GLS-Emergency Preparedness

Make a Heliograph for EmComm

http://www.gregleesays.com gregleesays@gmail.com

Emergency preparedness for resilience and sustainability.

This paper includes an excerpt from "The Book of Stars" by A. Frederick Collins, 1920, pp. 38-42.
It is presented here under the educational copyright free use clause.

This is part of the GECO Non-Radio Emergency Communications (EmComm) methods. It is presented as an alternative means of communication when radios are not available. EmComm capacity improves community disaster response and resilience. These non-radio communication methods can be taught to elementary school students. It integrates classroom academics and practical skills with emergency preparedness. It conforms to GLS Community-based Education (C-bE) **STEAMING** (**S**cience, **T**echnology, **E**ngineering, **A**rts, **M**athematics **I**ntegrating **N**ature and **G**eography).

STEAMING Components	
☑ Science	Astronomy, Physics
☑ Technology	Construction skill, use of tools
☑ Engineering	Construction knowledge
☑ Arts	Language, reading and following directions, interpreting diagrams and drawings, Morse code
☑ Mathematics	Measurement, fractions
☑ Integrating	Interdisciplinary study
☑ Nature	Types of natural disasters, weather
☑ Geography	Latitude, seasons, length of day

Introduction: A heliograph is an effective emergency communication (EmComm) using sunlight and Morse code to send flashing light messages a long distance. Historically, heliographs were used by the military to transmit messages line of sight (LOS) from mountain top heliograph stations. On a clear day and the size of the mirror, messages could be transmitted about 32, 64, 128, or 161 km.

Here are the instructions for making a simple heliograph by A. Frederick Collins excerpted from his book "The Book of Stars," pages 38-42.

"Signaling with the Sun's Rays. *— There are many ways of sending a signal or a message across space by day, as, for instance, by means of smoke, by flags and flashes of sunlight; by bonfires, pine-knot flames and burning arrows by night, and by wireless, which can be used either by day or by night.*

A simple and effective way to signal in the daytime when the Sun is shining is by using a mirror, that is, a looking glass, as it is commonly called. Every boy knows how to make flashes with a mirror, so it will be enough to say here that the glass is held in the hand in such a position that the sunlight falling upon it will be reflected in the direction you wish to send the signals. Fig. 38 shows how it is done.

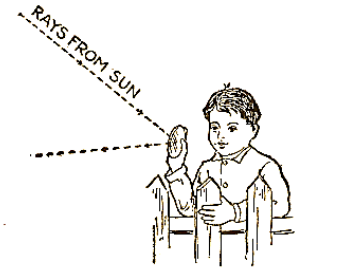


FIG. 38.—BOY SENDING FLASH SIGNAL WITH MIRROR.

Any sort of a code can be used, but it is far more interesting and will prove very useful if you are able to send and receive messages in the dot and dash alphabet, or Morse telegraph code, which is given in Fig. 39. A short flash represents a dot, a long flash a dash and short and long flashes represent letters. This is the same code that is used for wireless telegraphy.

How to Make a Simple Heliograph.-*A heliograph is merely a mirror mounted on a baseboard, but this is a big improvement rather than holding the mirror in the hand, for to send receive flashes over long distances the mirror must be carefully aimed and kept in position.*

To make a heliograph, get a board 12 inches long, 4 inches wide and 1 inch thick and cut a piece out of one end 4 inches long and 1 inch wide, as shown in Fig. 40. Bore a 1/4-inch hole through the slotted end and another 1/4-inch hole 4 1/2 inches from the slotted end, as shown in the cut.

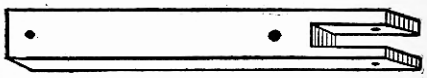


Fig. 40.—Base for Heliograph.

Make a block of wood 4 inches long, 1 inch wide and 1 inch thick and bore a %-inch hole through it near one end. To the other end of this stick fasten a mirror about 4 inches square. This mirror should be perfectly smooth—a plate glass mirror is the best—and have a hole 1/16 inch in diameter drilled through the center of the mirror for sighting the heliograph, as shown in Fig. 41. Any optician will drill the hole for you for a quarter or less. Fig. 42 shows a top view of the heliograph and Fig. 43 shows a side view of it*

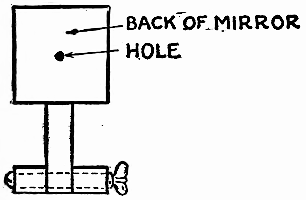


Fig. 41.—Back View of Heliograph.

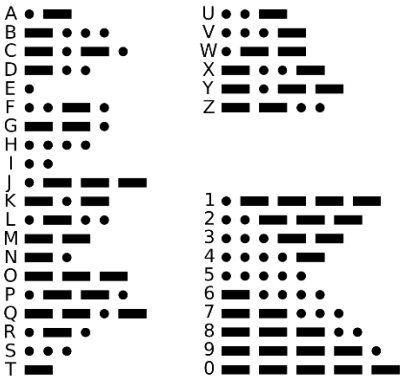
Make a wood frame so that the mirror can be fastened in it and screw the frame to a stick of wood. Get a bolt 5 inches long and 1/4 inch in diameter and have a thumb screw fitted to it. Set the end of the stick which has the mirror fastened to it into the slotted end of the baseboard, push the bolt through the holes and after slipping on the washer put on the thumb screw. The mirror can now be moved back and forth.

Into the hole in the front part of the base put a wire or a thin round stick to sight the mirror by. The heliograph is now ready for use.

After sighting the mirror at the place where the signals are to be received, set the mirror so that the reflected beam of sunlight shines directly on the place. To send signals in the Morse code all you need to do to make dots and dashes is to place a sheet of cardboard before the mirror and take it away; the length of time the mirror remains uncovered determines whether it is a dot or a dash. The heliograph complete is shown in Fig. 44." ◆

International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.



This replaces Continental Morse Code chart in the original article. (See also the Q codes later in this paper.

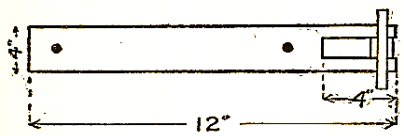


Fig. 42.—Top View of Heliograph.

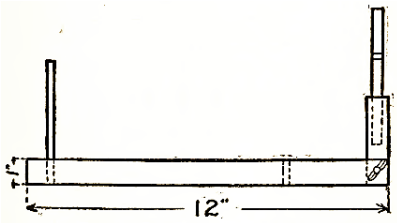


Fig. 43.—Side View of Heliograph.

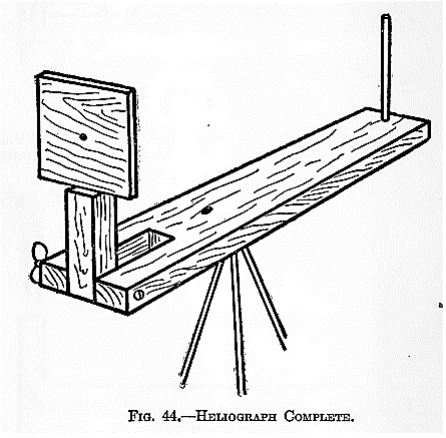


Fig. 44.—Heliograph Complete.

***Note:** Rather than drilling a hole in the glass mirror, you can consider very carefully scraping off the coating on the back of the mirror.

Possible GECO Refinements: We suggest considering adding these to your heliograph. These enhancements and adaptations may make it easier to use your heliograph.

1) Use a Tripod: You can drill a hole and glue an appropriate size nut for the camera tripod mounting screw to the underside of the heliograph base board. A camera tripod provides a stable mount. It will make it easier to set up and use the heliograph.
2) Circular Bubble Level: This will make it easier to "level" the heliograph for use. Permanently mount the bubble level on the upper surface of the heliography base board. Some camera tripods come with bubble levels.
3) Use of "Q-codes" and Morse Code Abbreviations: In amateur radio, Q-codes and Morse Code abbreviations help to speed up sending messages. Morse code letter abbreviations were created for common phrases. It was faster to send the Q codes than to spell out the entire phrase. We've selected a few of the "Q-codes" and Morse abbreviations to use with the heliograph to help speed up sending messages. If the receiving station does not know or use these abbreviations, just spell out the phrase in full.

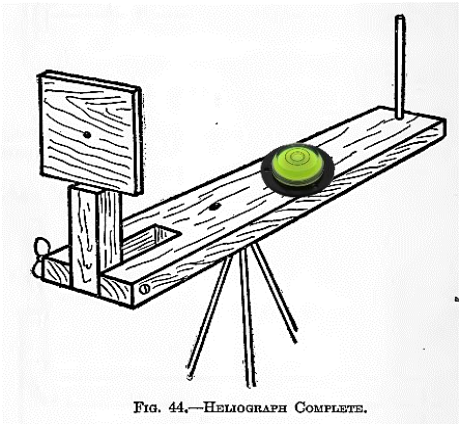


FIG. 44.—HELIOGRAPH COMPLETE.

Selected Abbreviated Codes Adapted Amateur Radio

Q-codes		Morse Code Abbreviations	
QRA	My station Name	AGN	Again, repeat
QRQ	Send faster	AR	End transmission
QRS	Send slower	AS	Wait
QRT	Stop sending	CFM	Confirm
QRU	Nothing to report	C	Yes, Correct
QRV	Have you anything for me?	CL	Closing my station
QRX	I will call again (at) ___(time); standby	CQD	Distress call following (send before SOS)
QRZ	Who is calling?	K	Invitation to transmit
QSL	Received and understood	N	No

Note: For non-radio EmComm, it is recommended a school make these simple heliographs in pairs. This way a team of students can practice sending and receiving signals.

Operating Considerations:

1) Bright Sun and Clear LOS: A heliograph needs sunlight to work. Sending and receiving stations must have a clear line-of-sight to each other.
2) Heliograph Station Equipment: The heliograph, Morse code card, watch, binoculars, magnetic compass, whistle, note pad and pen, logbook and, tripod. A megaphone (optional) to relay messages by voice if near command center. It may be helpful to have one at the command center, too. (See how to make one later in this paper.) Be prepared to hand-carry written messages to the command center if needed. If no watch is available, indicate the time as "morning" (dawn to noon), "afternoon" (noon to dusk) or "night" (after sunset and before sunrise). The sequence number provides a general idea of the time (though not a very precise). Consider making a portable sundial and practice using it before an emergency arises.

3) Operating Team: We suggest organizing teams of 4 people: 1) *Heliograph operator* (responsible to send messages); 2) *Observer / Recorder* (uses binoculars to observe incoming messages and records them on paper. Be sure to note date and time of the messages sent and received. (See sample message for later in this paper); 3) *Messenger* (can either shout message to station leader or hand carry written message as needed); and 4) an *Alternate* (keeps the message log; be ready to

take the place of other team members as needed). Everyone must cross train to do every job.

4) Keep a Message Log: Record each message by type (TX for sent or RX for received), date, time, and ID sequence number. (See sample Logbook later in this paper.)
5) Operating Accessories and Supplies: Have the basics of water, food, and shelter for team comfort. Prepare to be on station during daylight hours.
6) Heliograph Operating Sites: Consider selecting multiple heliograph stations. Designate a main station at the command center. Assign stations to monitor and report on key points of interest (e.g. shelters, evacuation routes, bridges, landslide areas, supply depots, landing zones, etc.). Record the station location (latitude, longitude, elevation above mean sea level, LOS distance and magnetic azimuth to all other stations), access route, physical site description with photos during different seasons. This is helps anyone not familiar with the site to find it.
7) Periodic EmComm Testing: Schedule regular training / practice operating from all heliograph stations to confirm the network and operators are operationally ready.
8) Possible Night Operations: Operations could be carried out at night IF a bright light illuminates the mirror in place of the sun. You should try this out before making it operational.

Make a Simple Megaphone / "Bat Ears:" We recycled a large plastic drink cup to make a combination megaphone / "Bat Ears." Carefully cut out the bottom of the cup. We put a lanyard on ours to make it easy to put around our neck. If you are near the command center, you can blow your whistle to get their attention. Then talk into the small end of the megaphone to project your voice. Hold the small end up to your ear to improve receiving the voices from others talking to you.

Sample Message Form: We assume some one in the command center will write the messages you will send. These messages would be transmitted by the heliograph operator. We suggest the message header have this information on it.

TX Header: Large letters "TX" at the upper left corner shows this is a message to be sent (TX = transmit).

TX	Date	Time	Msg Author	RX Sta. ID
Message To				
Heliograph Station Team Completes Items Below				
Seq #	TX Date	TX Time	Notes	
RX Sta ID	TX Operator	Msg RX ☐ confirm ☐ unconfirm		

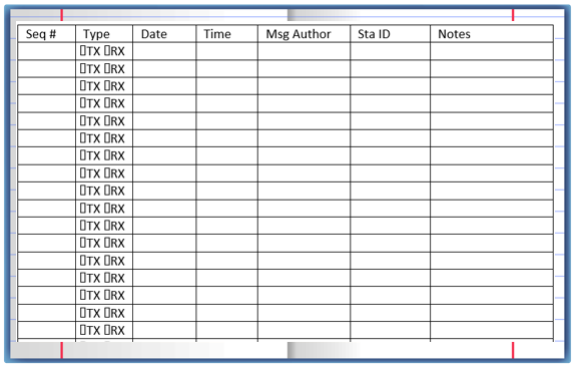
RX	Date	Time	Msg Author	TX Sta. ID
Message To				
Heliograph Station Team Completes Items Below				
Seq #	RX Date	TX Time	Date/Time message delivered to addresse	
TX Sta ID	TX Observer	Msg RX to TX ☐ confirm ☐ unconfirm		

Date: Use the format YYYY-MMM-DD. For example, 2020 Jan 15.
Time: Use 24-hour format in local time and note the UTC zone offset. For example, 0630 (UTC -8).
Message Author: Name of the person authorized to write the message. Any reply would be addressed to the message author.
Message Destination Station ID: Name of the heliograph station to receive the message.
Message To: The message begins with the name of the recipient.
Space for the Heliograph Team Notations: Message sequence number, date and time assigned when it arrives at the TX heliograph station; TX operator, confirmation RX station got the message.

RX Header: Large letters "RX" at the upper left corner show this is a received message (RX = received).
Date: Using the format YYYY-MMM-DD. For example, 2020 Jan 15.
Time: Use 24-hour format in local time and note the UTC zone offset. For example, 0630 (UTC -8).
Message Author: Name of the person originating the message. Any reply is addressed to the message author.
Message To: The message begins with the name of the recipient.

Space for the Heliograph Team Notations: Message sequence number, date and time assigned when it arrives at the RX heliograph station; TX station ID, RX Observer, confirmation to TX station acknowledging message received.

Sample Logbook Page: We suggest using a bound notebook or tablet as a Logbook. This will keep all the pages in order. The messages (both sent and received) are recorded sequentially with notes made in the appropriate columns. The notebook should be opened fully, so pages on both halves lay open. The header extends across the top of both pages of the notebook.



Seq #	Type	Date	Time	Msg Author	Sta ID	Notes
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					
	☐TX ☐RX					

Sequence #: Upon receipt of any message, enter the first available sequence number from the logbook into the proper space on the message form.

Message Type: Check the TX or RX box using the letters on the upper left corner of the message form.

Date: Write the date the message was transmitted (TX) or received (RX) at the heliograph station. Use the format YYYY-MMM-DD. For example, 2020 Jan 15.

Time: Use 24-hour format in local time and note the UTC zone offset. For example, 0630 (UTC -8).

Message Author: Use information from the message form.

Station ID: Use the information from the message form.

Notes: You should indicate the date/time any received messages were sent from the heliograph station to the addressee.

Attracting Attention: An added use of the heliograph is to attract attention of search and rescue aircraft, ships or ground teams. You have two basic choices: 1) flash S-O-S repeatedly in all directions. Then listen and watch for rescue services. 2) flash the mirror (no message, just several mirror flashes) while slowly sweeping the horizon all around your station. As the search and rescue unit gets closer, transmit your station or village name. Be careful your mirror flashes do not blind the search and rescue people.

Conclusion: Making a simple heliograph as a student project is a good way to prepare students for emergency communications (EmComm). They get to use school lessons in a practical project. It helps their school and village build emergency preparedness capacity and disaster resilience. Having a non-radio EmComm capability is vital skill following a disaster.