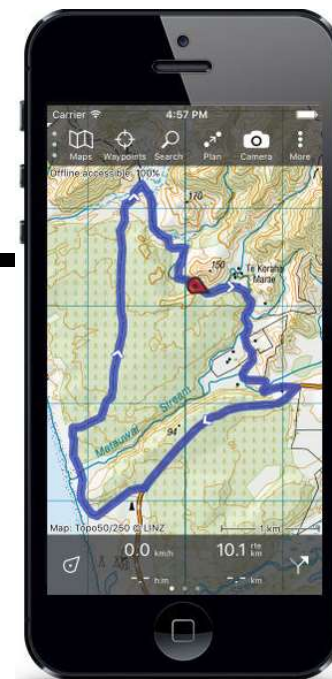


Wilderness GPS Navigation

Olympia Navigation Committee
The Mountaineers

Topics to Discuss

- GPS System Overview
- Devices: Smartphone vs Dedicated
- GPS Limitations
- Use: waypoints, routes vs tracks
- File Types
- SATCOM/ Emergency Use



If You Remember Nothing Else ...

Trust, But Verify

- GPS works best when used with a brain.

**GPS works together with
Map, Compass, Altimeter**
- It doesn't replace them.



Map



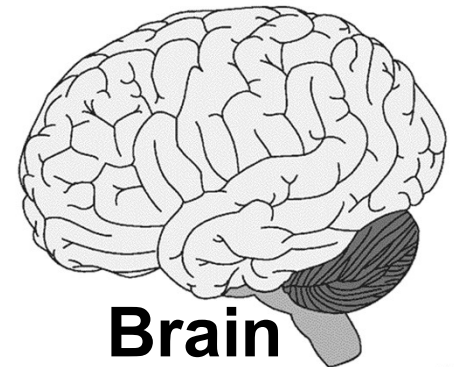
Compass



Altimeter



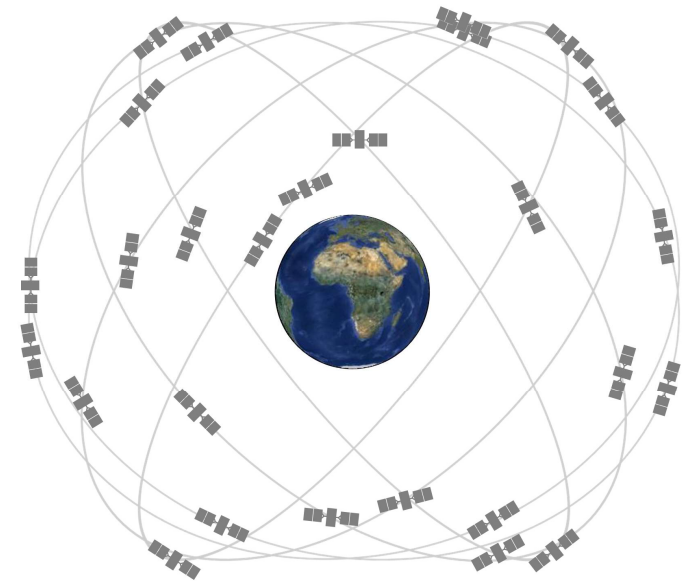
GPS



Brain

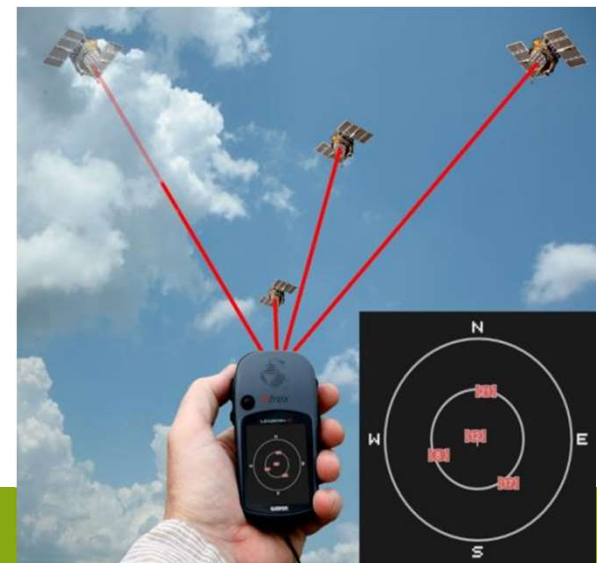
Global Navigation Satellite Systems

- (31) NAVSTAR/GPS (United State/ Space Force) 1993
- (24) GLONASS (Russia) 1995
- (30) GALILEO (Europe) 2016
- (45) BeiDou (China) 2018



How does GPS Work?

- Users need 3 or more satellites for **trilateration**
- 11 hours 58 minutes to orbit the Earth
- Satellites are continuously transmitting the current time and orbit information
- The GPS receiver calculates Time of Flight (TOF) of the signal from the satellite to the receiver
- The distance to the satellite can be calculated from the TOF
- $\text{TOF} = 12,550 \text{ mi} / 186,000 \text{ mi/s}$
- $\text{TOF} = 0.0675 \text{ seconds}$



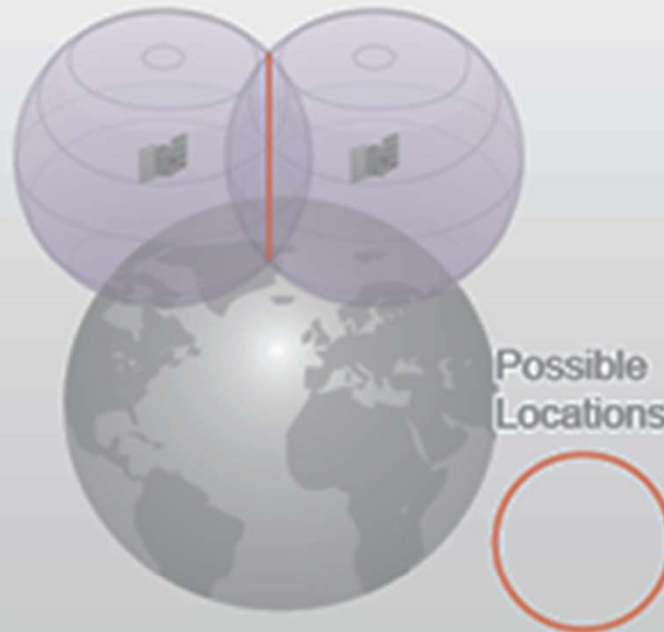


But really, we need to think about Spheres: Ideally, Four Satellites With Dispersed Positions

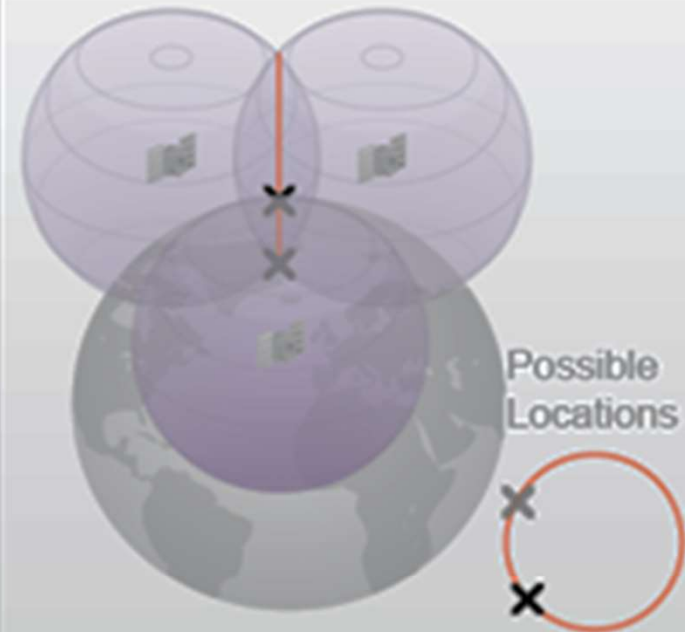
Satellite Ranging



One satellite: Position is anywhere on surface of sphere.



Two satellites: Position is anywhere on circle where spheres intersect.



Three satellites: Position is one of two locations where all three spheres intersect.

GPS Device can provide ...

- **Moving map centered on user**
- Location, Bearings, Routes, Elevation
- Record Tracks
- Distance & Elevation calculations
- Multiple maps, layers, images, etc
- Digital compass
- Audible alerts to locations, altitudes, time

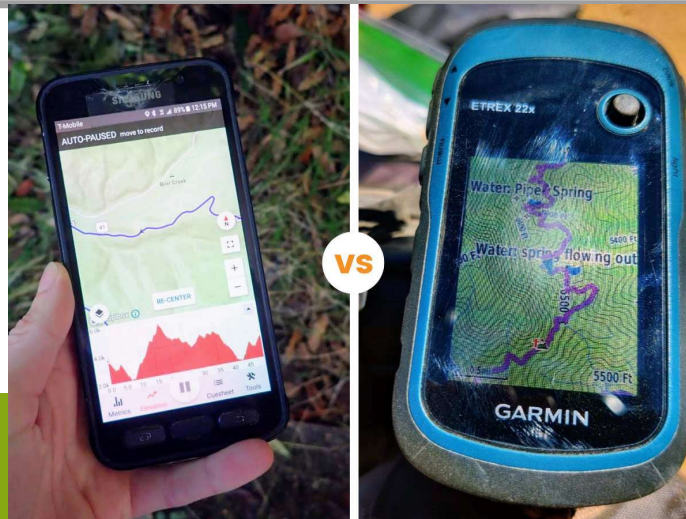
A GPS is a: Map, Compass, Altimeter, Clock, ...

Smartphone vs Dedicated Device

Vigorous debate = you decide for yourself

Advantages

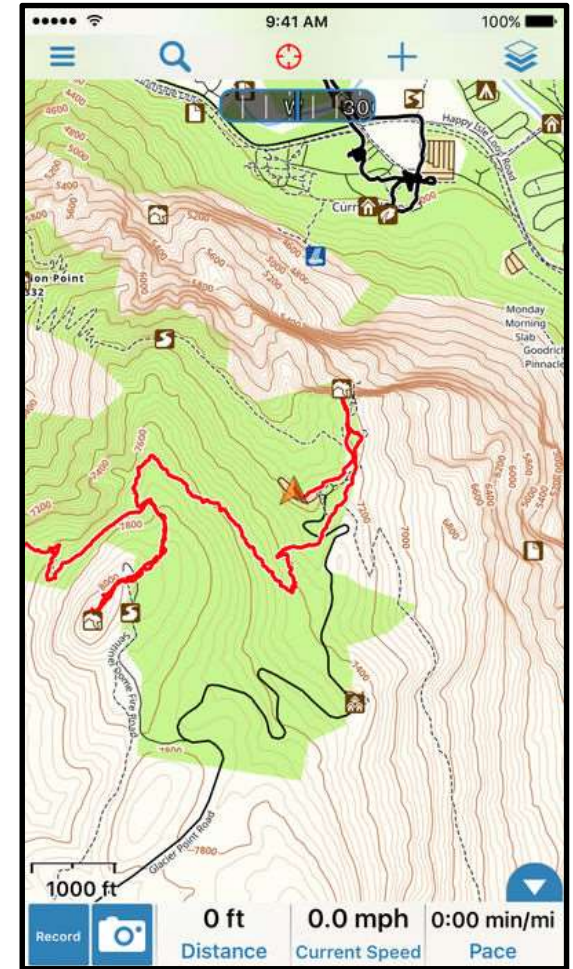
<u>Smart Phone App</u>	<u>Dedicated/Handheld GPS</u>
<u>Much</u> Less Expensive (software)	Better Battery-Life & Spares
You already carry phone (no weight)	Weather & Shock Proof (hopefully)
Larger, Better Screen	Better Reliability & (in theory) Accuracy
Huge Numbers of Maps & Images	Huge Numbers of Maps & Images



What More Could you Want??

A Topo Map that:

- **Leads you along a path**
- **Always knows where you are**
- **Points where you should go**
- **Tells you how far you've gone and have yet to go**
- (And maybe: calendar, horoscopes, celebrity gossip, food reviews, games, ...)
- **And it fits in your pocket!!!**



So Why Isn't GPS All I Need?



- **Electronics are Unreliable!**
 - Batteries, Diabolical Gremlins of Software, Operator Error, etc
 - Digital compasses require unpredictable re-calibration (often don't work when you need them)
- **Insufficient power for continuous operation**
- **Don't trust just one tool**
- **Some things are hard with GPS, easy with compass** (eg: intersections of bearings, etc)

Battery Management

Battery life is inconsistent
Could have a few hours to full week of life

Conserving Power

- New > Old
- Start with full battery
- Keep the phone warm
- Airplane mode
- Turn off all other apps
- Dim screen/ timeout
- **Carry Spare Batteries or charging unit! Have a power plan.**

To Track or Not?

Tracking and Screen Use are the largest power drains.



Common Accuracy Issues

- Restricted View of Sky (can't "see" satellites)
- Reflected Signals (multipath error)
- Atmospheric Conditions (signal attenuation)
- No Orbit Information/ Orbital Errors

**GPS is Usually Reliable
so Errors can Surprise you.**
(Hint: Use your Brain)

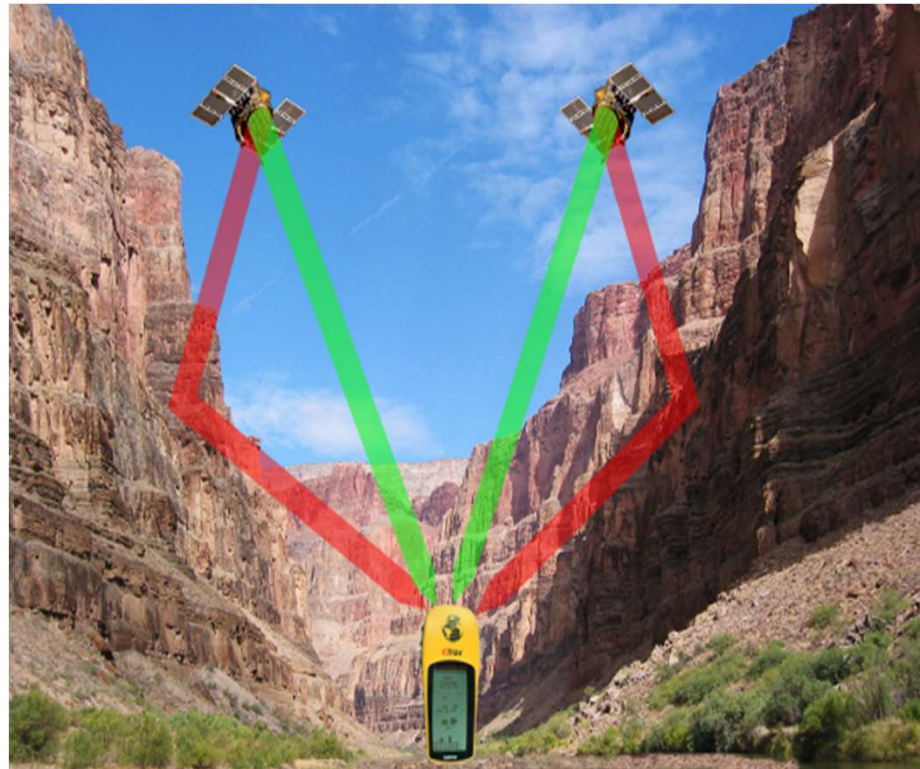
GPS Receivers ONLY need Satellite signals

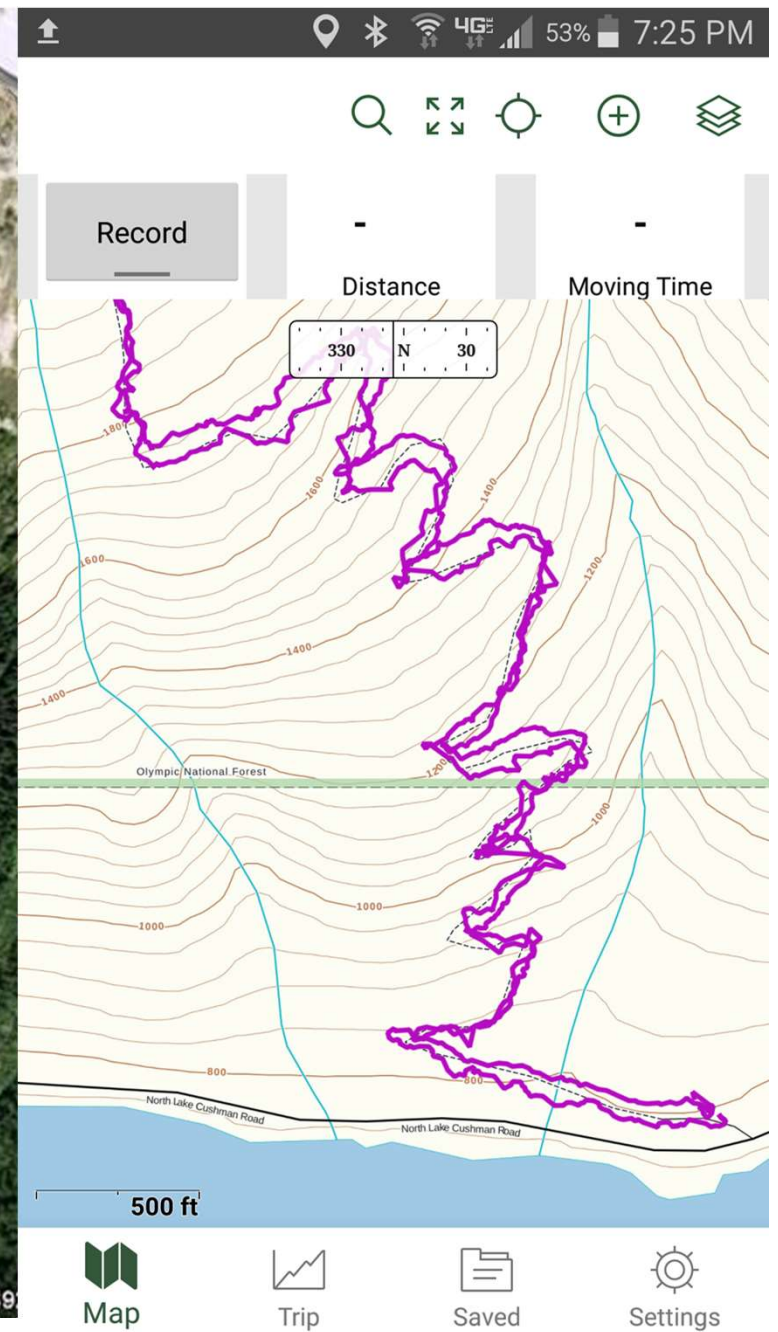
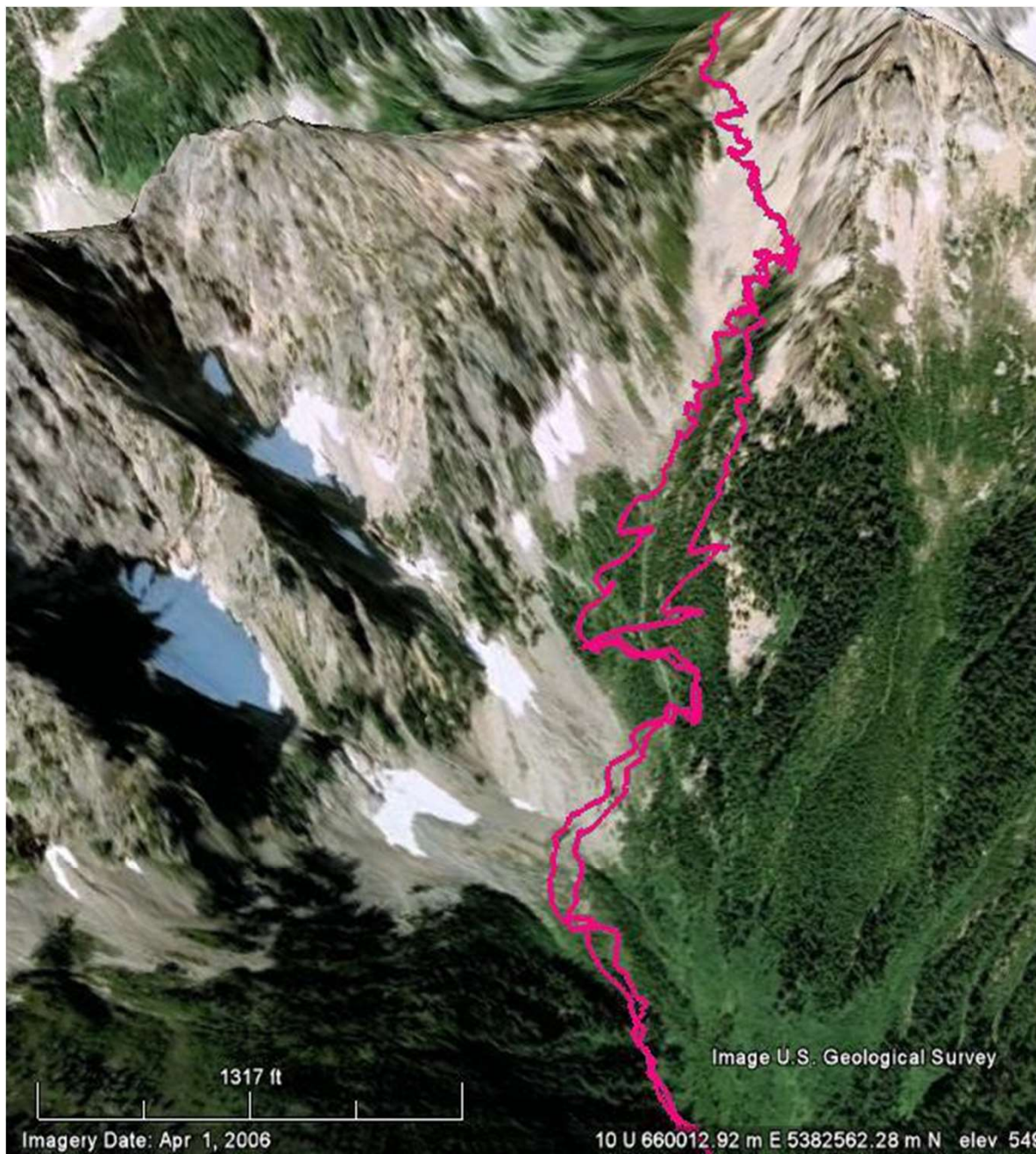
- No Signal No Service
- No need for WiFi, Cellular, or other signals
 - Helps save battery life!
- GPS only calculates position (including altitude)
- Using position, device and software computes:
 - Speed, Direction of travel
 - Routes, Tracks
 - Etc.



Signal Reflections - Multipath

- Signals reflect off of buildings or canyons, which increases Time of Flight, creating error



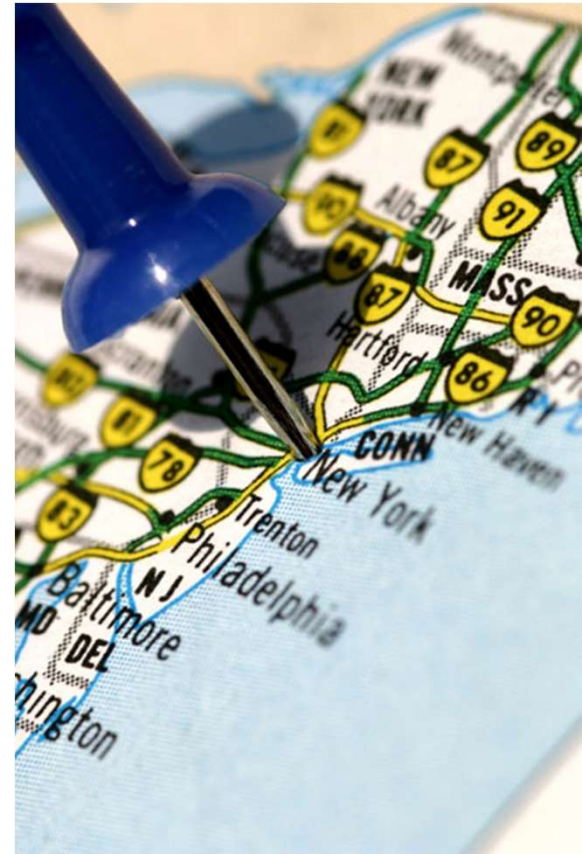


Position errors: Same trail both directions – GPS shows 2 tracks

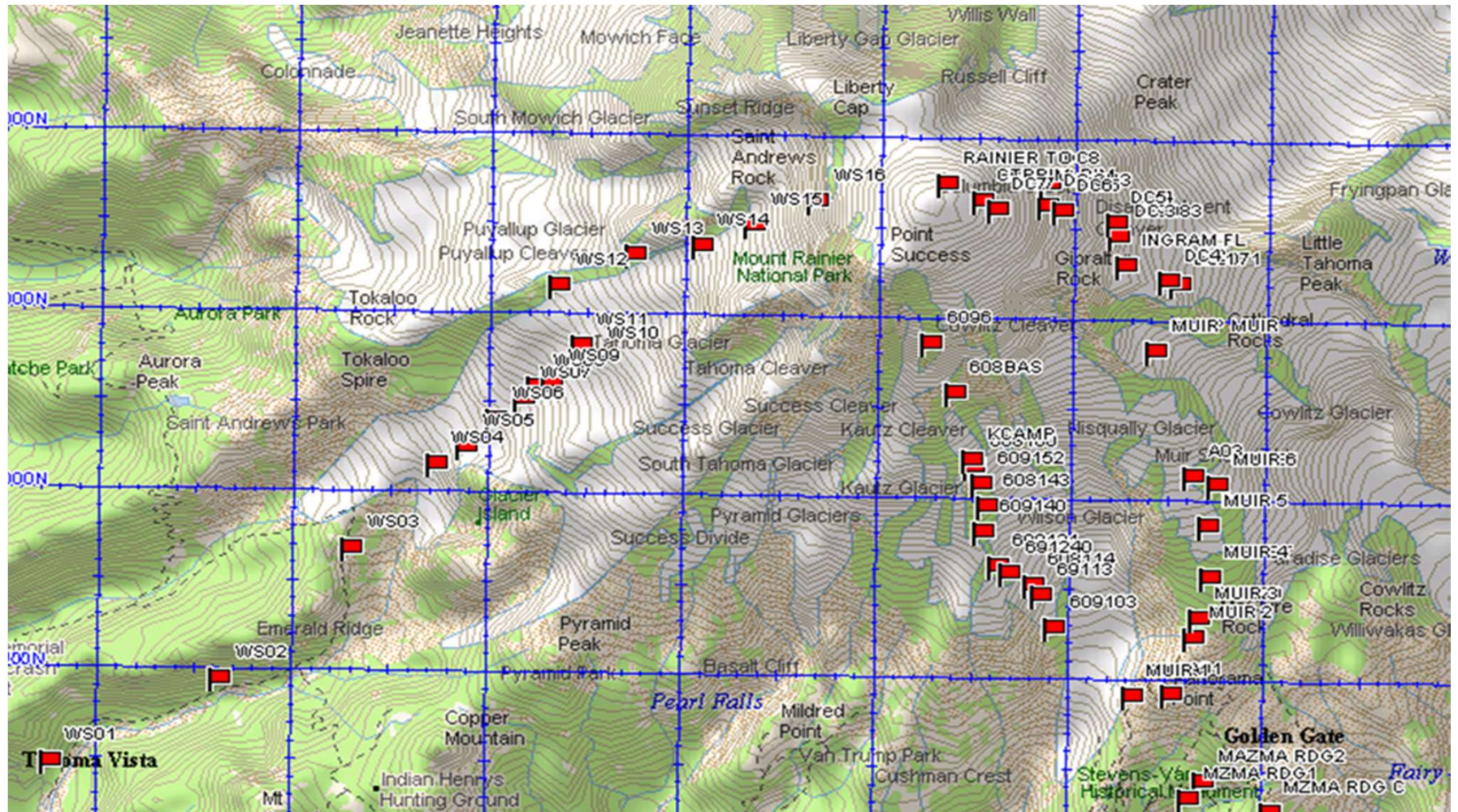
GPS Concepts: Waypoints

Waypoints are coordinates that identify a point on the ground.

- Mark Key Locations
 - "Leave Trail", "Descend Gully", "Beer & Pizza", etc
- GoTo Function
 - Use with compass to increase battery & convenience
- Create Routes
 - Sequences of waypoints



Setting Waypoints



Tracks vs Routes



- Tracks are “breadcrumbs” - showing your actual path (to accuracy of GPS)
- Tracking is extremely valuable, but power-hungry
- Tracks can be shared, BUT ...
Downloaded tracks are often “conceptual,” not real
- Routes are sequences of waypoints
 - Waypoint-only Routes – Useless
 - “Snapped” route to existing trails and roads – A plan
 - Tracks folks have actually “made” – More info to utilize especially off trail travel

Files Types

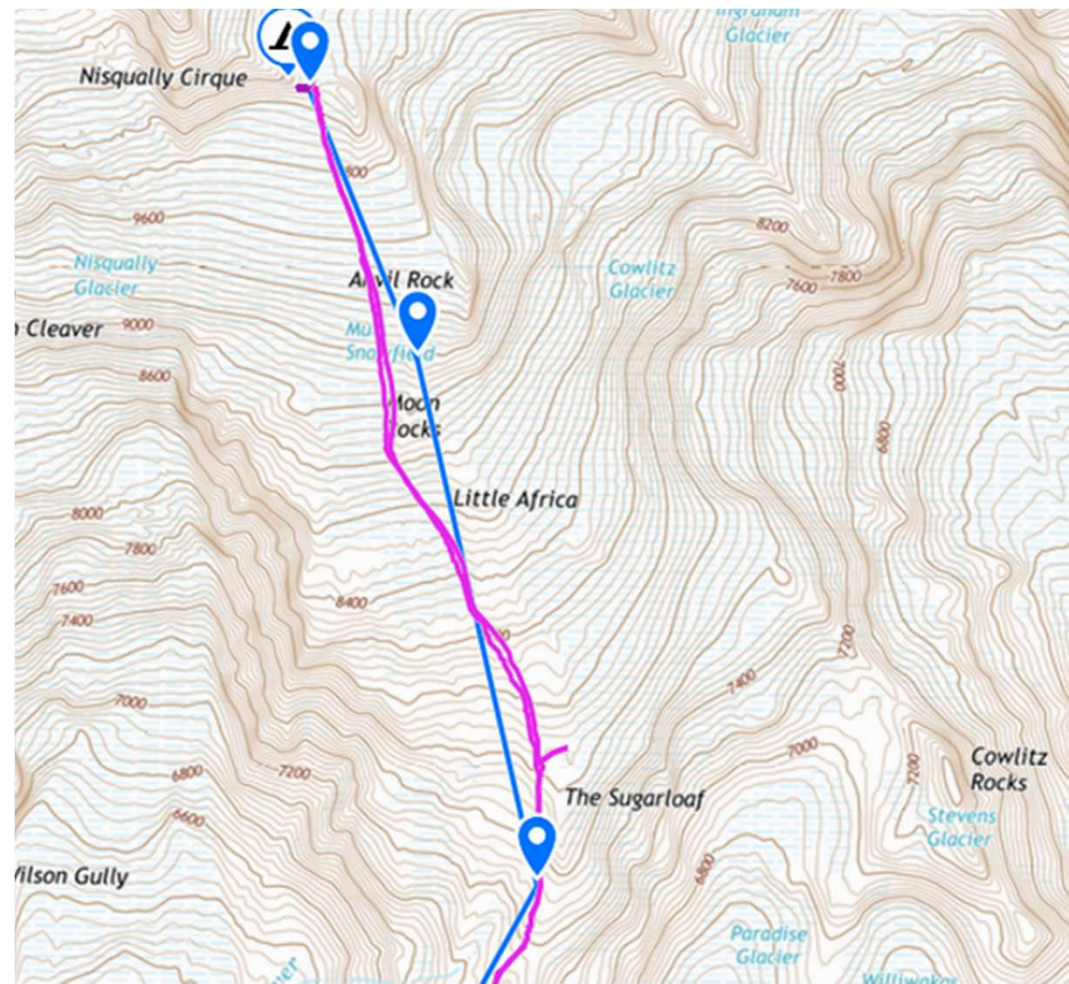
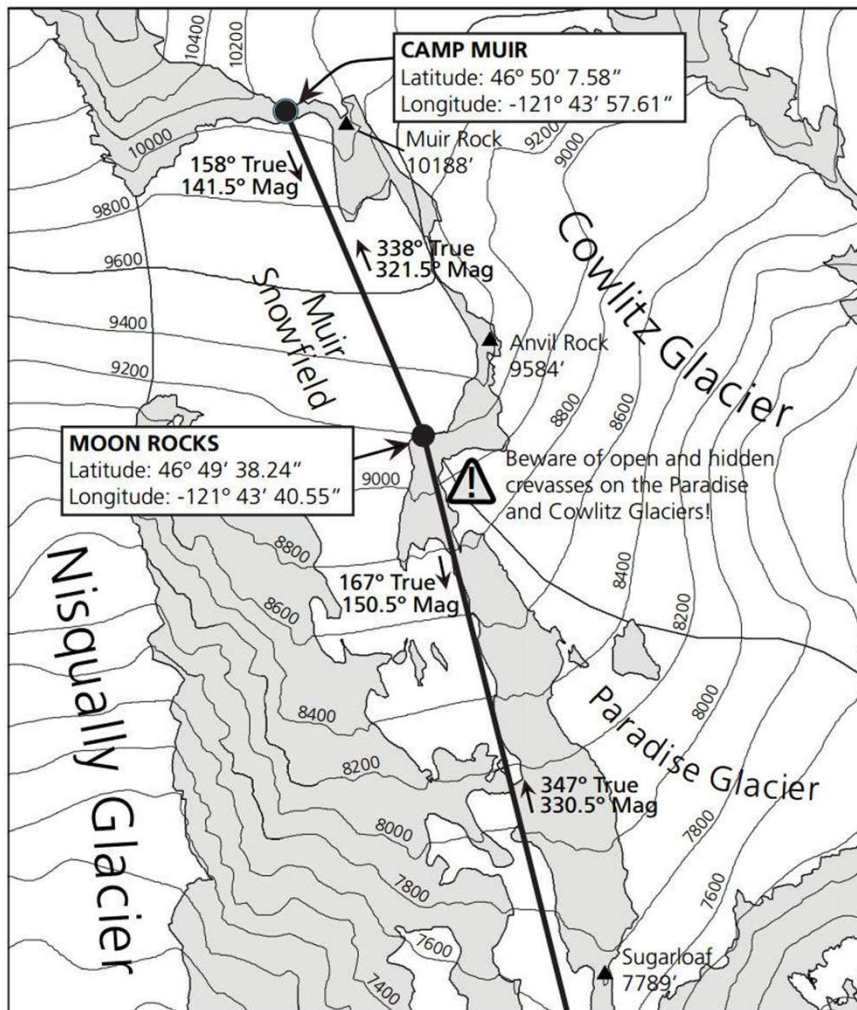
- Tracks are shared as .GPX Files
 - Basically text (XML file)
 - gpx = GPS eXchange format
- Other file types include:

- KML/KMZ
- geoJSON
- GDB
- FIT
- TCX

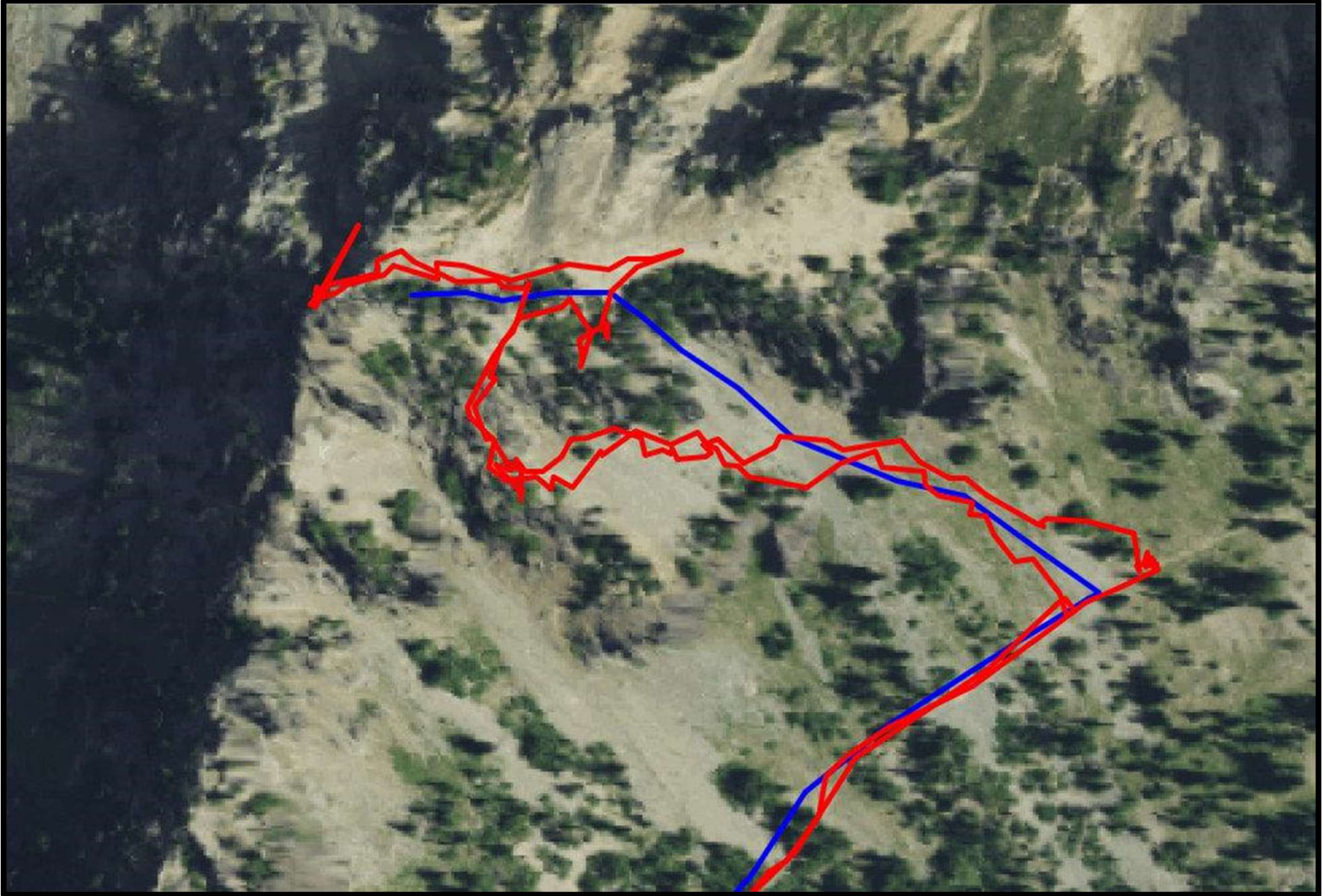
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1 <?xml version="1.0" encoding="UTF-8"?>
2 <gpx creator="Garmin Connect" version="1.1"
3   xsi:schemaLocation="http://www.topografix.com/GPX/1/1 http://www.topografix.com/GPX/1/1.xsd"
4   xmlns:ns3="http://www.garmin.com/xmlschemas/TrackPointExtension/v1"
5   xmlns="http://www.topografix.com/GPX/1/1"
6   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:ns2="http://www.garmin.com/xmlsch
7 <metadata>
8   <link href="connect.garmin.com">
9     <text>Garmin Connect</text>
10  </link>
11  <time>2019-09-19T13:14:46.000Z</time>
12 </metadata>
13 <trk>
14   <name>Coconino County Hiking</name>
15   <type>hiking</type>
16   <trkseg>
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18       <ele>2197.199951171875</ele>
19       <time>2019-09-19T13:14:46.000Z</time>
20       <extensions>
21         <ns3:TrackPointExtension>
22           <ns3:atemp>20.0</ns3:atemp>
23           <ns3:hr>87</ns3:hr>
24         </ns3:TrackPointExtension>
25       </extensions>
26     </trkpt>
27     <trkpt lat="36.05334355495870113372802734375" lon="-112.08372107706964015960693359375">
28       <ele>2197.199951171875</ele>
```


Conceptual Route vs Actual Tracks

Camp Muir



Another example: 3 Way Peak



SATCOM

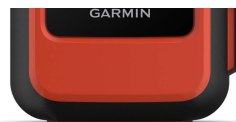
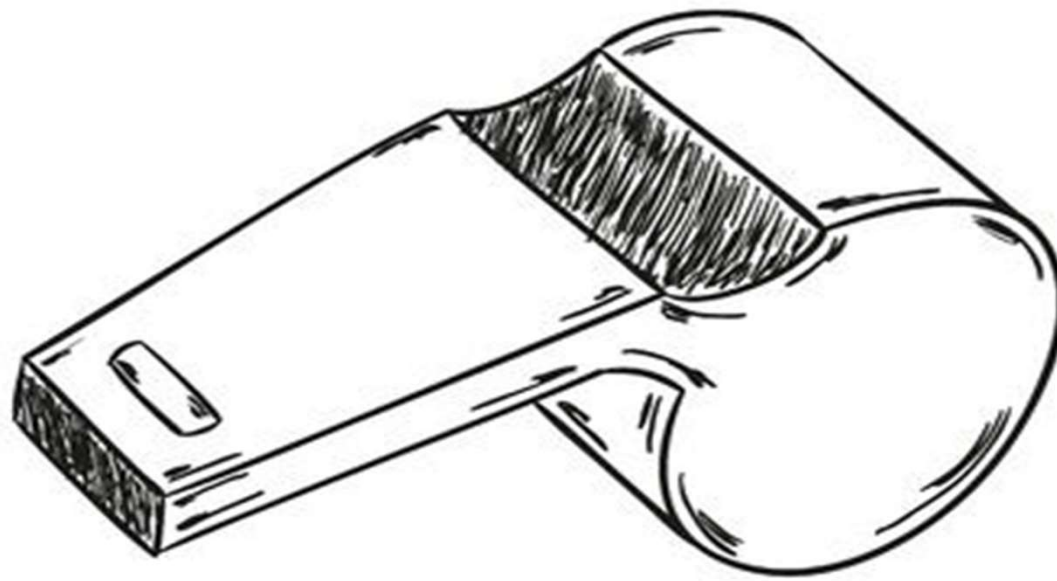
- GPS/Phone vs Satellite Communicator
- Personal Locator Beacon (1-way)
- SatPhone, Garmin, Spot, Apple/Verizon (2-way)
- All Require Subscription



SATCOM

- GPS/Phone vs Satellite Communicator
- Personal
- Satellite
- All Features

-way)



Emergency Communications - Satellite Devices

The following are examples of products available:

- **SPOT** - one and two way text messaging, SOS
 - Devices: Original (one way messaging), SpotX (two way messaging)
 - Uses a private satellite network, **Globalstar**.
 - Costs: one time device cost, plus subscription plans.
 - Battery not replaceable.
- **Garmin - InReach and GPSMap** – two way text messaging, SOS
 - Devices: Mini, GPSMap 66, 67, 86, Montana 710/760, Tread
 - Uses a private satellite network, **Iridium**.
 - Costs: one time device cost, plus subscription plans.
 - Battery not replaceable.
- **Personal Locator Beacons (PLBs)** - SOS only
 - Devices: ACR ResQLink & AquaLink (see product link below for details)
 - Costs: One time device cost, no subscription, battery replacement & service at 5 years required.
 - Uses an intergovernmental satellite network, **COSPAS-SARSAT**
 - ACR transmits on TWO frequencies: **406 MHz** signal for satellite communications, and **121.5 MHz** signal that can be received by rescue personnel as they get closer to your location.

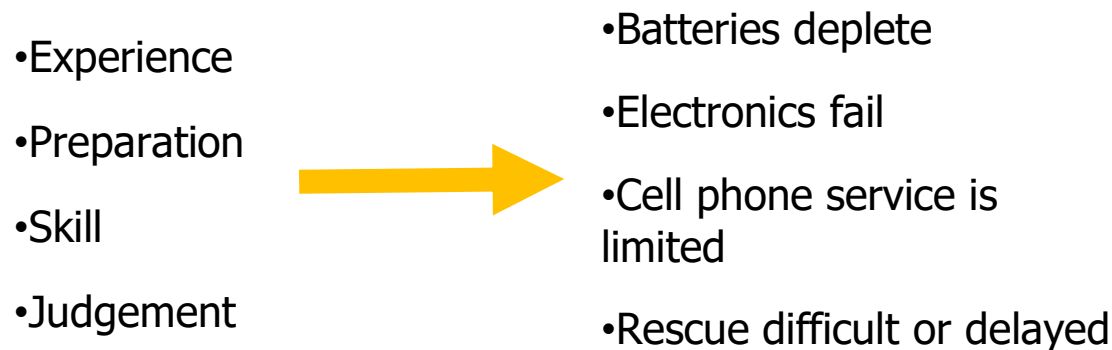


Emergency Communications & Self Reliance

Ethic of Self Reliance vs Emergency Communications.

Per Freedom of the Hills 9th edition:

Understanding the limits of PLBs and other communication tools is as important as understanding their usefulness. Batteries deplete, electronics fail, cell phone service is limited in most mountain locations; a rescue may not be possible due to weather conditions or availability of rescuers. A PLB or Satellite communicator is not a substitute for self-reliance. No party should set out ill prepared or inadequately equipped, nor should they attempt a route beyond their ability and assume that emergency help can be summoned. Safe return should depend on the your party's experience, preparation, skill, and judgement.



Emergency Communications & Self Reliance

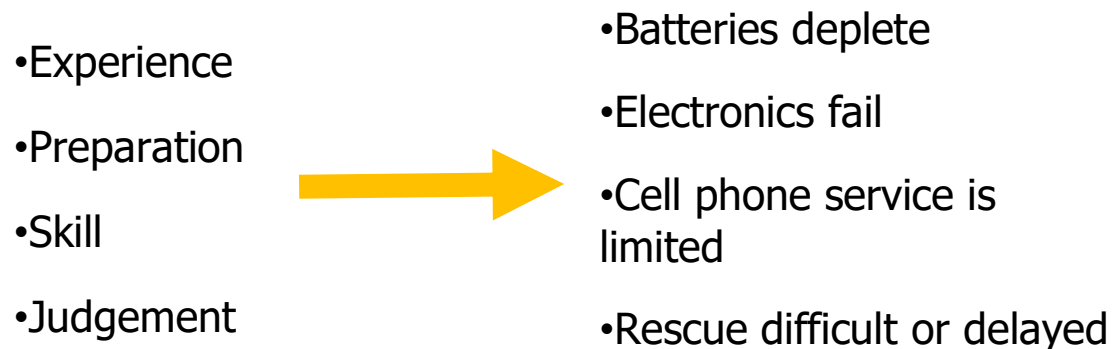
Ethic of Self Reliance vs Emergency Communications.

Per Freedom of the Hills 9th edition:

Understanding the limits of PLBs and other communication tools is as important as

Safe return should depend on the your party's experience, preparation, skill, and judgement. [Not just because you have a SATCOM device.]

summoned. Safe return should depend on the your party's experience, preparation, skill, and judgement.



Emergency Communications - Using Satellite Comms

Advice for using satellite communications & PLB's:

Preparation:

- Verify that your device works and is it setup correctly. Before your trip, verify that your subscription is active, that you can actually send communications (many devices have a test mode)
- Verify that your device is fully charged. Review your power management strategy for this device.
- At the trailhead, introduce your device to the team. If multiple people on your team have devices, discuss your strategy for using them (based on your emergency plan - who has them, how to operate them, primary vs backup).
- Carry other signaling devices - mirrors, tarps, anything that can be seen by rescue personal

During an Emergency:

- Get a view of clear sky when signaling your device.
- Be in a visible clearing - easier to be spotted by rescue personal.
- Don't move after SOS activation, and don't turn your device off after SOS activation.
- If you have a 2-way satellite device, be aware that you may have to send **many messages** back and forth to rescue personnel. Pairing with your smartphone to facilitate typing and sending can help. Practice this setup **before** your trip.



General Tips:

- Scene Safety is critical. Don't add more injuries to the situation.
- Identify a group leader. They can debrief on the situation when rescue personnel arrive.
- Be prepared to manage the situation for an extended period of time - it may take SAR hours to arrive.
- Manage power on your cell phones. Turn those off that are not needed.

Emergency Communications

A SAR Response

The following shows what happens behind the scenes with a SAR response after a call or beacon activation



SAR Initiation Phase -- via Beacon or 911 Call

- When a call or signal is initiated, location information is provided within Limitations of GPS function and network capabilities. You may need to provide more information via 911 or satellite messenger function.

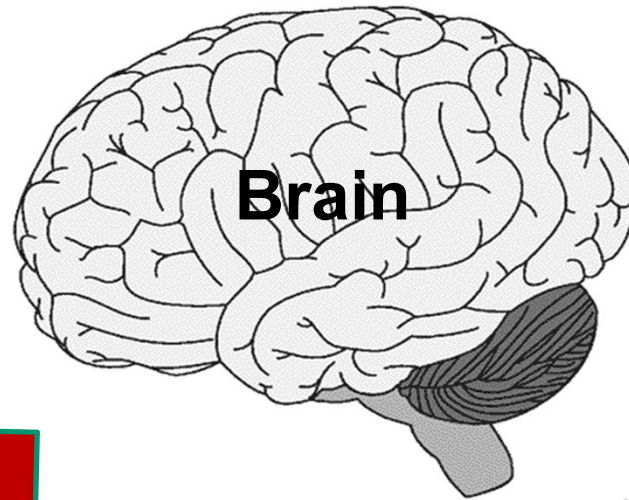
SAR Investigation Phase – SAR will gather more information:

- Check with the registered user. Check with emergency contacts.
- What was your expected route vs reported location?
- Was the distress actual or accidental?
- Use updated positions, periodic updates, tracking, messages by the party.

SAR Organization and Response Phase – SAR will organize the appropriate response:

- Search, Rescue, or Recovery?
- Injuries or No Injuries?
- Technical or Non-Technical?
- SAR Resources Available?
- Air, Land, Both required?
- SAR will then respond.
- Initiators should follow instructions, if any, that are given by SAR.
- Expect it to take hours or even overnight for SAR to arrive.

Did I mention that these all work together?



Brain



Compass



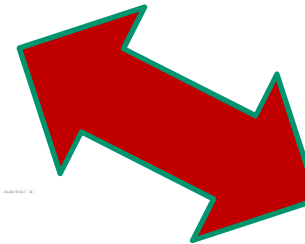
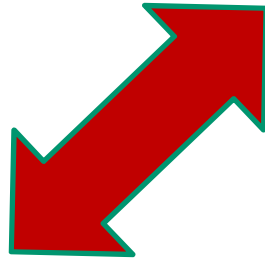
GPS



Map



Altimeter





THE END

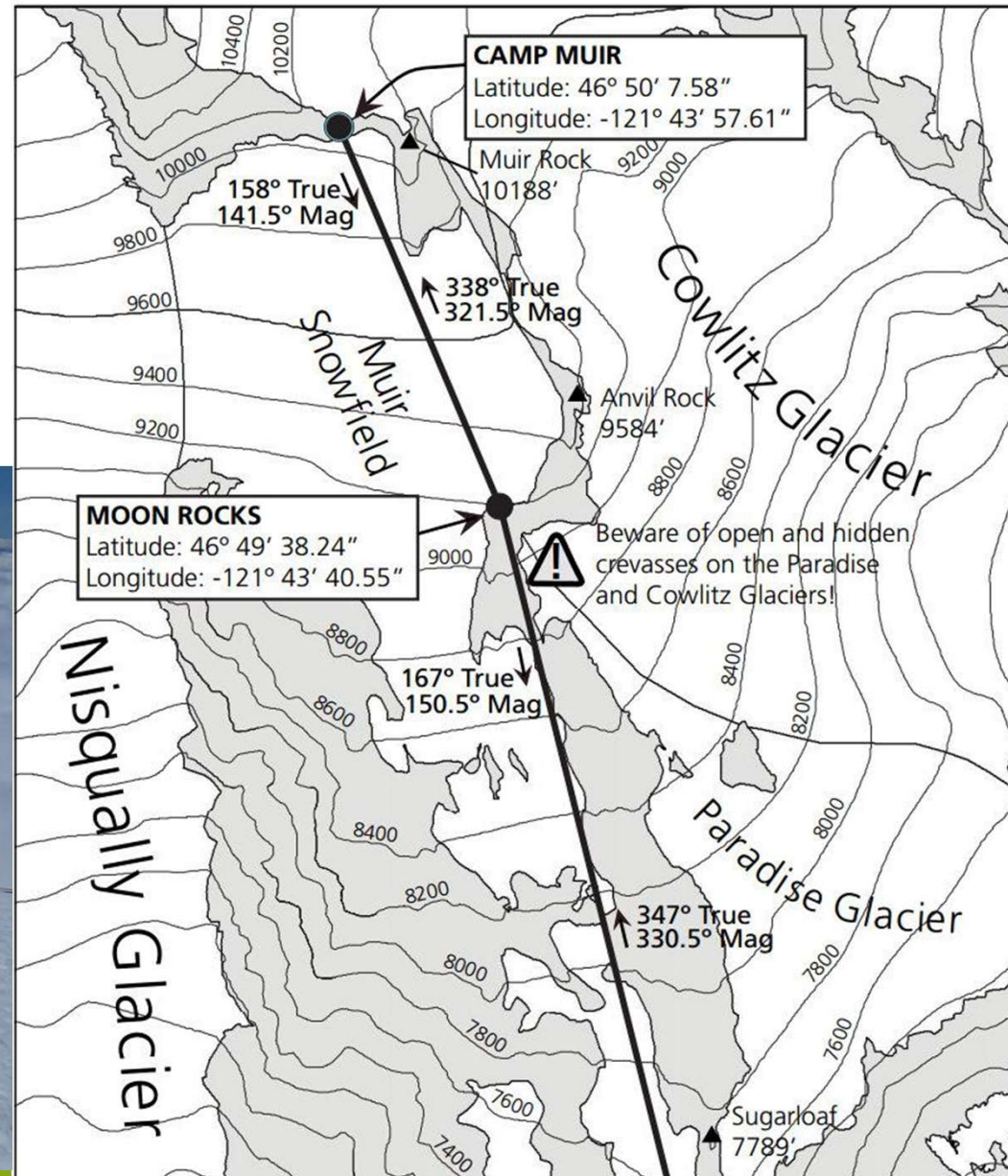
Field Exercise Prep for Sat or Sun

1. Install Gaia or Caltopo
2. Download map covering Kennedy Creek area
(Have off-line map loaded)
3. GPS exercises will be in small groups

Integrating Nav Tools for Survival: Muir Snow Field in Low Visibility

Nav Tools you will Want and Use!

- Map
- Compass
- Altimeter
- GPS - Points, Bearings, Tracks



Layers -

Loadable Maps, Images, etc

- Base and specialized maps
 - boundaries, camping, etc
- Aerial and Satellite images

Download Maps BEFORE your trip!

Can create your own overlays
(using Google Earth, etc)

Not all Maps have Altitude info

Datums need to match

