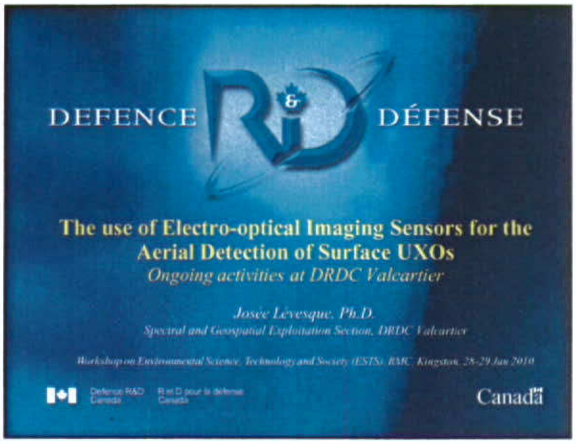
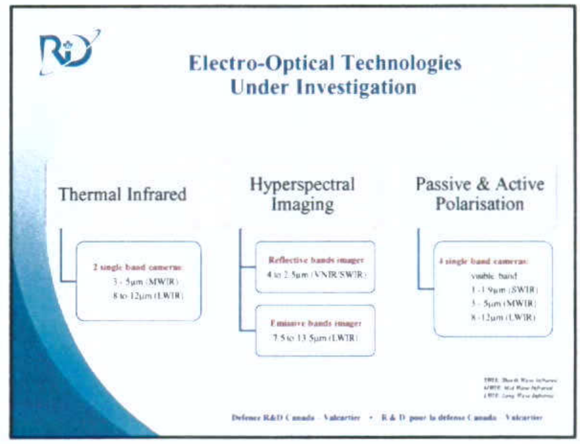
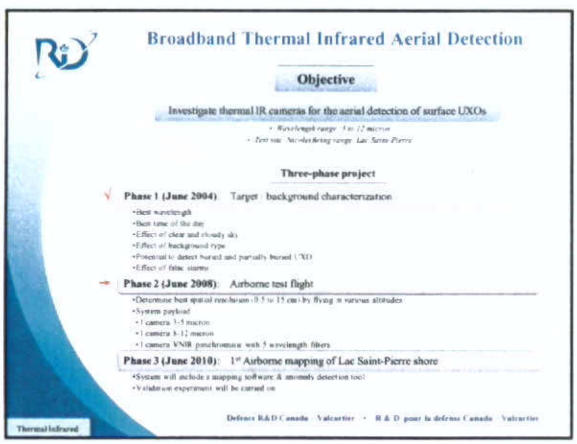
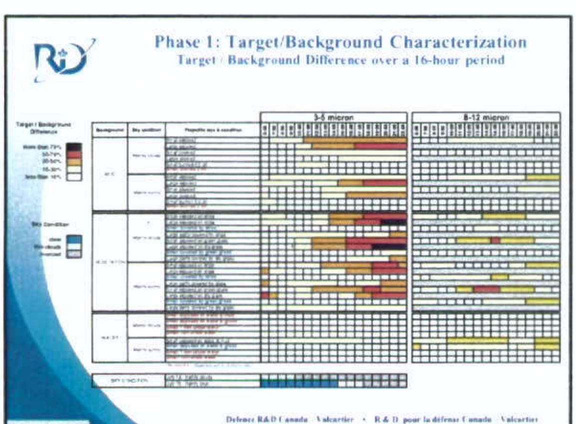
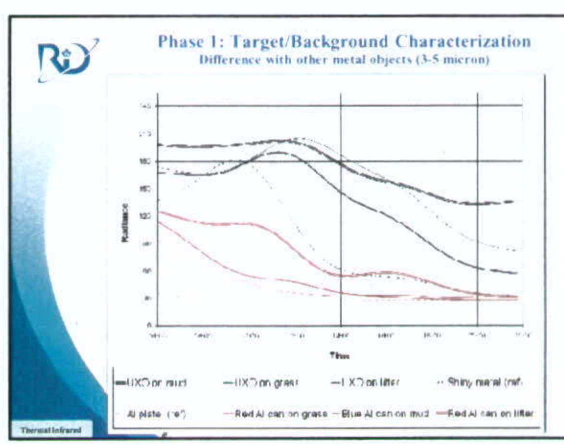

DEFENCE
DÉFENSE
The use of Electro-optical Imaging Sensors for the Aerial Detection of Surface UXOs
Ongoing activities at DRDC Valcartier
Josée Lévesque, Ph.D.
Spectral and Geospatial Exploitation Section, DRDC Valcartier
Workshop on Environmental Science, Technology and Society (ESTS), RMC, Kingston, 28-29 Jan 2010
Canada

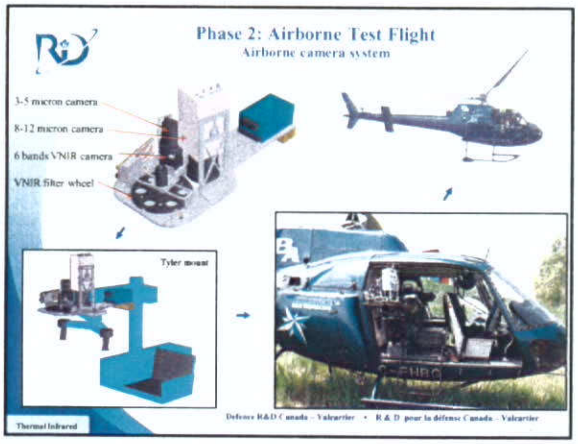

Electro-Optical Technologies Under Investigation
Thermal Infrared
Hyperspectral Imaging
Passive & Active Polarisation
2 single band cameras:
3 - 5µm (MWIR)
8 to 12µm (LWIR)
Reflective bands imager
4 to 2.5µm (VNIR/SWIR)
Emissive bands imager
7.5 to 13.5µm (LWIR)
4 single band cameras:
visible band
1 - 1.9µm (SWIR)
3 - 5µm (MWIR)
8 - 12µm (LWIR)
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier

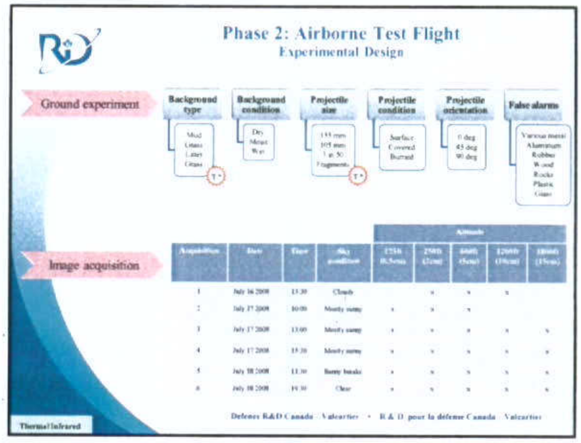

Broadband Thermal Infrared Aerial Detection
Objective
Investigate thermal IR cameras for the aerial detection of surface UXOs
Three-phase project
Phase 1 (June 2004): Target / background characterization
•Best wavelength
•Best time of the day
•Effect of clear and cloudy sky
•Effect of background type
•Potential to detect buried and partially buried UXO
•Effect of false alarms
Phase 2 (June 2008): Airborne test flight
•Determine best spatial resolution (0.5 to 15 cm) by flying at various altitudes
•System payload
•1 camera 3-5 micron
•1 camera 8-12 micron
•1 camera VNIR panchromatic with 5 wavelength filters
Phase 3 (June 2010): 1st Airborne mapping of Lac Saint-Pierre shore
•System will include a mapping software & anomaly detection tool
•Validation experiment will be carried on
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier
Thermal Infrared

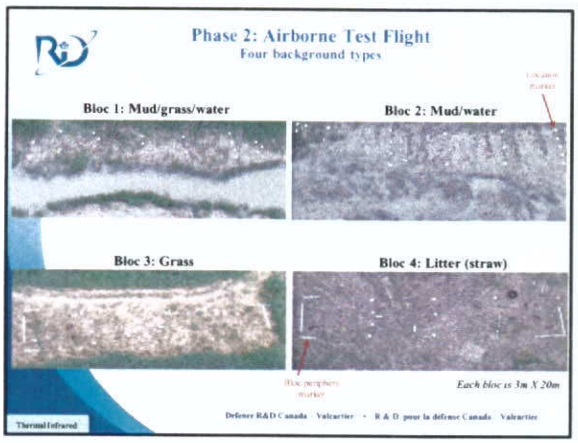

Phase 1: Target/Background Characterization
Experimental Design
Image acquisition
every 15 minutes over
a 16-hour period (6:00 to 22:00)
and a 24-hour period
5 types of background
Straw
Green grass
Dry grass
Mud
Water
1 July 14 2004 06:00 22:00 16 hours Cloudy
2 July 17-18 2004 18:45 18:30 24 hours Mainly clear
Thermal Infrared

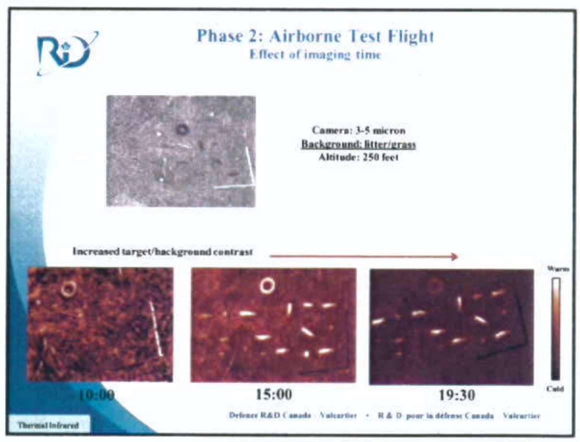

Phase 1: Target/Background Characterization
Target / Background Difference over a 16-hour period
3-5 micron
8-12 micron
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier
Thermal Infrared

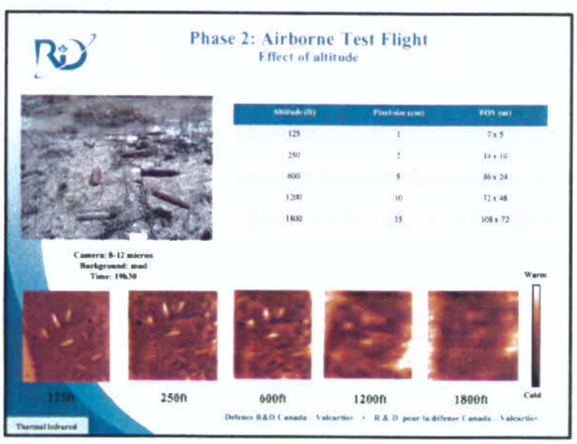

Phase 1: Target/Background Characterization
Difference with other metal objects (3-5 micron)
Radiance
Time
Shiny metal (ref)
Red Al can on grass
Blue Al can on mud
Red Al can on litter
Thermal Infrared

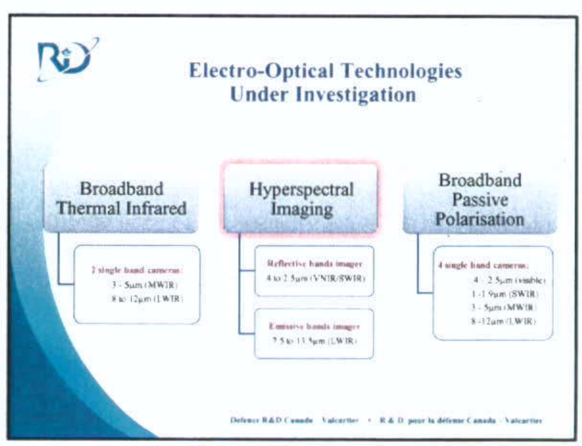

Phase 2: Airborne Test Flight
Airborne camera system
3-5 micron camera
8-12 micron camera
6 bands VNIR camera
VNIR filter wheel
Tyler mount
Thermal Infrared
Defence R&D Canada – Valcartier • R & D pour la défense Canada – Valcartier

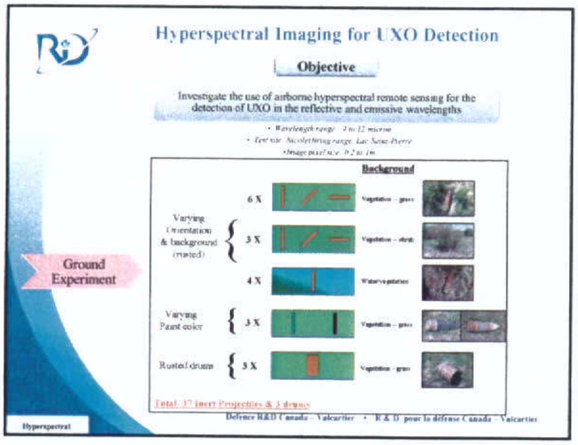

Phase 2: Airborne Test Flight
Experimental Design
Ground experiment
Background type
Background condition
Projectile size
Projectile condition
Projectile orientation
False alarms
Surface
Covered
Burried
0 deg
45 deg
90 deg
Image acquisition
Thermal Infrared
Defence R&D Canada – Valcartier • R & D pour la défense Canada – Valcartier


Phase 2: Airborne Test Flight
Four background types
Bloc 1: Mud/grass/water
Bloc 2: Mud/water
Bloc 3: Grass
Bloc 4: Litter (straw)
Each bloc is 3m X 20m
Thermal Infrared
Defence R&D Canada – Valcartier • R & D pour la défense Canada – Valcartier

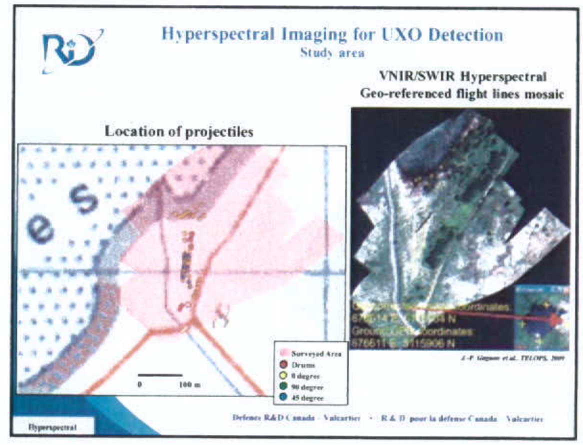

Phase 2: Airborne Test Flight
Effect of imaging time
Camera: 3-5 micron
Background: litter/grass
Altitude: 250 feet
Increased target/background contrast
Warm
Cold
10:00
15:00
19:30
Thermal Infrared
Defence R&D Canada – Valcartier • R & D pour la défense Canada – Valcartier


Phase 2: Airborne Test Flight
Effect of altitude
125 1 7 x 5
250 2 14 x 10
600 5 36 x 24
1200 10 72 x 48
1800 15 108 x 72
Camera: 8-12 micros
Background: mud
Time: 19h30
Warm
Cold
250ft
600ft
1200ft
1800ft
Thermal Infrared
Defence R&D Canada – Valcartier • R & D pour la défense Canada – Valcartier

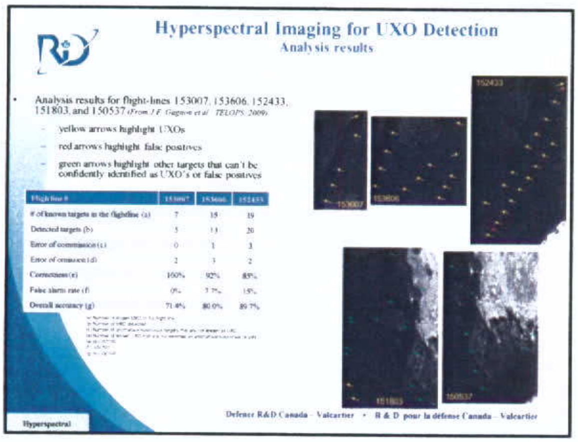

Electro-Optical Technologies Under Investigation
Broadband Thermal Infrared
2 single band cameras:
3 - 5μm (MWIR)
8 to 12μm (LWIR)
Hyperspectral Imaging
Reflective bands imager
.4 to 2.5μm (VNIR/SWIR)
Emissive bands imager
7.5 to 13.5μm (LWIR)
Broadband Passive Polarisation
4 single band cameras:
.4 - 2.5μm (visible)
1 -1.9μm (SWIR)
3 - 5μm (MWIR)
8 -12μm (LWIR)
Defence R&D Canada – Valcartier • R & D pour la défense Canada – Valcartier



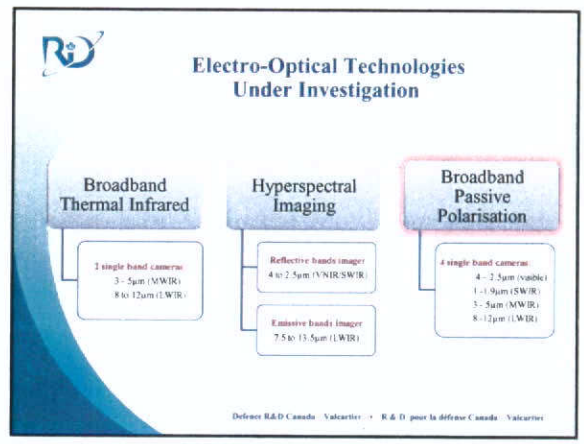
Hyperspectral Imaging for UXO Detection
Objective
Investigate the use of airborne hyperspectral remote sensing for the detection of UXO in the reflective and emissive wavelengths
Background
6 X
Varying Orientation & background (rusted)
3 X
4 X
Ground Experiment
Varying Paint color
3 X
Rusted drums
3 X
Total: 37 inert Projectiles & 3 drums
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier
Hyperspectral



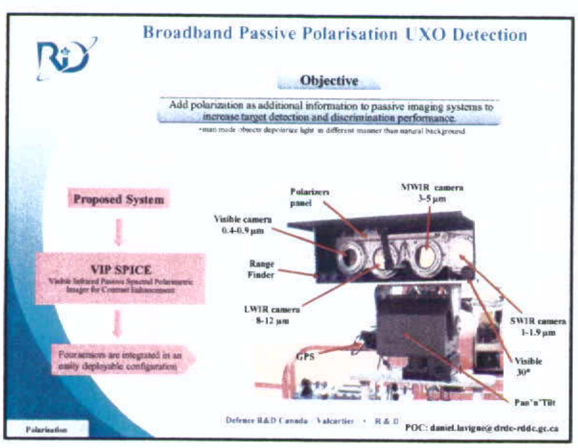
Hyperspectral Imaging for UXO Detection
Study area
VNIR/SWIR Hyperspectral
Geo-referenced flight lines mosaic
Location of projectiles
Surveyed Area
Drums
0 degree
90 degree
45 degree
100 m
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier
Hyperspectral



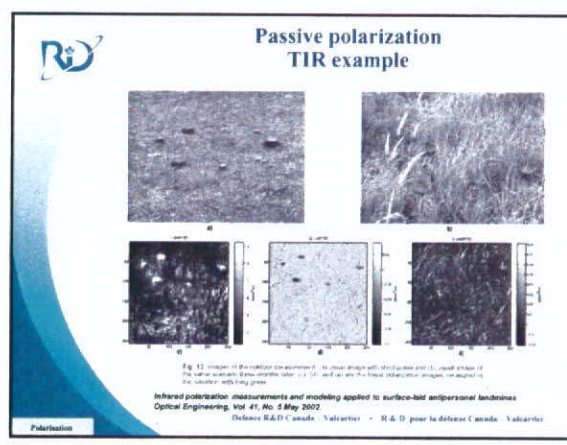
Hyperspectral Imaging for UXO Detection
Analysis results
Analysis results for flight-lines 153007, 153606, 152433, 151803, and 150537 (From J.F. Gagnon et al. TELOPS, 2009)
yellow arrows highlight UXOs
red arrows highlight false positives
green arrows highlight other targets that can't be confidently identified as UXO's or false positives
# of known targets in the flightline (a) 7 15 19
Detected targets (b) 5 13 20
Error of commission (c) 0 1 3
Error of omission (d) 2 3 2
Correctness (e) 100% 92% 85%
False alarm rate (f) 0% 7.7% 15%
Overall accuracy (g) 71.4% 80.0% 89.7%
152433
153007
153606
151803
150537
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier
Hyperspectral



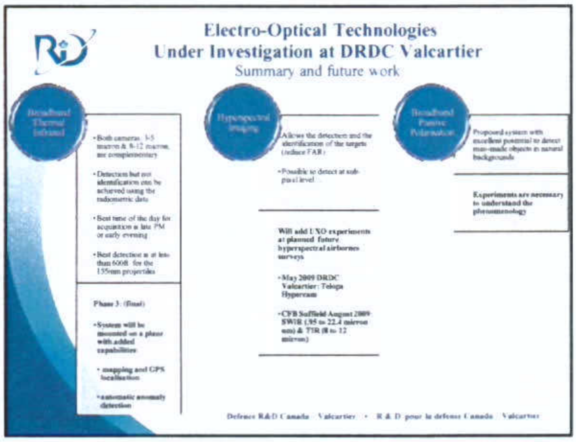
Electro-Optical Technologies Under Investigation
Broadband Thermal Infrared
Hyperspectral Imaging
Broadband Passive Polarisation
2 single band cameras
3 - 5μm (MWIR)
8 to 12μm (LWIR)
Reflective bands imager
4 to 2.5μm (VNIR/SWIR)
Emissive bands imager
7.5 to 13.5μm (LWIR)
4 single band cameras
4 - 2.5μm (visible)
1 - 1.9μm (SWIR)
3 - 5μm (MWIR)
8 - 12μm (LWIR)
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier



Broadband Passive Polarisation UXO Detection
Objective
Add polarization as additional information to passive imaging systems to increase target detection and discrimination performance.
Proposed System
VIP SPICE
Visible Infrared Passive Spectral Polarimetric Imager for Contrast Enhancement
Four sensors are integrated in an easily deployable configuration
Polarizers panel
MWIR camera 3-5 μm
Visible camera 0.4-0.9 μm
Range Finder
LWIR camera 8-12 μm
SWIR camera 1-1.9 μm
GPS
Visible 30°
Pan'n'Tilt
Defence R&D Canada - Valcartier • R & D
POC: daniel.lavigne@drdc-rddc.gc.ca
Polarisation



Passive polarization
TIR example
Infrared polarization measurements and modeling applied to surface-laid antipersonnel landmines
Optical Engineering, Vol 41, No. 5 May 2002
Defence R&D Canada - Valcartier • R & D pour la défense Canada - Valcartier
Polarisation


Electro-Optical Technologies
Under Investigation at DRDC Valcartier
Summary and future work
• Both cameras: 3-5 micron & 8-12 micron, are complementary
• Detection but not identification can be achieved using the radiometric data
• Best time of the day for acquisition is late PM or early evening
• Best detection is at less than 600ft for the 155mm projectiles
Phase 3: (final)
• System will be mounted on a plane with added capabilities
• mapping and GPS localisation
• automatic anomaly detection
Allows the detection and the identification of the targets (reduce FAR)
• Possible to detect at sub-pixel level
Will add UXO experiments at planned future hyperspectral airbornes surveys
• May 2009 DRDC Valcartier: Telops Hypercam
• CFB Suffield August 2009 SWIR (.95 to 22.4 micron nm) & TIR (8 to 12 micron)
Proposed system with excellent potential to detect man-made objects in natural backgrounds
Experiments are necessary to understand the phenomenology