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Test Procedures and Test Report for the Target Position Logger-Reporter

by Stephen Perry and Brian Liss

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Test Procedures and Test Report for the Target Position Logger-Reporter

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<p>The Target Position Logger-Reporter (TPLR) is a US Army Combat Capabilities Development Command Army Research Laboratory developmental item designed to log the GPS position of targets. The TPLR is typically used to record the real-time position of mobile targets for the purpose of evaluating sensor performance after the sensor testing event is completed. Default operation of the TPLR is enabled by simply switching the TPLR on. Additional user-selectable options are available in the TPLR's built-in menu system, which is accessible via common terminal emulation programs. This test report evaluates each specified requirement through inspection, analysis, demonstration, or test. Test results capture the initial findings, failures, implementation issues, and the results of any required regression testing. This test report concludes that the TPLR, with the final version of firmware installed, met all specified functional requirements and is suitable for its intended application by end users. Finally, this test report recommends that TPLR performance from a user perspective be evaluated after the TPLR has been in service for at least 1 year.</p>									
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Contents

List of Figures	iv
List of Tables	iv
1. Introduction	1
2. Operational and Test Environments	1
2.1 Operational Environment	1
2.2 Test Environment	1
2.3 Unit Under Test	2
3. Verification Methods (VMs)	2
3.1 Inspection (I)	2
3.2 Analysis (A)	3
3.3 Demonstration (D)	3
3.4 Test (T)	3
4. Test Procedures and Results	3
4.1 Verification of the Built-In User Interface: Main Menu	10
4.2 Verification of the Built-In User Interface: Maintenance Menu	11
5. Summary of Test Results	13
5.1 Summary of Test Findings	13
5.2 Details of Test Findings (Version 4, Update 7)	13
5.3 Details of Regression Test Findings (Version 4, Update 9)	15
6. Conclusions and Recommendations	16
7. References	17
Appendix. GPS Log Formats	18
List of Symbols, Abbreviations, and Acronyms	21

List of Figures

Fig. 1	Target position logger-reporter, first article.....	2
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List of Tables

Table 1	Configuration identifiers.....	2
Table 2	Test procedures and results.....	4
Table 3	Main menu for the TPLR built-in user interface	10
Table 4	Maintenance menu for the TPLR built-in user interface	12
Table 5	TPLR failure and undesirable behaviors (Version 4, Update 7).....	14
Table 6	TPLR failures and undesirable behaviors (Version 4, Update 9).....	15
Table A-1	NMEA message field details	19
Table A-2	NMEA GNRMC message field details.....	20
Table A-3	CSV message field details	20

1. Introduction

The Target Position Logger-Reporter (TPLR) is a US Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL) developmental item designed to log the GPS position of targets. The TPLR is typically used to record the real-time position of mobile targets for the purpose of evaluating sensor performance after the sensor testing event is completed.

Mr Stephen Perry conducted the TPLR testing at ARL, Adelphi, Maryland, from 28 January to 7 February 2024. This report details test procedures and test results for the TPLR First Article Test. Each specified requirement set forth in the Requirements Document, Target Position Logger-Reporter¹ is evaluated through inspection, analysis, demonstration, or test.

2. Operational and Test Environments

2.1 Operational Environment

The typical operational environment for TPLR is magnetically attached or strapped to a moving vehicle operating on paved and unimproved roads. After being powered on, TPLRs are generally placed on a flat, ferrous surface of a vehicle where it remains throughout the event. Six to 10 h per day for multiple days is typical. At the end of the day, the TPLR is removed and powered off. If necessary, the TPLR battery is recharged. This is repeated for multiple days until the conducted event is completed (3–5 days is typical). When the test event is completed, data collected by the TPLR is copied from the TPLR's removable storage media. When operating on a vehicle, TPLR is fully exposed to prevailing weather conditions. However, most operations associated with setup, pretesting, configuring, programming, or recharging the TPLR typically occur in a benchtop sheltered environment.

2.2 Test Environment

Portions of the TPLR testing were conducted in benchtop laboratory conditions. However, some of functional tests were conducted outdoors at the Adelphi Laboratory Center (ALC) due to the requirement to gain access to global positioning system (GPS) and GLObalnaya NAVigatsionnaya Sputnikovaya Sistema (GLONASS) Global Navigation Satellite System (GNSS). In addition, a small number of tests were conducted beyond the boundaries of the ALC to expose the TPLR to longer periods of operation that could be regularly observed by an assigned user.

2.3 Unit Under Test

Figure 1 depicts the TPLR. Table 1 defines hardware and software versions of the test article.



Fig. 1 Target position logger-reporter, first article

Table 1 Configuration identifiers

Configuration item	Start version/name	End version/name
Artemis Thing Plus Vendor: Spark Fun	WRL-15574 ROHS www.sparkfun.com/products/15574	No change
Ultimate GPS FeatherWing Vendor: Adafruit	3133 https://www.adafruit.com/product/3133	No change
Lithium Ion Battery Pack - 3.7 V 4400 mAh Vendor: Adafruit	354 https://www.adafruit.com/product/354	No change
FeatherWing OLED – 128 x 64 OLED Add-on For Feather - STEMMA QT / Qwiic Vendor: Adafruit	45650 https://www.adafruit.com/product/4650	No change
Firmware, TPLR Standard Vendor: Army Research Lab	tplr-standard version 4, update 7	TPLR standard version 4, update 9

3. Verification Methods (VMs)

3.1 Inspection (I)

Inspection determines whether a specification requirement associated with workmanship, size, weight, fit, mechanical safety, and so on, is satisfied. It involves the examination of material (equipment, documents, or drawings) to determine quality of compliance to standards. It is nondestructive and performed using methods requiring the physical senses, simple manipulations, gauging, and measurements. Acceptance is determined by comparing results of the physical examination to the configuration item requirements specified in the product specification.

3.2 Analysis (A)

Analysis determines whether a specification requirement is met by performing a technical evaluation and data reduction of measured and representative data using equations, charts, graphics, and calculations.

3.3 Demonstration (D)

Demonstration determines whether a specification requirement is met by observing the qualitative results of an operation or exercise performed under a specific condition. The data will normally be derived from displays and indications inherent in the system equipment. Acceptance is determined by comparing the observed results to predicted or specified requirements contained in the demonstration procedure.

3.4 Test (T)

Test determines whether a specific requirement is met by measuring, recording, and evaluating quantitative data obtained during controlled exercises using real and simulated stimuli.

4. Test Procedures and Results

Table 2 defines the verification method and related procedure to verify TPLR performance requirements. Verification Methods (VMs) are abbreviated in the table as N (No requirement), I (Inspection), A (Analysis), D (Demonstration), and T (Test). The last two columns of Table 2 capture the test results (Pass/Fail) and any values recorded during verification. Test requirements are listed in the order presented in the TPLR requirements document. Unless otherwise indicated in the test procedure, the order in which tests are conducted is at the discretion of the tester.

Table 2 Test procedures and results

Req No.	Title	VM	Procedure (P) and Verification (V)	Pass/Fail	Result values/comments
3.0	REQUIREMENTS	N	N/A	N/A	N/A
3.1	Real Time Data Logging	N	N/A	N/A	N/A
3.1.1	Log Position	D	P: Power TPLR On. Allow the TPLR 15 min to derive a GPS position. Walk TPLR in a straight-line northwest for 3 min. Output the log. Conduct with an independent GPS source that records position every minute noting UTC start and stop times and the number of GPS satellites received. V: Verify latitude, longitude, and elevation are correct for all entries.	PASS	Walked approximately 1/4 mile. Drove approximately 3 miles and compared logs with coordinates of actual routes. No issues observed.
3.1.2	Log Date-Time	D	P: Same as 3.1.1. V: Verify each entry includes a separate date-time stamp.	PASS	Times logged observed to be accurate. Displayed time observed to be accurate with time published at www.time.gov.
3.1.3	Log Velocity	T	P: Drive TPLR 1 km at 30 kph for 1 min. V: Verify the middle 80% of the logged results reflect the speed of the vehicle driven.	PASS	Observed that speeds logged (in meters per second) are consistent with the speed of the vehicle driven at 25 and 60 kph.
3.1.4	Log Direction	D	P: Same as 3.1.1. V: Verify the direction logged reflects a northwestern direction	PASS	Verified three segments of the path driven with azimuths provided by Google Earth. All were within 1° of the actual vehicle path.
3.1.5	Log Number of GPS Satellites Used	T	P: Same as 3.1.1. V: Verify the number of satellites logged is consistent with an independent GPS.	PASS	The number of satellites seen by the GPS receiver were logged (and displayed) the number of satellites observed were identical.
3.2	Global Positioning System Recording Formats	N	N/A	N/A	N/A
3.2.1	Position Format	T	P: Same as 3.1.1. V: Verify recorded format in log is compliant with the NMEA GPGGA and GNRMC and formats.	PASS	Verified the logger records one NMEA GPGGA and GNRMC message for each entry. In addition, a custom CSV file with similar data is also created for each entry. See the Appendix for file format details.
3.2.2	Position Resolution	N	None	N/A	Requirement deleted prior to development start.
3.2.3	Position Update Rate	T	P: Same as 3.1.1. V: Verify there are at least five entries per second throughout the entire log.	PASS	Verified TPLR can log position entries at intervals of 0.2, .0.8, 0.5, 1, 10, 360, and 3600 s.
3.2.4	Time Resolution	T	P: Same as 3.1.1. V: Verify all entries in the log are no more than 200 ms apart.	PASS	Verified TPLR can log time entries at intervals of 0.2, 0.8, 0.5, 10, 360, and 3600 s.
3.3	Initialization data	N	N/A	N/A	N/A

Notes: A = Analysis; CSV = comma-separated value; D = Demonstration; GLONASS = GLObalnaya NAvigatsionnaya Sputnikovaya Sistema; GNSS = Global Navigation Satellite System; GPS = global positioning system; I = Inspection; ID = identification; ICD = Interface Control Document; IPG = Interface Programmer’s Guide; N = no test; N/A = not applicable; NMEA = National Marine Electronics Association; OPSEC = Operations Security; SD = secure digital; T = Test; TPLR = Target Position Logger-Reporter; USB = Universal Serial Bus; UTC = Coordinated Universal Time; VM = verification method.

Table 2 Test procedures and results (continued)

Req No.	Title	VM	Procedure (P) and Verification (V)	Pass/Fail	Result values/comments
3.3.1	New Log Creation	D	P: Power the TPLR on. Record the date and time powered on. Allow 15 min to obtain a GPS position and then power the TPLR off. Repeat three times. V: Verify a new log is created for each time the TPLR was powered on.	PASS	Verified a new log file is created each time the TPLR is powered On and GPS time is acquired.
3.3.2	TPLR Device ID	D	P: Same as 3.3.1. V: Verify the TPLR device ID is included in the log header and log file name.	PASS	Verified the logger Unit ID is recorded in the file name generated by TPLR. Note the implementation changed the term “Device ID” to “Unit ID”.
3.3.3	Initialization Time	D	P: Same as 3.3.1. V: Verify the date and time the TPLR was powered on is recorded in the log header and log file name.	PASS	Verified the date and time are recorded in the file name and log header generated by TPLR.
3.3.4	Target Name	T	Requirement deleted. Redundant with requirement 3.5.1.	N/A	N/A
3.4	Initialization Self-Test	N	N/A	N/A	N/A
3.4.1	Battery Status	T	P: Power TPLR on. Measure battery voltage at battery output. V: Verify the battery voltage is recorded to a tenth of a volt and that the reading is within one-tenth of a volt of the battery reading.	PASS	Verified the loaded voltage of TPLR battery is within 0.1 V of the displayed value. The display value is in hundreds of a volt resolution (i.e., 4.11).
3.4.2	GPS Status	D	P: Power TPLR Off and On. Observe TPLR display to determine if TPLR displays “Fix”. Repeat in a location that does not have access to GPS signals. V: Within 15 min of being powered on, TPLR should report “Fix” or No Fix”	PASS	Verified TPLR reported “No Fix” when denied access to GNSS signals (GPS Sats = 1/1, GLONASS Sats = 0/0), and “Fix” when exposed to GNSS signals (GPS = 7/7, GLONASS = 5/5).
3.4.3	Communications Status	D	Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.5	User Inputs	N	N/A	N/A	N/A
3.5.1	Target Name		P: Power the TPLR On. Locally configure TPLR with a target name consisting of all upper- and lower-case letters, numbers, hyphens, and spaces, and then view the TPLR log (up to 32 characters at a time). Make multiple name changes if necessary. Repeat with no characters entered in the name field. V: Verified all characters are correctly represented in the TPLR log.	PASS	Implemented as “Unit Name” in light of OPSEC concerns. Verified TPLR unit name is variable and that up to 32 characters may be used in the Unit Name (or none). Also verified that TPLR accepts all upper- and lowercase letters, numbers, hyphen and spaces in the Unit Name.
3.5.2	Communications Frequency	D	Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.5.3	Spectrum Management	T	Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.5.4	Transmission Inhibit	T	Not tested. To be tested in a later version of TPLR.	N/A	Not tested.

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Table 2 Test procedures and results (continued)

Req No.	Title	VM	Procedure (P) and Verification (V)	Pass/Fail	Result values/comments
3.6	TPLR Status Response (Local and Remote)	N	N/A	N/A	N/A
3.6.1	Status Request		Note: The status message and status request command are not yet implemented. However, some configurable variables are available in built-in menu items that are presented when the TPLR is initially powered on. The available menu option items and associated default values shall be documented. All presented options must be operational or present information to the user that explains why a selected option is not executable. No displayed options will be undocumented.	PASS	See Tables 3 and 4. Verified that all selectable parameters are operable and documented.
3.6.2	Restart Real-time Reports	D	Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.6.3	Stop Real-time Reports	D	Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.6.4	Factory Reset	D	P: Perform after testing the requirements of 3.6.5. Power the TPLR on. Connect to the programming interface and request TPLR status for the following Status ID listed in the requirements document: 1) TPLR Device ID 2) Battery Status 3) GPS Location 8) Target Name 10) Store Data 11) Logging Status V: 1) Verify all setting are per Table 1 of Section 3.6.4 of the requirements document. 2) Verify any additional settings implemented in the TPLR have a factory default value defined in the TPLR IPG, ICD, or other source that matches the value presented by the TPLR and is consistent with “baseline operation” as defined by requirement 3.6.5.	PASS	Tables 3 and 4 document factory default values. The Factory Reset function is allocated to requirements 3.8.1, which is redundant to this requirement but explicit with respect to how factory defaults setting shall be invoked (by using the power switch).

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Table 2 Test procedures and results (continued)

Req No.	Title	VM	Procedure (P) and Verification (V)	Pass/Fail	Result values/comments
3.6.5	Baseline Operation	D	P: Power the TPLR on. Allow the TPLR to operate for 30 min while moving it to different locations that should be captured and logged in the TPLR. Turn the TPLR off. Remove the TPLR storage media and inspect the recorded content. V: 1) Verify all file headers for the most recently recorded logging session are complete, accurate, and representative of the geolocations the TPLR was in during the test procedure. 2) Verify all user interface switches and displays operate properly when TPLR is powered on and 3) when TPLR is powered off.	PASS	The TPLR was verified to meet all baseline operations (i.e., mimic the legacy logger) without use of a communications capability or a computer interface. The TPLR records GPS logs and all human interfaces function operate properly.
3.6.6	Local Command and Response Interface	A	P: Inspect the documentation for the TPLR programming interface. V: Verify the TPLR programming interface using USB.	PASS	Verified the TPLR built-in user interface is executable via a USB-C interface. The “Tera Term” application (Version 1.06) was used and connected with the following settings: Speed: 115200 Data: 8 bit Parity: none Stop bits: 1 bit Flow control: none. Transmit delays: none. Details of the interface was developed by the tester and documented in Tables 3 and 4.
3.6.7	Remote Command and Response Interface		Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.6.8	Remote Command and Response Interface		Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.7	Enclosure	N	N/A	N/A	N/A
3.7.1	Environmental Protection	A T	P: Inspect the TPLR mechanical design and bill of materials. Subject the TPLR to continuous rainfall conditions for a minimum of 1 h. Remove from water and dry TPLR completely. V: Verify no evidence of water in the TPLR.	PASS	Verified the TPLR showed no evidence of water intrusion after being subjected to continuous rainfall for 1 h.
3.7.2	Target Attachment	D	P: Magnetically attach TPLR to a flat, horizontal, ferrous surface. V: Verify the TPLR remains attached to the surface when the surface is flipped over and moderately shaken by hand for 10 s.	PASS	Verified the magnets on the bottom of the TPLR enable TPLR to remain firmly attached to a ferrous surface.
3.8	User Interface	N	N/A	N/A	N/A

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Table 2 Test procedures and results (continued)

Req No.	Title	VM	Procedure (P) and Verification (V)	Pass/Fail	Result values/comments
3.8.1	Power-On Button	I	P: Visually inspect the TPLR. V: Verify TPLR has user accessible controls to turn TPLR On, Off, and cause it to revert to factory defaults (Factory defaults invocation is tested as part of requirement 3.6.4).	PASS	The power switch turns TPLR on and off. Holding down the wake/reset button for 2–4 s while powering the TPLR On, sets the TPLR to factory defaults but retains the Unit ID and default Unit Name. Holding down the wake/reset button for 12–15 s while powering the TPLR On, sets the TPLR to factory defaults and requires the Unit ID be reprogrammed via the computer interface.
3.8.2	Power Indication	D	P: Power the TPLR on. V: Verify TPLR indicates the device is powered on. The indication must continue to indicate such as long as the TPLR remains powered on. P: Power the TPLR off V: Verify TPLR indicates the device is powered off. The indication must continue to indicate such as long as the TPLR remains powered off.	PASS	The TPLR power switch causes the TPLR to be powered on and off and is marked ON and OFF. Note: The power switch is overridden when TPLR is connected to a computer via its USB-C interface.
3.8.3	GPS Fix Indication	A	P: Power TPLR off, wait 1 min and power on.	NT	This requirement is redundant to Requirement 3.4.2.
3.8.4	Self-Test Results	A	P: Power TPLR on. Refer to the TPLR IPG, ICG, or other source that documents the self-test pass and fail criteria. V: 1) Verify that the TPLR IPC, ICD, or other source documents both pass and fail criteria for all TPLR self-tests. 2) Verify TPLR indicates pass or fail for all self-tests provided that creating a failing condition is not destructive and nonrecoverable. 3) Record and self-tests not documented on the TPLR IPG, ICD, or source but present in the actual self-test results.	PASS	Verified the TPLR self-test failed when the battery voltage dropped below 3.45 V and when the SD card was full.

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Table 2 Test procedures and results (continued)

Req No.	Title	VM	Procedure (P) and Verification (V)	Pass/Fail	Result values/comments
3.8.5	Stored Access	D	P: Power TPLR on. C: Verify the TPLR provides a continuous external or internal indication that it is successfully storing near real-time data on its removeable storage device. Also verify the indication stops when the storage media is full.	PASS	Initially failed this test (See Section 5). A “full” SD card was defined by the developer as one that has less than 128 MB of free storage. The implementation requires TPLR to report the SD card as full when the SD card has less than 128 MB of free space available. When this condition is met, TPLR will continue to log data until no storage memory is available. When the card becomes full, TPLR will stop logging (not overwrite any data) and present a notification to the user. This performance was verified.
3.8.6	Active Communications Indication		Not tested. To be tested in a later version of TPLR.	N/A	Not tested.
3.8.7	Use of Tools	I	P: Operate the TPLR throughout the test procedure. V: Verify no tools were required to during any TPLR operations to include those functions associated with recharging, and any requirements to use interfaces inside the TPLR enclosure. The use of tools may be permitted to configure or locally command the TPLR via its USB interface.	PASS	Verified no tools are required to execute any user function to include those executable at the computer interface.
3.9	Data Storage	T	P: Power TPLR on. Insert a 32 GB data SD card that is ~99% full. Operate TPLR until the storage media is full. C: Verify TPLR uses at least 32 GB of the storage media and record the behavior of the TPLR when it becomes “full.”	PASS	Verified the TPLR was capable of filling a 32 GB SD card using simulated data. When full, the TPLR display indicated the storage media was full and stopped recording data.
3.10	Mission Duration	T	P: Ensure the TPLR battery is at full capacity. Power the TPLR on and enable it to operate until the battery is expired (as indicated by the lack of a power indication). V: Verify the TPLR power indicator is positive. Inspect the storage media to verify TPLR was continually operational for at least 24 h.	PASS	TPLR was observed to operate in excess of 72 h without being recharged.

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4.1 Verification of the Built-In User Interface: Main Menu

During the TPLR test, the tester verified the functionality of each selectable parameter in the TPLR’s built-in use interface, the range of allowable entries, and where applicable, the parameter’s factory default value. Table 3 details the TPLR main menu.

Table 3 Main menu for the TPLR built-in user interface

Menu ID	Menu item name	Command definition	Valid input	Factory default
0/1	Unit ID	One-time value configured during first-time setup.	1 to 4094	New firmware loads will prompt user for a value. Otherwise, only editable in the maintenance menu.
1	Unit Name	Up to 32 characters	Any 32 characters using any combination of upper- and lowercase letters, numbers, hyphens, and underscores (no spaces).	Logger-Unit ID
2	Symbol Code ^a	MIL-STD-2525 ^b Symbol Code Position 1 and 4 are fixed to “S” (Warfighting) and “P” (Present), respectively.	Not used in TPLR Standard. Format is per MIL-STD 2525.	SKGPEV----
3	CSV Log Enable	Causes TPLR to create a custom log entry for each GPS log entry. See the Appendix.	y (Yes-Enable) or n (No-Disable) ^b	y (Yes-Enabled)
4	NMEA Log Enable	Causes TPLR to create a NMEA-0183 GPGGA and GNRMC log entry for each GPS log entry. See the Appendix.	y (Yes-Enable) or n (No-Disable) ^c	y
5	Log Interval	Enables user to select the interval that GPS position and time may be logged.	Values less than 1 may be 0.2 to 0.9. Values ≥ 1 in whole number to 3600.	y
6	Startup Display	Defines the number of seconds TPLR will pause after initial bootup to enable the user to enter the built-in setup menu.	3 to 254 s	15 s
7	Screen Saver Delay	Defines the number of minutes the TPLR before the screen will start the screen saver function.	3 to 254	15 min

Notes: ID = identification; GPS = global positioning system; NMEA = National Marine Electronics Association; SD = secure digital; TPLR = Target Position Logger-Reporter.

^a Since this function has no use in TPLR Standard, the function should be either removed, made unselectable, or present information that it has no function.

^b MIL-STD-2525. Interface standard, common warfighting symbology. Department of Defense; 2008 Nov 17.

^c All Yes, No, and lettered menu item selections are executable with either an uppercase or lowercase instance of the letter.

Table 3 Main menu for the TPLR built in user interface (continued)

Menu ID	Menu item name	Command definition	Valid input	Factory default
8	Screen Brightness	Defines the brightness level of the TPLR Screen	0 = Bright, do not dim for screen saver 1 = Bright 2 = Medium 3 = Dim	1 = Bright
D	Restore default configuration ^c	Resets all user-selectable settings to the defaults defined in this table.	No selectable options.	User-selectable settings assume values in this table. Unit Name will be “Logger-#” where “#” is the Unit ID Number. Unit ID is not reset by this function.
E	Erase/format sd card ^c	Formats the SD card (and deletes all data)	User is required to confirm this function by entering a randomly generated number that is presented to the user.	N/A
M	Maintenance menu ^c	Causes TPLR to display the maintenance menu. See Table 4	Enter “tplr” when prompted for password.	N/A
X	eXit menu ^c	Causes TPLR to exit the setup menu and begin normal operation as a position logger.	N/A	N/A

Notes: ID = identification; GPS = global positioning system; NMEA = National Marine Electronic Association; SD = secure digital; TPLR = Target Position Logger-Reporter.

^a Since this function has no use in TPLR Standard, the function should be either removed made unselectable, or present information that it has no function.

^b MIL-STD-2525. Interface standard, common warfighting symbology. Department of Defense; 2008 Nov 17.

^c All Yes, No, and lettered menu item selections are executable with either an uppercase or lowercase instance of the letter.

4.2 Verification of the Built-In User Interface: Maintenance Menu

Table 4 details the TPLR maintenance menu. The maintenance menu is accessible from the main menu. When prompted, enter “tplr” to enter the maintenance menu.

Table 4 Maintenance menu for the TPLR built-in user interface

Menu ID	Menu item name	Command definition	Valid input	Factory default
1	Unit ID	Enables user to change the Unit ID number.	1 to 4094	A new firmware load will prompt user for a value. Otherwise, only editable via this menu.
2	SD Card Slot	Informs TPLR if the SD card slot is present (expects an SD card) or absent (do not expect an SD card)	Present or Absent	Present
3	Screen Orientation	Enables user to flip the text on the display 180°	Normal (top of display near top of TPLR) or Flipped (top of display near bottom of TPLR)	Normal
4	Screen Connection ^a	Defines the connection configuration in use. TPLR Standard only uses “Qwiic”	0 = None 1 = QWIIC 2 = Feather	Qwiic ^b
5	Battery ^a	Informs TPLR if the battery is present (installed) or absent (not installed). ^c	Present or Absent	Present
C	Console mode ^d	Enables user console mode to select the interval that GPS position and time may be logged.	Valid console mode options are defined in the console help. Type “help” to view available options.	N/A
G	GPS cold start ^{d,e}	Resets the GPS subsystem’s settings to factory defaults.	N/A	N/A
W	Wipe all configuration from flash ^d	Clears all user-selectable settings as well as other configuration information stored by the system. Use if the TPLR firmware appear to become unstable or corrupted.	User is required to confirm this function by entering a randomly generated number that is presented to the user after selecting the opinion and before confirming the entry.	N/A
X	eXit to main menu ^d	Causes TPLR to exit the Maintenance menu and return to the main menu.	N/A	N/A

Notes: ID = identification; GPS = global positioning system; N/A = not applicable; SD = secure digital; TPLR = Target Position Logger-Reporter.

^a Since this function has no use in TPLR Standard, the function should be either removed made unselectable, or present information that it has no function.

^b Capitalization of the term “QWIIC” is not consistent in the menu.

^c Not applicable to TPLR Standard. This option supports applications which use the TPLR hardware but may not require a battery to be installed.

^d All Yes, No, and lettered menu item selections are executable with either an upper case or lower case instance of the letter.

^e The menu option provides no user feedback or any indication that the function was executed. to confirm the adoption was executed. However, no notable delay in GNSS acquisition was noted after the TPLR was moved significant distances (over 2000 miles).

5. Summary of Test Results

5.1 Summary of Test Findings

With one exception, the First Article Test for the TPLR met all requirements set forth in the TPLR requirements document¹ in the initial test of the TPLR (see Section 5.2). However, several requirements implementations were either not consistent with the vision of the requirements document's author or a portion of the implementation beyond the scope of the requirement failed or demonstrated undesirable behavior. In some cases, the cause of the undesirable behavior was due to abnormal (unlikely) user input. In all cases, a reasonable work-around was found to be effective with no impact on the TPLR's use as a basic position logger.

After a review of the test results, the TPLR developer modified the TPLR Version 4, Update 7, firmware to address the failure and undesirable behaviors. After the First Article was updated with the new firmware (Version 4, Update 9), the TPLR was retested to reevaluate the failure and undesirable behaviors (see Section 5.3). The failure condition was not able to be replicated. The undesirable behaviors were either determined to be suitable or modified as indicated in Section 5.3.

5.2 Details of Test Findings (Version 4, Update 7)

Table 5 summarizes all failures and undesirable behaviors of the First Article TPLR. Table 5 defines the list of failures and undesirable behaviors recorded against the Version 4, Update 7, firmware.

Table 5 TPLR failure and undesirable behaviors (Version 4, Update 7)

Req No.	Description	Discussion/recommendation
Failure		
3.8.5	Note: A “full” SD card was defined by the developer as one that has only 128 MB of free storage. After filling the SD card to this condition, the TPLR continuously rebooted, acquired a fix, and then restarted over 10 times. The TPLR indicated only once that the SD card was unformatted. Switching TPLR on and off, resetting the TPLR to factory defaults, or clearing all user configuration data did not correct the issue.	This problem went away when the SD card was reformatted. Work-Around: Do not use an SD card that has less than 128 MB of free storage.
Undesirable behaviors		
3.2.3	When a logging interval over 1 s is selected, the logger uses a 1-s interval. In addition, the maximum selectable interval is 6553 s (1.8 h) Work-around: None.	Using a 1.8-h logging interval is questionable. A 360-s interval is a more reasonable implementation.
3.5.1	The number of allowed characters (32) exceeds the requirement by 100%. This change impacts the field length associated GUI’s must support.	Determine if Unit Name of up to 32 impacts TPLR-based GUIs in an undesirable manner.
3.5.1	When the 32-character limit is exceeded, the user is presented with an error message that states the <i>Unit ID</i> is limited to 32 characters.	Correct the error message to use the term “Unit Name.” The maximum allowable length should be presented <i>after</i> the user selects the menu item and <i>before</i> the user enters a name.
3.5.1	When multiple special characters were used, the TPLR failed to load the name and entered an unstable error condition. This failure is repeatable by entering the 11 special characters at the top of the keyboard and selecting “n” when confirming the name.	The use of special characters should be limited or disallowed. Although an unlikely user input causes this condition, no erroneous user input should cause the TPLR to become unstable. Work-around: Restart the TPLR and enter a more conventional name.
3.6.1	Three of the selectable menu items (Symbol Code, Display Connection, and Battery) have no practical use for a TPLR Standard user.	Either depreciate the menu item (i.e., gray it out), remove it from the menu, or explain to the user that the function is not applicable to the TPLR Standard configuration.
3.6.1	When the post-boot sequence informs the user to “reformat” the SD card,” the word “reformat” is not in the menu, but rather the term is “Erase.”	Reformat and Erase are often considered to be different functions. Regardless, these terms should match.
3.8.4	Additional information is required to pass/fail the self-test requirement?	Specifically, what is tested and what is the pass/fail criteria for each self/test? a. What is good and bad battery? b. True/false/edit: A “good” SD card is one that the TPLR can write onto and has more than 128 MB of free memory available. c. Are there other self-tests??

Notes: ID = identification; GUI = graphical user interface; SD = secure digital; TPLR = Target Position Logger-Reporter.

5.3 Details of Regression Test Findings (Version 4, Update 9)

Table 6 was created after firmware Version 4, Update 9, was installed and regression tested to evaluate how the developer addressed issues in the Version 4, Update 7, firmware. In Table 6, the description of each Version 4, Update 7, issue is copied into the table and paired to a description of how the issue was observed to be addressed by the new firmware.

Table 6 TPLR failures and undesirable behaviors (Version 4, Update 9)

Req No.	Description of failure/issue	Regression test result/resolution
Failures		
3.8.5	Note: A “full” SD card was defined by the developer as one that has only 128 MB of free storage. After filling the SD card to this condition, the TPLR continuously rebooted, acquired a fix, and then restarted over 10 times. The TPLR indicated only once that the SD card was unformatted. Switching TPLR on and off, resetting the TPLR to factory defaults, or clearing all user configuration data did not correct the issue. This problem went away when the SD card was reformatted.	An investigation into this problem was not able to replicate the failure condition. Subsequently, this issue was deemed an anomaly. It would take months of real-time data to fill the SD card to the volume evaluated by this test. Work-Around: Do not use an SD card that has less than 128 MB of free storage.
Undesirable behaviors		
3.2.3	When a logging interval over 1 s is selected, the logger uses a 1-s interval. In addition, the maximum selectable interval is 6553 s (1.8 h) Work-Around: None.	PASS. The user input interval is now limited to 3600 s (1 h). The selected input is now accepted and properly operates when over 1 s. In addition, the user is informed of the input constraints when the interval change option is selected.
3.5.1	The number of allowed characters (32) exceeds the requirement by 100%. This change impacts the field length associated GUI’s must support.	RESOLVED. The 32-character limit was decided to be desirable.
3.5.1	When the 32-character limit is exceeded, the user is presented with an error message that states the <i>Unit ID</i> is limited to 32 characters.	RESOLVED. The term “Unit ID” has been corrected to “Unit Name.” If the user attempts to exceed the 32-character limit, the user is informed of the limit.
3.5.1	When multiple special characters were used, the TPLR failed to load the name and entered an unstable error condition. This failure is repeatable by entering the 11 special characters at the top of the keyboard and selecting “n” when confirming the name.	RESOLVED. The type of allowable characters is limited to upper- and lowercase letters, numbers, hyphens, and underscore. If the user inputs any other special characters, the user is informed of the input constraints.
3.6.1	Three of the selectable menu items (Symbol Code, Display Connection, and Battery) have no practical use for a TPLR Standard user.	RESOLVED. The three selectable options will be retained and explained in the user manual. It was also determined that the since the MIL-STD 2525 ^a symbol code is recorded in the CSV log, it may be useful to TPLR users.
3.6.1	When the post-boot sequence informs the user to “reformat” the SD card”, the word “reformat” is not in the menu, but rather the term is “Erase.”	RESOLVED. The post-boot sequence text was modified to use the term “Erase/Format” and matches the text in the menu.
3.8.4	Additional information is required to pass/fail the self-test requirement?	RESOLVED. Pass/Fail criteria for the battery and SD card were determined and recorded in the test results.

Notes: CSV = comma-separated value; GUI = graphical user interface; ID = identification; SD = secure digital; TPLR = Target Position Logger-Reporter.

^a MIL-STD-2525. Interface standard, common warfighting symbology. Department of Defense; 2008 Nov 17.

6. Conclusions and Recommendations

The TPLR is a new configuration item that the ARL team is only beginning to use. Furthermore, TPLR use only occurs during a limited portion of the year when instrumented field tests require it. Additionally, it is probable that additional issues may arise as more users interact with the TPLR. Therefore, it is recommended that an effort be made to follow-up with TPLR users after the TPLR has been in service for at least 1 year to determine if any undocumented functional issues or undesirable behaviors are occurring.

7. References

1. DEVCOM ARL. Requirements document, target position logger-reporter. Version 1.1. DEVCOM Army Research Laboratory (US); 2023 Nov.

Appendix. GPS Log Formats

Tables A-1, A-2, and A-3 detail each field of the messages the Target Position Logger-Reporter (TPLR) generates when storing data on its secure digital (SD) card. The GPGGA (GPS) and GNRMC (GLONASS) messages are logged when the user enables “NMEA Logging.” The comma-separated value (CSV) GPS Log is generated when the user enables “CSV (Comma Separated Value) Logging.”

A.1 National Marine Electronics Association (NMEA) GPGGA Message Format

A.1.1 NMEA GPGGA Message Format Example

```

1      2      3      4      5      6      7      8      9      10     11     12     13     14
$GPGGA,193.144,00,3308.67241,N,11714.46945,W,1,06,1.15,119.2,M,-33.3,M,7A

```

Table A-1 NMEA message field details

Field	Description of this field	Field format	Example data
1	Log header.	...	GPGGA
2	Coordinated Universal Time (UTC) time status of position (hours/minutes/seconds/decimal seconds)	hhmmss.ss	202134.00
3	Latitude (DDmm.mm)	llll.ll	5106.9847
4	Latitude direction (N = North, S = South)	a	N
5	Longitude (DDDmm.mm)	yyyyy.yy	11402.2986
6	Longitude direction (E = East, W = West)	a	W
7	GPS Quality Indicator	x	1
8	Number of satellites in use. May be different to the number in view.	xx	10
9	Horizontal dilution of precision	x.x	1.0
10	Antenna altitude above/below mean sea level	x.x	1062.22
11	Units of antenna altitude (M = meters)	M	M
12	Undulation - the relationship between the geoid and the WGS84 ellipsoid	x.x	-16.271
13	Units of undulation (M = meters)	M	M
14	Age of correction data (in seconds) The maximum age reported here is limited to 99 s. Empty when no differential data.	xx	...
15	Differential base station ID, empty when no differential data.	xxxx	...
16	Check sum	*hh	*48
17	Sentence terminator		[CR][LF]

A.2 NMEA GNRMC Message Format

A.2.1 NMEA GNRMC Message Format Example

```

1      2      3      4      5      6      7      8      9      10     11     12     13
$GNRMC,143909.00,A,5107.0020216,N,11402.3294835,W,0.036,348.3,210307,0.0,E,A*31

```

Table A-2 NMEA GNRMC message field details

Field	Description of this field	Field format	Example data
1	Log header.	...	GPRMC
2	Coordinated Universal Time (UTC) time status of position (hours/minutes/seconds/decimal seconds)	hhmmss.ss	143909.00
3	Position status (A = data valid, V = data invalid)	x	A
4	Latitude (DDmm.mm)	11.1111	5107.00202
5	Latitude direction (N = North, S = South)	x	N
6	Longitude (DDDmm.mm)	11.1111	11402.3294835
7	Longitude direction (E = East, W = West)	x	W
8	Speed over the ground in knots	n.nnn	0.036
9	Track angle in degrees True	nnn.n	348.3
10	Date	yymmdd	
11	Unused	N/A	N/A
12	Unused	N/A	N/A
13	Positioning system mode indicator, A = Autonomous, D = Differential, E = Estimated, F = Float RTK, M = Manual input, N = No fix, P = Precise, R = Real time kinematic, S = Simulator	x	E
14	Navigational Status: S = Safe, C = Caution, U = Unsafe, V = Void	x	S
15	The checksum data, beginning with *	*cs	*31

A.3 CSV Message Format

A.3.1 CSV Message Format Example

```

1 2 3 4 5 6 7 8 9 10 11 12 13 14
5, Logger- SKGPEV- 2024-02- 1, 32.70175, -114.608, 76.8, 4.1, 15.8, 1.7, 5, 3.99, 9.7
5, ---, 05T06:24:24.084,

```

Table A-3 CSV message field details

Field	Description of this field	Field format	Example data
1	Logger Unit ID Number (0-4096)	hhmmss.ss	5
2	Logger Unit Name (32 characters maximum; upper- and lowercase letters, numbers, underscore, and hyphen)	An_-32	Log-Veh_1
3	MIL-STD 2525 ^a (Positions 1 and 4 fixed to meet cursor or target requirements)	See MIL-STD 2525	SKGPEV----
4	Date and Coordinated Universal Time (UTC)	yyyy-mm-ddT hh:mm:ss.sss	N
5	Valid Indicator. 0 = No 'Valid Fix', 1 = Valid Fix, 2 = Position data further corrected by differential system.	n	1
6	Latitude in decimal degrees (DD)	ll.lllll	32.70175
7	Longitude in decimal degrees (DD)	ll.lllll	114.60812
8	Mean sea level (MSL) altitude in meters	mm.m	-76.8
9	Speed in meters per second	s.s	4.1
10	Course in degrees true	cc.c	15.8
11	Horizontal dilution of precision (HDOP)	hh.h	1.7
12	Number of satellites in use. Number of satellites displayed but not logged.	nn	5
13	Battery voltage	bb.bb	3.99
14	Temperature in degrees Celsius	tt.tt	19.7

^a MIL-STD-2525. Interface standard, common warfighting symbology. Department of Defense; 2008 Nov 17.

List of Symbols, Abbreviations, and Acronyms

A	Analysis
ALC	Adelphi Laboratory Center
ARL	Army Research Laboratory
CSV	comma-separated value
D	Demonstration
DEVCOM	US Army Combat Capabilities Development Command
GLONASS	GLObalnaya NAVigatsionnaya Sputnikovaya Sistema
GNSS	Global Navigation Satellite Systems
GPS	global positioning system
h	hours
I	Inspection
ICD	Interface Control Document
ID	identification
IPG	Interface Programmer's Guide
N	No Test
NMEA	National Marine Electronics Association
OPSEC	Operations Security
P	Procedure
SD	secure digital
T	Test
TPLR	Target Position Logger-Reporter
USB	Universal Serial Bus
UTC	Coordinated Universal Time
V	Verified
VM	verification methods