

RESTRICTED

EL 7ARRESS RCWS

**REMOTE CONTROLLED WEAPON STATION
OPERATOR MANUAL (CONDENSED)**

TUNISIAN MINISTRY OF DEFENSE

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DISTRIBUTION LIST

This document is RESTRICTED and shall only be distributed to:

- Authorized military operators
- Training personnel
- Maintenance personnel (as required)
- Command staff

DESTRUCTION NOTICE

DESTROY BY: Shredding or burning when superseded or no longer needed.

WARNINGS AND CAUTIONS

LETHAL WEAPON SYSTEM

This system controls a live weapon platform. Failure to follow safety procedures can result in death or serious injury. Always treat the weapon as if it is loaded and armed.

NO-FIRE ZONES

Always verify reticle position is NOT in a no-fire zone before engaging. Violating no-fire zones may result in friendly casualties or civilian harm.

EMERGENCY STOP

The emergency stop button must be accessible at all times. Know its location and be prepared to activate immediately if unsafe conditions develop.

ELECTRICAL HAZARDS

The RCWS operates on high-voltage power systems. Only qualified personnel shall perform maintenance. Disconnect power before servicing.

MOVING PARTS

The gimbal system contains high-speed rotating components. Keep clear of moving parts during operation. Do not place hands or objects near turret during movement.

CAMERA DAMAGE

Do not point cameras directly at the sun or intense light sources. Permanent sensor damage may occur.

DEAD MAN SWITCH

The Dead Man Switch must be held during all weapon operations. Release immediately in emergency situations to safe the weapon.

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QUICK REFERENCE CARD - CRITICAL CONTROLS

Emergency Controls

Control	Location	Function
EMERGENCY STOP	DCU (RED button)	Immediately stops all motion and safes weapon
Dead Man Switch	Joystick grip	Must be held for weapon operation; release to safe
Gun Arm/Safe Switch	DCU control panel	Arms or safes the weapon system
Station Enable/Disable	DCU control panel	Enables/disables entire system

Joystick Controls (Essential)

Control	Function
Main Stick	Gimbal slew (azimuth left/right, elevation up/down)
Trigger	Fire weapon (when armed and authorized)
Track Select Button	Initiate/abort tracking
Camera Switch Button	Toggle between Day and Thermal cameras
LRF Button	Activate laser rangefinder
Zoom Control	Camera zoom in/out

DCU Indicator Lights (Critical Status)

Light	Color	Meaning
System Ready	Green	System operational and ready
Gun Armed	Red	Weapon is armed - CAUTION
Ammo Loaded	Yellow	Ammunition detected
Fault/Alarm	Red (flash)	System fault - check status display
Emergency Active	Red (solid)	Emergency stop engaged

On-Screen Display (OSD) - Key Elements

AZ: 045	EL: +12	DAY	FOV: 9
[RETICLE]			
+			
(*) CCIP Pipper			
RNG: 850m	TRACK: ACTIVE		
MODE: Manual	STATUS: ARMED		

Safety Rules (Memorize)

1. **NEVER** point weapon at friendly forces or civilians
2. **ALWAYS** verify no-fire zones before engagement
3. **ALWAYS** hold Dead Man Switch during operation
4. **ALWAYS** confirm target identification before firing
5. **IMMEDIATELY** press Emergency Stop if unsafe conditions develop

PROGRAM OF INSTRUCTION (POI)

Course Overview

Course Title: El 7arress RCWS Operator Qualification Course

Course Code: RCWS-OQC-001

Course Length: 40 hours (condensed training program)

Class Size: Maximum 8 students per instructor

Prerequisites

- Active military service
- Basic weapons qualification
- Security clearance (RESTRICTED level or higher)
- Medical fitness for duty
- Visual acuity 20/20 (corrected or uncorrected)

Course Description

This condensed course qualifies military operators to safely and effectively operate the El 7arress Remote Controlled Weapon Station (RCWS). Students will learn system operation, targeting procedures, tracking techniques, ballistic compensation, emergency procedures, and live fire engagement through intensive practical training.

Training Hours Breakdown

Lesson	Title	Hours	Type
1	Safety Brief & System Overview	3	Classroom + Walk-Around
2	Basic Operation	4	Classroom + Practical
3	Menu System & Settings	2	Practical
4	Motion Modes & Surveillance	3	Classroom + Practical
5	Target Engagement Process	4	Classroom + Simulator
6	Ballistics & Fire Control	4	Classroom + Practical
7	System Status & Monitoring	2	Classroom + Practical
8	Emergency Procedures	2	Classroom + Practical
9	Operator Maintenance & Troubleshooting	2	Classroom + Practical
10	Practical Training & Evaluation	6	Practical + Exam
Live Fire	Live Fire Qualification	8	Range
TOTAL		40	

Graduation Requirements

To successfully complete the course, students must:

1. **Attend** all classroom and practical sessions (100% attendance required)
2. **Pass** written examination with minimum 80% score
3. **Pass** hands-on performance evaluation (GO/NO-GO on all critical tasks)
4. **Demonstrate** safe weapons handling throughout training
5. **Complete** live fire qualification with minimum 70% accuracy

Certificate: Upon successful completion, graduates receive the **RCWS Operator Qualification Certificate** valid for 24 months. Annual refresher training required. Full recertification required every 24 months.

Failure to Meet Standards: Students who fail to meet graduation requirements will be recycled to the next available course or removed from training per command guidance.

LEARNING OBJECTIVES

Terminal Learning Objective (TLO)

At the end of this course, the student will be able to:

Safely and effectively operate the El 7arress RCWS system to acquire, track, and engage targets in accordance with military standards and safety regulations, while performing operator-level maintenance and troubleshooting procedures.

Enabling Learning Objectives (ELO)

LESSON 1

- ELO 1.1: Identify safety hazards
- ELO 1.2: Demonstrate emergency stop
- ELO 1.3: Explain zone restrictions
- ELO 1.4: Identify system components
- ELO 1.5: Describe component functions

LESSON 2

- ELO 2.1: Perform system startup
- ELO 2.2: Operate DCU controls
- ELO 2.3: Control gimbal movement
- ELO 2.4: Switch cameras
- ELO 2.5: Operate zoom controls
- ELO 2.6: Interpret OSD elements
- ELO 2.7: Perform shutdown

LESSON 3

- ELO 3.1: Navigate menus
- ELO 3.2: Configure reticle
- ELO 3.3: Access system status
- ELO 3.4: Modify settings safely

LESSON 4

- ELO 4.1: Explain motion modes
- ELO 4.2: Switch modes safely
- ELO 4.3: Operate sector scan
- ELO 4.4: Utilize TRP scan
- ELO 4.5: Define no-fire zones
- ELO 4.6: Define no-traverse zones
- ELO 4.7: Save/load configurations

LESSON 5

- ELO 5.1: Describe engagement sequence
- ELO 5.2: Initiate tracking
- ELO 5.3: Adjust acquisition box
- ELO 5.4: Interpret tracking status
- ELO 5.5: Execute engagement
- ELO 5.6: Abort tracking

LESSON 6

- ELO 6.1: Perform zeroing
- ELO 6.2: Adjust zeroing offsets
- ELO 6.3: Configure environment
- ELO 6.4: Apply corrections
- ELO 6.5: Enable lead angle
- ELO 6.6: Interpret CCIP
- ELO 6.7: Engage moving targets

LESSON 7

- ELO 7.1: Access status displays
- ELO 7.2: Interpret device status
- ELO 7.3: Monitor temperatures
- ELO 7.4: Recognize abnormalities
- ELO 7.5: Read diagnostics

LESSON 8

- ELO 8.1: Execute emergency stop
- ELO 8.2: Perform tracking abort
- ELO 8.3: Weapon safe procedures
- ELO 8.4: Respond to failures
- ELO 8.5: Emergency shutdown

LESSON 9

- ELO 9.1: Pre-operation checks
- ELO 9.2: Post-operation procedures
- ELO 9.3: Diagnose issues
- ELO 9.4: Troubleshoot problems
- ELO 9.5: Escalate to maintenance
- ELO 9.6: Complete logs

LESSON 10

- ELO 10.1: Demonstrate proficiency
- ELO 10.2: Execute simulations
- ELO 10.3: Maintain safety compliance
- ELO 10.4: Meet time standards
- ELO 10.5: Qualify live fire

ABBREVIATIONS & GLOSSARY

Acronyms

- **AHRS** - Attitude and Heading Reference System
- **AZ** - Azimuth
- **BDA** - Battle Damage Assessment
- **CCIP** - Continuously Computed Impact Point
- **DCU** - Display and Control Unit
- **EL** - Elevation
- **ELO** - Enabling Learning Objective
- **FFC** - Flat Field Correction
- **FOV** - Field of View
- **HFOV** - Horizontal Field of View
- **LAC** - Lead Angle Compensation
- **LRF** - Laser Range Finder
- **OSD** - On-Screen Display
- **POI** - Program of Instruction
- **RCWS** - Remote Controlled Weapon Station
- **RPM** - Revolutions Per Minute
- **TLO** - Terminal Learning Objective
- **TRP** - Target Reference Point
- **VFOV** - Vertical Field of View

Key Terms

Acquisition Box: Yellow box displayed on screen for selecting tracking target area.

Active Lock: Tracking state where system is successfully following target.

Azimuth: Horizontal angle measured clockwise from North (0° to 360°).

Ballistics: Science of projectile flight and trajectory.

Boresight: Alignment between camera line of sight and weapon bore axis.

CCIP Pipper: Impact prediction point with all ballistic corrections applied.

Coast Mode: Temporary tracking state when target is briefly obscured.

Dead Man Switch: Safety switch that must be held for weapon operation.

Elevation: Vertical angle measured from horizon (-20° to +60° typical).

Gimbal: Two-axis rotating mount for cameras and weapon.

No-Fire Zone: Defined area where weapon discharge is prohibited.

No-Traversal Zone: Defined area where gimbal movement is restricted.

Reticle: Aiming crosshair displayed on screen.

Sector Scan: Automatic scanning pattern between two defined points.

Slew: Rotate or move the gimbal.

Stabilization: Automatic compensation for platform movement.

Tracking: Automatic following of a selected target.

Zeroing: Process of aligning weapon point of impact with camera crosshair.

Part I

SYSTEM FUNDAMENTALS

Chapter 1

LESSON 1: SAFETY BRIEF & SYSTEM OVERVIEW

Duration: 3 hours
Type: Classroom + Walk-Around
References: Safety manual, system schematics

1.1 Introduction

Lesson Purpose: This lesson establishes the critical safety foundation for RCWS operations and provides an overview of system components and capabilities.

Learning Objectives:

- Identify all safety hazards associated with RCWS operation
- Demonstrate emergency stop procedures
- Explain no-fire and no-traverse zone restrictions
- Identify all major system components during walk-around
- Describe the function of each major component

1.2 Safety Brief

1.2.1 Five Fundamental Safety Rules

RULE 1: TREAT EVERY WEAPON AS LOADED

- Always assume the RCWS weapon is loaded and armed
- Never point the system at anything you do not intend to destroy
- Maintain constant awareness of muzzle direction

RULE 2: KNOW YOUR TARGET AND WHAT LIES BEYOND

- Positively identify targets before engagement
- Consider overpenetration and ricochets
- Be aware of civilians, friendly forces, and infrastructure
- Verify range and backstop conditions

RULE 3: VERIFY NO-FIRE AND NO-TRAVERSE ZONES

- Check zone status on OSD before every engagement
- Do not override zones without proper authorization
- Understand that zones protect friendly forces and civilians
- Report zone violations immediately

RULE 4: KEEP DEAD MAN SWITCH ENGAGED ONLY WHEN READY TO FIRE

- Release Dead Man Switch immediately when not engaging
- Dead Man Switch is on joystick grip
- System automatically safes when switch is released
- Practice rapid release in training

RULE 5: USE EMERGENCY STOP WHEN IN DOUBT

- Large RED button on DCU panel
- Activates immediately - no confirmation required
- Stops all gimbal motion and safes weapon
- Use without hesitation if any unsafe condition develops

1.2.2 Specific Hazards

HAZARD 1: Weapon Discharge

- **Risk:** Death or serious injury from live ammunition
- **Mitigation:**
 - Follow all five safety rules
 - Verify Gun Armed light before trigger pull
 - Clear weapon per Appendix A before maintenance
 - Never bypass safety interlocks

HAZARD 2: Gimbal Movement

- **Risk:** Crushing injury from rotating turret
- **Mitigation:**
 - Stay clear of turret during operation (minimum 2 meters)
 - Use Emergency Stop if personnel enter hazard zone
 - Never place hands or tools near moving parts
 - Disable Station Enable switch before approaching turret

HAZARD 3: Electrical Shock

- **Risk:** Electrocution from high voltage (110-240V AC)

- **Mitigation:**
 - Only qualified maintenance personnel open panels
 - Disconnect power before any internal work
 - Do not operate with damaged cables
 - Report exposed wiring immediately

HAZARD 4: Laser Rangefinder

- **Risk:** Eye damage from laser (Class 3B laser device)
- **Mitigation:**
 - Never look directly into laser aperture
 - Do not aim at reflective surfaces at close range
 - Laser safety goggles required for maintenance
 - LRF automatically times out after 5 seconds

HAZARD 5: Thermal Camera Overheating

- **Risk:** Sensor damage from excessive heat
- **Mitigation:**
 - Never point thermal camera at sun
 - Do not aim at fires or intense heat sources
 - Allow Flat Field Correction (FFC) to complete
 - Monitor camera temperature on status display

1.2.3 Emergency Procedures (Quick Reference)

Emergency	Immediate Action	Follow-Up
Runaway Gun	Press EMERGENCY STOP	Notify command, clear area
Misfire	Maintain aim 30 sec, safe weapon	Follow misfire procedures
Injury	Press EMERGENCY STOP	Administer first aid, call medic
Fire/Smoke	Press EMERGENCY STOP, evacuate	Use fire extinguisher if safe
Zone Violation	Release trigger, safe weapon	Report incident immediately
Loss of Video	Press EMERGENCY STOP	Check connections, restart system
Jammed Weapon	Safe weapon, engage manual mode	Clear jam per weapon manual

i MEMORIZE

Emergency Stop button location and Dead Man Switch release are your PRIMARY safety controls.

1.3 System Overview

1.3.1 System Description

The El 7arress RCWS (Remote Controlled Weapon Station) is a stabilized, remotely operated weapon platform designed for vehicle-mounted applications. The system provides:

- **360° azimuth rotation** (continuous)
- **-20° to +60° elevation** range
- **Day and thermal imaging** capability
- **Automatic target tracking**
- **Laser rangefinding** (50m to 4000m)
- **Ballistic compensation** for accurate fire
- **Zone protection** for safety

Typical Applications:

- Perimeter defense
- Convoy protection
- Border surveillance
- Force protection
- Area denial

1.3.2 Major System Components

The RCWS consists of three main subsystems:

1. Display and Control Unit (DCU)

- **Location:** Inside vehicle, operator station
- **Functions:**
 - Video display (1024×768 resolution)
 - Control buttons and switches
 - Status indicator lights
 - Menu navigation
 - System settings

2. Joystick Controller

- **Location:** Inside vehicle, operator's right hand position
- **Functions:**
 - Gimbal slew control (azimuth/elevation)
 - Camera zoom
 - Weapon trigger
 - Tracking control
 - Function buttons
 - Dead Man Switch (safety)

3. Turret Assembly

- **Location:** Exterior vehicle roof mount
- **Components:**
 - Electro-Optical System (cameras + laser rangefinder)
 - Gimbal mechanism (2-axis stabilized)
 - Weapon mount
 - Drive motors and actuators
 - Internal sensors and electronics

1.4 Component Walk-Around

1.4.1 Pre-Operation Inspection Sequence

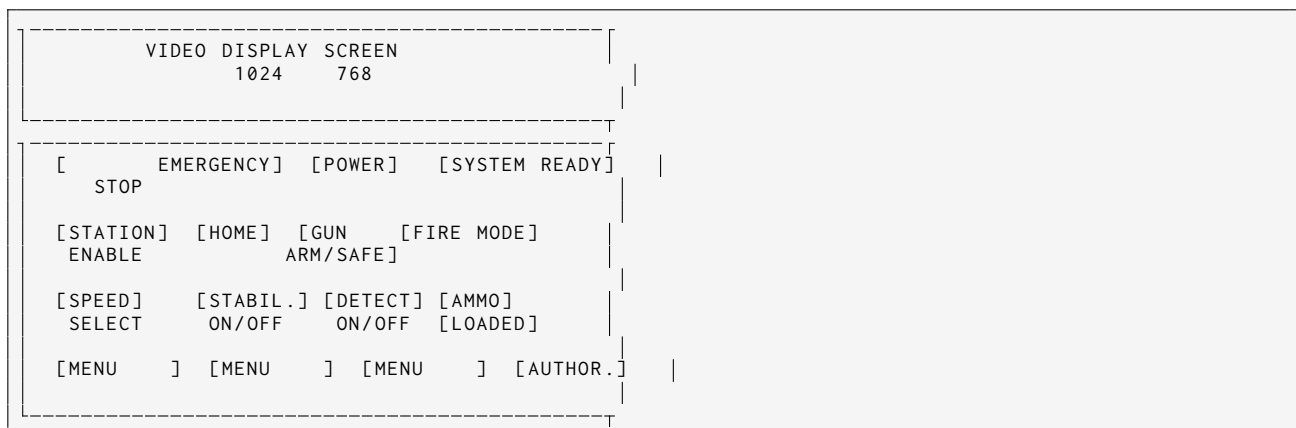
Perform this walk-around before every operation. Use checklist in Appendix C.

STATION 1: Display and Control Unit (DCU)

Visual Inspection:

1. Check display screen for cracks or damage
2. Verify all buttons and switches move freely
3. Confirm indicator lights are not broken
4. Check cable connections are secure
5. Ensure ventilation ports are not blocked

DCU Control Panel Layout:



Button Functions (detailed in Lesson 2):

- **Emergency Stop (RED):** Immediate system shutdown
- **Station Enable:** Master power for system
- **Home Position:** Return gimbal to forward (0° AZ, 0° EL)
- **Gun Arm/Safe:** Toggle weapon arming
- **Fire Mode Selector:** Single / Short Burst / Long Burst
- **Speed Select:** Low / Medium / High gimbal slew speed
- **Stabilization On/Off:** Enable/disable platform stabilization
- **Detection On/Off:** Enable/disable automatic target detection
- **Menu //:** Navigate menus

Indicator Lights:

- **Power (Green):** System powered on
- **System Ready (Green):** All subsystems operational
- **Gun Armed (Red):** Weapon is armed - DANGER
- **Ammo Loaded (Yellow):** Ammunition detected
- **Authorized (Green):** Operator authorization active
- **Fault/Alarm (Red Flashing):** System error - check status

GO/NO-GO Criteria:

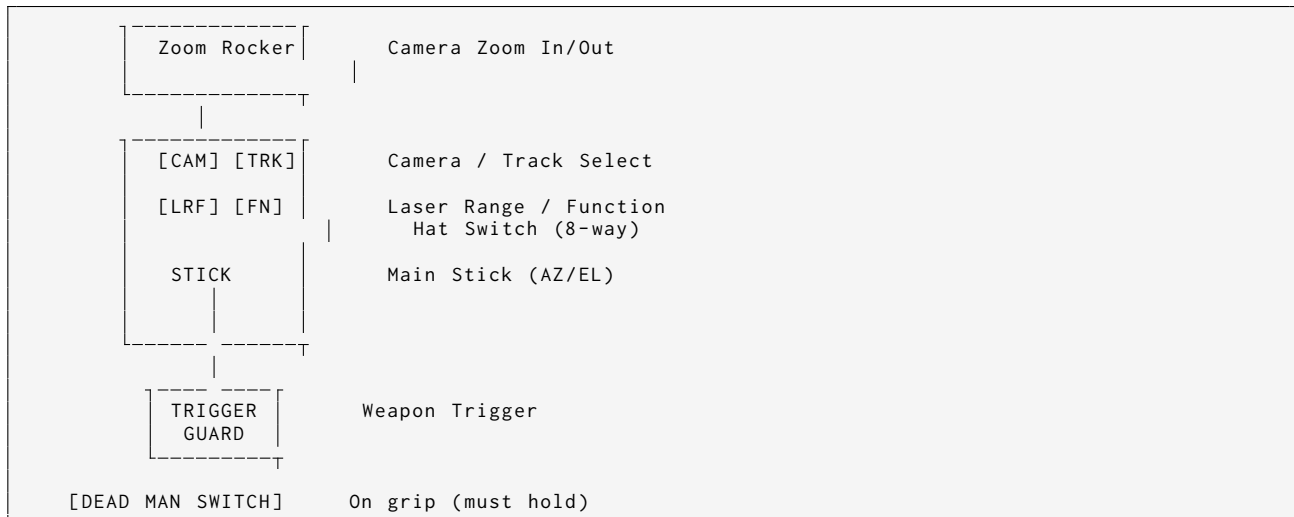
- ☒ All lights illuminate during power-up self-test
- ☒ No physical damage to display or controls
- ☒ All buttons click and return properly
- ☐ Any cracked screen → NO-GO (maintenance required)
- ☐ Stuck buttons → NO-GO (maintenance required)

STATION 2: Joystick Controller

Visual Inspection:

1. Check joystick moves smoothly in all directions
2. Verify trigger guard is intact
3. Test Dead Man Switch spring-back
4. Confirm all buttons click properly
5. Check cable connection is secure

Joystick Layout:



Control Functions (detailed in Lesson 2):

- **Main Stick**: Gimbal slew (left/right = azimuth, up/down = elevation)
- **Trigger**: Fire weapon (when armed)
- **Dead Man Switch**: Must be held for weapon operation
- **CAM Button**: Toggle Day/Thermal camera
- **TRK Button**: Initiate/abort tracking
- **LRF Button**: Activate laser rangefinder
- **FN Button**: Context-sensitive function
- **Hat Switch**: Tracking box control / menu navigation
- **Zoom Rocker**: Camera zoom in/out

GO/NO-GO Criteria:

- ☒ Stick returns to center when released
- ☒ Trigger has smooth pull with positive click
- ☒ Dead Man Switch springs back when released
- ☒ All buttons respond to press
- ☐ Sticky or binding stick → NO-GO
- ☐ Dead Man Switch does not return → NO-GO (CRITICAL SAFETY)
- ☐ Trigger does not return → NO-GO (CRITICAL SAFETY)

STATION 3: Turret Assembly - Exterior Inspection

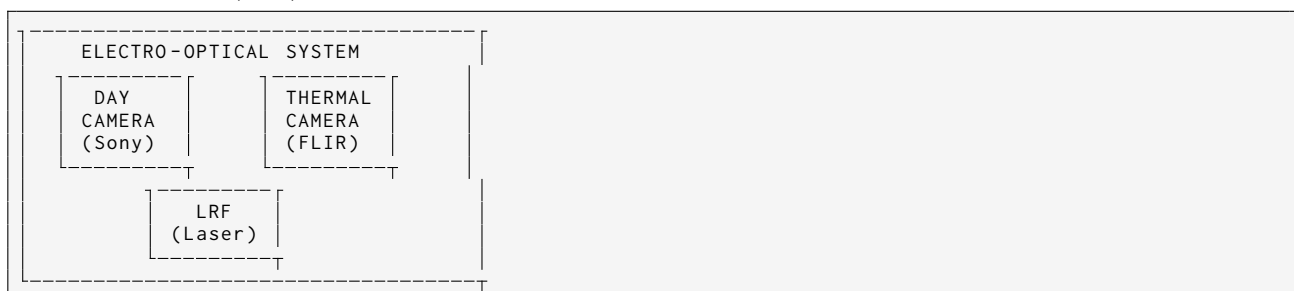
⚠ WARNING

Ensure Station Enable switch is OFF before approaching turret.

3A. Electro-Optical System

The Electro-Optical (EO) System is an integrated assembly containing:

- Day Camera (visible spectrum)
- Thermal Camera (infrared)
- Laser Rangefinder (LRF)



Inspection Checklist:

Day Camera:

- Lens is clean and unscratched
- Lens cap removed (if installed)
- No cracks in protective housing
- Cable connections secure

Thermal Camera:

- Lens is clean (use lens cloth only)
- No moisture or condensation visible
- Protective cover removed
- Camera not pointed at sun

Laser Rangefinder:

- Aperture is clean
- No obstructions in front of lens
- Warning labels intact

WARNING

NEVER look directly into LRF aperture

GO/NO-GO Criteria:

- ☒ All lenses clean and clear
- ☒ No visible damage to housings
- ☒ No loose cables or connections
- ☐ Cracked lens → NO-GO (maintenance required)
- ☐ Moisture inside camera → NO-GO (maintenance required)
- ☐ Obstructed field of view → NO-GO (clear obstruction first)

3B. Gimbal Mechanism

Visual Inspection:

1. Check for fluid leaks (hydraulic/oil)
2. Verify no loose bolts or fasteners
3. Confirm cables are properly routed (not pinched)
4. Look for signs of impact damage
5. Check that gimbal rotates freely by hand (power OFF only)

Gimbal Axes:

- **Azimuth Axis** (horizontal rotation): 360° continuous
- **Elevation Axis** (vertical tilt): -20° to +60°

Mechanical Limits:

- Hard stops prevent over-rotation
- Limit sensors detect end of travel
- Software limits prevent sensor contact

GO/NO-GO Criteria:

- ☒ No fluid leaks
- ☒ Gimbal moves smoothly by hand (power off)
- ☒ No grinding or binding noises
- ☒ All cables secured with proper strain relief
- ☐ Fluid leaks → NO-GO (maintenance required)
- ☐ Binding or resistance → NO-GO (maintenance required)
- ☐ Loose mounting bolts → NO-GO (torque to spec)

3C. Weapon Mount

WARNING

Treat all weapons as loaded. Follow weapon-specific clearing procedures (Appendix A).

Visual Inspection:

1. Weapon is properly secured in mount
2. Feed system (belt/magazine) is intact
3. No obstructions in barrel or ejection port
4. Mounting bolts are tight
5. Weapon safety is engaged (if applicable)

GO/NO-GO Criteria:

- ☒ Weapon securely mounted
- ☒ Feed mechanism functions properly
- ☒ Barrel clear of obstructions
- ☐ Loose weapon → NO-GO (re-secure per manual)
- ☐ Damaged feed system → NO-GO (repair/replace)
- ☐ Barrel obstruction → NO-GO (clear and inspect)

3D. Environmental Protection

Check:

1. Weatherproof covers are intact
2. Drainage holes are not blocked
3. Cable glands are sealed

4. No corrosion on exposed metal
5. Protective covers removed before operation

GO/NO-GO Criteria:

- ☒ All seals intact
- ☒ No water ingress visible
- ☒ Drainage holes clear
- ☐ Water pooling inside → NO-GO (dry and check seals)
- ☐ Severe corrosion → NO-GO (maintenance required)

1.4.2 Walk-Around Completion

After completing all inspection stations:

1. **Document Results:** Mark checklist (Appendix C) with GO/NO-GO for each item
2. **Report Discrepancies:** Any NO-GO items must be reported to maintenance immediately
3. **Supervisor Review:** Have supervisor verify inspection before operation
4. **Clear Area:** Ensure all personnel clear of turret before power-up
5. **Proceed to Startup:** If all items are GO, proceed with Lesson 2 startup procedure

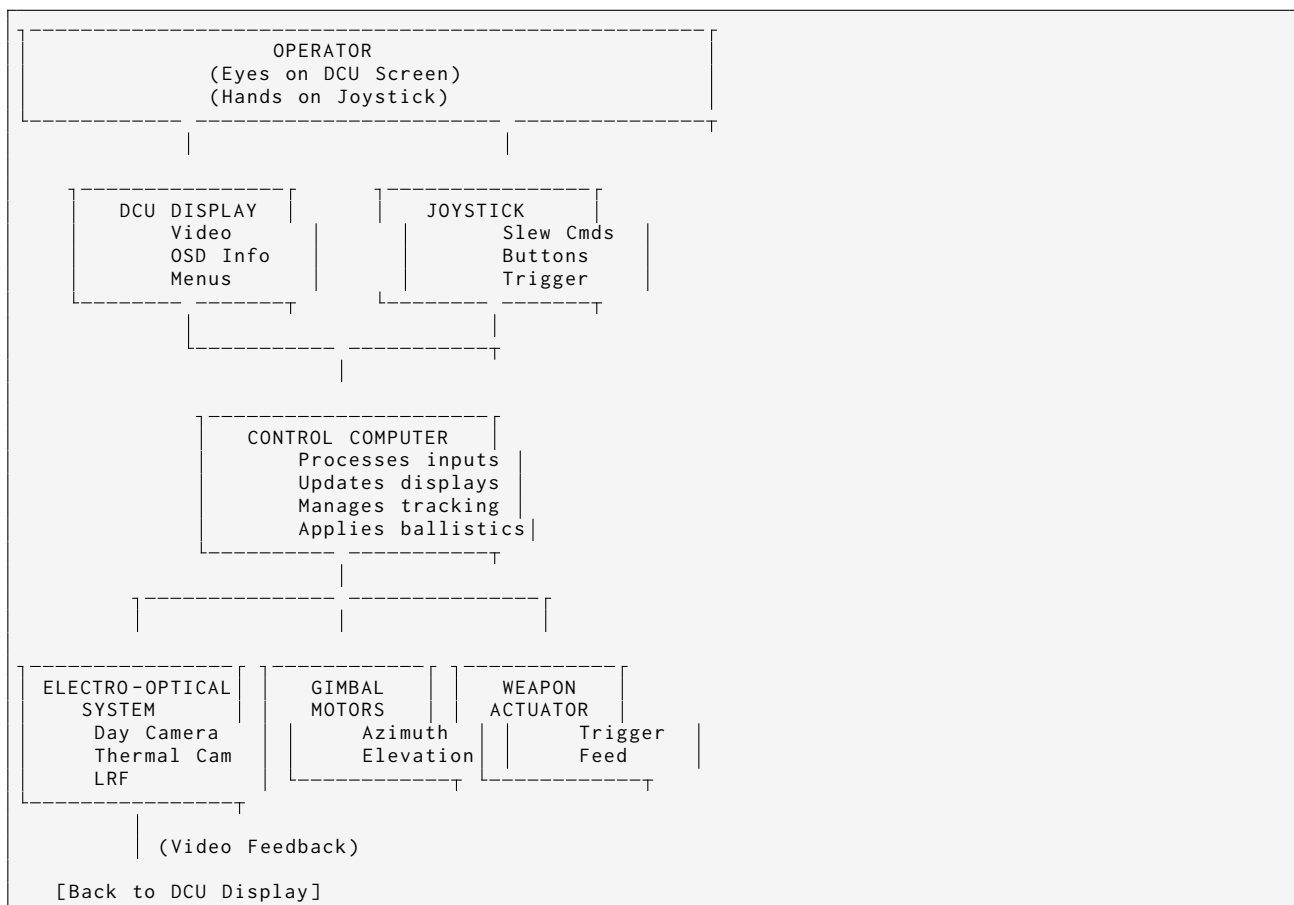
i SAFETY

Never operate RCWS with any NO-GO items. Equipment failure can result in injury or death.

1.5 System Architecture (Simplified)

Understanding how information flows through the system helps with troubleshooting.

1.5.1 Data Flow Diagram



Key Points:

- Operator sees video on DCU and controls gimbal with joystick
- Control computer processes all inputs and manages subsystems
- Cameras provide real-time video feedback
- System is a closed-loop: operator adjusts based on what they see

i NOTE

You don't need to understand the electronics, just the concept:

- **INPUT:** Your joystick commands
- **PROCESSING:** Computer calculates aim point with ballistics
- **OUTPUT:** Gimbal moves, weapon fires
- **FEEDBACK:** You see results on screen and adjust

1.6 Safety Zone Concepts

1.6.1 No-Fire Zones

Definition: Geographic areas where weapon discharge is absolutely prohibited.

Purpose:

- Protect friendly forces
- Protect civilians and infrastructure
- Prevent fratricide
- Comply with rules of engagement (ROE)

How It Works:

- Zones are pre-programmed by command
- System monitors gimbal position continuously
- **OSD displays "NO-FIRE ZONE" warning** when reticle enters zone
- Trigger is **software locked** when in no-fire zone
- Override requires commander authorization code

Example No-Fire Zones:

- Friendly vehicle positions
- Civilian buildings (schools, hospitals, mosques)
- Infrastructure (power plants, water treatment)
- Friendly patrol routes

Operator Responsibility:

- **Always check OSD for no-fire zone warning before engaging**
- Do not attempt to fire if warning is displayed
- Report zone boundary errors to command
- Never share override codes

1.6.2 No-Traversal Zones

Definition: Geographic areas where gimbal movement is restricted or prohibited.

Purpose:

- Prevent gimbal from hitting vehicle structure
- Protect antennas, equipment, or personnel on vehicle
- Prevent pointing weapon at vehicle crew positions
- Avoid damaging cables or sensors

How It Works:

- Zones are defined during system installation
- Gimbal slew is **automatically stopped** at zone boundary
- You will feel joystick resistance near boundary
- **OSD displays "NO-TRAVERSE" warning** when approaching zone
- System prevents entry even if you force joystick

Example No-Traversal Zones:

- Rear 90° arc (to avoid vehicle cabin)
- Areas with antennas or equipment
- Personnel access hatches
- Cable routing areas

Operator Responsibility:

- Learn your vehicle's no-traverse zones
- Do not fight the system if gimbal stops
- Report if zones are too restrictive for mission
- Never disable no-traverse zones without authorization

1.6.3 Zone Violation Procedures

If you accidentally enter a zone:

1. **Release Trigger Immediately** (if weapon armed)
2. **Slew gimbal out of zone** using joystick
3. **Verify OSD warning clears**
4. **Report incident** to supervisor
5. **Do not re-enter zone** unless mission requires and authorized

If system prevents zone entry but mission requires it:

1. **Do NOT force the system**
2. **Report to commander** immediately
3. **Request zone boundary adjustment** if appropriate
4. **Obtain override authorization** if permitted by ROE
5. **Document all overrides** in mission log

 REMEMBER

Zones exist for safety. Violating zones can kill friendlies.

1.7 Student Review Questions

1. What are the five fundamental weapon safety rules?
2. Where is the emergency stop button located?
3. What is the azimuth range of the El 7arress RCWS?
4. What must be held continuously during weapon arming?
5. Name three physical hazards associated with RCWS operation.
6. What are the three major system components?
7. What is the purpose of no-fire zones?
8. What happens when the gimbal approaches a no-traverse zone?
9. What is the GO/NO-GO criteria for the Dead Man Switch inspection?
10. When should the Emergency Stop be used?

Chapter 2

LESSON 2: BASIC OPERATION

Duration: 4 hours
Type: Classroom + Practical
References: Operator manual, system startup checklist

2.1 Introduction

Lesson Purpose: This lesson teaches complete system startup, DCU and joystick operations, OSD interpretation, and proper shutdown procedures.

Learning Objectives:

- Perform complete system startup procedure
- Operate all DCU buttons, switches, and controls
- Control gimbal movement using joystick
- Switch between day and thermal cameras
- Operate camera zoom controls
- Interpret all OSD elements correctly
- Perform normal system shutdown

2.2 System Startup Procedure

2.2.1 STARTUP QUICK REFERENCE CHECKLIST

EL 7ARRESS RCWS - STARTUP CHECKLIST

Step	Action	Check
PRE-POWER CHECKS		
1	Walk-around inspection complete (Lesson 1)	<input type="checkbox"/>
2	Weapon cleared per Appendix A	<input type="checkbox"/>
3	Ammunition accounted for / removed if required	<input type="checkbox"/>
4	Personnel clear of turret (2+ meters)	<input type="checkbox"/>
5	Vehicle power available (20-30V DC)	<input type="checkbox"/>
6	Operator qualified and authorized	<input type="checkbox"/>
7	Mission briefing received (zones, ROE, threats)	<input type="checkbox"/>
8	Communication established with command	<input type="checkbox"/>
POWER-UP SEQUENCE		
9	Station Enable switch = OFF	<input type="checkbox"/>
10	Apply vehicle power (circuit breaker ON)	<input type="checkbox"/>
11	Power light = GREEN	<input type="checkbox"/>
12	Boot self-test = All devices [OK]	<input type="checkbox"/>
13	Station Enable switch = ON	<input type="checkbox"/>
14	System Ready light = GREEN	<input type="checkbox"/>
15	Gimbal homes to 0° AZ / 0° EL	<input type="checkbox"/>
FUNCTIONAL CHECKS		
16	Camera select: DAY / THERMAL both work	<input type="checkbox"/>
17	Gimbal slew: All directions smooth	<input type="checkbox"/>
18	Zoom: In/Out functional	<input type="checkbox"/>
19	LRF: Range reading on known target	<input type="checkbox"/>
20	Stabilization: Toggle ON, verify OSD	<input type="checkbox"/>
FINAL STATUS		
21	Power light: GREEN	<input type="checkbox"/>
22	System Ready: GREEN	<input type="checkbox"/>
23	Gun Armed: OFF (SAFE)	<input type="checkbox"/>
24	Fault light: OFF	<input type="checkbox"/>
25	OSD: No warnings displayed	<input type="checkbox"/>

IF ANY CHECK FAILS: DO NOT PROCEED. Report to maintenance.

2.2.2 Pre-Startup Checklist

Before powering on the system, verify:

- ☐ Walk-around inspection complete (Lesson 1) - all items GO
- ☐ Weapon cleared per Appendix A

- ☐ Ammunition removed or accounted for
- ☐ All personnel clear of turret (minimum 2 meters)
- ☐ Vehicle power available (check voltage: 20-30V DC nominal)
- ☐ Operator qualified and authorized
- ☐ Mission briefing received (zones, ROE, threats)
- ☐ Communication established with command

WARNING

Do not start system if any checklist item is not complete.

2.2.3 Startup Sequence (10 Steps)

Perform steps in order. Do not skip steps.

STEP 1: INITIAL POWER-UP

Action:

- Ensure **[Station Enable]** switch is in OFF position
- Apply vehicle power to RCWS (circuit breaker ON or power cable connected)

Expected Result:

- **Power** indicator light illuminates (Green)
- DCU screen displays boot logo
- System begins self-test (approximately 30 seconds)

If NO Power Light:

- Check vehicle power supply (voltage 20-30V DC)
- Check circuit breaker
- Check cable connections
- Report to maintenance if power available but no light

STEP 2: BOOT SELF-TEST

Action:

- Observe DCU screen during boot
- Wait for self-test to complete (DO NOT interrupt)

Expected Display Sequence:

```
Checking Devices...
[ OK ] Day Camera
[ OK ] Thermal Camera
[ OK ] Laser Rangefinder
[ OK ] Azimuth Motor
[ OK ] Elevation Motor
[ OK ] Joystick Controller
[ -- ] Weapon Actuator (if not installed)

System Ready
Press STATION ENABLE to continue
```

If Any Device Shows [FAIL]:

- DO NOT PROCEED with startup
- Note which device failed
- Report to maintenance immediately
- System may operate in degraded mode but requires supervisor approval

STEP 3: ENABLE STATION

Action:

- Move **[Station Enable]** switch from OFF to ON

Expected Result:

- **System Ready** light illuminates (Green)
- Gimbal motors energize (you may hear a soft hum)
- Video feed appears on DCU screen
- OSD overlay displays system information
- Gimbal automatically moves to Home Position (0° AZ, 0° EL)

CAUTION

Gimbal will move during this step. Ensure area is clear.

STEP 4: VERIFY HOME POSITION

Action:

- Observe OSD azimuth and elevation readings
- If not at home (AZ: 000°, EL: 00°), press **[Home]** button

Expected Result:

- OSD displays: **AZ: 000° EL: 00°** ($\pm 2^\circ$ tolerance)
- Reticle is centered on screen
- Gimbal points directly forward relative to vehicle

Detailed Homing Sequence (50ms Control Loop)

The homing process follows a precise timing sequence:

```
Cycle 0:  Operator presses HOME button
          State = Requested
          OSD displays: "homing init"

Cycle 1:  (50ms later)
          GimbalController sends HOME command to PLC42
          State = InProgress
          OSD displays: "HOMING..."
          30-second timeout timer starts

Wait:     Oriental Motor servos execute homing sequence
          Azimuth motor moves to home position
          Elevation motor moves to home position
          Motors send HOME-END signals when complete
          Azimuth HOME-END (DI6), Elevation HOME-END (DI7)

Complete: Both HOME-END signals received
          State = Completed
          OSD displays: "HOME COMPLETE" (5 seconds)
```

Homing Timeout Handling:

- **30-second timeout** if HOME-END signals not received
- OSD displays: **HOMING TIMEOUT - FAULT** (red flashing)
- **Recovery procedure:**
 1. Press Emergency Stop
 2. Clear any gimbal obstruction
 3. Release Emergency Stop
 4. Retry homing procedure

WARNING

If homing fails repeatedly, report to maintenance. Do not operate gimbal without successful homing.

STEP 5: SELECT CAMERA

Action:

- Press **[CAM]** button on joystick to select Day or Thermal camera
- Default camera is DAY (visible spectrum)

Expected Result:

- OSD displays camera type: **DAY** or **THERMAL**
- Video image switches between color (day) and grayscale/colorized (thermal)
- FOV (Field of View) value updates on OSD

STEP 6: TEST GIMBAL MOVEMENT

Action:

- Gently move joystick in all directions (left/right/up/down)
- Verify gimbal responds smoothly
- Return joystick to center (gimbal stops)

Expected Result:

- Gimbal slews in direction of joystick movement
- OSD azimuth/elevation values update in real-time
- No grinding, binding, or unusual noises
- Gimbal stops when joystick returns to center

STEP 7: TEST CAMERA ZOOM

Action:

- Press Zoom Rocker UP (zoom in) and DOWN (zoom out)
- Observe video image magnification change

- Observe FOV value on OSD

Expected Result:

- Image magnifies when zooming in (FOV decreases)
- Image wide-angle when zooming out (FOV increases)
- Zoom is smooth with no jerking
- OSD FOV updates continuously

STEP 8: TEST LASER RANGEFINDER (LRF)**Action:**

- Aim reticle at a known object 100m+ away
- Press and hold **[LRF]** button on joystick

Expected Result:

- Laser fires (you will NOT see visible beam - infrared)
- OSD displays range reading: **RNG: XXXm**
- Range updates within 1 second
- LRF automatically times out after 5 seconds

⚠ WARNING

Do not aim LRF at people, animals, or reflective surfaces at close range. Eye damage can occur.

STEP 9: ENABLE STABILIZATION**Action:**

- Set **[Stabilization]** switch to ON

Expected Result:

- OSD displays **STAB: ON**
- Gimbal compensates for vehicle movement
- Reticle remains steady on target even if vehicle rocks

STEP 10: SYSTEM READY - FINAL CHECK**Verify all indicator lights:**

- **Power:** Green (ON)
- **System Ready:** Green (ON)
- **Gun Armed:** OFF (system is SAFE)
- **Fault/Alarm:** OFF (no errors)

Verify OSD displays:

- Live video feed (day or thermal)
- Azimuth and elevation values
- Current FOV
- System mode (Manual)
- No warning messages

If All Checks Pass: System is ready for operation

2.2.4 Startup Troubleshooting

Problem	Possible Cause	Action
No power light	No vehicle power	Check circuit breaker, voltage
Self-test fails	Device malfunction	Note failed device, report to maintenance
No video feed	Camera error	Check camera connections, restart system
Gimbal won't move	Motors disabled or fault	Check Station Enable, check for faults
Erratic gimbal	Joystick calibration	Recalibrate joystick (maintenance task)
LRF no reading	Out of range or bad target	Aim at closer/better reflective target
Thermal frozen	FFC in progress	Wait 5 seconds for FFC to complete

2.3 Display and Control Unit (DCU) Operations**2.3.1 DCU Button and Switch Functions****Emergency Stop Button (RED)**

Location: Top left of DCU panel, large RED button

Function: Immediate system shutdown for safety emergencies

Operation:

1. Press button (no confirmation required)
2. System immediately:

- Stops all gimbal movement
- Safes weapon (trigger disabled)
- Locks servos in place
- Displays "EMERGENCY STOP ACTIVE" on OSD

To Reset:

1. Twist/pull button to release
2. Verify emergency condition is resolved
3. Press **[Station Enable]** OFF then ON to restart

! CRITICAL

Do NOT hesitate to use Emergency Stop. Better safe than sorry.

Emergency Stop System Details

The Emergency Stop system includes advanced monitoring and recovery features:

Debounce Protection:

- **50ms debounce period** prevents false activations from electrical noise
- Button state must remain stable for 50ms before triggering
- Protects against accidental momentary contact

Recovery Period (El-7arress H100 Compliance):

- When Emergency Stop is **released**, system enters recovery period
- **500ms minimum** before normal operation resumes
- Prevents immediate re-activation from switch bounce
- OSD displays: "RECOVERY IN PROGRESS..."
- After recovery: "RECOVERY COMPLETE - Normal operation permitted"

Event Logging (Audit Trail):

- All Emergency Stop events are logged with timestamp
- Log includes: Activation time, duration, source (hardware/software)
- Useful for incident investigation and maintenance
- Log accessible via System Status → Emergency Log

Software Emergency Stop:

- System can trigger software emergency stop for critical faults
- Same effect as hardware button
- Triggered by: PLC communication loss, servo fault, safety violation
- OSD displays: "SOFTWARE EMERGENCY STOP - [reason]"

2.3.2 Safety Interlock System

The El 7arress RCWS employs a comprehensive Safety Interlock system that enforces El-7arress H100 safety requirements. All weapon and motion operations require multiple safety conditions to be met.

FIRE Permission - canFire() Safety Hierarchy

ALL conditions must be met to fire the weapon:

#	Condition	Required State	Denial Message
1	Emergency Stop	NOT Active	"EMERGENCY STOP ACTIVE"
2	Station Enable	Enabled	"Station not enabled"
3	Dead Man Switch	Held	"Dead man switch not held"
4	Gun Arm Switch	Armed	"Gun not armed"
5	Operational Mode	Engagement Mode	"Invalid operational mode"
6	Authorization	Authorized	"System not authorized"
7	No-Fire Zone	NOT In Zone	"In NO-FIRE zone"
8	Charging State	NOT Charging	"Charging in progress"
9	Charge Fault	NO Fault	"Charge fault - reset required"

! SAFETY HIERARCHY

Conditions are checked in priority order. Emergency Stop is **always** highest priority. If ANY condition fails, weapon **WILL NOT FIRE**.

CHARGE Permission - canCharge() Safety

Conditions for weapon charging (cocking actuator):

Condition	Notes
Emergency Stop NOT active	Highest priority
Station Enabled	Motors require power
NOT already charging	Cannot interrupt cycle
NOT in lockout period	4-second El-7arress spec lockout

NO fault state	Reset required first
----------------	----------------------

NOTE: Charging does NOT require:

- Gun Armed (can charge with safety on)
- Dead Man Switch (charging is not firing)
- Authorization (preparation step)

MOVEMENT Permission - canMove() Safety

Conditions for gimbal movement:

Condition	Applies To	Notes
Emergency Stop NOT active	All motion modes	Highest priority
Station Enabled	All motion modes	Motors require power
Dead Man Switch Held	Manual, AutoTrack, ManualTrack	Pattern mode exempt

Motion Mode Dead Man Requirements:

- **Manual Mode:** Dead Man Switch REQUIRED for joystick slew
- **AutoTrack Mode:** Dead Man Switch REQUIRED for tracking
- **ManualTrack Mode:** Dead Man Switch REQUIRED
- **Pattern Mode (Sector Scan, TRP):** Dead Man Switch NOT required (autonomous scan)

ENGAGEMENT Permission - canEngage()

Conditions to enter Engagement Mode:

- ☐ Emergency Stop NOT active
- ☐ Station Enabled
- ☐ Dead Man Switch Held

HOMING Permission - canHome()

Conditions for homing operation:

- ☐ Emergency Stop NOT active
- ☐ Station Enabled
- ☐ NOT already homing (prevents double-trigger)

Safety Denial Indicator Messages

When an operation is denied, the OSD displays the specific reason:

Message	Required Action
"EMERGENCY STOP ACTIVE"	Release E-stop, wait for recovery
"Dead man switch not held"	Hold Button 3 (palm switch)
"Station not enabled"	Toggle Station Enable switch ON
"Gun not armed"	Move Gun Arm switch to ARM
"System not authorized"	Obtain authorization from command
"In NO-FIRE zone"	Slew out of zone, or obtain override
"In NO-TRAVERSE zone"	Cannot enter zone boundary
"Charging in progress"	Wait for charge cycle to complete
"Charge lockout active (wait 4 sec)"	Wait for lockout timer
"Charge fault - reset required"	Press Charge button to reset
"Homing in progress"	Wait for homing to complete
"PLC communication lost"	Check connections, restart system

Station Enable Switch

Positions: OFF / ON

OFF Position:

- Gimbal motors disabled (turret cannot move)
- Video still displays (cameras remain powered)
- Weapon is safed
- Safe to approach turret for inspection

ON Position:

- Gimbal motors enabled
- All subsystems operational
- Turret can move if joystick input received
- Stay clear of turret

Gun Arm/Safe Switch

Positions: SAFE / ARM

SAFE Position (Default):

- Weapon trigger disabled
- Gun Armed light is OFF
- Trigger pull has no effect
- Safe for non-combat operations

ARM Position:

- Weapon trigger enabled
- Gun Armed light illuminates RED
- Trigger pull will fire weapon (if other conditions met)
- Only use during combat or live fire training

⚠ WARNING

When Gun Armed light is RED, treat weapon as HOT. One trigger pull away from firing.

Fire Mode Selector

Positions: SINGLE / SHORT BURST / LONG BURST

SINGLE:

- One round per trigger pull
- Most accurate mode
- Use for precision engagement

SHORT BURST:

- 3-5 rounds per trigger pull

- Good balance of accuracy and firepower
- Use for moving targets

LONG BURST:

- Continuous fire while trigger held
- Less accurate due to recoil
- Use for area suppression

Speed Select Switch

Positions: LOW / MEDIUM / HIGH

Speed	Use Case	Max Slew Rate
LOW	Zeroing, fine adjustments, precision	5°/second
MEDIUM	Normal surveillance, target acquisition	20°/second
HIGH	Close-range threats, emergencies	60°/second

2.3.3 DCU Indicator Lights

- **Power** (Green): Vehicle power supplied
- **System Ready** (Green): All subsystems operational
- **Gun Armed** (Red): Weapon is armed
- **Ammo Loaded** (Yellow): Ammunition detected
- **Authorized** (Green): Operator authorized
- **Fault/Alarm** (Red): System error detected

2.4 Joystick Controller Operations**2.4.1 Joystick Control Techniques****Proper Grip****Right Hand Position:**

1. Wrap fingers around joystick grip
2. Index finger rests on trigger (outside trigger guard when not firing)
3. Thumb on top, near CAM and TRK buttons
4. Dead Man Switch on rear of grip - squeeze with palm/fingers to engage

Gimbal Slew Technique**Small Movements** (Precision):

- Deflect stick slightly from center (10-20%)
- Gimbal moves slowly
- Good for: Tracking, zeroing, fine adjustments

Large Movements (Rapid Slew):

- Deflect stick fully (80-100%)
- Gimbal moves at maximum speed
- Good for: Searching, responding to threats, sector scans

2.4.2 Joystick Button Functions

The joystick provides 19 programmable buttons (Button 0-18) plus analog axes and a hat switch.

Complete Joystick Button Reference (19 Buttons)

Button	Function	Operation
0	Engagement Mode / Master Arm	Press = Enter engagement, Release = Exit engagement
1	LRF (Laser Range Finder)	Single press = Single measurement, Double-click = Toggle continuous LRF (5Hz)
2	Lead Angle Compensation (LAC)	Toggle LAC ON/OFF (joystick ONLY - no menu access!)
3	Dead Man Switch (Palm Switch)	MUST HOLD for weapon operation and LAC toggle

4	Tracking Control	Single = Cycle tracking phase, Double-click (<1 sec) = ABORT tracking
5	Fire Weapon	Trigger - fires weapon when armed
6	Zoom +	Increase camera magnification (hold for continuous)
7	Thermal LUT +	Next thermal video look-up table (thermal camera only)
8	Zoom -	Decrease camera magnification (hold for continuous)
9	Thermal LUT -	Previous thermal look-up table (thermal camera only)
10	LRF Clear	Clear range reading, stop continuous LRF mode
11	Mode Cycle	Cycle: Manual → Sector Scan → TRP → (Radar) → Manual
12	Reserved	Available for future use
13	Mode Cycle	Duplicate of Button 11 (ergonomic placement)
14	Select Next Zone/TRP	Next TRP page or sector scan zone (during surveillance)
15	Reserved	Future use
16	Select Previous Zone/TRP	Previous TRP page or sector scan zone (during surveillance)
17	Reserved	Future use
18	Reserved	Future use

Analog Controls

Control	Function
Main Stick X-Axis	Gimbal azimuth slew (left/right)
Main Stick Y-Axis	Gimbal elevation slew (up/down)
Hat Switch (D-Pad)	Tracking gate resize during Acquisition phase / Menu navigation

CRITICAL

Button 2 (LAC) is the **ONLY** method to activate Lead Angle Compensation. There is NO menu access for LAC. Dead Man Switch (Button 3) must be held when toggling LAC.

Camera Switch (CAM Button)

When to Use Day Camera:

- Good lighting conditions
- Need color information
- Need maximum zoom range (2° to 60° FOV)

When to Use Thermal Camera:

- Darkness, dawn, dusk
- Smoke, fog, dust
- Detecting hidden personnel (heat signatures)
- Identifying recently fired weapons (barrel heat)

Laser Rangefinder (Button 1)

Single Measurement Mode (default):

1. Aim reticle at target
2. Press Button 1 (single press)
3. Laser fires (invisible infrared beam)
4. OSD displays range: **RNG: XXXm**
5. Range used for ballistic calculations

Continuous LRF Mode (5Hz automatic ranging):

1. **Double-click Button 1** (within 1 second)
2. System announces: "CONTINUOUS LRF ENABLED"
3. LRF fires automatically at 5Hz (5 times per second)
4. Range continuously updates on OSD
5. **Double-click Button 1 again** to disable
6. Or press **Button 10** (LRF Clear) to stop

NOTE

Continuous LRF mode is useful for tracking moving targets where range is constantly changing. Disable when not needed to preserve laser life.

Specifications:

Range: 50m to 4000m

Accuracy: ±5 meters

Continuous Rate: 5Hz (when enabled)

! WARNING

Class 3B laser. Do not aim at people or reflective surfaces at close range.

Dead Man Switch

Location: Rear of joystick grip

Purpose:

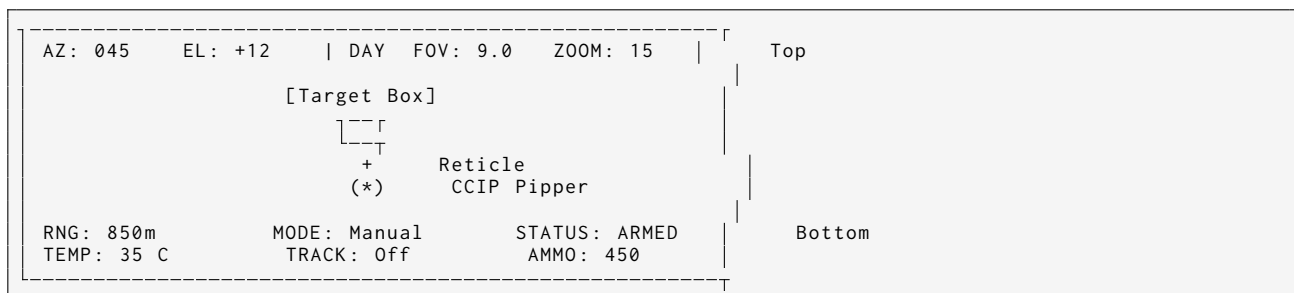
- Prevents accidental discharge if operator is incapacitated
- Automatic safety if operator loses grip
- Required safety interlock for firing

! CRITICAL SAFETY RULE

Release Dead Man Switch immediately when not actively engaging a target.

2.5 On-Screen Display (OSD) Interpretation

2.5.1 Complete OSD Layout



2.5.2 Top Bar Elements

- **AZ: XXX°:** Current azimuth position (000° to 359°)
- **EL: ±XX°:** Current elevation position (-20° to +60°)
- **DAY / THERMAL:** Active camera type
- **FOV: X.X°:** Current field of view
- **ZOOM: XXx:** Zoom magnification factor

2.5.3 Center Area Elements

Reticle (+):

- Main aiming point
- Where the gun is currently aimed (with zeroing applied)
- Fire weapon with reticle on target

CCIP Pipper ((*)):

- Continuously Computed Impact Point
- Shows where bullet will actually hit with all ballistic corrections
- May be offset from reticle if ballistics are applied
- Always aim with CCIP for accurate hits

2.5.4 Bottom Bar Elements

Left Side:

- **RNG: XXXm:** Distance to target
- **TEMP: XX°C:** System temperature

Center:

- **MODE:** Current motion mode

- **TRACK:** Tracking status

Right Side:

- **STATUS:** Weapon system status
- **AMMO:** Remaining rounds
- **STAB:** Stabilization status

2.5.5 Warning Messages

Critical warnings appear in center screen:

- **NO-FIRE ZONE WARNING:** Red, flashing - Do NOT fire
- **NO-TRAVERSE WARNING:** Yellow - Movement restricted
- **EMERGENCY STOP ACTIVE:** Red, solid - System safed
- **SYSTEM FAULT:** Red/yellow - Check status
- **TARGET LOST:** Yellow - Tracking lost, coast mode

2.6 System Shutdown Procedure

2.6.1 SHUTDOWN QUICK REFERENCE CHECKLIST

EL 7ARRESS RCWS - SHUTDOWN CHECKLIST

Step	Action	Check
SAFE THE SYSTEM		
1	Release Fire button and Dead Man Switch	<input type="checkbox"/>
2	Gun Arm/Safe switch = SAFE	<input type="checkbox"/>
3	Gun Armed light = OFF	<input type="checkbox"/>
4	Exit Engagement Mode if active	<input type="checkbox"/>
RETURN TO STOW		
5	Press HOME button - gimbal returns to 0° AZ / 0° EL	<input type="checkbox"/>
6	Wait for "HOME COMPLETE" message	<input type="checkbox"/>
7	Stabilization switch = OFF	<input type="checkbox"/>
MENU SHUTDOWN		
8	Press MENU button	<input type="checkbox"/>
9	Navigate to "Shutdown System"	<input type="checkbox"/>
10	Press MENU to select	<input type="checkbox"/>
11	Confirm "YES, Shutdown"	<input type="checkbox"/>
12	Wait for "SHUTDOWN COMPLETE" message	<input type="checkbox"/>
POWER DOWN		
13	Station Enable switch = OFF	<input type="checkbox"/>
14	System Ready light = OFF	<input type="checkbox"/>
15	Circuit breaker = OFF (if end of shift)	<input type="checkbox"/>
16	Power light = OFF (if power removed)	<input type="checkbox"/>
SECURE		
17	Weapon cleared per Appendix A (if required)	<input type="checkbox"/>
18	Ammunition removed/secured (if required)	<input type="checkbox"/>
19	Protective covers installed (if required)	<input type="checkbox"/>
20	Operator log entry completed	<input type="checkbox"/>

WAIT for "SHUTDOWN COMPLETE" before removing power!

2.6.2 Shutdown Sequence (7 Steps)

STEP 1: SAFE THE WEAPON

- Move **[Gun Arm/Safe]** switch to SAFE
- Verify Gun Armed light is OFF
- Release Dead Man Switch on joystick

STEP 2: RETURN TO HOME POSITION

- Press **[Home]** button on DCU
- Wait for gimbal to slew to 0° AZ, 0° EL

STEP 3: DISABLE STABILIZATION

- Move **[Stabilization]** switch to OFF

STEP 4: ACCESS SHUTDOWN MENU

- Press **[MENU]** button
- Navigate to SYSTEM → Shutdown
- Select "Shutdown System"
- Confirm shutdown
- System performs orderly shutdown
- Wait for "SHUTDOWN COMPLETE" message

STEP 5: DISABLE STATION

- Move **[Station Enable]** switch to OFF
- System Ready light turns OFF
- Gimbal motors de-energize

STEP 6: REMOVE VEHICLE POWER**If end of mission/shift:**

- Turn off circuit breaker, OR
- Disconnect power cable (if external)
- Power light turns OFF
- DCU screen goes black

STEP 7: SECURE WEAPON AND EQUIPMENT

- Clear weapon per Appendix A (if required)
- Remove ammunition (if required by SOP)
- Install protective covers on cameras
- Lock operator station (if applicable)
- Complete operator log entry

2.6.3 Post-Shutdown Checks

- ☐ Gun Armed light is OFF
- ☐ Gimbal is at home position (0° AZ, 0° EL)
- ☐ Station Enable is OFF
- ☐ Weapon is cleared (if required)
- ☐ Covers installed (if required)
- ☐ Operator log entry complete

2.7 Student Review Questions

1. What is the first step in the system startup procedure?
2. What should you do if a device shows [FAIL] during self-test?
3. Where is the Emergency Stop button located?
4. What are the three fire mode settings?
5. What is the difference between the reticle and CCIP pipper?
6. When should you use the thermal camera instead of the day camera?
7. What is the purpose of the Dead Man Switch?
8. What does **STAB: ON** indicate on the OSD?
9. What is the proper sequence for system shutdown?
10. What must be done before removing vehicle power?

Chapter 3

LESSON 3: MENU SYSTEM & SETTINGS

Duration: 2 hours
Type: Practical
References: Menu navigation guide, configuration manual

3.1 Introduction

Lesson Purpose: This lesson teaches complete menu navigation, display configuration, and system settings management.

Learning Objectives:

- Navigate all menu structures using DCU controls
- Configure reticle types and display colors
- Access system status information
- Modify operational settings safely

3.2 Menu Navigation Basics

3.2.1 Accessing the Main Menu

Method: Press [MENU] button on DCU

Result:

- Video feed dims (still visible in background)
- Menu window appears in center of screen
- Current selection is highlighted
- Menu title displayed at top



3.2.2 Menu Controls

Button	Function
[MENU]	Open menu / Confirm selection / Exit menu
[MENU]	Move selection up / Increase value
[MENU]	Move selection down / Decrease value

Alternative: Joystick HAT switch can also be used for menu navigation

3.2.3 Navigation Workflow

5-Step Process:

1. **Open Menu:** Press [MENU] - Main menu appears
2. **Navigate:** Press  or  to highlight desired option
3. **Select:** Press [MENU] to enter submenu or activate option
4. **Return:** Navigate to "Return..." option, press [MENU]
5. **Exit:** Continue pressing "Return..." until back at live video

TIP

If you get lost in menus, keep selecting "Return..." until you exit completely.

3.3 Main Menu Structure

3.3.1 Complete Menu Tree

```

MAIN MENU
--- --- RETICLE & DISPLAY ---
|--- Personalize Reticle
|--- Personalize Colors
|--- Display Brightness
--- --- BALLISTICS ---
|--- Zeroing (Lesson 6)
|--- Clear Active Zero
|--- Windage (Lesson 6)
|--- Clear Active Windage
|--- Environmental Settings (Lesson 6)
|--- Clear Environmental Settings

```

```

--- --- CALIBRATION ---
|   |   Preset Home Position
|
--- --- SYSTEM ---
|   |   Zone Definitions (Lesson 4)
|   |   Detection: ENABLED/DISABLED
|   |   Shutdown System
|
--- --- INFO ---
|   |   Help/About
|   |   Return ...

```

i MENU UPDATE

The menu structure includes options for Display Brightness, Calibration section with Preset Home Position, Detection toggle, and separate Clear functions for ballistic settings.

NOTE

Ballistics and Zone Management are covered in detail in later lessons. This lesson focuses on display settings and basic navigation.

3.4 Reticle & Display Settings

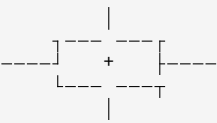
3.4.1 Personalize Reticle

Access: Main Menu → "Personalize Reticle"

Purpose: Select reticle type (crosshair style) for aiming

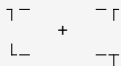
Available Reticle Types

1. Box Crosshair (Default)



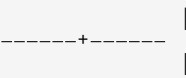
- Cross with surrounding box
- Good for general purpose and tracking
- Recommended for most operations

2. Brackets Reticle



- Corner brackets with center crosshair
- Enhanced visibility
- Good for low-contrast targets

3. Duplex Crosshair



- Thick outer lines, thin center
- Sniper/precision style
- Good for long-range

4. Fine Crosshair



- Thin precision crosshair
- Minimal obstruction
- Best for extreme precision

5. Chevron Reticule



- Downward pointing chevron
- CQB (Close Quarters Battle) style
- Good for rapid engagement

How to Change Reticle

CHANGING RETICLE

1. Press **[MENU]**
2. Navigate to "Personalize Reticle" ()
3. Press **[MENU]** to enter
4. Use / to highlight desired reticle
5. Press **[MENU]** to select
6. Reticle changes immediately on screen
7. Navigate to "Return..." ()
8. Press **[MENU]** to return to Main Menu

Recommendation: Use **Box Crosshair** for combat, **Fine Crosshair** for long-range surveillance.

3.4.2 Personalize Colors

Access: Main Menu → "Personalize Colors"

Purpose: Change OSD color scheme for visibility

Available Color Themes

Theme	Primary Color	Use Case
Green	Bright green	Default - good for day and night
Red	Red	Night vision compatible
Yellow	Yellow	High contrast, bright conditions
Cyan	Cyan	Alternative for user preference
White	White	Maximum contrast

What Changes:

- Reticle color
- OSD text color
- Menu text color
- Tracking box color (when not status-coded)

What Does NOT Change:

- Warning messages (always red or yellow)
- Tracking status colors (yellow/red/green based on state)
- CCIP pipper color

How to Change Color

CHANGING COLOR SCHEME

1. Press **[MENU]**
2. Navigate to "Personalize Colors" ()
3. Press **[MENU]** to enter
4. Use / to highlight desired color
5. Press **[MENU]** to select
6. OSD changes immediately
7. Evaluate visibility
8. Change again if needed, or select "Return..."

Best Practices:

- **Green:** Good all-around choice (default)
- **Red:** Use with night vision equipment
- **Yellow:** Use in bright sunlight or snow
- **White:** Maximum contrast on dark backgrounds

3.4.3 Display Brightness

Access: Main Menu → "Display Brightness"

Purpose: Adjust DCU display brightness for optimal visibility in varying ambient light conditions.

Brightness Control Parameters

Parameter	Value/Details
Range	10% to 100%
Step Size	10% per button press
Default	System default (typically 70%)
Preview	Real-time preview as you adjust
Cancel	BACK restores original brightness

How to Adjust Brightness

ADJUSTING DISPLAY BRIGHTNESS

1. Press **[MENU]**
2. Navigate to "Display Brightness" ()
3. Press **[MENU]** to enter brightness adjustment
4. **Screen displays:** "Adjust display brightness."
5. Use **[MENU]** to **increase** brightness (+10%)
6. Use **[MENU]** to **decrease** brightness (-10%)
7. **Preview is immediate** - observe screen as you adjust
8. Press **[MENU]** to **APPLY** the new brightness
9. **Confirmation:** "Brightness Applied" message appears
10. Press **[MENU]** to return to Main Menu

CANCEL OPTION

Press **[BACK]** at any time during adjustment to **cancel** and restore the previous brightness level. This is useful if you accidentally set it too dark or bright.

Brightness Recommendations:

- **100%:** Bright daylight, direct sunlight
- **70-80%:** Normal daylight, overcast conditions (default)
- **40-60%:** Dawn/dusk, shaded areas
- **20-30%:** Night operations (preserves night vision adaptation)
- **10%:** Extreme low-light (minimum visible)

NIGHT OPERATIONS

High display brightness at night will illuminate your position and impair your night vision adaptation. Reduce brightness to 30% or lower for night operations.

3.5 Calibration Menu Options

3.5.1 Preset Home Position

Access: Main Menu → "Preset Home Position"

Purpose: Define the HOME reference position for the gimbal. This is where the gimbal returns when the HOME function is activated.

Why Set a Custom Home Position?

The default home position may not be optimal for your vehicle configuration or operational needs:

- Orient weapon toward expected threat direction
- Align with vehicle front for stowage
- Position for vehicle travel mode
- Set up for specific defensive sectors

Preset Home Position Procedure

SETTING PRESET HOME POSITION

Step 1: Position Gimbal

1. Press **[MENU]**
2. Navigate to "Preset Home Position"
3. Press **[MENU]** to enter procedure
4. **Screen displays:** "POSITION GIMBAL TO HOME LOCATION"
5. Use **JOYSTICK** to slew the gimbal to your desired home position
6. Current Az/El position is displayed on screen in real-time
7. Align with your visual/mechanical reference
8. Press **[MENU]** when positioned correctly

Step 2: Confirm Home Position

9. **Screen displays:** "CONFIRM HOME POSITION"
10. Displayed position: "AZ: XX.XX deg | EL: XX.XX deg"
11. Review the position carefully
12. Press **[MENU]** to **CONFIRM** and save

Step 3: Completion

13. **Screen displays:** "PRESET HOME POSITION SET!"
14. Motor controller stores the position as zero reference
15. Press **[MENU]** to return to Main Menu

MOTOR CONTROLLER

The preset home position command (HR10) is sent to the motor controller (PLC42) which stores it in non-volatile memory. This position will persist across power cycles.

CANCEL

Press **[BACK]** at any step to cancel the procedure and return to the Main Menu without changing the home position.

Verifying Home Position:

1. After setting, press **[Home]** (joystick Button 4)
2. Gimbal should slew to the position you just set
3. If incorrect, repeat the Preset Home Position procedure

3.6 System Menu Options

3.6.1 Zone Definitions

Access: Main Menu → "Zone Definitions"

Purpose: Manage no-fire zones, no-traverse zones, sector scans, and TRPs

Detailed Coverage: See Lesson 4 (Motion Modes & Surveillance)

Quick Access Functions:

- View active zones
- Enable/disable zones
- Navigate to zone editor (supervisor/commander function)

OPERATOR NOTE

Zone modification usually requires supervisor authorization. Operators can VIEW zones but typically cannot CHANGE them.

3.6.2 Detection Toggle

Access: Main Menu → "Detection: ENABLED/DISABLED"

Purpose: Enable or disable AI-based automatic target detection for the Day camera.

Detection Availability

Condition	Detection Status
Day Camera Active	Available - Can be enabled/disabled
Night Camera Active	Unavailable - Menu shows "(Night - Unavailable)"

Menu Display States:

- "Detection: ENABLED" - Detection is ON (Day camera)
- "Detection: DISABLED" - Detection is OFF (Day camera)
- "Detection (Night - Unavailable)" - Night camera active, cannot toggle

How to Toggle Detection

ENABLING/DISABLING DETECTION

1. Ensure **Day camera** is active (switch camera if needed)
2. Press **[MENU]**
3. Navigate to "Detection: ENABLED" or "Detection: DISABLED"
4. Press **[MENU]** to toggle the state
5. Detection state changes immediately
6. Menu closes automatically

Detection Indicators:

- When ENABLED: Detection boxes appear around identified targets
- When DISABLED: No automatic target highlighting
- OSD shows detection status in system status area

NIGHT CAMERA LIMITATION

Detection is **ONLY** available on the Day camera. If you switch to Night camera while detection is enabled, detection will automatically suspend and resume when you switch back to Day camera.

PERFORMANCE NOTE

Detection processing uses significant computing resources. Disable detection when not needed to improve system responsiveness.

3.6.3 System Status

Access: Main Menu → "System Status"

Purpose: View detailed system health and diagnostics

Detailed Coverage: See Lesson 7 (System Status & Monitoring)

Quick Preview:

Displays status of all subsystems:

- Cameras (Day/Night)
- Servos (Azimuth/Elevation)
- Laser Rangefinder
- Joystick
- Stabilization System
- Tracking System
- Weapon Actuator

When to Check:

- At startup (verify all green)
- When Fault light illuminates
- Before critical operations
- During troubleshooting

3.6.4 Shutdown System

Access: Main Menu → "Shutdown System"

Purpose: Perform orderly software shutdown before powering off

Why Use Menu Shutdown:

- Saves configuration settings
- Saves zone data
- Closes log files properly
- Prevents data corruption
- Powers down subsystems in correct sequence

Shutdown Procedure

MENU SHUTDOWN

1. Press **[MENU]**
2. Navigate to "Shutdown System" (multiple times)
3. Press **[MENU]**
4. Confirmation prompt appears: "SHUTDOWN SYSTEM?"
5. Select "YES, Shutdown"
6. Press **[MENU]** to confirm
7. System shuts down:
 - "SHUTTING DOWN..." message appears
 - Progress indicator shows shutdown steps
 - Cameras power off
 - Motors de-energize
 - "SHUTDOWN COMPLETE - Safe to power off" message
8. Disable **[Station Enable]** switch on DCU
9. Cut vehicle power (if end of shift)

IMPORTANT

Wait for "SHUTDOWN COMPLETE" message before cutting power. Interrupting shutdown can corrupt configuration files.

3.6.5 About / Info

Access: Main Menu → "About"

Purpose: Display system information for troubleshooting and support

Information Displayed:

- System name: "El Tarress RCWS"
- Software version (e.g., "v4.5.2")
- Build date
- Serial number (if configured)
- Uptime (hours since power-on)
- Operator name (if logged in)

Use Case: Provide this information when reporting issues to maintenance.

3.7 Ballistics Menu (Overview)

Access: Main Menu → "— BALLISTICS —" section

The ballistics menu provides access to fire control settings. These are covered in detail in **Lesson 6** but are introduced here for awareness.

3.7.1 Ballistics Submenu Options

1. Zeroing

- Align weapon point of impact with camera crosshair
- Adjust azimuth and elevation offsets
- Save/load zeroing profiles
- **Detailed in Lesson 6.1**

2. Environmental Parameters

- Set temperature (°C)
- Set altitude (meters above sea level)
- Set crosswind speed and direction
- Apply environmental corrections to ballistics
- **Detailed in Lesson 6.2**

3. Lead Angle Compensation (View Only)

- **View** lead angle status (Off/On/Lag/ZoomOut)
- Displays current LAC system state
- **NOTE: LAC cannot be toggled from menu!**
- **LAC is activated ONLY via joystick Button 2**
- See Lesson 6.3 for LAC activation procedure

IMPORTANT

Lead Angle Compensation (LAC) can **ONLY** be toggled using joystick **Button 2** while holding the Dead Man Switch (Button 3). There is **NO** menu option to enable/disable LAC.

OPERATOR NOTE

Do not modify ballistics settings unless trained. Incorrect settings can cause missed shots or dangerous ricochets. Zeroing and environmental settings are usually performed by designated personnel.

3.8 Menu Quick Reference

3.8.1 Common Menu Tasks

Task 1: Change Reticle

MENU → "Personalize Reticle" → MENU
→ Select reticle (/) → MENU
→ "Return..." → MENU
Time: 10 seconds

Task 2: Change Color Scheme

MENU → "Personalize Colors" → MENU
→ Select color (/) → MENU
→ "Return..." → MENU
Time: 10 seconds

Task 3: Check System Status

MENU → "System Status" → MENU
→ Review status → "Return..." → MENU
Time: 15 seconds (plus review time)

Task 4: Shutdown via Menu

MENU → "Shutdown System" → MENU
 → "YES, Shutdown" → MENU
 → Wait for "SHUTDOWN COMPLETE"
 → Disable Station Enable → Cut power
Time: 45 seconds

3.8.2 Menu Navigation Tips

1. **Muscle Memory:** Practice menu navigation until you can do it without looking at button labels
2. **HAT Switch Alternative:** Use joystick HAT switch if your hands are already on the joystick
3. **Quick Exit:** If lost in menus, repeatedly press **[MENU]** on section headers to back out quickly
4. **Video Still Visible:** Menu is semi-transparent - you can still monitor situation while in menu
5. **Menu Timeout:** Some menus auto-exit after 60 seconds of inactivity
6. **Combat Discipline:** Minimize menu time during operations

3.8.3 Menu Troubleshooting

Problem	Possible Cause	Solution
Menu won't open	Button stuck or fault	Try joystick HAT switch, restart system
Can't select option	On section header	Use / to move to selectable item
Menu frozen	Software hang	Press Emergency Stop, restart system
Settings don't save	Shutdown without menu	Always use "Shutdown System" menu
Menu text unreadable	Color scheme issue	Change to White or Yellow theme

3.9 Menu Best Practices

3.9.1 When to Use Menus

DO use menus for:

- Changing display preferences (reticle, color)
- Checking system status
- Reviewing zone definitions
- Configuring ballistics (when trained)
- Orderly system shutdown

DO NOT use menus during:

- Active engagement
- Emergency situations
- When gimbal must be controlled continuously
- Under time pressure

RULE OF THUMB

Menus are for setup and configuration, not combat operations.

3.9.2 Settings That Persist

Saved Between Power Cycles:

- Reticle type selection
- Color scheme
- Zeroing offsets (if saved)
- Environmental parameters (if saved)
- Zone definitions

NOT Saved (reset on power-up):

- Gimbal position (returns to home)
- Active tracking (aborted)
- Temporary warnings
- Menu navigation position

3.9.3 Operator vs. Supervisor Functions

Operator Can:

- Change reticle and colors
- View system status
- View zones
- Access ballistics menus (view)
- Shutdown system

Operator Usually CANNOT (requires authorization):

- Modify zone boundaries
- Override no-fire zones
- Change ballistics profiles
- Access maintenance menus

- Modify system configuration files
Consult your unit SOP for specific authorization levels.

3.10 Student Review Questions

1. What button is used to access the main menu?
2. Name three available reticle types.
3. Which color scheme is recommended for night vision operations?
4. What menu option would you use to view system diagnostics?
5. Why is it important to use the menu shutdown before cutting power?
6. Can operators modify no-fire zone boundaries?
7. What settings are saved between power cycles?
8. What is the recommended reticle for general combat operations?
9. How do you exit from a submenu?
10. What should you do if the menu becomes frozen?

Chapter 4

LESSON 4: MOTION MODES & SURVEILLANCE

Duration: 3 hours
Type: Classroom + Practical
References: Zone management guide, surveillance procedures

4.1 Introduction

Lesson Purpose: This lesson teaches motion mode selection, automated surveillance patterns, and zone management for safe and effective operations.

Learning Objectives:

- Explain the purpose of each motion mode
- Switch between motion modes safely
- Operate automatic sector scan mode
- Utilize Target Reference Point (TRP) scan mode
- Define and manage no-fire zones
- Define and manage no-traverse zones
- Save and load zone configurations

4.2 Motion Modes Overview

4.2.1 What Are Motion Modes?

Motion modes control **how the gimbal moves** during operations:

- **Manual Mode:** You control gimbal directly with joystick
- **Auto Sector Scan:** System automatically scans between two points
- **TRP Scan:** System sequentially visits pre-defined Target Reference Points
- **Radar Slew** (if equipped): Gimbal follows radar detections

Purpose: Different missions require different surveillance patterns. Motion modes let you switch between direct control and automated surveillance.

4.2.2 Mode Selection

How to Change Modes:

- Press joystick **[Button 11]** or **[Button 13]** (either button cycles modes)
- Modes cycle in sequence:

Manual	AutoSectorScan	TRP Scan	Radar Slew	Manual
--------	----------------	----------	------------	--------

i NOTE

Radar Slew is only available if radar hardware is installed. On systems without radar, the mode cycle is: Manual → Sector Scan → TRP → Manual

Current Mode Display: OSD bottom center shows: **MODE: Manual**, **MODE: Sector Scan**, **MODE: TRP**, or **MODE: Radar**

! RESTRICTION

Cannot change modes during tracking acquisition. Must abort tracking first (press TRK button).

4.3 Manual Mode

Description: Direct operator control via joystick (default mode)

When to Use:

- Direct target engagement
- Precise aiming
- Immediate threat response
- Search operations requiring operator judgment

Operation:

- Joystick LEFT/RIGHT → Azimuth control
- Joystick UP/DOWN → Elevation control
- Stick deflection = gimbal speed
- Center stick = gimbal stops

i NOTE

Already Covered: See Lesson 2, Section 2.3 for detailed joystick control

4.4 Auto Sector Scan Mode

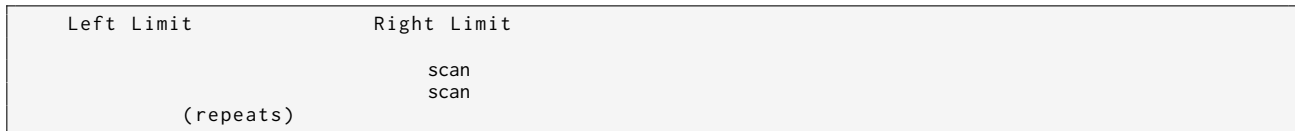
4.4.1 What Is Sector Scan?

Definition: Automated gimbal movement that continuously scans between two pre-defined points (left and right limits)

Purpose:

- Perimeter surveillance
- Monitoring a defined sector without operator input
- Frees operator to monitor other systems or threats

Visual:



Gimbal continuously scans left-to-right, then right-to-left, repeat.

4.4.2 Activating Sector Scan

Prerequisites:

1. Sector scan zone must be defined
2. At least one sector scan zone exists
3. System is in AutoSectorScan mode

SECTOR SCAN ACTIVATION

1. **Cycle to Sector Scan Mode:** Press Button 11 or 13 until OSD shows: **MODE: Sector Scan**
2. **System Behavior:**
 - Gimbal automatically slews to left limit of active sector
 - Scans to right limit (slow, smooth movement)
 - Reverses, scans back to left limit
 - Repeats continuously
3. **Scan Speed:** Default: 5°/second (configurable)
4. **Elevation:** Scans at elevation defined in zone (usually 0° horizon)

4.4.3 While Sector Scanning

Operator Actions:

CAN DO:

- Monitor video feed as sector scans
- Switch cameras (CAM button)
- Zoom in/out (Zoom rocker)
- Fire LRF (LRF button) at targets of interest
- Initiate tracking (TRK button) - aborts sector scan, switches to Manual

CANNOT DO:

- Joystick axes do NOT control gimbal (ignored)
- Cannot manually slew gimbal (must exit mode first)

To Override:

- Press Button 11/13 to return to Manual mode
- OR: Press TRK to start tracking (auto-switches to Manual)

4.4.4 Multiple Sector Zones

If Multiple Sectors Defined:

- System scans active sector (last selected via menu or joystick)
- To change active sector via menu:
 1. Cycle to Manual mode
 2. Access menu: Zone Definitions → Sector Scans
 3. Select desired sector
 4. Return to AutoSectorScan mode

4.4.5 Zone Selection via Joystick (Buttons 14/16)

NEW CAPABILITY: Rapid zone switching during surveillance **without menu access.**

JOYSTICK ZONE SELECTION

During AutoSectorScan Mode:

- **Button 14:** Select NEXT sector scan zone
- **Button 16:** Select PREVIOUS sector scan zone

- Zone switches immediately, scanning resumes in new zone

During TRP Scan Mode:

- **Button 14:** Select NEXT TRP location page
- **Button 16:** Select PREVIOUS TRP location page
- TRP scan continues with new page's target points

Operational Benefit:

- Rapid zone switching **without leaving surveillance mode**
- Hands stay on joystick, eyes stay on video
- Faster reaction to changing threat sectors
- No menu navigation required

Example - Sector Scan Zone Cycling:

```
Currently scanning: "Front Gate" (Zone 1)
Press Button 14    Switch to "East Perimeter" (Zone 2)
Press Button 14    Switch to "Rear Area" (Zone 3)
Press Button 14    Wrap to "Front Gate" (Zone 1)
```

Example - TRP Page Cycling:

```
Currently on: "Page 1: Checkpoints"
Press Button 14  Switch to "Page 2: Hilltops"
Press Button 14  Switch to "Page 3: Route Monitoring"
Press Button 14  Wrap to "Page 1: Checkpoints"
```

i NOTE

Zone/TRP selection via joystick only works during **Surveillance** operational mode while in AutoSectorScan or TRPScan motion modes. During Tracking or Engagement, these buttons perform tracking gate control instead.

4.5 TRP Scan Mode

4.5.1 What Is TRP Scan?

TRP = Target Reference Point (pre-defined location of interest)

Definition: System sequentially slews to each TRP, dwells (pauses) for observation, then moves to next TRP in list.

Purpose:

- Checkpoint verification (e.g., gate 1, gate 2, gate 3)
- Known threat areas (e.g., sniper hide sites)
- Periodic scans of fixed locations
- More efficient than manual searching

Visual:

```
TRP 1 (30s dwell)    TRP 2 (30s dwell)    TRP 3 (30s dwell)    TRP 1
```

4.5.2 Activating TRP Scan

Prerequisites:

1. At least one TRP must be defined
2. System is in TRP Scan mode

TRP SCAN ACTIVATION

1. **Cycle to TRP Scan Mode:** Press Button 11 or 13 until OSD shows: **MODE: TRP**
2. **System Behavior:**
 - Gimbal slews to first TRP in list
 - Dwells for configured time (default: 30 seconds)
 - Slews to next TRP
 - Dwells again
 - Repeats through entire TRP list, then loops back
3. **Dwell Time:** Configurable per TRP (5-120 seconds)

4.5.3 While TRP Scanning

During Dwell (gimbal stationary at TRP):

- Observe video
- Switch cameras
- Zoom
- Fire LRF
- Initiate tracking (if threat detected)

During Slew (gimbal moving between TRPs):

- Gimbal is in motion
- Video may be blurred (fast slew)

- Wait for next dwell to observe

4.5.4 TRP Scan Best Practices

1. **Define TRPs During Planning:**
 - Pre-mission: Identify key locations
 - Enter TRP coordinates via menu
 - Test TRP scan before mission start
2. **Prioritize TRPs:** Place highest-threat areas first in list
3. **Appropriate Dwell Times:**
 - Short dwell (10-15s) for quick checks
 - Long dwell (60s+) for detailed observation
4. **Combine with Manual:** Use TRP scan for routine surveillance, switch to Manual when threat detected

4.6 Radar Slew Mode (Optional)

Availability: Only if radar system is integrated

Description: Gimbal automatically slews to radar-detected targets

Purpose:

- Rapid threat response
- Automated cueing from radar
- Reduces operator workload

RADAR SLEW OPERATION

1. **Cycle to Radar Slew Mode:** Press Button 11/13 until OSD shows: **MODE: Radar**
2. **System Behavior:**
 - Waits for radar detection
 - When radar detects target → Gimbal slews to radar coordinates
 - OSD displays: **RADAR CUE** or **SLEWING TO RADAR**
 - Operator confirms threat visually on video
3. **Operator Decision:**
 - If threat confirmed → Initiate tracking or engage
 - If false alarm → Wait for next radar cue or cycle to Manual

NOTE

Most El 7arress RCWS systems do NOT have radar. This mode will show "RADAR NOT AVAILABLE" if no radar connected.

4.7 Motion Mode Quick Reference

Mode	Use Case	Gimbal Control	Exit to Manual
Manual	Direct engagement	Joystick	N/A (already manual)
AutoSectorScan	Perimeter surveillance	Automatic	Cycle mode or press TRK
TRP Scan	Checkpoint monitoring	Automatic	Cycle mode or press TRK
Radar Slew	Radar integration	Automatic	Cycle mode or press TRK

Emergency Return to Manual: Press Button 11/13 repeatedly until **MODE: Manual** displays

4.8 Zone Management - Sector Scans

4.8.1 Defining Sector Scan Zones

Sector scan zones set the **left and right limits** for AutoSectorScan mode.

Access: Main Menu → Zone Definitions → Sector Scans

Sector Scan Zone Parameters

Parameter	Description	Typical Value
Name	Zone identifier	"Front Gate", "Perimeter East"
Left Limit (Az)	Starting azimuth	045°
Right Limit (Az)	Ending azimuth	135°
Elevation	Scan elevation angle	0° (horizon)
Scan Speed	Degrees per second	5°/sec
Active	Enable/disable zone	ON / OFF

Creating a Sector Scan Zone

Method 1: Manual Entry (via menu)

MANUAL SECTOR CREATION

1. **Access Menu:** MENU → Zone Definitions → Sector Scans → Add New Sector
2. **Enter Name:** Use / to enter name characters, MENU to confirm
3. **Set Left Limit:**
 - Method A: Slew gimbal to desired left position, press MENU to "Capture Current Position"
 - Method B: Manually enter azimuth value using /
4. **Set Right Limit:** Same as left limit
5. **Set Elevation:** Enter elevation angle (typically 0°)
6. **Set Scan Speed:** Enter degrees/second (5°/sec recommended)
7. **Enable Zone:** Set Active = ON
8. **Save:** MENU → "Save Sector Scan"

Method 2: Quick Capture (using joystick)

QUICK SECTOR CAPTURE

1. **Position Gimbal:**
 - Use Manual mode to slew to desired left limit
 - Press **[FN Button]** + Hold for 2 seconds
 - OSD displays: "LEFT LIMIT CAPTURED"
2. **Position Right Limit:**
 - Slew to desired right limit
 - Press **[FN Button]** + Hold for 2 seconds
 - OSD displays: "RIGHT LIMIT CAPTURED, SECTOR SCAN ZONE CREATED"
3. **System Auto-Creates Zone:**
 - Default name: "Sector X"
 - Default elevation: Current elevation
 - Default speed: 5°/sec
4. **Edit if Needed:** Access menu to rename or adjust parameters

4.8.2 Activating / Deactivating Sector Zones

Multiple Zones:

- You can define multiple sector scan zones
- Only ONE can be active at a time

To Activate a Zone:

1. MENU → Zone Definitions → Sector Scans
2. Use / to select desired zone
3. MENU → "Set as Active"
4. OSD displays: "SECTOR ZONE [Name] ACTIVE"

To Deactivate All Sectors:

1. MENU → Zone Definitions → Sector Scans
2. Select active zone
3. MENU → "Deactivate"

4.9 Zone Management - Target Reference Points

4.9.1 Defining TRPs

TRPs are **fixed locations** the system can automatically slew to.

Access: Main Menu → Zone Definitions → TRPs

TRP Parameters

Parameter	Description	Typical Value
Name	TRP identifier	"Gate 1", "Bunker", "Hill 203"
Azimuth	Direction to TRP	090°
Elevation	Angle to TRP	+5°
Dwell Time	Observation time	30 seconds
Active	Enable/disable	ON / OFF

Creating a TRP

Method 1: Capture Current Position

TRP CAPTURE

1. **Manual Mode:** Slew gimbal to desired TRP location, zoom/focus on exact point
2. **Access Menu:** MENU → Zone Definitions → TRPs → Add TRP
3. **Capture Position:** Select "Capture Current Position", MENU to confirm
4. **Enter Name:** Use / to enter TRP name, MENU to confirm
5. **Set Dwell Time:** Enter seconds (5-120), Default: 30 seconds
6. **Enable:** Set Active = ON
7. **Save:** MENU → "Save TRP"

Method 2: Manual Coordinate Entry

TRP MANUAL ENTRY

1. **Access Menu:** MENU → Zone Definitions → TRPs → Add TRP
2. **Enter Azimuth:** Use / to enter degrees (000-359)
3. **Enter Elevation:** Use / to enter degrees (-20 to +60)
4. **Continue:** Enter name, dwell time, enable, and save

4.9.2 Managing TRP List

TRP Sequence:

- TRPs are visited in the order they appear in list
- To reorder:
 1. MENU → Zone Definitions → TRPs
 2. Select TRP
 3. "Move Up" or "Move Down"

Editing TRPs:

- Select TRP from list
- MENU → "Edit TRP"
- Modify parameters
- Save changes

Deleting TRPs:

- Select TRP from list
- MENU → "Delete TRP"
- Confirm deletion

4.10 Zone Management - Complete Zone Types

The El 7arress RCWS supports **FIVE** distinct zone types for comprehensive operational control:

4.10.1 Zone Type Summary

Zone Type	Primary Purpose	System Behavior
Safety Zone	Vehicle/crew protection	Configurable: may restrict fire and/or traverse
No-Fire Zone	Prevent firing into protected areas	Blocks weapon fire , allows gimbal traverse
No-Traverse Zone	Prevent gimbal damage/obstruction	Blocks gimbal movement into zone
Sector Scan Zone	Automated surveillance patterns	Defines scan limits for AutoSectorScan mode
Target Reference Point	Pre-defined observation points	Defines dwell locations for TRP Scan mode

4.10.2 Zone Type 1: Safety Zones

Purpose: Define areas requiring special operational restrictions for crew/equipment safety.

Access: Main Menu → Zone Definitions → New Zone → Safety Zone

Parameters:

Parameter	Description	Values
Start Azimuth	Left boundary (clockwise)	0° - 359°
End Azimuth	Right boundary (clockwise)	0° - 359°
Min Elevation	Lower boundary	-20° to +60°
Max Elevation	Upper boundary	-20° to +60°
Enabled	Zone active status	ON / OFF
Overridable	Can be bypassed with authorization	YES / NO

Creating a Safety Zone:

CREATING SAFETY ZONE - AIMING METHOD

1. Access: MENU → Zone Definitions → New Zone
2. Select: "Safety Zone" → MENU
3. **AIM FIRST CORNER:**
 - Use joystick to slew gimbal to corner 1 (Az/El)
 - Press MENU when positioned
 - OSD: "Corner 1 captured"
4. **AIM SECOND CORNER:**
 - Slew to opposite corner (defines rectangle)
 - Press MENU to capture
 - OSD: "Corner 2 captured"
5. **SET PARAMETERS:**

- Enabled: Toggle ON/OFF
- Overridable: Toggle YES/NO
- Press "Validate" to save

4.10.3 Zone Type 2: No-Fire Zones (NFZ)

Purpose: Prevent weapon discharge into protected areas (friendly positions, civilians, sensitive infrastructure).

Access: Main Menu → Zone Definitions → New Zone → No-Fire Zone

Behavior:

- **BLOCKS:** Weapon fire when reticle is inside zone
- **ALLOWS:** Gimbal traverse through zone
- **OSD Display:** Red "NO-FIRE ZONE" warning when inside
- **Trigger Pull:** Has NO effect while in NFZ (weapon safed)

Creating a No-Fire Zone:

CREATING NO-FIRE ZONE

1. Access: MENU → Zone Definitions → New Zone
2. Select: "No-Fire Zone" → MENU
3. **AIM CORNER 1:** Slew to first corner, MENU
4. **AIM CORNER 2:** Slew to opposite corner, MENU
5. **SET PARAMETERS:**
 - Enabled: ON (default)
 - Overridable: Set per SOP (requires authorization to override)
6. Validate to save zone

⚠ CRITICAL SAFETY

No-Fire Zones are **ENFORCED BY SOFTWARE**. If you attempt to fire while in an NFZ, the system will **BLOCK** the fire command. OSD displays: "IN NO-FIRE ZONE - FIRE BLOCKED"

4.10.4 Zone Type 3: No-Traverse Zones (NTZ)

Purpose: Prevent gimbal movement into areas that could cause mechanical damage or injury.

Access: Main Menu → Zone Definitions → New Zone → No-Traverse Zone

Behavior:

- **BLOCKS:** Gimbal movement into zone boundaries
- **Gimbal Response:** Stops at zone boundary, will not enter
- **OSD Display:** Yellow "NO-TRAVERSE ZONE" when approaching
- **Collision Prevention:** System predicts movement and stops before entering

Typical Use Cases:

- Vehicle structure (antenna mast, exhaust, hatches)
- Personnel areas (open hatches, exposed crew)
- Equipment (radar dishes, sensors)

Creating a No-Traverse Zone:

CREATING NO-TRAVERSE ZONE

1. Access: MENU → Zone Definitions → New Zone
2. Select: "No-Traverse Zone" → MENU
3. **AIM CORNER 1:** Slew to first corner, MENU
4. **AIM CORNER 2:** Slew to opposite corner, MENU
5. **SET PARAMETERS:**
 - Enabled: ON (highly recommended)
 - Overridable: Usually NO (safety critical)
6. Validate to save zone

Movement Collision Checking:

- System continuously monitors gimbal position vs. zone boundaries
- When approaching NTZ: Movement slows and stops at boundary
- Cannot "push through" an NTZ even with full joystick deflection
- Automatic scan modes (Sector, TRP) also respect NTZ boundaries

4.10.5 Zone Type 4: Sector Scan Zones

Purpose: Define azimuth/elevation limits for automated sector scanning.

Access: Main Menu → Zone Definitions → New Zone → Sector Scan

Parameters:

Parameter	Description	Typical Value
Point 1 (Az/El)	Starting scan position	045° / 0°

Point 2 (Az/El)	Ending scan position	135° / 0°
Scan Speed	Degrees per second	1-10 (default: 5)
Enabled	Zone active status	ON / OFF

Creating a Sector Scan Zone:

CREATING SECTOR SCAN ZONE

1. Access: MENU → Zone Definitions → New Zone
2. Select: "Sector Scan" → MENU
3. **AIM START POINT:** Slew to scan start position, MENU
4. **AIM END POINT:** Slew to scan end position, MENU
5. **SET PARAMETERS:**
 - Enabled: ON
 - Scan Speed: 1-10 deg/sec (use UP/DOWN to adjust)
6. Validate to save zone

4.10.6 Zone Type 5: Target Reference Points (TRP)

Purpose: Define pre-set observation points with configurable dwell times.

Access: Main Menu → Zone Definitions → New Zone → Target Ref Point

Parameters:

Parameter	Description	Typical Value
Azimuth	Direction to TRP	0° - 359°
Elevation	Vertical angle to TRP	-20° to +60°
Location Page	TRP grouping (1-200)	1
TRP Index in Page	Position within page (1-50)	1-50
Halt Time	Dwell time in seconds	1.0 - 60.0 sec

Creating a TRP:

CREATING TARGET REFERENCE POINT

1. Access: MENU → Zone Definitions → New Zone
2. Select: "Target Ref Point" → MENU
3. **AIM AT TRP:** Slew gimbal to exact TRP location, MENU
4. **SET PARAMETERS:**
 - Location Page: Assign page number (for grouping)
 - TRP Index: Position within page (visit order)
 - Halt Time: Dwell time at this TRP (seconds)
5. Validate to save TRP

TRP Pagination:

- TRPs are organized into **Location Pages** (1-200)
- Each page can contain up to 50 TRPs
- During TRP scan, system visits all TRPs on the active page
- Use **Button 14/16** to switch pages during scanning

4.10.7 Zone Management Operations

Modifying Existing Zones

MODIFY ZONE

1. Access: MENU → Zone Definitions → Modify Zone
2. Select zone type (Area Zone, Sector Scan, TRP)
3. Browse zone list with UP/DOWN
4. Select zone to modify, press MENU
5. Modify parameters as needed
6. Press "Validate" to save changes

Deleting Zones

DELETE ZONE

1. Access: MENU → Zone Definitions → Delete Zone
2. Select zone type
3. Browse and select zone to delete
4. Confirm: "Delete Zone ID X?" → Select "Yes"
5. Zone is permanently removed

! CAUTION

Deleting a zone is **PERMANENT**. Ensure you have saved the zone configuration if you may need the zone later.

Zone Map Display

While in the Zone Definition menu, a **map overlay** displays all zones:

- **Safety Zones:** Blue shaded rectangles
- **No-Fire Zones:** Red shaded rectangles
- **No-Traversal Zones:** Yellow shaded rectangles
- **Sector Scan Zones:** Green lines between start/end points
- **TRPs:** Green crosshair markers
- **Current Gimbal:** White crosshair showing current position
- **Work-In-Progress Zone:** Dashed outline during creation

4.11 Zone Management - Legacy No-Fire & No-Traversal Reference

4.11.1 Viewing No-Fire Zones

Access: Main Menu → Zone Definitions → No-Fire Zones

Display:

- List of all defined no-fire zones
- Each zone shows:
 - Name (e.g., "Friendly FOB", "Civilian Area 1")
 - Boundary type (Polygon, Circle, Arc)
 - Active status (ON/OFF)
- **Operator Permission:**
 - **CAN:** View zones, see boundaries on map overlay
 - **CANNOT:** Modify boundaries, delete zones, override zones

i NOTE

Modification usually requires commander/supervisor authorization.

4.11.2 Viewing No-Traversal Zones

Access: Main Menu → Zone Definitions → No-Traversal Zones

Display:

- List of all defined no-traversal zones
- Each zone shows:
 - Name (e.g., "Rear 90°", "Antenna Area")
 - Azimuth limits
 - Active status
- **Purpose Reminder:**
 - No-traversal zones prevent gimbal movement into restricted areas
 - Protects vehicle structure, equipment, personnel

4.12 Saving & Loading Zone Configurations

4.12.1 Saving Zone Configuration

Purpose: Save all zones (sectors, TRPs, no-fire, no-traversal) to file for later use

SAVE CONFIGURATION

1. **Access Menu:** MENU → Zone Definitions → Save/Load → Save Configuration
2. **Enter Filename:** Use / to enter filename (e.g., "MISSION_20250115")
3. **Confirm Save:** MENU → "Save"
4. OSD displays: "ZONE CONFIG SAVED"

File Location: Saved to internal storage (typically /configs/zones/)

4.12.2 Loading Zone Configuration

Purpose: Load previously saved zone configuration

LOAD CONFIGURATION

1. **Access Menu:** MENU → Zone Definitions → Save/Load → Load Configuration
2. **Select File:** Use / to browse saved configurations
3. **Confirm Load:** MENU → "Load"
4. OSD displays: "ZONE CONFIG LOADED"

WARNING

Loading a configuration OVERWRITES current zones. Save current zones first if needed.

4.12.3 Default Zone Configuration

Default Zones:

- System ships with default no-traverse zones (vehicle-specific)
- Default no-fire zones may be empty (mission-dependent)

Restoring Defaults:

1. MENU → Zone Definitions → Save/Load → Restore Defaults
2. Confirm: "RESTORE DEFAULT ZONES?"
3. MENU → "YES"

4.13 Surveillance Best Practices

4.13.1 Choosing the Right Mode

Situation	Recommended Mode	Rationale
Direct threat engagement	Manual	Full control, immediate response
Perimeter watch (quiet)	AutoSectorScan	Automated, frees attention
Checkpoint routine	TRP Scan	Efficient for fixed locations
High-threat area scan	Manual	Requires operator judgment
Radar-integrated ops	Radar Slew	Rapid response to radar cues

4.13.2 Combining Modes with Tracking

Workflow Example:

1. Start in AutoSectorScan (perimeter surveillance)
2. Threat detected during scan
3. Press TRK → System switches to Manual, starts tracking acquisition
4. Lock onto threat (second TRK press)
5. Engage or monitor as threat tracked
6. Abort tracking (third TRK press)
7. Resume surveillance: Press Button 11/13 to return to AutoSectorScan

4.13.3 Zone Discipline

Before Mission:

- ☐ Load appropriate zone configuration
- ☐ Verify no-fire zones match current ROE
- ☐ Test sector scans and TRPs
- ☐ Brief all operators on zones

During Mission:

- ☐ Respect all zone warnings
- ☐ Never attempt to override no-fire zones without authorization
- ☐ Report zone boundary errors to command
- ☐ Update TRPs as mission evolves (if authorized)

After Mission:

- ☐ Save zone configuration if modified
- ☐ Debrief on zone effectiveness
- ☐ Recommend adjustments for future missions

4.14 Student Review Questions

1. What are the four motion modes available on the RCWS?
2. How do you cycle between motion modes?
3. What is the purpose of Auto Sector Scan mode?
4. What does TRP stand for?
5. What is the typical dwell time at a TRP?
6. How do you create a sector scan zone using the quick capture method?
7. Can operators modify no-fire zone boundaries?
8. What happens when you load a zone configuration?
9. Which motion mode is recommended for direct threat engagement?
10. How do you reorder TRPs in the scan sequence?

Chapter 5

LESSON 5 - TARGET ENGAGEMENT PROCESS

Duration: 4 hours (Classroom 1h + Simulator 3h)
Type: Classroom + Practical
References: Operator manual, tracking system documentation

5.1 LEARNING OBJECTIVES

Upon completion of this lesson, operators will be able to:

- Execute complete target engagement sequence
- Operate tracking system through all phases
- Adjust acquisition gate for target selection
- Perform emergency tracking abort
- Execute simulated weapons engagement

5.2 TARGET ENGAGEMENT SEQUENCE

5.2.1 THE SIX-PHASE ENGAGEMENT CYCLE

The complete engagement process follows six distinct phases:

DETECT → IDENTIFY → ACQUIRE → TRACK → ENGAGE → ASSESS

Phase	Operator Actions	Expected Duration
1. DETECT	Scan area (manual/auto modes), visual detection	Continuous
2. IDENTIFY	Slew to target, zoom in, PID (Positive ID), verify ROE	5-15 seconds
3. ACQUIRE	Enter tracking acquisition, position gate, size gate	5-10 seconds
4. TRACK	Lock-on, monitor track quality	Continuous until engagement
5. ENGAGE	Range, LAC (if moving), Master Arm, Fire, Observe	2-30 seconds
6. ASSESS	BDA (Battle Damage Assessment), re-engage or cease	5-10 seconds

5.2.2 DETECT & IDENTIFY (PHASES 1-2)

Detection Methods

- Manual scan (joystick control)
- Auto Sector Scan (Lesson 4)
- TRP Scan (Lesson 4)
- Radar cues (if available)

Identification Requirements

- **PID (Positive Identification)** mandatory before engagement
- Use zoom to magnify target (**[Button 6/8]**)
- Thermal camera may aid identification (night, obscurants)
- Verify target meets Rules of Engagement (ROE)
- Confirm NOT friendly forces

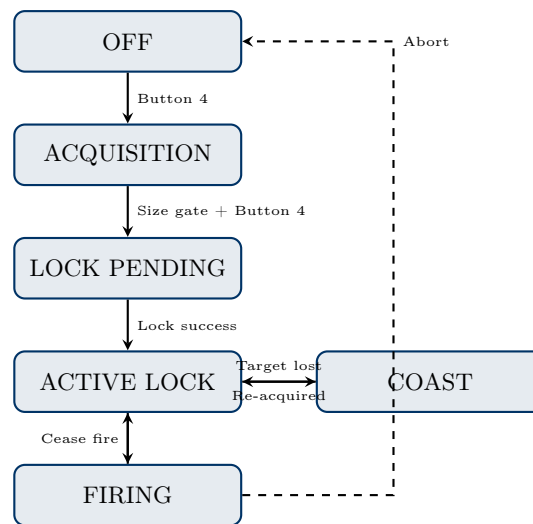
WARNING

Failure to achieve PID before engagement violates ROE and may result in fratricide.

5.3 TRACKING SYSTEM OVERVIEW

5.3.1 TRACKING PHASE STATE MACHINE

The tracking system operates through discrete phases:



5.3.2 TRACKING PHASE REFERENCE

Phase	OSD Status	Box Color	Box Style	Duration	Gimbal Control
Off	MODE: Manual	None	N/A	Until acquisition	Operator (joystick)
Acquisition	ACQUISITION	Yellow	Solid	5-10 sec	Operator (joystick)
Lock Pending	LOCK PENDING	Cyan	Solid/Flash	0.5-2 sec	Operator (hold steady)
Active Lock	TRACKING	Green	Dashed	Continuous	Automatic (tracker)
Coast	TRACKING (COAST)	Yellow	Dashed	1-5 sec	Automatic (predict)
Firing	TRACKING (FIRING)	Green	Solid	While firing	Automatic (hold)

5.3.3 TRACKING CONTROLS

Control	Function	Active Phase(s)
[Button 4] (single)	Start Acquisition / Request Lock-On	Off → Acq, Acq → Lock Pending
[Button 4] (double <1 sec)	EMERGENCY ABORT	Any phase → Off
[D-Pad]	Decrease gate height (-4 px)	Acquisition only
[D-Pad]	Increase gate height (+4 px)	Acquisition only
[D-Pad]	Decrease gate width (-4 px)	Acquisition only
[D-Pad]	Increase gate width (+4 px)	Acquisition only

5.4 ACQUISITION PHASE

5.4.1 ENTERING ACQUISITION MODE

Prerequisites

- ☐ Motion mode: Manual
- ☐ Target on-screen and identified
- ☐ Target approximately centered in reticle

ENTERING ACQUISITION

1. Press [Button 4] (Track Select)

Result:

- System enters **ACQUISITION** phase
- Yellow acquisition gate appears (centered on reticle)
- OSD displays: **MODE: ACQUISITION**
- Joystick gimbal control remains active
- D-Pad now controls gate size

5.4.2 SIZING THE ACQUISITION GATE

Objective: Frame target with 10-30% margin on all sides

D-Pad Controls

- [UP]: Decrease height
- [DOWN]: Increase height

- **[LEFT]**: Decrease width
- **[RIGHT]**: Increase width
- **Step size**: 4 pixels per press

Gate Sizing Guidelines

Target Framing	Effect on Tracking	Recommendation
Too Tight (<10% margin)	Tracker may lose target if target rotates/expands	Avoid
Optimal (10-30% margin)	Best tracking performance	Ideal
Too Loose (>50% margin)	Background clutter may confuse tracker	Avoid

Best Practices

- **Vehicles**: Frame entire hull, exclude ground
- **Personnel**: Include torso/legs, minimize background
- **Moving targets**: Size slightly larger (anticipate motion)
- **Default size**: 100×100 pixels (adjust as needed)

5.4.3 REQUESTING LOCK-ON

When Ready

- ☐ Target fully visible and framed in gate
- ☐ Target has good contrast against background
- ☐ Target not moving erratically

Action: Press **[Button 4]** (second press)

Result:

- System → **LOCK PENDING** phase
- Gate color: Yellow → Cyan (or flashing)
- OSD: **MODE: LOCK PENDING**
- Tracker initialization begins (0.5-2 seconds)

! CAUTION

Do NOT make rapid gimbal movements during Lock Pending. Hold gimbal steady.

5.5 LOCK PENDING → ACTIVE LOCK

5.5.1 LOCK PENDING PHASE

Purpose: Tracking system initializes on target

Duration: 0.5 to 2 seconds (typically 1 second)

Operator Action: **WAIT** - maintain steady gimbal

What Happens

1. System captures reference image of target
2. Initializes tracker algorithm
3. Calculates target features
4. Begins tracking target in video stream

Transition Outcomes

SUCCESS:

- System → **ACTIVE LOCK** phase
- Gate color: Green
- Gate style: Dashed outline
- OSD: **MODE: TRACKING** or **ACTIVE LOCK**
- Gimbal control switches to automatic

FAILURE (rare):

- System → **ACQUISITION** phase (retry)
- Possible causes: Poor contrast, target too small, target motion
- Operator: Adjust gate size or abort and restart

5.5.2 ACTIVE LOCK PHASE

System Behavior

- Tracker follows target at 30 Hz (30 times/second)
- Gimbal automatically moves to keep target centered
- Reticle stays on target center
- Joystick axis inputs **IGNORED** (tracking in control)

Visual Indicators

- **Tracking Gate**: Green dashed outline around target
- **OSD: MODE: TRACKING** or **ACTIVE LOCK**
- **Control Panel**: TRACKING light ON (green)

- **Track Confidence:** >70% (good), 50-70% (marginal), <50% (poor)

5.5.3 OPERATOR ROLE DURING ACTIVE LOCK

Primary Role: MONITOR - system is tracking automatically

Monitor For

1. Track Quality:

- Green gate = Good track
- Yellow gate = Marginal (may lose soon)
- Track confidence >70% (good), <50% (prepare for coast)

2. Target Status:

- Target correctly identified (didn't jump to wrong object)
- Target still valid (meets engagement criteria)
- Target not obscured or about to be obscured

3. Gimbal Position:

- Staying within operational limits
- Not approaching no-traverse zones
- Elevation within -20° to +60°

Controls Still Active

ACTIVE CONTROLS	
[Button 0]	Master Arm
[Button 2]	LAC toggle
[Button 3]	Dead Man Switch
[Button 4]	Double-click abort
[Button 5]	Fire
[Button 6/8]	Zoom (use cautiously, may affect track)
BLOCKED CONTROLS	
[Button 11/13]	Mode cycle - BLOCKED during tracking
Joystick axes (X/Y)	IGNORED during tracking

5.6 COAST MODE

5.6.1 WHEN COAST ACTIVATES

Triggers:

- Target temporarily obscured (passes behind object)
- Target leaves field of view briefly
- Tracker loses visual lock
- Dust, smoke, or other obscurants

5.6.2 System Behavior

- Tracker **predicts** target position based on last known velocity
- Gimbal continues to predicted position
- System attempts to re-acquire target
- Tracking gate: Green → Yellow (dashed)

5.6.3 Display Changes

- **OSD: MODE: COAST** or **TRACKING (COAST)**
- **Gate:** Yellow/amber dashed outline
- **Warning:** "COASTING - TARGET LOST" may display

5.6.4 COAST OUTCOMES

Typical Duration: 1-5 seconds

Outcome 1: Target Re-Acquired (Success)

- Target reappears in field of view
- Tracker re-locks on target
- System → **ACTIVE LOCK** phase
- Gate: Yellow → Green
- Tracking continues normally

Outcome 2: Coast Timeout (Failure)

- Target not re-acquired within timeout (5 seconds)
- System gives up
- System → **OFF** phase
- Tracking stops
- Operator must restart tracking if desired

5.6.5 Operator Action During Coast

- Wait patiently (system attempting re-acquisition)
- Be ready for track to resume

- Do NOT abort prematurely (give system time)
- Do NOT make manual gimbal movements (joystick ignored)

Abort Coast If:

- Target definitely not coming back (destroyed, permanently obscured)
- Tracker coasting in wrong direction (confused)
- Mission changed

5.7 TRACKING ABORT (EMERGENCY)

5.7.1 WHEN TO ABORT TRACKING

Abort tracking **IMMEDIATELY** if:

- Tracking wrong target (friendly, civilian, incorrect target)
- Target no longer valid (fails ROE)
- Safety concern (entering no-fire zone, gimbal obstruction)
- Mission change (new priority, orders to cease)
- Tracking erratic (unexpected gimbal behavior)

5.7.2 ABORT PROCEDURE

EMERGENCY ABORT

Action: DOUBLE-CLICK [Button 4] (<1 second between presses)

Effect (IMMEDIATE):

1. Tracking **STOPS**
2. System → **OFF** phase
3. Gimbal holds current position
4. Tracking gate disappears
5. Weapon fire **INHIBITED** (even if Master Arm engaged)
6. OSD: **MODE: MANUAL**

Timing

- Press 1 → Press 2 within **1000 milliseconds** (one second)
- **Too slow** (>1 second): System interprets as two single presses (may restart tracking)

CRITICAL

Practice double-click timing during training until muscle memory established.

5.7.3 AFTER ABORT

System State:

- Manual mode active
- Joystick gimbal control restored
- No tracking active

Next Actions (mission-dependent):

- Re-acquire correct target and restart tracking
- Return to surveillance mode
- Engage different target
- Follow commander's orders

5.8 WEAPON CHARGING (COCKING ACTUATOR)

5.8.1 COCKING ACTUATOR OVERVIEW

The cocking actuator is a servo-controlled mechanism that cycles the weapon's bolt to chamber a round. This must be performed before the weapon can fire.

Weapon-Specific Charging Cycles

Weapon Type	Cycles Req.	Notes
M2HB (.50 cal)	2 cycles	Closed bolt weapon - Cycle 1: pulls bolt, picks up round; Cycle 2: chambers round, weapon ready
M240B	1 cycle	Open bolt weapon - single cycle chambers round
M249 SAW	1 cycle	Open bolt weapon
MK19 (40mm)	1 cycle	Grenade launcher

⚠ M2HB CRITICAL

The M2HB requires **TWO** complete charging cycles before the weapon is ready to fire. A single cycle will NOT chamber a round.

5.8.2 CHARGING MODES

The charging system supports two operational modes:

Mode 1: Short Press (Automatic Cycle)

SHORT PRESS CHARGING

1. Press **[Charge]** button (joystick Button 9)
2. Release button immediately (short press)
3. System **automatically** cycles: Extend → Retract
4. For M2HB: System automatically performs second cycle
5. **Charging Complete** when retraction finishes
6. 4-second lockout begins (prevents immediate re-charge)

Advantages: Faster, automatic multi-cycle for M2HB **Best For:** Standard charging operations

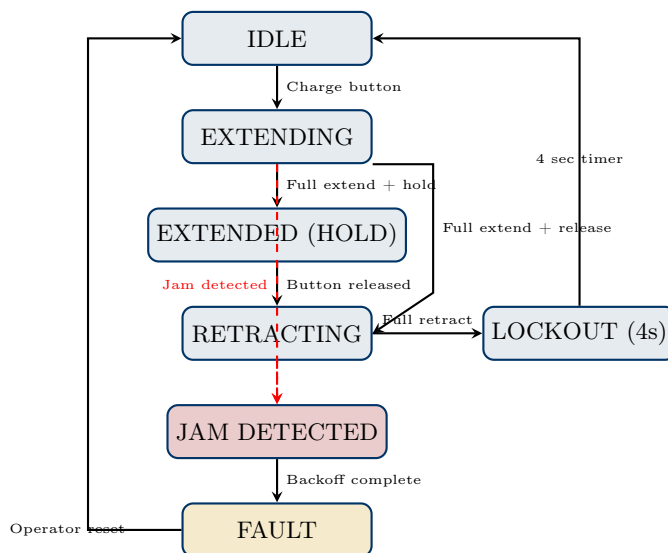
Mode 2: Continuous Hold (Manual Control)

CONTINUOUS HOLD CHARGING

1. Press and **HOLD** **[Charge]** button
2. Actuator extends (pulls bolt back)
3. **Hold position** while button is held
4. **Release** button to initiate retraction
5. Actuator retracts (releases bolt)
6. Repeat for additional cycles (M2HB)
7. 4-second lockout begins after final cycle

Advantages: Operator controls timing, can hold bolt back **Best For:** Clearing jams, inspection, controlled operations

5.8.3 CHARGING STATE MACHINE



5.8.4 CHARGING STATE REFERENCE

State	OSD Display	Description
IDLE	CHARGING: Ready	Weapon ready to charge
EXTENDING	CHARGING: Extending	Actuator moving forward, pulling bolt
EXTENDED	CHARGING: Extended (HOLD)	Bolt pulled back, awaiting button release
RETRACTING	CHARGING: Retracting	Actuator returning, releasing bolt
LOCKOUT	CHARGING: Lockout (4s)	El-7aress H100 4-second post-charge safety period
JAM DETECTED	CHARGING: JAM!	High torque + no movement = mechanical jam
FAULT	CHARGING: FAULT	Requires operator acknowledgment and reset

5.8.5 4-SECOND EL-7ARESS H100 LOCKOUT

⚠ LOCKOUT PERIOD

Per El-7aress H100 specification, a **4-second lockout period** follows each completed charging cycle. During this time:

- Charging button is **IGNORED**
- Prevents accidental double-charge
- Allows weapon to fully seat round
- OSD displays countdown or "Lockout" status

5.8.6 JAM DETECTION AND RECOVERY

The charging system includes automatic jam detection:

Jam Detection Criteria

- **High Torque:** Actuator motor exceeds torque threshold (>80%)
- **No Movement:** Position not changing despite motor effort
- **Confirmation:** Condition persists for multiple samples (anti-false-positive)

Automatic Jam Response

1. **IMMEDIATE STOP:** Motor halts to prevent damage
2. **STATE TRANSITION:** System enters JAM DETECTED state
3. **ALARM:** OSD displays "CHARGING: JAM!"
4. **DELAYED BACKOFF:** After 200ms stabilization, actuator retracts to home
5. **FAULT STATE:** System enters FAULT state, awaits operator reset

Jam Clearing Procedure

CLEARING A CHARGING JAM

1. **STOP:** Do NOT repeatedly press charge button
2. **OBSERVE:** Note jam position on OSD (if displayed)
3. **WAIT:** Allow automatic backoff to complete
4. **VERIFY:** Check OSD shows "FAULT" state
5. **INSPECT:** If possible, visually inspect weapon for obstruction
6. **CLEAR:** Remove any visible obstruction (per weapon manual)
7. **RESET:** Press [**Charge**] button once to reset fault
8. **RETRY:** Actuator performs safe retraction to home position
9. **RE-CHARGE:** After successful reset, perform normal charging

⚠ SAFETY

If jam persists after 2 reset attempts, **STOP** and request maintenance support. Repeated jam cycling can damage the weapon or actuator.

5.8.7 CHARGING SAFETY INTERLOCKS

Charging is **BLOCKED** when:

Condition	Reason/Resolution
Emergency Stop Active	Clear E-stop before charging
Station Disabled	Enable station with Station Enable switch
Charge Already In Progress	Wait for current cycle to complete
Lockout Active	Wait 4 seconds after previous charge
Fault State	Reset fault by pressing Charge button

5.8.8 STARTUP ACTUATOR CHECK

On system startup, if the actuator is found in an extended position:

- System automatically performs **safe retraction**
- Returns actuator to home (retracted) position
- Shorter timeout used (best-effort recovery)
- Prevents leaving weapon in unsafe partially-charged state

5.9 WEAPONS ENGAGEMENT SEQUENCE

5.9.1 PRE-ENGAGEMENT CHECKLIST

Before engaging, verify **ALL** items:

- ☐ Target positively identified (**PID**)
- ☐ Target valid (meets ROE)
- ☐ Fire authorization received (if required)
- ☐ NOT in no-fire zone (check OSD for zone warnings)
- ☐ Friendly forces clear
- ☐ Weapon loaded and ready
- ☐ Zeroing active (if applicable)
- ☐ Environmental parameters set (if applicable)
- ☐ Track established (if using tracking)

WARNING

IF ANY ITEM CANNOT BE CHECKED, DO NOT FIRE.

5.9.2 ENGAGEMENT PROCEDURE (STEP-BY-STEP)

STEP 1: Acquire and Track Target

1. Detect and identify target (PID mandatory)
2. **[Button 4]** → Enter acquisition mode
3. **[D-Pad]** → Size gate to frame target (10-30% margin)
4. **[Button 4]** → Request lock-on
5. Wait for **ACTIVE LOCK** (green gate, OSD: TRACKING)
6. Monitor track quality (confidence >70%, green gate)

STEP 2: Range Target

1. Fire Laser Range Finder (LRF trigger)
2. Wait for range reading (OSD: **RNG: xxxx m**)
3. Verify range reasonable
4. Range used for ballistic calculations (CCIP)

NOTE

LRF may fire automatically during tracking (configuration-dependent). Verify range displayed.

STEP 3: Enable Lead Angle Compensation (If Moving Target)

If target is moving (lateral motion, speed >5 m/s, range >100m):

1. Hold **[Dead Man Switch (Button 3)]**
2. Press **[LAC Toggle (Button 2)]**
3. Verify LAC status:
 - **"LEAD ANGLE ON"** (green) = Ready
 - **"LEAD ANGLE LAG"** (yellow) = Wait for tracking data
 - **"ZOOM OUT"** (red) = FOV too narrow, zoom out
4. Observe CCIP reticle offset ahead of target (lead point)

If target stationary: LAC not necessary (CCIP at target center)

NOTE

Detailed LAC procedures in Lesson 6.

STEP 4: Final Safety Checks

- ☐ Verify target still valid
- ☐ Verify tracking active (green gate, good confidence)
- ☐ Check OSD for warnings:
 - **"ZONE VIOLATION"** = DO NOT FIRE
 - **"NO-FIRE ZONE"** = DO NOT FIRE
 - No warnings = Clear to fire
- ☐ Verify friendly forces clear
- ☐ Verify backstop (if required)

STEP 5: Engage Master Arm

1. Pull trigger to **Stage 1** (half-pull) → **Master Arm** (**[Button 0]**)
 - OR toggle Master Arm switch on Control Panel
2. Verify **"ARMED"** indicator light ON (red)
3. OSD may display: **WEAPON ARMED**

! WARNING

WEAPON IS NOW HOT

STEP 6: Fire Weapon

1. Final aim verification (CCIP on target or lead point)
 2. Pull trigger to **Stage 2** (full-pull) → **Fire** ([Button 5])
 3. Weapon fires
 4. Hold trigger for desired burst:
 - **Single Shot:** Quick press/release (1 round)
 - **Burst:** Hold 2-3 seconds (controlled burst)
 - **Sustained:** Hold longer (use cautiously)
- During Firing:**
- Tracking keeps reticle on target
 - Gimbal compensates for recoil
 - Observe rounds impacting
 - Adjust fire as needed
- System State:**
- Tracking phase → **FIRING**
 - OSD: **MODE: TRACKING (FIRING)**
 - Gate: Green solid outline
 - Enhanced stabilization active

Dead Reckoning During Firing (El-7aress Doctrine)**! IMPORTANT - DEAD RECKONING**

Per El-7aress H100 specification: "When firing is initiated, the system aborts Target Tracking. Instead the system moves according to the speed and direction of the WS just prior to pulling the trigger. The system will not automatically compensate for changes in speed or direction of the tracked target during firing."

Dead Reckoning Behavior:

- When trigger is pulled, system captures **last known target velocity**
- Gimbal continues moving at captured velocity (azimuth and elevation rates)
- Tracker is **NOT actively following** target during firing
- System **predicts** target position based on last velocity
- If target maneuvers during firing, rounds may miss

Operator Implications:

- Best for targets with **constant velocity** (vehicles on road)
- Less effective against **maneuvering targets**
- Fire short bursts, reassess, fire again for erratic targets
- After firing stops, must **re-acquire** target to resume tracking

STEP 7: Cease Fire

1. Release **Fire button** ([Button 5] / trigger stage 2)
2. Weapon stops firing
3. Release **Master Arm** ([Button 0] / trigger stage 1)
4. Verify "**ARMED**" indicator OFF
5. Tracking continues (unless aborted)

STEP 8: Assess Target (BDA)**Battle Damage Assessment:**

- Target destroyed? → Stop tracking, report success
- Target damaged? → Re-engage (repeat Steps 5-7)
- Target missed? → Check zeroing/environmental/LAC, re-engage
- Target suppressed? → Maintain track, ready to re-engage

STEP 9: Post-Engagement Actions

1. If target neutralized: **Stop tracking** (double-click [Button 4])
2. Report engagement results to command
3. Update ammunition count
4. Scan for additional targets
5. Resume surveillance or follow orders

5.10 ENGAGEMENT BEST PRACTICES**5.10.1 TARGET SELECTION FOR TRACKING****Good Targets**

- High contrast against background

- Clearly defined edges
- Sufficient size (>30 pixels)
- Relatively stable motion

Difficult Targets

- Low contrast (camouflaged)
- Very small (distant)
- Erratic motion (evasive)
- Partially obscured

If Tracking Fails

- Try manual engagement (no tracking)
- Improve contrast (switch camera or thermal LUT)
- Wait for better tracking opportunity

5.10.2 LEAD ANGLE COMPENSATION TIPS

When to Use LAC

- Target moving laterally (crossing FOV)
- Target speed >5 m/s (10 mph)
- Range >100 meters

When NOT Needed

- Stationary targets
- Targets moving radially (toward/away from you)
- Very close range (<50m)

LAC Limitations

- Requires tracking active
- Requires sufficient FOV (may need to zoom out)
- Assumes constant target velocity (less accurate if maneuvering)

5.10.3 AMMUNITION CONSERVATION

Fire Discipline

- Use controlled bursts (2-5 rounds) vs. full-auto spray
- Assess after each burst before re-engaging
- Precision over volume

Round Count

- Track ammunition expenditure
- Report when low (<20% remaining)
- Conserve for high-priority targets

5.10.4 SAFETY REMINDERS

ALWAYS

- Verify target before engaging (PID mandatory)
- Check for friendly forces
- Verify NOT in no-fire zone
- Follow Rules of Engagement (ROE)
- Have fire authorization (if required)

NEVER

- Fire without positive identification
- Fire into no-fire zones
- Fire if friendlies potentially in line of fire
- Fire without authorization (if required)
- Assume tracking is infallible (monitor track quality)

5.11 TRACKING QUICK REFERENCE

Situation	Action	Button/Control
Start tracking	Enter acquisition mode	[Button 4] (1st press)
Size gate larger	Increase dimensions	[D-Pad ↑] (height) / [←] (width)
Size gate smaller	Decrease dimensions	[D-Pad ↓] (height) / [→] (width)
Request lock-on	Lock onto target	[Button 4] (2nd press)
Monitor track	Observe gate color & confidence	Visual (OSD)
Track degrading	Prepare for coast or abort	Stand by [Button 4]
Emergency abort	Stop tracking immediately	[Button 4] (double-click <500ms)
Enable LAC	Activate lead compensation	[Button 3 + Button 2]
Arm weapon	Engage Master Arm	[Button 0] (or trigger stage 1)
Fire weapon	Discharge weapon	[Button 5] (or trigger stage 2)
Cease fire	Safe weapon	Release [Button 5 & Button 0]

Chapter 6

LESSON 6 - BALLISTICS & FIRE CONTROL

Duration: 5 hours (Classroom 2h + Practical 3h)
Type: Classroom + Practical
References: Ballistics manual, environmental procedures, LAC guide

6.1 LEARNING OBJECTIVES

Upon completion of this lesson, operators will be able to:

- Perform weapon zeroing (boresight alignment)
- Configure environmental parameters for ballistic corrections
- Activate and employ Lead Angle Compensation (LAC) for moving targets
- Interpret fire control status indicators
- Combine zeroing, environmental settings, and LAC for accurate engagements

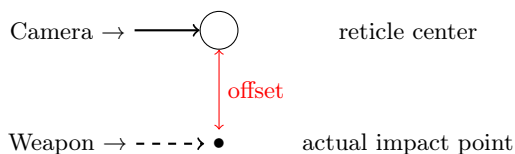
6.2 WEAPON ZEROING (BORESIGHT ALIGNMENT)

6.2.1 THE BORESIGHT OFFSET PROBLEM

Physical Reality

- Camera and weapon barrel are physically separated (typically 15-30cm)
- Camera points at reticle center
- Weapon points at different location
- **Without correction:** Weapon impacts below/beside reticle aim point

Diagram



Zeroing Solution

- Applies angular offsets to compensate for physical separation
- **Azimuth Offset:** Horizontal correction (left/right)
- **Elevation Offset:** Vertical correction (up/down)
- **After Zeroing:** Reticle shows where weapon will actually hit

6.2.2 ZEROING PROCEDURE

Pre-Zeroing Requirements

Environmental Conditions:

- ☐ Calm wind (<5 knots)
- ☐ Good visibility (daylight preferred)
- ☐ Stable platform (vehicle stationary)
- ☐ Temperature moderate

Range Setup:

- ☐ Known range to target (recommended 100-300m)
- ☐ Fixed target (large, visible, safe backstop)
- ☐ No obstructions

System Status:

- ☐ Station powered and initialized
- ☐ Camera operational (day camera for initial zero)
- ☐ Weapon loaded and ready
- ☐ Manual mode (no active tracking or motion modes)

COMPLETE ZEROING PROCEDURE (STEP-BY-STEP)

STEP 1: Access Zeroing Menu

1. Press **[MENU]** on Control Panel
2. Navigate to **"Zeroing"** option (**[↑]**)
3. Press **[VAL]** to enter

4. Zeroing screen appears with instructions

STEP 2: Aim at Target

1. Use joystick to center reticle on target center
2. Ensure stable aim
3. Target should be large (minimum 30cm × 30cm)
4. Target at known range (100-300m recommended)

STEP 3: Fire Test Shot(s)

1. Hold **[Button 0]** (Master Arm)
2. Press **[Button 5]** (Fire) - single shot or short burst
3. Observe impact point on target
4. Note offset from reticle center (direction and distance)

Example:

- Reticle centered on target bullseye
- Impact observed 20cm low and 10cm right
- This offset will be corrected in next steps

STEP 4: Adjust Reticle to Impact

OSD displays: Use JOYSTICK to move main RETICLE to ACTUAL IMPACT POINT

1. Use joystick to move reticle from target center to **actual impact location**
2. Position reticle exactly where weapon hit
3. This movement is captured as zeroing offset
4. Do NOT fire again during this step

Example Continued:

- Move joystick down and right
- Reticle now positioned at impact point (20cm low, 10cm right of center)
- System records this offset

STEP 5: Apply Zero

1. Press **[MENU / VAL]** button to apply
2. System calculates offsets (Azimuth, Elevation)
3. Completion screen shows: **Zeroing Adjustment Applied!**
4. Displays final offsets (e.g., "Az: 0.85°, El: -1.23°")
5. **"Z"** indicator appears on OSD (confirms zero active)

STEP 6: Verify Zero

1. **Return reticle to target center** (joystick)
2. Fire verification shot
3. Impact should now match reticle center
4. **If offset remains:** Repeat procedure
5. **If accurate:** Zero complete

i NOTE

Zero values saved to configuration file, loaded automatically on startup.

6.2.3 MULTI-RANGE ZERO VALIDATION

Why Multiple Ranges Matter

- Ballistic arc is curved, not straight
 - Zero at 100m may not be accurate at 500m
 - Single-range zero is a compromise
- Recommended Zero Range: 200-250m** (best for general-purpose zero, acceptable accuracy 50m-600m)

MULTI-RANGE VALIDATION PROCEDURE

After initial zero at 200m, test at multiple ranges:

Range	Procedure	Acceptable Error
100m	Aim at center, fire test shot	±5cm
300m	Aim at center, fire test shot	±10cm
500m	Aim at center, fire test shot	±20cm (may be low due to drop)

If Errors Exceed Acceptable:

- Re-zero at primary engagement range (e.g., 250m)
- Compromise between short and long range accuracy

6.2.4 CLEARING ACTIVE ZERO**When to Clear Zero**

- Weapon or camera repositioned (maintenance, replacement)
- Zero no longer accurate (tested and failed verification)
- Different weapon or ammunition type installed

CLEARING ZERO PROCEDURE

1. [MENU] → Zeroing → **Clear Zero**
2. Confirm: **CLEAR ACTIVE ZERO?**
3. [MENU] → **YES**
4. OSD **Z** indicator disappears
5. System returns to factory boresight (no offset)
6. Must perform new zeroing procedure before live fire

6.3 ENVIRONMENTAL PARAMETERS**6.3.1 ENVIRONMENTAL EFFECTS ON BALLISTICS**

Ballistic trajectory is affected by environmental conditions:

Parameter	Effect on Trajectory	System Correction
Temperature	Air density changes → drag changes	Ballistic LUT adjustment
Altitude	Lower air pressure → less drag	LUT adjustment for altitude
Crosswind	Lateral projectile drift	Azimuth offset correction

System Fields (SystemStateData)

- environmentalTemperatureCelsius (default: 15°C)
- environmentalAltitudeMeters (default: 0m / sea level)
- environmentalCrosswindMS (meters per second)
- environmentalAppliedToBallistics (boolean flag)

6.3.2 ENVIRONMENTAL PARAMETERS SETUP**ACCESSING ENVIRONMENTAL MENU**

1. Press [MENU]
2. Navigate to **"Environmental Parameters"** ([/])
3. Press [VAL] to enter
4. Environmental configuration screen appears

SETTING TEMPERATURE

Purpose: Correct for air density changes due to temperature

TEMPERATURE CONFIGURATION

1. Select **"Temperature"** option
2. Use [/] to adjust value (range: -40°C to +60°C)
3. Set to **current ambient temperature**
4. Press [VAL] to confirm

Temperature Guidelines:

Condition	Temp.	Air Density	Trajectory Effect
Cold	<0°C	High (dense air)	More drag, shorter range
Standard	15°C	Standard (ISO)	No correction
Hot	>30°C	Low (thin air)	Less drag, longer range

i NOTE

Temperature measured at **shooter location**, not target location.

SETTING ALTITUDE

Purpose: Correct for air pressure changes with elevation

ALTITUDE CONFIGURATION

1. Select **"Altitude"** option
2. Use [/] to adjust value (range: -500m to +4000m)
3. Set to **current altitude above sea level** (meters)

- Press **[VAL]** to confirm

Altitude Guidelines:

Altitude	Air Pressure	Trajectory Effect
Sea Level (0m)	Standard (101.3 kPa)	No correction
1000m	Lower (90 kPa)	Less drag, longer range, less drop
2000m+	Much lower	Significantly less drag, flatter trajectory

i TIP

Use GPS, map, or barometric altimeter to determine altitude.

SETTING CROSSWIND

Purpose: Correct for lateral projectile drift due to wind

CROSSWIND CONFIGURATION

- Select "**Crosswind**" option
- Use **[/]** to adjust value (range: 0-25 m/s)
- Set to **estimated crosswind speed** (perpendicular to fire direction)
- Press **[VAL]** to confirm

Crosswind Assessment:

Wind (m/s)	Wind (knots)	Visual Cues
0-2	0-4	Calm, smoke rises vertically
3-5	6-10	Light breeze, leaves rustle, flags extended
6-10	12-20	Moderate wind, small branches move, dust raised
11-15	21-30	Fresh wind, small trees sway
16+	31+	Strong wind, large branches move

Crosswind Direction

- **Full crosswind:** Wind perpendicular to fire direction (maximum effect)
- **Partial crosswind:** Wind at angle to fire direction (reduced effect)
- **Headwind/Tailwind:** Wind along fire direction (minimal lateral drift, affects range only)

System Assumption: Crosswind value entered represents **full crosswind component** (perpendicular). Operator should estimate effective crosswind speed accounting for wind angle.

APPLYING ENVIRONMENTAL SETTINGS

APPLYING SETTINGS

STEP 1: Configure All Parameters

- Temperature set
- Altitude set
- Crosswind set

STEP 2: Apply to Ballistics

- Select "**Apply Environmental Settings**"
- Confirm: **APPLY TO BALLISTICS?**
- Press **[VAL]** → **YES**
- OSD displays: **ENV** indicator (confirms environmental corrections active)

STEP 3: Verify Active

- Check OSD for **ENV** indicator
- Environmental corrections now applied to CCIP reticle
- All subsequent shots use environmental-corrected ballistics

CLEARING ENVIRONMENTAL SETTINGS

When to Clear:

- Environmental conditions changed significantly
- Moving to different location (altitude, temperature change)
- Wind conditions changed
- Returning to standard conditions

CLEARING ENVIRONMENTAL SETTINGS

- [MENU]** → Environmental Parameters → **Clear Settings**
- Confirm: **CLEAR ENVIRONMENTAL SETTINGS?**
- [MENU]** → **YES**
- OSD **ENV** indicator disappears
- System returns to standard conditions (15°C, 0m altitude, 0 m/s wind)

6.3.3 ENVIRONMENTAL PARAMETERS QUICK REFERENCE

Situation	Temp.	Alt.	Wind	Apply?
Sea level, standard day, calm	15°C	0m	0 m/s	No (default)
Desert, hot, calm	40°C	0m	0 m/s	Yes (temp)
Mountain, cold, windy	-10°C	2000m	8 m/s	Yes (all)
Temperate, mild, light breeze	20°C	300m	3 m/s	Optional

6.4 LEAD ANGLE COMPENSATION (LAC)

⚠ CRITICAL - JOYSTICK ONLY

Lead Angle Compensation (LAC) can **ONLY** be toggled using joystick **Button 2** while holding the Dead Man Switch (Button 3). There is **NO** menu access for LAC activation. The menu only displays LAC status.

6.4.1 THE MOVING TARGET PROBLEM

Without Lead Compensation

Time T=0 (Fire) Time T=TOF (Impact)

Target: [X] Target: -----> [X]

↓

Bullet: • Bullet: •

Result: MISS (bullet hits where target WAS)

With Lead Compensation

Time T=0 (Fire) Time T=TOF (Impact)

Target: [X] Target: -----> [X]

↓ (aim ahead)

Bullet: →→→ • Bullet: •

Result: HIT (bullet meets target at predicted position)

6.4.2 LEAD ANGLE FUNDAMENTALS

Lead Angle: Angular offset between target's current position and predicted intercept point

Factors Affecting Lead Angle

1. **Target Velocity:** Faster target = more lead
2. **Target Direction:** Crossing target = maximum lead, approaching/receding = minimal
3. **Range to Target:** Greater range = longer TOF = more lead
4. **Projectile Velocity:** Slower projectile = longer TOF = more lead
5. **Target Angular Rate:** How fast target crosses FOV

System Calculation Process (30 Hz update rate)

1. Measure target motion (tracking system provides angular rates)
2. Determine range (LRF)
3. Calculate Time-of-Flight (TOF)
4. Predict target position (current position + angular rate × TOF)
5. Calculate lead angle
6. Apply offset to CCIP reticle

6.4.3 LAC ACTIVATION REQUIREMENTS

Prerequisites

- ☐ Active target track established (Tracking Phase = Active Lock)
- ☐ Valid range data from LRF
- ☐ Target exhibiting motion (angular rate > threshold)
- ☐ Sufficient camera FOV (not zoomed in excessively)
- ☐ System initialized and operational

Safety Interlock

- **Dead Man Switch ([Button 3]) MUST be held** during activation

6.4.4 LAC ACTIVATION PROCEDURE

PRE-CONDITIONS

- ☐ Target tracked (Active Lock achieved)

- ☐ Target moving at measurable velocity
- ☐ Range data valid (LRF fired successfully)
- ☐ Camera FOV adequate (avoid max zoom)

LAC ACTIVATION

ACTIVATION:

1. Hold **[Button 3]** (Dead Man Switch)
2. Press **[Button 2]** (LAC Toggle)
3. Release Button 2
4. Release Button 3

VERIFICATION:

- ☐ **LAC: ON** indicator appears (GREEN)
- ☐ CCIP reticle shifts to lead position (ahead of target)
- ☐ Track confidence remains >70%

El-7aress-Compliant LAC Latching Behavior

Per El-7aress H100 specification, LAC follows specific latching rules:

2-SECOND MINIMUM INTERVAL

"A minimum of 2 seconds must be waited before reuse of lead angle compensation feature."

LAC Latching Behavior:

- When LAC is toggled ON, system **latches** current target tracking rate
- Lead calculation uses latched rate, not continuously updated rate
- If operator toggles LAC OFF then ON again, must wait **2 seconds minimum**
- System will **block** LAC toggle if attempted too soon

Warning - Target Switching:

WARNING

"If target #2 is not properly acquired, the WS will fire outside the desired engagement area by continuing to apply the lead angle acquired from target #1."

Operator Procedure for Target Switch:

1. Toggle LAC OFF (Button 2 while holding Button 3)
2. Acquire new target (tracking lock on target #2)
3. Wait minimum 2 seconds
4. Toggle LAC ON for new target
5. Verify **LAC: ON** before firing

6.4.5 LAC STATUS INDICATORS

The OSD displays LAC status in the following formats:

LAC: OFF	(gray)	- LAC disabled
LAC: ON	(green)	- LAC active and functioning
LAC: LAG	(yellow)	- Insufficient tracking data, wait 2-5 sec
LAC: ZOOM OUT	(red)	- FOV too narrow, zoom out required

STATUS: "LAC: ON" (GREEN)

Meaning: LAC active and functioning correctly

Display:

- OSD shows: **LAC: ON** in green
- CCIP reticle offset ahead of target
- Lead offset calculated and applied

Operator Action:

- Aim at CCIP reticle (not at target directly)
- CCIP shows where to aim for predicted intercept
- Fire when CCIP on target (system handles lead)

STATUS: "LAC: LAG" (YELLOW)

Meaning: Insufficient tracking data for accurate lead calculation

Causes:

- Track recently established (<2 seconds)
- Target velocity not yet stable
- Tracking confidence fluctuating

Display:

- OSD shows: **LAC: LAG** in YELLOW
- Reticle may show partial lead offset (unreliable)

Operator Action:

- **WAIT** (2-5 seconds) for tracking to stabilize
- Do NOT fire until status changes to **LAC: ON** (GREEN)
- If LAG persists >10 seconds: Check tracking quality, verify target moving

STATUS: "LAC: ZOOM OUT" (RED)

Meaning: Camera FOV too narrow for accurate lead calculation

Causes:

- Zoomed in too far (max zoom or near-max zoom)
- Target angular rate too high for current FOV
- System cannot measure target velocity accurately

Display:

- OSD shows: **LAC: ZOOM OUT** in RED
- LAC non-functional (lead calculation disabled)

Operator Action:

1. **Zoom out** ([Button 8]) gradually
2. Wait for status to change to **LAC: ON** (GREEN)
3. If problem persists: Zoom out more
4. Acceptable FOV: Typically Wide or Mid zoom (not Tele/Max)

i NOTE

Extremely fast-moving targets may require wide FOV even at close range.

6.4.6 LAC DEACTIVATION PROCEDURE**When to Deactivate**

- Target stops moving
- Lost track of target
- "ZOOM OUT" warning persists
- "LEAD ANGLE LAG" persists
- Engagement complete
- Switching to stationary target

LAC DEACTIVATION**DEACTIVATION:**

1. Hold [Button 3] (Dead Man Switch)
2. Press [Button 2] (LAC Toggle)
3. Release Button 2
4. Release Button 3

VERIFICATION:

- ☐ **LEAD ANGLE ON** indicator disappears
- ☐ **LAC** bracket removed from CCIP reticle
- ☐ Reticle pipper returns to boresight alignment
- ☐ System ready for stationary target engagement

6.4.7 USING LAC IN ENGAGEMENT**MOVING TARGET ENGAGEMENT (WITH LAC)****COMPLETE PROCEDURE**

1. **Acquire and Track Target** (Lesson 5)
 - Enter acquisition mode ([Button 4])
 - Size gate, request lock-on
 - Achieve Active Lock (green gate, tracking)
2. **Range Target**
 - Fire LRF (or automatic ranging during tracking)
 - Verify range displayed (OSD: **RNG: xxxx m**)
3. **Enable LAC**
 - Hold [Button 3] + Press [Button 2]
 - Verify **LEAD ANGLE ON** (GREEN)
 - Wait if **LEAD ANGLE LAG** (YELLOW)
 - Zoom out if **ZOOM OUT** (RED)
4. **Observe Lead Offset**
 - CCIP reticle offset ahead of target in direction of motion
 - Lead offset adjusts continuously as target moves
 - **Aim at CCIP reticle** (not at target center)
5. **Fire**
 - Master Arm ([Button 0])
 - Fire ([Button 5])

- Rounds impact at predicted intercept point
- 6. Observe Effect**
- Rounds should hit target (not behind target)
 - If missing: Check tracking quality, verify LAC ON, verify range accurate

6.4.8 LAC LIMITATIONS

When LAC Works Best

- Target moving laterally (crossing FOV)
- Target speed >5 m/s (10 mph)
- Range >100 meters
- Constant target velocity

When LAC is NOT Needed

- Stationary targets (LAC shows no offset)
- Targets moving radially (toward/away) - minimal lateral lead
- Very close range (<50m) - TOF too short for significant lead

LAC Limitations

- Requires active tracking (cannot use LAC without track)
- Requires sufficient FOV (may need to zoom out)
- Assumes constant target velocity (less accurate if target maneuvering)
- Not effective for erratic or unpredictable motion

6.5 TWO INDEPENDENT BALLISTIC CORRECTION SYSTEMS

⚠ CRITICAL UNDERSTANDING

The El 7arress RCWS employs **TWO INDEPENDENT** ballistic correction systems. Understanding the difference is essential for accurate fire.

6.5.1 SYSTEM 1: BALLISTIC DROP COMPENSATION (AUTOMATIC)

Activation: AUTOMATIC when LRF has valid range data

What It Corrects:

- **Gravity drop** - Bullet falls due to gravity over distance
- **Wind deflection** - Crosswind pushes bullet laterally
- **Environmental factors** - Temperature, altitude affect trajectory

System Variables:

- ballisticDropOffsetAz - Azimuth correction (wind deflection)
- ballisticDropOffsetEl - Elevation correction (gravity drop)
- ballisticDropActive - True when valid LRF range exists

Operator Action: NONE REQUIRED - System applies corrections automatically when range is valid.

OSD Indicator: ENV appears when environmental parameters are active.

6.5.2 SYSTEM 2: MOTION LEAD COMPENSATION (MANUAL TOGGLE)

Activation: MANUAL via joystick Button 2 (LAC toggle)

What It Corrects:

- **Moving target lead** - Aim ahead of moving target
- Based on target angular velocity from tracker
- Based on range (LRF) and time-of-flight calculation

System Variables:

- motionLeadOffsetAz - Azimuth lead offset for moving target
- motionLeadOffsetEl - Elevation lead offset for moving target
- leadAngleCompensationActive - True when operator toggles LAC ON

Operator Action: REQUIRED - Must press Button 2 to enable for moving targets.

OSD Indicator: LAC: ON / LAC: LAG / LAC: ZOOM OUT

6.5.3 COMBINED CCIP CALCULATION

The CCIP (Continuously Computed Impact Point) pipper shows where the bullet will actually hit:

$$\begin{aligned} \text{CCIP (*)} &= \text{Gun Boresight} + \text{Zeroing Offset} \\ &+ \text{Ballistic Drop Compensation (auto when range valid)} \\ &+ \text{Motion Lead Compensation (only if Button 2 toggled ON)} \end{aligned}$$

i KEY DISTINCTION

Ballistic Drop is for **stationary** targets (compensates for gravity/wind).
Motion Lead is for **moving** targets (compensates for target velocity).
 Both can be active simultaneously for moving targets at range with environmental factors.

6.6 COMBINING FIRE CONTROL SYSTEMS

6.6.1 FIRE CONTROL SOLUTION HIERARCHY

The complete fire control solution combines multiple corrections:

$$\text{FINAL AIM POINT} = \text{Gun Boresight} + \text{Zeroing Offset} + \\ \text{Environmental Corrections} + \text{Lead Angle Offset}$$

System Integration

1. **Gun Boresight:** Factory default (camera-to-weapon offset)
2. + **Zeroing Offset:** Operator-configured (corrects boresight error)
3. + **Environmental Corrections:** Ballistic LUT adjustments (temperature, altitude, wind)
4. + **Lead Angle Offset:** Real-time moving target compensation

OSD Indicators

- **Z:** Zeroing active
- **ENV:** Environmental parameters active
- **LEAD ANGLE ON:** LAC active
- **All Active Example:**
- OSD displays: **Z ENV LEAD ANGLE ON**
- CCIP reticle shows: Zeroing + Environmental + Lead corrections
- Most accurate engagement solution

6.6.2 ENGAGEMENT SCENARIOS

SCENARIO 1: Stationary Target, Standard Conditions

Configuration:

- Zeroing: Active (Z)
- Environmental: Not needed (standard conditions)
- LAC: Not needed (stationary target)

OSD: Z

Fire Control: Zeroing offset only

SCENARIO 2: Stationary Target, Hot Desert, High Altitude

Configuration:

- Zeroing: Active (Z)
- Environmental: Active (Temp: 45°C, Alt: 1500m, Wind: 0 m/s)
- LAC: Not needed (stationary target)

OSD: Z ENV

Fire Control: Zeroing + Environmental (temperature, altitude)

SCENARIO 3: Moving Target, Windy Conditions, Mountain

Configuration:

- Zeroing: Active (Z)
- Environmental: Active (Temp: -5°C, Alt: 2500m, Wind: 10 m/s)
- LAC: Active (target moving 15 m/s lateral)

OSD: Z ENV LEAD ANGLE ON

Fire Control: Zeroing + Environmental + Lead Angle (full solution)

SCENARIO 4: Close Range, Moving Target, Standard Conditions

Configuration:

- Zeroing: Active (Z)
- Environmental: Not needed
- LAC: Active (target moving, but close range <100m may not require much lead)

OSD: Z LEAD ANGLE ON

Fire Control: Zeroing + Lead Angle

6.6.3 FIRE CONTROL QUICK REFERENCE

Target Type	Range	Conditions	Zero	Env.	LAC	OSD
Stationary	Any	Standard				Z
Stationary	Any	Extreme temp/alt				Z ENV
Stationary	Any	Windy		(wind)		Z ENV

Target Type	Range	Conditions	Zero	Env.	LAC	OSD
Moving (slow)	<100m	Standard			Optional	Z (LEAD ANGLE ON)
Moving (fast)	>100m	Standard				Z LEAD ANGLE ON
Moving (fast)	>100m	Extreme				Z ENV LEAD ANGLE ON

6.7 FIRE CONTROL BEST PRACTICES

6.7.1 ZEROING

Best Practices

- Zero weapon before first operational use
- Verify zero periodically (weekly or after transport)
- Re-zero if weapon or camera serviced/replaced
- Use consistent ammunition type for zeroing and operations
- Zero at primary engagement range (200-250m recommended)

Common Errors

- Skipping multi-range validation (zero may be inaccurate at long range)
- Moving gimbal between firing test shot and adjusting reticle (invalidates offset measurement)
- Assuming zero is permanent (mechanical drift can occur over time)

6.7.2 ENVIRONMENTAL PARAMETERS

Best Practices

- Update environmental settings at mission start
- Re-assess if conditions change significantly during mission
- Use handheld weather instruments (thermometer, anemometer, altimeter) for accuracy
- Estimate conservatively (err toward standard conditions if unsure)

Common Errors

- Using old/stale environmental data from previous mission
- Ignoring significant temperature or wind changes
- Over-correcting for minor environmental variations (<5°C temp change, <2 m/s wind)

6.7.3 LEAD ANGLE COMPENSATION

Best Practices

- Only use LAC for targets moving >5 m/s at ranges >100m
- Wait for **LEAD ANGLE ON** (GREEN) before firing (ignore "LAG" yellow)
- Zoom out if **ZOOM OUT** (RED) warning appears
- Trust the system - aim at CCIP reticle, not at target

Common Errors

- Activating LAC for stationary targets (adds unnecessary complexity)
- Firing while **LEAD ANGLE LAG** (YELLOW) - lead calculation incomplete
- Ignoring **ZOOM OUT** (RED) warning - LAC non-functional
- "Kentucky windage" (manually aiming off-target) while LAC active - double-correcting

6.7.4 SAFETY REMINDERS

ALWAYS

- Verify zero before live fire operations
- Update environmental parameters for current conditions
- Check OSD indicators before firing (Z, ENV, LEAD ANGLE ON)
- Use Dead Man Switch when activating/deactivating LAC (safety interlock)

NEVER

- Fire without valid zero (impacts will be off-target)
- Assume environmental corrections are active (verify "ENV" indicator)
- Fire with **ZOOM OUT** (RED) warning (LAC non-functional)
- Bypass Dead Man Switch safety interlock

Chapter 7

LESSON 7 - SYSTEM STATUS & MONITORING

Duration: 2 hours
Type: Classroom
References: System status manual, device specifications

7.1 LEARNING OBJECTIVES

Upon completion of this lesson, operators will be able to:

- Access System Status display
- Interpret device status indicators
- Identify fault conditions
- Determine when to escalate to maintenance

7.2 ACCESSING SYSTEM STATUS

7.2.1 SYSTEM STATUS MENU ACCESS

ACCESSING SYSTEM STATUS

1. Press [MENU]
2. Navigate to "System Status"
3. Press [VAL]

7.2.2 Display Sections

The System Status display provides real-time monitoring of all critical subsystems:

- Azimuth/Elevation Servos
- IMU (Inertial Measurement Unit)
- Laser Range Finder (LRF)
- Day/Night Cameras
- Control Panels
- Servo Actuator
- Alarms/Warnings

7.3 DEVICE STATUS REFERENCE

7.3.1 GIMBAL SERVOS (AZIMUTH & ELEVATION)

Parameter	Normal	Warning	Fault	Action
Connected		-		Notify maintenance
Torque	0-50%	50-80%	>80% sustained	Allow cooling, reduce motion
Motor Temp	20-60°C	60-70°C	>70°C	Halt operations, allow cooling
Driver Temp	20-60°C	60-70°C	>70°C	Halt operations, allow cooling
Fault Flag	No	-	Yes	E-Stop, notify maintenance

Servo Monitoring Guidelines

Normal Operation:

- Torque values fluctuate with gimbal motion
- Higher torque during rapid movements or when carrying loads
- Temperatures rise gradually during extended operations

Warning Signs:

- Sustained high torque (>50%) during light movements
- Rapidly rising temperatures
- Unusual vibrations or noises

7.3.2 IMU (INERTIAL MEASUREMENT UNIT)

Parameter	Normal	Warning	Fault	Action
Connected		-		Stabilization offline, notify maint
Roll/Pitch	±30°	±30-45°	>45°	Platform unstable, secure vessel
Temperature	20-60°C	60-70°C	>70°C	Allow cooling

! IMU CRITICAL FUNCTION

IMU offline = No stabilization. Manual mode only.

IMU Role in System

The IMU provides:

- Platform orientation data (roll, pitch, yaw)
- Angular rate measurements for stabilization
- Motion compensation for tracking
- Essential data for ballistic calculations

Impact of IMU Failure:

- No gyrostabilization (image shake during platform motion)
- Degraded tracking performance
- Reduced ballistic accuracy
- Manual mode operations only

7.3.3 LASER RANGE FINDER (LRF)

Parameter	Normal	Warning	Fault	Action
Connected		-		Manual range estimation, notify maint
Temperature	20-50°C	50-60°C	>60°C	Reduce firing rate, allow cooling
Laser Count	Incrementing	-	Not incrementing	LRF malfunction
No Echo	Occasional	Frequent	Always	Target too far, obscured, or LRF fault

! LRF CRITICAL FUNCTION

LRF offline = No ballistics, no LAC. Manual engagement only.

LRF Status Interpretation

Laser Count:

- Increments with each successful ranging attempt
- Should increment even if "NO ECHO" received
- If frozen: LRF communication failure

"NO ECHO" Conditions:

- Target beyond maximum range (5km for hard targets)
- Target obscured by smoke, fog, rain
- Target surface non-reflective (absorbs laser)
- Laser beam blocked by obstruction
- LRF receiver malfunction (if persistent)

7.3.4 CAMERAS (DAY & THERMAL)

Parameter	Normal	Warning	Fault	Action
Connected		-		Switch cameras if available
Error Flag	No	-	Yes	Switch cameras, notify maint
Thermal FFC	Occasional	Frequent (<5min)	Constant	Thermal camera fault
Focus	Clear	Slightly blurred	Very blurred	Autofocus off, manual focus

! CAMERA CRITICAL FUNCTION

Both cameras offline = Mission abort. Cannot engage without visual.

Camera Status Notes

Thermal FFC (Flat Field Correction):

- Normal: Occurs every 5-15 minutes
- Recalibrates thermal sensor for accurate temperature readings
- Brief image freeze (1-2 seconds) during FFC
- Frequent FFC (<5 min intervals): Sensor instability

Focus Issues:

- Autofocus may struggle with low-contrast scenes
- Manual focus available via menu controls
- Persistent blur: Lens contamination or camera fault

7.3.5 CONTROL PANELS

Device	Function	Fault Impact	Action
DCU	Buttons, switches, lights	No local control, joystick only	Notify maint (ops continue)
Joystick	Gimbal control, tracking, fire	Mission abort if no backup	Emergency: Use DCU manual control

Control Panel Redundancy

Primary Control: Joystick

- All operator functions accessible
- Preferred for normal operations
- Ergonomic, intuitive control

Backup Control: DCU (Direct Control Unit)

- Limited functionality (basic gimbal control)
- Use if joystick fails
- Slower, less precise than joystick

7.4 ALARM INTERPRETATION

7.4.1 CRITICAL ALARMS (RED)

Alarm	Meaning	Immediate Action
EMERGENCY STOP ACTIVE	E-Stop engaged	Identify cause, reset when safe
WEAPON ARMED (NO AUTH)	Safety violation	Disarm immediately, investigate
ZONE VIOLATION	Entering No-Fire/No-Traverse	Halt motion, verify zone config
SERVO FAULT	Gimbal malfunction	E-Stop, notify maintenance

Critical Alarm Response Priority

Priority 1: Immediate Safety Threats

1. **WEAPON ARMED (NO AUTH):** Disarm weapon immediately
2. **ZONE VIOLATION:** Halt all motion, assess situation
3. **SERVO FAULT:** E-Stop if gimbal behaving erratically

Priority 2: System Protection

1. **EMERGENCY STOP ACTIVE:** Determine if intentional or fault-triggered

7.4.2 WARNING ALARMS (YELLOW)

Alarm	Meaning	Action
HIGH TEMPERATURE	Device overheating	Reduce operations, monitor
LOW CONFIDENCE TRACKING	Track quality poor	Verify target, consider manual
ZOOM OUT	LAC FOV insufficient	Zoom out ([Button 8])
LEAD ANGLE LAG	Tracking data insufficient	Wait 2-5 seconds

Warning Alarm Management

HIGH TEMPERATURE:

- Identify which device is overheating (check System Status)
- Reduce operational tempo (slower movements, less frequent firing)
- Monitor temperature trend (rising or stabilizing?)
- If temperature continues to rise: Cease operations, allow cooling

LOW CONFIDENCE TRACKING:

- Verify target is still visible and properly framed
- Check for obstructions or lighting changes
- Consider switching to manual engagement
- Re-acquire track if confidence drops below 50%

7.4.3 INFO MESSAGES (GREEN/BLUE)

Message	Meaning	Action
ZEROING APPLIED	Zero active	Normal ops
ENV APPLIED	Environmental settings active	Normal ops
TRACKING	Tracking active	Monitor

Informational Message Interpretation

These messages confirm that optional features are active:

- **ZEROING APPLIED:** Weapon boresight correction in effect
- **ENV APPLIED:** Ballistic corrections for temperature, altitude, wind active
- **TRACKING:** Automatic target tracking engaged

No Action Required: These are status confirmations, not warnings.

7.5 WHEN TO ESCALATE TO MAINTENANCE

7.5.1 OPERATOR-LEVEL ISSUES (Fix Yourself)

The following issues can be resolved by the operator:

- Reset E-Stop (after clearing danger)
- Power cycle system (soft reboot)
- Switch cameras (if available)
- Adjust zoom/focus
- Re-zero weapon (if needed)

7.5.2 MAINTENANCE-LEVEL ISSUES (Notify Immediately)

The following issues require maintenance personnel:

- Device disconnected (and doesn't reconnect after reboot)
- Persistent fault flags
- Servo malfunction (erratic motion, no motion)
- Physical damage observed
- Thermal runaway (temperature $>80^{\circ}\text{C}$)
- Unusual noises (grinding, clicking, squealing)

7.5.3 Escalation Decision Matrix

Symptom	Operator Action	Escalate If
Device offline	Power cycle, check connections	Still offline after reboot
High temperature	Reduce operations, allow cooling	Temp $>80^{\circ}\text{C}$ or rising
Tracking failure	Adjust gate, improve contrast	Fails on all targets
LRF no reading	Re-fire, try different target	Persistent "NO ECHO" on all targets
Poor video	Switch cameras, adjust focus	Both cameras offline or error
Servo slow/jerky	Check torque, allow cooling	Fault flag or erratic motion
Unusual noises	Identify source, check status	Grinding, clicking, or squealing

7.5.4 Documentation for Maintenance

When escalating to maintenance, provide:

- ☐ Specific symptoms observed
- ☐ When problem first occurred
- ☐ Any recent changes (maintenance, configuration, environment)
- ☐ System Status screenshot (if possible)
- ☐ Any error messages or alarm codes
- ☐ Operator-level troubleshooting already attempted

i NOTE

Better documentation = Faster repair. Be specific and thorough.

7.6 SYSTEM STATUS MONITORING BEST PRACTICES

7.6.1 Regular Monitoring Schedule

Before Each Mission:

- Check System Status display
- Verify all devices connected
- Note any warnings or elevated temperatures
- Document baseline status

During Operations:

- Monitor temperature trends (especially during extended operations)
- Watch for new alarms or warnings
- Check device status after any unusual events

After Mission:

- Final System Status check
- Note any new faults or warnings
- Document any issues for maintenance
- Report any degraded performance

7.6.2 Proactive Monitoring

Prevent Problems Before They Occur:

- Monitor temperature trends (rising temps indicate potential issues)
- Note gradual performance degradation (slower tracking, reduced accuracy)
- Report intermittent faults (even if they self-clear)
- Watch torque levels (sustained high torque indicates mechanical problems)

 **CAUTION**

Don't ignore intermittent problems. They often become permanent failures.

Chapter 8

LESSON 8 - EMERGENCY PROCEDURES

Duration: 3 hours (Classroom 1h + Practical 2h)
Type: Classroom + Practical
References: Emergency procedures manual, safety guidelines

8.1 LEARNING OBJECTIVES

Upon completion of this lesson, operators will be able to:

- Execute Emergency Stop (E-Stop)
- Perform emergency tracking abort
- Respond to weapon malfunctions
- Handle runaway gimbal
- Execute emergency system shutdown

8.2 EMERGENCY STOP (E-STOP)

8.2.1 E-STOP BUTTON

Location

Red mushroom button on Control Panel

When to Use

Use E-Stop **IMMEDIATELY** when:

- Personnel in line of fire
- Gimbal moving toward restricted area
- Runaway/uncontrolled motion
- Any immediate danger

8.2.2 E-STOP ACTIVATION

EMERGENCY STOP ACTIVATION

Action: STRIKE E-STOP BUTTON

Effect (IMMEDIATE):

1. All gimbal motion halted
2. Weapon fire control disabled
3. Tracking stopped
4. System functions locked out
5. OSD: **EMERGENCY STOP ACTIVE** (RED)

E-STOP IS IRREVERSIBLE

Once activated, E-Stop cannot be overridden. System remains locked until manually reset.

E-Stop System Behavior

What Stops:

- All servo motor power
- Weapon arming circuits
- Tracking algorithms
- Automatic motion modes

What Continues:

- Power to cameras (video feed maintained)
- Power to control panels
- System monitoring (can view System Status)
- Communication systems

8.2.3 E-STOP RESET

Pre-Reset Safety Verification

Only reset after verifying **ALL** items:

- ☐ Immediate danger cleared
- ☐ Personnel clear

- ☐ No equipment damage
- ☐ Cause identified
- ☐ Safe to resume

E-STOP RESET PROCEDURE

1. Twist E-STOP button clockwise
2. Button pops out
3. System resets (takes 5-10 seconds)
4. Check System Status for faults
5. Perform health check before resuming ops

⚠ DO NOT RESET IF

DO NOT RESET E-STOP IF:

- Cause unknown
- Damage visible
- Personnel in danger
- Maintenance required

Post-Reset Verification

After E-Stop reset, verify:

- ☐ All devices show "Connected" in System Status
- ☐ No fault flags present
- ☐ Gimbal responds to joystick inputs (test in manual mode)
- ☐ Tracking system functional (test acquisition)
- ☐ Safety systems operational (test Master Arm/Disarm)

8.3 EMERGENCY TRACKING ABORT

8.3.1 WHEN TO ABORT TRACKING

Abort tracking **immediately** when:

- Tracking wrong target
- Target enters restricted zone
- Friendlies near target
- Lost positive ID
- System erratic
- Civilian identified

8.3.2 TRACKING ABORT PROCEDURE

EMERGENCY TRACKING ABORT

Procedure: DOUBLE-CLICK [Button 4] (<500ms)

Effect:

- Tracking stops immediately
- Tracking gate disappears
- Returns to Manual mode
- Weapon fire inhibited

i NOTE

No Dead Man Switch required for abort. Works from any phase.

Tracking Abort vs. E-Stop

Use Tracking Abort When:

- Wrong target being tracked
- Need to quickly disengage tracking
- System otherwise functioning normally

Use E-Stop When:

- Immediate danger to personnel
- System malfunction (runaway gimbal)
- Need to halt **all** system motion

8.3.3 Post-Abort Actions

After aborting tracking:

1. Verify gimbal in Manual mode

2. Assess situation (why was abort necessary?)
3. Re-acquire correct target (if applicable)
4. Report incident (if target misidentification occurred)

8.4 WEAPON EMERGENCY PROCEDURES

8.4.1 ACCIDENTAL DISCHARGE

Recognition

If weapon fires unintentionally:

- Fire button not pressed, but weapon firing
- Single shot when burst intended (or vice versa)
- Weapon fires on Master Arm engagement

Immediate Actions

ACCIDENTAL DISCHARGE RESPONSE

Immediate Actions (in order):

1. **Release [Button 5]** (Fire) - cease fire
2. **Release [Button 0]** (Master Arm) - disarm
3. **Point gimbal to safe direction** (skyward)
4. **E-STOP** if motion continues
5. **Turn Station power OFF**

CRITICAL SAFETY VIOLATION

Accidental discharge is a **CRITICAL SAFETY EVENT**. All operations must cease until investigation complete.

Post-Incident Actions

- ☐ Ensure weapon safe
- ☐ Check for damage/casualties
- ☐ Notify chain of command immediately
- ☐ Preserve system logs
- ☐ Do NOT resume operations until investigation complete

Investigation Requirements:

- Maintenance personnel must inspect fire control circuits
- Software logs must be reviewed
- Trigger mechanism must be tested
- Safety interlocks must be verified
- Commander's authorization required before resuming operations

8.4.2 WEAPON JAM / MALFUNCTION

Symptoms

- Weapon fires then stops mid-burst
- Unusual sounds (click, no firing)
- Fire button pressed, no response
- Partial firing (rounds not feeding properly)

Immediate Actions

WEAPON JAM RESPONSE

1. **Release Fire button** (cease trigger)
2. **Release Master Arm** (disarm)
3. **Turn Gun Arm switch to SAFE**
4. **Point gimbal to safe direction**
5. **Notify command** - weapon malfunction

DO NOT ATTEMPT TO CLEAR JAM

DO NOT:

- Attempt to clear jam from operator station
- Continue firing attempts
- Inspect weapon without proper clearance

Action: Weapon maintenance personnel required.

Operator Limitations

Operators are NOT authorized to:

- Clear weapon jams
- Perform weapon maintenance
- Inspect weapon mechanisms
- Override weapon safety interlocks

Operators ARE authorized to:

- Safe the weapon (Gun Arm to SAFE)
- Report malfunction symptoms
- Secure the area
- Await maintenance personnel

8.5 RUNAWAY GIMBAL

8.5.1 SYMPTOMS

Runaway gimbal indicators:

- Gimbal moves without joystick input
- Cannot stop gimbal with joystick
- Gimbal moving toward no-traverse zone
- Erratic, unpredictable motion
- Gimbal oscillating rapidly

8.5.2 IMMEDIATE ACTIONS

RUNAWAY GIMBAL RESPONSE

Immediate Actions (in order):

1. **E-STOP** (strike immediately)
2. **Verify E-Stop engaged** (button latched, motion stopped)
3. **Turn Station power OFF**
4. **Notify maintenance** - servo malfunction

DO NOT RESET

Do NOT reset E-Stop until:

- Maintenance personnel inspect system
- Cause identified and resolved
- Safety verified

8.5.3 Runaway Gimbal Causes

Common Causes:

- Servo driver malfunction
- Software control loop error
- Encoder feedback failure
- Electrical short circuit
- Control signal interference

All require maintenance intervention.

8.5.4 Prevention

Reduce risk of runaway gimbal:

- Perform daily pre-operation checks
- Monitor servo torque and temperature
- Report unusual gimbal behavior immediately
- Keep E-Stop button clear and accessible
- Practice E-Stop activation during training

8.6 LOST COMMUNICATION

8.6.1 OPERATOR TO COMMAND

Symptoms

- Radio/intercom dead
- No response to radio calls
- Static or interference on all channels

Actions

LOST COMMUNICATION WITH COMMAND

- ☐ Switch to backup radio
- ☐ Use hand signals (if line of sight)
- ☐ Continue mission per SOP (if applicable)
- ☐ Return to safe position (if no comms recovery)

Standing Orders:

- If communications lost during active engagement: Complete engagement, then return to safe position
- If communications lost during surveillance: Continue surveillance, attempt recovery every 5 minutes
- If communications not recovered within 30 minutes: Return to base/rally point

8.6.2 SYSTEM TO DEVICES

Symptoms

- Device disconnected (LRF, Camera, Servo)
- "Device Offline" message in System Status
- Loss of specific functionality (ranging, video, motion)

Actions

LOST DEVICE COMMUNICATION

1. Check System Status (identify device)
2. Power cycle system (soft reboot)
3. If device does not reconnect: Operate without device (degraded mode)
4. Notify maintenance

Mission Impact

Device Offline	Mission Impact
LRF offline	Manual range estimation only, no LAC. Reduced accuracy at long range.
Camera offline	Switch to alternate camera. If both offline: mission abort.
Servo offline	Mission abort - cannot control gimbal.
IMU offline	No stabilization. Manual mode only. Degraded tracking.
Joystick offline	Use DCU backup controls (limited functionality).

8.7 EMERGENCY SYSTEM SHUTDOWN

8.7.1 WHEN TO PERFORM FULL SHUTDOWN

Perform emergency shutdown when:

- Fire/smoke from system
- Multiple critical faults
- Safety concern requiring immediate powerdown
- Ordered by command
- Electrical burning smell
- Unusual arcing or sparking

8.7.2 EMERGENCY SHUTDOWN PROCEDURE

EMERGENCY SYSTEM SHUTDOWN

1. **E-STOP** (if not already engaged)
2. **Turn Gun Arm to SAFE**
3. **Turn Station Enable switch to OFF**
4. **Turn main power switch to OFF**
5. **Disconnect external power** (if directed)

8.7.3 Post-Shutdown Actions

- ☐ Ensure all motion stopped
- ☐ Ensure weapon safe
- ☐ Notify command/maintenance
- ☐ Secure area (prevent unauthorized restart)
- ☐ Document circumstances leading to shutdown

DO NOT RESTART

Do NOT attempt to restart system until:

- Cause of emergency identified
- Maintenance personnel inspect system
- Commander authorizes restart

8.7.4 Fire Response

If fire or smoke observed:

1. Perform emergency shutdown (above procedure)
2. Evacuate immediate area
3. Alert fire response team
4. Use fire extinguisher if:
 - Fire is small and contained
 - Safe to approach
 - Proper extinguisher type available (electrical fires: CO2 or dry chemical)
5. Do NOT use water on electrical fires

8.8 EMERGENCY QUICK REFERENCE

Emergency	Action	Button/Switch
Immediate Danger	Emergency Stop	E-STOP (red mushroom)
Wrong Target	Tracking Abort	[Button 4] (double-click)
Accidental Fire	Cease Fire, Disarm	Release [Button 5], Release [Button 0]
Weapon Jam	Disarm, Safe Weapon	Release [Button 0], Gun Arm SAFE
Runaway Gimbal	Emergency Stop, Power Off	E-STOP, Station Power OFF
Fire/Smoke	Full Shutdown	E-STOP → Station OFF → Main Power OFF

8.9 EMERGENCY RESPONSE TRAINING

8.9.1 Required Emergency Drills

All operators must practice the following emergency responses:

Drill 1: E-Stop Activation

- Practice striking E-Stop button from operating position
- Time to E-Stop: <1 second from recognition
- Verify system lockout
- Practice reset procedure

Drill 2: Tracking Abort

- Practice double-click abort during tracking exercise
- Time to abort: <500ms
- Verify tracking stops immediately
- Practice re-acquisition after abort

Drill 3: Accidental Discharge Response

- Simulated accidental discharge scenario
- Practice immediate cease-fire and disarm sequence
- Practice safe gimbal positioning
- Practice emergency shutdown

Drill 4: Runaway Gimbal Response

- Simulated runaway gimbal (instructor-initiated)
- Practice immediate E-Stop
- Practice emergency shutdown
- Verify no attempt to reset without authorization

8.9.2 Emergency Response Evaluation Criteria

Proficiency Standards:

- E-Stop activation: <1 second recognition-to-action time
- Tracking abort: <500ms double-click execution
- Correct procedure selection: 100% (no procedural errors)
- Post-emergency verification: All steps completed

TRAINING REQUIREMENT

Operators must demonstrate proficiency in all emergency procedures before operational qualification.

8.10 STRESS MANAGEMENT IN EMERGENCIES

8.10.1 Staying Calm Under Pressure

Emergency Response Psychology:

- Recognize stress response (tunnel vision, rapid heartbeat, loss of fine motor control)
- Focus on immediate action (don't overthink)
- Trust your training (muscle memory)
- Breathe (deliberate breathing reduces stress)

8.10.2 Decision Making in Emergencies

Priority Framework:

1. **Life Safety:** Prevent injury to personnel (highest priority)
2. **Equipment Protection:** Prevent damage to system (secondary)
3. **Mission Continuity:** Resume operations (lowest priority)

When in Doubt:

- Default to most conservative action (E-Stop)
- Request guidance from command
- Do NOT resume operations until safe

Chapter 9

LESSON 9 - OPERATOR MAINTENANCE & TROUBLESHOOTING

Duration: 3 hours (Classroom 1h + Practical 2h)
Type: Classroom + Practical
References: Maintenance manual, troubleshooting guide

9.1 LEARNING OBJECTIVES

Upon completion of this lesson, operators will be able to:

- Perform daily operator checks
- Troubleshoot common issues
- Apply systematic troubleshooting methodology
- Determine when to escalate to maintenance

9.2 DAILY OPERATOR CHECKS

9.2.1 PRE-OPERATION CHECKLIST

Perform before each mission / daily:

System	Check	GO Criteria	NO-GO Criteria
Power	Main power, Station power	All ON, no alarms	Power OFF, alarms present
Control Panel	Buttons, switches, lights responsive	All functional	Non-responsive, lights out
Joystick	Axes, buttons, Dead Man Switch	Smooth motion, all buttons work	Sticky, unresponsive
Gimbal	Azimuth/Elevation motion	Smooth, quiet, full ROM	Grinding, jerky, limits hit
Cameras	Day & Thermal video	Clear video, both cameras	No video, errors
LRF	Ranging test (known target)	Range within $\pm 5m$	No reading, error
Tracking	Acquisition test	Gate appears, tracking functional	No gate, tracking fails
Weapon	Arming, Safe	Arm/Safe switches functional	Switches stuck, no response
System Status	All devices connected	All Connected	Devices disconnected/faulted

NO-GO CRITERIA

If NO-GO: Do NOT proceed with mission. Notify maintenance.

9.2.2 Pre-Operation Check Procedure

DAILY PRE-OPERATION CHECK

1. Visual Inspection

- Inspect gimbal for physical damage
- Check cable connections (secure, not frayed)
- Verify E-Stop button not engaged
- Check for fluid leaks, corrosion, loose parts

2. Power-Up Sequence

- Turn main power ON
- Turn Station Enable ON
- Observe startup sequence (all lights illuminate)
- Wait for system initialization (30 seconds)

3. System Status Check

- Access System Status display
- Verify all devices "Connected"
- Check for fault flags (should be none)
- Note baseline temperatures

4. Functional Tests

- Joystick: Test all axes and buttons
- Gimbal: Test azimuth/elevation motion (smooth, full range)

- Cameras: Switch between day/thermal, verify clear video
- LRF: Range test on known target (verify $\pm 5\text{m}$ accuracy)
- Tracking: Quick acquisition test (gate appears, lock achieved)
- Weapon: Test arm/safe switches (DO NOT load weapon)
- 5. Documentation**
 - Record check completion in logbook
 - Note any discrepancies or warnings
 - Sign off as "GO" or "NO-GO"

9.3 TROUBLESHOOTING METHODOLOGY

9.3.1 STOP-LOOK-ASSESS-FIX (SLAF) METHOD

S - STOP

Don't rush to "fix" without understanding

- Take E-Stop if safety concern
- Document symptoms precisely
- Don't make random changes hoping for improvement
- Pause and think before acting

L - LOOK

Observe all symptoms carefully

- Check System Status display
- Review recent actions (what changed?)
- Note all error messages and alarms
- Observe physical indicators (lights, sounds, motion)

A - ASSESS

Narrow down to specific subsystem

- Check simplest causes first (power, connections, switches)
- Consult troubleshooting charts
- Eliminate possibilities systematically
- Determine if problem is operator-level or maintenance-level

F - FIX

Apply appropriate solution

- Apply operator-level fix if authorized
- Escalate to maintenance if needed
- Verify fix resolved issue
- Document actions taken

9.3.2 Troubleshooting Best Practices

- **Start simple:** Check power, cables, switches before assuming complex failure
- **Change one thing at a time:** If you change multiple things, you won't know what fixed it
- **Verify the fix:** Test that the problem is actually resolved
- **Document everything:** What was the symptom? What did you try? What worked?

9.4 COMMON ISSUES & FIXES

9.4.1 JOYSTICK NOT RESPONDING

Symptoms

- No gimbal motion when joystick moved
- Buttons not working
- Joystick LED off

Diagnosis

JOYSTICK DIAGNOSIS

1. Check USB cable (both ends firmly connected)
2. Check joystick power LED (should be illuminated)
3. Check System Status → Joystick Connected
4. Try moving joystick (any response?)

Operator-Level Fixes

- ☐ Reconnect USB cable firmly (both ends)
- ☐ Power cycle system (turn Station OFF, wait 10 seconds, turn ON)
- ☐ Try different USB port (if available)
- ☐ Check for physical damage to cable or joystick

Escalate if: Still not detected after power cycle.

9.4.2 NO VIDEO FROM CAMERA

Symptoms

- Black screen
- "No Signal" message
- Frozen image
- Severe pixelation or artifacts

Diagnosis

CAMERA DIAGNOSIS

1. Check camera selection (Day vs. Night - Button 10/12)
2. Check System Status → Camera Connected
3. Verify lens cap removed (if applicable)
4. Check for obstructions in front of lens

Operator-Level Fixes

- ☐ Switch cameras ([Button 10/12])
- ☐ Power cycle system
- ☐ Check video cable connections (if accessible)
- ☐ Clean lens (if dirty/foggy)
- ☐ Adjust focus (if autofocus failed)

Escalate if: Both cameras offline.

9.4.3 TRACKING FAILS TO LOCK

Symptoms

- Stays in LOCK PENDING indefinitely
- Returns to ACQUISITION after lock attempt
- Gate flickers or disappears
- Lock achieved but immediately lost

Diagnosis

TRACKING DIAGNOSIS

1. Check target contrast (clearly visible on screen?)
2. Check acquisition gate sizing (10-30% margin?)
3. Check gimbal stability (holding steady during lock?)
4. Check target motion (stationary or slow-moving?)

Operator-Level Fixes

- ☐ Improve target contrast (switch camera, adjust thermal LUT)
- ☐ Re-size acquisition gate (ensure 10-30% margin around target)
- ☐ Hold gimbal steady during lock attempt (no joystick input)
- ☐ Select better target (higher contrast, larger, clearer edges)
- ☐ Switch to manual engagement (no tracking)

Escalate if: Tracking fails on all targets (tracker malfunction).

9.4.4 GIMBAL NOT MOVING

Symptoms

- Joystick input has no effect
- Gimbal completely frozen
- Only one axis moving (azimuth OR elevation)
- Very slow, sluggish motion

Diagnosis

GIMBAL DIAGNOSIS

1. Check E-Stop (engaged/latched?)
2. Check Station Enable switch (ON?)
3. Check motion mode (Manual mode selected?)
4. Check System Status → Servos Connected
5. Check for gimbal limit switches (at mechanical limit?)

Operator-Level Fixes

- ☐ Reset E-Stop (if engaged)
- ☐ Turn Station Enable ON

- ☐ Cycle to Manual mode (**[Button 11/13]**)
- ☐ Move gimbal away from limits (if at limit switch)
- ☐ Power cycle system

Escalate if: Servos disconnected or faulted.

9.4.5 LRF NOT RANGING

Symptoms

- No range reading displayed
- "NO ECHO" message (persistent)
- Range reading frozen/stale
- Wildly inaccurate range (e.g., 50,000m)

Diagnosis

LRF DIAGNOSIS

1. Check target distance (within max range 5km for hard targets?)
2. Check target reflectivity (solid surface, not transparent/absorbent?)
3. Check LRF temperature (System Status - overheated?)
4. Check atmospheric conditions (fog, smoke, heavy rain?)
5. Check for obstructions between LRF and target

Operator-Level Fixes

- ☐ Re-fire LRF (multiple attempts - 3-5 tries)
- ☐ Aim at different target (more reflective surface)
- ☐ Allow LRF to cool (if overheated - wait 5-10 minutes)
- ☐ Switch to manual range estimation (map, known landmarks)
- ☐ Wait for atmospheric conditions to improve

Escalate if: LRF disconnected or constant fault flag.

9.4.6 HIGH TEMPERATURE WARNING

Symptoms

- "HIGH TEMP" alarm (yellow or red)
- Device temperature $>60^{\circ}\text{C}$ in System Status
- Thermal shutdown (device stops functioning)

Diagnosis

HIGH TEMPERATURE DIAGNOSIS

1. Check System Status → which device is overheating?
2. Check ambient temperature (extreme heat environment?)
3. Check operation tempo (continuous motion/firing?)
4. Check ventilation (blocked air intakes?)

Operator-Level Fixes

- ☐ Reduce operations (slower movements, less frequent firing)
- ☐ Allow cooling period (5-15 minutes, depending on device)
- ☐ Limit continuous motion/firing (use intermittent operations)
- ☐ Increase ventilation (if possible - open vents, improve airflow)
- ☐ Monitor temperature trend (should decrease during cooldown)

Escalate if: Temperature remains $>80^{\circ}\text{C}$ after cooldown period.

Temperature Management

Prevention:

- Avoid sustained high-tempo operations in hot environments
- Allow periodic cooling breaks (5 minutes every 30 minutes in extreme heat)
- Monitor temperature trends proactively
- Plan operations during cooler times of day (if possible)

9.5 TROUBLESHOOTING QUICK REFERENCE

Symptom	Likely Cause	Operator Fix	Escalate If
No joystick response	USB disconnected	Reconnect USB, reboot	Still offline after reboot
Black video	Camera fault	Switch cameras	Both cameras offline
Tracking won't lock	Poor contrast, bad gate	Improve contrast, resize gate	Fails on all targets

Symptom	Likely Cause	Operator Fix	Escalate If
Gimbal frozen	E-Stop, Station OFF	Reset E-Stop, Station ON	Servo fault flag
LRF no reading	Target too far/obscured	Re-fire, different target	LRF disconnected
High temp	Overuse	Reduce ops, cool down	Temp stays $>80^{\circ}\text{C}$
Weapon won't arm	Safety interlocks	Check switches, authorization	Switches non-functional
Lost zero accuracy	Drift, maintenance	Re-zero weapon	Persistent after re-zero

9.6 ADVANCED TROUBLESHOOTING

9.6.1 INTERMITTENT PROBLEMS

Characteristics

- Problem appears and disappears randomly
- Works sometimes, fails other times
- Difficult to reproduce consistently

Troubleshooting Approach

Document the Pattern:

- When does it occur? (time of day, temperature, specific operation)
- What makes it better/worse?
- How often does it happen?
- Any common factors when it occurs?

Common Causes:

- Loose connections (intermittent contact)
- Temperature-related (works cold, fails hot)
- Software timing issues (race conditions)
- Electrical interference (when other systems operating)

! CAUTION

Intermittent problems often indicate impending failure. Report immediately even if problem self-clears.

9.6.2 MULTIPLE SIMULTANEOUS FAULTS

Diagnosis Strategy

When multiple systems fail simultaneously:

1. **Look for common cause:**
 - Power supply issue (affects all systems)
 - Main computer failure (affects all subsystems)
 - Communication bus failure (multiple devices offline)
 2. **Prioritize troubleshooting:**
 - Start with power (most fundamental)
 - Then communication (affects device connectivity)
 - Then individual devices
 3. **Consider cascade failures:**
 - One device failure may cause others
 - Example: IMU failure → tracking fails → LAC fails
- Escalate immediately if:**
- >3 devices offline simultaneously
 - Power supply issues suspected
 - Unknown common cause

9.6.3 DEGRADED PERFORMANCE

Symptoms

- System works, but not as well as before
- Slower response times
- Reduced accuracy
- Increased errors/retries needed

Investigation

Compare to Baseline:

- Check tracking confidence (was 90%, now 70%?)
- Check ranging accuracy (was $\pm 2\text{m}$, now $\pm 10\text{m}$?)
- Check gimbal smoothness (jerky vs. smooth)
- Check response time (lag vs. immediate)

Possible Causes:

- Mechanical wear (servos, bearings)
- Sensor degradation (camera, LRF, IMU)
- Software configuration drift
- Environmental factors (temperature, contamination)

Operator Actions:

- Document specific performance degradation
- Attempt re-calibration (re-zero, re-configure)
- Report to maintenance (even if still operational)

9.7 PREVENTIVE MAINTENANCE

9.7.1 OPERATOR-LEVEL MAINTENANCE

Daily Tasks

- Clean camera lenses (soft cloth, approved cleaner)
- Inspect cables and connectors (secure, no damage)
- Check fluid levels (if applicable)
- Wipe down control panels (remove dirt, moisture)
- Visual inspection for damage or corrosion

Weekly Tasks

- Verify zero accuracy (test shot at known range)
- Exercise full range of motion (azimuth/elevation)
- Test all emergency procedures (E-Stop, tracking abort)
- Check backup systems (backup radio, backup camera)
- Review system logs (check for recurring errors)

Monthly Tasks (or as directed)

- Re-zero weapon
- Full system health check (all devices, all functions)
- Update system software (if authorized and available)
- Lubricate moving parts (if authorized and trained)

i NOTE

Preventive maintenance prevents failures. Regular checks catch problems before they become critical.

9.7.2 WHAT OPERATORS SHOULD NOT DO

Operators are NOT authorized to:

- Open sealed enclosures
- Repair circuit boards or electronics
- Replace major components (servos, cameras, computers)
- Modify software or configuration files
- Perform calibrations beyond re-zeroing
- Disable safety interlocks

Operators ARE authorized to:

- Clean external surfaces and lenses
- Reconnect loose cables (external only)
- Re-zero weapon
- Adjust user settings (zoom, brightness, environmental parameters)
- Power cycle system
- Replace batteries (if trained and authorized)

9.8 MAINTENANCE ESCALATION

9.8.1 WHEN TO CALL MAINTENANCE

Call maintenance immediately for:

- Device disconnected (doesn't reconnect after reboot)
- Persistent fault flags
- Servo malfunction (erratic motion, no motion, unusual noises)
- Physical damage observed
- Thermal runaway (temperature >80°C, not decreasing)
- Electrical issues (burning smell, smoke, arcing)
- Weapon malfunction (jam, accidental discharge, failure to fire)
- Safety system failure (E-Stop, interlocks not working)

9.8.2 INFORMATION TO PROVIDE

When calling maintenance, provide:

- ☐ System serial number / unit identifier
- ☐ Specific symptoms (be detailed)
- ☐ When problem first occurred
- ☐ Frequency (constant, intermittent, getting worse?)
- ☐ Recent events (maintenance, configuration changes, incidents)
- ☐ System Status information (which devices faulted?)
- ☐ Error messages or alarm codes

- ☐ Troubleshooting already attempted
- ☐ Current system state (powered on, E-Stopped, etc.)

9.8.3 MAINTENANCE RESPONSE PRIORITIES

Priority 1 - Immediate Response:

- Safety system failure
- Fire/smoke/electrical hazard
- Weapon malfunction
- Multiple critical systems offline

Priority 2 - Same Day Response:

- Single critical system offline (LRF, camera, servo)
- Degraded but operational (reduced capability)

Priority 3 - Scheduled Maintenance:

- Minor issues (cosmetic damage, non-critical warnings)
- Preventive maintenance tasks
- Performance optimization

9.9 TROUBLESHOOTING CASE STUDIES

9.9.1 CASE STUDY 1: Tracking Works Initially, Then Fails

Symptoms:

- Tracking locks successfully
- After 5-10 minutes, tracking becomes erratic
- Eventually loses lock completely
- Problem recurs each mission

SLAF Analysis:

- **Stop:** Problem is intermittent, temperature-related?
- **Look:** Check System Status → Camera temperature rising
- **Assess:** Camera overheating, thermal FFC becoming more frequent
- **Fix:** Report to maintenance - camera cooling system fault

Lesson: Intermittent problems that worsen over time indicate component failure. Don't ignore!

9.9.2 CASE STUDY 2: Gimbal Moves Slowly in One Direction

Symptoms:

- Azimuth movement slow when turning left
- Normal speed turning right
- Elevation normal
- No fault flags in System Status

SLAF Analysis:

- **Stop:** Asymmetric problem suggests mechanical issue
- **Look:** Check torque readings → high torque on left turns
- **Assess:** Mechanical resistance (bearing wear, obstruction)
- **Fix:** Escalate to maintenance - mechanical inspection needed

Lesson: Directional or asymmetric problems often indicate mechanical issues, not software/electrical.

9.9.3 CASE STUDY 3: System Won't Power Up

Symptoms:

- Main power switch ON, but no lights
- No response from any system
- Complete dead system

SLAF Analysis:

- **Stop:** Total power failure - electrical issue
- **Look:** Check external power source (generator, battery)
- **Assess:** External power available? Cables connected? Circuit breaker tripped?
- **Fix:**

- If external power issue: Restore external power
- If external power OK: Escalate - internal power supply fault

Lesson: Start troubleshooting from the outside in. Check simplest causes (external power) before assuming complex internal failures.

Chapter 10

LESSON 10 - PRACTICAL TRAINING & EVALUATION

Duration: 8 hours (Hands-On Training & Evaluation)
Type: Practical + Evaluation
References: All previous lessons, evaluation checklist

10.1 LEARNING OBJECTIVES

Upon completion of this lesson, operators will be able to:

- Demonstrate proficiency in all operator tasks
- Pass written examination (80% minimum)
- Pass practical performance evaluation
- Qualify for operational duty

10.2 PRACTICAL TRAINING EXERCISES

10.2.1 EXERCISE 1: SYSTEM STARTUP & HEALTH CHECK

Duration: 30 minutes

Task

Power up system, perform pre-operation checks

Performance Standards

- ☐ Correct power-up sequence
- ☐ All devices detected and connected
- ☐ Pre-operation checklist 100% complete
- ☐ Ready for operations within 5 minutes

Evaluation Criteria

Task Element	Weight	Standard
Power-up sequence	25%	All steps in correct order
Device verification	25%	All devices confirmed online
Checklist completion	30%	All items checked, documented
Time to ready	20%	<5 minutes from power-on

Common Errors to Avoid

- Skipping System Status check
- Not documenting baseline temperatures
- Failing to test all motion axes
- Rushing through checklist (missing items)

10.2.2 EXERCISE 2: MANUAL GIMBAL CONTROL

Duration: 30 minutes

Task

Navigate gimbal to designated azimuth/elevation coordinates

Performance Standards

- ☐ Smooth, controlled movements
- ☐ Accuracy: $\pm 2^\circ$ azimuth, $\pm 2^\circ$ elevation
- ☐ Complete 5 targets within 3 minutes

Target Coordinates

Target	Azimuth	Elevation	Time Limit
Target 1	45°	+10°	30 seconds
Target 2	180°	+20°	30 seconds
Target 3	270°	-5°	40 seconds
Target 4	90°	+30°	40 seconds
Target 5	0°	0°	40 seconds

Evaluation Criteria

GO Criteria:

- All targets acquired within $\pm 2^\circ$
- No jerky or erratic motion

- No gimbal limit violations
- Completed within time limit
- **NO-GO Criteria:**
- Accuracy $>\pm 5^\circ$ on any target
- Exceeds time limit by $>50\%$
- Gimbal limit violation
- Unsafe control (rapid, uncontrolled movements)

10.2.3 EXERCISE 3: TARGET ACQUISITION & TRACKING

Duration: 1 hour

Task

Acquire and track stationary and moving targets

Performance Standards

- ☐ Acquisition gate correctly sized (10-30% margin)
- ☐ Lock achieved within 10 seconds
- ☐ Track maintained >30 seconds
- ☐ Clean abort on command

Scenarios

Scenario A: Stationary Target

1. Instructor designates stationary target
2. Student acquires and locks tracking
3. Maintain track for 30 seconds
4. Abort tracking on command

Scenario B: Slow-Moving Target

1. Instructor designates moving target (vehicle, simulated)
2. Student acquires and locks tracking
3. Maintain track through target motion
4. Monitor track confidence (should remain $>70\%$)

Scenario C: Fast-Moving Target

1. Instructor designates fast-moving target
2. Student adjusts FOV (zoom out if needed)
3. Acquire and lock tracking
4. Manage "LEAD ANGLE LAG" warning (wait for green)

Evaluation Criteria

Task Element	Weight	Standard
Gate sizing	20%	10-30% margin, target fully visible
Lock achievement	30%	<10 seconds from gate sizing
Track maintenance	30%	>30 seconds, confidence $>70\%$
Abort execution	20%	Immediate, clean, returns to manual

10.2.4 EXERCISE 4: SIMULATED ENGAGEMENT

Duration: 1 hour

Task

Complete engagement sequence (no live fire)

Performance Standards

- ☐ PID confirmed before engagement
- ☐ Tracking established (Active Lock)
- ☐ LAC activated (moving target)
- ☐ Safety checks complete
- ☐ Simulated fire (correct procedure)
- ☐ BDA (Battle Damage Assessment)

Engagement Sequence

SIMULATED ENGAGEMENT

Phase 1: Target Detection & Identification

1. Instructor designates target (verbal or visual cue)
2. Student detects and slews to target
3. Student identifies target (announces type, description)
4. Student confirms PID and ROE compliance

Phase 2: Target Acquisition

1. Enter acquisition mode ([Button 4])
2. Size gate appropriately
3. Request lock-on ([Button 4])
4. Achieve Active Lock (green gate)

Phase 3: Fire Control Setup

1. Range target (LRF or manual estimation)
2. Enable LAC if target moving ([Button 3 + Button 2])
3. Verify LAC status (LEAD ANGLE ON if applicable)
4. Announce range and lead status

Phase 4: Safety Checks

1. Verify no zone violations (check OSD)
2. Verify friendlies clear (announce "CLEAR")
3. Verify target still valid
4. Announce "READY TO ENGAGE"

Phase 5: Simulated Engagement

1. Engage Master Arm ([Button 0])
2. Announce "ARMED"
3. Simulate fire (*do not press Button 5, announce "FIRE"*)
4. Announce "CEASE FIRE"
5. Disarm ([Button 0])

Phase 6: Battle Damage Assessment

1. Observe simulated impact
2. Announce BDA result (destroyed/damaged/missed)
3. Stop tracking if target neutralized

Critical Errors (Automatic Failure)

- No PID before engagement
- Zone violation not recognized
- Friendlies not checked
- Wrong target engaged
- Skipped safety checks

10.2.5 EXERCISE 5: WEAPON ZEROING

Duration: 1 hour

Task

Zero weapon at 200m range

Performance Standards

- ☐ Correct zeroing procedure
- ☐ Zero applied successfully
- ☐ Verification shot within $\pm 5\text{cm}$
- ☐ "Z" indicator appears on OSD

Zeroing Procedure

1. Access Zeroing menu ([MENU] → Zeroing → [VAL])
2. Aim at target center (200m range)
3. Fire test shot (observe impact location)
4. Move reticle to impact point (joystick)
5. Apply zero ([MENU])
6. Verify "Z" indicator on OSD
7. Fire verification shot (should hit reticle center)

Evaluation Criteria**GO Criteria:**

- Correct procedure followed
- Zero applied (Z indicator visible)
- Verification shot within $\pm 5\text{cm}$ of aim point

NO-GO Criteria:

- Incorrect procedure (steps out of order)
- Zero not applied (no Z indicator)
- Verification shot $> \pm 10\text{cm}$ from aim point

i NOTE

If verification shot fails, student may retry zeroing procedure once.

10.2.6 EXERCISE 6: EMERGENCY PROCEDURES

Duration: 1 hour

Task

Respond to simulated emergencies

Scenarios

Scenario 1: Wrong Target Identified

- **Setup:** Student tracking target
- **Event:** Instructor announces "FRIENDLY FORCES IN TRACKING GATE"
- **Required Action:** Immediate tracking abort ([**Button 4**] double-click)
- **Standard:** Abort within 500ms of announcement

Scenario 2: Runaway Gimbal

- **Setup:** Instructor simulates runaway gimbal (unexpected motion)
- **Event:** Gimbal moves erratically without joystick input
- **Required Action:** Immediate E-Stop, then Station Power OFF
- **Standard:** E-Stop within 1 second, power OFF within 3 seconds

Scenario 3: Accidental Discharge

- **Setup:** Simulated weapon armed
- **Event:** Instructor announces "WEAPON FIRING" (unintended)
- **Required Action:** Release fire, release Master Arm, point safe, E-Stop, power OFF
- **Standard:** All steps within 5 seconds

Scenario 4: Lost Communication

- **Setup:** Operator performing surveillance
- **Event:** Instructor simulates radio failure
- **Required Action:** Switch backup radio, attempt recovery, follow SOP
- **Standard:** Backup radio within 30 seconds, correct SOP followed

Performance Standards

- ☐ Immediate recognition of emergency (<2 seconds)
- ☐ Correct procedure executed
- ☐ Reaction time <2 seconds (critical emergencies)
- ☐ All safety steps completed

10.2.7 EXERCISE 7: TROUBLESHOOTING

Duration: 1 hour

Task

Diagnose and resolve simulated faults

Faults Presented

Fault 1: Joystick Disconnected

- **Symptom:** No gimbal response, no joystick LED
- **Expected Diagnosis:** USB cable disconnected
- **Expected Fix:** Reconnect USB, verify System Status

Fault 2: Camera Offline

- **Symptom:** Black screen, "No Signal"
- **Expected Diagnosis:** Camera disconnected or fault
- **Expected Fix:** Switch to alternate camera, power cycle if both offline

Fault 3: Tracking Failure

- **Symptom:** Cannot achieve lock, stays in LOCK PENDING
- **Expected Diagnosis:** Poor target contrast or gate sizing
- **Expected Fix:** Improve contrast (switch camera/LUT), resize gate

Fault 4: LRF No Reading

- **Symptom:** Persistent "NO ECHO"
- **Expected Diagnosis:** Target too far or obscured
- **Expected Fix:** Re-fire on closer/more reflective target, or manual range estimation

Performance Standards

- ☐ Correct diagnosis using SLAF method
- ☐ Operator-level fix applied (if applicable)
- ☐ Proper escalation to maintenance (if needed)
- ☐ Solution verified (problem resolved)

Evaluation Criteria

Task Element	Weight	Standard
Problem diagnosis	40%	Correct root cause identified
Troubleshooting method	20%	SLAF method applied correctly
Fix application	30%	Appropriate fix attempted
Escalation decision	10%	Correct escalation if needed

10.3 WRITTEN EXAMINATION

10.3.1 EXAMINATION FORMAT

Format: 50 multiple-choice questions

Passing Score: 80% (40/50 correct)

Time Limit: 60 minutes

10.3.2 Topics Covered

Topic	Questions	Weight
Safety procedures	10	20%
Basic operation	10	20%
Tracking & engagement	10	20%
Ballistics & fire control	10	20%
Emergency procedures	5	10%
System status & troubleshooting	5	10%
TOTAL	50	100%

10.3.3 Sample Questions

Safety Procedures

- When should the E-Stop button be activated?
 - A) Only when ordered by command
 - B) When personnel are in line of fire
 - C) After every mission
 - D) Only during maintenance

Correct Answer: B

Tracking & Engagement

- What is the correct acquisition gate sizing margin around the target?
 - A) 0-5% margin
 - B) 10-30% margin
 - C) 50-75% margin
 - D) Gate should be as tight as possible

Correct Answer: B

Emergency Procedures

- How do you perform an emergency tracking abort?
 - A) Press E-Stop button
 - B) Single-click Button 4
 - C) Double-click Button 4 (<500ms)
 - D) Turn Station Power OFF

Correct Answer: C

10.3.4 Examination Rules

- Closed book (no reference materials)
- No electronic devices
- Questions may be asked for clarification (instructor will not provide answers)
- Review allowed if time permits
- Minimum 80% required to pass

10.4 PERFORMANCE EVALUATION

10.4.1 EVALUATION FORMAT

Format: Instructor-observed practical assessment

Duration: 2-3 hours

Passing Standard: 80% overall, NO critical errors

10.4.2 Evaluation Criteria

Task	Weight	GO/NO-GO Criteria
System Startup	10%	All steps correct, <5 min
Manual Control	10%	Smooth, accurate ($\pm 2^\circ$)
Tracking	20%	Lock achieved, maintained >30s
Simulated Engagement	25%	Full sequence, all safety checks
Zeroing	15%	Correct procedure, accurate
Emergency Response	15%	Immediate, correct procedure
Troubleshooting	5%	Correct diagnosis & action
TOTAL	100%	80% required

10.4.3 Critical Errors (Automatic Failure)

Any of the following results in automatic NO-GO:

- Safety violation (no-fire zone, friendly fire)
- Failed to E-Stop when required
- Accidental discharge (simulated)
- Wrong target engagement
- Bypassed safety interlocks
- Damaged equipment through negligence

10.4.4 Scoring

Individual Task Scoring

Each task scored 0-100%:

- **100%:** Flawless execution
- **90%:** Minor errors, corrected immediately
- **80%:** Meets minimum standard
- **70%:** Below standard, requires additional training
- **<70%:** Unsatisfactory, significant deficiencies

Overall Score Calculation

1. Calculate weighted score for each task
2. Sum all weighted scores = Overall Score
3. Check for critical errors (automatic failure if any)
4. Final result: GO (80%, no critical errors) or NO-GO (<80% or critical error)

Example Calculation:

- System Startup: $90\% \times 10\% = 9$ points
- Manual Control: $85\% \times 10\% = 8.5$ points
- Tracking: $95\% \times 20\% = 19$ points
- Simulated Engagement: $80\% \times 25\% = 20$ points
- Zeroing: $90\% \times 15\% = 13.5$ points
- Emergency Response: $100\% \times 15\% = 15$ points
- Troubleshooting: $75\% \times 5\% = 3.75$ points
- **Overall Score: 88.75% = GO**

10.5 QUALIFICATION REQUIREMENTS

10.5.1 TO QUALIFY AS EL 7ARRESS RCWS OPERATOR

Must pass **ALL**:

- ☐ Written examination (80%)
- ☐ Practical evaluation (80%)
- ☐ Zero critical errors
- ☐ Instructor recommendation

10.5.2 Qualification Certificate

Upon successful completion, operator receives:

- Certificate of Qualification
 - Operator ID card
 - Entry in training records
 - Authorization for operational duty
- Qualification Valid:** 12 months from date of issue

10.5.3 REQUALIFICATION REQUIREMENTS

Requalification required:

- **Annually** (refresher training + re-test)
- **After >6 months away from system**
- **After major system upgrade**
- **If unsafe practices observed**
- **Upon commander's discretion**

Requalification Process

Annual Requalification:

1. 4-hour refresher training (classroom)
2. Abbreviated written exam (25 questions, 80% required)
3. Practical evaluation (key tasks only: engagement, emergencies)
4. Verification of zero proficiency

Extended Absence (>6 months):

1. Full course review recommended
2. Full written examination
3. Full practical evaluation
4. May require full re-qualification at instructor's discretion

10.6 REMEDIAL TRAINING

10.6.1 IF STUDENT FAILS QUALIFICATION

Failed Written Exam:

- Review incorrect answers with instructor
- Additional study (weak areas identified)
- Re-test after minimum 24 hours
- Maximum 2 re-test attempts

Failed Practical Evaluation:

- Review performance with instructor (identify deficiencies)

- Additional practice on failed tasks
- Re-test after minimum 48 hours
- Maximum 2 re-test attempts

Critical Error:

- Immediate training halt
- Safety review with instructor and commander
- Mandatory additional training (duration determined by commander)
- Re-start evaluation from beginning

10.6.2 Maximum Attempts

- **Written Exam:** 3 attempts maximum (initial + 2 retakes)
- **Practical Eval:** 3 attempts maximum (initial + 2 retakes)
- **If failed after 3 attempts:** Student removed from training, command decision on future training

10.7 POST-QUALIFICATION

10.7.1 CONTINUING EDUCATION

Qualified operators are expected to:

- Maintain proficiency through regular operations
- Attend quarterly refresher training sessions
- Review operator manual periodically
- Stay current on system updates and modifications
- Mentor junior operators (once experienced)

10.7.2 ADVANCED TRAINING

Experienced operators may qualify for advanced courses:

- **Instructor Operator:** Train new operators
- **Maintainer Cross-Training:** Operator-level maintenance
- **Tactics Development:** Advanced employment techniques
- **System Specialist:** Deep technical expertise

10.7.3 PERFORMANCE TRACKING

Operator performance tracked through:

- Mission logs (accuracy, efficiency)
- Incident reports (any safety issues)
- Peer evaluations (teamwork, professionalism)
- Annual requalification scores

Outstanding performance may result in:

- Commendation
- Selection for advanced training
- Instructor duty assignment
- Leadership positions

10.8 FINAL CHECKLIST

10.8.1 BEFORE FINAL EVALUATION

Student should verify:

- ☐ Attended all lessons (1-10)
- ☐ Completed all practical exercises
- ☐ Reviewed all reference materials
- ☐ Practiced emergency procedures
- ☐ Comfortable with all system functions
- ☐ Any questions answered by instructor
- ☐ Well-rested and prepared for evaluation day

10.8.2 ON EVALUATION DAY

Bring:

- Government-issued ID
- Training record
- Writing materials (pen/pencil for written exam)
- Appropriate uniform
- Positive attitude and confidence

Arrive:

- 15 minutes before scheduled time
- Well-rested and alert
- Ready to demonstrate proficiency

10.9 CONCLUSION

10.9.1 IMPORTANCE OF QUALIFICATION

El 7arress RCWS operators hold a position of great responsibility:

- Control of lethal weapon system
 - Protection of friendly forces
 - Engagement of hostile threats
 - Safety of personnel and equipment
- Qualification ensures operators are:
- Technically proficient
 - Safety-conscious
 - Tactically sound
 - Ready for operational duty

10.9.2 FINAL WORDS

“A qualified operator is not just someone who knows how to operate the system - it is someone who can be trusted with a weapon, who makes sound decisions under pressure, and who puts safety and mission accomplishment above all else.”

— El 7arress Training Doctrine

Good luck on your qualification!

Chapter 11

APPENDIX A - QUICK REFERENCE CARDS

11.1 STARTUP SEQUENCE

SYSTEM STARTUP PROCEDURE

1. Main Power ON
2. Station Enable ON
3. Wait for boot (60 seconds)
4. Check System Status (all devices connected)
5. Perform pre-operation checks
6. Ready for operations

11.2 CONTROL REFERENCE

11.2.1 JOYSTICK

Control	Function
X-Axis	Azimuth (left/right)
Y-Axis	Elevation (up/down)
Button 0	Master Arm
Button 2	LAC Toggle (hold Button 3)
Button 3	Dead Man Switch
Button 4	Track Select (single=start, double=abort)
Button 5	Fire
Button 6/8	Zoom In/Out
Button 7/9	Thermal LUT
Button 10/12	Camera Switch
Button 11/13	Motion Mode Cycle
D-Pad	Acquisition gate sizing (in Acquisition mode)

11.2.2 CONTROL PANEL (DCU)

Control	Function
E-STOP	Emergency Stop (red mushroom)
Station Enable	Power on/off weapon station
Gun Arm / Safe	Weapon arming switch
MENU	Menu access / Validate
/	Menu navigation
Authorization Key	Enable weapon fire
Indicator Lights	System status (Armed, Tracking, Faults)

11.3 OSD INDICATORS

Indicator	Meaning
Z	Zeroing active
ENV	Environmental parameters active
LEAD ANGLE ON (GREEN)	LAC active, ready to fire
LEAD ANGLE LAG (YELLOW)	LAC waiting for tracking data
ZOOM OUT (RED)	LAC FOV insufficient
ZONE VIOLATION (RED)	No-Fire/No-Traverse zone warning
TRACKING	Tracking active
ACQUISITION	Acquisition mode
RNG: xxxx m	Laser range reading

11.4 EMERGENCY ACTIONS

Emergency	Immediate Action
Personnel in danger	E-STOP
Wrong target	[Button 4] (double-click)

Emergency	Immediate Action
Accidental fire	Release [Button 5], Release [Button 0]
Runaway gimbal	E-STOP → Station Power OFF
Fire/Smoke	E-STOP → Main Power OFF

11.5 TRACKING QUICK REFERENCE

TRACKING SEQUENCE

1. **Start Acquisition:** [Button 4] (single press)
2. **Size Gate:** [D-Pad] (10-30% margin)
3. **Request Lock:** [Button 4] (second press)
4. **Monitor Track:** Green gate = good, Yellow = marginal
5. **Emergency Abort:** [Button 4] (double-click <500ms)

11.6 ENGAGEMENT CHECKLIST

PRE-ENGAGEMENT VERIFICATION

- ☐ Target positively identified (PID)
- ☐ Target valid (meets ROE)
- ☐ Fire authorization received
- ☐ NOT in no-fire zone
- ☐ Friendly forces clear
- ☐ Weapon loaded and ready
- ☐ Zeroing active (Z indicator)
- ☐ Track established (if using tracking)

IF ANY ITEM CANNOT BE CHECKED: DO NOT FIRE

11.7 BALLISTICS QUICK REFERENCE

11.7.1 Zeroing Status

OSD Indicator	Meaning	Action
Z visible	Zeroing active	Normal ops
No Z	No zero applied	Re-zero before firing
ENV visible	Environmental corrections active	Normal ops
LEAD ANGLE ON	LAC active	Aim at CCIP reticle

11.7.2 Fire Control Combinations

Target	Conditions	Z	ENV	LAC	OSD Display
Stationary	Standard				Z
Stationary	Extreme temp/alt				Z ENV
Moving (fast)	Standard				Z LEAD ANGLE ON
Moving (fast)	Extreme				Z ENV LEAD ANGLE ON

11.8 TROUBLESHOOTING QUICK GUIDE

Symptom	Quick Fix	Escalate If
No joystick	Reconnect USB, reboot	Still offline
Black video	Switch cameras	Both offline
Won't track	Resize gate, improve contrast	Fails all targets
Gimbal frozen	Reset E-Stop, Station ON	Servo fault
LRF no reading	Re-fire, try different target	LRF disconnected
High temp	Reduce ops, cool down	Temp >80°C

11.9 SYSTEM STATUS QUICK CHECK

HEALTHY SYSTEM INDICATORS

- All devices: **Connected**
- Servo torque: **0-50%**
- Temperatures: **20-60°C**
- No fault flags
- Track confidence: **>70%**
- No alarms (RED or YELLOW)

DEGRADED SYSTEM INDICATORS

- Servo torque: **50-80%** (marginal)
- Temperatures: **60-70°C** (warning)
- Track confidence: **50-70%** (marginal)
- YELLOW alarms present

FAULTED SYSTEM (NO-GO)

- Any device: **Disconnected**
- Servo torque: **>80%** sustained
- Temperatures: **>70°C**
- Fault flags present
- RED alarms present

11.10 ENVIRONMENTAL PARAMETERS GUIDE

11.10.1 When to Apply Environmental Settings

Situation	Temp	Alt	Wind	Apply?
Sea level, standard, calm	15°C	0m	0 m/s	No
Desert, hot, calm	40°C	0m	0 m/s	Yes
Mountain, cold, windy	-10°C	2000m	8 m/s	Yes
Temperate, mild breeze	20°C	300m	3 m/s	Optional

11.11 LAC (LEAD ANGLE COMPENSATION) GUIDE

LAC ACTIVATION

1. Establish Active Lock (green gate)
2. Hold **[Button 3]** (Dead Man Switch)
3. Press **[Button 2]** (LAC Toggle)
4. Release both buttons
5. Verify: **LEAD ANGLE ON** (GREEN)

LAC STATUS MEANINGS

- **LEAD ANGLE ON** (GREEN): Ready to fire
- **LEAD ANGLE LAG** (YELLOW): Wait 2-5 seconds
- **ZOOM OUT** (RED): Zoom out, LAC non-functional

WHEN TO USE LAC

- Target moving laterally (crossing FOV)
- Target speed >5 m/s
- Range >100 meters

WHEN NOT TO USE LAC

- Stationary targets
- Targets moving radially (toward/away)
- Very close range (<50m)

11.12 SAFETY REMINDERS

⚠ CRITICAL SAFETY RULES

ALWAYS:

- Verify target before engaging (PID mandatory)
- Check for friendly forces
- Verify NOT in no-fire zone
- Follow Rules of Engagement (ROE)
- Have fire authorization (if required)

NEVER:

- Fire without positive identification
- Fire into no-fire zones
- Fire if friendlies potentially in line of fire
- Fire without authorization (if required)
- Bypass safety interlocks

Chapter 12

APPENDIX B - TECHNICAL SPECIFICATIONS

12.1 SYSTEM CAPABILITIES

12.1.1 Gimbal Performance

Parameter	Specification
Azimuth Range	360° continuous
Elevation Range	-20° to +60°
Azimuth Speed	0-60°/sec
Elevation Speed	0-45°/sec
Pointing Accuracy	±0.5°
Stabilization	3-axis (roll, pitch, yaw)
Max Weapon Caliber	12.7mm (.50 cal)

12.1.2 Performance Notes

Azimuth Range

- Full 360° continuous rotation
- No physical stops or cable wrap concerns
- Slip ring technology for continuous rotation

Elevation Range

- Depression: -20° (below horizon)
- Elevation: +60° (above horizon)
- Typical engagement range: -10° to +30°
- Mechanical stops at limits

Slew Rates

- Maximum slew rates achievable in manual mode
- Tracking mode: typically 30-40°/sec maximum
- Variable speed control via joystick
- Acceleration limits protect mechanical components

12.2 ELECTRO-OPTICAL SYSTEM

12.2.1 DAY CAMERA (SONY)

Parameter	Specification
Resolution	1920×1080 (Full HD)
Zoom	Optical continuous
FOV (Wide)	15° H
FOV (Tele)	1.5° H
Focus	Autofocus / Manual
Frame Rate	30 fps
Low Light	0.01 lux (minimum)

Day Camera Features

Zoom Capabilities:

- Continuous optical zoom
- 10:1 zoom ratio (approximately)
- No discrete zoom steps
- Digital zoom available (reduces quality)

Focus System:

- Autofocus: Continuous or single-shot
- Manual focus: Available via menu
- Focus range: 10m to infinity
- Close focus: 10m minimum

Image Quality:

- Full HD resolution (1920×1080)
- 30 frames per second
- Wide dynamic range (WDR) capable
- Low-light capable (0.01 lux)

12.2.2 THERMAL CAMERA (FLIR TAU 2)

Parameter	Specification
Resolution	640×512 pixels
Detector Type	Uncooled VOx microbolometer
FOV (Wide)	10.4° H × 8° V
FOV (Narrow)	5.2° H × 4° V
Digital Zoom	2× / 4×
Spectral Range	7.5-13.5 m (long-wave infrared)
NETD	<50 mK (thermal sensitivity)
Frame Rate	30 Hz (60 Hz option)

Thermal Camera Features

Field of View:

- Wide FOV: 10.4° H × 8° V (default)
- Narrow FOV: 5.2° H × 4° V (2× optical zoom)
- Digital zoom: 2× and 4× available
- Combined zoom: Up to 8× total (2× optical + 4× digital)

Look-Up Tables (LUTs):

- White-Hot: Hot objects appear white
- Black-Hot: Hot objects appear black
- Rainbow: Color-coded temperature
- Ironbow: Enhanced detail color-coding
- Additional LUTs available

Flat Field Correction (FFC):

- Automatic: Performed every 5-15 minutes
- Manual: Can be triggered via menu
- Duration: 1-2 second image freeze
- Purpose: Recalibrate sensor for accurate temperature reading

12.2.3 LASER RANGE FINDER

Parameter	Specification
Range (Hard Target)	20m - 5000m
Range (Soft Target)	20m - 2000m (typical)
Accuracy	±5m
Wavelength	1550nm (eye-safe)
Max Fire Rate	1 Hz (continuous)
Beam Divergence	<0.5 mrad
Laser Class	Class 1M (eye-safe)

LRF Performance Notes

Range Performance:

- Hard targets (metal, concrete): Up to 5000m
- Soft targets (vegetation, fabric): Up to 2000m
- Minimum range: 20m
- Accuracy: ±5m across entire range

Environmental Factors:

- Fog/Rain: Reduces maximum range
- Smoke: Severely degrades performance
- Heat shimmer: May affect accuracy at long range
- Target reflectivity: Dark/absorbent surfaces reduce range

Eye Safety:

- 1550nm wavelength (eye-safe)
- Class 1M laser (safe under normal conditions)
- Do not view through magnifying optics
- Safe for use near personnel

12.3 INERTIAL MEASUREMENT UNIT (IMU)

12.3.1 IMU Specifications

Parameter	Specification
Model	MicroStrain 3DM-GX3-25 AHRS
Update Rate	100 Hz
Roll/Pitch Accuracy	<0.5° (static), <2° (dynamic)
Yaw Accuracy	<2° (with magnetometer)
Angular Rate Range	±300°/sec
Acceleration Range	±5g
Operating Temp	-40°C to +85°C

12.3.2 IMU Role in System

Stabilization:

- Measures platform motion (roll, pitch, yaw)

- Provides real-time orientation data
- Enables gyrostabilization (compensates for vehicle motion)
- Update rate: 100 Hz (100 times per second)

Tracking Support:

- Provides angular rate data for target tracking
- Compensates for platform motion during tracking
- Essential for accurate lead angle calculation

Ballistics:

- Platform tilt compensation
- Motion compensation for moving platforms
- Critical for accurate fire control

12.4 POWER REQUIREMENTS

12.4.1 Power Specifications

Parameter	Specification
Input Voltage	24-28 VDC
Nominal Voltage	28 VDC
Max Current	40A (peak), 20A (nominal)
Power Consumption	500W nominal, 1000W peak
Startup Inrush	<60A for <1 second

12.4.2 Power Distribution

Power Consumers:

- Servo motors: 300-600W (depending on motion)
- Main computer: 100W
- Cameras: 50W total
- LRF: 20W average, 50W peak (during firing)
- Control panels: 30W
- IMU and sensors: 20W

Power Management:

- Soft-start circuitry limits inrush current
- Over-current protection (60A trip)
- Over-voltage protection (>32V trip)
- Under-voltage warning (<22V)
- Thermal management (reduces power if overheating)

12.5 ENVIRONMENTAL SPECIFICATIONS

12.5.1 Operating Environment

Parameter	Specification
Operating Temp	-20°C to +55°C
Storage Temp	-40°C to +70°C
Humidity	5% to 95% RH (non-condensing)
Ingress Protection	IP54 (dust/water splash protected)
Altitude	-500m to 4000m ASL
Shock	20g (11ms, half-sine)
Vibration	MIL-STD-810G

12.5.2 Environmental Notes

Temperature:

- Operating range: -20°C to +55°C
- Performance may degrade at temperature extremes
- Servo torque increases at low temperatures
- Thermal management active above 40°C

Humidity:

- Sealed enclosures protect electronics
- Lens fogging possible at temperature extremes
- Desiccant packs in critical areas
- Regular maintenance in high-humidity environments

Ingress Protection:

- IP54 rating (dust/water splash)
- Protected against rain and dust
- NOT waterproof (do not submerge)
- Pressure washing not recommended

12.6 MECHANICAL SPECIFICATIONS

12.6.1 Physical Dimensions

Parameter	Specification
Gimbal Diameter	600mm
Height (Stowed)	500mm
Total Weight	80 kg (without weapon)
Weapon Weight	+25-35 kg (12.7mm MG)
Mounting Interface	4× M12 bolts (square pattern)

12.6.2 Materials

Primary Structure:

- Aluminum alloy (7075-T6)
- Stainless steel (fasteners, bearings)
- Composite materials (non-structural covers)

Coatings:

- Hard anodized aluminum (corrosion protection)
- Powder coat (selected components)
- Nickel-plated steel (high-wear areas)

12.7 COMMUNICATION INTERFACES

12.7.1 Control Interfaces

Interface	Specification
Joystick	USB 2.0 (HID device)
Control Panel	RS-485 (Modbus RTU)
Video Output	HDMI 1.4 (1920×1080 @ 60Hz)
Ethernet	10/100 Mbps (diagnostics, updates)

12.7.2 Device Communication

Internal Communications:

- Servo drives: CAN bus (1 Mbps)
- IMU: RS-232 (115200 baud)
- LRF: RS-232 (38400 baud)
- Cameras: IP network (internal switch)

12.8 BALLISTIC SPECIFICATIONS

12.8.1 Supported Ammunition

Primary: 12.7×99mm NATO (.50 BMG)

- M2 Ball (standard)
- M8 API (Armor Piercing Incendiary)
- M20 APIT (Armor Piercing Incendiary Tracer)
- Mk 211 Mod 0 (Multipurpose)

12.8.2 Ballistic Computer

Parameter	Specification
Range Calculation	20m to 2000m
Update Rate	30 Hz
Environmental Inputs	Temp, altitude, wind
Drag Model	G1 (standard projectile)
Ballistic Tables	Pre-computed LUT

12.8.3 Fire Control Accuracy

Expected Accuracy (M2 Ball, 500m):

- With zeroing: ±0.5 mil (±25cm @ 500m)
- With zeroing + environmental: ±0.3 mil (±15cm @ 500m)
- With zeroing + environmental + LAC: ±0.5 mil (±25cm @ 500m, moving target)

i NOTE

Accuracy specifications assume properly zeroed weapon, accurate range data, and good tracking (if using LAC). Operator skill and weapon dispersion also affect accuracy.

12.9 MEAN TIME BETWEEN FAILURES (MTBF)

12.9.1 Reliability Estimates

Component	MTBF (hours)
Servo Motors	10,000 hours
IMU	50,000 hours
Day Camera	20,000 hours
Thermal Camera	15,000 hours
LRF	10,000 hours (laser diode)
Main Computer	40,000 hours
Overall System	5,000 hours (operational)

12.9.2 Maintenance Intervals

Operator Maintenance:

- Daily: Pre-operation checks, cleaning
- Weekly: Detailed inspection, zero verification
- Monthly: Re-zeroing, lubrication (if authorized)

Maintenance Personnel:

- Quarterly: Detailed inspection, calibration verification
- Annually: Major service, component replacement as needed
- As-needed: Fault repair, component replacement

Chapter 13

APPENDIX C - ACRONYMS & GLOSSARY

13.1 ACRONYMS

Acronym	Definition
AHRS	Attitude and Heading Reference System
API	Armor Piercing Incendiary
APIT	Armor Piercing Incendiary Tracer
ASL	Above Sea Level
BDA	Battle Damage Assessment
BMG	Browning Machine Gun (12.7×99mm cartridge)
CCIP	Continuously Computed Impact Point
DCU	Display and Control Unit
E-Stop	Emergency Stop
FFC	Flat Field Correction (Thermal camera calibration)
FLIR	Forward Looking Infrared
FOV	Field of View
HD	High Definition
HFOV	Horizontal Field of View
HID	Human Interface Device
Hz	Hertz (cycles per second)
IMU	Inertial Measurement Unit
IP	Ingress Protection (dust/water resistance rating)
LAC	Lead Angle Compensation
LRF	Laser Range Finder
LUT	Look-Up Table (Thermal imaging color palette)
LWIR	Long Wave Infrared
MG	Machine Gun
MTBF	Mean Time Between Failures
NATO	North Atlantic Treaty Organization
NETD	Noise Equivalent Temperature Difference
OSD	On-Screen Display
PID	Positive Identification
RCWS	Remote Controlled Weapon Station
RH	Relative Humidity
ROE	Rules of Engagement
ROM	Range of Motion
RTU	Remote Terminal Unit (Modbus protocol)
SLAF	Stop-Look-Assess-Fix (troubleshooting methodology)
SOP	Standard Operating Procedure
TOF	Time of Flight
TRP	Target Reference Point
USB	Universal Serial Bus
VFOV	Vertical Field of View
VOx	Vanadium Oxide (thermal detector material)
WDR	Wide Dynamic Range

13.2 GLOSSARY

13.2.1 A

Acquisition: The phase where operator positions and sizes the tracking gate over the target before requesting lock-on. The tracking gate is adjustable using the D-Pad controls to ensure proper target framing with appropriate margin.

Active Lock: Tracking phase where the tracking algorithm has successfully locked onto the target and is automatically following it. Indicated by a green dashed tracking gate and "TRACKING" status on the OSD.

Azimuth: Horizontal angle, measured in degrees (0-360°). 0°=North, 90°=East, 180°=South, 270°=West. Controlled by the joystick X-axis.

13.2.2 B

Ballistic Computer: The computational system that calculates projectile trajectory based on range, environmental conditions, and ammunition type to provide accurate CCIP reticle positioning.

Boresight: The alignment between the camera line-of-sight and the weapon bore axis. Without correction, these are offset due to physical separation. Zeroing corrects boresight offset.

Battle Damage Assessment (BDA): Post-engagement evaluation to determine if target was destroyed, damaged, or missed. Critical for determining if re-engagement is necessary.

13.2.3 C

CCIP (Continuously Computed Impact Point): The reticle that shows where the weapon will impact, accounting for zeroing, ballistics, environmental conditions, and (if active) lead angle compensation. Updated at 30 Hz.

Coast Mode: Tracking phase where the target is temporarily lost (obscured, leaves FOV, etc.) and the system predicts target position based on last known velocity to maintain track. Indicated by yellow dashed tracking gate.

Crosswind: Wind component perpendicular to the direction of fire. Causes lateral projectile drift. Environmental parameters menu allows input of crosswind speed for ballistic correction.

13.2.4 D

Dead Man Switch: Safety interlock requiring continuous operator pressure to enable certain functions. Button 3 on joystick must be held when activating/deactivating LAC. Prevents accidental activation.

Drag Function: Mathematical model of projectile air resistance. G1 drag function used for standard projectiles. Different drag functions exist for different projectile shapes (G7 for boat-tail bullets, etc.).

13.2.5 E

Elevation: Vertical angle, measured in degrees. 0° =horizon, $+90^\circ$ =zenith (straight up), -90° =nadir (straight down). Controlled by joystick Y-axis. System range: -20° to $+60^\circ$.

Emergency Stop (E-Stop): Red mushroom button on control panel that immediately halts all gimbal motion, disables weapon fire control, and locks out system functions. Used when personnel in danger or system malfunction.

Environmental Parameters: Atmospheric conditions (temperature, altitude, wind) that affect projectile trajectory. Can be input into system for ballistic corrections via Environmental Parameters menu.

13.2.6 F

Field of View (FOV): The angular extent of the observable area through the camera. Measured in degrees horizontal and vertical. Wider FOV = more area visible but less detail. Narrower FOV = more detail but smaller area.

Flat Field Correction (FFC): Thermal camera recalibration process that corrects for sensor non-uniformities. Causes brief (1-2 second) image freeze. Occurs automatically every 5-15 minutes or can be triggered manually.

Firing Phase: Special tracking phase active during weapon discharge. Enhanced stabilization and gimbal hold active. Indicated by solid green tracking gate.

13.2.7 G

Gimbal: The stabilized platform that holds the camera and weapon, allowing azimuth and elevation motion. Provides 3-axis stabilization (roll, pitch, yaw) to compensate for platform motion.

Gyrostabilization: The system's ability to use IMU angular rate data to compensate for platform motion, keeping the gimbal pointed at the target despite vehicle movement, ship roll/pitch, etc.

13.2.8 I

IMU (Inertial Measurement Unit): Sensor package that measures platform orientation (roll, pitch, yaw) and angular rates. Essential for stabilization, tracking, and ballistic calculations. MicroStrain 3DM-GX3-25 AHRS used in El 7arress.

Ingress Protection (IP): Rating system for enclosure protection against dust and water. IP54 = Protected against dust (5) and water splash from any direction (4). Not waterproof.

13.2.9 L

LAC (Lead Angle Compensation): Automatic calculation and application of angular offset to compensate for target motion. Predicts where moving target will be when projectile arrives (after TOF) and positions CCIP reticle at intercept point.

Laser Range Finder (LRF): 1550nm eye-safe laser that measures distance to target by timing laser pulse return. Range: 20-5000m (hard targets), accuracy: ± 5 m. Essential for ballistic calculations and LAC.

Lead Angle: The angular offset between a moving target's current position and the predicted intercept point, compensating for projectile time-of-flight. Larger lead angles required for faster targets, longer ranges, and slower projectiles.

Lock Pending: Brief tracking phase where the system is initializing the tracker algorithm on the target. Typically lasts 0.5-2 seconds. Indicated by cyan solid or flashing tracking gate.

Look-Up Table (LUT): In thermal imaging, a color palette that maps thermal intensities to display colors. Examples: White-Hot (hot=white), Black-Hot (hot=black), Rainbow (color-coded temperatures).

13.2.10 M

Master Arm: Safety control (Button 0 or trigger Stage 1) that must be engaged before weapon can fire. "ARMED" indicator light illuminates when active. Critical safety interlock.

Motion Mode: Operating mode determining how gimbal responds to inputs. Manual mode: Direct joystick control. Tracking mode: Automatic target following. Other modes: Sector scan, TRP scan, stabilization.

13.2.11 N

No-Fire Zone: Geographically defined area where weapon discharge is prohibited. System provides "ZONE VIOLATION" warning if gimbal enters no-fire zone with weapon armed.

No-Traverse Zone: Area where gimbal motion is restricted to prevent damage (e.g., pointing at own vehicle structure, antenna, personnel). Software and/or mechanical limits enforce.

13.2.12 O

On-Screen Display (OSD): Text and graphical overlays on video feed showing system status, indicators, and information. Examples: Reticle, range reading, tracking status, zeroing indicator, alarms.

13.2.13 P

Chapter 14

APPENDIX D - MAINTENANCE LOG TEMPLATE

14.1 DAILY OPERATOR LOG

14.1.1 Log Header

DAILY OPERATOR LOG - HEADER INFORMATION	
Date: _____	Mission ID: _____
Operator Name: _____	Rank: _____
Unit: _____	Vehicle ID: _____
Mission Type: _____	
Weather Conditions: _____	

14.1.2 PRE-OPERATION CHECKS

System	Status	GO/NO-GO	Notes
Power	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Control Panel	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Joystick	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Gimbal Motion	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Day Camera	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Thermal Camera	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
LRF	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Tracking	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
Weapon Arm/Safe	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	
System Status	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> GO <input type="checkbox"/> NO-GO	

OVERALL PRE-OPERATION STATUS: ☐ GO ☐ NO-GO

If NO-GO: Do NOT proceed with mission. Notify maintenance immediately.

14.1.3 BASELINE SYSTEM READINGS

Record baseline readings at start of operations:

Time: _____

Azimuth Servo Temp: _____ Elevation Servo Temp: _____

IMU Temp: _____ LRF Temp: _____

Day Camera Status: _____ Thermal Camera Status: _____

Zero Status: ☐ Z Indicator Present ☐ No Zero AppliedEnvironmental Settings: ☐ ENV Indicator Present ☐ Not Applied

14.2 OPERATIONS LOG

14.2.1 Operational Events

Time	Activity	Notes

14.2.2 ENGAGEMENT LOG

Record all weapon engagements:

Time	Target Type	Range (m)	Rounds	BDA	Notes

NOTE

BDA Codes: D=Destroyed, DM=Damaged, M=Missed, S=Suppressed, MK=Mobility Kill, FK=Firepower Kill

14.3 POST-OPERATION CHECKS

14.3.1 System Verification

System	Status	Pass/Fail	Notes
All Devices Connected	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL	
No Fault Warnings	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL	
Zero Still Valid	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL	
System Secured	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL	
Weapon Safed	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL	
Station Powered Down	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL	

14.3.2 Final System Readings

Record final readings at end of operations:

Time: _____

Azimuth Servo Temp: _____

Elevation Servo Temp: _____

IMU Temp: _____

LRF Temp: _____

Total Operating Hours: _____

Rounds Fired: _____

14.4 FAULTS / ISSUES OBSERVED

Issue Description	Time	Action Taken	Escalated?
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

WARNING

If any issues were escalated to maintenance, provide detailed information including:

- Specific symptoms observed
- System Status screenshot/data (if available)
- Error messages or alarm codes
- Actions already attempted

14.5 AMMUNITION EXPENDITURE

Ammunition Type: _____		
Starting Rounds: _____	Ending Rounds: _____	
Rounds Fired: _____	Rounds Remaining: _____	
Malfunctions: <input type="checkbox"/> None	<input type="checkbox"/> Jams: _____	<input type="checkbox"/> Misfires: _____
Notes: _____		

14.6 OPERATOR CERTIFICATION

OPERATOR CERTIFICATION	
<p>I certify that:</p> <ul style="list-style-type: none"> All pre-operation checks were completed All system operations were conducted per standard procedures All engagements met Rules of Engagement (ROE) All faults/issues were documented and escalated as appropriate All post-operation checks were completed System is secured and safe 	
<p>Operator Name (Print): _____</p>	
<p>Operator Signature: _____</p>	<p>Date: _____</p>

14.7 SUPERVISOR REVIEW

SUPERVISOR REVIEW (If Required)
<p>Review Comments:</p>
<p>Supervisor Name (Print): _____</p>
<p>Supervisor Signature: _____ Date: _____</p>

14.8 LOG RETENTION

14.8.1 Retention Requirements

- Daily logs:** Retain for minimum 90 days
- Logs with engagements:** Retain for minimum 1 year
- Logs with incidents:** Retain indefinitely (until investigation complete + 5 years)
- Storage:** Secure location, restricted access
- Digital copies:** Recommended for long-term retention

14.8.2 Log Distribution

Upon completion, provide copies to:

- Unit operations office (original)
- Maintenance section (if faults reported)
- Commander (if engagements occurred)
- Training section (for performance tracking)

14.9 MAINTENANCE LOG TEMPLATE

14.9.1 FOR MAINTENANCE PERSONNEL USE

MAINTENANCE WORK ORDER

Work Order #: _____

Date: _____

System/Vehicle ID: _____

Priority: ☐ 1 ☐ 2 ☐ 3

Problem Description (from operator):

Maintenance Actions Taken:

Parts Replaced:

Status: ☐ Repaired ☐ Requires Further Work ☐ Parts on Order

Technician Name: _____

Date: _____

Technician Signature: _____

Hours: _____

14.10 NOTES AND BEST PRACTICES

14.10.1 Log Completion Best Practices

- **Be specific:** "LRF intermittent at 3000m+" vs. "LRF not working"
- **Record times:** All events should have timestamps
- **Document everything:** Even minor issues can become trends
- **Be legible:** Use clear handwriting or digital entry
- **Complete immediately:** Don't rely on memory hours later
- **Report upward:** Ensure chain of command aware of issues

14.10.2 Common Log Errors to Avoid

- Incomplete pre-operation checks
- Missing timestamps
- Vague problem descriptions
- Not documenting operator-level troubleshooting attempts
- Forgetting to record ammunition expenditure
- Not signing/dating the log

END OF EL 7ARRESS RCWS OPERATOR MANUAL

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