HamSCI
Personal Space Weather Station (PSWS) Architecture and Current Status

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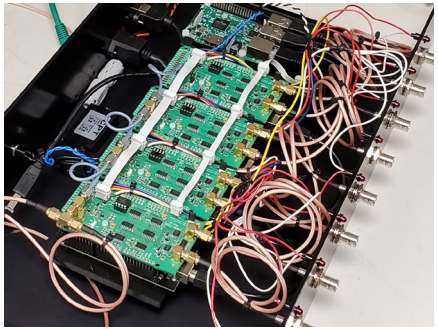
[6]TAPR
[7]HamSCI
[8]MIT Haystack Observatory
[9]Systems & Technology Research

Amateur Radio, Space Weather, & Propagation

W3USR University of Scranton



N8UR multi-TICC: Precision Time Interval Counter

AB4EJ Home Station

Field Day / Emergency Prep

KD2JAO & WB2JSV at K2MFF

K3LR Contest Super Station

DXing from Adak Island

K2BSA Scout Jamboree

What is a Personal Space Weather Station?

- The **HamSCI Personal Space Weather Station (PSWS)** is a multi-instrument, ground-based device designed to observe space weather effects both as a single-point measurement and as part of a larger, distributed network.
- It is **"Personal"** because it is being designed such that an individual should be able to purchase one and operate it in their own backyard.
- **For amateur radio operators, the PSWS should provide information about current radio propagation conditions both locally and as part of a global network.**
- In addition, the PSWS design **takes into account the needs of professional researchers** who want to study specific aspects of the ionosphere and space weather.
- The PSWS is being developed as a collaborative project under the **Ham Radio Science Citizen Investigation (HamSCI)** collective, led by the University of Scranton with collaborators at Case Western Reserve University, the New Jersey Institute of Technology (NJIT), the University of Alabama, the MIT Haystack Observatory, **TAPR**, and volunteers from additional universities and the amateur radio community.

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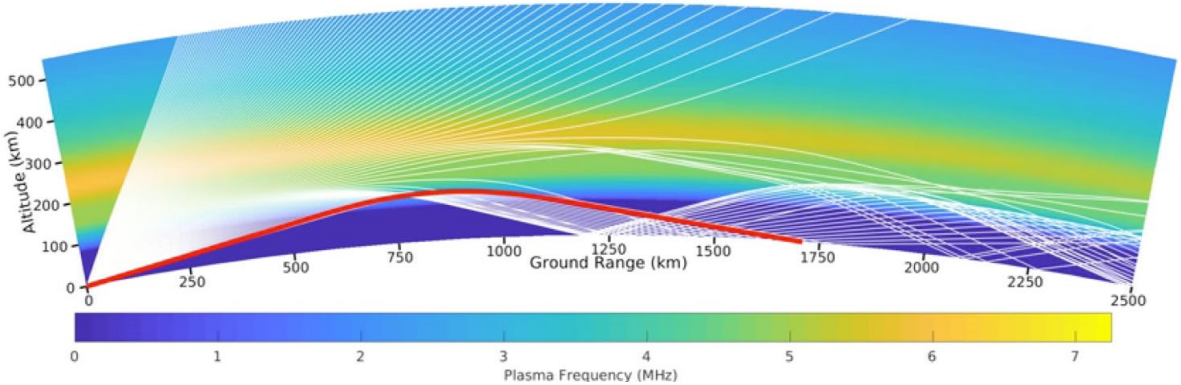
Amateur Radio Frequencies and Modes

Eclipsed SAMI3 - PHaRLAP Raytrace

1600 UT 21 Aug 2017 • 14.03 MHz • TX: AA2MF (Florida) • RX: WE9V (Wisconsin)



PHaRLAP: Cervera & Harris, 2014, https://doi.org/10.1002/2013JA019247
SAMI3: Huba & Drob, 2017, https://doi.org/10.1002/2017GL073549

- **Amateurs routinely use HF-VHF transionospheric links.**
- **Often ~100 W into dipole, vertical, or small beam antennas.**
- **Common HF Modes**
  - Data: FT8, PSK31, WSPR, RTTY
  - Morse Code / Continuous Wave (CW)
  - Voice: Single Sideband (SSB)

	Frequency	Wavelength
LF	135 kHz	2,200 m
MF	473 kHz	630 m
	1.8 MHz	160 m
HF	3.5 MHz	80 m
	7 MHz	40 m
	10 MHz	30 m
	14 MHz	20 m
	18 MHz	17 m
	21 MHz	15 m
	24 MHz	12 m
	28 MHz	10 m
VHF+	50 MHz	6 m
	And more…	

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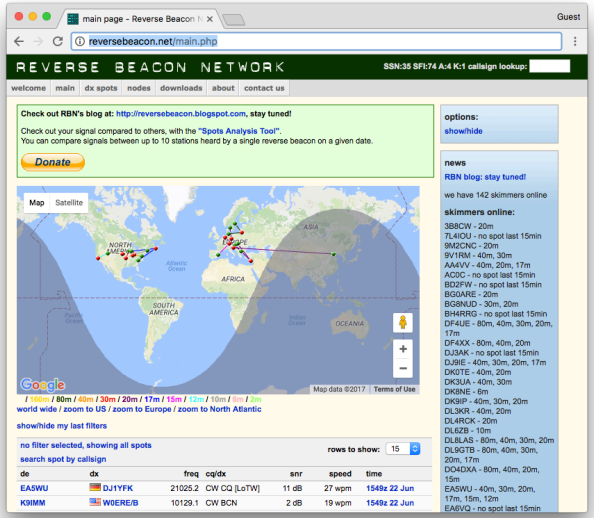
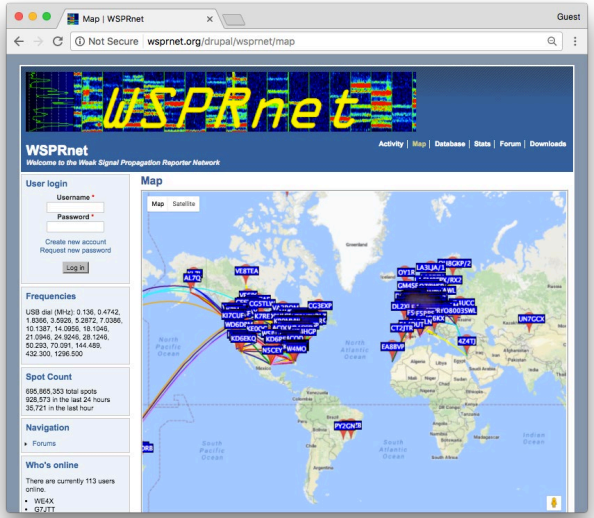
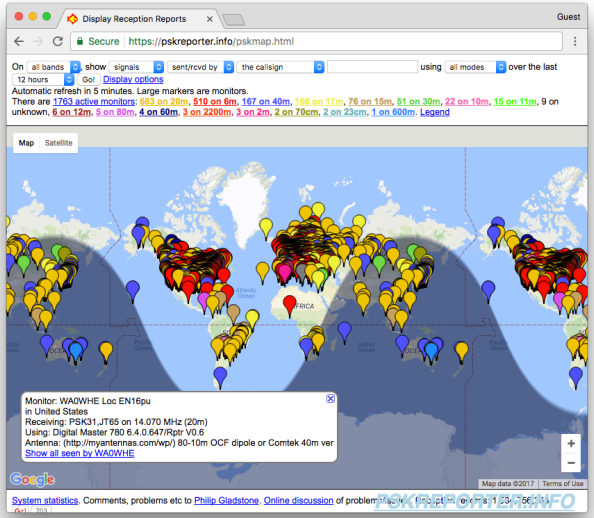
Current Amateur Radio Observation Networks



Reverse Beacon Network (RBN)
reversebeacon.net



WSPRNet
wsprnet.org



PSKReporter
pskreporter.info

- Quasi-Global
- Organic/Amateur Radio Run
- Unique & Quasi-random geospatial sampling

- Data back to 2008 (A whole solar cycle!)
- Available in real-time!

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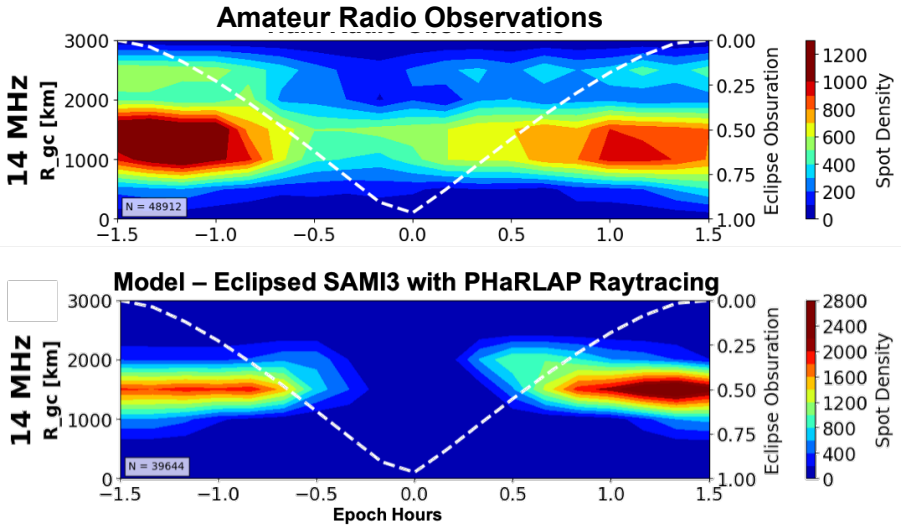
Examples of Amateur Radio Research

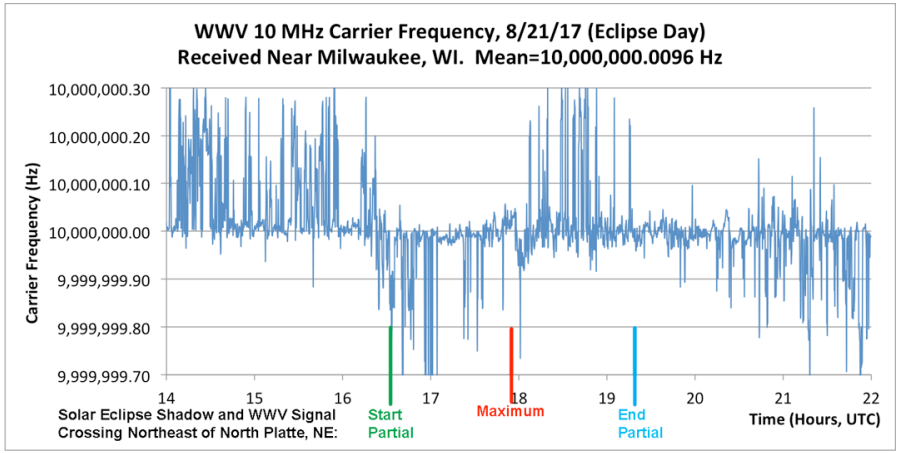
- Existing amateur radio observations networks, not specifically designed for scientific use, have already enabled ionospheric observations using amateur radio.

2017 Eclipse Continental US Observations



[Frissell et al., 2018, https://doi.org/10.1029/2018GL077324]

2017 Eclipse WWV Doppler Shift Observations



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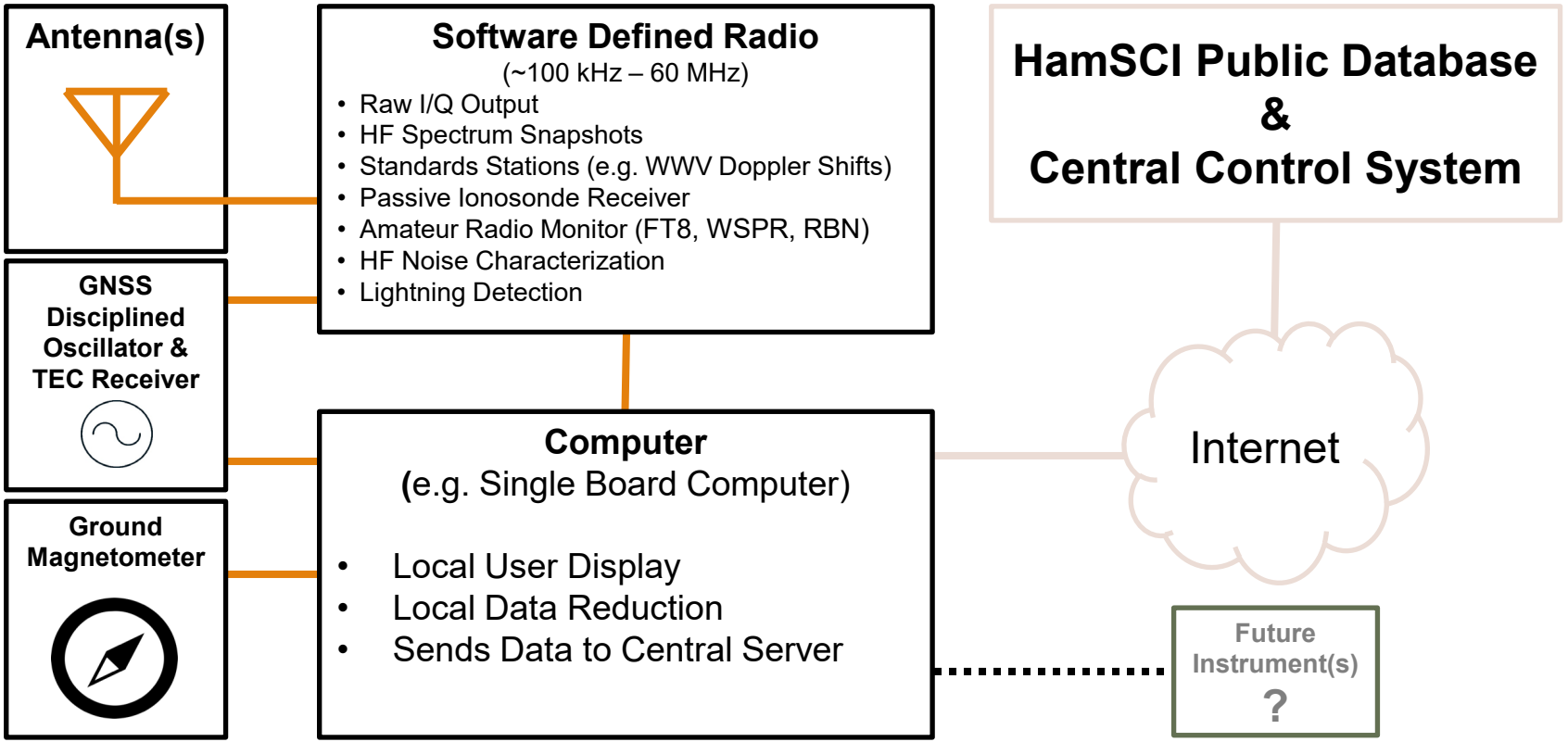
What makes up a PSWS?



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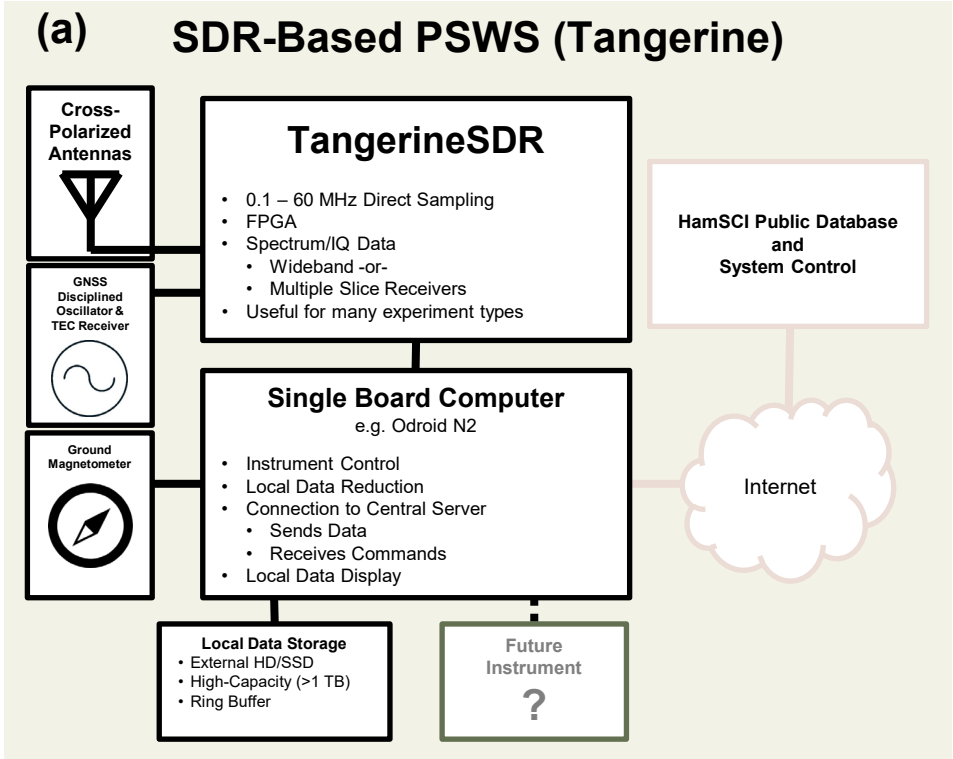
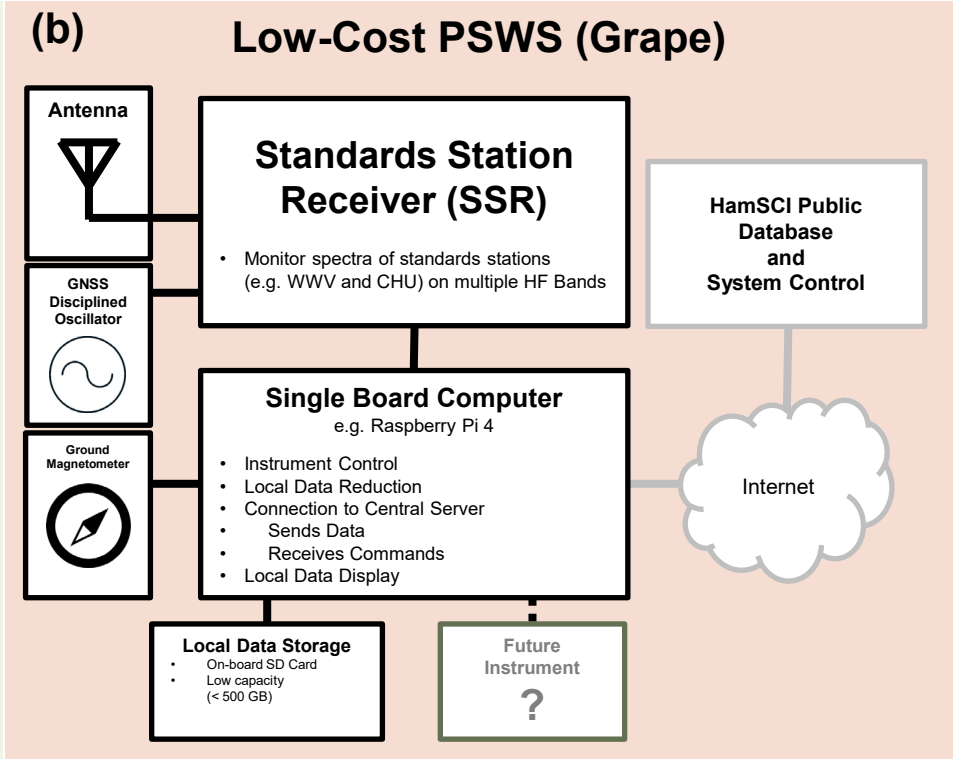
SDR-Based and Low-Cost PSWS Versions





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PSWS Teams

University of Scranton
- **Nathaniel Frissell W2NAF (PI)**
- Dev Joshi KC3PVE(Post-Doc)
- Jonathan Rizzo KC3EEY
- Veronica Romanek KD2UHN

Responsibilities
- Lead Institution
- HamSCI Lead
- Radio Science Lead

TAPR & Zephyr Engineering
- **Scotty Cowling WA2DFI (Chief Architect)**
- Tom McDermott (RF Board)
- John Ackerman N8UR (Clock Module)
- David Witten KD0EAG (Magnetometer)
- Jules Madey K2KGJ (Magnetometer)
- David Larsen KV0S (Website)

Responsibilities
- TangerineSDR (High Performance)
- Data Engine
- Ground Magnetometer

University of Alabama
- **Bill Engelke AB4EJ (Chief Architect)**
- Travis Atkison (PI)

Responsibilities
- Central Database
- Central Control Software
- Local Control Software

Case Western Reserve University
Case Amateur Radio Club W8EDU
- **David Kazdan AD8Y (Lead)**
- Kristina Collins KD8OXT
- John Gibbons N8OBJ
- Rob Wiesler AC8YV
- Soumyajit Mandal (PI)
- Matt McConnell KC8AWM
- Skylar Dannhoff KD9JPX
- Aidan Montare KB3UMD

Responsibilities
- Low Cost PSWS System

MIT Haystack Observatory
- **Phil Erickson W1PJE**

Responsibilities
- Science Collaborator

New Jersey Institute of Technology
- **Hyomin Kim KD2MCR (PI)**
- Gareth Perry KD2SAK
- Andy Gerrard KD2MCQ
- Diego Sanchez KD2RLM

Responsibilities
- Ground Mag Oversight & Testing
- Science Collaborators

PSWS Current Engineering Status

- **Tangerine Data Engine (MAX10)**
  - Schematic capture: 90% complete
  - BOM: 100% complete
  - Preliminary CAD work started (part libraries created)
  - Preliminary PCB placement completed
- **Tangerine RF Module (dual-channel 0.1-54MHz)**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - PC Board placement and layout: 100% complete
  - Ready for Prototype build Waiting on compatibility review with DE
- **Tangerine Clock Module (ZED-F9T GPSDO)**
  - Preliminary design/part selection: 75% complete
  - Block diagrams: 75% complete
  - Connector pin definition: 100% complete
  - Schematic work not started
- **MagnetoPi Hat**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - PC Board placement and layout: 100% complete
  - Prototype parts buy started
  - Ready for Prototype build Waiting on compatibility review with LC-PSWS

- **Low Cost PSWS (Grape)**
  - Grape Generation 1 consists of a Leo Bodnar GPSDO frequency standard, a low IF receiver and a USB based A/D converter running a modified version of FLDIGI executing on a Raspberry Pi.
  - 7 Grape Generation 1 stations operational
  - 3 nodes built with commercial receivers operational
- **Control Software and Database**
  - Prototype of local control software exists
  - Runs on Odroid N2 Single Board Computer
  - Uses data from a TangerineSDR Simulator (FlexRadio with GPSDO + DAX IQ output)
  - Can monitor up to 16 band segments at a time
  - 4 types of data collection: Snapshotter, Ring Buffer, Firehose(L+R), and FT8/WSPR Propagation Monitoring
  - Proof of concept code working for all modes except WSPR and Firehose L (supercomputer interface)

Summary

- HamSCI is a collective that aims to bring together the amateur radio and professional space science research communities for mutual benefit.
- In an effort to improve the scientific usability of amateur radio observations and aid in amateur radio communications, HamSCI is developing a Personal Space Weather Station designed with science requirements in mind from the very beginning. These modular systems will include:
  - HF Radio Receivers for studying the ionosphere using signals of opportunity
  - Ground Magnetometer with ~10 nT resolution
  - GNSS Receivers for precision timestamping and frequency stability
  - Target price between $100 - $1000, depending on capabilities.

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Acknowledgements

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Thank You!

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