TeleLaunch
The Altus Metrum Wireless Launch Control System

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License

Acknowledgments

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Thanks also to our friends in the Kloudbusters, both for helping us understand what it takes to run truly great large-scale launches, and for providing some completely deserved, scathing feedback on an early prototype of TeleLCO.

Have fun using these products, and we hope to meet all of you out on a rocket flight line somewhere.

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Chapter 1. Introduction and Overview

Welcome to the Altus Metrum community! Our circuits and software reflect our passion for both hobby rocketry and Free Software. We hope their capabilities and performance will delight you in every way, but by releasing all of our hardware and software designs under open licenses, we also hope to empower you to take as active a role in our collective future as you wish!

Thank you for your interest in TeleLaunch, a wireless control system for launching hobby rockets. Each TeleLaunch system contains at least two units, a launch control box (TeleLCO) and one or more launch initiation boxes (TeleFire). In this manual, we hope to provide all the information required to configure and successfully operate a TeleLaunch system.

Unlike other Altus Metrum products, that are usually provided as circuit boards that the user must arrange to mount and wire up, all products in the TeleLaunch system are sold as fully packaged, almost-ready-to-use units. This means that with only minimal one-time configuration of each unit, a TeleLaunch system can be made ready for use very quickly.

Because documentation is just as prone as software to contain "bugs", and can always be improved… If you have questions that aren't answered in this manual, or just need a little help figuring things out, we strongly suggest joining the Altus Metrum user email list, which you can do by visiting https://lists.gag.com/mailman/listinfo/altusmetrum.

Chapter 2. Configuration

There are three things you need to configure identically in each unit that is part of a TeleLaunch system for wireless communications to succeed. Those are the operating frequency, the callsign, and a key for the AES encryption algorithm. Additionally, each TeleFire unit also needs to be configured with a unique bank number.

Please note that these values must match exactly, or the system will not operate as expected. That means the callsign needs to have the same choices of upper or lower case, no trailing spaces, etc. And the operating frequency and AES key must match.

2.1. Connecting to a Unit

Configuring each unit of a TeleLaunch system requires use of a micro USB cable, and a computer with a suitable terminal emulation program. Connect a suitable cable, open your favoriate terminal emulation program, and power up the unit. By pressing <enter> you should see a command prompt.

2.2. TeleLCO

The USB connector on TeleLCO is accessible without opening the lid of the Pelican box. Look for the blue dust cap over the connector under the handle.

2.3. TeleFireEight

The USB connector on TeleFireEight is located on the circuit board. To access it, open the box and flip the lid up. you should be able to spot a vertical micro USB connector on the board near the DIP switch.

⚠️ Please take care when closing the TeleFireEight lid not to pinch any wires.

2.4. Operating Frequency

The TeleLaunch system supports operation over much of the "70cm" Amateur Radio band, with the filters optimized for a center frequency of 435 MHz. For each system, a single operating frequency should be selected and programmed into each unit.

The default frequency for units leaving the factory is 435.750 MHz. Since Altus Metrum flight computers operate by default on 10 100khz channels from 434.550 to 435.450 MHz, we chose this frequency to be far enough away from flight computers to avoid any interference, but still close enough to the radio subsystem design center frequency for great performance.

To configure the frequency, use your terminal emulator to issue two commands. First, use 'c F xxxxxx' where the xxxxxx is replaced with the desired operating frequency in kHz. Then use the 'c w' command to save this value into non-volatile memory. For example, the default 435.750 MHz would be configured using

c F 435750 c w

Note that the 'f' parameter is a frequency calibration value that you really, really, really don't want to change. So, please be careful to make sure you use capital 'F', not lower case 'f' when changing the operating frequency!

2.5. Callsign

In the US, you need an amateur radio license or other authorization to legally operate the radio transmitters that are part of TeleLaunch.

The default callsign shipped from the factory is "N0CALL", which is not a valid callsign and meant to humorously point out that the callsign hasn't been configured yet.

Individual owners of a TeleLaunch system should use their own callsign.

Club owners of a TeleLaunch system should pick the callsign of one club member who is willing to be designated as the control operator of the system. Under FCC Part 97 rules, being the control operator does not mean you have to be LCO all the time, it just means taking responsibility for ensuring the system is being operated in compliance with the rules.

To configure the callsign, use your terminal emulator to issue two commands. First, use 'c c callsign' to set the callsign, then use 'c w' to write to non-volatile memory. For example, to set the default N0CALL, the commands would be

c c N0CALL
c w

2.6. AES Key

For safety, TeleLaunch uses cryptographic checksums to help prevent interference, intentional or un-intentional. This means each system must have a shared AES encryption key identically configured into each unit.

The key size required is 128 bits, which must be expressed as a 32-digit hexadecimal number.

To configure the AES key, use 'c a key' followed by 'c w' to write the key to non-volatile memory. For example, to configure your system with a key that is the answer to life, the universe, and everything, the commands would be

c a 00000000000000000000000000000042
c w

2.7. Bank Number

Each TeleFire unit needs to be configured with a bank number, and bank numbers should be unique within a given system. For most systems with 8 or fewer banks, just use the DIP switch on the circuit board inside the TeleFire unit to select the desired bank. Only one switch should be turned on. Switch one means bank one, etc.

To allow systems to have more than 8 banks, if all the DIP switches are "off", the unit will use the bank configured in non-volatile memory.

To configure the bank number, use 'c B bank' followed by 'c w' to write to non-volatile memory. For example, to set the bank to 42, the commands would be:

c B 42
c w

Chapter 3. Operation

Operating a TeleLaunch system is pretty easy, and we hope fairly intuitive for anyone who has ever launched rockets before. Basic instructions are printed on a decal inside the lid of each TeleLCO unit, which early customers (before this manual was even written) reported were sufficient to successfully use the system.

The remainder of this section assumes the system has already been properly configured with callsign, AES key, and bank numbers for each TeleFire box.

3.1. Charging Batteries

TeleLCO has an internal Lithium Polymer battery that is charged over USB. A weather-tight micro USB connector is installed with a blue cap under the handle. This position was chosen so that TeleLCO can be charged while the lid is closed and standing handle-up. Attach a micro USB cable to a computer or other source of USB power. There are two charge indicators on the panel that will illuminate during charging, red for charge in progress and green for charge complete.

TeleFire has an internal sealed lead acid 12V battery, and is provided with an external AC charger. Connect this charger to the PowerPole connector on the back face of the box to charge the battery. Other sources of charging current for a nominal 12V sealed battery may be used. The charge connector can also be used to attach an external battery if needed.

3.2. Setting Up

Each unit in the TeleLaunch system needs a suitable antenna attached. A typical configuration would involve the provided omni-directional antenna or optional directional antenna aimed at the field mounted on a pole attached to TeleLCO at the launch control station, and the provided rubber whip antennas on each TeleFire box.

If deploying the system in rough terrain, on a field with dense vegetation, or at great distances (some away cells), you may need a better antenna or at least to mount the antenna higher off the ground. All units in the TeleLaunch system have tri-color RF signal strength indicators. A system should show green on all units during normal operation. An occasional dip to amber is ok, but frequent amber or any red indicates a need to improve the antenna situation.

Antenna made for use near 435 Mhz in the ham radio "70cm band" should work, and there are many online sources of information on making inexpensive, highly effective antennas at home.

The TeleLCO unit should be placed on a table at the Launch Control position. It can be helpful for the LCO (the human(s) too, not just the electronics!) to be provided with some shade, but the use of reflective LCDs for the digit displays and ultri-bright LEDs make TeleLCO operation reasonable even in direct sunlight.

Each TeleFire box should be placed in proximity to the launch rails it will service. Whip clips made from AC power cords (not provided) should be attached to TeleFire and routed to each launch rail. The pyro output on each channel is connected to the "line" and "neutral" pins on the

outlet, while the ground pin is attached to chassis ground.

3.3. Turning System On

Turn on all TeleFire pad boxes in the system. At power-on, all LEDs will turn on briefly so you can verify they're all working. The radio signal strength indicators will show red until TeleLCO is turned on.

Turn on TeleLCO. All LCD segments and LEDs will turn on briefly so you can verify they're all working. An exception are the two battery charger LEDs, which only illuminate when the battery is charging. The LCD displays will then briefly display the internal battery voltage, which should be at least 3.9V for normal operation. TeleLCO then scans to locate all TeleFire boxes that are in range and configured for the same frequency, callsign, and AES key. During this process, the Bank LCD diplays will appear to be counting up from 1 to 99. When the search is complete, the Pad display will show the number of TeleFire devices found. TeleLCO beeps when ready.

3.4. Launch One Rocket

Switch the TeleFire to 'Safe' and confirm it is silent.

Put a rocket on a launch rail / rod, and connect whip clips from a pad output on a TeleFire unit to the motor igniter. Verify igniter continuity using the LED associated with that output. Green is good.

Switch the TeleFire unit from 'Safe' to 'Arm', at which point it will start "chirping" to indicate that it is "armed and dangerous". Move to the TeleLCO at a safe distance away.

Ensure the TeleLCO blue Drag Race switch is on Normal and the blue Drag Race LED is extinguished.

Select the desired TeleFire unit by pushing the TeleLCO selector knob until the "Bank" LED is lit, then rotating the knob until the desired box is selected. Then push the knob until the Pad LED is lit and rotate the knob until the desired pad is selected. Verify the Remote Armed LED is lit, and that the selected pad's Igniter Continuity LED is lit.

Perform range safety checks.

Move the TeleLCO SAFE/ARM switch to ARM. This will cause the selected TeleFire unit's strobe to start flashing and siren to become more insistent.

Perform count-down.

Depress the LAUNCH button and hold until the rocket launches.

Move the TeleLCO SAFE/ARM switch back to SAFE.

3.5. Launch A Multi-Rocket "Drag Race"

To enable drag race mode, move the TeleLCO blue switch to Drag Race. The blue Drag Race LED should illuminate.

Select pads to include in the drag race by using the same process as for a single rocket to select each Bank and Pad, then press Add/Remove to toggle the currently selected pad in the race. The continuity LEDs blink ON/off for selected, and on/OFF for deselected (long ON means in the race).

A drag race can be configured to include pads on multiple TeleFire boxes, but the blinking continuity indicators to show which pads are included can only indicate the currently selected bank.

Verify remotes are ready and armed by using the Remote Armed and Igniter Continuity LEDs.

Perform range safety checks.

Move the TeleLCO SAFE/ARM switch to ARM. This will cause the selected TeleFire units strobes to start flashing and sirens to become more insistent.

Perform count-down.

Depress the LAUNCH button and hold until rockets launch.

Move the TeleLCO SAFE/ARM switch back to SAFE.

Move Drag Race switch back to Normal.

Note that if there is a mis-fire in a drag race and you want to fix igniters and try again, the current drag configuration is preserved as long as you stay in Drag Race mode. So you can SAFE the system, fix igniters, and try again before leaving Drag Race mode if desired.

Chapter 4. Specifications

The TeleLaunch system can handle up to 99 banks with each bank having up to 8 pads, for a total of 792 pads.

Each unit in the TeleLaunch system is water-resistant, but is not intended to be directly immersed in water. Brief rain showers during a launch should pose no problem, but it's recommended to cover units or bring them inside when not in use or during extended periods of bad weather.

TeleLCO uses an internal single-cell 2Ah Lithium Polymer battery, which is sufficient for multiple days of typical operation. This battery is charged over USB.

TeleFire uses an internal sealed lead-acid 12V battery, which is charged by an external charger attached through the PowerPole connector on the rear panel.

Pyro initiation uses the 12V sealed lead-acid battery. Current to any pad can exceed 30A, and with typical igniters every pad on a TeleFire can be successfully included in a drag race. The system controls current flow to prevent damage, and has a self-resetting circuit breaker for ultimate protection should something go badly wrong.

TeleLaunch uses AES encryption with a shared key between each unit in the system to ensure the integrity of safe launch operations.

The TeleLaunch system uses radio frequency communications in the vicinity of 435 Mhz. A US amateur radio license or equivalent authorization is required to legally use the system. The operating frequency should be chosen to avoid conflict with other devices, or put differently, nothing else should be operating on the same frequency while TeleLaunch is in use.

Chapter 5. Updating Firmware

The firmware for each unit can be updated over USB. More details will be forthcoming if/when a firmware update is required.

Appendix A: Making Pad Cables

Pad cables can be made from standard AC extension cords and alligator clips...

Appendix B: Troubleshooting

B.1. TeleFire Fails to Arm

If turning the TeleLCO key switch from "SAFE" to "ARM" does not cause the selected TeleFire box to start flashing and sounding its siren, the most likely cause is that the TeleFire box was left with the local safe/arm switch in the safe position. The Remote Arm LED on TeleLCO shows the state of the safe/arm switch on the currently selected TeleFire box and can be used to confirm this situation.

Note that in a cross-bank drag race configuration, any TeleFire boxes involved in the drag race that are fully armed will launch, while any TeleFire boxes involved in the drag race that are not fully armed will not launch. Pay attention to make sure all involved TeleFire boxes are flashing their strobe lights and sounding their sirens before launch to ensure all desired rockets will actually participate in such a drag race.

B.2. Radio Signal Strength

Each unit in the TeleLaunch system has a debugging feature that can be used to view the actual received radio signal strength of each packet. To use this feature, connect to the desired unit (TeleLCO is probably the most useful place to start) with a laptop and terminal program as explained in the configuration section of the manual. Then, you can enable debug tracing using 'D 1' command.

Debug mode is fairly chatty, but each time the TeleLCO unit queries the currently selected TeleFire unit for igniter status, the return packet will print out the RSSI value. RSSI is "received signal strength indicated" and is expressed in decibel units relative to a milliwatt, or "dBm".

Observing the RSSI is a great way to compare antennas, antenna mounting arrangements, and so forth with more granularity than provided by the red/amber/green operational LED indicators.

The system is good down to below -100dBm, and it takes about 6dB to double the range. So a reading of -80dBm means that you could extend the distance between the units by a factor of 10 before losing the link. Note, however, that real world range is affected by terrain, vegetation, etc. And you really don't ever want to be operating close to the minimum signal threshold! Keep the RF signal indicators green with good antenna choices and installations for maximum satisfaction.