



Not Your Father's 105

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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**





Agenda





















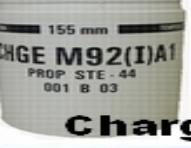



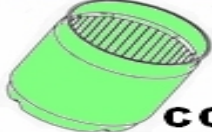

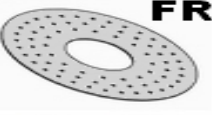


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2. Integrated System Approach

- 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 useable system.
- The following slide shows a system hierarchy.

THE SYSTEM HIERARCHY

SYSTEM NAME	LEVEL	CONFIGURATION EXAMPLES
Operational Force	8	 Navy  Airforce  Army
Combat Grouping	7	    Facilities Combat Team
User System	6	 LWT  Cannon  Crew  Facilities Facilities
Products System	5	 G6  Ammo  Fire Control  Recovery   Logistics
Product	4	 G6  Charges  Projectiles
Product Subsystem	3	 Charge  Fuze  Projectile  Recoil Mechanism
Component	2	 CC  Propellant  FRD
Characteristics, Material / Process	1	 Steel Forging  Cotton Linter



Integrated System Approach (cont.)

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

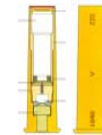


2.1 Inter-dependence of sub-systems

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





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 influence 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.



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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.

IGALA Family of Projectiles For 105mm



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.



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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**





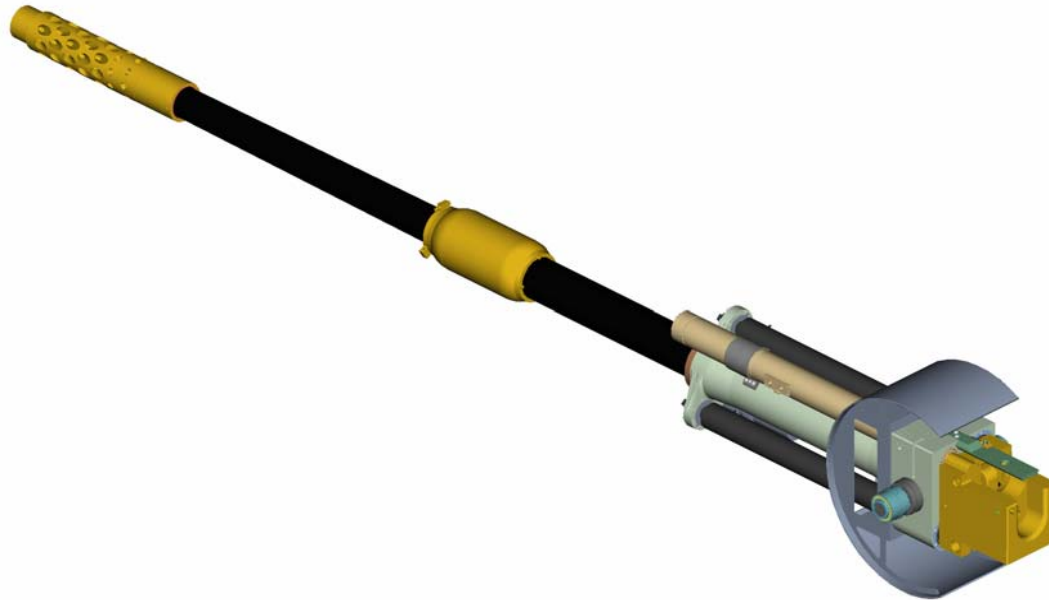
105mm System Specification Solution

- 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



SP Cannon

- Barrel 52 Caliber with 5 Caliber Muzzle Brake
- Breech Swing & Slide
- Recoil Dual Concentric
- Recuperator Gas Filled

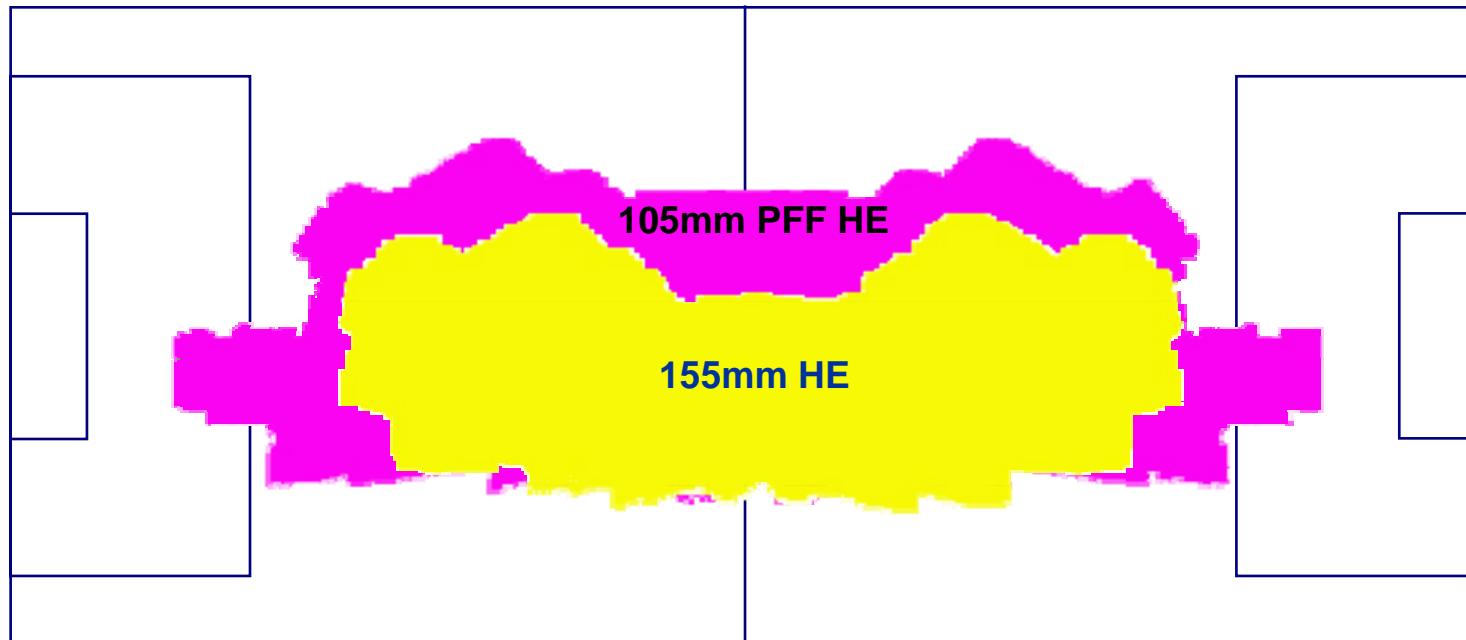
105mm IGALA Ammunition Suite

- 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!*

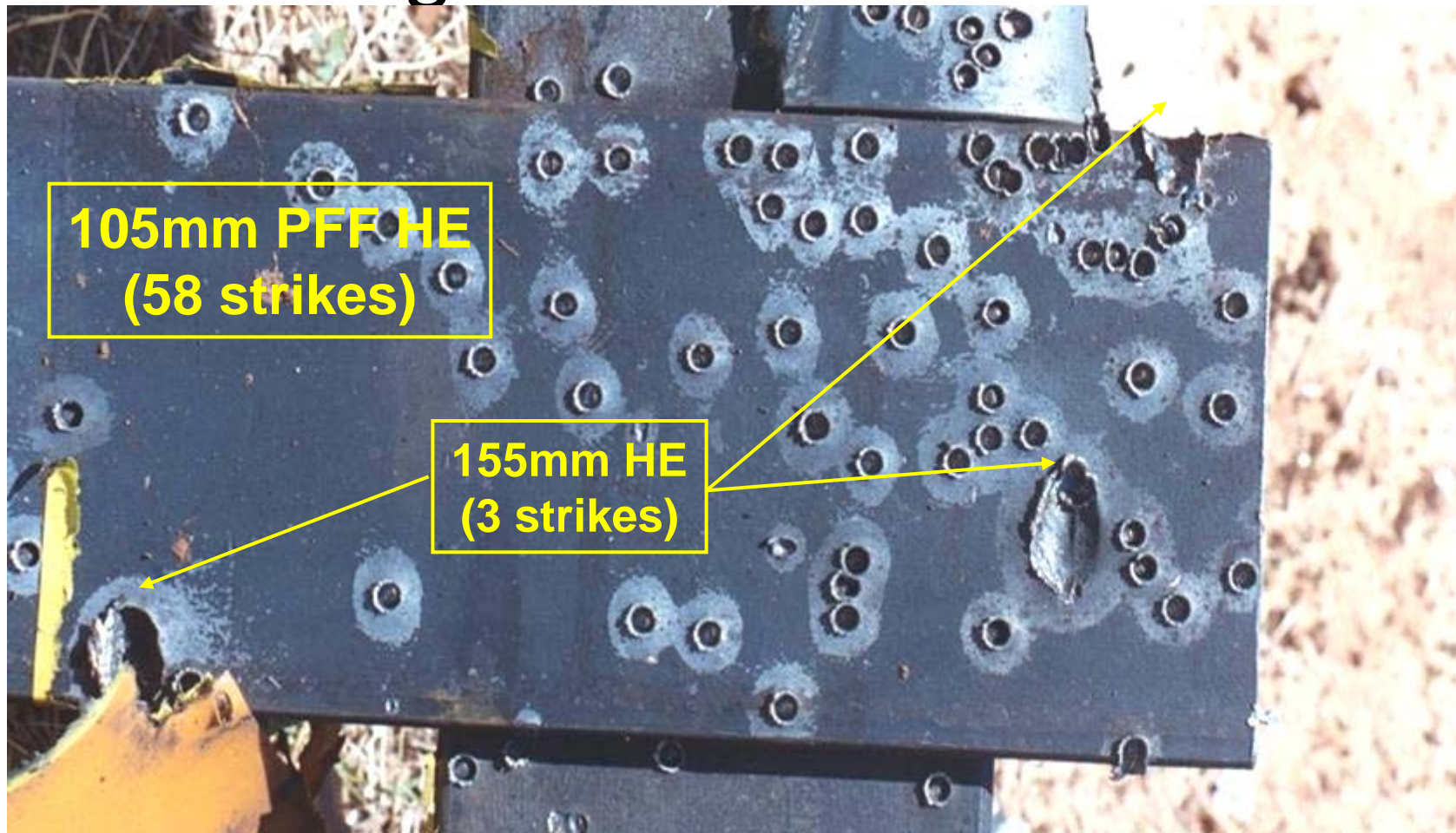
Lethality



100% LETHAL AREA: **1,015 m²** **1,684 m²**
155mm 105mm

**66% Greater Lethal Area for 105mm PFF
Versus 155mm M107**

Greater Lethality Against Personnel and Light Skinned Vehicles



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

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

**Delivers
HE, Smoke
and Illum
to 30 km**



EFEC 105mm

BT = Boat Tail
BB = Base Bleed

24 Km BT
M2020 PFF HE
M2019 HE
M0101 Smoke
M0102 Illum
M0102 Prac

30 Km BB
M2020 PFF HE
M2019 HE
M0101 Smoke
M0102 Illum
M0102 Prac

40 km VLAP
HE

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



Accuracy



105mm LEO Howitzer Accuracy Data

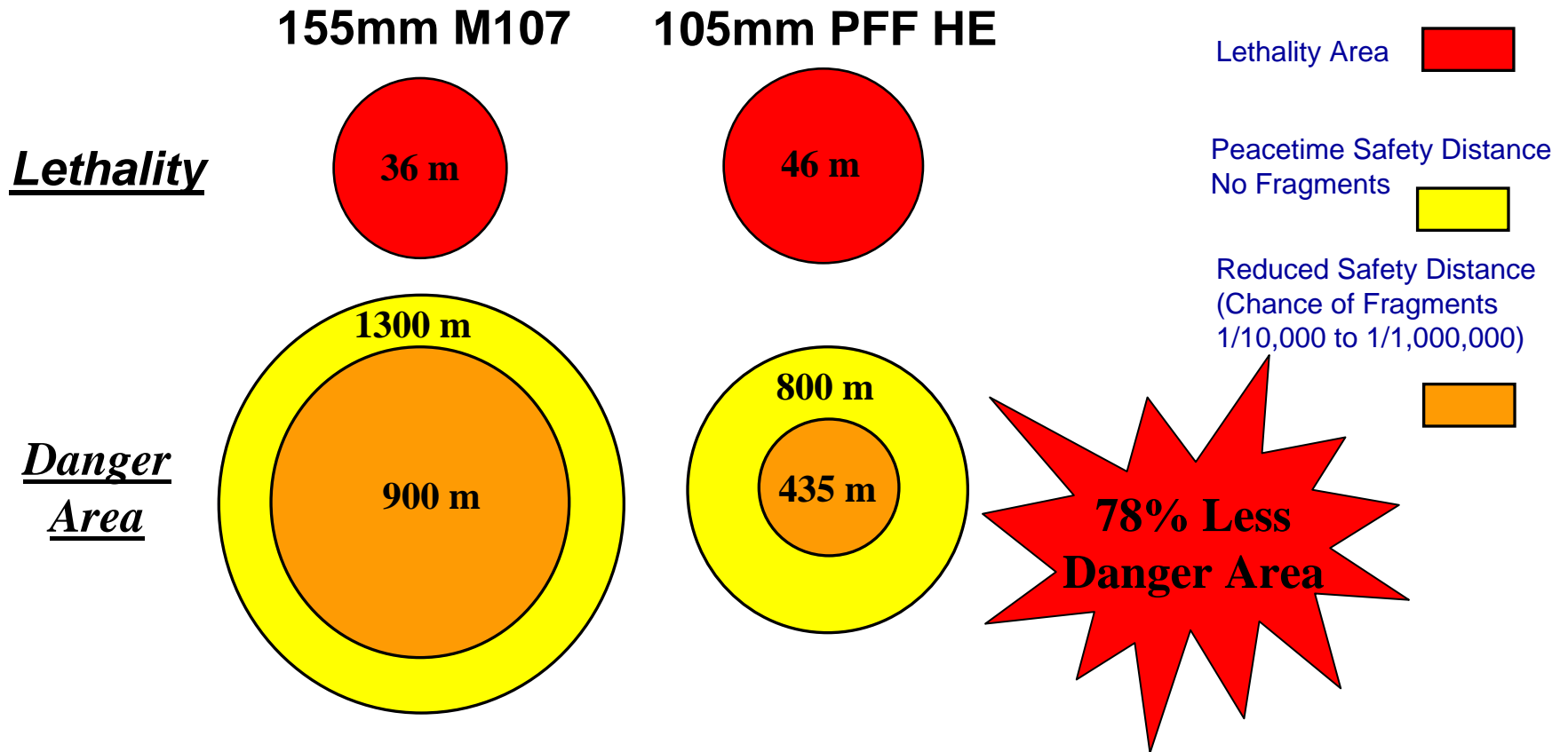
- Boat Tail (24,000 meters) $PE_{(R)} < 0.3\%$
CEP < 80 meters
- Base Bleed (30,000 meters) $PE_{(R)} < 0.4\%$
CEP < 120 meters

The Payoff -

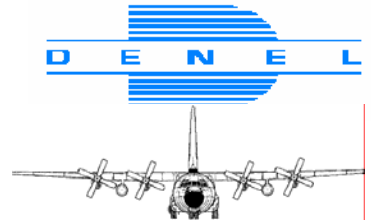
- Better **CEP** equals fewer rounds expended to attack target
- Better **lethality** equals fewer rounds needed to destroy, neutralize or suppress target
- **Logistical efficiency** is enhanced requiring **< 1/2** the tonnage / volume of ammunition for a 155mm SPH



Fire Support



DENEL 105mm PFF HE
Better lethality + smaller danger & collateral damage footprints = **BETTER FIRE SUPPORT!**



105mm Stryker SPH

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

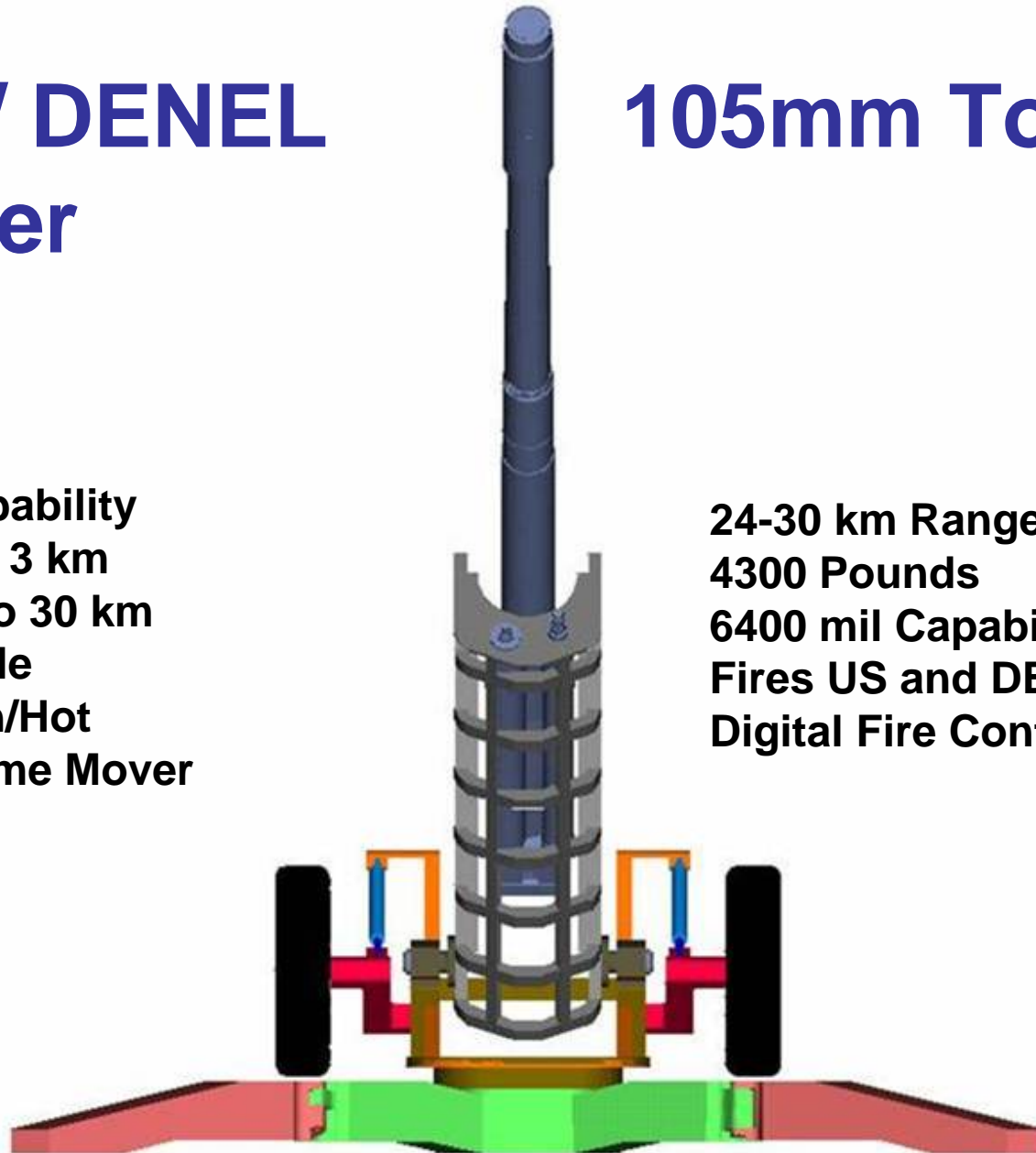


GDLS / DENEL Howitzer

105mm Towed

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

155mm M777 plus 100 rounds



4100 kg



5300 kg

Total system weight: 9400 kg

105mm EFEC plus 100 rounds



1950 kg



2200 kg

Total system weight: 4150 kg

*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!

GENERAL DYNAMICS

Land Systems

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)



GENERAL DYNAMICS

105mm Transformational Artillery Team

Land Systems

Land Systems - Canada

Ordnance and Tactical Systems

Armament and Technical Products

GD Canada



GENERAL DYNAMICS
Land Systems



THANK YOU