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# System Configuration for Demonstration of the Integration of Unattended Ground Sensors (UGSs), Unmanned Aircraft Systems (UASs), and Android Team Awareness Kits (ATAKs)

by Timothy Gregory and Jinho Kim

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# System Configuration for Demonstration of the Integration of Unattended Ground Sensors (UGSs), Unmanned Aircraft System (UASs), and Android Team Awareness Kits (ATAKs)

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**14. ABSTRACT**
This technical note describes the configuration of components used in an experiment to demonstrate the use of Unattended Ground Sensors (UGSs) to cue the operator of an Android Tactical Assault Kit (ATAK) end-user device to direct an Unmanned Aircraft System (UAS) to the detection area. The UAS will then provide target identification and localization.

**15. SUBJECT TERMS**
Unattended Ground Sensor, UGS, Android Tactical Assault Kit, ATAK, Unmanned Aircraft System, UAS, Network and Computational Sciences

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## 1. Introduction

This technical note provides a description of the configuration of systems needed for a demonstration of object detection and localization using an Unmanned Aircraft System (UAS).

This demonstration requires a UAS, the Android Team Awareness Kit (ATAK) End-User Device (EUD), Tactical Assault Kit (TAK) server, atak_bridge Robot Operating System (ROS) package, Open Standard for Unattended Sensors (OSUS) system, TRSS ETU-II Unattended Ground Sensors UGSs, and a receiver to receive the TRSS messages.

The TRSS sensors will report a detection to the TAK server. The TAK server will forward the message to the connected clients. The UAS will then be directed to the area to observe and classify the detected object.

You will need to check and change the configuration of the system if you change the WiFi router.

This document WILL NOT provide information for configuring ROS.

## 2. Required Software and Equipment

Software:

- OSUS controller
- TAK server
- ATAK client
- atak_bridge

Hardware:

- Sensors, TRSS Encoder-Transmitter Unit Version II (TRSS ETU-II) sensors
- Receiver (power supply, USB/power cable, antenna w/SMA adapter)
- Wireless access point (WAP)
- PC/laptop running OSUS and TAK server
- Tablet/phone running ATAK (ATAK EUD)

# 3. Hardware Setup

## 3.1 Receiver, Antenna, Power Supply

1) Connect the antenna to the SMA jack labeled “ANTENNA.”
2) Connect the circular connector to the jack labeled “USB RADIO.”
3) Connect the USB-A male connector to the USB jack on the laptop.
4) Connect the 3-pin power connectors together.
5) Plug the NEMA 5-15P into a wall power outlet.

## 3.2 Wireless Access Point (WAP)

1) TP-LINK Model: TL-WR902AC.
2) The WAP is USB powered. Use either a USB wall power supply or a PC.
3) There are two SSIDs configured TAKSERVER-5 and TAKSERVER-2.4.
4) The password for both is TAKSERVER.

## 3.3 Laptop

1) Power on the laptop.
2) Connect to the TAK server WiFi (Fig. 1).

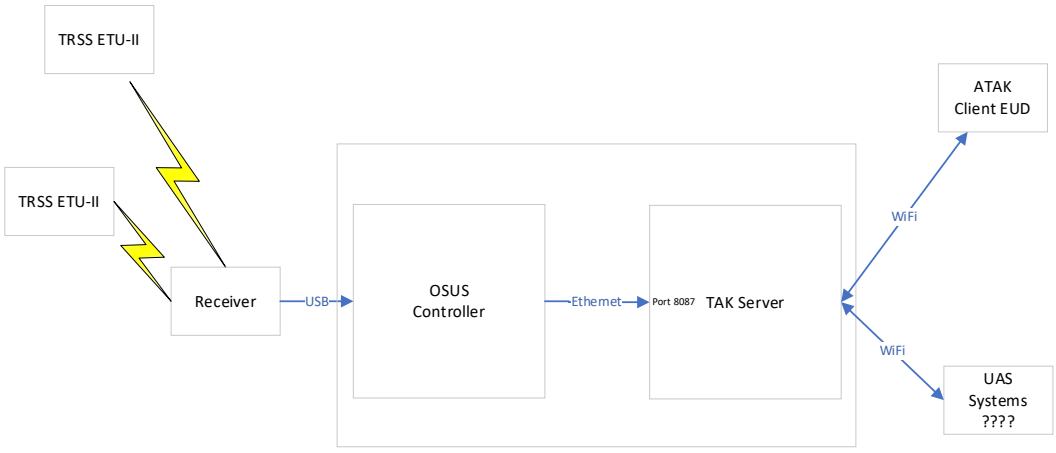


**Fig. 1 System architecture**

# 4. Starting the Software Components

The TAK server runs in a Virtual Machine (VM) under VMWare Workstation Pro.

1) Start VMware Workstation Pro using the desktop link. 

    a) Start the Centos VM (contains the TAK server)
2) Start the OSUS controller: use the link/icon labeled “Start OSUS” on the desktop to start the OSUS controller.
3) Start atak_bridge: atak_bridge runs on an onboard computer of UAS.
    a) Connect to the onboard computer of UAS through SSH. The onboard computer of UAS must be connected to the same network with TAK server.
    b) In atak_bridge package folder, find launch files in the launch folder. Run one of the launch files by “roslaunch atak_bridge <launch file name>.”
4) Start ATAK Client: start the ATAK client application on the EUD. Use the menu system to connect to the TAK server.

# 5. Component Descriptions

## 5.1 Open Standard for Unattended Sensors (OSUS)

The OSUS system allows rapid sensor integration and interchangeability with larger systems thru a standardized set of services that lets Open-Source Gateway Initiative-compliant (OSGI) bundles execute on any OSUS platform.

The OSUS system will receive and process messages from the TRSS ETU-II sensors. The resulting events will be sent in Cursor-on-Target (CoT) XML format to the TAK server. This requires the use of a receiver to receive messages from the TRSS ETU-II sensors.

OSUS is installed on the experiment laptop in the following path: D:\ARLDeveloper\FROM_TH050\th\

For configuring the OSUS controller, see Section 6.2, “OSUS Configuration.”

### 5.2 TAK Server

The TAK server is a tactical information management platform that provides data access and encryption across disparate networks.

This instance of the TAK server runs in a VM under VMware Workstation Pro on the experiment laptop. The TAK server will be configured to receive unencrypted messages on port 8087. These messages will be processed and forwarded on port 8088 to the listeners. No encryption is supported on ports 8087 or 8088. ATAK clients connect to the TAK server on port 8089 using Transport Layer Security (TLS).

### 5.3 atak_bridge ROS Package

The atak_bridge ROS package generates a node to translate CoT messages to ROS messages and vice versa. The communication between the TAK server and UAS allows sending the UAS to the goal position and displays data, such as the position of the UAS and detected targets and so on, on ATAK clients.

### 5.4 ATAK Client

The ATAK client will run on an Android tablet or Android phone.

## 6. Configuration

### 6.1 UGS: TRSS ETU-II Configuration

The TRSS ETU-II sensor electronics assembly is configured through the serial interface.

The serial port parameters are as follows: baud rate: 38400, 8 data bits, no parity, 1 stop bit, no flow control.

The “Programming Menu” will solicit setting the necessary parameters: transmit channel, Device ID, Mode, Target Masking and Statement of Health Interval.

Channel 555 was chosen because it falls in the USA Multi-Use Radio Service (MURS) band at 151.875 MHz. The ETU-II power of 2 W also meets the MURS requirements.

The “Device ID” changes for each sensor as follows:

```
************************************************************

Transmit Channel (001-599)              = 555
Tamper Detection Enabled (Y/N)          = N
Device ID                               = 58
SA Gain (High/Med/Low/Ext only)         = High
Mode (000 = NRT, 001-127 interval hrs)  = 001
Sleep Mode Enabled? (Y/N)               = N
Delayed Power-on Enabled? (Y/N)         = N
State Of Health Report Interval (HH:MM) = 01:00
Mask Target(s)? (U/P/V/W/T/N-none)      = N
Battery                                 = Normal
Firmware Self Test                      = Pass
SW Version                              = 1.2.1.1
Time (HH:MM)                            = 00:00
Date (YY/MM/DD)                         = 00/00/00

************************************************************
```

Refer to *Product Specification for the Encoder-Transmitter Unit Version II Sensor Electronics Assembly and Transducer Cable Assembly 0001A0016 Revision B29,* December 2006, Appendix A, Section 4, for details on configuring the TRSS ETU-II sensor.

## 6.2 OSUS Configuration

### 6.2.1 Sensor Locations

The TRSS ETU-II sensor locations are specified in a text file. The file path is: D:\ARLDeveloper\FROM_TH050\th\ETULocations.txt.

### 6.2.2 Required Plugins

The required plug-ins should already be installed. The following OSUS plug-ins are required:

mil.arl.th.trss.novaLinkLayer.NovaLinkLayer

mil.arl.th.trss.etu2Asset.ETUAsset

mil.arl.th.toCot.TH2Cot

### 6.2.3 OSUS Configuration

If you change network environments, you will need to change the configuration of the OSUS controller. You will likely need to change “CotServerIP” and “LocalAddress.” These parameters are specified in the file named “configs.xml.”

This file is in the “conf” (D:\ARLDeveloper\FROM_TH050\th\conf) directory of the OSUS installation home.

“CotServerIP” is the IP address of the TAK Server VM. “CotServerUdpPort” and “CotServerTcpPort” are the ports used by TAK server.

“LocalAddress” is the IP address of the network interface on the PC/server running OSUS. (This is necessary to disambiguate network interfaces on a system with multiple interfaces.)

These addresses are specified in a file named “configs.xml.”

The communications (COM) port may also need to be changed. Change the “PhysicalLink” name as shown below. Then change the value of “th.physical.link.name” to match “PhysicalLink.”

If TRSS sensor channel has changed, you will need to set “cis.defaultTxChannel” appropriately.

After changing the configuration parameters, OSUS must start with a clean setup. This is done by removing the following subdirectories: D:\ARLDeveloper\FROM_TH050\th\felix-cache and D:\ARLDeveloper\FROM_TH050\th\datastores. This will allow the new configurations to take effect.

### 6.2.4 Mil.arl.th.toCot.TH2Cot

The TH2Cot plug-in sends the CoT messages to the TAK server. The following snippet of XML from the configuration file (configs.xml) provides a template for configuring the TH2Cot plug-in.

```
<osgiConfigs>
   <factoryPid>mil.arl.th.toCot.TH2Cot</factoryPid>
   <properties key="Run" value="true"/>
         <properties key="CotServerIP" value="192.168.1.15" />
         <properties key="CotServerUdpPort" value="8087" />
         <properties key="CotServerTcpPort" value="8087" />
         <properties key="SendProtocol" value="udp" />
         <properties key="LocalAddress" value="192.168.1.6" />
         <properties key="LocalPort" value="18031" />
</osgiConfigs>
```

### 6.2.5 Physical Link

The TRSS messages are received by a receiver. OSUS communicates with the receiver through a serial port. A physical link for the serial port must be created in

OSUS. In the Windows operating system, the serial ports are named “COMn”, where “n” is a digit. In this case, COM4 is being used to communicate with the radio. The following is the detail for the creation of the PhysicalLink in the configuration file.

```
<factoryObjects name="COM4">
        <factoryType>PhysicalLink</factoryType>
        <physicalLinkType>SerialPort</physicalLinkType>
        <createPolicy>FirstRun</createPolicy>
</factoryObjects>
```

### 6.2.6 Link Layer

Communication between OSUS and the receiver is handled by a link layer plug-in. The link layer must be created using the plug-in named: mil.arl.th.trss.novaLinkLayer.NovaLinkLayer.

The configuration of the link layer plug-in is specified by properties. The communications port must be specified in the property named “th.physical.link.name” to match the “PhysicalLink” created above. Under the Windows operating system, this may be similar to “COM4.”

The following is the configuration settings for the factory object for the NovaLinkLayer. Note that the parameter “cis.defaultTxChannel” is used to specify the receive channel. (This is due do an error in the NovaLinkLayer plugin.)

```
<factoryObjects name="NovaLL-COM5">
        <factoryType>LinkLayer</factoryType>
        <properties key="th.activate.on.startup" value="true" />
        <properties key="th.physical.link.name" value="COM4"/>
        <properties key="cis.defaultTxChannel" value="555"/>
        <!--<properties key="cis.defaultTxChannel" value="190"/> -->
        <properties key="cis.rxChannel" value="125"/>
        <productType>mil.arl.th.trss.novaLinkLayer.NovaLinkLayer</productType>
        <createPolicy>FirstRun</createPolicy>
</factoryObjects>
```

## 6.3 atak_bridge ROS Package Configuration

The ATAK client code is based on work found at https://github.com/pinztrek/takpak.git. Transformation from “base_link” to “UTM” is used to find the robot position and the location of detected objects in “global frame.”

### Parameters

- name (string, default: 'ranger'). Used to namespace topics.
- callsign (string, default: 'default_callsign'). The call sign used by this system to identify itself on TAK.
- team_name (string, default: 'Cyan'). This system's team name. This should align with ATAK teams, usually colors.
- team_role (string, default: 'Team Member'). This system's role in the team. This should align with team roles.
- tak_ip (string, default: '127.0.0.1'). The IP address of the server.
- tak_port (string, default: '8088'). The port for an unsecure connection to the server.
- baselink_frame (string, default: 'base_link'). The name of the frame that as at the base of the robot.
- map_frame (string, default: 'map'). The global frame that is converted to Lat/Long before being sent/received from the ATAK server. Usually 'ranger/map'.

### Published Topics

- ~/nav_goal/2d (geometry_msgs/PoseStamped): the location that the ATAK system is requesting the robot to move to.
- ~/nav_goal/path (nav_msgs_msgs/Path): the path that the ATAK system is requesting the robot to following to.

### Subscribed Topics

- /detection_localization/out/detections/local (vision_msgs/Detection2DArray): Current location of objects of interest. This is used to update the TAK server on the position of objects of interest.
- /tflite_ros/detections_image (sensor_msgs/Image): Image output of objects of interest. This is used to see images of the detected objects captured from the UAS.

# 7. Troubleshooting

## 7.1 Cannot Connect to the TAK Server

Occasionally the TAK server will stop running or hang up. Restarting the TAK server usually remedies the situation. Use one of the following methods to restart the TAK server.

1) Use the VMware Workstation GUI to restart the TAK server virtual machine.
2) Use a terminal program (such as ssh,teraterm) to log into the TAK Server VM. Then restart the takserver service using the systemctl utility. (sudo systemctl restart takserver).

## 7.2 OSUS Controller Not Sending Reports

Occasionally, the OSUS controller will malfunction. Restarting the OSUS controller usually remedies the situation.

1) Restart the OSUS controller from the command line.
    a) At the THOSE command prompt, type “stop 0.”
    b) Start OSUS again using the “Start OSUS” icon on the desktop.
2) Reboot the PC.
    a) Use the Windows tools to reboot the PC.
    b) Log into the PC.
    c) Restart the OSUS controller using the desktop icon.

## 7.3 VM Does Not Have a WiFi Connection

If the VM cannot connect to the WiFi, you may need to add a virtual network device for the WiFi adapter. The following instructions will assist in adding the appropriate wireless adapter.

1) In the VMware GUI:
2) Edit->Virtual Network Editor-> (Fig. 2)

3) Press the “Change Settings” button on the lower right of the “Virtual Network Editor” GUI. This will cause the operating system to go ask for administrator privileges.

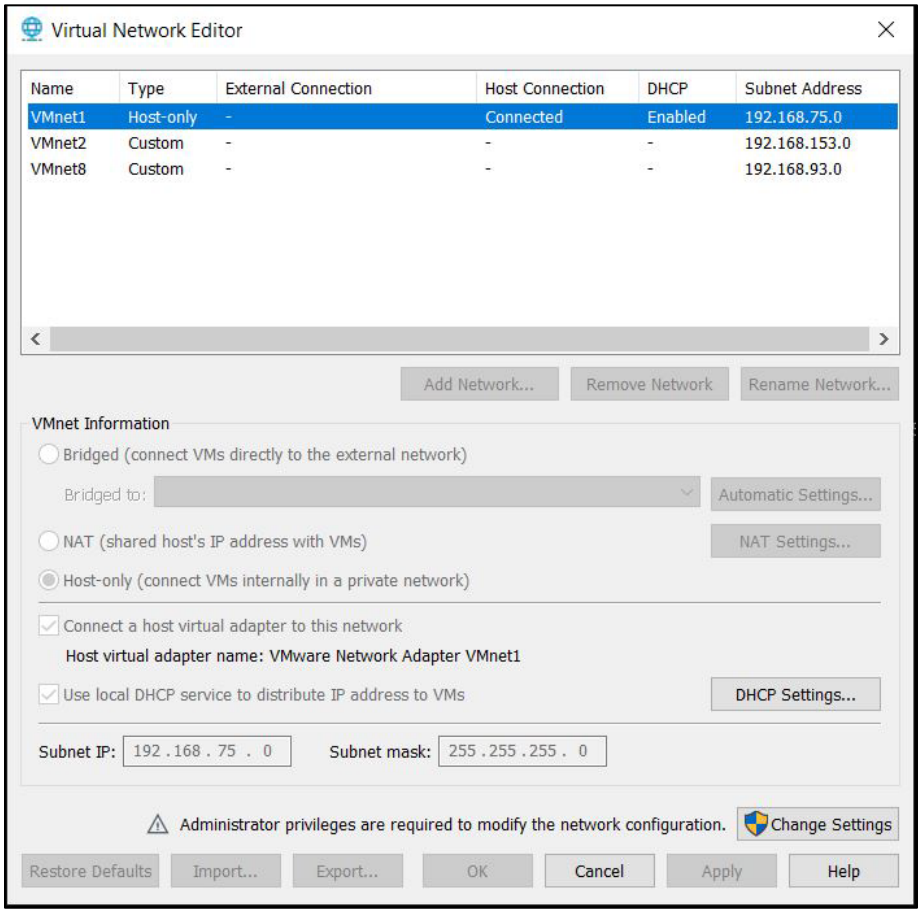


**Fig. 2 Virtual network editor**

4) Select the item that has the external connect shown as the wireless network adapter. In this case “VMnet2” shows as the “Intel Dual Band Wireless AC8265” (Fig. 3). Press the OK button. Then you should be able to start the wireless network connection from the guest operating system.

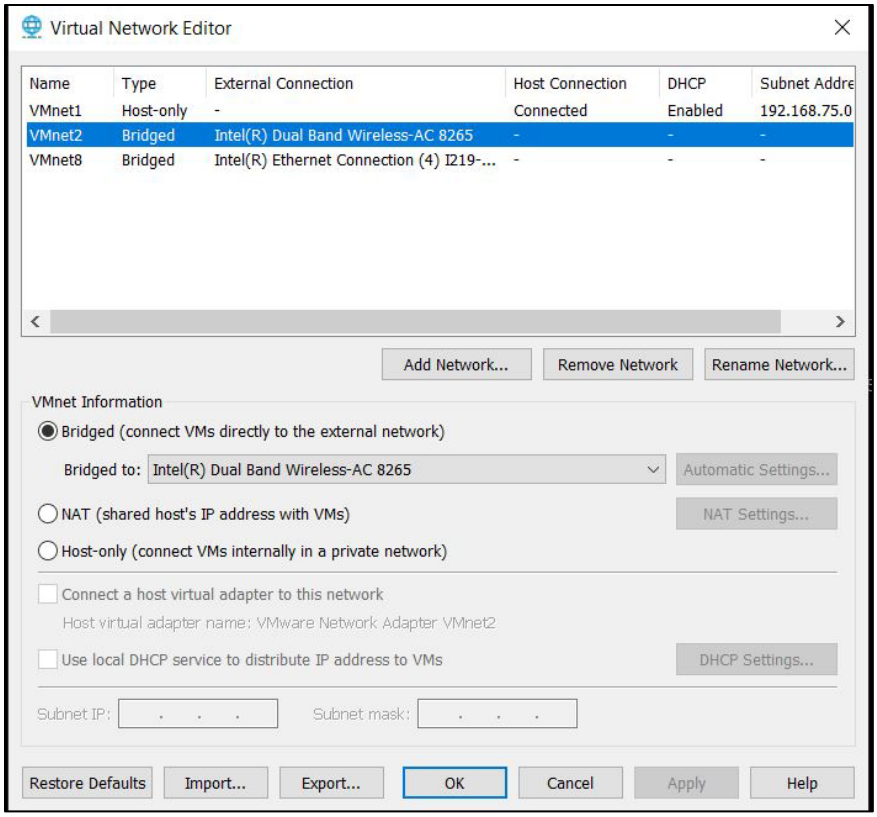


**Fig. 3 Intel dual band wireless AC8265**

## List of Symbols, Abbreviations, and Acronyms

| | |
|---|---|
| ATAK | Android Team Awareness Kit |
| COM | communications |
| CoT | Cursor-on-Target |
| EUD | End-User Device |
| GUI | graphical user interface |
| IP | Internet Protocol |
| MURS | Multi-Use Radio Service |
| OSGI | Open-Source Gateway Initiative |
| OSUS | Open Standard for Unattended Sensors |
| PC | Personal Computer |
| ROS | Robot Operating System |
| SMA | SubMiniature version A |
| SSH | Secure Shell Protocol |
| SSID | service set identifier |
| TAK | Tactical Assault Kit |
| TLS | Transport Layer Security |
| TRSS | Tactical Remote Sensor System |
| TRSS ETU-II | TRSS Encoder-Transmitter Unit Version II |
| UAS | Unmanned Aircraft System |
| UGS | Unattended Ground Sensor |
| USB | Universal Serial Bus |
| VM | Virtual Machine |
| WAP | wireless access point |
| WiFi | wireless network |
| XML | Extensible Markup Language |

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