U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – SOLDIER CENTER

Changes to Camouflage Spectral Reflectance Requirements – Session #18

JAPBI Brief - 7 November 2019

U19-1586

07 Nov 2019

CHANGES TO CAMOUFLAGE SPECTRAL REFLECTANCE REQUIREMENTS – PART 1

- **Session 1: Part 1**

❑ Introduction/Agenda	CCDC-SC
❑ SWIR Background	CCDC-SC
❑ Test Methodology/Apparent Calculator for SWIR/NIR	CCDC-SC
❑ Q&A	

- **Session 2: Part 2**

❑ Acquisition Strategy & Schedule	Army, PdM-SCIE
❑ Acquisition Strategy & Schedule	USMC, PM-ICE
❑ Path Forward	CCDC-SC
❑ Q&A	

Bottom Line Up front (BLUF)

- **Problem**: New sensing modalities (imagers & intensifiers) proliferating at low costs drives increased signature management requirements for the deployed warfighter
- **Solution**: Passive modifications to existing personal protective equipment (PPE)
  - Develop new mitigation materials - replace existing stock at lowest cost
- **Benefit**: Increased warfighter survivability, and increased mission success

FORM, FIT, FUNCTION STAYS THE SAME
SIGNATURE PERFORMANCE IMPROVEMENT

Military Operating Environment (MOE) / Militarily Relevant Environment (MRE)

- MOEs/MREs chosen in multiple locations globally
- Generation of Shortwave Infrared (SWIR) image/spectral database with locations specified in accordance with US ARMY Corps of Engineers
- Woodland and Arid USMC Marine Pattern (MARPAT) uniforms, Operational Camouflage Pattern (OCP) uniforms and Load Carriage kits built and tested in tactically relevant environments

Apparent Reflectivity Approach

- Apparent reflectance is used as a comparative factor for evaluating SWIR image data. It is useful for comparing the reflectivity of different families of samples against various backgrounds.

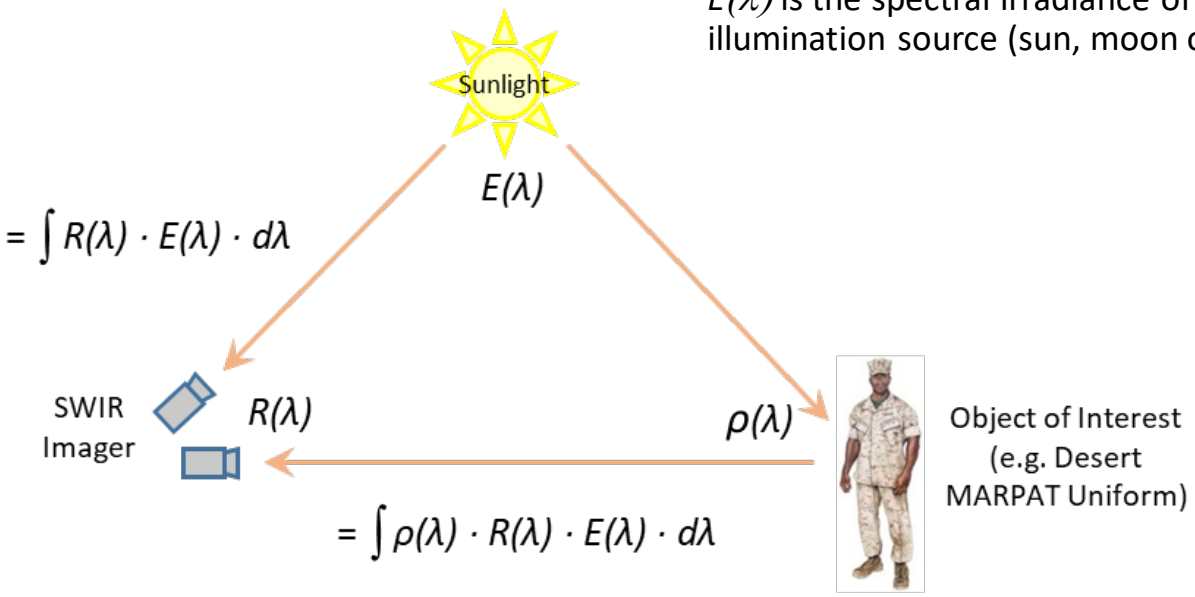
$$\rho_A = \frac{\int \rho(\lambda) \cdot R(\lambda) \cdot E(\lambda) \cdot d\lambda}{\int R(\lambda) \cdot E(\lambda) \cdot d\lambda}$$

ρ_A is the apparent reflectivity of the object of interest

$\rho(\lambda)$ is the absolute reflectivity of the object of interest

$R(\lambda)$ is the normalized response of the specified spectral band (camera/lens system)

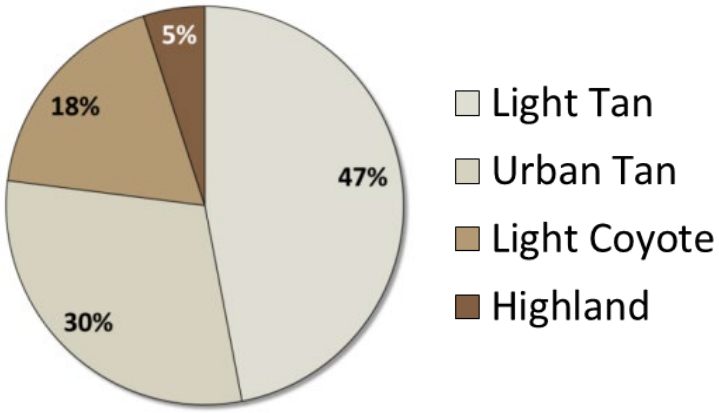
$E(\lambda)$ is the spectral irradiance of a given natural illumination source (sun, moon or nightglow)



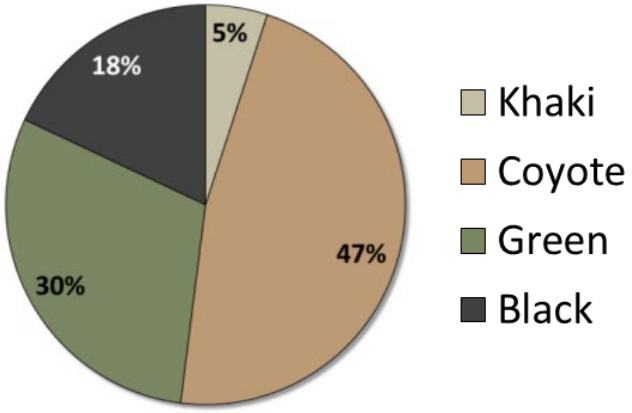
Designating Shortwave Infrared Values

- SWIR daylight images collected
- Calibrated images generate mean reflectance value (standard panels)
- Uniform colors assigned SWIR reflectance based on proportion of color
  - 3 values for desert, 3 values for woodland, 3 values for transitional
  - Have to use MARPAT/OCP pattern percentages
  - Average of three values approximately equal to mean of cumulative distribution
  - Assign low SWIR values to dark colors and high SWIR values to light colors

Desert MARPAT

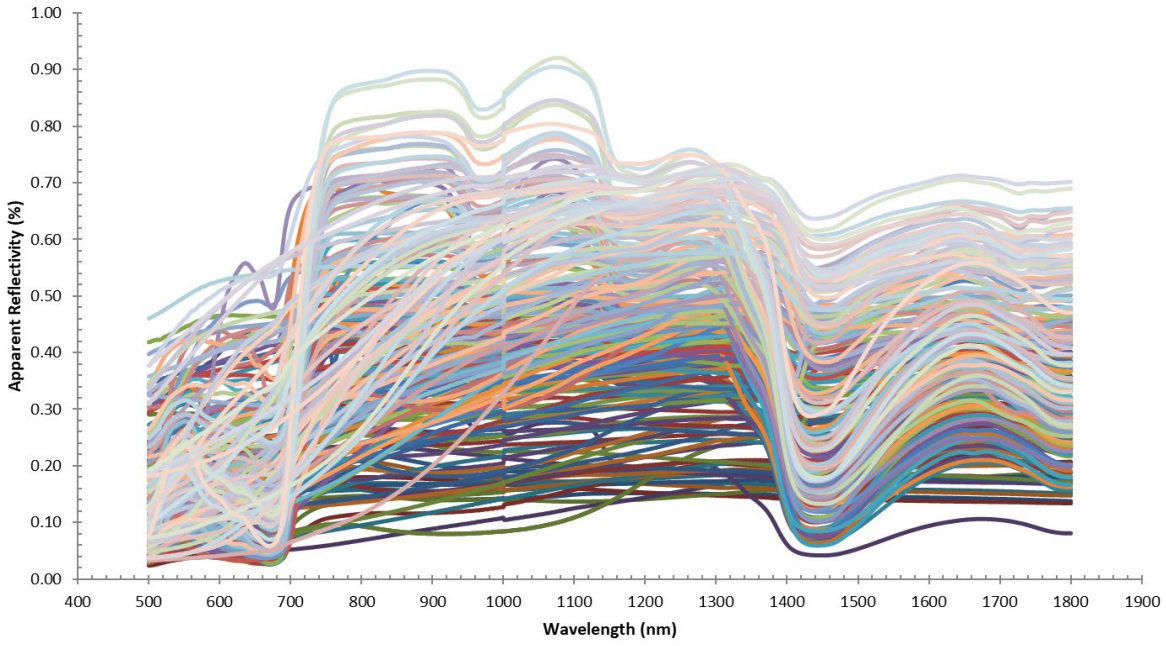


Woodland MARPAT



Utilization of Spectral Database

- Spectrophotometry of 108 Desert and 171 Woodland/tropical spectral environmental samples and artifacts (organic & inorganic) in 14 MRE's
- Absolute reflectance spectra's chosen as representative for both woodland & desert
  - Correlates to mean image value
  - Produce guidance curves for low, medium, and high reflectance values



- combined set of 279 desert and woodland FieldSpec environmental samples

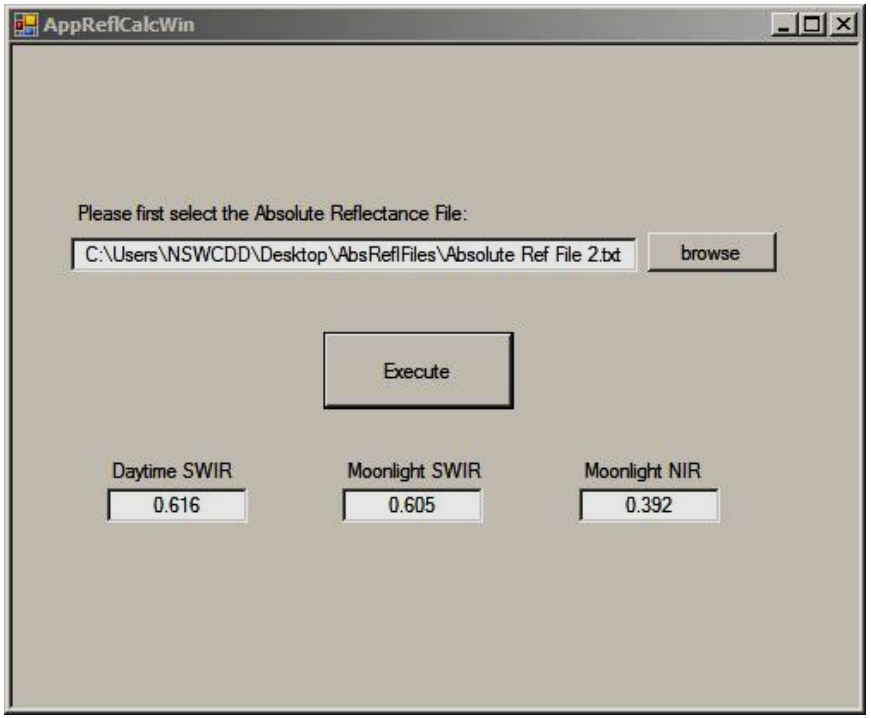
Apparent Reflectivity Calculator

Calculation convolving:

- Sensor (detector) response
- Lens transmission
- Illumination profile (daylight/moonlight)
- Absolute reflectance

Input:
absolute reflectance of material

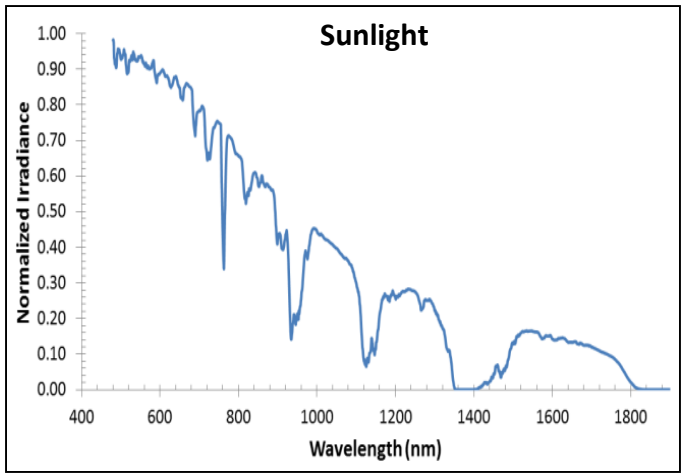
Output:
apparent reflectance values

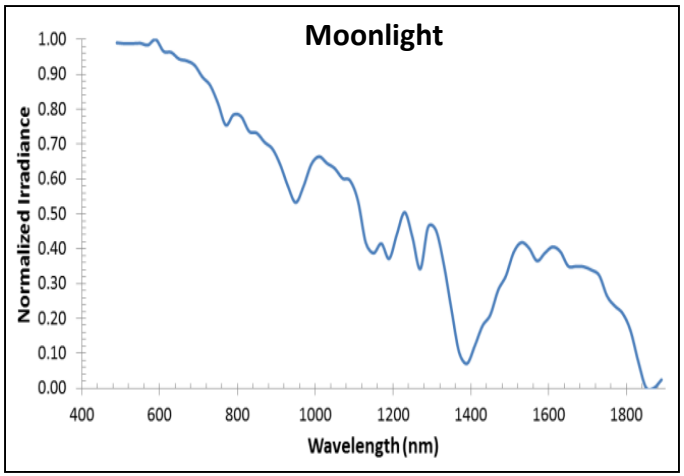


Apparent Reflectivity Calculator Components

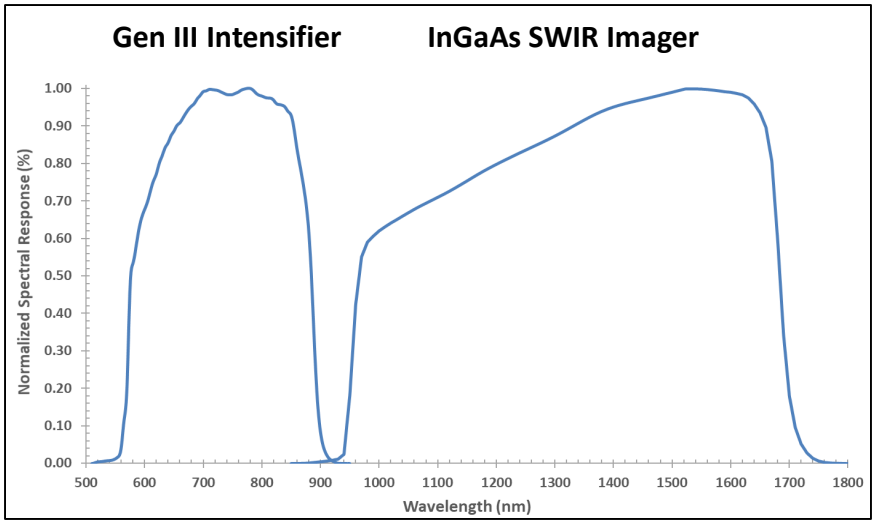
- The apparent reflectivity calculator currently uses the following spectral input data:

E(λ):





R(λ):



Current Development

- Demonstrated improved spectral camouflage in the visible, near-infrared (NIR) and short-wave infrared (SWIR) bands
  - Proof of concept generated (Phase 2) with significant improvement over baseline uniforms
- Shortwave Infrared (SWIR) reflectivity Key Performance Parameters/Key Systems Attributes (KPP/KSA) tables
  - Desert MARPAT Values; Woodland MARPAT Values; OCP Values

Current Evaluation Method

Laboratory Characterization

- Absolute Reflectance data collected per material pattern per color
- Color matching using L*a*b* color space- metric defined by the International Commission on Illumination to express color using standard values

Apparent Reflectivity Analysis

- In-band summation of reflectivity equation factoring in: imager system response, illumination profile and material reflectance
- Apparent Reflectivity Calculator to produce: Moonlight Near Infrared (NIR), Daylight SWIR, and Moonlight SWIR apparent reflectivity values

Field Evaluation

- Militarily Relevant Environments (Woodland; Desert; Transitional)
- Calibrated image, ROI pixel value gives approximate in band Apparent Reflectivity – initial assessment quantitative evaluation
- Final target comparison with mean value of established database of representative reflective values

Opportunity for Industry

- Visible imagery and spectrum specifications, correlates to 3-dimensional values (example: RGB)
- NIR & SWIR broadband imagery monochromatic, 0%-100% reflectance

Example:

- **Marine Corps Combat Utility Uniform (MCCUU) Spectral NIR Target Table**
- **NIR target value with +/- tolerance replaces per wavelength target**

Wavelengths	Lt. Tan 479		Lt. Coyote 481 & Highland 480		Urban Tan 478	
Nanometers	Min.	Max.	Min.	Max.	Min.	Max.
700	38	53	19	41	25	44
720	38	54	20	41	25	45
740	39	55	20	42	25	46
760	40	56	21	42	26	47
780	41	57	21	42	27	48
800	43	58	22	43	28	50
820	45	59	23	4	30	52
840	48	62	24	46	33	55
860	50	65	25	48	36	58
Woodland table <4/14 failures; Arid Table <4/9 Specification Failures Passes Garment						

Questions?

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Changes to Camouflage Spectral Reflectance Requirements – Session #22

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Project Manager Soldier
Protection and Individual Equipment

PRECISION
is the Standard

Every Ounce Matters, Every Bullet Counts

Product Manager Soldier Clothing and Individual Equipment (PdM SCIE)

Short Wave Infrared (SWIR)

Technology Implementation Plan

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7 November 2019

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Implementing SWIR Technology

Where We Are:

- Near Infrared Technology is currently incorporated into uniforms and load carriage equipment.
- We are funding and supporting the Joint Service Signature Management program.
- We are evaluating commercial multi-spectral mitigation garments as they become available.

Where We Are Going:

- SWIR technology will transition to PM SCIE in 4FY21
- Army & Air Force user evaluation in 2FY22 (FRACU & ACS)
- Fabric specs and item purchase descriptions modified with SWIR beginning 3FY22
- Prioritization on combat uniforms and load carriage items pending contract renewal
- This will be a gradual phase in eventually encompassing all OCP items

Program Manager Infantry Combat Equipment (PM ICE)

Short Wave Infrared (SWIR)

Technology Implementation Plan

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NexGen MCCUU

FR

- Current Policy allows for FROG/EFRCE use for contingency operations only
- Growing need/training requirements lead to improve FR capabilities of existing uniform
- Low-Cost and Durable FR Treatment to the Marine Corps Combat Utility Uniform (MCCUU)
- USMC & Army – Natick R&D
  - Maintain current MCCUU attributes, including 50 wash cycles
- SBIR – FR MCCUU
  - Cost increase: < 5% (objective) / < 10% (threshold)
  - FR durability: 100 (objective) / 50 (threshold) laundering cycles
  - Minimal impact on non-FR performance

SWIR

- USMC and Army effort with CCDC Soldier Center & NSWC Dahlgren
  - Objective: Reduce/eliminate SWIR detection from uniforms and equipment
  - Solution: Passive Modifications to Existing PPE (paint/pigment)
- SWIR signature mitigation of deployed warfighter (USMC and US Army) combat kit (uniforms and 500D nylon load carriage)
- Extended Spectrum (Visible – Long Wave Thermal IR) signature mitigation development effort of deployed warfighter (longer term)
- Apparent Reflectivity signature measurement reduction

Baseline MARPAT vs. Proof Of Concept SWIR Developmental Materials.

Where We Are:

- Near Infrared Technology is currently incorporated into uniforms and load carriage equipment.
- USMC maintains separate FR uniform (EFRCE) and non-FR uniforms (MCCUU) w/out SWIR mitigation.
- Joint Service Signature Management program has demonstrated success in SWIR mitigation.
- FR Treatment of 50/50 NyCo shows promise

Intent is to merge SWIR Mitigation and FR into the NexGen MCCUU

Where We Are Going:

- FY 20 – Publish Changes to Fabric Specifications & Item Purchase Descriptions (Phase 1 End Items)
- FY 21 – User Evaluations on changes – refine Fabric Specifications & Item Purchase Descriptions
- FY 21 (4Q) – Transition to production with final changes to Fabric Specifications & Item Purchase Descriptions
  - Phased approach encompassing ICE items (uniforms, load carriage)
  - Prioritization on combat uniforms and load carriage items that are pending contract renewal

CHANGES TO CAMOUFLAGE SPECTRAL REFLECTANCE REQUIREMENTS – PART 2

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Path Forward

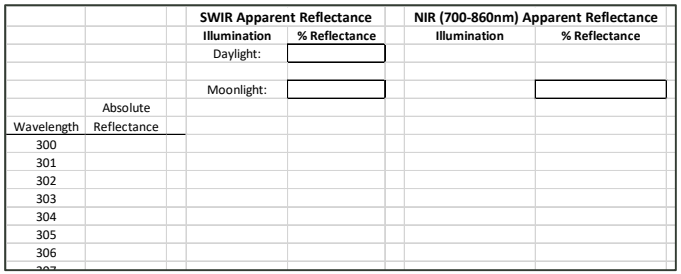
- ❑ Submit Request For Information (RFIs)
  - ❖ Require Non Disclosure Agreement (NDA) for Target Values / Apparent Reflectivity Calculator
  - ❖ Specify End Items / Materials (Gradual Phase)
    - ❖ Phase 1
      - ❖ US Army:
        - ❖ Flame Resistant (FR) Army Combat Uniform (FRACU), MIL-DTL-32635 (GL-PD-14-04A, 05A)
        - ❖ Advanced Combat Shirt (ACS), GL-PD-10-02F
        - ❖ Load Carriage Items, MIL-DTL-32439
        - ❖ Webbing
      - ❖ US Marine Corps:
        - ❖ Marine Corps Combat Utility Uniform (MCCUU), MIL-PRF-MCCUU
        - ❖ Enhanced FR Combat Ensemble (EFRCE), MIL-PRF-EFRCE
        - ❖ Load Carriage Items, MIL-DTL -32439
        - ❖ Webbing
    - ❖ Phase 2 – TBD
  - ❖ Submit Materials with Test Data

CHANGES TO CAMOUFLAGE SPECTRAL REFLECTANCE REQUIREMENTS – PART 2

Path Forward cont.

- ❑ Timeline:
  - ❖ FY 20 – Materials Optimization (Phase 1 End Items)
  - ❖ FY 21 – User Evaluations
  - ❖ FY 21 (4Q) – Transition to PdM-SCIE / PM-ICE
  - ❖ FY 22 – Changes to Fabric Specifications & Item Purchase Descriptions

- ❑ Conduct Industry Site Visits
  - ❖ Review of Test Protocol / Standard Operating Procedure (SOP)
    - Spectrophotometer Parameters
      - Wavelength Range, Nanometer Resolution, etc.
    - Material Backing Layers
  - ❖ Review Apparent Reflectivity Calculator (MS Excel File)
    - Graphical User Interface (GUI)
    - CSV File from Spectrophotometer (Input)
    - Data Layout



		SWIR Apparent Reflectance		NIR (700-860nm) Apparent Reflectance	
		Illumination	% Reflectance	Illumination	% Reflectance
		Daylight:			
		Moonlight:			
	Absolute				
Wavelength	Reflectance				
300					
301					
302					
303					
304					
305					
306					

QUESTIONS