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Analysis of Electro-Optical Sensor Performance Using a 3D Synthetic Environment

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Background

- Canadian Forces uses electro-optic sensors for various applications.
- Variety of sensors in different bands.

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Analysis of the complete system

- Target to human chain of observation
- Impact of each element
- Evaluation methods: Field trials are costly and labour intensive

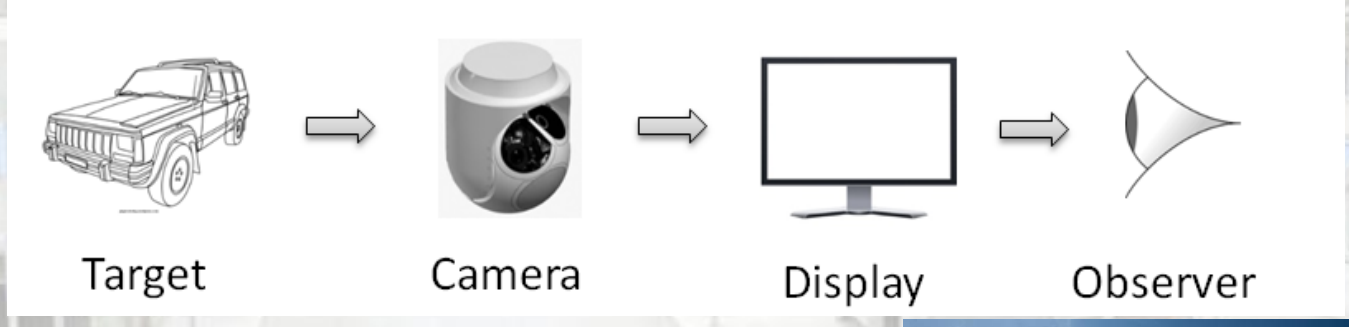
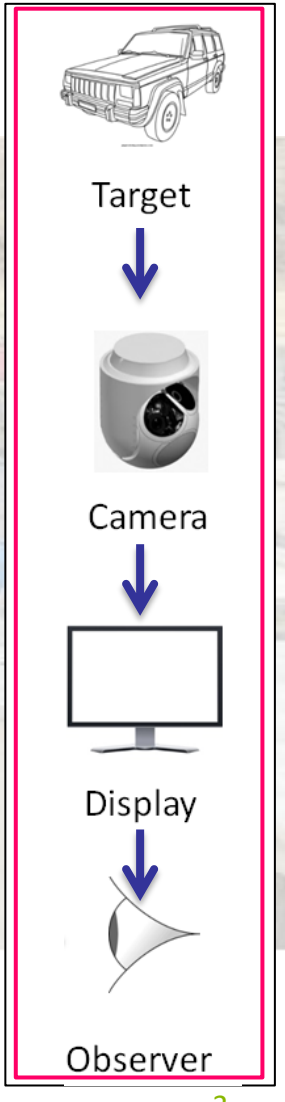
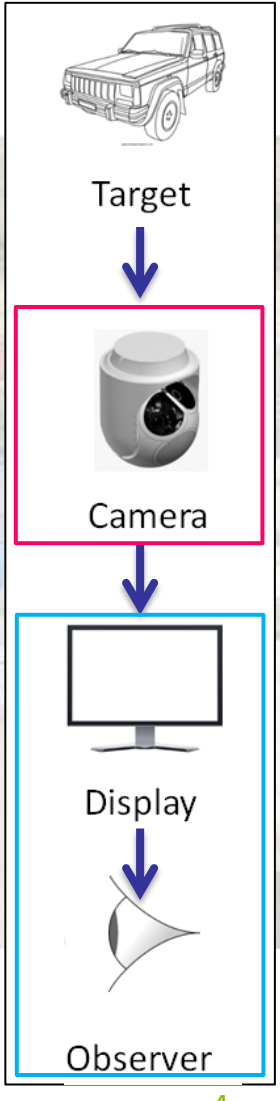


Photo credit: Corporal Gary Calvé, Imagery Technician, ATF RENAISSANCE.

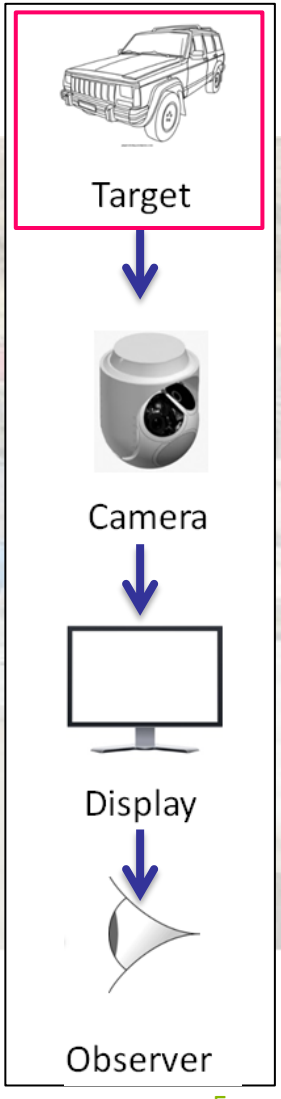
Real scenarios



Real scenarios



Real scenarios

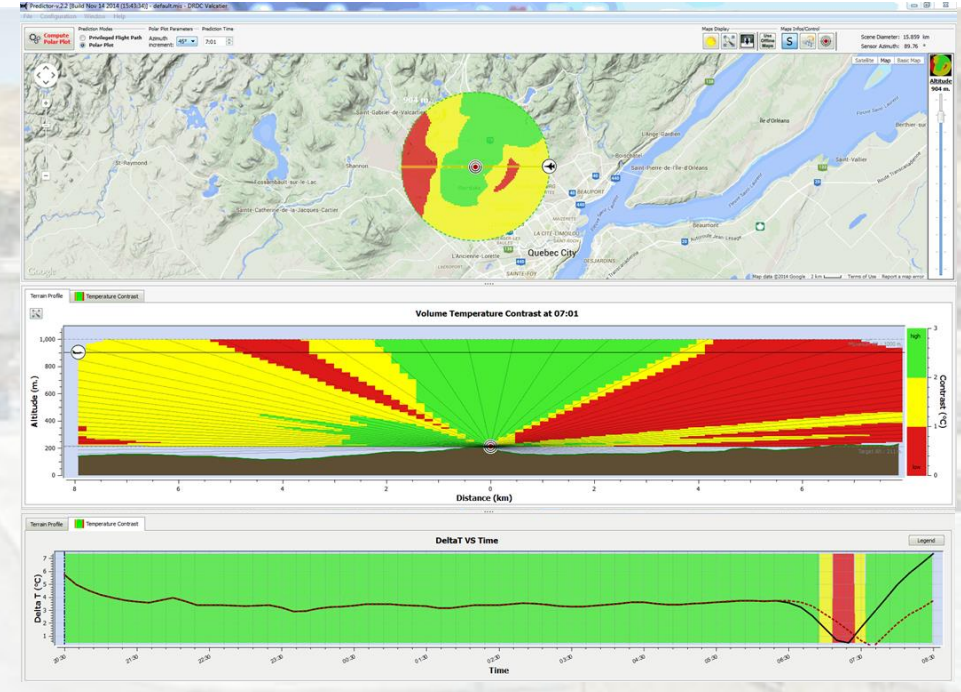


Simulation 3D Environment: Karma

- Environment to create scenarios that include various platforms, weapons systems, sensors, countermeasures, target signatures, weather conditions and environments (e.g. desert, urban, maritime, and rural).
- Scene generator based on Unreal Engine 4 and Open Scene Graph
- High fidelity models developed using a physics based approach.

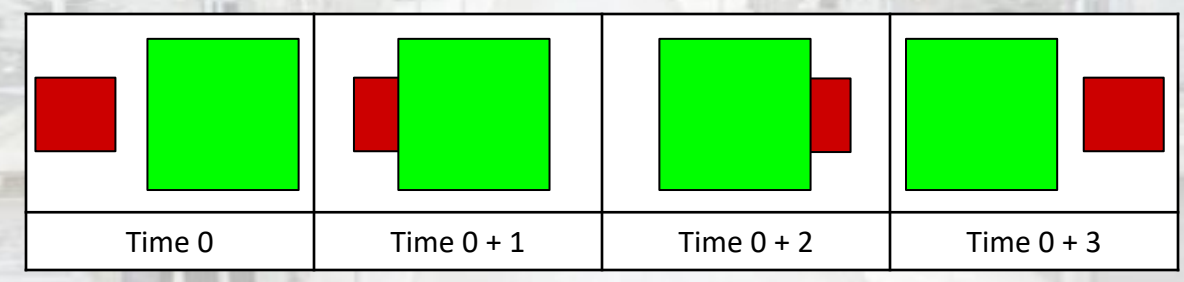
EO/IR sensor range performance predictor: Tactical decision Aid

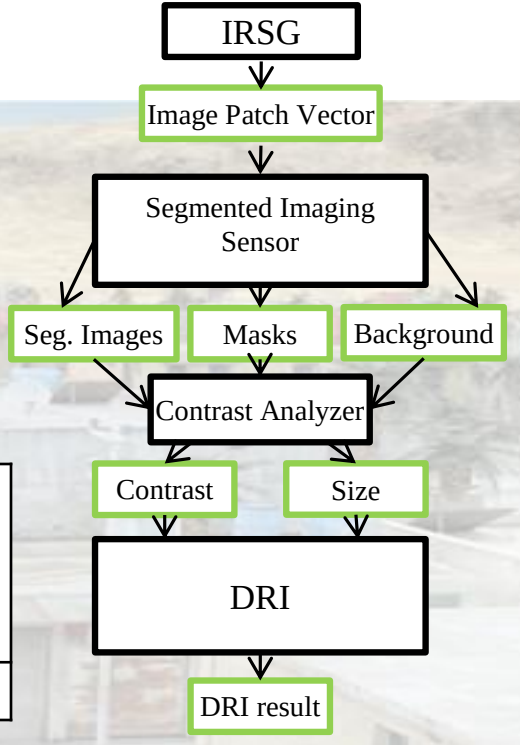
- Based on system characteristics (such as MRC, MRTD)
- Predictions based on weather forecast
- Results: Best observation angle and time of the day to perform ISR task for a given location and topography



Integration of Range Predictor in Karma

- Creation of new models (Segmented Imaging Sensor, Contrast Analyzer, Detection Recognition Identification)
- Simple scenario: Moving big block in front of a small static block.



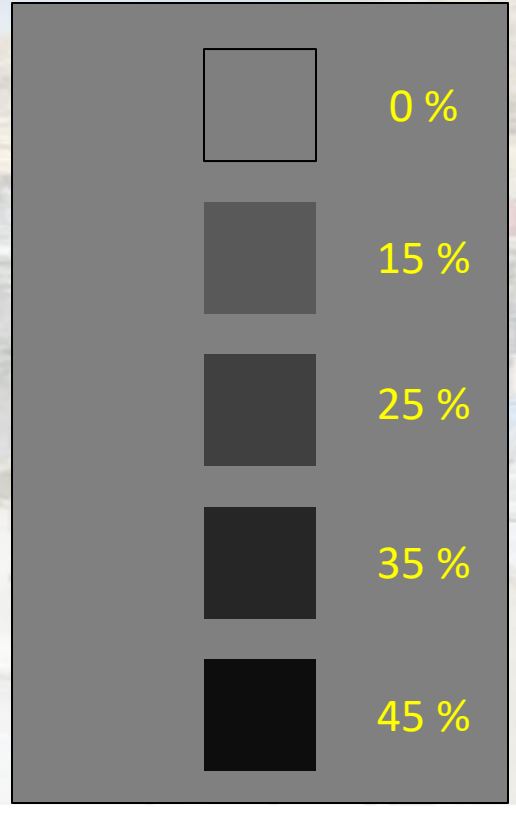


Contrast Analyzer Model

- Contrast evaluation adapted for scene generation
- In a image, contrast corresponds to:
  - C = max-min (for a given target in the scene)
- In scene generation = contrast radiance at the pixel level

$$C_I = I_t - \alpha I_b$$

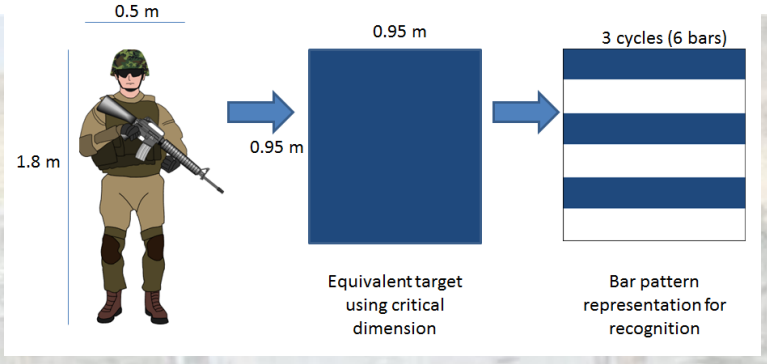
- Contrast radiance depends of the layers opacity, the atmospheric transmission and the nature of the object

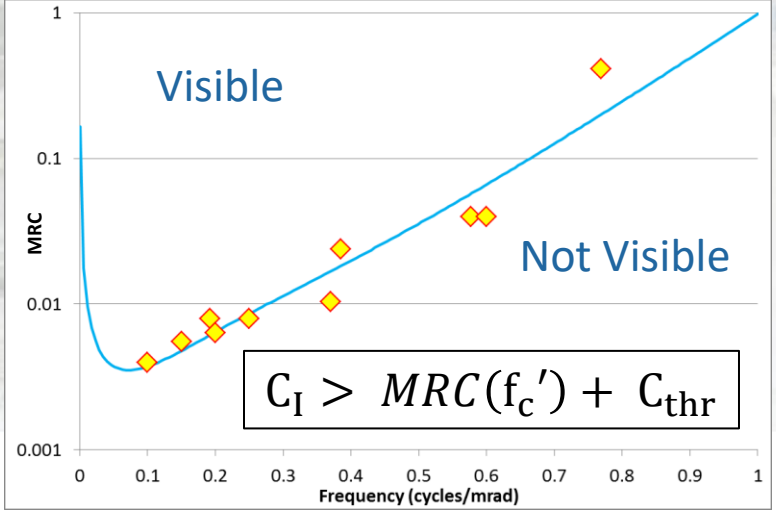


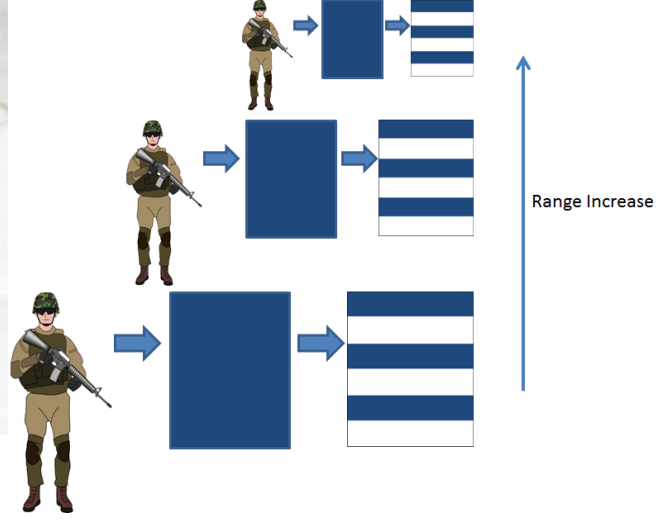
Range Prediction Basis: DRI model

- Johnson Criteria: Detection, Recognition and Identification task
  - Standard values 1, 3, 6 cycles
- MRC usage to determine the threshold

$$f_c\ (\text{cycle/mrad}) = \frac{1}{2000} \cdot \frac{R}{l_c} = \frac{1}{2\theta_{eff}}$$







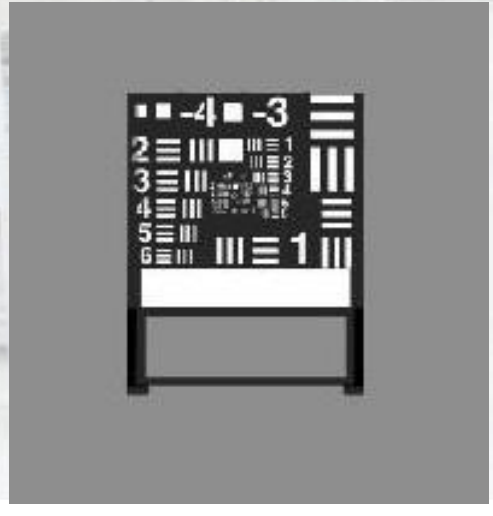
Results from range estimator

- Simple scenario: airborne sensor with fix FOV looking down a target on an uniform background
- From given altitude, the sensors moves downward and crosses the different threshold to each ISR task
- Results: some differences due to the scene generation
- Recent tests with varying FOVs reveal larger discrepancies

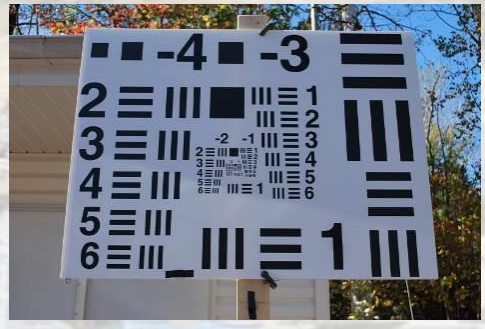
DRI Flag	Range (km)	
	Karma	EOSPEC
Detection	3.978	3.12
Recognition	1.128	1.05
Identification	0.558	0.58

Approaching reality with Karma (part.1)

- Experimental measurements
- Measurements of reference targets at various ranges (100 to 900 m)
- Simulated image are sharp



Heated target (front view)



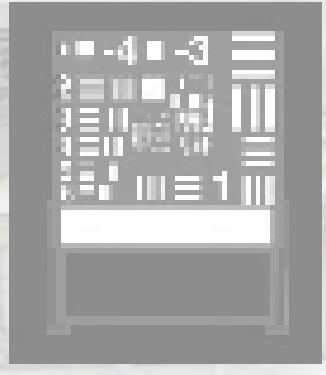
Coroplast target

Heated target (side view)

Aluminum target

Approaching reality with Karma (part.2)

- Reproduction of sensor effects using FPAImager (M&S tool in Karma)
- Calculations based on sensor characteristics versus in-laboratory measurements



Simulated

Original

Conclusion

- Range estimation using 3D environment is promising
  - Various scenarios, environments, conditions, etc.
- Preliminary results showed the potential of this tool
- This tool can provide helpful support to mission planning

- Future Works:
  - Continue the development of the tool to perform evaluation in a more complex scenario with a single sensor (ground or airborne)
  - Extend the usage in complex environments (complex backgrounds) and scenarios which include multiple vehicle types and humans

Questions

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