

ÄRTEN™ project



www.w1sye.org

Amateur Radio Training Experiment Network

Experiments in the Ham bands from ≈ 1 to 10 GHz (3 to 33 cm)

Presentation for

Microwave Update 2023

Hilton Garden Inn at Bradley Airport

Windsor, Connecticut

April 14-15, 2023

plus 46th Eastern VHF/UHF Conference

Speaker: K1YBE, Paul Fredette, MSEE

For the Newport County Radio Club (w1sye.org)

ÄRTEN™ project



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Amateur Radio Training Experiment Network

Experiments in the Ham bands from ≈ 1 to 10 GHz (3 to 33 cm)

I think of the SHF bands as the new “short wave radio” of this century, HF(10m to 100m) was considered short wave when Ham radio was established

Now it's time for 3 cm/10 GHz to 30 cm/1 GHz to be a catalyst

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This project includes the use of the AREDN Mesh software

An ARRL Foundation Grant of \$7,975 was awarded in Dec 2022

ÄRTEN™ - Idea for the name



arten v. (Latin)

To compel, force, or induce (sb. to do sth.);

to induce or bring about (a result);

ärten n. (Swedish) - definite singular of ärt

*The **Ä** umlaut (dots) is intended to represent a charge dipole radiating knowledge.*

TEN - A nod to 10 GHz

cm Bands available to all classes of Amateur Licensees



- **33 Centimeters (902-928 MHz) 13 inches**
- **23 Centimeters (1240-1300 MHz) 9 inches**
- **13 Centimeters (2300-2310 and 2390-2450 MHz) 5 inches**
- **9 Centimeters (3300-3500 MHz) 3.5 inches**
- **5 Centimeters (5650.0-5925.0 MHz) 2 inches**
- **3 Centimeters (10000.000-10500.000 MHz) 1.2 inches**

Already established technology allows us to put them to use in novel ways

- We have these radios in our homes now in low cost WiFi routers at 2.4 and 5 GHz.
- WiFi frequencies can reuse the many *AREDN*[™] equipment solutions

USE IT OR LOSE IT - continuing pressure on the FCC to reallocate spectrum

Channel Allocations



900 MHz	Channel	4	5	6	7
	Ctr Freq	907	912	917	922
	Status	Shared with US unlicensed			

Unshared 10 MHz channel

2.4 GHz	Channel	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8*
	Ctr Freq	2.387	2.392	2.397	2.402	2.407	2.412	2.417	2.422	2.427	2.432	2.437	2.442	2.447
	Status	non-US only		Unshared		Cannot Use	Shared with US unlicensed							

* Only 5 MHz channel width is available on channel 8

3.4 GHz	Channel	76	77	78	79	80	81	82	83	84	85	86	87	88	89
	Ctr Freq	3.380	3.385	3.390	3.395	3.400	3.405	3.410	3.415	3.420	3.425	3.430	3.435	3.440	3.445
	Status	US Amateur operations remain on a secondary basis but are subject to removal at any time by FCC notice*													

* per FCC 20-138 (V-E-09)

5.8 GHz	Channel	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	
	Ctr Freq	5.855	5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.905	5.910	5.915	5.920	5.925	5.930	5.935	5.940	
	Status	Shared with US unlicensed indoor/outdoor DFS & Radar Avoidance																		
	Channel	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	
	Ctr Freq	5.745	5.750	5.755	5.760	5.765	5.770	5.775	5.780	5.785	5.790	5.795	5.800	5.805	5.810	5.815	5.820	5.825	5.830	
	Status	Shared with US unlicensed indoor/outdoor																		
	Channel	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	
	Ctr Freq	5.835	5.840	5.845	5.850	5.855	5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.905	5.910	5.915	5.920	
	Status	Shared with Unlicensed			Shared with US unlicensed mainly indoor												Shared with Intelligent Transportation System			

CONCEPTS

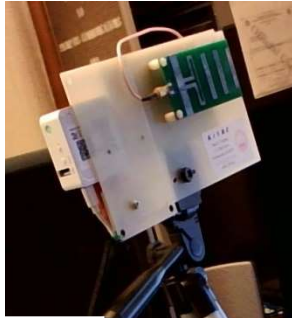


- **NCRC will plan and own an array of local mesh nodes and encourage attachment by Hams with an entry level Technician and higher class licenses.**
- **Traffic will be open using published protocols and not encrypted except in emergencies.**
- **TLS and other encryption protocols will be monitored and blocked in normal use.**
 - **This makes *ÄRTEN* an experiment in cybersecurity.**
- **Internet connections are allowed but traffic will be monitored to avoid commercial use.**
- **Low Cost for personal equipment will encourage youth access**
 - **Many of the components are available for less than \$50 and a station can be <\$100.**
 - **Most of this can be done with reprogrammed WiFi routers and home brew antennas,**
 - **The size of cm band antennas make 3D printing them a reality.**
- **Make the learning material (youtubes and online documents) available for all.**

AN EXAMPLE NODE OPERATED AT 3 MILES



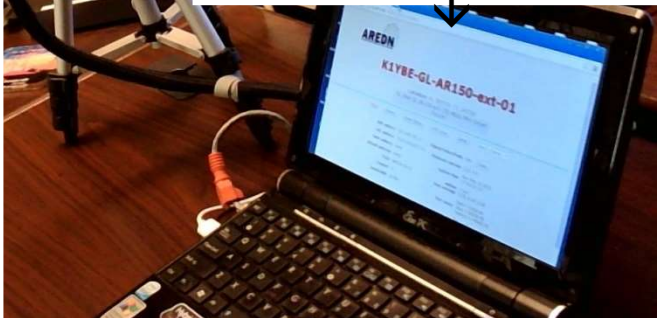
< Yagi-Uda side



Router/Radio(white) >

4 W Amp (black)

Control Web page
from the router



Equipment:

Approx. \$70
Plus a computer
(Raspberry PI is
adequate)

Current 2023 Initiatives



1) Access to a quality 6GHz VNA and training for RF component and antenna calibration

- 1) Workforce training for RF/ wireless / xG-NR deployments (see next slide)
- 2) Incremental exposure to radio and antenna measurement technologies.
- 3) <https://nediv.arrl.org/2023/02/17/ham-radio-is-a-gateway-to-technology/>

Q. When was the first time you saw and then used a VNA?

2) CO₂ Sensors in farm fields to collect data that illustrates the Oxygen/CO₂ life cycle.

- 1) Weather and solar irradiance data will also be collected to help understanding of the measurements
- 2) APRS reporting of CO₂ concentration will be prototyped.
- 3) Data will be provided to local Middle and High schools for classroom project analysis.

3) Exposure to Networking

- 1) Mesh nodes allow any IP application to be used. Nodes provide complex functions like Remote Radio control as well as simple MESHCHAT
- 2) Advanced monitoring of mesh traffic can be used to demonstrate and implement cyber security techniques
- 3) QSOs by chat messaging would use CW procedures to teach these messaging skills.

4) Radio fun

- 1) While Mesh radio at 2397 MHz is the initial deployment for sensor data transmission, the equipment can be use to connect with nodes being deployed in many Mesh projects including the NE Mesh initiative making . ***CQ MESH and POTA are near term realities***

Projected Job Growth - 5G



SUMMARY TABLE 1: THE THREE WAVES OF WIRELESS JOB GROWTH

		MAIN LOCUS OF JOB GROWTH	PERCENT OF ECONOMY AFFECTED	JOBS CREATED (AS OF DATE)
Wave 1 The Rise of Wireless	1990 - 2007	Wireless industry , providing mobile voice/text/email services	1%	200,000 (2007)
Wave 2 The App Economy	2007 - 2019	Digital industries such as entertainment, finance, communications and social networks	20%	2.2 million (2019)
Wave 3 The 5G Revolution	2019 - 2034	Digital plus physical industries such as agriculture, energy, construction, manufacturing, transportation, education, healthcare, government (including defense)	100%	4.6 million (2034) 106,000 (2020)

Data: Bureau of Labor Statistics; Progressive Policy Institute; Indeed.com; author projections

Very Nice Analyzer Initiatives



- ❑ A quality two port 6GHz VNA was procured and 3 events at Fab Newport held.
- ❑ Biweekly meeting at FabNewport from 3 to 5 pm engages youth using the center 's concurrent STEM activities. Visitors encouraged to attend.
- ❑ Coupled with:
 - ❑ <https://fabnewport.org/pull-it-apart/>
- ❑ ARRL recognition
 - ❑ <https://nediv.arrl.org/2023/02/17/ham-radio-is-a-gateway-to-technology/>



MESHING Around: ÄRTEN Workshops Continue



Posted at W1SYE.ORG on March 23, 2023 by Rob

- ❑ *The ÄRTEN™ project demonstrated a five (5) node MESH network at the March 20, 2023 FabNewport workshop.*
- ❑ *The network consisted of: a range-extended GL.iNet AR150-Ext node (on tripod); a regular GL.iNet AR150-Ext; two GL.iNet AR300M16-Ext; and a Microtik SXTSQ Lite 2.*
- ❑ *In addition, K1YBE demonstrated collecting CO₂ measurements with two Vaisala GMP343 probes.*
- ❑ *ÄRTEN™ Project goals were reviewed and a way forward using an Ethernet-enabled CO₂ sensor was approved. A lively discussion on environmental monitoring in general and CO₂ monitoring in specific ensued.*



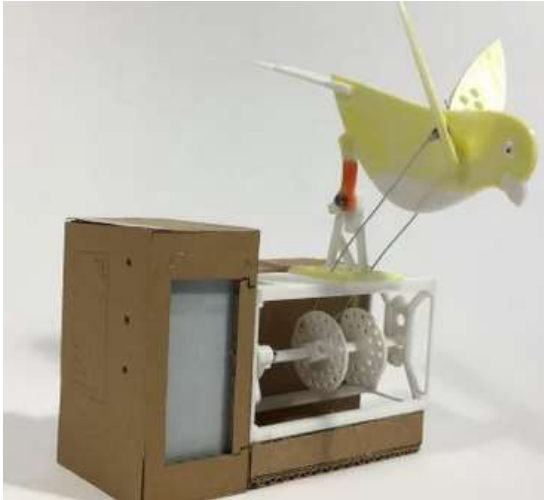
OUTSTANDING IN OUR FIELD



- Initial CO₂ sensor location
- Pop corn growing area
- Antenna height ≈12 ft
- Solar power for charging and photosynthesis calibration
- CO₂ concentration and Weather data sampled day and night. APRS output
- 2.4 GHz AREDN Mesh node for radio and network learning
- Looking for nearby relay points
- <https://www.vaisala.com/en/products/instruments-sensors-and-other-measurement-devices/instruments-industrial-measurements/gmp343>



We are not alone -



DesignSpark Environmental Sensor Development Kit

<https://www.rs-online.com/designspark/jude-pullen-air-quality-canary-project>

<https://www.rs-online.com/designspark/air-quality-and-activist-engineering-update>

Contest Ideas



Defined awards

- ❑ **ARTEN DYDX - 1 yard at 1-10 GHz = 1 Mile of HF DX**
 - ❑ ***Encourages short and direct connection (without a repeater) experiments with significant frequency reuse up to about 8 miles (180° great circle)***
 - ❑ ***Longer connections are classified as Extra Terrestrial and allow Moon-bounce, Moon QSOs, and satellite radio operation projects***
 - ❑ ***Band Factor included to allow lower frequencies and make <30MHz the same as HF DX and encourage >10 GHz***

- ❑ **ARTEN WAN -I,V,X,L,C “Worked All Nodes” Certificates**

FUTURE CONTEST IDEAS



ARTEN WEB “Worked Every Band” Award

ARTEN CAN “Connected to All Nodes” Award

ARTEN WAM “Worked All Modes” Award

ARTEN MEN Moon (ours) - Earth Networked

ARTEN WOMEN World (e.g. Planet) Or Moon (e.g. Europa) to Earth Networked

Other mesh projects - Much is happening



- ❑ **Western States have been deploying emergency and dense city networks for some years now. This was the impetus behind the development of the AREDN mesh software that continues to be improved.**
 - **www.arednmesh.org**
- ❑ **World map --- <http://usercontent.arednmesh.org/K/5/K5DLQ/livemap2.html#2/66.2/-67.9>**
- ❑ **ARRL NE-DIV has a working group on Spectrum Protection and Use that meets on Mesh status on alternate meetings.**
- ❑ **https://nediv.arrl.org/spectrum-protection-utilization/#New_England_Mesh_Networking**
- ❑ **AR|DC grants have been issued to RI (Fire Tower Sites), Maine (15 sites) and**
- ❑ **one applied for by New Hampshire (MerrimackValleyARA.org) to build out wireless amateur radio mesh networks on 2.4 and 5.8 GHz with the larger goal of linking the New England region.**
- ❑ **Bill Richardson, NG1P, presented at the Maine State Convention and Hamfest on Saturday March 25.**
- ❑ **<https://www.ardc.net/apply/grants/2022-grants/grant-rhode-island-emergency-mesh-network-and-digital-voice-repeater-network/>**

NEXT STEPS



If the ideas presented interest you and you want further information, send me an email at:

K1YBE@YAHOO.COM

You can follow us at www.w1sye.org (ARTEN project)

Special thanks to our ARRL Foundation Grant Collaborators:
KB1ZZU(Rob White), KC1NEK (Nancy Austin), K1NPT (Mike Cullen),
Fab Newport, and many others

Futures..

- NCRC General/Extra seminar will highlight details about ARTEN tech as this is already on the license exams.
- Projects building web based HF radio control panels.
- Sending IF I/Q digital samples from a shared remotely controlled dish antenna for local decoding by several operators.
- Any internet availability can be used for testing but commercial internet access(\$/mo) is not needed to operate locally on a HAM mesh network