Trakka Interceptor Protection System

(TIPS-C)

Maneuver & Fires Integration Experiment (MFIX)

29 November-17 December 2021

Tactical Assessment Report

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1. OVERVIEW

This report covers the analytic performance results of the Trakka Interceptor Protection System (TIPS-C) at the Maneuver & Fires Integration Experiment (MFIX).

This demonstration provided a structured, operationally realistic environment for the United States Army Fires Center of Excellence to assess system Measures of Performance (MOPs) in support of defense against Small Unmanned Aerial Systems (sUAS). MFIX is the premier US Army game to develop and determine the potential of Counter-Drone Systems.

The Demonstration was conducted by the Army Fires Center of Excellence from 29 November-17 December 2021 at the Thompson Hill Tactical Range on Ft. Sill, OK. The Trakka team setup the TIPS-C system on the range and used the system's Radio Frequency (RF) Detection, Radar, and Electro-Optical/Infrared (EO/IR) camera to detect and track drones. The local air track data was presented to US Army soldiers who manned a Battalion Tactical Operations Center, by means of a remoted Drone Sentry C2 display.

Structured and controlled live "simulated enemy" drone events were conducted during the demonstration using instrumented drones. The drones were flown in the vicinity of the Thompson Hill range at designated times. Time Space Precision Information (TSPI) information was collected by the drones and provided as KML Files. System detection and tracking data was recorded by the TIPS-C System. Screen recordings were also collected.

a. The Drone Sentry C2 provided a composite Integrated Air Picture to allow the TIPS-C operator to report tracks on the Voice Net to the Battalion TOC.
b. The TIPS-C also provided a composite Integrated Air Picture to a US Army Forward Area Air Defense Command and Control (FAAD C2) via IP radio and the Cursor-On-Target format to allow situational awareness at outside nodes.

Analysis was also conducted on the Operational Mission by getting soldier feedback on the Drone Sentry C2 display and the ability of the TIPS-C to provide Situational Awareness.

2. EVENT DESCRIPTION

The TIPS-C was deployed as a system using multi-modality sensors, fused together using the DroneShield - SmartHub MK II and displayed to the operator on the DroneSentry-C2 Displays. The below picture shows the deployed system at the Ft. Sill Thompson Hill Range:

Key components of the TIPS-C System

Command and Control Systems:

1. DroneShield - SmartHub MK II & DroneSentry C2 display: The SmartHub produced a composite air picture from multiple tracking sensors to provide fused track information. The SmartHub operated in the vehicle. All sensors fed detection and tracking data into the SmartHub. The SmartHub output a single fused Integrated Air Picture to a DroneSentry-C2 display. An Army Soldier using the Drone Sentry C2 display ensured tracks suspected to be UAS were properly identified on the Workstation. The Soldier operators used track data and the camera system display as their primary means of UAS recognition.

2. FAAD C2. The FAAD C2 is the US Army C-UAS C2 System of Record to display the fused air picture for user action. The FAAD operated in the Battalion TOC. The TIPS-C was able to successfully integrate with the FAAD C2 and provide track data over IP radio.

Detection and Tracking Systems:

1. TrakkaCam TC-300 HDIR. The TrakkaCam provided multi-mission (Aerial and Ground) threat detection by utilizing a Continuous zoom HD MWIR thermal imager, continuous zoom color HDTV with low light mode, laser range finder (LRF), NVG compatible laser illuminator and laser pointer, an embedded video auto tracker and IMU/INS/GPS with static heading sensor, and advanced real-time HD image processing engine for video tracking, image enhancement, and image blending. It provided 360-degree coverage from below the horizon to the zenith in elevation (straight up above the sensor). The TrakkaCam is a completely passive sensor that can be cued by radar tracks or operated independently. The TrakkaCam operated from the top of the mast on the vehicle.

2. Echodyne Echoguard Radar. The Echoguard radar is an Ultra-low size, weight, and power (SWaP) active beam steering ESA radar. It is a 3D multi-mission radar for high performance ground and air surveillance. The Echoguard Radars operated from the top of the mast on the vehicle.

3. DroneSentry-X. The Drone Sentry is a hardware and software-based solution that detects Radio Frequency Signals between drones and the ground control stations. It provides information such as frequency, type of protocol and general area of detection. DroneSentry reports were displayed to the operator on the DroneSentry C2 Display. This system is operated from the top of the vehicle’s Cab.

System Architecture and Data Recording Points

The TIPS-C system has on-board data capture. It captures .csv files for both radar and RF system detections. The TIPS-C also has on board video capture of both the C2 and camera displays. The video recording system used standard video capture software to capture the display as an .mp4 file.

The analysis for this report compared drone TSPI data to the data files generated by the TIPS-C system.

Sample Radar Data:

```
id,time,radar_id,radar_name,system_track_id,target_id,primary,latitude,longitude,altitude,speed,heading,confidence,classification,rcs,toca,doca,prob_uav,prob_unk
6301663,12/14/2021 22:14:41.06241,1,,190068,10050,true,34.695212959,-98.5508288339,28.82,6.51,0.0,0.2,Unknown,-29.3,4294955.0,16.16,0.0,1.0
6301662,12/14/2021 22:14:40.811383,1,,190068,10050,true,34.6952125886,-98.5508385802,28.365,6.51,0.0,0.23,Unknown,-29.3,4294955.0,16.16,0.0,1.0
6301661,12/14/2021 22:14:40.560033,1,,190068,10050,true,34.6952119713,-98.5508548240333,27.593332,6.51,0.0,0.28,Unknown,-29.3,4294955.5,16.16,0.0,1.0
6301660,12/14/2021 22:14:40.31101,1,,190068,10050,true,34.69521135395,-98.5508710678,26.825,6.51,0.0,0.36,Unknown,-29.3,4294955.5,16.16,0.0,1.0
6301659,12/14/2021 22:14:40.060253,1,,190068,10050,true,34.695210736633,-98.5508873116667,26.056665,6.51,0.0,0.41,Unknown,-29.3,4294956.0,16.16,0.0,1.0
6301658,12/14/2021 22:14:39.797476,1,,190068,10050,true,34.69521011935,-98.5509035555,25.285,6.51,0.0,0.49,Unknown,-29.3,4294956.0,16.16,0.0,1.0
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6301655,12/14/2021 22:14:39.047873,1,,190068,10050,true,34.6952083908,-98.5509490382,23.135,6.51,0.0,0.67,Unknown,-29.3,4294957.0,16.16,0.0,1.0
6301654,12/14/2021 22:14:38.808076,1,,190068,10050,true,34.6952077734667,-98.5509652820333,22.366667,6.51,0.0,0.72,Unknown,-29.3,4294957.0,16.16,0.0,1.0
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6301652,12/14/2021 22:14:38.307489,1,,190068,10050,true,34.6952065388,-98.5509977698667,20.83,6.51,0.0,0.85,Unknown,-29.3,4294957.5,16.16,0.0,1.0
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6301649,12/14/2021 22:14:37.556112,1,,190068,10050,true,34.6952047686,-98.5510447235,18.575,6.66,0.0,1.0,Unknown,-29.3,4294958.5,16.01,0.0,1.0
```

Sample RF Data:

```
id,rf_sensor_id,rf_sensor_name,site_name,duration,start_time,end_time,vendor,protocol,mac_address,frequency_min,frequency_max,num_detections,start_replay_time,end_replay_time,num_detections,avg_azimuth_rad
19426,1,,Trakka TIPS-C,16.253299,2021-12-14 20:51:59.499065Z,2021-12-14 20:52:15.752359Z,DJI,OS FHSS,"",2449000000.0,2456000000.0,7,,,7,1.961531026e-08
19425,1,,Trakka TIPS-C,101.537725,2021-12-14 20:49:24.952376Z,2021-12-14 20:51:06.490101Z,DJI,OS FHSS,"",2428000000.0,2470000000.0,26,,,26,1.961531026e-08
19424,1,,Trakka TIPS-C,2.767953,2021-12-14 20:44:31.731264Z,2021-12-14 20:44:34.499217Z,DJI,LB FHSS,"",2449000000.0,2449000000.0,2,,,2,1.961531026e-08
19423,1,,Trakka TIPS-C,23.952167,2021-12-14 20:44:04.878563Z,2021-12-14 20:44:28.830732Z,DJI,LB FHSS,"",2407000000.0,2463000000.0,10,,,10,5.4977870267949
19422,1,,Trakka TIPS-C,2.235613,2021-12-14 20:43:51.124645Z,2021-12-14 20:43:53.360258Z,DJI,LB FHSS,"",2442000000.0,2442000000.0,2,,,2,1.961531026e-08
19421,1,,Trakka TIPS-C,35.141276,2021-12-14 20:43:51.092809Z,2021-12-14 20:44:26.234085Z,DJI,LB OFDM,"",2476500000.0,2476500000.0,8,,,8,5.4977870267949
19420,1,,Trakka TIPS-C,104.760341,2021-12-14 20:43:39.903211Z,2021-12-14 20:45:24.663552Z,DJI,LB FHSS,"",2421000000.0,2442000000.0,16,,,16,4.7123890267949
19419,1,,Trakka TIPS-C,108.529896,2021-12-14 20:43:06.430009Z,2021-12-14 20:44:54.959905Z,DJI,LB OFDM,"",2476500000.0,2476500000.0,34,,,34,1.961531026e-08
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Targets

Both Rotary and Fixed-wing types of drones were flown against the TIPS-C:

Intense Eye:

Strato-Surfer:

Both types of targets provided excellent examples of potential threats. They also allowed an assessment of the full range of TIPS-C capabilities.

3. C-UAS SURVEILLANCE AIR PICTURE ASSESSMENT OBJECTIVES

Below are the Measures of Performance assessed during the event. The goal of the assessment was to:

Collect and analyze QUANTITATIVE data to validate TIPS-C capabilities.

MOP 1. Detection Completeness. Assesses the completeness of the air picture between the local track store on the individual system based on sensor data and the number of known sUAS in the area.
Completeness, within system capabilities, was over 97%
MOP 2. Clutter. Assesses the amount of "actionable tracks" vs the number of "all tracks" presented to the operator in each period.
While Clutter tracks exited, they were quickly assessed by the operator to be false by the camera
MOP 3. System Track Accuracy. Assess the positional accuracy of the tracks produced by the CTC vs the GPS provided truth (azimuth error from system location).
Azimuth Error was +/- 2.5 degrees, well within standard acceptable practices.
MOP 4. Tracks per TOI. Count the number of tracks numbers, both simultaneous and sequential (Dualling / track # changes), per an individual Target.
Tracks per TOI was 1, ensuring continuity of track, and assisting rules of engagement

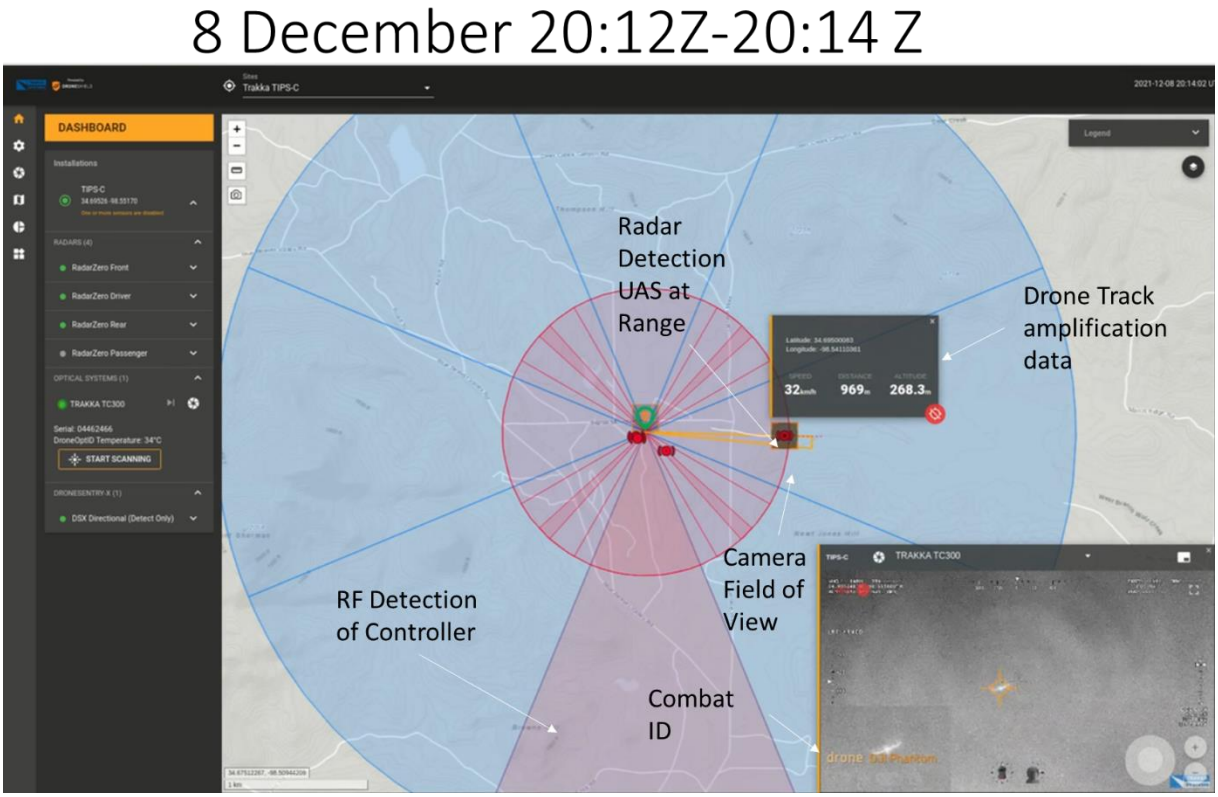
4. RESULTS SUMMARY

System Integration & Soldier Use

The TIPS-C successfully integrates the multimodality sensors into an on-board system and displays the data in a Graphical User Interface that requires minimal training.

The soldier Operators in the Battalion TOC successfully utilized the Drone Sentry C2 system to view the battlefield and understand the situation.

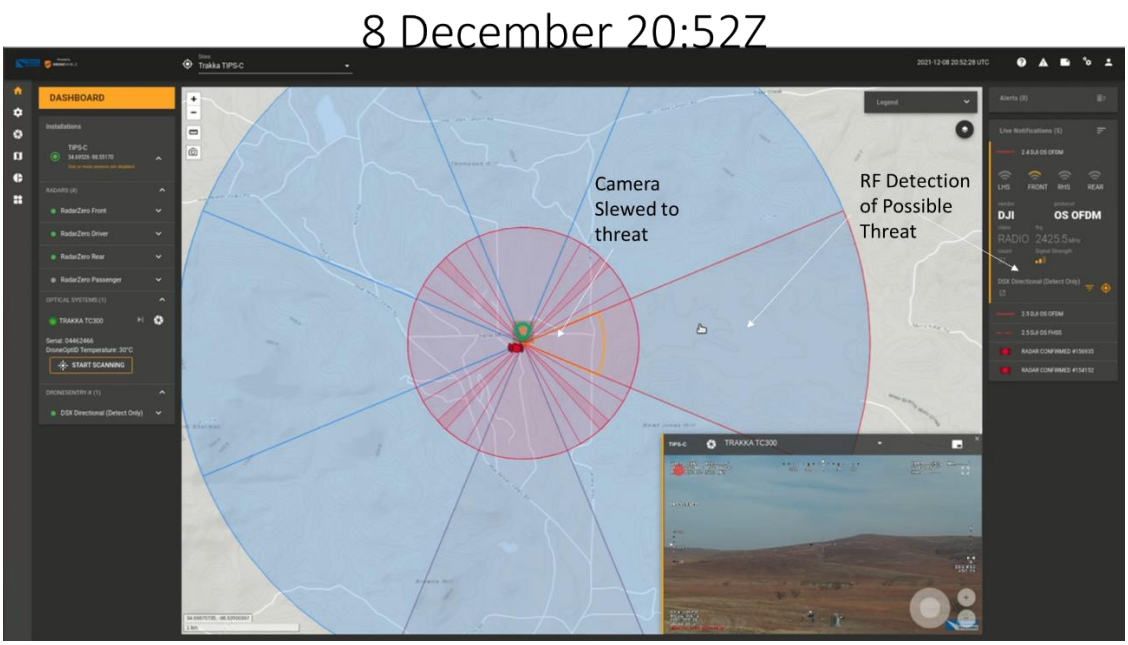
The below picture shows the basics of the display in support of the counter drone Mission. The system is very intuitive and was quickly understood by Field Artillery trained soldiers with zero training.



The above picture depicts the typical display for the soldiers in a Drone Attack. An RF Detection of the ground control station is detected and displayed by the octant going red. The Drone is detected by radar at 1km. The camera detects the track, and the field of view is shown one the map in yellow. Operators can get basic kinematic data by clicking on the track. Once the drone gets closer, the system automatically identifies the drone by type, in this case a “DJI Phantom.”

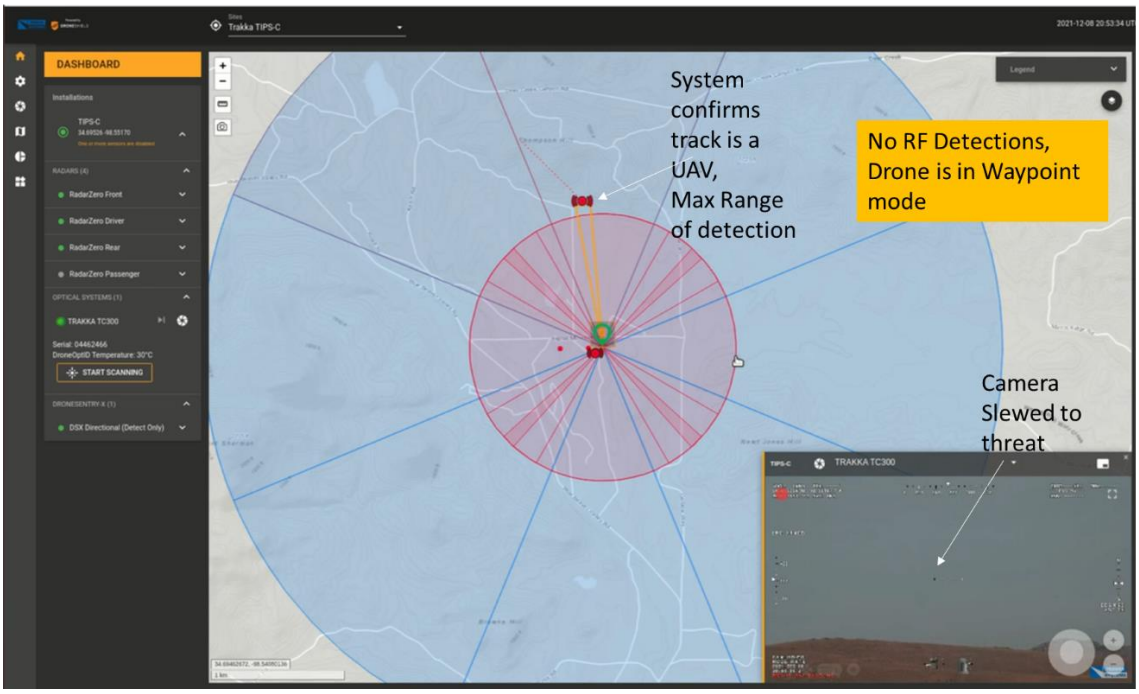
The next three diagrams show the typical drone detection to tracking thread.

As seen below, the system cues the operator that a drone is being initialized by a Ground Control Station. The operator moves the camera to the octant indicated on the display.



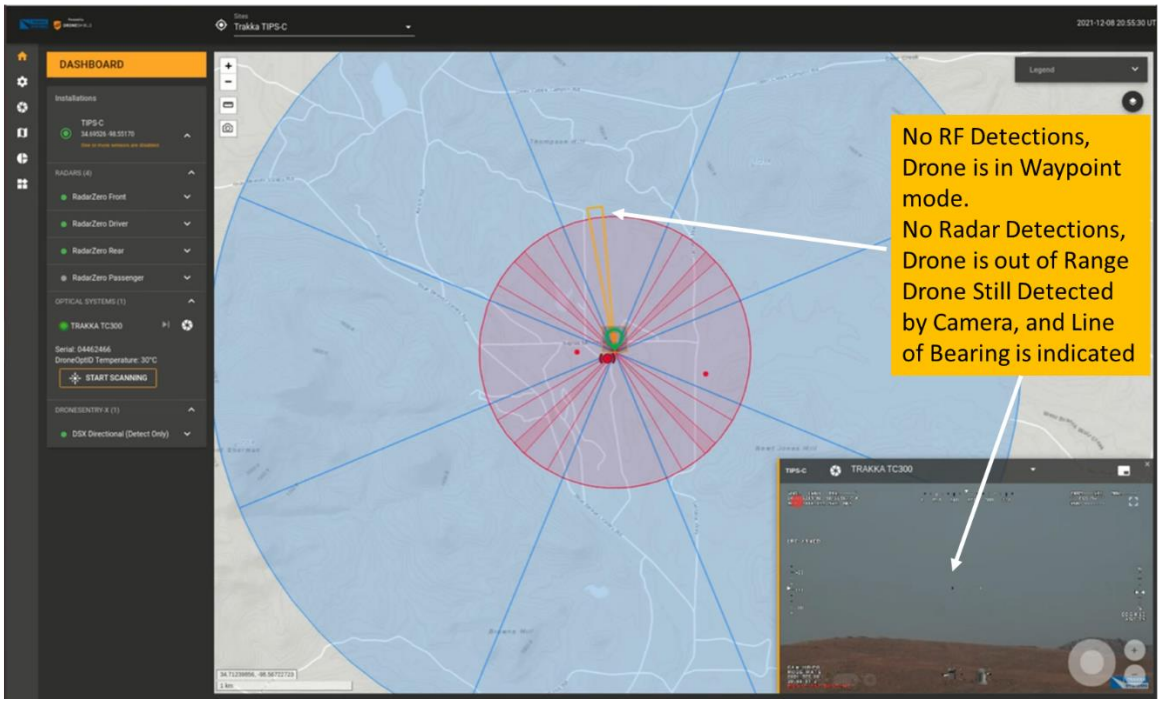
Once in radar track, the operator sees the track on the map, and the camera keeps it in Field of view. The drone is tracked though its track path.

Radar Tracks to Max Range 20:53



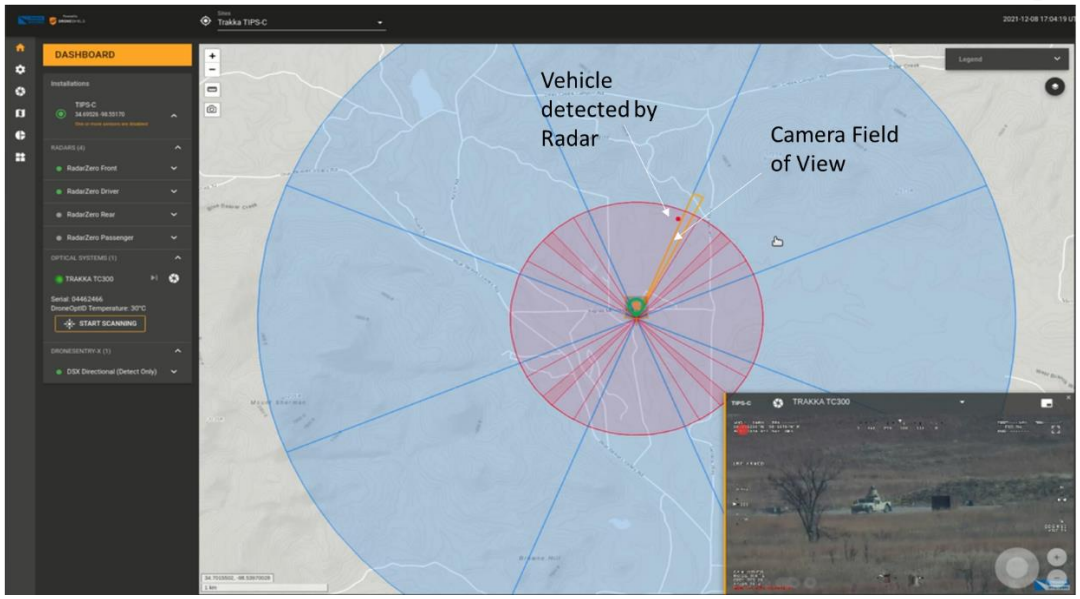
Finally, the drone goes out of range, but the operator continues to track with the camera, including an indicated line of bearing.

Camera Continues to Track Past Radar Range 20:55



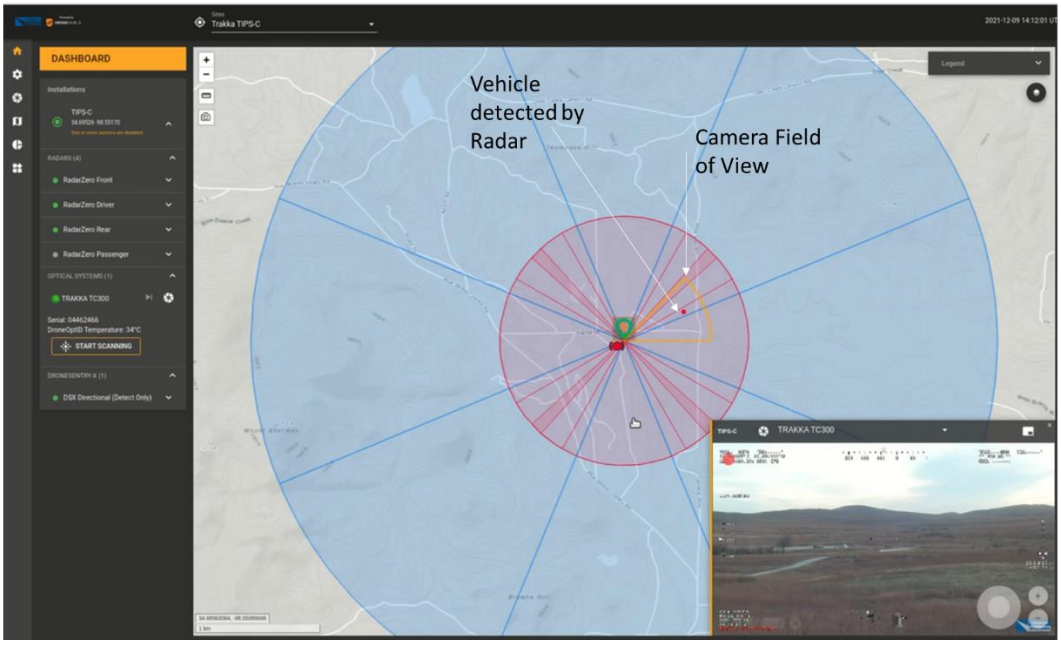
The TIPS-C system also demonstrated its ability to do **ground target tracking**. The below diagram depicts it tracking of a stationary vehicle.

8 December 17:04Z Ground Vehicle Tracking



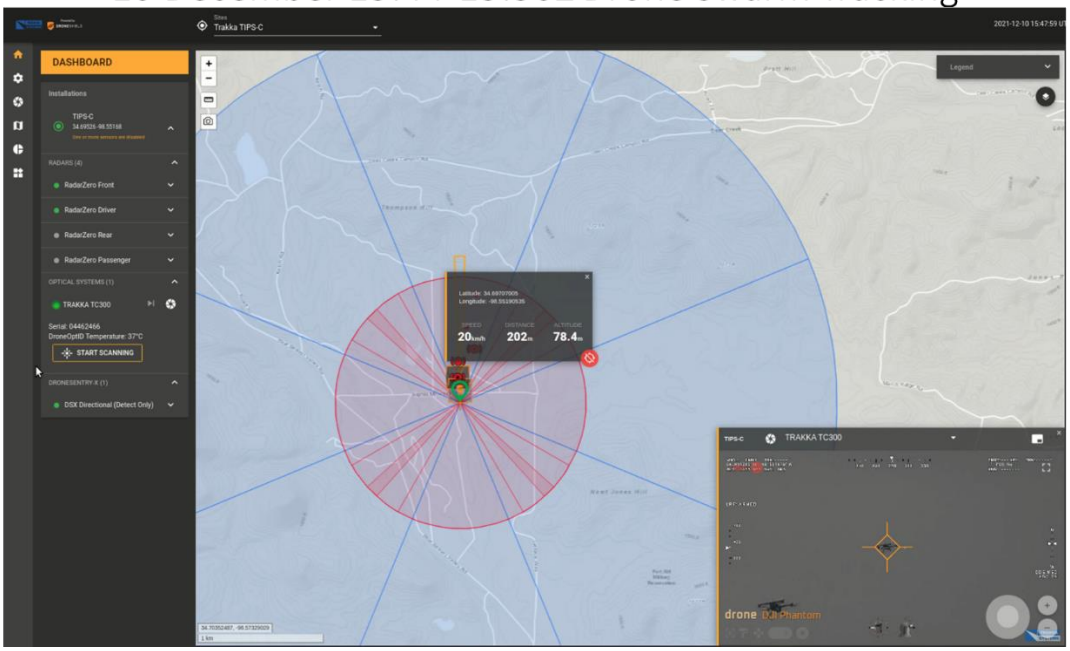
Below depicts the tracking of an inbound fast-moving vehicle.

9 December 14:12

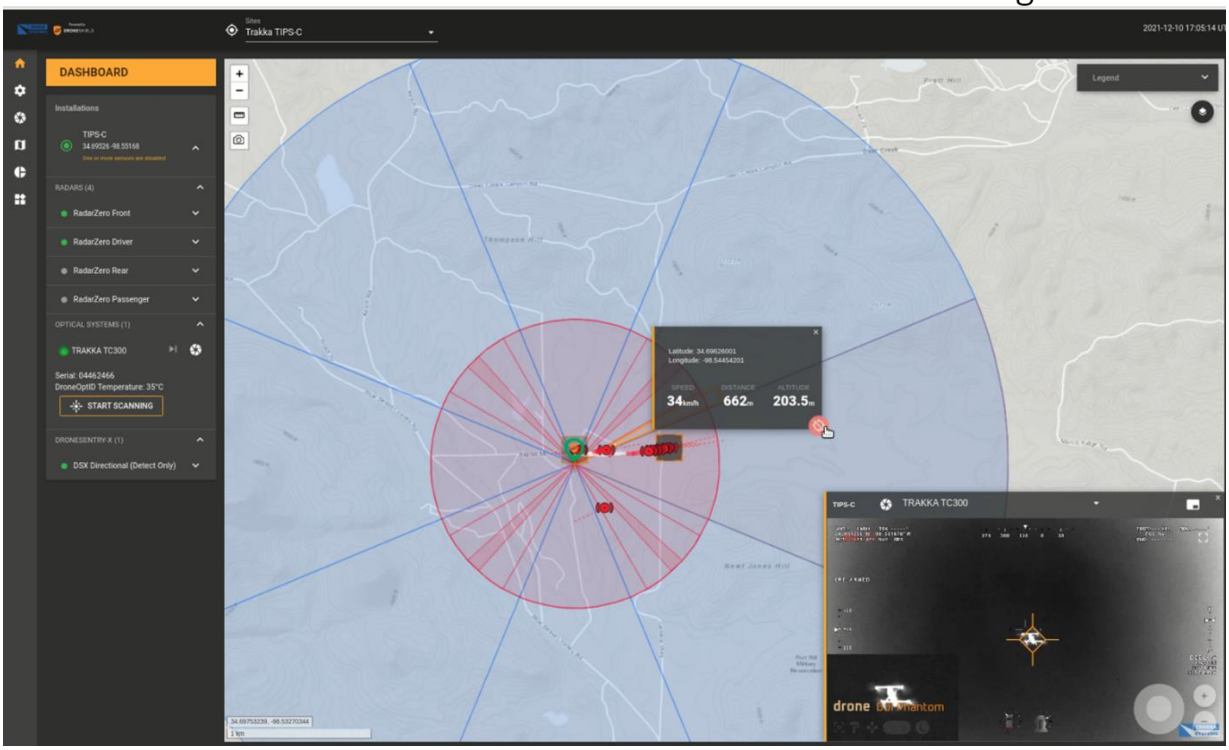


Finally, the TIPS-C was evaluated against **Drone Swarm** attacks. TIPS-C was not only able to track the individual drones by radar; but also had them in camera field of view, and was able to conduct Combat ID.

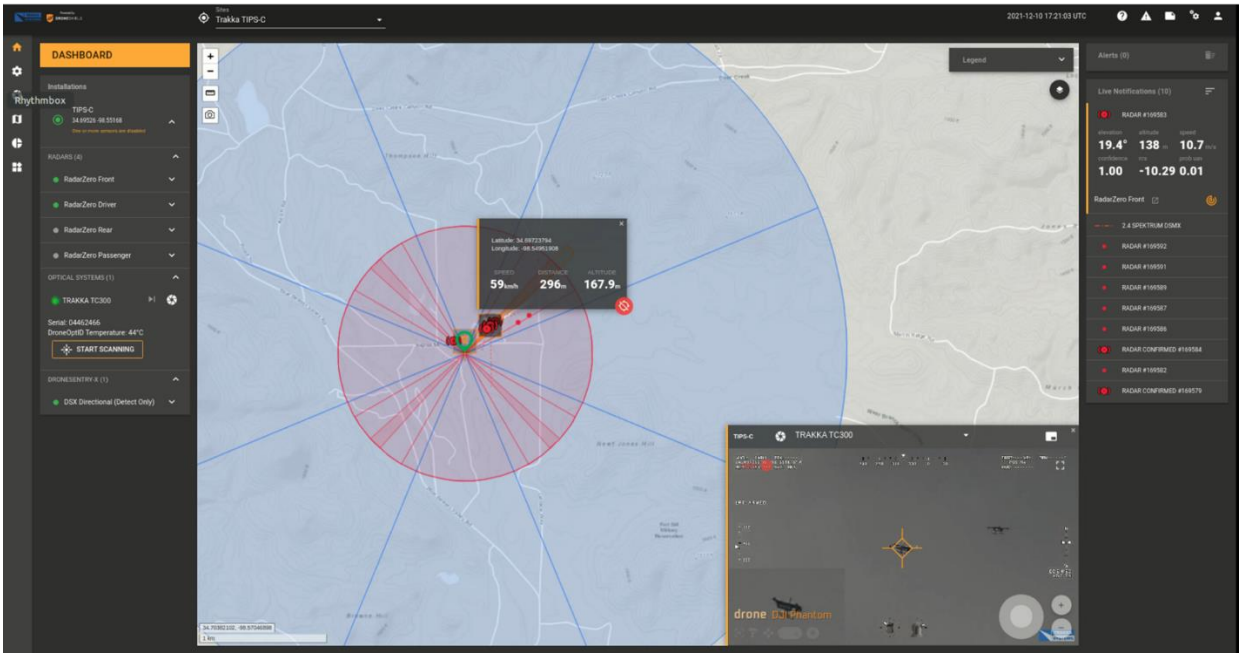
10 December 15:44-15:50Z Drone Swarm Tracking



10 December 17:04-17:05Z Drone Swarm Tracking



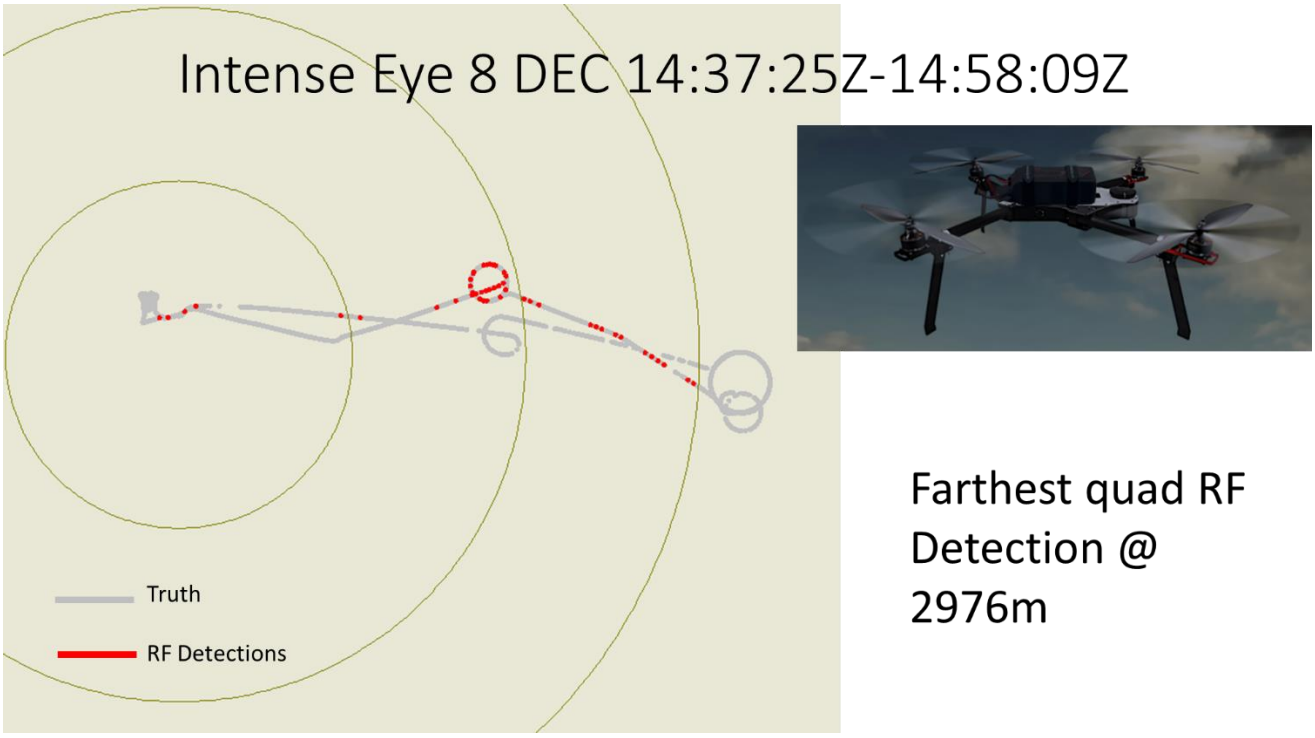
10 December 17:21-17:24Z Drone Swarm Tracking



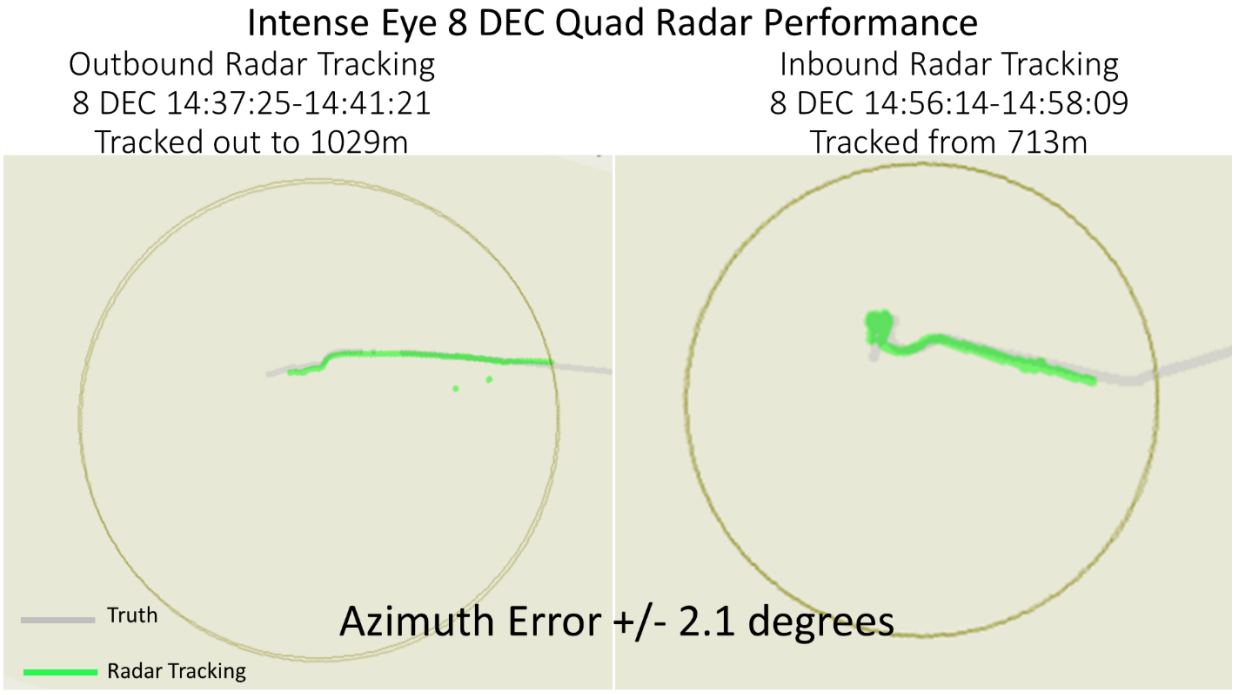
Measures of Performance

Performance against Rotary Wing Drones:

Below depicts typical RF Sensor Detection vs Quad Copters

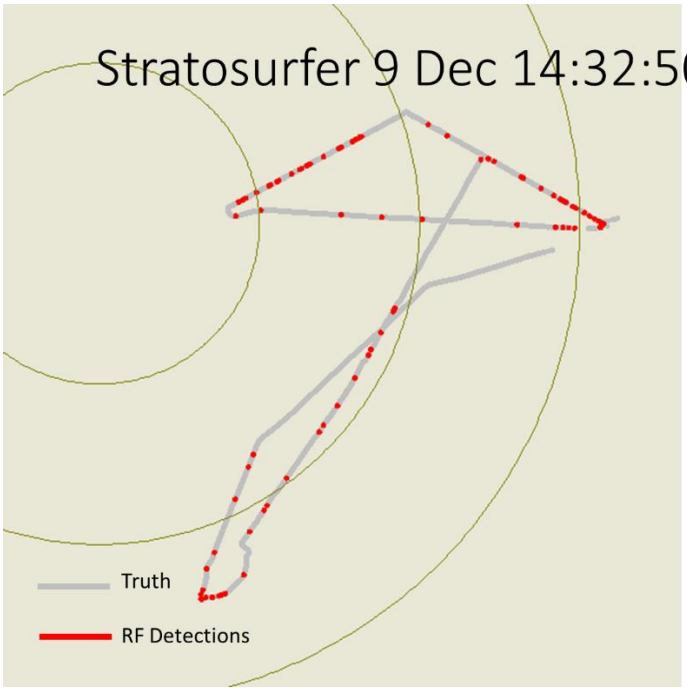


Below depicts typical Radar Detection vs Quad Copters:



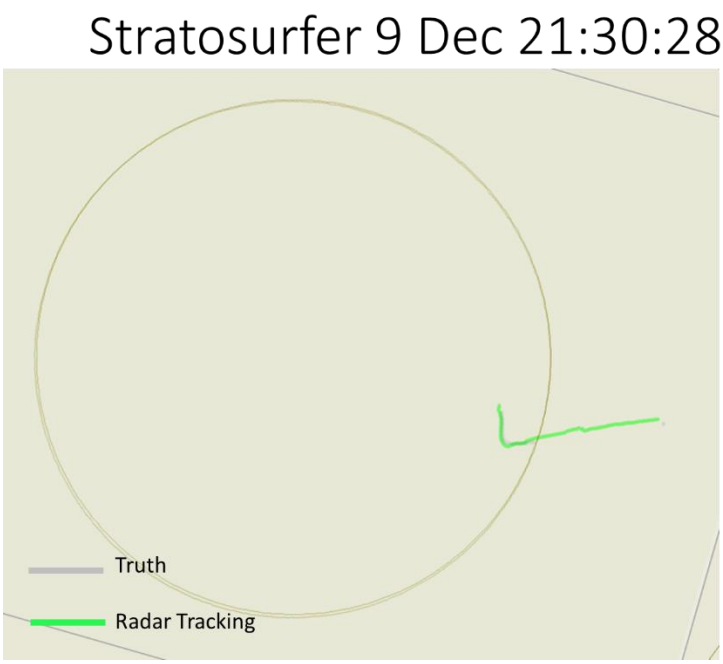
Performance against Fixed Wing Drones:

Below depicts typical RF Detection of Fixed Wing drones was beyond 3km:



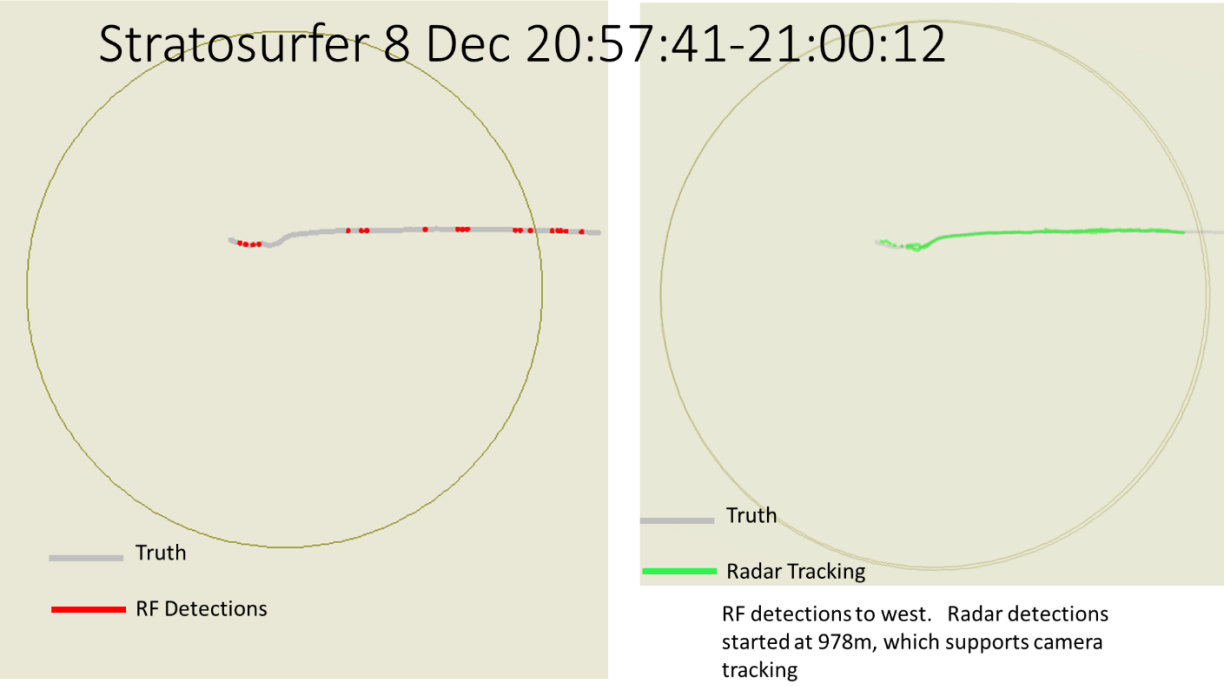
Farthest FW Detection @ 3167m

Below depicts typical Radar Detection of Fixed Wing drones was beyond 1.3km:



Radar detections at 1375m

Below depicts an inbound attack by a fixed wing drone with both Radar and RF Tracking:



RF detections to west. Radar detections started at 978m, which supports camera tracking

Note from the time of first detect to time on target is just over 1 minute. The TIPS-C system provided consistent Radar, RF, and camera tracking for the Soldier operators to react appropriately.

5. CONCLUSIONS AND RECOMMENDATIONS

Key Lessons Learned:

1. Three Different Sensor Modality Types provide effective Counter-Drone detection.
The combination of the Trakka camera, the Echodyne radar and DroneSentry passive RF detection effectively supported Detect, Track, and ID of small drones..

2. Integration is the FORCE MUPLIPLIER. The DroneSentry C2 system was an effective C2 system for Counter-UAS operations. Its "easy to operate" interface, was essential to maintaining operator situational awareness. The fact it was able to integrate with the Army C2 System of record, FAAD C2, only added to its capability to be rapidly fielded in a Joint and Multinational Environment.

3. On-board data recording is an essential feature.
On-board recording supports Intelligence exploitation of data and forensic analysis of threat drone patterns.