Bits, Bytes, and Nibbles

Digesting amateur radio computer networks, one piece at a time.

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NH6ET@kali: $ whoami

- Motorola Certified Systems Engineer
- Aviat Certified Microwave Networks Engineer
- Avaya Certified Voice Systems Engineer
- Lucent Certified Switching Systems Engineer
- State Certified Peace Officer
- FBI Certified Hostage Negotiator
- Licensed Amateur Radio Operator

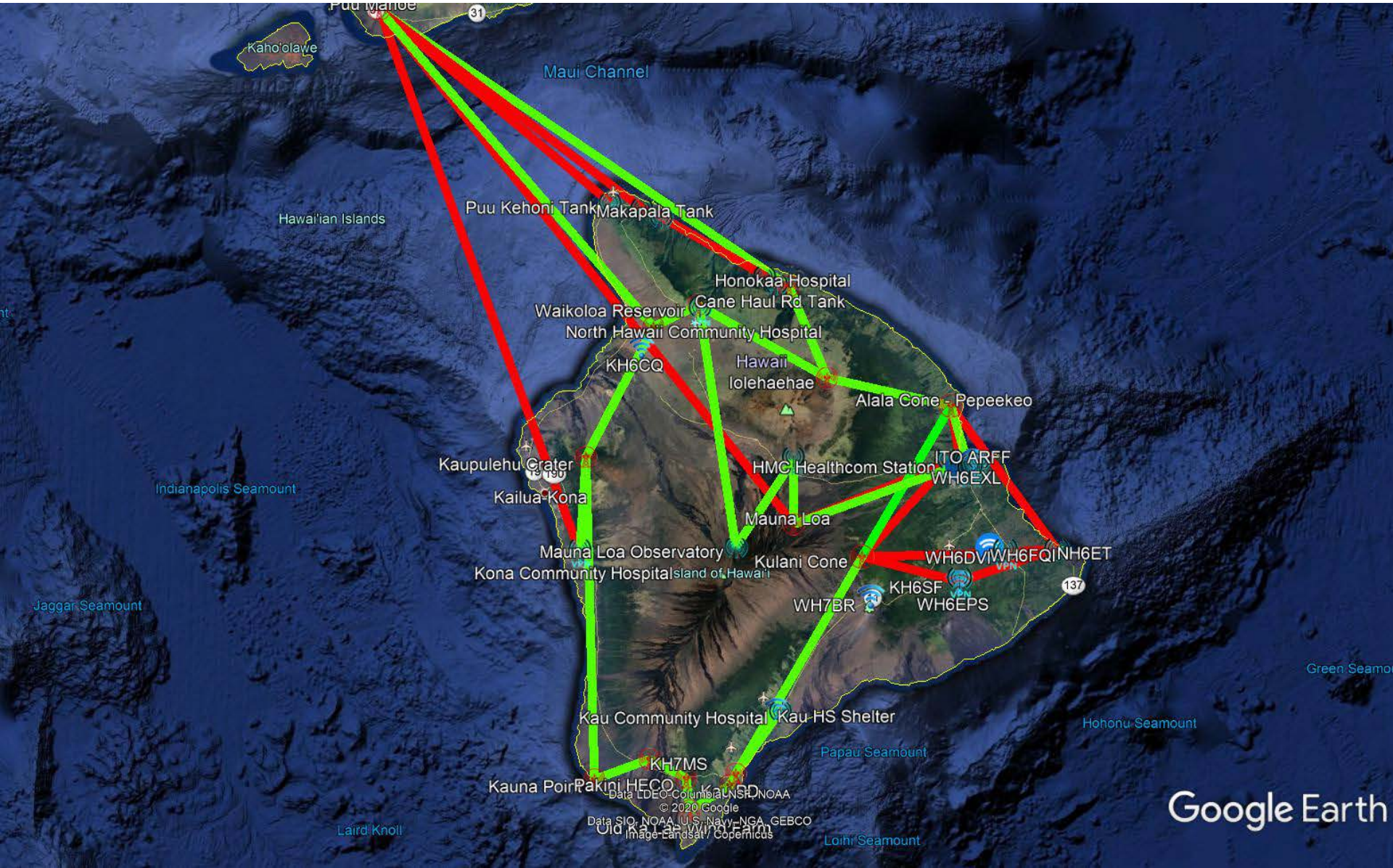
NH6ET@kali: $ whoami | grep truth

Basically, I'm a hermit who lives off of the grid,
deep in the jungle,
who just so happens to like to play with the grid
for fun and profit.

NH6ET@kali: $ ls /var/log/contents

- Backhaul networks
  - Public internet (tunneling)
  - Private networks
    - Carrier based
    - Amateur deployed
      - Part 15 based
      - Part 97 based
      - Borrowed/traded capacity
- Mesh networking – namely ARDEN
- Individual and group efforts on the Big Island

The goal is something that looks like this



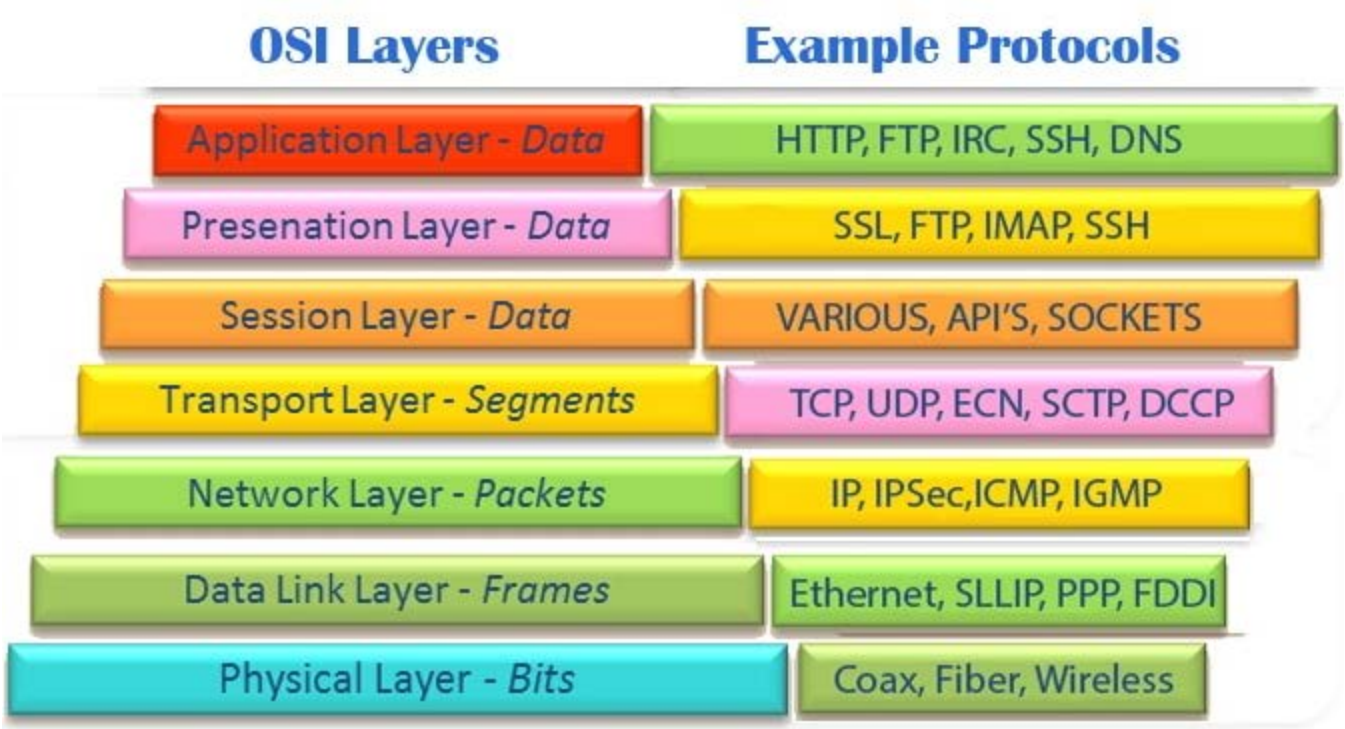
Lets digest this thing like a nice slice of cake

One byte at a time

Remember, all good cakes have layers

Just like the OSI model

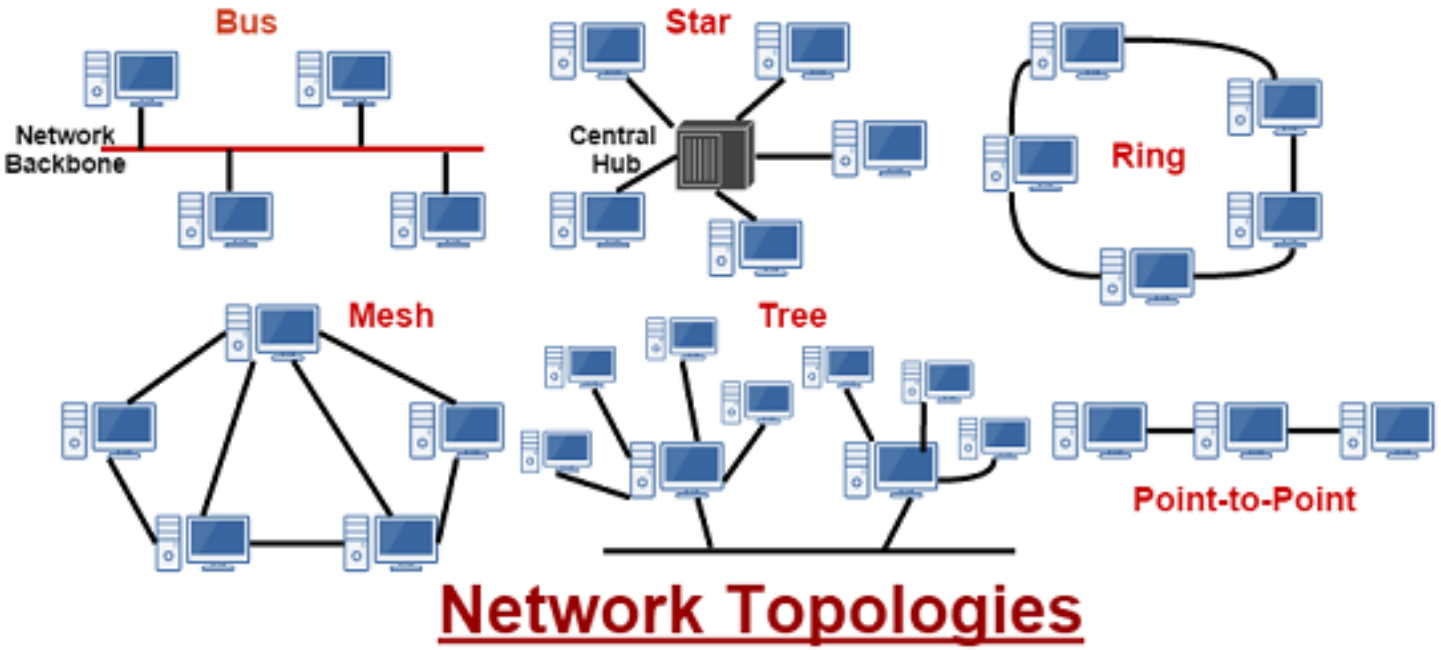
Layer 7
Layer 6
Layer 5
Layer 4
Layer 3
Layer 2
Layer 1



Network Topographies

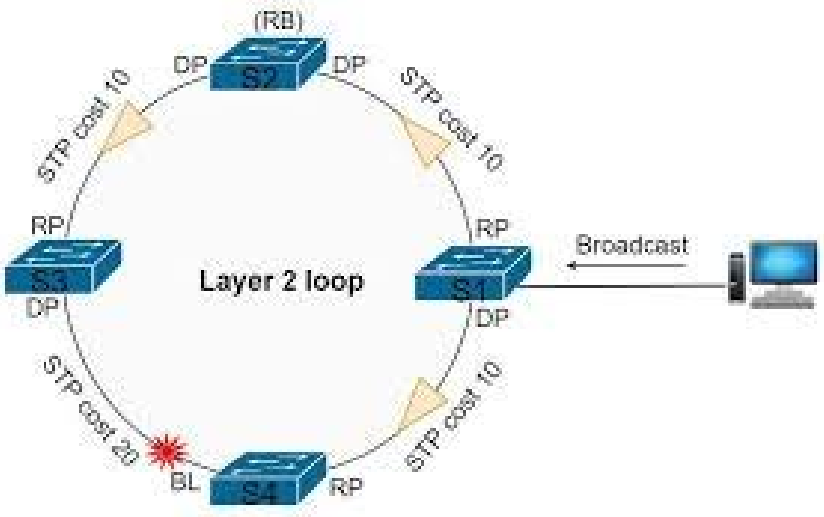
- Ring
  - Is considered the best practice
- Linear
  - Point to point to point
- Mesh
  - Most resilient when truly meshed
  - Second least resistant when collapsed routes exist
- Hub and spoke (AKA Star or Point to Multipoint)
  - Least resilient

All meshes and rings are made up of lots of layer 2 linear paths.



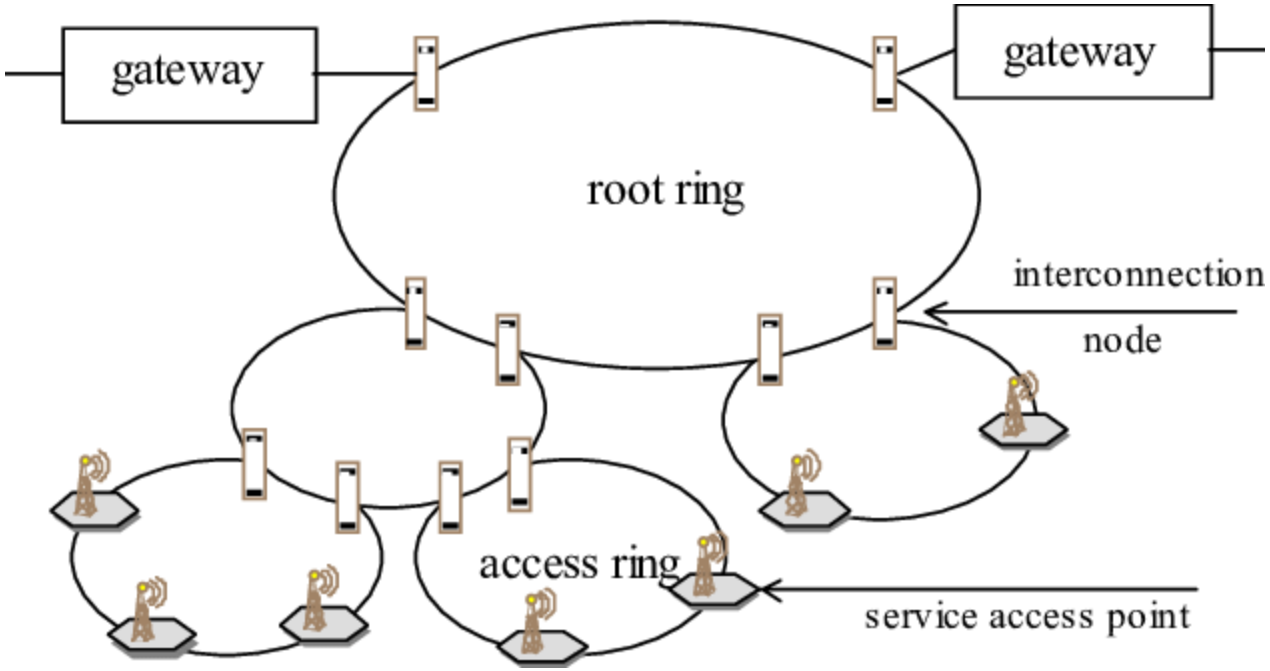
Broadcast storms, address spaces and bears, oh my.

- A broadcast storm is like hooking an amplifier's input to its output.
- If layer 2 loops are so bad, why are layer 2 rings good?
  - Even worse, rings of rings?
- STP?

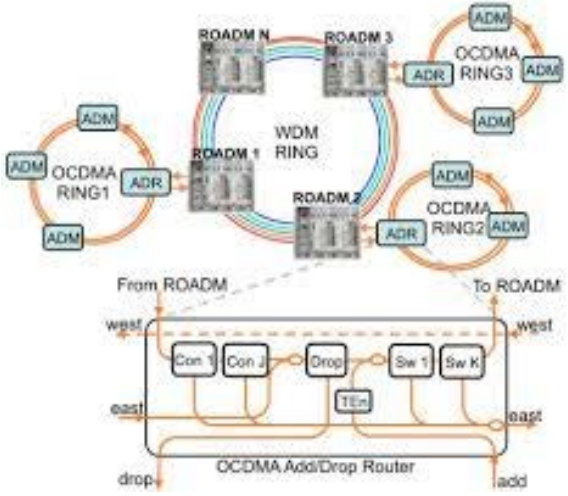


The SONET SLiP model

- Section
- Line
- Path



- Subtending



Layer 2 just can’t do it alone

- Even with the proprietary resilient ring protocols
- Even with STP
- Even with RSTP
- Even with careful engineering

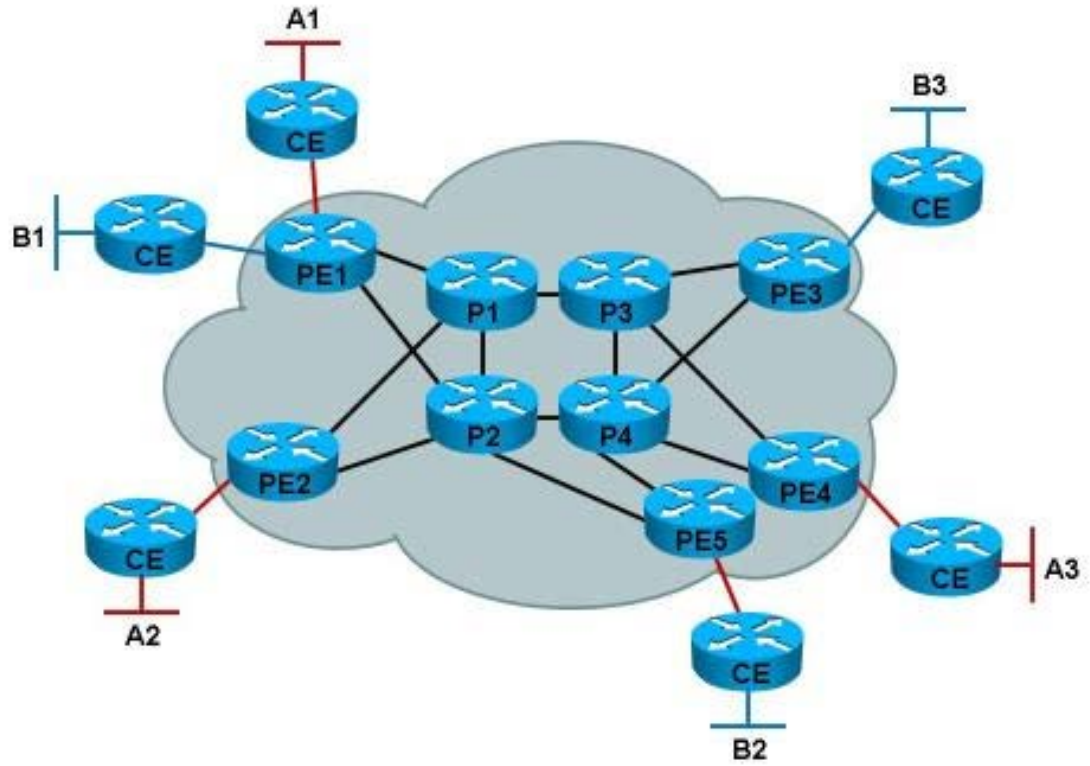
All it takes is one improper connection. I’ve seen three broadcast storm outages in the last year.

Layer 3 does it, but a little too well

- No Layer 2 loops if everything is routed
- Now you have to deal with:
  - Multicasts
  - Routing loops
  - Address spaces
  - Security vulnerabilities
  - High costs
  - Low throughputs

MPLS is the answer

- A “Layer 2.5” protocol
- Makes your network look like a set of linear links, no matter the physical topology



MPLS brings:

- Costs
- Speed
- Complexity of administration
- Resiliency
- More acronyms

VPLS to carry the AREDN mesh?

- Absolutely
  - The mesh islands see each other through the cloud as if they were neighbors.
- Layer 2 tunnels fit right in.
  - Now have islands connected by multiple clouds.

Like a politician, it needs a backbone

- That's where my efforts are focused.
  - I'm hoping that this is a Field of Dreams scenario; if I build it, will they come?
  - I can't build it all alone. However, I am in a unique position to start it.
    - I have unique knowledge of the existing infrastructure.
    - I have existing relationships to leverage.
      - I have my foot in the door of many of our potential partners.
    - I'm a professional ~~nerd~~ Technologist.

Band selection

- Based on purpose as much as path.
- Has to coexist with existing equipment at sites.
- Is primarily influenced by the power and EIRP limits of Part 15.

Part 15 Power and EIRP limits

- Part 15 imposes a 36dBm EIRP limit for all intentional radiators in the ISM bands.
- However, Part 15 has different rules for point point (PTP) links in 2.4GHz and 5.8GHz.
  - In the 2.4GHz band you can increase gain to get an EIRP above 36 dBm.
    - But for every 3dBi increase of gain you must reduce the power by 1 dBm.
    - The practical limit is about 28dBm into a 21dBi antenna, resulting in about **49dBm** with a **2 foot dish.**
    - Going all the way to a 6 foot dish only gets you to 55dBm

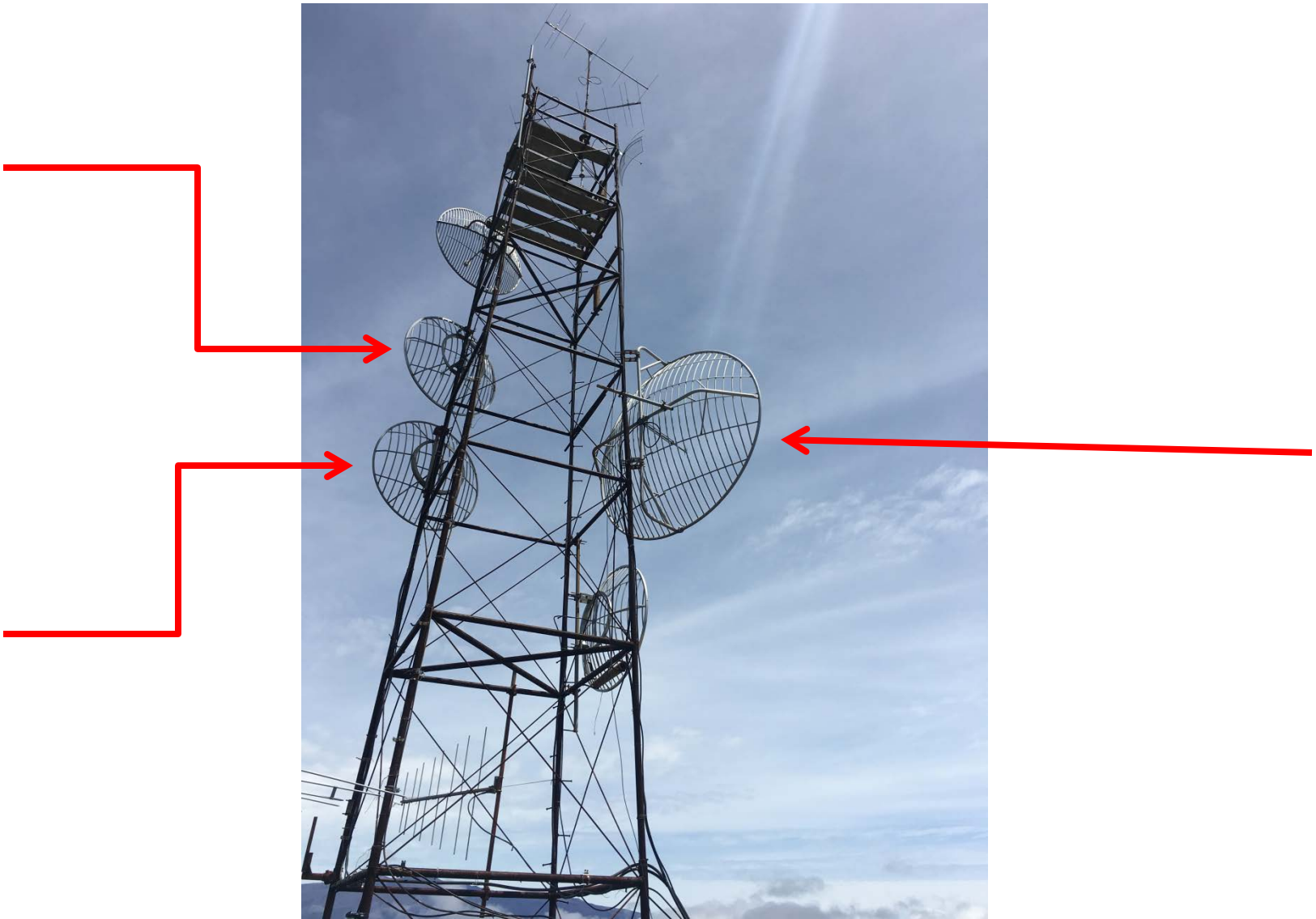
The 5.8GHz EIRP advantage

- There is no maximum EIRP rule for PTP the 5cm band
  - That's a big reason why there is little cause to operate them under part 97.
  - ***But the EIRP limit comes back if it's PtMP***
- Uses a smaller lighter dish, and still get better gain.
  - This better allows for multiple chains and/or diversity receivers.
- The Fresnel zone isn't as much of an issue.
- The free space loss makes interference less of an issue.
- Isn't as affected by water as 2.4GHz

So, if 5.8GHz is best, why is there so much 900MHz on the map?

- 5.6GHz needs a perfectly clear line of sight.
- 900MHz is NLOS capable, to an extent.
- In some installations an omni or a Yagi will work, where a dish will not.
- And…

A lot of 900MHz abandoned equipment is out there on towers



900MHz Pros and Cons

- Pros:
  - NLOS Capable
  - Lower cost equipment
  - Yagis and omnis, not dishes
- Cons:
  - Bandwidth constricted
  - Limited commercial offerings
  - Generally a high noise floor, especially in urban areas
  - Low EIRP limit of 36dBm
  - Low antenna gain

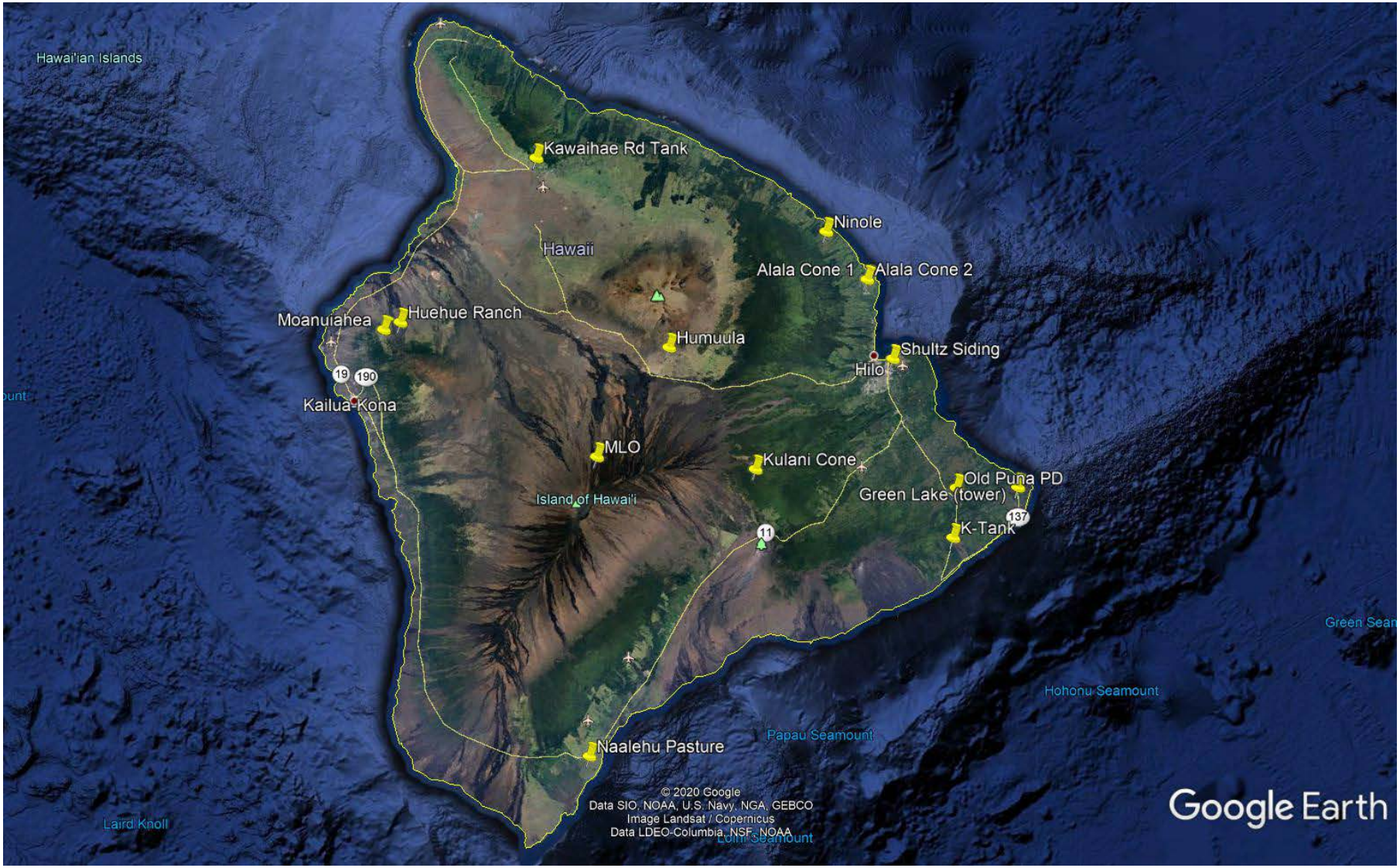
900MHz Access Points

- NLOS Capable (can’t stress this enough)
- Relay node links
- Mobile data
- Ad hoc installations (think shelter activations)
- 47 CFR § 15.247 Says 2.4GHz and 5.8GHz PtMP access points must limit to 36dBm, just like 900MHz.
  - However, 900MHz has lower free space loss.

So what is 2.4GHz good for?

- The mesh
- Shorter links
- Links where the 5.8 spectrum is saturated
- Part 97 operations
  - Where EIRP doesn't matter
- Heating up coffee to have with your OSI cake.

A lot of abandoned wood poles are out there



Part 15 or Part 97 links

- Commerce
  - PPPs cannot happen if we have nothing to offer.
    - Having capacity will get us in the locations.
    - If you have nothing to offer, they will have no reason to partner with us.
    - If we can't carry their traffic, they won't carry ours.
- Most 5.8GHz equipment is Part 15 compliant, and offers no real benefit when going Part 97.
  - Spectrum issues are best addressed by careful band selection.
  - Most TDD equipment does not exceed part 15 power limits anyway, due to the antenna switch current carrying capacity

Good Partners

- Government
  - Noncommercial by definition
  - Need redundant backhaul
  - Need services they can’t afford, like camera at their tower sites.
  - EMCOMM
- Healthcare
  - Commercial by nature
  - EMCOMM
- Utilities
  - Commercial by nature
  - Need redundant backhaul
  - May have unmet SCADA needs
  - Need services they can’t afford, like camera at their water tanks.

So where does Part 97 Operations fit into this

- The Mesh
  - Last mile to the operator
  - Shelters
- The services over the mesh
  - Winlink
  - Repeaters
  - VOIP
    - Careful about commerce if tied to the PSTN.

So what about that mesh

- Best for:
  - Ad Hoc
    - Shelters
    - Events
  - Permanent
    - Access Points
    - Tunnel nodes
- Needs the backbone

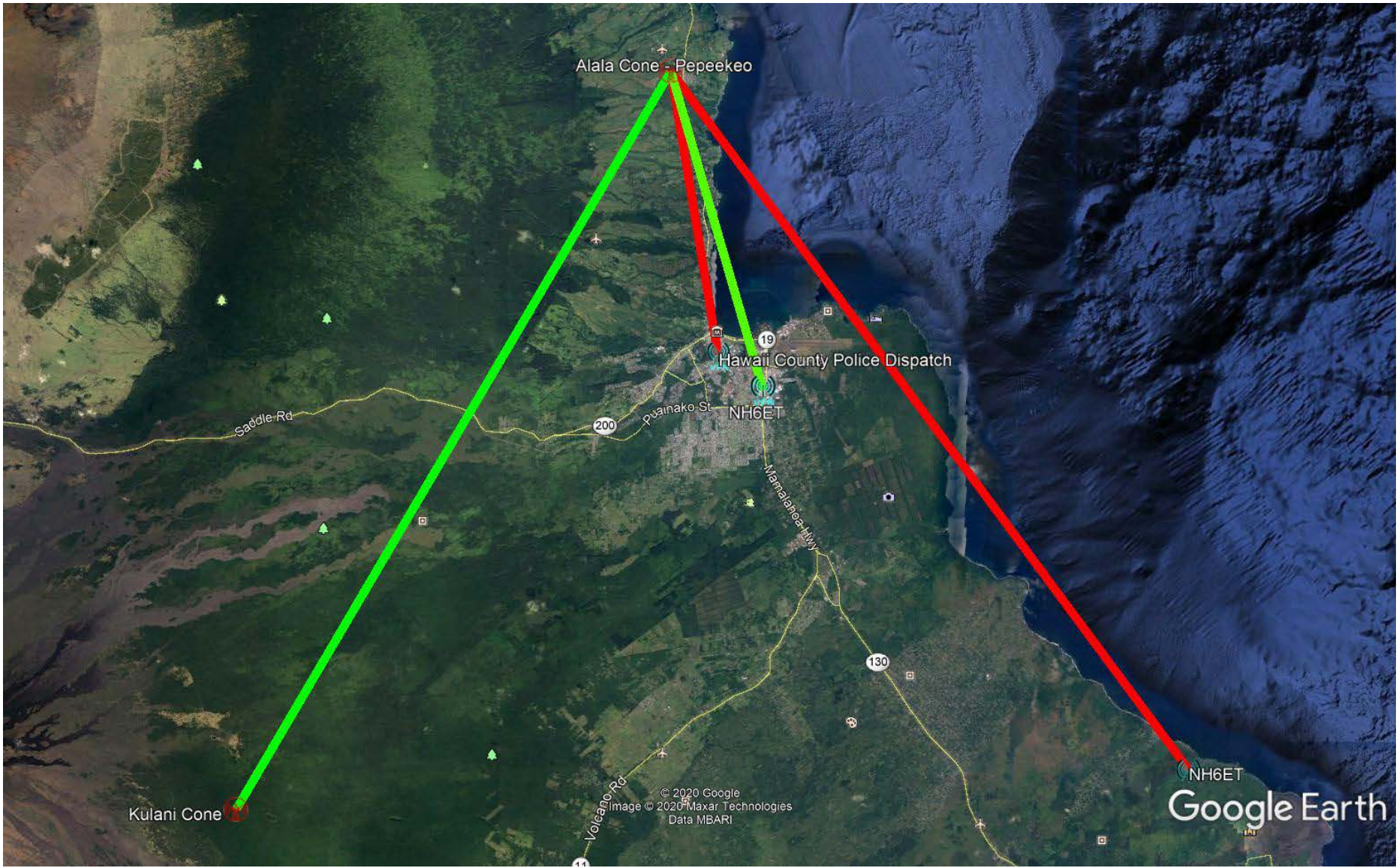
Considerations for meshing over the backbone

- Relay link bandwidth
- Backbone bandwidth
- Must always be segregated within its own VLAN
  - Mesh internet connection is accomplished within the mesh, even if that is done at a single node mesh island created for that purpose.

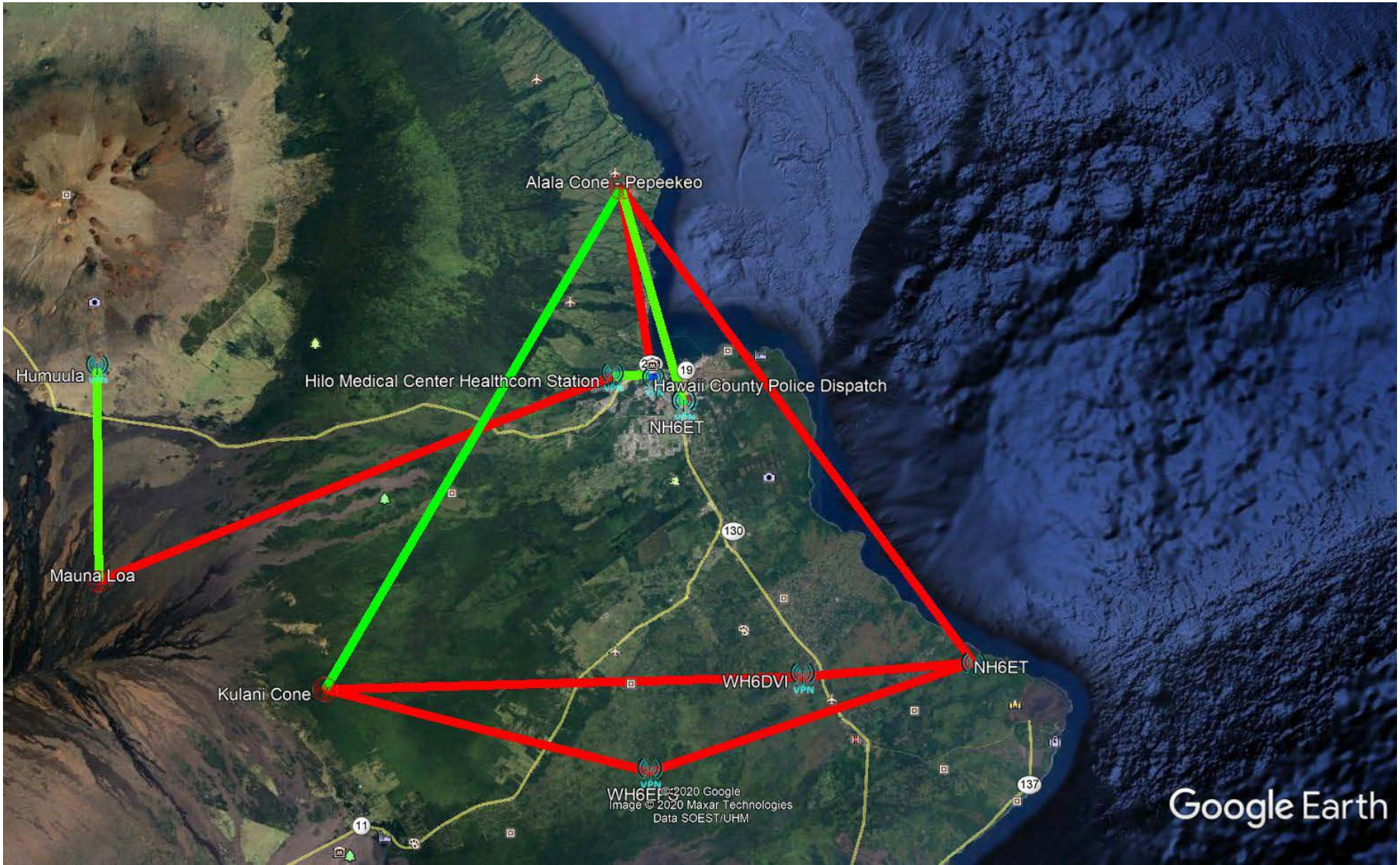
The geometry can get a bit complex

- OLSR Layer 3 traffic within the mesh island leaves over a VLAN on the relay link which is encapsulated at the ingress PE router and is then label switched over the MPLS network through the backbone to the egress PE router, where it is de-encapsulated, and passed out over a VLAN on a relay link to the destination mesh island

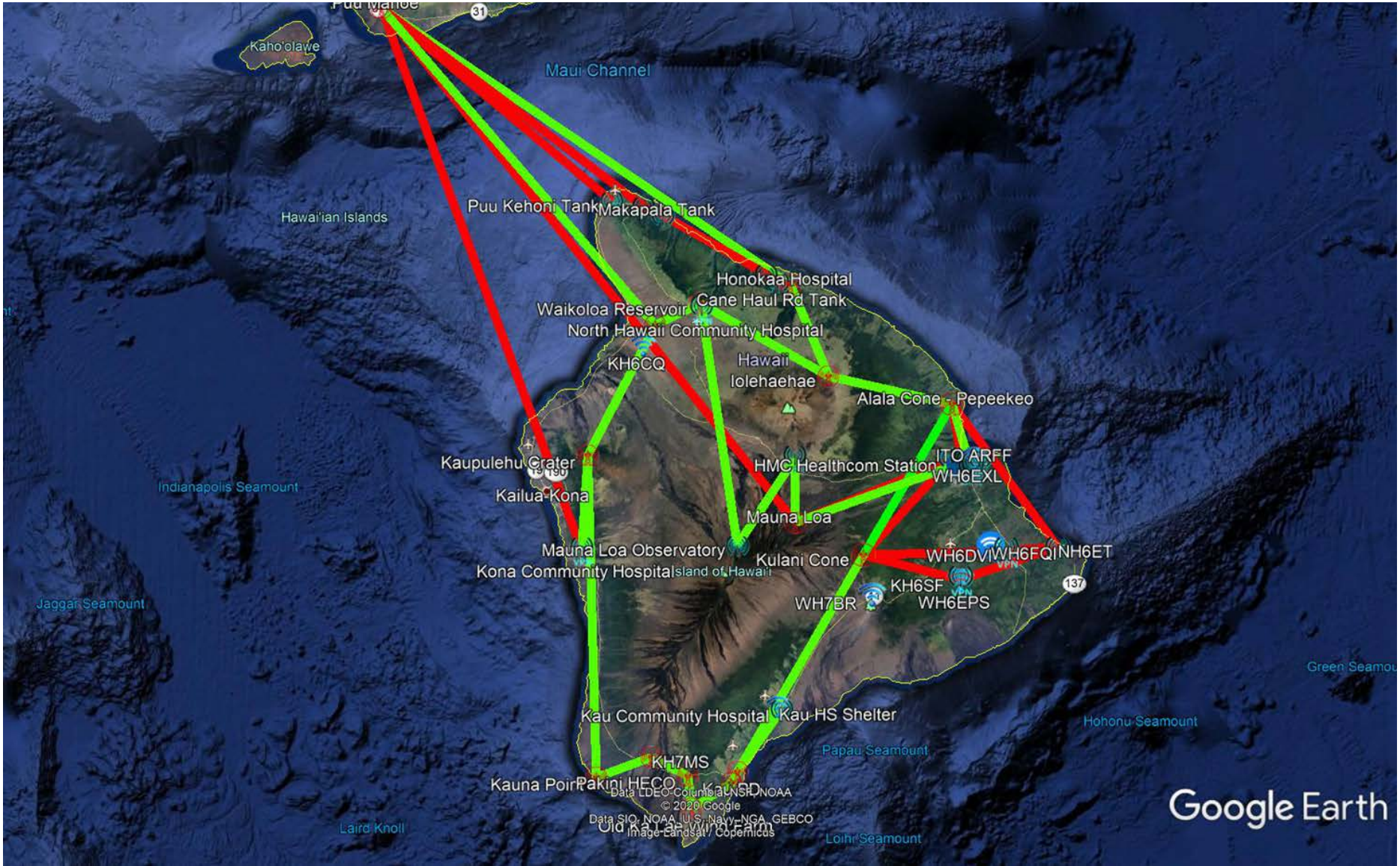
My efforts will only start the ball rolling – I'm starting with this:



I’m hearing others are on board to turn that into this



With the hope that others will join to get us to this



With the end goal being the entire state of Hawaii

(Insert time consuming design here)

Thank you for having me!

Questions?