Not Your Father’s 105

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General Dynamics Land Systems
Agenda

1. Introduction
2. Integrated Systems Approach
3. Integrated System Approach Benefits
4. 105mm Howitzer System
5. Benefits to the Customer
6. Conclusions
1. Introduction

- It was realized in the late 70’s and early 80’s that Artillery products (sub-systems) could not be developed in isolation of the system or each other.
- To launch a projectile consistently, all aspects of the launch had to be under control.
- The interaction between the different sub-systems in a system is too big a factor to ignore.
- Cost and time to re-develop because of compatibility problems between sub-systems is too high.
1. Introduction Continued

To launch a projectile consistently, the following must be under control:

– A good ram with small variations
– Controlled ignition of the charge by the primer
– Controlled combustion cycle
– Consistent shot start characteristics
– Normal wear pattern of barrel
– Small muzzle velocity variation
– Small pressure variation
1. Introduction

- Longstanding 105mm Deficiencies
  - Lack of range
  - Lack of lethality
1. Introduction

2. Integrated Systems Approach

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2. Integrated System Approach

- A system designer must work according to a system hierarchy that is based on different system levels.

- Level 5 is the system level where all level 4 sub-systems (products) are integrated into an usable system.

- The following slide shows a system hierarchy.
<table>
<thead>
<tr>
<th>SYSTEM NAME</th>
<th>LEVEL</th>
<th>CONFIGURATION EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Force</td>
<td>8</td>
<td>Navy, Airforce, Army</td>
</tr>
<tr>
<td>Combat Grouping</td>
<td>7</td>
<td>Facilities, Combat Team</td>
</tr>
<tr>
<td>User System</td>
<td>6</td>
<td>LWT, Cannon, Crew, Facilities</td>
</tr>
<tr>
<td>Products System</td>
<td>5</td>
<td>G6, Fire Control, Recovery, Ammo, Logistics</td>
</tr>
<tr>
<td>Product</td>
<td>4</td>
<td>G6, Charges, Projectiles, Recoil Mechanism</td>
</tr>
<tr>
<td>Product Subsystem</td>
<td>3</td>
<td>Fuze, Charge, Projectile, CC, FRD</td>
</tr>
<tr>
<td>Component</td>
<td>2</td>
<td>Steel Forging, Cotton Linter</td>
</tr>
<tr>
<td>Characteristics, Material / Process</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Diagram showing the system hierarchy with images and examples.
To follow the Integrated Ballistic System Approach, the following logical points have to be taken into account and adhered to:

- Inter-dependence of sub-systems
- Optimization of the ballistic system
- System Engineering
2.1 Inter-dependence of sub-systems

The following sub-systems are applicable to an artillery system with each consisting of its own sub-systems:

- **Ammunition** - This includes all the different projectile types (HE, Carrier, DPICM), fuze types (mechanical, electronic), fuze setters, charge systems and primer.
- **Gun** - The gun includes the barrel, breech, muzzle brake, recoil, trunnion, etc.
- **Weapon Platform** - The weapon platform includes the vehicle, the dynamic influences, stability, etc.
- **C4I** - This includes the Command and Control, Communication, Target Acquisition, Fire Control, Meteorology, etc.
- **Logistics** - Includes all the logistic aspects of the system (packaging, maintenance, etc.)
Sub-systems of a ballistic system

MAIN WEAPON

FUZE

SHELL

BB

CHARGE

PERCUSSION TUBE
2.2 Optimizing a Ballistic System

- The inter-dependence of the sub-systems are to be taken into account during development.

- Optimization of a ballistic system during development is a complex process.

- Optimization commences with the development of the level 4 sub-systems.

- A lot of measurements are done and analyzed during the development tests to determine if any unwanted behavior exists.
2.2 Optimizing (cont.)

- If any unwanted behavior was detected, possible solutions are proposed and the testing with the upgraded design proceeds.

- The spider web concept of action/reaction is illustrated very well at this point:
  - If you tweak one parameter, it will always influences the system elsewhere (just like a spider web, the whole web moves when it is disturbed at one point).
2.3 System Engineering

- Important to adhere to the system engineering principles as part of the integrated system approach.

- Interface management is a pre-requisite for successful system development.

- Change management is to be controlled tightly.

- Before a change may be implemented on a sub-system, the change should be evaluated and approved by the system authority to ensure that the implementation of the change will not have a negative effect on the performance of the system.
1. Introduction

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3. Integrated Approach

Benefits

The following benefits can be listed as a result of the integrated system approach:

- One common ammunition system
- A system is developed which conforms to the system requirement
- Optimized system
3.1 One Common Ammunition System

- Different ammunition systems can be developed with certain common modular sub-systems.
- Projectiles can accommodate the same Fuzes, Payloads and Base Bleed motors.
- Projectiles can be optimized to fly the same even though there are variations in length and weight.
Ballistically matched projectiles with the same boat tails/ base bleeds and fuzes, but with different weights and lengths
105mm Modular Charge System

- Five uni-charge increments for tactical use
- Based upon proven 155mm MCS currently in production
- Uni-charge offers ease of logistics and reuse of all increments
- Linked charges for ease in handling
3.2 System Requirement as Input

- A system is being developed with a system requirement as input.

- This implies that the sub-systems are developed to comply to the same set of system requirements.

- In some cases the set requirements can not be met due to the law of physics:
  - An example is the trade off between minimum and maximum range. If a Customer wants 3km minimum range and 30km maximum range with a modular charge system, it is not possible to keep within the pressure budget at the top and not get propellant and cartridge case that don’t burn out (slivers and residue in chamber and barrel after a shot) with the bottom charge.
3.2 System Requirement as Input (cont.)

- All the sub-systems are evaluated and tested in the system context during development to measure the sub-system performance against the system requirement.
- A sub-system cannot be developed in isolation of the system.
- The system is optimized regarding the performance and cost within the scope of the set requirements.
- Interfaces between the sub-systems are developed and managed to ensure optimum performance and reliability within the set system requirements.
- The test bed with which development is done, should be representative of the gun/platform until qualification is complete.
- The test gun should remain at a level where it represents the final system dynamically.
3.3 Optimized System (cont.)

- JBMoU requirements should be seen as a physical interface tool.

- This implies that the projectile of one supplier will fit in the barrel of another, the charge system of a third supplier will fit the chamber and the fuze will fit the cavity of the projectile and it will be safe to fire.

- It does not mean that the system or any of the sub-systems will perform to specification. There are too many characteristics within a system that have an influence on the level 4 sub-systems and this should be optimized during the development phase.
GENERAL DYNAMICS
Land Systems

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4. 105mm LEO Towed Howitzer

- Using the system approach, DENEL began a 105mm Howitzer Program in 1996 to correct the noted 105mm deficiencies
- The armament system, the projectile system and the propellant system were developed to meet a system specification
The 105mm Specification

- The GDLS/DENEL system specification required:
  - Light weight
  - 155mm range
  - 155mm lethality
105mm System Specification Solution

- 4-30 km range ammunition
- Modular charge system (MCS) like the 155mm MACS
- Projectiles which are ballistically matched
- Fragmentation lethality BETTER than 155mm HE
- Ammunition weight of 48 pounds
- Same armament for both towed and self-propelled versions
- System (cannon, projectiles, and propellant) tuned to provide the most efficient and effective solution

Efficient, Lethal and Light Weight Solution
GD/DENEL 105mm LEO Cannon

Same cannon for both SP and towed versions

- Barrel: 52 Caliber with 5 Caliber Muzzle Brake
- Breech: Swing & Slide
- Recoil: Dual Concentric
- Recuperator: Gas Filled
105mm IGALA Ammunition Suite

- All projectiles are ballistically matched
- Range
  - 24 km with boat tail
  - 30 km with base bleed
- Visual or Infrared (IR) Illumination
- Bi-spectral Smoke (visual and IR)
- Available with Insensitive Munitions

Only one firing table needed for all projectiles!

GDLS/DENEL Proprietary
105mm PFF HE

155mm HE

100% LETHAL AREA:

105mm PFF HE: 1,684 m²

155mm M107: 1,015 m²

66% Greater Lethal Area for 105mm PFF Versus 155mm M107
Greater Lethality Against Personnel and Light Skinned Vehicles

105mm PFF HE (58 strikes)
155mm HE (3 strikes)

Unparalleled performance against “soft” targets!
105mm Modular Charge System (MCS)

- Modular charge system developed by GD / DENEL
- Five uni-charge increments for tactical use
- Based upon proven South African 155mm MCS currently in production
- Uni-charge offers ease of logistics and reuse of all increments
- Linked charges for ease in handling
Range Advantage

M119
With M2020 PFF HE

EFEC 105mm

M1 HE
11.5 Km

M760 HE
14.4 Km

15.5 Km
Boat Tail

18.4 Km
Base Bleed

M913 HERA
19.5 Km

BT = Boat Tail
BB = Base Bleed

Delivers HE, Smoke and Illum to 30 km

Range Increase Without Rocket Assist
Double the Range With Rocket Assist
Accuracy

105mm LEO Howitzer Accuracy Data

- Boat Tail (24,000 meters)  \( PE_{(R)} < 0.3\% \)
  \( CEP < 80 \text{ meters} \)
- Base Bleed (30,000 meters)  \( PE_{(R)} < 0.4\% \)
  \( CEP < 120 \text{ meters} \)

The Payoff -

- Better CEP equals fewer rounds expended to attack target
- Better lethality equals fewer rounds needed to destroy, neutralize or suppress target
- Logistical efficiency is enhanced requiring < 1/2 the tonnage / volume of ammunition for a 155mm SPH
Fire Support

**DENEL 105mm PFF HE**

Better lethality + smaller danger & collateral damage footprints = **BETTER FIRE SUPPORT!**
## GDLS 105mm Advantage

- **30 km unassisted range ammunition**
- **Fragmentation lethality BETTER than 155mm HE**
- **Ammunition weight of 48 lbs vs 126 lbs for the 155mm**
- **Fires all current US 105mm artillery ammunition and new ACA²P ammunition and the modular charge system**
- **Same armament for both towed and SP versions**
- **System (cannon, projectiles, and propellant) tuned to provide the most efficient and effective solution**
- **No spades required – ready to fire when stopped**

## Operational Benefits

- **C-130 Transportable:**
  - Without preparation
  - With 26 rounds and ½ tank of fuel
- **Carries 56 rounds on board**
- **Commonality with Stryker**
- **Mobility equal to protected force**
- **Less logistical burden**
- **Better fire support to units in contact**
GDLS / DENEL 105mm Towed Howitzer

- 6400 mil Capability
- Direct Fire > 3 km
- Indirect <4 to 30 km
- Air Droppable
- UH-60L High/Hot
- HMMWV Prime Mover

- 24-30 km Range
- 4300 Pounds
- 6400 mil Capability
- Fires US and DENEL Ammunition
- Digital Fire Control (TAD-like)
### Unique Advantages

#### 105mm vs. 155mm M777

<table>
<thead>
<tr>
<th>Gun Type</th>
<th>Weight, kg</th>
<th>Rounds</th>
<th>Total Weight, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>155mm M777 plus 100 rounds</td>
<td>4100</td>
<td>5300</td>
<td>9400</td>
</tr>
<tr>
<td>105mm EFEC plus 100 rounds</td>
<td>1950</td>
<td>2200</td>
<td>4150</td>
</tr>
</tbody>
</table>

**A Weight Savings of 5250 kg is Significant!**

Twice the Gun and Ammo at the 155mm Weight!
SADF 105mm Program

• Program Status
  – Start 2004-requirements definition
  – Hardware acquisition 2006
  – Armament system qualification
    • Start June 2006
    • Will use Stryker 105mm armament system for qualification firing
    • Qualifies to US standards
  – Hardware acquisition – 2006/2007
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5. Benefits to the Customer

- The benefits for the Customer due to the Integrated Ballistic System Approach are:
  - The Customer buys an optimized system. All the sub-systems are developed within the system concept and it ensures that the system conforms to the set system requirements.
  - The Customer can be assured that the system conforms to the set requirements and there will be no surprises with regards to sub-systems that does not perform according to specification.
  - The Customer can be assured that in the unlikely event of a failure occurring with the system, an investigation is launched at system level and the problem solved through the integrated system approach.
  - Through the integrated system approach during an investigation, the root cause will be identified and rectified. This solution will be qualified up to system level 5
Benefits to the Customer
(cont.)

- This approach will reduce the risk for the Customer and may have a positive effect on the program schedule.

- If the different sub-systems are bought from different suppliers, someone must be responsible to integrate the system and will then be held responsible if a failure occurs or the system does not conform to specification.
Meets All Requirements of Operation Iraqi Freedom Field Artillery
Lessons Learned

• Deliver HE with high precision
• Shoot long range
• Limit collateral damage
• Increase rate of fire
• Reduce logistics tail
6. Conclusions

- The speaker tried to illustrate the importance of the Integrated Ballistic System Approach to ensure a successful Artillery system.

- If a sub-system is developed in isolation of the final system, it will not be optimized and the chance for a failure (even a critical failure) is excellent.

- GDLS/DENEL embrace this philosophy of an integrated system approach as a result of experience gained through the years of developing artillery systems. This approach cannot be replaced by another approach if the Customer is serious about his system.
Light, Lethal, Mobile and Air Transportable

Not your father’s 105mm!
The General Dynamics Artillery Team

- GD Land Systems (GDLS)
  - Systems Engineering - GDLS
  - Prime Movers - GDLS Canada
- GD Ordnance and Tactical Systems (GDOTS) / DENEL-Naschem / DENEL-Somchem
  - 105mm Projectiles and Modular Charge System
- GD Armament and Technical Products (GDATP) / Western Design / Vista Controls
  - Projectile and Propellant Ammunition Handling Systems
- GD Canada
  - Digital Fire Control System and Interface with AFATDS
- DENEL Land Systems Lyttelton
  - 105mm Cannon and Turret
- SAGEM-IR sights
- Honeywell-Inertial Navigation System (INS)
THANK YOU