings and forgings to various shipyards
Our Defence Customers
Industrial License granted to BHEL Haridwar Unit:

Manufacture of all types of Guns including
- Field Guns
- Air Defence Guns
- Mortars
for Army, Navy, Air Forces and Para-Military Forces

Manufacture of all types of
- Air Borne Assemblies, Systems & Equipment For Unmanned Aerial Vehicles
- Aerostats
- Unmanned Combat Aerial Vehicles
- Unmanned Under Water Vehicles
- Surface Based Unmanned Vehicles
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Product</th>
<th>Foreign OEMs</th>
<th>BHEL Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Super Rapid Gun Mount (SRGM) 76/62</td>
<td>OTO Melara Italy (Now Finmeccanica DSD)</td>
<td>Haridwar</td>
</tr>
<tr>
<td>2.</td>
<td>Integrated Platform Management System</td>
<td>Avio Italy</td>
<td>Bangalore</td>
</tr>
<tr>
<td>3.</td>
<td>Simfire Vijayanta</td>
<td>Lockheed Martin Information Systems, UK</td>
<td>Bangalore</td>
</tr>
<tr>
<td>4.</td>
<td>Simfire T-72</td>
<td>Lockheed Martin Information Systems, UK</td>
<td>Bangalore</td>
</tr>
<tr>
<td>5.</td>
<td>Gun Control System for MBT Arjun</td>
<td>Bosch Rexroth, Germany</td>
<td>Bhopal</td>
</tr>
<tr>
<td>6.</td>
<td>Mobile Launcher</td>
<td>DRDL Hyderabad</td>
<td>Ranipet</td>
</tr>
<tr>
<td>7.</td>
<td>Mobile Autonomous Launcher</td>
<td>R&amp;D Establishment Pune</td>
<td>Ranipet</td>
</tr>
<tr>
<td>8.</td>
<td>Armoured Recovery Vehicle (ARV)</td>
<td>ZTS / Unimpex Slovakia</td>
<td>Trichy</td>
</tr>
</tbody>
</table>
Achievement in key areas of Naval Gun Systems
Salient Features of SRGM

- 76/62 Super Rapid Gun Mount
- Light weight, Rapid-fire naval gun
- High performance and flexibility in any air defence and anti surface role, particularly in anti-air role.
- Firing rate from single shot to firing 120 rds/min.
- Standard deviation at firing is less than 0.3 mrad, thus providing excellent accuracy.
- Capable of sustained fire, which is a fundamental requirement in any scenario involving the simultaneous engagement of multiple maneuvering target in case of asymmetric warfare scenarios.
Achievements in Key Technology Areas

- Capability to perform Structural, thermal, vibration, fatigue analysis under static and transient states
- Use of state of Art CAE/CAD/CAM software providing seamless manufacturing
- Procurement of Raw Material from vast vendor base
- Experience in assimilation ToT from OEMs for critical technology
- Having separate centers of Metallurgy, Testing, Inspection
- Continuous support from Center of Excellence at Corporate R&D
- Development of extensive Vendor base for components, castings etc.
Achievements in Key Technology Areas

- Expertise in FEA/FEM/CFD
Achievements in Key Technology Areas
Achievements in Key Technology Areas

**Manufacturing technology**

- Established expertise of fabrication of special grade Alloy steel, Aluminum Alloy, Bronze, Copper and dissimilar materials
- Surface treatments such as Alodyne, Hard Chrome, Phosphate, Bronze spray, Painting
- Developed capability in Hydraulic Subsystems
- In-house capability for Precision machining of Special Grade Alloy Steel, Titanium alloy, Aluminum alloy, Bronze
- Established expertise in manufacturing, assembly, defect investigation & rectification, testing of Gun System
- Self reliant in Mechanical, Electrical & Electronics testing & assembly
On-board services & System Engineering:

• Self reliant in providing onboard services ranging from installation and all acceptance trials- ITF, HATs and SATs

• Self reliant in Mechanical, Electrical & Electronics assembly and testing

• Well versed with Gun System- Engineering and Integration

• Indigenous procurement of MIL grade Lubricants and Consumables
Achievements in Key Technology Areas

**Service after sales:**

- Acquired expertise in execution of all kinds of repair, faults identification & rectification and overhauling.

- Undertaken modifications and updations after post commissioning feedback through in-house R&D and OEM.

- Stringent Quality inspection checks and assurance right from induction of material up to assembly level under DQAN, DNAI supervision

- Health audits of Gun systems

- Ground support Equipment and training facilities at Dockyard/Naval base

- Customer training through certified trainers in Mechanical and Electrical domain

- Customized training packages as per special requirements
BHEL Haridwar Gun manufacturing facilities

SRGMs under final assembly at works

COT Console and associated test equipment
BHEL Haridwar : A technology power house
Haridwar
BHEL Haridwar Unit

Heavy Electrical Equipment Plant (HEEP)

Central Foundry Forge Plant (CFFP)

Pollution Control & Research Institute (PCRI)
New Blade Shop

Over speed balancing tunnel for balancing of large rotors of Turbines and Generators
BHEL Haridwar Facilities: An overview

Single Spindle 5 Axis M/c

Double Spindle 5 Axis M/c
BHEL Haridwar Facilities: An overview

Three Spindle 5-Axis M/c

Machining Centers
BHEL Haridwar Facilities: An overview

Forging at Central Forge & Foundry Plant Haridwar

Steel Melting Shop: Central Forge & Foundry Plant Haridwar
Way Ahead: Upcoming projects & new opportunities
## WAY AHEAD : UPCOMING PROJECTS

<table>
<thead>
<tr>
<th>Particular</th>
<th>30mm Naval Surface Gun</th>
<th>127mm Medium Caliber Gun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>Indian Navy/ Coast Guard</td>
<td>Indian Navy</td>
</tr>
<tr>
<td>Quantity</td>
<td>118</td>
<td>13</td>
</tr>
<tr>
<td>FF</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>SKD</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>CKD</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>IM</td>
<td>86</td>
<td>9</td>
</tr>
<tr>
<td>RFP Issued</td>
<td>September 4, 2015</td>
<td>RFP-1: Nov 12, 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RFP-2: Mar 21, 2014</td>
</tr>
<tr>
<td>Bid Submission</td>
<td>March 8, 2016</td>
<td>RFP 1: Mar 12, 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RFP 2: Sept 5, 2014</td>
</tr>
</tbody>
</table>
UPCOMING PROJECTS

30mm Naval Surface Gun with EOFCS (MoD RFP)

- High accuracy and effectiveness for day and night operations
- Main armament for small size vessels
- Secondary armament for larger ships
- No deck penetration & Simpler Installation
- Suitable for NATO std 30mmx173 ammunition family
- Bi-axial stabilized NSG(EOD and Gun)
- Fire control functions with help of EOD and FCS(Ship)
- An Electro-Optic Device (EOD) with viewing devices fully stabilized in elevation and azimuth axes
- FCS provides complete ballistic solution including dynamic roll compensation for enhanced hit probability
- ROF : More than 200 rds per min
- Weight of Gun System less than 2000 Kg
- Maximum effective Range greater than 3 Km
- Suitable for various types of ammunition : TP, HE, tracer, armour piercing etc
- Interfacing with Ship Gyros, Log and anemometer
Upcoming Projects

- 30mm Naval Surface Gun with EOFCS
- Remote Control Stabilized Weapon System Architecture
127/64 mm MEDIUM CALIBER GUN SYSTEM

- State of art medium caliber gun for large and medium ships for surface fire and naval fire
- Suitable for all standard NATO ammunition
- Light weight & High reliability
- Low Radar Cross Section
- Full Automatic Operations
- Low time to Maintenance and Repair
- Digital/analog interface
- Smooth integration with any Combat Management System
127/64 mm MEDIUM CALIBER GUN SYSTEM

- Low time to Maintenance and Repair
- Equipped with Modular feeding magazine
- Reloading during firing
- Ammunition flow is reversible
- Striking down of ammunition for next engagements
- Automatic Ammunition Handling System (AAHS) for ammunition as an option
New opportunities in upgrades

76/62 SRGM STRALES

- Increased flexibility to manage different types of ammunitions
- Guidance system for the DART guided projectile
- Standard supply includes the new Digital Control Console (DCC) capitalizing the digital technology to increase the functions available to the operator and to the maintainers
- Automatically handling & selection of different kind of ammunitions contained in each branch;
- Both branches can be alternatively connected to the hoist
- Movement of ammunition in the branches is reversible
- Multi Feeding Control Box manages Multiple Feeding System.
- Servo Motor Feeding controls the brushless motors to manage the movement of each branch in the feeding, loading and firing actions
- Local Panel controls the local operations to the feeding branches, unload ammunitions, remap and select a particular ammunition.
# New opportunities in upgrades

## 76/62 SRGM STRALES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 SR MF</td>
<td></td>
</tr>
<tr>
<td>Rate of Fire</td>
<td>120 rds/min (tolerance ±5%)</td>
</tr>
<tr>
<td>Service rounds</td>
<td>76 stored in the 2 branches</td>
</tr>
<tr>
<td></td>
<td>90/91 with Automatic Feeding System completely loaded</td>
</tr>
<tr>
<td>Weight (without ammunition)</td>
<td>8300 kg (tolerance ±5%)</td>
</tr>
<tr>
<td>Training arc</td>
<td>± 160°</td>
</tr>
<tr>
<td>Elevation arc</td>
<td>-15° to +85°</td>
</tr>
<tr>
<td>Servo performance</td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>Max speed: 1 rad/s, Max acceleration: 1.25 rad/s^2</td>
</tr>
<tr>
<td>Elevation</td>
<td>Max speed: 0.6 rad/s, Max acceleration: 1.25 rad/s^2</td>
</tr>
</tbody>
</table>
Challenges in indigenization
Challenges in Indigenization

- Requirement of high capital for absorption of critical technology
- Economy of scale.
- Cyclicality of business in-flow
- Long gestation period of projects
- Time and cost overruns due to delayed contract finalization
- Limited depth of Transfer of technology which warrants close association between R&D organizations and PSUs.
- Limited collaborative research/partnership /JV between Defence R&D organizations and PSUs other than DPSU
- Technology transfer from OEMs does not cover know-whys
- System integration on-board with other systems supplied by different vendors
Challenges in Indigenization

• In absence of Long-term commitment regarding regular inflow of orders, makes it difficult to commit new resources

• Time for bid submission vis-à-vis looking for technology partners and finalizing scope and investment share

• Higher the component of indigenous work share, cost may be more.

• Taxes and duties for imports against orders of IN, ICG (recently withdrawn wef April 1, 2016)
Thank you!

Powering Progress…
…Brightening Lives