CIELO™ MOCKINGBIRD RF EMULATOR

OWNER'S MANUAL | VERSION 2.1.0.

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syncopated PRODUCTS

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Mockingbird RF Emulator

1. Product Overview

Mockingbird is an RF signal and traffic emulator capable of emulating multiple “radio personalities” and manipulating the spectrum in a low SWAP device. Mockingbird includes a reconfigurable 2x2 MIMO Software Defined Radio (SDR), an embedded hardware accelerator and a simple and intuitive web application that enables the creation of sophisticated RF scenes and provides complete spectral situational awareness. Modular RF kits provide interchangeable RF front ends including antennas and power amplifiers to provide tailored RF performance for specific missions while leveraging the same simple user experience. Software Waveform toolboxes are available to emulate specific emitters including military communications, commercial wireless, SATCOM, and radar systems. The SENSE/LEARN/MIMIC cognitive cycle learns RF signatures and communications battle rhythms directly from actual RF systems. The low SWAP form factor runs off a single 2590 battery or DC power, and supports mounting solutions for mast, vehicle, manpack and small UAS. Typical use cases include EW/ECM, RF signature monitoring and management, as well as EW and SIGINT training and simulation.

1.1. System Use Cases

The primary system uses cases include:

- RF Signal and Traffic Emulation
- RF Spectral Analysis and Monitoring
- RF Signal Capture

1.2. Key Features

Table 1: Mockingbird Key Features and Benefits

Feature	Benefit
Signal Generators (“Radio Personalities”)	Direct emulation of signals (SINCGARS, LTE, SATCOM, Radar etc.). Extend with optional waveform toolboxes.
Traffic Conductor (Communication Battle Rhythms)	Creates realistic randomized traffic profiles and mixtures of RF signals and signatures to emulate the RF communications battle rhythm or pattern of life.
SENSE / LEARN / MIMIC Cognitive Cycle	RF signatures and traffic profiles are learned directly from actual RF system(s) and emulated from the compactly stored features. Requires less storage than record/playback and adds more realistic variability.
Wideband Transceiver (50-6000 MHz RF range, 40MHz IBW)	Wideband Software Defined Radio (SDR) that enables emulation of a broad variety of RF systems (communications, radar) in a low SWAP device. Optimize and extend with various RF kits.
RF Kits	Field-Exchangeable RF kits that provide tailored RF performance with higher transmit power profiles over specific frequency bands of interested (e.g. VHF, UHF, X-Band).
Web Interface	Simple and intuitive web interface enables creative RF scene development including mixtures of waveforms and traffic patterns, multi-channel spectrum analysis, signal capture, radio and system control.
Remote-Control	Optional Remote-Control via Iridium or LoRa (other options available)

2. Document Overview

This document provides guidance on how to install, configure, maintain, and troubleshoot the system.

3. How to Install the System

This section describes the system hardware installation and setup. The system does not require installation of software on an external computer. All software is provided within the system

3.1. Unpack the System

The Mockingbird system is delivered in a rugged shipping case that includes the following components:

Table 2: System Components

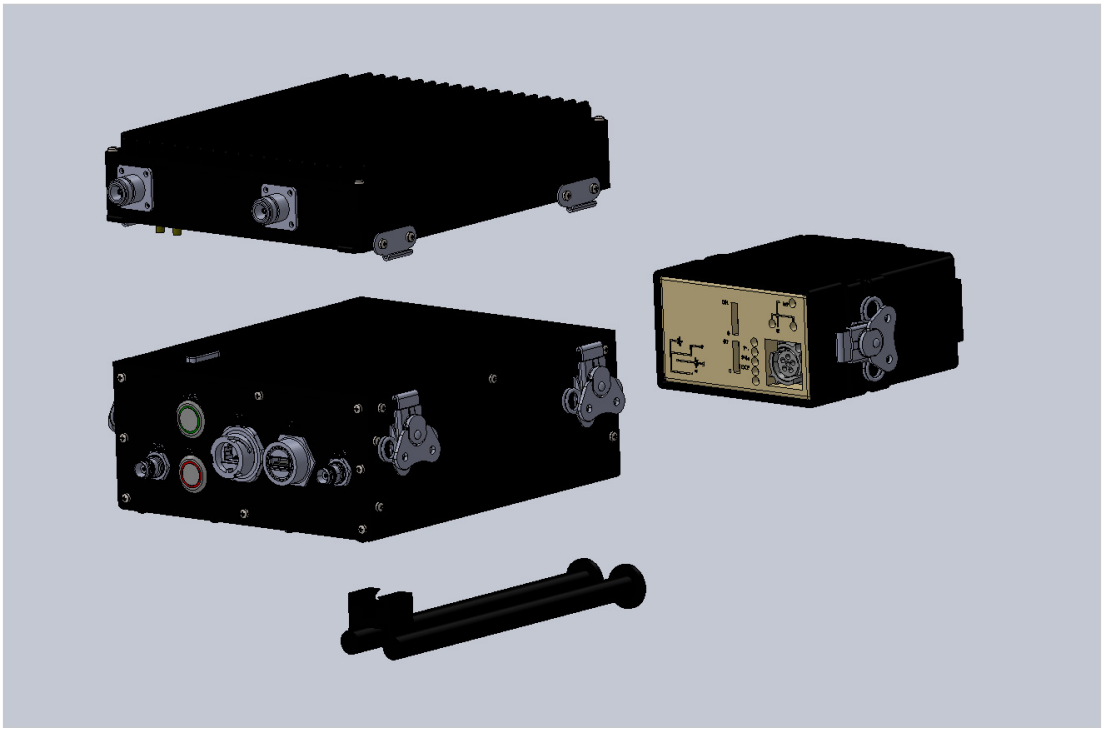
Item	Description
Cognitive Radio Base Unit	Ruggedized cognitive radio (primary system)
RF Kit(s)	Modular RF kit(s) (1 standard, >1 optional)
Battery Enclosure	2590 battery enclosure
BB2590 Battery	Rechargeable lithium-ion battery
Tripod	Tripod for ground deployment
Battery Eliminator*	Battery eliminator for use indoors
GPS Antenna*	GPS antenna [TNC]
Remote-Control*	Remote-Control Antenna [TNC]
Fixed Mast Mount*	Fixed mast mount
Magnetic Mount*	Magnetic mount

* *Optional Components*

The diagram below shows how the system is typically packed in the case:

3.2. System Assembly

This system assembly includes attaching the RF kit, the battery and the installing the tripod. The diagram below shows an exploded view of the system. The RF kit is attached to the top of the cognitive radio base unit, the battery is placed in the battery enclosure and attached to the rear of the cognitive radio base unit, and the tripod is attached to the bottom of the cognitive radio base unit.



The diagram below shows the standard installation with the transmit antenna attached.

Figure 1: Mockingbird Typical System Installation

3.2.1. How to Attach the RF Kit

See RF kit connector on the top of the cognitive radio base unit in the diagram below:

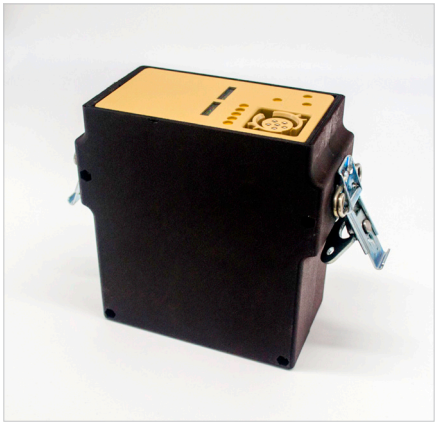
- Align the connectors on the bottom of the RF kit with those on the top of the cognitive radio base unit
- Press the RF kit down on to the cognitive radio base unit
- Use the four (4) latches on each side of the cognitive radio base unit to latch the RF kit in place

3.2.2. How to Remove the RF Kit

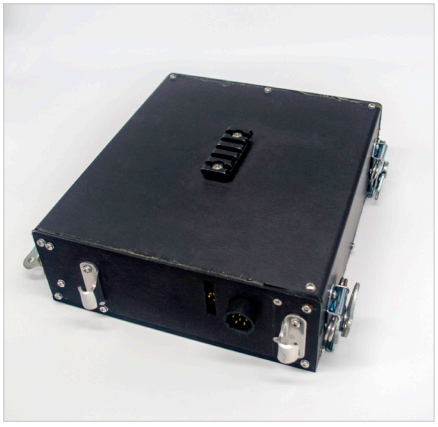
- Unlatch the four (4) latches on each side of the cognitive radio base unit that holds the RF kit in place
- Gently pull up on the RF kit to remove from the cognitive radio base unit
- Place the kit back in the case, making sure to protect the exposed connectors on the bottom of the RF kit

3.2.3. How to Attach the Battery

See battery in enclosure in the diagram below:



See battery connector on the rear of the cognitive radio base unit in the diagram below:



- Place the 2590 battery in the battery enclosure
- Align the battery connector with the cognitive radio base platform and press into place
- Use the two (2) latches on each side of the battery enclosure to latch the battery in place

3.2.4. How to Remove the Battery

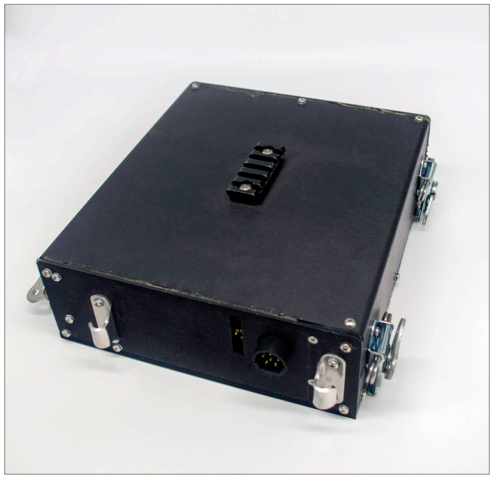
- Ensure the system is powered down.
- Unlatch the two (2) latches on each side of the battery enclosure that holds the battery in place
- Gently disconnect the battery by pulling the battery backwards away from the cognitive radio base unit

3.2.5. How to Install the Battery Eliminator

- Remove the battery if installed.
- Connect the battery eliminator to the battery connector on the back of the cognitive radio base unit (circular connector on battery eliminator)
- Plug the battery eliminator into an AC power source (standard AC power connector on battery eliminator)

3.2.6. How to Install the Tripod

See tripod connector (Picatinny Rail) on the bottom of the cognitive radio base unit in the diagram below.



- Loosen the mounting screw on the tripod mounting connector by hand.
- Attach the tripod to the Picatinny rail on the bottom of the cognitive radio base unit and tighten mounting screw by hand.
- Extend the tripod legs by loosening the grip on the end of each leg, extend the lower section and re-tighten the grips to ensure the tripod legs are secure.
- Position the tripod by pulling backwards on the circular screw on each leg and rotate to correct position

3.2.7. How to Install the Fixed Mast Mount

Attach Mast Mount to the Picatinny Rail on the bottom of the cognitive radio unit

3.2.8. How to Install the Magnetic Mount

Attach Mast Mount to the Picatinny Rail on the bottom of the cognitive radio unit

3.3. System Setup

3.3.1. System Interfaces

The system interfaces accessible via the top of the cognitive radio base unit are shown in the diagram below and described in the following table.

Figure 2: Mockingbird System Interfaces

Table 3: System Interface

Interface	Description
RF Transmit (Tx)	Transmit antenna port: (N-Type connector, 50 ohm)
RF Receive (Rx)	Receive antenna ports: (N-Type connector, 50 ohm)
GPS Antenna (GPS)	GPS Receive antenna port: (TNC connector, 50 ohm)
Auxiliary Antenna (AUX)	Optional remote control antenna port (Iridium or LoRa): (TNC connector, 50 ohm)
ETHERNET (ETH)	ETHERNET interface for system control and status
USB (USB)	USB interface for system control and status
PWR Switch	Apply System Power [ON / OFF]
Interrupt Button	Provides the ability to wake up system during sleep cycles. Provides the ability to reset the system to the factory default configuration

3.3.2. How to Setup the System

- Attach RF Antennas to transmit [Tx Port] and receive [Rx Port] antenna ports based on mission application
- Attach GPS Antenna to GPS port
- Attach Remote Control antenna to AUX port
- Attach Ethernet cable to ETH port and external controlling computer [e.g. external laptop]
- Power on the system by pressing the power button (power button will glow green temporarily and then fade to off]

The diagram below shows a typical system setup including connection to the host computer.

4. How to Configure the System

4.1. Pre-Conditions

System is connected via Ethernet to an external controlling computer and powered on (see System Setup in previous sections).

4.2. Network Configuration

To access the system web interface, you must first establish an IP network connection to the system via the Ethernet port. Then open a web browser and enter the IP address of the Mockingbird system. The default network configuration of the system is as follows:

Table 4: Factory Default Network Configuration Parameters

IP Address	192.168.1.100
Netmask	255.255.0.0
Gateway	192.168.1.1

4.2.1. How to Establish an Initial Network Connection

Pre-conditions:

- Mockingbird system is powered on and in the default factory configuration
- Mockingbird system is connected to an external controlling computer via an Ethernet cable

Procedure:

- Determine if the controlling computer has an IP route for the 192.168.1.0 local network
    - LINUX: Type `route` at the command prompt
    - MAC: Type `route` at the command prompt
    - WINDOWS: Type `route PRINT` at the command prompt
    - Verify IP address 192.168.1.0 is present in the displayed command response
- If IP address is present, network is configured. Proceed to verify network connection.
- If IP address is not present, add IP route for the 192.168.1.0 local network for your Ethernet device represented below as `<ethernet-device>`
    - LINUX: `sudo route -n add -host 192.168.1.100 dev <ethernet-device>`
    - MAC: `sudo route -n add -host 192.168.1.100 -iface <ethernet-device>`
    - Windows: `route add -host 192.168.1.100 if <ethernet-device>`
- Verify network connection:
    - Open a web browser (e.g. Chrome or Firefox) and enter default Mockingbird IP address: 192.168.1.1, which will result in the display of the Mockingbird User Interface.

4.2.2. How to Modify the Network Connection

Pre-Conditions:

- Controlling computer is connected to the Mockingbird system and the user interface is open in web browser.

Procedure:

- Navigate to System Control module, then System Configuration component
- Edit the Network Configuration (e.g. add a new static IP address)
- Save the Network Configuration
- Enter the new IP address in the web browser on the controlling computer and verify user interface is displayed.

Note: Once the IP address is changed, you will need to enter the new IP address to connect to the system. Write down the new IP address and save in a secure place in order to re-connect to the system. The system can be reconfigured to the default factory settings, which allows connection via the default IP address (see section on How to Establish an Initial Network Connection), however this also deletes any stored user data (see section on How to Factory Reset)

5. How to Verify the System

Note: See the User Guide for detailed instructions on system operation and usage.

5.1. Verify the Network Connection System

- Open a web browser (e.g. Chrome or Firefox) and enter the Mockingbird IP address
- Verify the Mockingbird User Interface is displayed.

5.2. Verify the Transmitter

WARNING: The user should ensure that there is an antenna connected to the transmitter antenna port (Tx) when transmitting.

Note: See User Guide for more details.

- Create a Tone waveform
- Transmit the waveform
- Verify transmitted signal with a spectrum analyzer

5.3. Verify the Receiver

WARNING: **RF Input (Rx):**): As a receiver, the DC voltage component and the maximum continuous power of the AC (RF) input signal component cannot exceed 5VDC and 24dBm.

Note: See User Guide for more details.

- Establish a signal source by attaching the receive antenna or via an external signal source (note input power should be limited to less than 24dBm)
- Navigate to Radio Control module and tune the radio via the Manual Tune.
- Navigate to Spectral View module and verify received signal spectrum

6. How to Maintain the System

There are no direct maintenance activities required of the system, other than charging the battery.

6.1. How to Install System Software Updates

Note: See User Guide for more details.

Once you have received a new software/firmware update file, you can update the system with the following procedure:

- Navigate to System Control module, view Firmware Upgrade component.
- Select Upgrade Firmware and follow the steps.

7. How to Troubleshoot the System

Symptom	Corrective Action
User Interface does not display	Verify network settings (see section on network configuration)
System does not transmit	Verify Transmit enabled under *System Control / Transmitter Settings*
System spectrum display is blank	Verify Receive is enabled, and the radio receive has been configured via manually tuning or select a frequency scan.

8. How to Reset the System to the Factory Default Configuration

The system can be reset to the factory default state in order to re-establish a network connection using the default IP address. The factory reset does not alter the installed Mockingbird software, only the system configuration parameters.

Performing a factory reset will result in the following actions:

- The network settings will revert to the factory default static IP address
- Removal of all stored user-defined system configurations including waveforms, traffic patterns, RF scene schedules, and frequency scan list
- Removal of all stored user-defined RF scenes
- Removal of all installed license upgrades, resulting in only the default product licenses

The procedure defined below performs a factory reset operation. During this process the timing of the operations is important and will result in two system reset cycles. The factory reset procedure uses the Power (green ring) and Interrupt (red ring) buttons on the Mockingbird physical system enclosure. The buttons are considered in the “ON” state when the button is depressed.

The factory reset procedure is as follows:

- With the system powered off (Power OFF), press the Interrupt button (Interrupt ON)
- Initiate Factory Reset.
  Note: The following steps must be completed within 20 seconds.
  - Turn the system on by pressing the power button (Power ON)
  - Repeatedly press the Interrupt button cycling between Interrupt ON and OFF (at least five times within 20 secs of system power)
- Power button green light will brighten and then dim indicating start of factory reset
- After approximately 30 seconds, Power button green light will brighten and dim a second time indicating completion of factory reset
- System is now in configured with the factory default settings including network parameters.

About Syncopated

Syncopated is a creative provider of custom products and solutions for cognitive radio and edge analytic hardware acceleration. Our solutions enable you to start further down the development path, reducing time-to-market and allowing you to focus on your innovative solution. Unlike many vendors, customization of our products for your specific needs is embraced not discouraged.

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