HamWAN 2.0
MEGABITS, MICROWAVE, AND EMCOMM
Rob Salsgiver (Rob when he is in trouble) is the founder and owner of Granite Systems. His passion is building productive, reliable systems and solving real-world problems.

Rob has spent over 35 years in the technology and engineering fields including aerospace, automotive, medical, retail, security, tech, and nuclear power fields. His most recent accomplishment was as a key architect, engineer, and minority owner in growing a local startup from $3000 in sales to $10 million in just 7 years.

Like a toddler trying to reach a forbidden object, Rob must have a problem in front of him to solve at all times. Whether a Fortune 500 global mail system conversion, developing control systems and machinery products for a new market, or assembling talented individuals to build a new department or division, there always HAS to be a mission. There are other likenesses to toddlers and children that probably shouldn’t be discussed in a public.

Rob lives in Granite Falls with his wife Shelly, 3 miniature wiener dogs, a spastic springer spaniel who thinks it’s a wiener dog, 4 cats, 5 horses, cows, and assorted wildlife that shows up from time to time. All of which conspire to create additional problems to solve, keep him busy, and out of the bars at night.

When that doesn’t work he’s usually behind in solving problems for one of the Ham Radio groups he’s involved with – either as a board member, technical resource, or just the village idiot who can’t say “no”.

This is precisely how he wound up being a speaker at the 2019 Communications Academy.
Why HamWAN?

November 2018 – Governor Inslee directs WA EMD to develop proposal for communication system that would allow communications across state government and between State and Local EOCs following a catastrophic incident.
Disaster assumptions

- Landline telephones, cellular telephone networks, broadband and cable networks will be significantly degraded or will completely fail.
- Infrastructure that is in-ground or crosses bridges and overpasses will be significantly degraded or will completely fail.
- Microwave systems will be shaken out of alignment.
- It will take weeks to months to completely restore these systems.
Communications between the Washington State Emergency Operations Center (SEOC) and the EOCs or ECCs of Washington’s counties and the cities of Seattle, Tacoma, Bellevue, Kent, Everett, and Renton (the emergency management programs of Spokane, Vancouver, are integrated with those of their counties) and with the emergency operations centers of WSP, WSDOT, DOH, DNR, DSHS, DES, Commerce, and ECY.

The ability to expand the system as funds become available to include communications with additional state agencies, cities, hospitals, and other critical infrastructure providers.

Capacity for 20 simultaneous conversations.

Capacity for two simultaneous conference calls involving 50 participants each.

Capacity for hand-held devices to participate on the system.

Ability for Federal agencies to communicate on the system in the event of a catastrophic incident.

Ability to connect to commercial communications systems outside of the incident area.

Ability to transmit data (text, email, documents).

Ability to communicate between SEOC and EOCs in Oregon, Idaho and British Columbia at a minimum.

Ability to connect to National Guard armories in Washington State.

Ability to connect to maritime asset communications.

Capable of mobile control and remote access should SEOC be relocated.
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- HamWAN 2019 – where we’re going this year
- Hardware – what do I need?
- Example builds / Use cases
- Getting Started
- Wrap-up / Q&A
HamWAN 1.0 – A review

This space intentionally left blank
HamWAN Founders and Principals

- Bart Kus
- Cory Johnson – NQ1E
- Curt Black – WR5J
- Ben Krueger
- Nigel VanderHouwen
- And others
HamWAN – the organization

- Formally established Feb 12, 2013
- Non-profit organization (501C3)
- Built and supported by Amateurs
  - RF Engineers
  - IT Professionals
  - 20+ core amateurs
- Non-profit
  - Volunteer based – no paid staff
  - All donations support installations and maintenance
Allocated AMPR subnet 44.24.240.0/20 on Feb 13, 2013

YAY – Public Internet Space!
What is HamWAN?

- An independent, high speed carrier-grade independent wireless network operating on Amateur Radio frequencies.
- Connects hams, EOCs, Hospitals, and others via high-power, long range WiFi
- Multiple Internet connections for connectivity during localized outages
- Does not rely on cable or DSL, with same and higher speeds
- Operates on Amateur Radio frequencies
- HamWAN dedicated services available even if widespread Internet access is lost
High speed network links capable of supporting multiple network services

Long-distance network links up to 100 miles achieved

Link speeds up to 100Mbits between major sites

10Mbit – 40Mbit between client sites

Scalable

Compare to DSL (1.5 to 12Mbit) and Cable (5-50Mbit) speeds
What can HamWAN do?

Provide network connections to EOCs, Hospitals, and other connected response organizations during disasters

- Web and email
  - Transparent access to Internet sites
  - Direct access to redundant HamWAN services if/when Internet is down in major disaster

- VOIP telephones
  - 4 digit dialing to connected HamWAN EOCs, hospitals, etc
  - Offload data-intensive activities like sending photos and attachments from radios, opening them up for voice or data communications with non-HamWAN enabled locations.

- Uses same tools as daily life
- Connect other Amateur Radio and disaster support systems
What can HamWAN do?

- Linking repeaters (DMR, Echolink, IRLP, etc)
- Real-time video feeds
- Connect APRS I-gates
- Experiment with microwave frequency designs
- Provide network and internet access to remote mountain-top sites (repeaters, etc)
- Learn and develop IT skills
EMCOMM uses

- VOIP phones
- Email and web access
- Real-time video
- Email attachments and document sharing
- Tactical chat systems
- Ability to host dedicated servers and services
- Ability to integrate with other amateur radio communication technologies like D-Star, Packet, and WinLink
- Easier to use by amateur operators – same tools they use at home or work
EMCOMM uses

- Backup data communications for Hospitals / EOCs
- Another faster path for high-density data – solves the nagging “how do we do that” with high speed, commonly used tools that almost every amateur uses daily
- Relieve amateurs of backbone communications and let them focus on field operations where existing technologies really shine.
- Replace repeater Internet links with redundant Internet connections
- Log exercise or incident traffic by remotely recording band traffic via SDR
- Remotely operate radios
Ok – What CAN’T I use it for?

- Cannot conduct business over it – Part 97 still applies
- Encryption not allowed – same as voice or packet
- What about https?
How reliable is HamWAN?

- Based on mountain-top cell sites
- Backup power on all key sites
- Multiple connections between cell sites for redundancy in disasters
- Multiple connections to public Internet
- Network re-routes around detected failures
- Operates on Amateur Radio frequencies – does not compete with commercial services
- Designed and supported by Fortune-500 Amateur licensed Network Administrators and Engineers
Mountain-top Coverage

- Victoria BC
- Everett
- Marysville
- Monroe / Sky Valley
- Seattle
- Sultan
- Issaquah / East Side
- Tacoma
- Olympia
- Portland
How is this Ham Radio?

- What is Ham radio – communications?
  - Why do we communicate / why are we hams?
  - Human contact (rag chewing)
  - Contesting
  - EMCOMM
  - Technical development
  - Texting
  - Videos
  - Email
  - Web
Snohomish County

- Arlington
- Bothell
- Everett
- Gold Bar
- Granite Falls
- Lake Stevens
- Lynnwood
- Marysville
- Mill Creek
- Monroe
- Mukilteo
- Snohomish
- Sultan
- Tulalip
- Woodinville
King County

- Arlington
- Bothell
- Everett
- Gold Bar
- Granite Falls
- Lake Stevens
- Lynnwood
- Marysville
- Mill Creek
- Monroe
- Mukilteo
- Snohomish
- Sultan
- Tulalip
- Woodinville
Thurston County

- Tumwater
- Olympia
- Maytown
- Littlerock
- Bordeaux
- Boston Harbor
- Evergreen State College
- Skookumchuck
- Fir Tree
- Kelly’s Korner
- East Olympia
- Grand Mound
- Helsing Junction
- Sunnydale
Gray’s Harbor / Pacific / Other

- Montesano
- Satsop
- Elma
- Centralia
- Chehalis
- Fords Prairie
- Littell
- Claquato
- Ceres
- Boistfort
- Napavine
- St Urban
- Mary’s Corner
- Newaukum
- Winlock
## What can HamWAN **NOT** do?

<table>
<thead>
<tr>
<th>Restricted use</th>
<th>Benefit / reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannot conduct business activities</td>
<td>Disaster communications only / FCC Part 97</td>
</tr>
<tr>
<td>Does NOT connect to in-house IT infrastructure</td>
<td>HIPAA and in-house IT friendly</td>
</tr>
<tr>
<td>Does NOT replace existing Amateur Radios</td>
<td>Offloads data like files and email to allow better use for voice services in the field</td>
</tr>
<tr>
<td>Not encrypted</td>
<td>Compliant with FCC regulations</td>
</tr>
</tbody>
</table>
HamWAN 2019
HamWAN 2019

- 16+ sites currently in project planning
- North Sound, Cental Sound, Peninsula, Pacific County, Everett
- New initiative to extend HamWAN into Oregon – oregonhamwan.org
- Oregon joins other sister HamWAN deployments in Tampa, FL; Memphis, TN; Kelowna, B.C.; Albuquerque, NM; and Georgia.
Pacific County

- Strong interest from EMCOMM perspective to link coastal communities to State EOC
- Strong support for key installation facilities
- Project planning / mapping / stakeholder consolidation
- Adds redundant paths from Puget Sound to Portland
Pacific County – overall map

Strong interest from EMCOMM perspective to link coastal communities to State EOC

Strong support for key installation facilities

Project planning / mapping / stakeholder consolidation

Adds redundant paths from Puget Sound to Portland
Pacific County – Closer-up
Pacific County North

All named coastal communities covered

Additional coverage along Chehalis river for Hoquiam, Aberdeen, Cosmopolis, Montesano, Satsop, and Elma
Pacific County South

Megler provides majority coverage of Long Beach to Seaside

Nicolai covers Cathlamet, infill to missing areas, and link SE to Larch/Portland
Pacific County – KO Peak

Provides redundant paths to most client communities from Ocean City to Seaside

Key bridge and redundant trunk/link path between North and South County
Everett

- Interested parties
  - Everett Clinic, Everett Fire, Providence, Snohomish Health District, Red Cross, Everett Community College
- Many sites able to hit existing HamWAN cells @ SnoDEM or Haystack
- Redundant paths if Providence or Everett Clinic can install full or partial cell sites.
- Sporadic sites potentially covered by Buck Cell
Everett

Shoreline coverage west of Providence in North Everett

Everett Fire Station 2

Snohomish Health District/Rucker?
Everett

Shoreline coverage west of Hwy 99 through Lynnwood, Edmonds, to Seattle

Everett Fire Station 6
Everett Fire Station 7
North Sound

- Invite by current tenant to install/test backhaul links at one of several sites on Lookout Mountain SE of Bellingham
- 2PTP links, 2 sectors, site hardware and mounts in-hand when weather clears.
- PTP links to SnoDEM and Triangle will provide 2nd path from Puget Sound to B.C.
- Coverage of Whatcom, Skagit, Island Counties and Lower B.C. mainland
North Sound – Lookout B.C. coverage
North Sound – Lookout North US
North Sound – Lookout coverage

- Victoria (different angle)
- Whatcom, Skagit, Island County Hospitals and EOCs
- Portions of San Juan County and EOC
- Possible link paths to Blynn on peninsula, Mt. Seymour/others in BC for link-hop across Northern WA to Omak/Spokane
Central Sound

- Gold Mountain Repairs
- Buck Mountain additions
- Seattle ACS Capitol Park improvements
Central Sound - Gold

Repair/Replacement of

- Sector 1
- Sector 3
- PDU

Install PTP dish on-location onto tower to provide 2nd link to Buck

S3 can provide coverage to Mason EOC
Central Sound - Buck

Client and Sector-2 (SE) installed late 2018

2nd link PTP to Gold installed at site, need to install Gold end of link for redundant path.

Replace client to sector connection @ SnoDEM with PTP

Add Sector 1 for North coverage?
Central Sound – Capital Park

Thanks to new HamWAN Admins Randy Neals, Doug Kingston; and Seattle ACS for their support!

Work Completed
• Upgraded all sectors to MIMO
• Added 24GHz (700Mbit) link to Beacon site
• Larger central router installed
• Optimized Sector 3 placement
• Upgraded PTPs to MIMO w/shields
• Added Local WiFi for maintenance

Tasks Remaining
• New link to Haystack
• New link to Gold
• Add surge supressors
• Solar/battery backup
Peninsula

- Mt Blynn
  - Coverage
    - Sequim, Pt Townsend, Whidbey Island
    - Victoria (reverse angle to existing)
    - Camano Island (West)
    - S. Mt Vernon (from SW)
    - West shoreline of East Puget Sound from Seattle to Everett (W of 99)
  - Possible links via
    - Lookout, Mt McDonald
Peninsula—B.C., San Juans
Peninsula – Sequim, Pt Townsend
Peninsula – W. Whidbey/Camano
Peninsula

Waterfront coverage from Everett to Edmonds, extending down to NW Seattle
Hardware – What do I need?

- Depends on what you are doing!
  - Connecting a single (client) site
  - Redistributing HamWAN to my local area (Cell site)
  - Relay / Linking to other Cell sites (Point to Point Links)
Hardware – what do I need?

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High speed client site (Low RF zone)

RB912UAG-5HPnD-OUT
$90

ARC Wireless
ARC-DA5830SD1 30dB
$130

Total: $215

Mimo radio and dish – horiz/vert pol, higher speeds!
High speed client site (High RF zone)

RB912UAG-5HPnD
$80
StationBox S Carrier Class Enclosure - $35

ARC Wireless
ARC-DA5830SD1 30dB
$130

Total: $245

Mimo radio and dish – horiz/vert pol, higher speeds!
Other low-cost options

- $41 - $350

Not including shipping, gain figures vary based on equipment chosen, etc.

YOU MUST HAVE THE INTERNATIONAL VERSIONS!!
US versions are frequency locked and cannot use Amateur frequencies!
Basic Client Site

- High gain dual channel antenna (50 + miles)
- Dual channel wireless radio – up to 2x high speed cable service
- Level 5 Firewall with wireless access point
- SNOM VOIP phone
- Provides single phone and higher speed connection to HamWAN network
- Can connect multiple PCs, laptops, phones or additional devices (not included)
- $575 + shipping
Redundant Client Site

- Same as Basic Client Site
- Multiple antennas to provide additional connections to HamWAN in case single link goes down
- $900-$1100 + shipping
Cell Site

- Mountain top or key installations
- Installed at Snohomish County DEM
- Provides 360 coverage to allow connection by client sites
- Provides client and distribution capabilities
- $2500 - $4500 + shipping
Other items

- Outdoor CAT5/Cat6 cable and connectors
- Mounting hardware for tower / building
- Remote Power Distribution Unit (allows remote resets of gear if/when needed)
- Tower cable cushions
- Lightning protection
- UPS (if desired)
A little bit about Firewalls

- Linksys/Netgear/Dlink/etc
  - Good for standard situations
  - Well supported
  - Relatively easy to program / maintain
  - Best suited for single ISP connections
  - Not optimum for multiple WAN connections (ISPs)
  - Available everywhere
A little bit about Firewalls

- Mikrotik – not your Father’s Netgear/Linksys firewall
  - GUI, Web, and Command-line (ssh) programmable
  - More like Cisco/others than consumer routers
  - MANY more configuration options
  - Options add complexity to programming
  - Better suited for multiple WAN connections
  - Better capabilities, but requires greater technical skill
  - Great opportunity to learn beyond your home router/firewall
Example Builds / Use Cases
Dual-linked Key sites to Mountaintops

Anytown EOC

Anytown General Hospital
Multi-pathed Community Hub
Everett, WA

A real-world Example

SnoDEM / Paine Field coverage
Everett, WA

A real-world Example

Haystack coverage
Everett, WA

Providence coverage
Everett, WA

Everett Clinic (TEC) coverage
Filling in the Maps/Gaps
Getting Started
Community Involvement

- City/County Hall, Public Works, other key facilities
- Emergency Management
- School District
- Fire Department
- Police Department
- Red Cross / Shelter sites
- PUD/Utilities
Site planning / evaluation

- Addresses / GPS coordinates
- Site contact (Name, phone, email)
- Evaluating Lines of Sight (LOS)
- CalTopo (www.caltopo.com)
- Radio Mobile Online (http://www.ve2dbe.com/rmonline.html)
- HeyWhat’sThat? (https://www.heywhatsthat.com)
- Site willingness/ability to host antennas (height, access, etc)
- Lines of Sight (LOS) to other community facilities
Other considerations

- Credentialing process for support Amateur Radio operators
- IT awareness (involvement not needed, separate infrastructure)
- $$$ (budget, grants, etc)
- Coordination with HamWAN NetOps Project Management
- Tower climbers (if available)
Wrap-Up
Communications between the Washington State Emergency Operations Center (SEOC) and the EOCs or ECCs of Washington's counties and the cities of Seattle, Tacoma, Bellevue, Kent, Everett, and Renton (the emergency management programs of Spokane, Vancouver, are integrated with those of their counties) and with the emergency operations centers of WSP, WSDOT, DOH, DNR, DSHS, DES, Commerce, and ECY.

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## 2019 Projects - Infrastructure

<table>
<thead>
<tr>
<th>Project #</th>
<th>Site</th>
<th>Type of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gold #1</td>
<td>Repairs</td>
</tr>
<tr>
<td>2</td>
<td>Lookout</td>
<td>New site</td>
</tr>
<tr>
<td>3</td>
<td>Buck</td>
<td>Expansion</td>
</tr>
<tr>
<td>4</td>
<td>Rattlesnake</td>
<td>Expansion</td>
</tr>
<tr>
<td>5</td>
<td>Blyn</td>
<td>New site</td>
</tr>
<tr>
<td>6</td>
<td>Constitution</td>
<td>Info/TBD</td>
</tr>
<tr>
<td>7</td>
<td>Gig Harbor</td>
<td>Planning</td>
</tr>
<tr>
<td>8</td>
<td>SERS Granite</td>
<td>Info</td>
</tr>
<tr>
<td>9</td>
<td>Capitol Park</td>
<td>Active / E</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Project #</th>
<th>Site</th>
<th>Type of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Gold #2</td>
<td>Upgrade</td>
</tr>
<tr>
<td>11</td>
<td>Capital Peak</td>
<td>Info/TBD</td>
</tr>
<tr>
<td>12</td>
<td>Camp Murray</td>
<td>New site</td>
</tr>
<tr>
<td>13</td>
<td>Ballard/Magno.</td>
<td>Info/Future</td>
</tr>
<tr>
<td>14</td>
<td>PC – Holy Cross</td>
<td>Planning</td>
</tr>
<tr>
<td>15</td>
<td>PC – KO Peak</td>
<td>Planning</td>
</tr>
<tr>
<td>16</td>
<td>PC – Megler</td>
<td>Planning</td>
</tr>
<tr>
<td>17</td>
<td>PC – Nicolai</td>
<td>Planning</td>
</tr>
<tr>
<td>18</td>
<td>PC – Minot</td>
<td>Planning</td>
</tr>
</tbody>
</table>
## 2019 Projects - Infrastructure

<table>
<thead>
<tr>
<th>Project #</th>
<th>Site</th>
<th>Type of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Providence Everett</td>
<td>Current client site – Upgrade Development/Planning</td>
</tr>
<tr>
<td>20</td>
<td>Everett Clinic</td>
<td>Planning</td>
</tr>
<tr>
<td>21</td>
<td>SnoCo DEM</td>
<td>Upgrade to support Buck/Lookout coming online</td>
</tr>
<tr>
<td>22</td>
<td>Oregon HamWAN</td>
<td>Coordination of interconnects with SW WA</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
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<tr>
<td>24</td>
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<td>26</td>
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# 2019 Projects - Organizational

<table>
<thead>
<tr>
<th>Project #</th>
<th>Site</th>
<th>Type of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Website update</td>
<td>Maps / documentation</td>
</tr>
<tr>
<td>2</td>
<td>Network monitoring</td>
<td>Upgrade / automation</td>
</tr>
<tr>
<td>3</td>
<td>VOIP system</td>
<td>Enhance resilience</td>
</tr>
<tr>
<td>4</td>
<td>Network services</td>
<td>Improve distributed service development</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
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<td>8</td>
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</tbody>
</table>
How can I get involved/help?

- Join the PSDR mailing list (psdr-join@HamWAN.org)
- Join the IRC chat group (IRC channel #HamWAN-Support on irc.freenode.org)
- Tower climbers
- Ground crew
- Site sponsors
- Software / Systems development
- Onsite RF path testing (client or cell sites)
- Help needed all through WWA
- USE IT!
Ongoing support

- HamWAN is donation funded
  - Personal Client sites: N/A
  - Client sites (organizations): $360/yr
  - Cell sites (organizations): $720/yr
Ongoing support – Client sites

- Client sites: $360/yr
  - $30 / month
  - 6-8 Coffees / month

- Individual Amateurs – Not required, but any amount helps.
Ongoing support – Cell sites

- Cell sites: $720/yr
  - $60 / month
  - < 1 tank of gas / month
Where does it go?

- Repairs – establish and maintain spare parts inventory distributed through WWA for needed repairs without the need to wait on GSA or budget approval
  - Antennas
  - Radios
  - Batteries
- Site lease costs
- HamWAN is all volunteers – nobody gets paid.
- Supporting sites get prioritized higher for repairs/etc
What does it cost?

- **Client Sites**
  - EOCs, Hospital endpoint connections
  - Basic Connection (Individuals) - $215-$245 and up
  - Advanced Connection - $575 (+$360/yr)
  - Redundant Connections - $900-$1250 (+$360/yr)

- **Cell Site**
  - Communications hubs and mountain-top sites
  - Allows multiple EOCs or Hospitals to connect to cell site and each other
  - $2500-$4500 (+$720/yr)
Questions?
<table>
<thead>
<tr>
<th>Technology</th>
<th>Speed(s)</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Packet</td>
<td>1200 bps</td>
<td>• Good coverage (20 mi)</td>
<td>• Slower speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Doesn’t need line of sight</td>
<td>• Needs proficient operator</td>
</tr>
<tr>
<td>UHF Packet</td>
<td>9600 bps</td>
<td>• Good coverage (20 mi)</td>
<td>• Slower speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Doesn’t need line of sight</td>
<td>• Needs proficient operator</td>
</tr>
<tr>
<td>D-Star</td>
<td>9600 bps –</td>
<td>• Good coverage</td>
<td>• Specialized equipment</td>
</tr>
<tr>
<td></td>
<td>128 kbit</td>
<td>• Able to link via Internet</td>
<td>• Medium operator proficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Doesn’t need line of sight</td>
<td></td>
</tr>
<tr>
<td>HamWAN</td>
<td>5mbit – 50</td>
<td>• High speed</td>
<td>• Requires clear line of sight (LOS)</td>
</tr>
<tr>
<td></td>
<td>mbit</td>
<td>• Supports multiple users</td>
<td>• Better for fixed install locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ideal critical backbone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Independent of Internet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Connects to Internet</td>
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<tr>
<td></td>
<td></td>
<td>• Provides service without Internet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can be used to connect Packet, D-Star, Internet, and others</td>
<td></td>
</tr>
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</table>
# Speed comparisons

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Typical Speed</th>
<th>Transfer time 200k email</th>
<th>Transfer time 1mb photo</th>
<th>Transfer time 10mb attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Packet radio</td>
<td>1200 bps</td>
<td>25 min</td>
<td>2.1 hrs</td>
<td>-----</td>
</tr>
<tr>
<td>UHF Packet radio</td>
<td>9600 bps</td>
<td>3 min</td>
<td>16 min</td>
<td>-----</td>
</tr>
<tr>
<td>Dialup internet</td>
<td>56,000 bps (56k bps)</td>
<td>31 sec</td>
<td>2.7 min</td>
<td>27 min</td>
</tr>
<tr>
<td>DSL</td>
<td>12 mbps</td>
<td>&lt; 1 sec</td>
<td>&lt; 1 sec</td>
<td>7 sec</td>
</tr>
<tr>
<td>Cable</td>
<td>20 mbps</td>
<td>&lt; 1 sec</td>
<td>&lt; 1 sec</td>
<td>4 sec</td>
</tr>
<tr>
<td>HamWAN (1)</td>
<td>6 mbps</td>
<td>&lt; 1 sec</td>
<td>1 sec</td>
<td>14 sec</td>
</tr>
<tr>
<td>HamWAN (2)</td>
<td>10 mbps</td>
<td>&lt; 1 sec</td>
<td>&lt; 1 sec</td>
<td>8 sec</td>
</tr>
<tr>
<td>HamWAN (3)</td>
<td>50 mbps</td>
<td>&lt; 1 sec</td>
<td>&lt; 1 sec</td>
<td>1 sec</td>
</tr>
</tbody>
</table>
System testing @ Providence

- Test conducted Saturday October 26, 2013
- 12.5 mile connection between Providence and Snohomish County DEM
- Achieved 6Mbit data transfers up and down
- Youtube videos at full speed!
- Email and web browsing
System testing @ Valley General

- Test conducted Saturday October 12, 2013
- 5.7 mile connection between Providence and Snohomish County DEM
- Achieved 10Mbit data transfers up and down
- Youtube videos at full speed!
- Email and web browsing