S&T Activities in Support of the Canadian Small Arms Replacement Program

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Canadian Forces Soldier System Vision

The Soldier as an integrated weapons platform: a "System of Systems"
Small Arms Replacement Program

- Acquisition valued at over $1.0 B
- Aim:
  - To replace or modernize CF small arms inventory and associated ammunition and fire control systems
  - To deliver a modern, networked, integrated direct fire, multi-effect, portable anti-personnel and anti-material capability that includes weapons, fire control, munitions, training systems and logistic support for the CF in the 2012 to 2022 period (CF SRB 21 Sept 2007)
- Timeline:
  - Project 1 – Acquisition of pistols, Canadian Ranger’s rifle, Weapon sights, Weapon accessories
  - Project 2 – Acquisition of a Personal Defence Weapon (PDW), Tactical Shotgun, Grenade Launcher System, Naval boarding party weapons, breaching systems and hand grenades; and
  - Project 3 – Modernization / replacement of the CF Individual Combat Weapon capability
Major S&T Activities Supporting Small Arms Replacement Program

Statement of Operational Requirements (SOR) Development Effort

- Objectives
  - Develop science-based operational requirements for CF man portable future direct fire capability (FDFC) as part of the Small Arms Replacement Program

- Components
  - Soldier Integrated Precision Effects System (SIPES) Technology Demonstration Project to explore system integration issues (financed)
  - Applied Research Projects (ARP) to build up knowledge and technology base
  - Engineering Development Models (EDM) to integrate the results of SIPES, ARP, and SSTRM in TRL 8 level systems

Soldier Systems Technology Road Map (SSTRM)

- Objectives
  - To develop a comprehensive technology roadmap (TRM) that will support the Canadian Forces soldier modernization effort using Industry Canada TRM framework: a fair and transparent process open to all stakeholders (financed)
  - Much larger than soldier weapons
Soldier Systems Technology Roadmap Project

- **Government Role**
  - To provide Industry and Academia with an equal opportunity to be aware, understand and discuss future DND needs

- **Industry/Academia Role**
  - To provide DND insight on novel technologies maturing in 3-15 year and leading to potential important increases in soldier capabilities
  - Industry plays an integral role in the TRM process

- **Soldier Systems TRM Process**
  - Visioning and technical workshops
    - 6 including lethal and non-lethal weapons
  - Novel Collaboration Tool (ICee)
    - Innovation Collaborative Exchange Environment
    - Public/Password controlled data base / Wiki
      - "http://soldiersystems.collaboration.gc.ca"
  - R&D projects aligned with identified priorities
SIPES Technical Strategy

PHASE 1: SYSTEM CONCEPT DEFINITION
- Capability parameter space
- Capability requirements
- Capability constraints
- Capability integration concept drivers
- CF Needs, Priorities, and Directives / Scenarios
- Technology reviews

PHASE 2: SYSTEM CONCEPT DEVELOPMENT
- Concept
- Functional Prototypes
- Spiral Technologies to Operation

Why? and When? Not just What?

EVALUATION PROCESS
- Multi-Criteria Decision Analysis
- Workshops
- Operational Research Analyses
- Lethality & Vulnerability Modelling
- Physics Based Modelling
- Laboratory and Field Experiments
- User Consultations and Field Trials
SIPES ICW Integrated Weapon System Concept

1) Seamless, soldier system integration with graceful degradation (Power, communications, information, mechanical)

2) Mission reconfigurable optimized for integration and modularity

3) Integrated power and data distribution

4) Weight and balance optimized electronic weapon platform

5) Optronic/optical multi-sensor sight with image fusion, HMD capability, video capture and wireless transmission

6) On board automatic target cueing and FCS with assisted target engagement for kinetic and grenade rounds

7) Networked weapon (BMS) with seamless target handoff, video and data transmission and integrated global and cardinal positioning

8) Semi-automatic, recoil compensated grenade launcher/shotgun with electronic initiation

9) Integrated non lethal capabilities for escalation of force

10) On board service life and logistics monitoring

11) On board integrated training system

Full sub-system support

ICW Integrated System Concept

Affordability
Cost Benefit Analysis

SIPES

R & D pour la défense Canada  •  Defence R&D Canada
SIPES ICW Platform Concept

Electrical and Data System Architecture

Enterprise
- Sub-systems
- Target DR and Cueing
- FCS and BMS Sensors

Power and Data Rail
- FCS and Ballistic Computer
- Removable Primary Battery
- Dynamic Power Management

Weapon Management System / Internal Bus
- Secondary Battery
- Manual Ignition System
- Primary Ignition Circuit 5.56 mm
- Primary Ignition Circuit 40 mm
- Primary Ignition Circuit 12 gauge

ISSP Power Bus
- Ignition signal
- Power
- Data
SIPES ICW Platform Concept

Operational Objectives

- Increased mission effectiveness through
  - Weapon configuration flexibility (mission configurable)
  - Integrated escalation of force
  - Soldier networking
  - Optimized usage of electrical power
- Increased lethality through
  - Increased accuracy
  - Increased fragmenting round capability
- Increased usability through
  - reducing total carriage
  - optimizing weapon system handling

A weapon platform with the capability to maximize the use of future technological innovations
Overview of SIPES Plan

Primed by Colt Canada
- Canadian Partners: GD-OTS Canada and HSI Inc
- Potential International Partners: Caseless Technology AG, Metal Storm

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Selected Thoughts from Phase 1 of SIPES
The Issue of Weight and Balance

- Weight constraints
  - Total carriage
  - Weapon system effectiveness
- Total Carriage
  - Average soldier carries 10.8 kg over maximum allowable (26.2 kg)
  - Weapon and ammunition accounts for 24% of total weight (8.9 kg)
- Weapon System Effectiveness
  - NATO RTO studies indicate that
    - 5.35 kg is completely acceptable
    - 6.83 kg is somewhat acceptable depending on CG
  - Present weight of C7 + 2 Mags + C79 is 5.09 kg
  - Present weight of C7 + 2 Mags + C79 + M203 + Ammo is 7.42 kg
- Weight is an issue for a future weapon system with increased capability
The Argument for Electronic Ignition

- Kinetic Round
  - Increased control of automatic/burst fire with more rounds on the target
  - Increased accuracy under all conditions with automatic target cuing and assisted target engagement

- Fragmenting Round
  - More and faster delivery of rounds on target
    - With minimum weight penalty (innovative technological approach)
    - Without taking eyes off target
  - Firing from behind cover through seamless connectivity between launcher and FCS

- System
  - Enhances level of system integration
  - Provides flexibility in weapon configuration
  - Provides potential technical solutions for caseless ammunition
    - Chamber sealing (firing pin)
    - Cook-off (temperature sensors)
    - Light percussion
Characterization of Electronically initiated caseless ammunition

Objective

- Determine whether available electronically initiated caseless (EIC) ammunition technology is acceptable for a weapon platform prototype
- Evaluate key parameters applicable to weapon system design – chamber pressure profile, lock time, action time, accuracy, cook-off, ...

Results for non-telescoped rounds

- Muzzle velocity variation: $\sigma_{\text{EIC}}/\sigma_{\text{Stnd}} = 0.7$
- Consistency: $\sigma_{\text{EIC}}/\sigma_{\text{Stnd}} = 0.5$
- Lock time + action time: $t_{\text{EIC}}/t_{\text{Stnd}} = 0.45$
- Still need to evaluate telescoped ammunition

![Graphs and images showing pressure profiles and dispersion data.]
Automatic Target Cueing (ATC) and Assisted Target Engagement (ATE)

Objective
- Reduce the effect of soldier stress on shot accuracy through assisting the soldier to fire at the optimal time

Concept Exploration
- Preliminary concept demonstration
  - VEC-91 rifle, MOTS TWS, frame-grabbing and thermal target
- ATC-ATE Mod 1
  - Purpose designed TWS with no FCS to be demonstrated on SIPES weapon platform
- ATC-ATE Mod 2
  - Addition of FCS
Assisted Target Engagement Concept Analysis

Objective

- Characterize rifle slew rate, shot delay and general aiming behavior of soldiers to provide design and analysis input for the ATE concept
- Data analyzed was thru sight video from NATO RTO trials using US Marines (significant Canadian participation)
Characterization of Bullet Lethality

Present Effort

- Development of a methodology to experimentally characterize the flight dynamics of bullets
- Development of a methodology to experimentally evaluate the terminal effect of bullets on human surrogates
- Development of a methodology to numerically model the terminal effect of bullets on human surrogates

Canadian version of work done by Joint Services Wound Ballistics IPT
A Methodology to Characterize Bullet Flight Dynamics

Objective
- Develop a measurement methodology and perform preliminary characterization of the yaw behavior of C77 rounds fired under various conditions

Observations
- Significant round-to-round variations
- Cyclical variation with distance confirmed
- Yaw dependence on barrel temperature
- Yaw dependence on barrel type (Mann barrel)

Two orthogonal camera stations
Summary

- The Canadian small arms replacement program is being supported by two major S&T initiatives
  - SOR Development Effort, government directed
  - Soldier Systems Technology Roadmap, industry focused
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