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Small UAS Analysis of Laser Designation and Search and Target Acquisition Capabilities in an Urban Environment

76th MORS Symposium 10-11-12 June 2008

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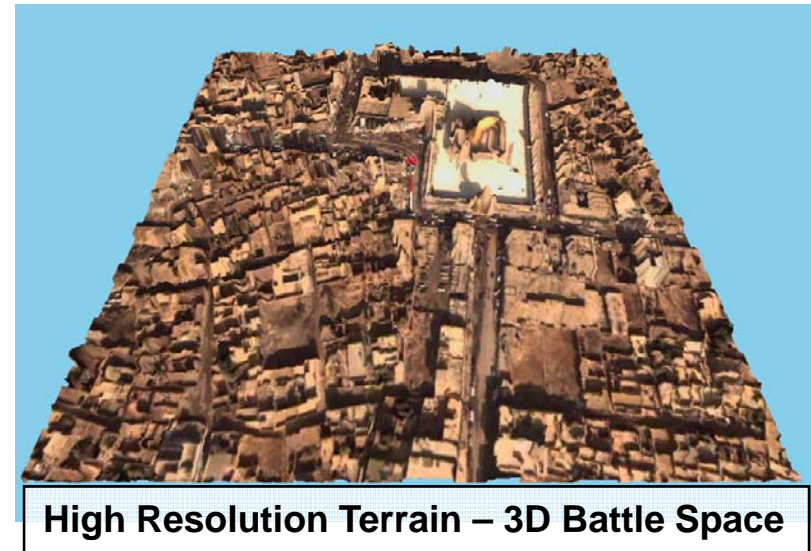


- **Completed for TRAC in September 2007 as a follow-on to TRAC UAS Mix Analysis of 2006**
- **Analysis Goals**
 - Small UAS Laser Designation targets in urban environment
 - Rotary Wing (RW) versus Fixed Wing (FW) UAS detection
- **Implementation**
 - FOCUS was used for all modeling and analysis
 - Two missions: laser designation and persistent surveillance
 - Three flight modes: FW, RW, P&S
- **Results**
 - Poor LD of moving targets in high density terrain
 - Inconsistent LD of moving targets in medium density terrain
 - Good LD of stationary targets
 - Perch-and-Stare could be the best choice for persistent surveillance
 - Surveillance of an intersection by hovering gives better performance than a circular flight path around the area

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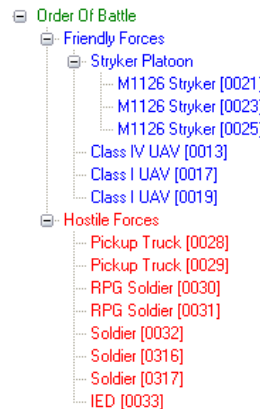
Platform & Sensor Libraries w/ Performance Data

Frequency	MRT / MRC
0	0.032
0.028	0.033
0.167	0.034
0.35	0.04
0.46	0.05
0.527	0.06



FOCUS solves these problems

- Modeling of C4ISR functions using flexible architecture
- Explicit modeling of fusion processes
- Fast turn-around time-- Graphical mission tools and integrated analysis package
- System of systems analysis



Order of Battle Creation

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Search and Target Acquisition



Track Information
 Type: Pickup Truck
 At: (-60.05,293.55,)
 Contributing Sensors:
 1. Class IV UAV [0013]: Lynx-Like MTI
 2. Class I UAV [0017]: Class I UAV FLIR
 Contributing Ground Truth Targets:
 1. Pickup Truck [0028]

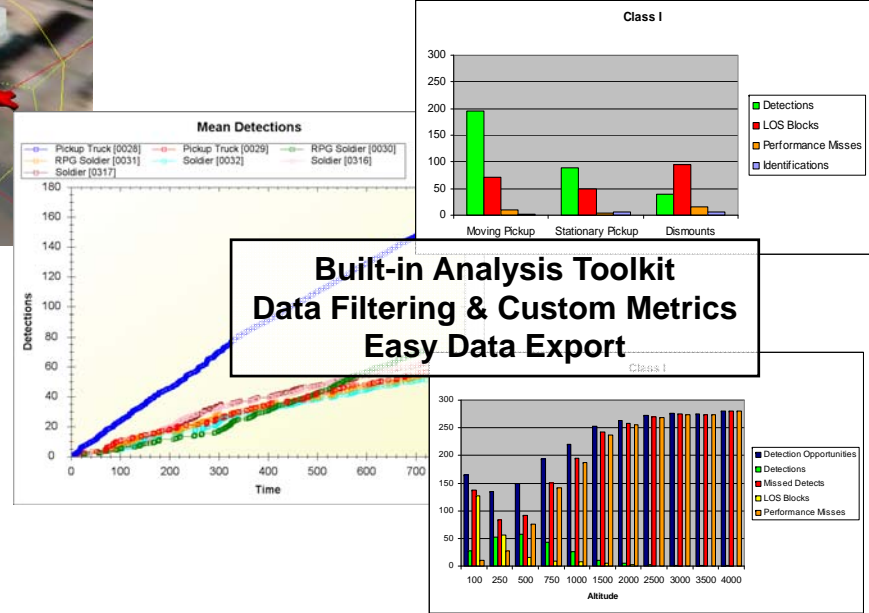
Multi-Sensor Data Fusion & Target Tracking

Potential Applications

- C4ISR analysis
 - Sensor mix questions
 - C4ISR in urban terrain
 - Collection / search strategy evaluation
 - Fusion effects
 - Unit behavior effectiveness
 - Sensor Cueing / collaborative C4ISR
- TTP Development and Analysis

Other Projects

- UAS Mix Pilot Study
- Sensor Fusion Analysis
- Fusion Algorithm Test Bed





Caveats/Limitations/Assumptions



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- **Limited Scenarios**
- **UAS Movement**
 - No jitter
 - Fixed-Wing UAS
 - Minimum turn radius used for path; circular flight path around intersection
 - Hovering UAS
 - Stays behind target when tracking; standoff when lasing
 - Hovers at a point with LOS to intersection for 5 minutes then moves
 - Perch-and-Stare
 - Edge of building, 10 m from intersection
 - Altitudes: 20 m (High Density), 10 m (Medium Density)
- **C4ISR**
 - Communications simplified
- **Sensors**
 - 3-axis mount, 2 FOVs
- **Warhead receiver**
 - Low fidelity representation
 - Horizontal safe angle
 - Assumed LOS
 - Power on Receiver measured by NVLaserD Model at each time step



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High Density

- Samarra, Iraq
- Tall buildings (3-5 story), tightly packed
- Narrow streets with some intersecting wide avenues



Medium Density

- Fallujah, Iraq
- Low residential buildings (1-2 story)
- Narrow streets and back alleys
- Enclosed courtyards



Run Matrix



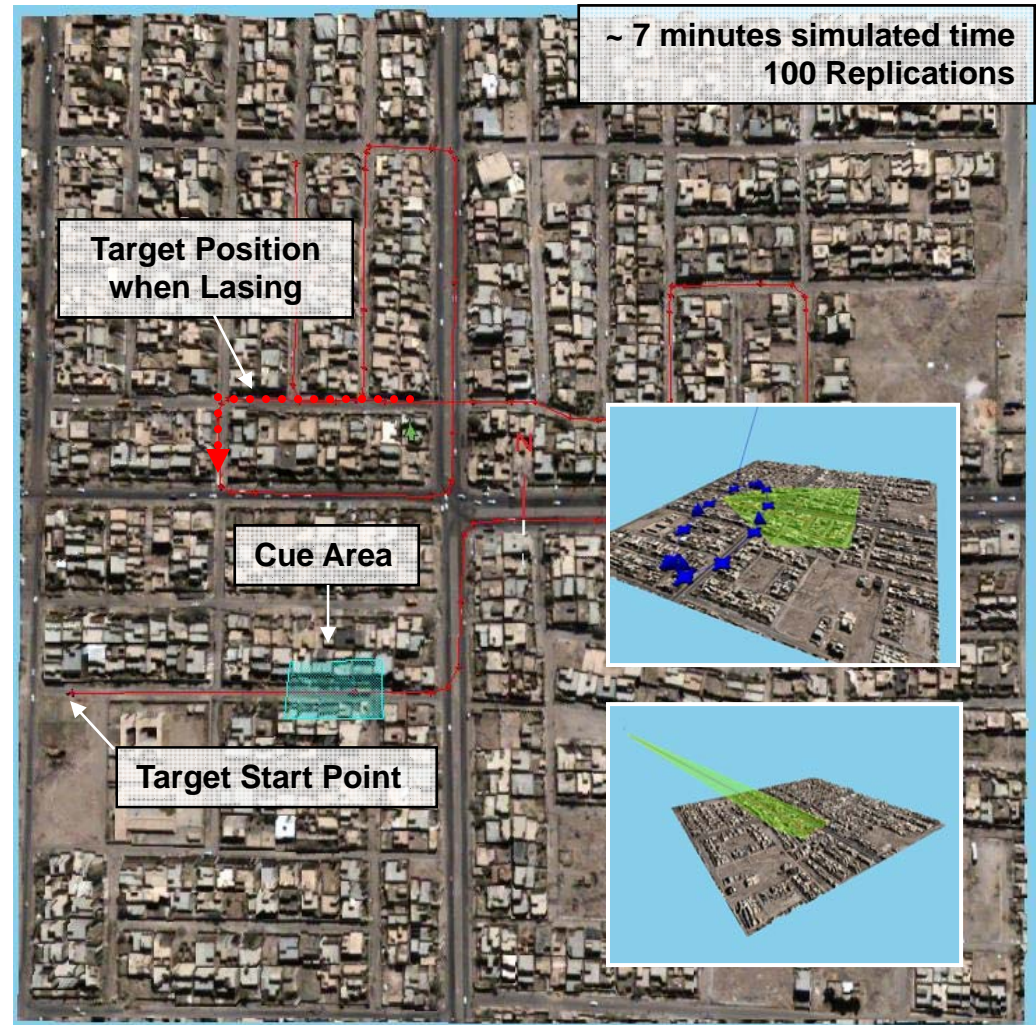
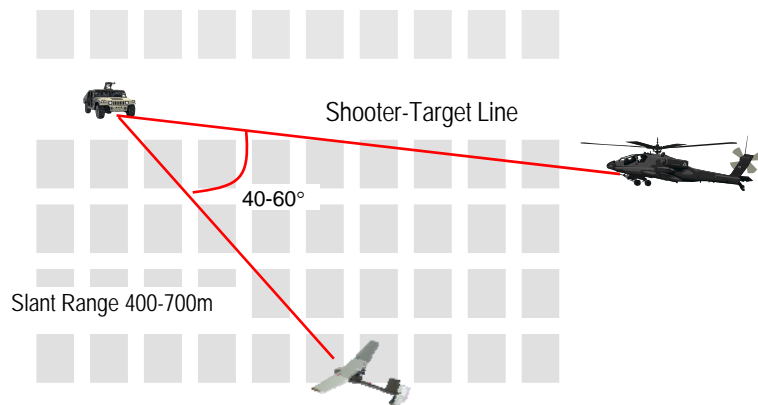
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UAS Follow-On Study Run Matrix			
Laser Designation Scenario			
Run #	Target Type	Terrain	Flight Characteristic
1	Moving	High Density	Fixed-Wing
2	Moving	High Density	Rotary-Wing
3	Moving	Medium Density	Fixed-Wing
4	Moving	Medium Density	Rotary-Wing
5	Stationary	High Density	Fixed-Wing
6	Stationary	High Density	Rotary-Wing
7	Stationary	Medium Density	Fixed-Wing
8	Stationary	Medium Density	Rotary-Wing
Intersection Surveillance Scenario			
Run #	Sensor Type	Terrain	Flight Characteristic
9	IR	High Density	Fixed-Wing
10	IR	High Density	Rotary-Wing
11	IR	High Density	Perch-and-Stare
12	IR	High Density	Perch-and-Stare Wide FOV
13	IR	Medium Density	Fixed-Wing
14	IR	Medium Density	Rotary-Wing
15	IR	Medium Density	Perch-and-Stare
16	IR	Medium Density	Perch-and-Stare Wide FOV
17	TV	High Density	Fixed-Wing
18	TV	High Density	Rotary-Wing
19	TV	Medium Density	Fixed-Wing
20	TV	Medium Density	Rotary-Wing
Sensitivity Analysis			
	Altitudes	100,200,300,400,500	
	Standoff Ranges	100,200,400,500,700	
Run #	Scenario	Terrain	Flight Characteristic
21	LD Moving	High Density	Fixed-Wing
22	LD Moving	High Density	Rotary-Wing
23	Surveillance	High Density	Fixed-Wing
24	Surveillance	High Density	Rotary-Wing

- Fixed Wing
- Rotary Wing
- Perch/Stare
- Perch/Stare Wide FOV

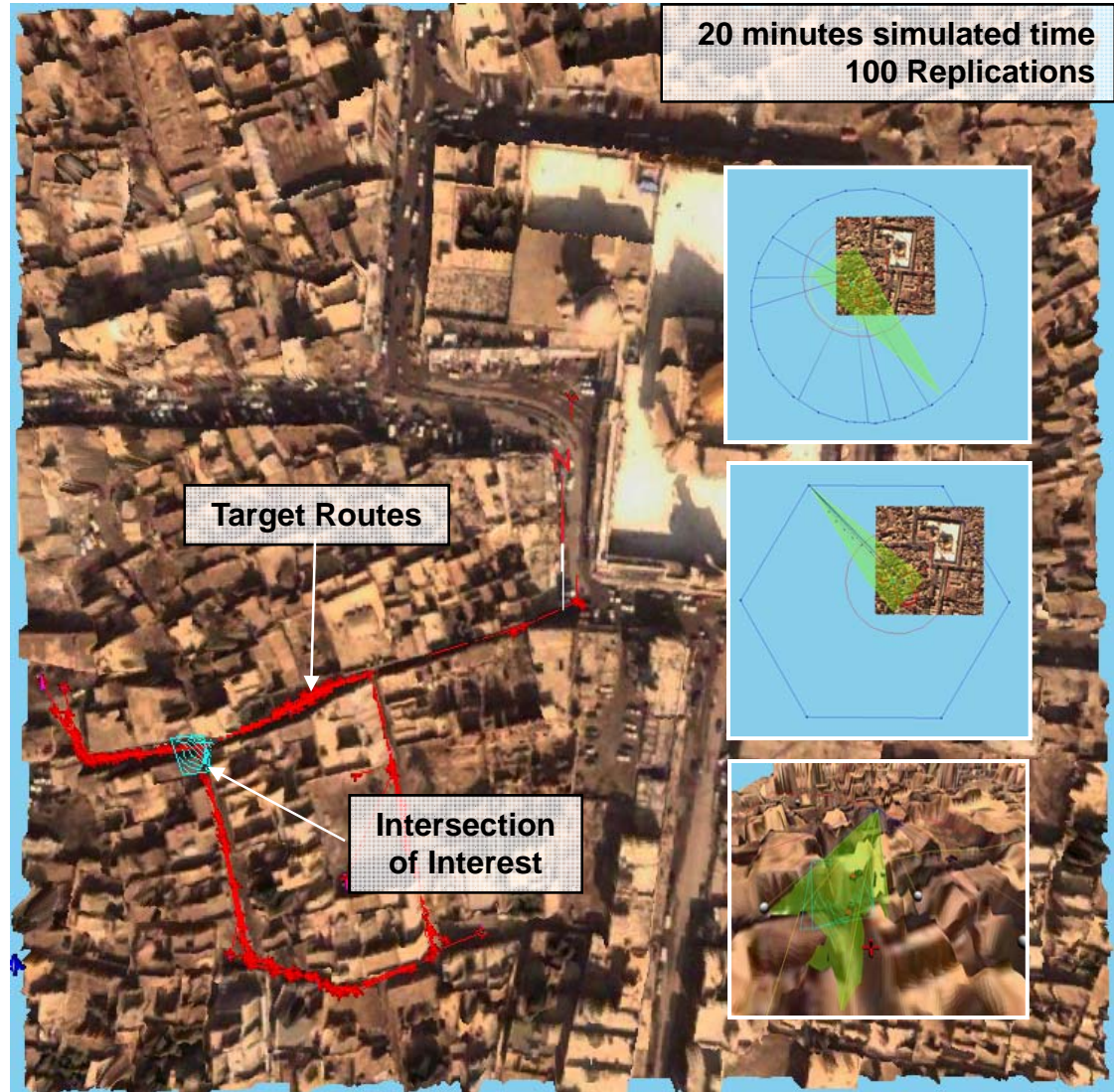
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- Moving or Stationary Target
- After tracking target for 5 minutes, UAS moves into slant range while maintaining “safe angle”
- Warhead/Receiver moves toward target
- Once warhead reaches target, simulation ends



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- 20 minute coverage w/ FLIR or TV
- Targets circle around block
- Sensor only attempts detection at intersection
- FW UAS – circular flight path
- RW UAS – hovers at points on circle for 5 minutes
- Perch-and-Stare UAS – Fixed position at edge of building



20 minutes simulated time
100 Replications

Target Routes

Intersection of Interest

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Issue 1: Can a Small UAS laser designate targets in an urban environment?

- **Moving Target**
 - High Density – LOS blocks result in unacceptable Lock-On times
 - Medium Density - Target maneuvering results in inconsistent Lock-On
- **Stationary Target**
 - Lock-On near 100% of overall lasing time for all scenarios



Stationary Target Positions



Moving Target Positions during Lasing



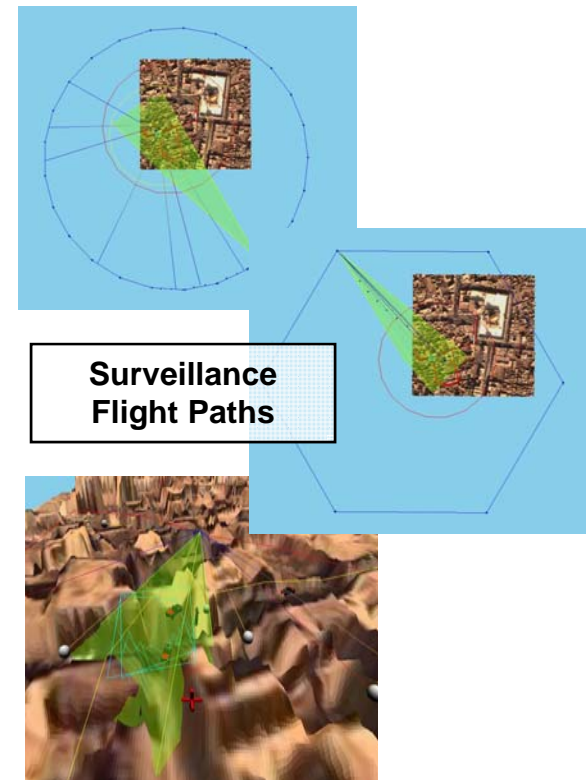
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Issue 2: Does a Fixed-Wing UAS provide better acquisition performance than a Rotary-Wing UAS?

- **Laser Designation**
 - Similar results for both FW and RW cases
 - LOS blocks caused by constrained movement
- **Surveillance**
 - High Density – hovering can increase acquisition performance
 - Medium Density – FW and RW UAS perform equally well
 - Perch-and-Stare Operations, when given an appropriate sensor, increases performance in High Density Environments



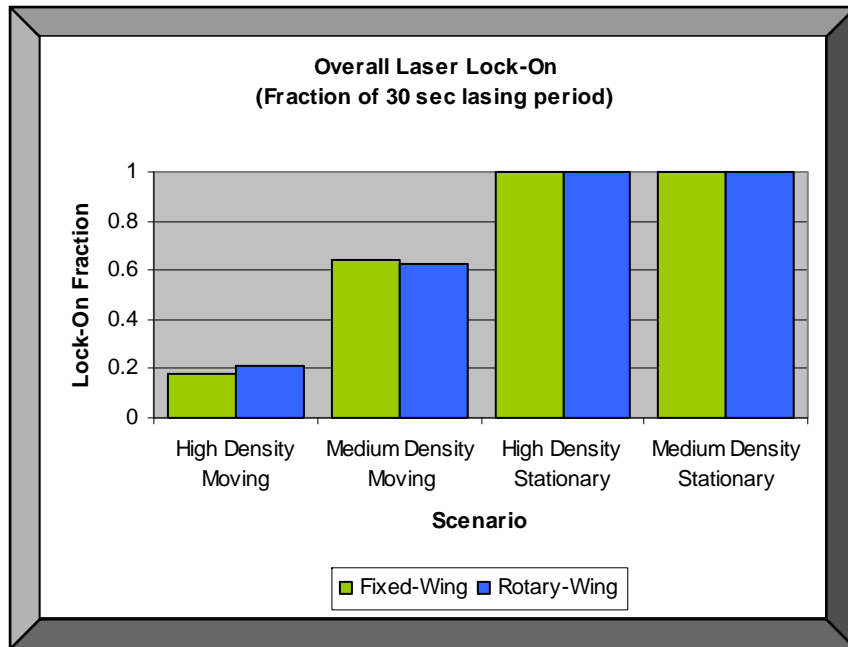
Lasing Flight Paths



Surveillance Flight Paths

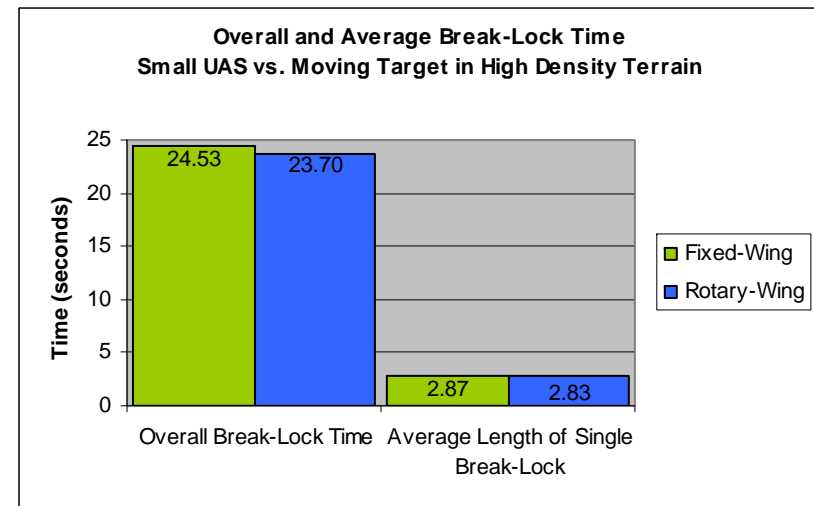
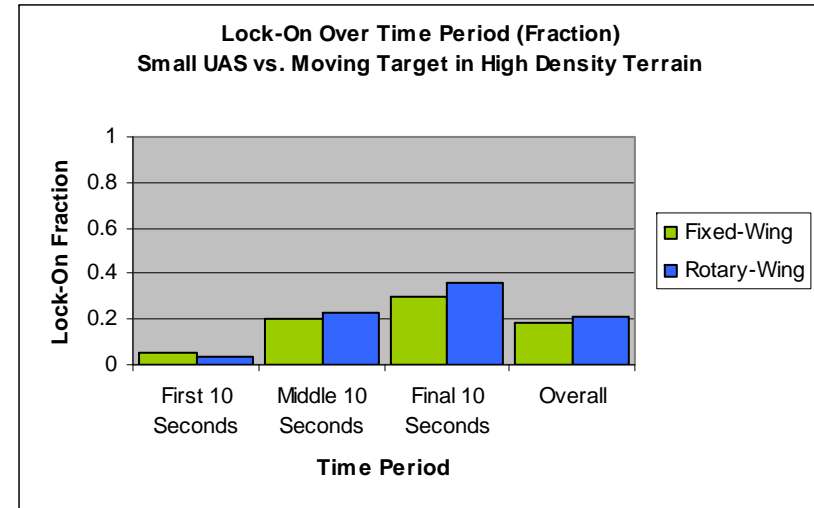
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Overall Lock-On Results



- Similar performance for FW and RW UAS
- Moving Target – laser rarely keeps a continuous lock on the target due to LOS blocks

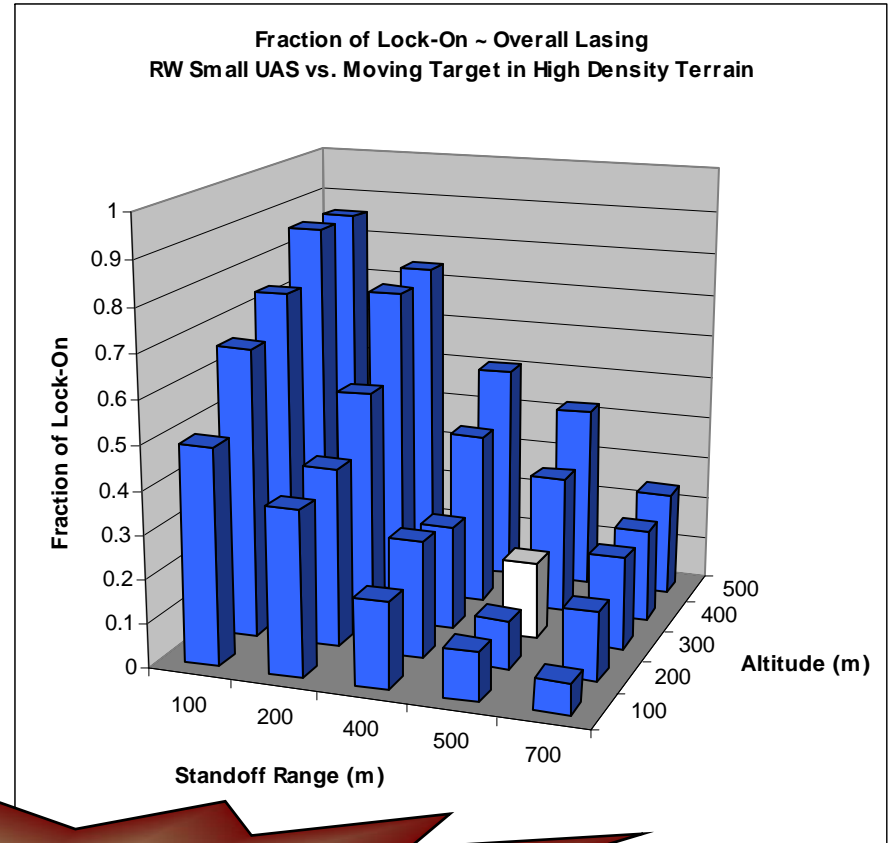
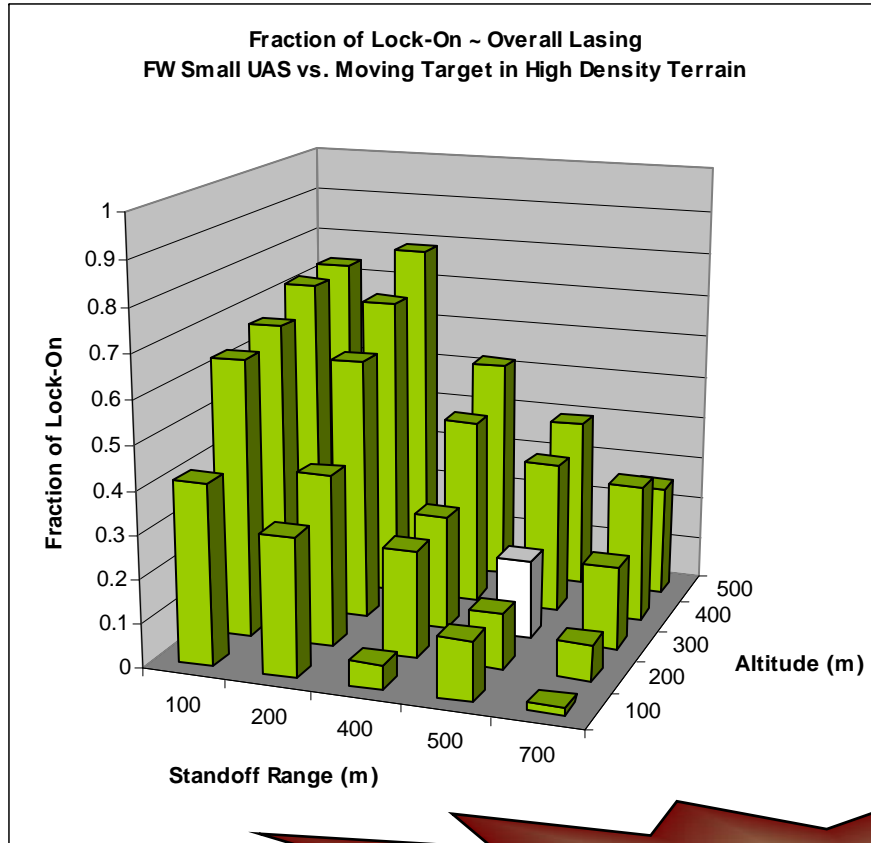
Moving Target / High Density Terrain In Depth Results



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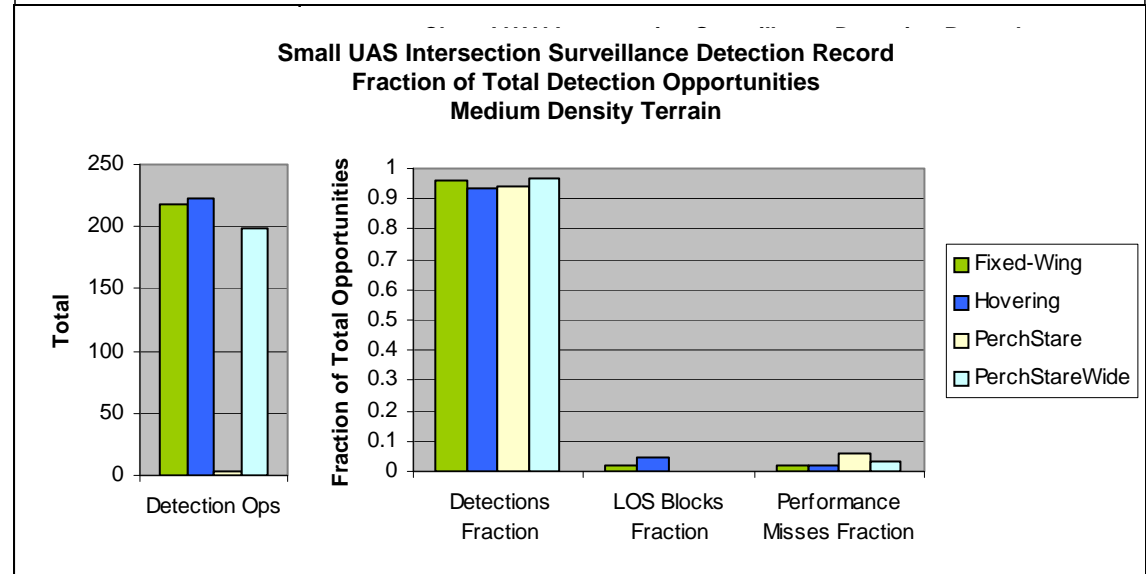
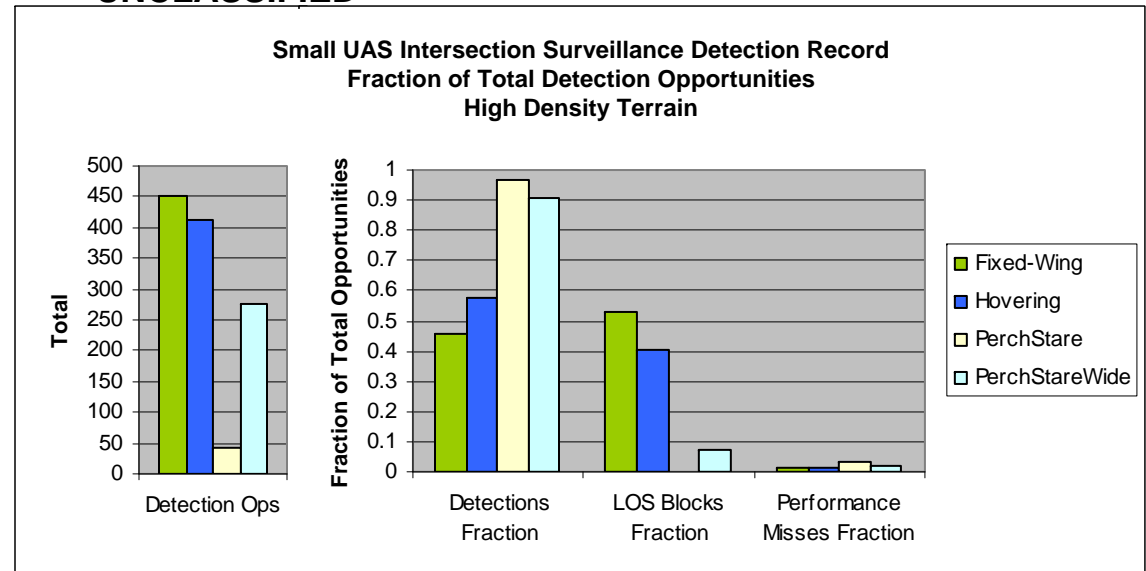
The probability of Lock-On success increases with an increase in altitude and/or decrease in ground standoff range

Operational Parameters

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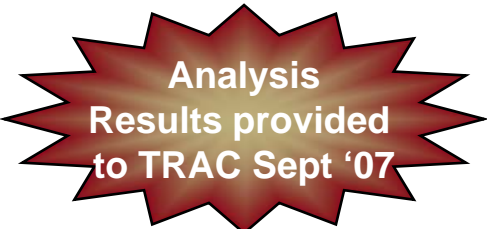
- **High Density Terrain**
 - Hovering UAS performance exceeds Fixed Wing
 - Determining Factor: LOS
 - Perch-and-Stare given wider FOV outperforms flights at operational altitude
- **Medium Density Terrain**
 - Hovering and Fixed-Wing UAS perform equally well
- **Perch-and-Stare**
 - Poorly performs due to the size of the FOV (low Ops)
 - Footprint shrinks as UAS is closer to ground level
- **TV Sensor gives similar results to IR Sensor**



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Analysis
Results provided
to TRAC Sept '07

- **Conclusions**
 - Small UAS has extreme difficulty lasing moving targets in high density urban environments
 - Lasing moving targets in medium density terrain is possible but not certain
 - Lasing of stationary targets is not an issue given LOS
 - Perch-and-Stare may be the best choice for surveillance of a point or intersection
 - Surveillance of an intersection by hovering gives better performance than a circular flight path around the area
- **Next Steps**
 - TRAC used this data in conjunction with Soldier interviews on the operational ability/benefits of the FW and RW Small UAS when compiling the final report
 - AMSAA will be conducting an additional UAS Mix Analysis using improved methodology for FOCUS



Questions/Comments?



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ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY

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