



TangerineSDR

A Modular Open Source
Software Defined Radio

for

HamSCI, Satellite, Experimenters and Academics

Scotty Cowling, WA2DFI

HamSCI Workshop

March 19, 2021



What is the TangerineSDR Project...?

The TangerineSDR Project is a modular, open source hardware and software platform for development of all components of a Software Defined Radio.

It is also a group of volunteers led by TAPR, dedicated to the building of a pool of open-source Software Defined Radio design information.

Kind of like openHPSDR. Kind of like ORI. Kind of like HamSCI. But ***different***.





TangerineSDR



We gratefully acknowledge support of this project from NSF Grants AGS-2002278, AGS-1932997, and AGS-1932972.

TAPR would also like to acknowledge the generous ARDC grant in support of the prototype build.



AMATEUR RADIO DIGITAL COMMUNICATIONS



What is a TangerineSDR radio?

A TangerineSDR radio has the following features:

- ❑ Wide-range cost-based performance
 - ❑ From \$300 to \$1000+
- ❑ Based upon an open source model (OHL/NCL hardware, GPL software)
- ❑ Extremely modular, configurable and expandable
- ❑ Advances the State of the Radio Art





What is a TangerineSDR radio?

A TangerineSDR radio has four basic components:

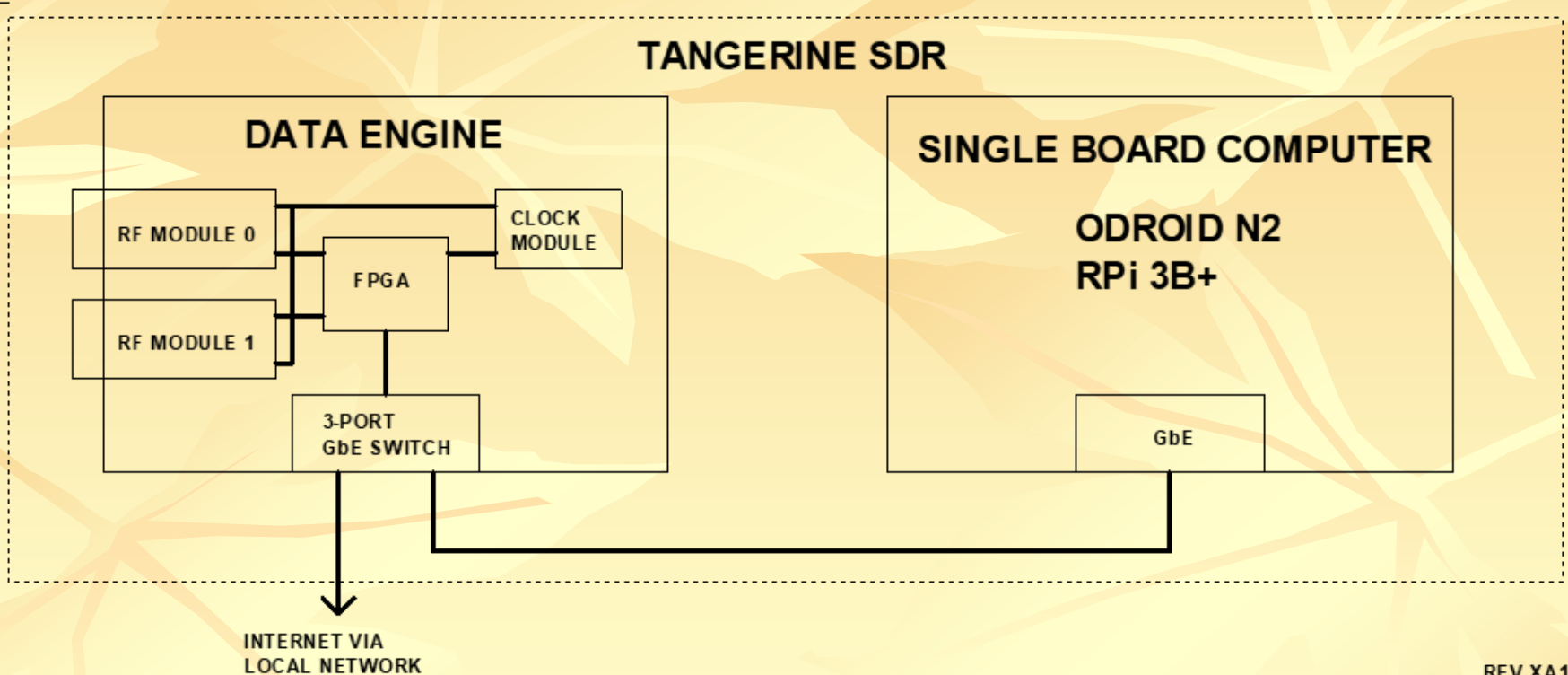
- ❑ Data Engine baseboard
- ❑ RF Modules (RFM) – two supported
- ❑ Clock Module (CKM)
- ❑ Compute Engine (typically an SBC Host Computer)





What is a TangerineSDR radio?

TANGERINE SDR



REV XA1

TangerineSDR System





Hardware Features

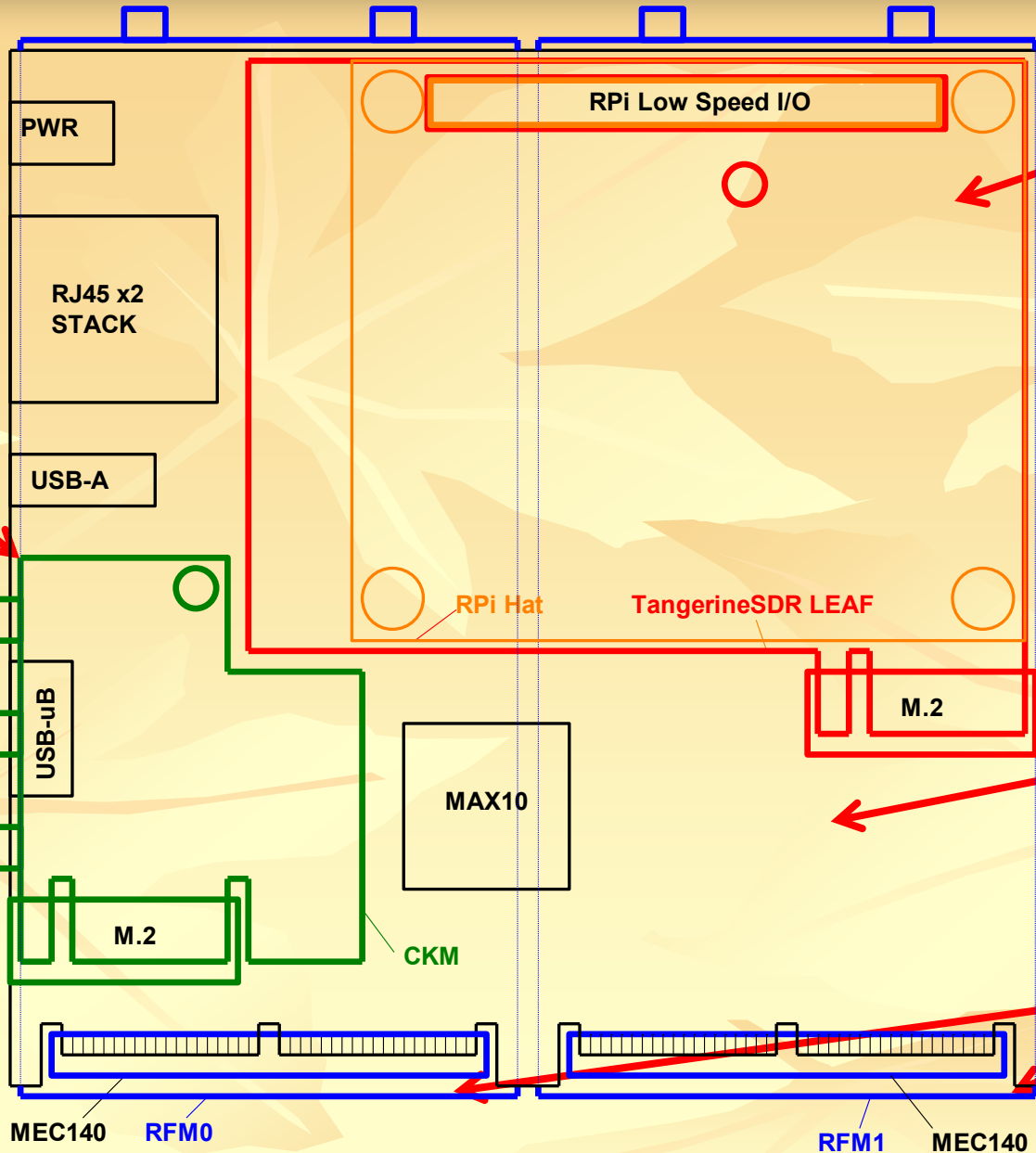
TangerineSDR Features

- ❑ FPGA-based Gb Ethernet direct sampling receiver
- ❑ Full receive coverage from 100kHz to 60MHz
- ❑ Web-based configuration
- ❑ Multiple UDP streams cover all bands from 160-6m
- ❑ Dual GbE, USB 3.0 and USB 2.0 simultaneous I/O
- ❑ Full transmit capability is future option





CKM



LEAF/HAT
(above)

Data Engine

RFMs
(below)





Hardware Features

TangerineSDR DE Features

- ❑ Altera/Intel 10M50DAF672I6G FPGA **50K LEs**
- ❑ 512MByte (256Mx16) DDR3L SDRAM
- ❑ 4Mbit (512K x 8) QSPI serial flash memory
- ❑ 512Kbit (64K x 8) serial EEPROM
- ❑ μ SDXC memory card up to 2TByte





Hardware Features

TangerineSDR DE Features

- ❑ 11-15V wide input, low noise SMPS
- ❑ 3-port GbE Switch (Dual GbE data interfaces)
- ❑ Cryptographic processor with key storage
- ❑ Temperature sensors (FPGA, ambient)
- ❑ Power-on reset monitor, fan header

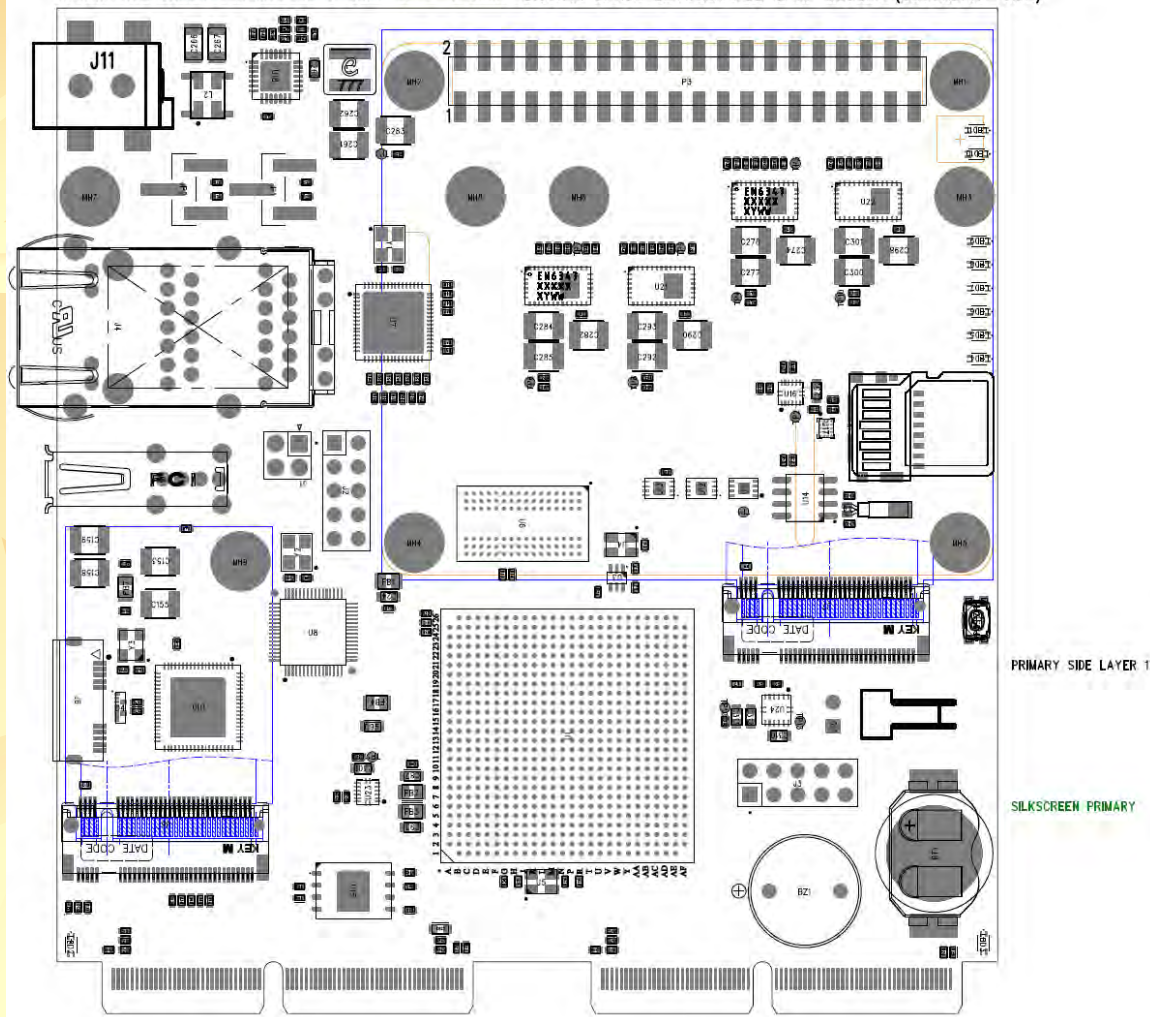




Hardware Features

ASSEMBLY DRAWING PRIMARY

CLEARANCE UNDER CLK MODULE & LEAF BD = 4.14mm 2.35mm SPACE BETWEEN PCB & RF MODULE (SECONDARY SIDE)



TangerineSDR Data Engine





Hardware Features

Future TangerineSDR DE Boards

- ❑ Larger, faster FPGAs
- ❑ More DRAM storage
- ❑ More non-volatile (SATA, SSD, etc) storage
- ❑ Higher speed data ports (10GE, 40GE, USB 3.2, etc)

BUT...

The same RFM ports allow reuse of RF boards





Hardware Features

TangerineSDR PSWS/HF RX Module

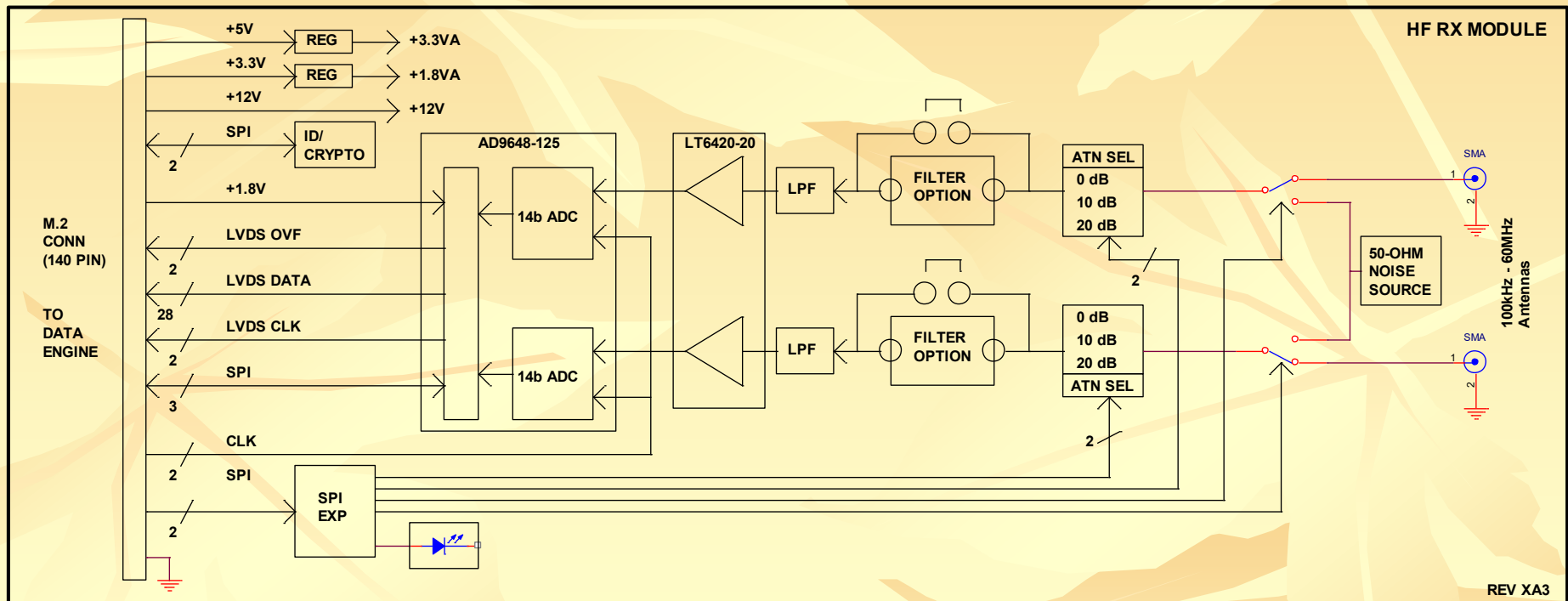
- ❑ AD9648-125 dual 14-bit 122.88Msps ADC
- ❑ 0dB/10dB/20dB/30dB remotely switchable attenuator
- ❑ LTC6420-20 20dB LNA
- ❑ Fixed 55MHz Low Pass Filter
- ❑ Optional user-defined plug-in filter
- ❑ On-board, switchable 50-ohm calibration noise source
- ❑ On-board low-noise power supplies
- ❑ Dual SMA antenna connectors





Hardware Features

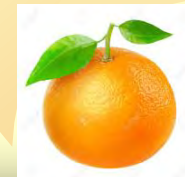
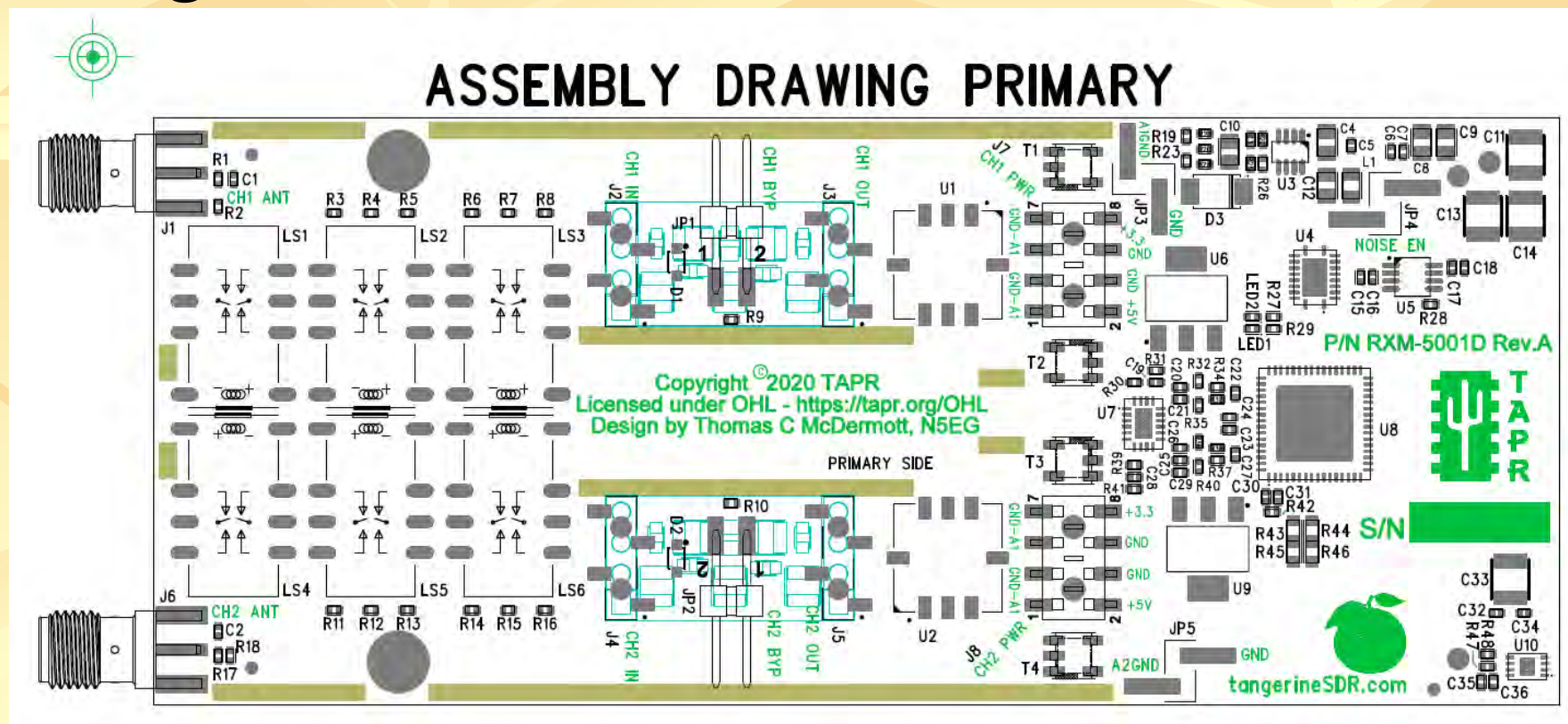
TangerineSDR PSWS/HF RX Module





Hardware Features

TangerineSDR PSWS/HF RX Module





Hardware Features

TangerineSDR RF Modules

- ❑ Personal Space Weather Station Receiver (no TX needed)
- ❑ VLF Receiver Module for 10kHz to 200kHz reception
- ❑ P4G RX and P4G TX modules **or** P4G TRX single module
- ❑ AD9361 MIMO transceiver module (70MHz – 6GHz)?
- ❑ Lime LMS7002M SDR Module (100kHz – 3.8GHz)?
- ❑ Lime LMS8001+ SDR Module (100kHz – 12GHz)?

Thank you to Tom McDermott N5EG for the PSWS RFM design!

Jonathan Rizzo KC3EEY will talk on the VLF RFM at 12:00PM today





Hardware Features

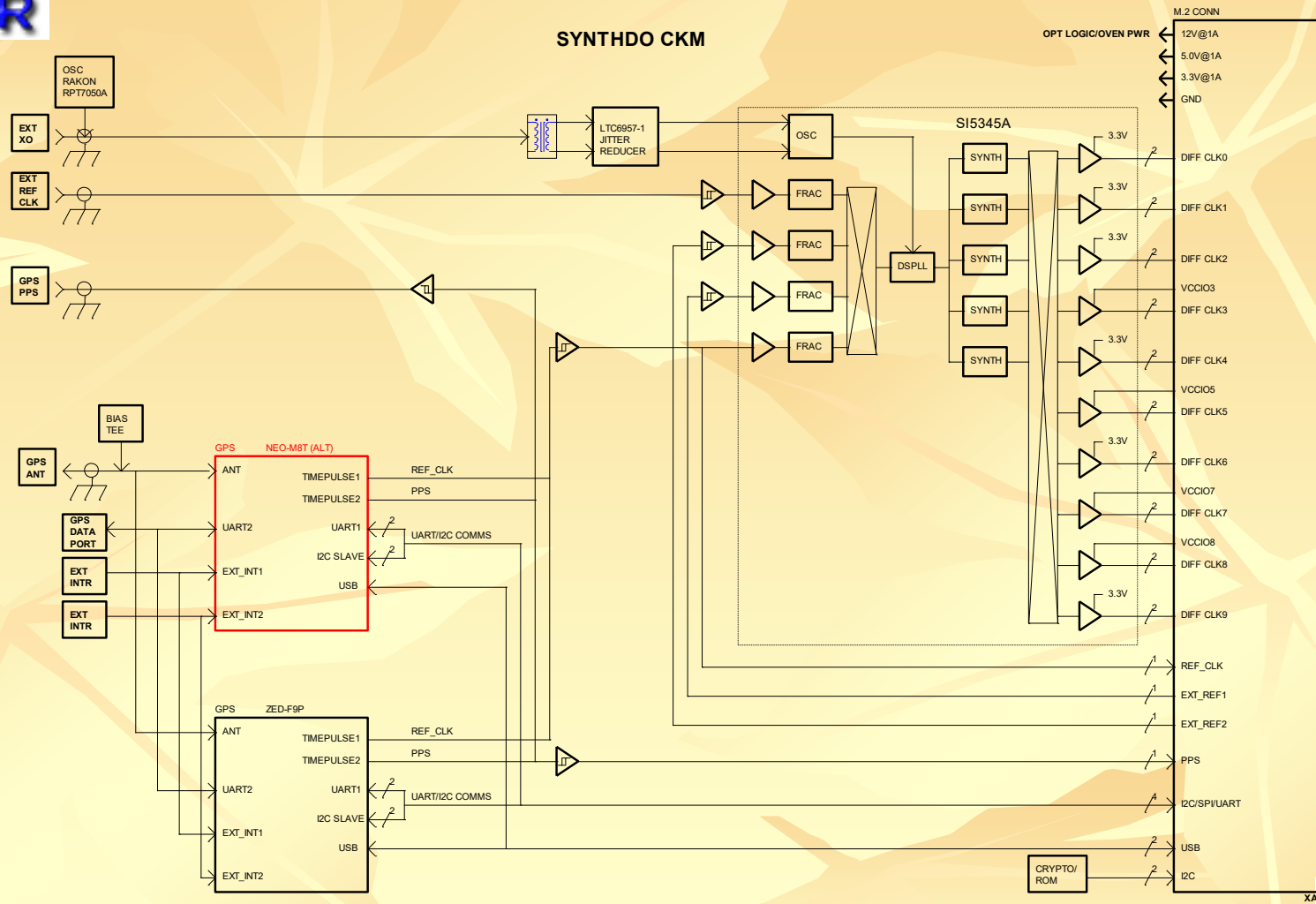
TangerineSDR CKM Clock Module

- ❑ Rakon RPT7050A Ultra Stable TCXO
 - ❑ Sub 0.1ppm frequency stability
 - ❑ RMS phase noise down to 0.13ps
- ❑ High performance ublox ZED-F9T GPS
- ❑ Silicon Labs very low-jitter Si5345A multi-channel synthesizer
- ❑ Integrates directly with Data Engine
- ❑ Useable as a near-laboratory standard in optional carrier board





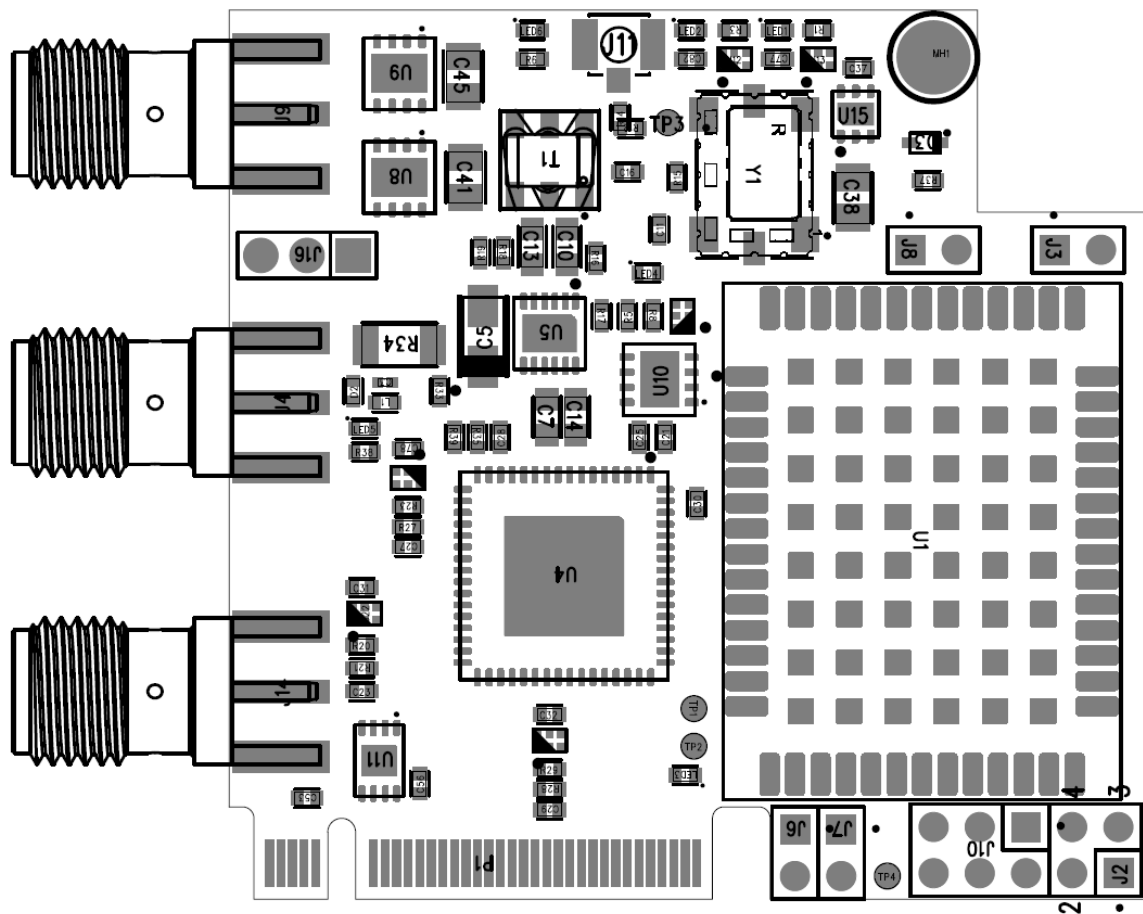
Hardware Features





Hardware Features

ASSEMBLY DRAWING PRIMARY



TangerineSDR
SynthDO CKM





Hardware Features

TangerineSDR CKM Clock Modules

- ❑ SYNTHDO CKM High Performance
 - ❑ High performance ublox ZED-F9T dual band GPS
- ❑ SYNTHDO Mid-grade performance (mfg option)
 - ❑ ublox NEO-M8T single-band GPS
- ❑ SYNTHDO Low-cost (mfg option)
 - ❑ ublox NEO-M9N single-band GPS, no pps output

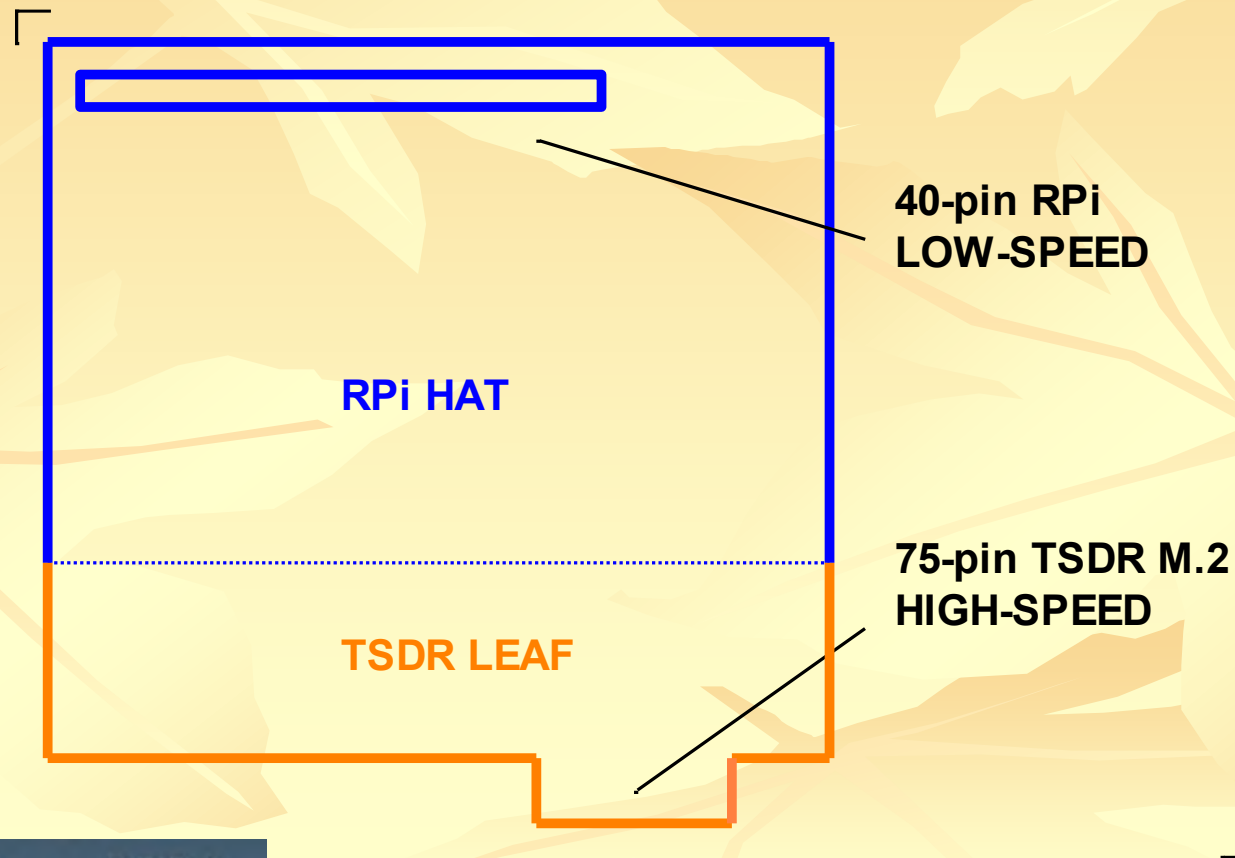
John Ackermann, N8UR, will tell you all about it right after my talk!





LEAF

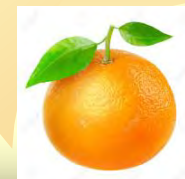
Low-speed Expansion Adapter Fixture





SDR Feature Comparison

Board	type	RX ADC	TX DAC	data i/f	user i/f	DSP	Freq	Max BW	Cost
TangerineSDR	Direct	14b@122M	n/a	GbE/UDP+USB 3	Web	10M50	100k-60M	20M	~\$500
RTL-SDR HF	Direct	8b@28.8M	n/a	USB 2	USB 2	n/a	raw I/Q	1.6M	\$25
RTL-SDR VHF+	Mix								
Red Pitaya 125-14	Direct	10b@125M	10b@125M	GbE	UDP	7010	300k-500M	60M	\$212
Red Pitaya 122-16	Direct	16b@122M	14b@122M			7020	DC-50M		\$604
Kiwi SDR	Direct	14b@66.7M	n/a	10/100 Ethernet	Web	XC7A35	10k-30M	30M	\$299
HackRF One	Mix	8b@22M	10b@22M	USB 2	USB 2	XC2C64	1M-6G	20M	\$299
HPSDR Atlas	Direct	16b@122M	14b@122M	10/100 Ethernet	UDP	3C40+	10k-55M	768k	~\$1500
HPSDR Hermes				GbE		3C40			~\$900
Hermes Lite	Mix	12b@76.8M	12b@153.6M	GbE	UDP	4CE22	130k-38.4M	384k	\$278
LimeSDR USB	Mix	12b@160M	12b@640M	USB 3	USB 3	4CE40	100k-3.8G	61.44M	\$315
Pluto	Mix	12b@61M	12b@61M	USB 2	USB 2	7010	325M-3.8G	20M	\$249
RX-188 HF	Direct	16b@122M	n/a	USB 3	USB 3	CYUSB	0-30M	8M	\$190
RX-188 VHF+	Mix	8b@32M					30M-1.8G	2.4M	





What can I use it for?

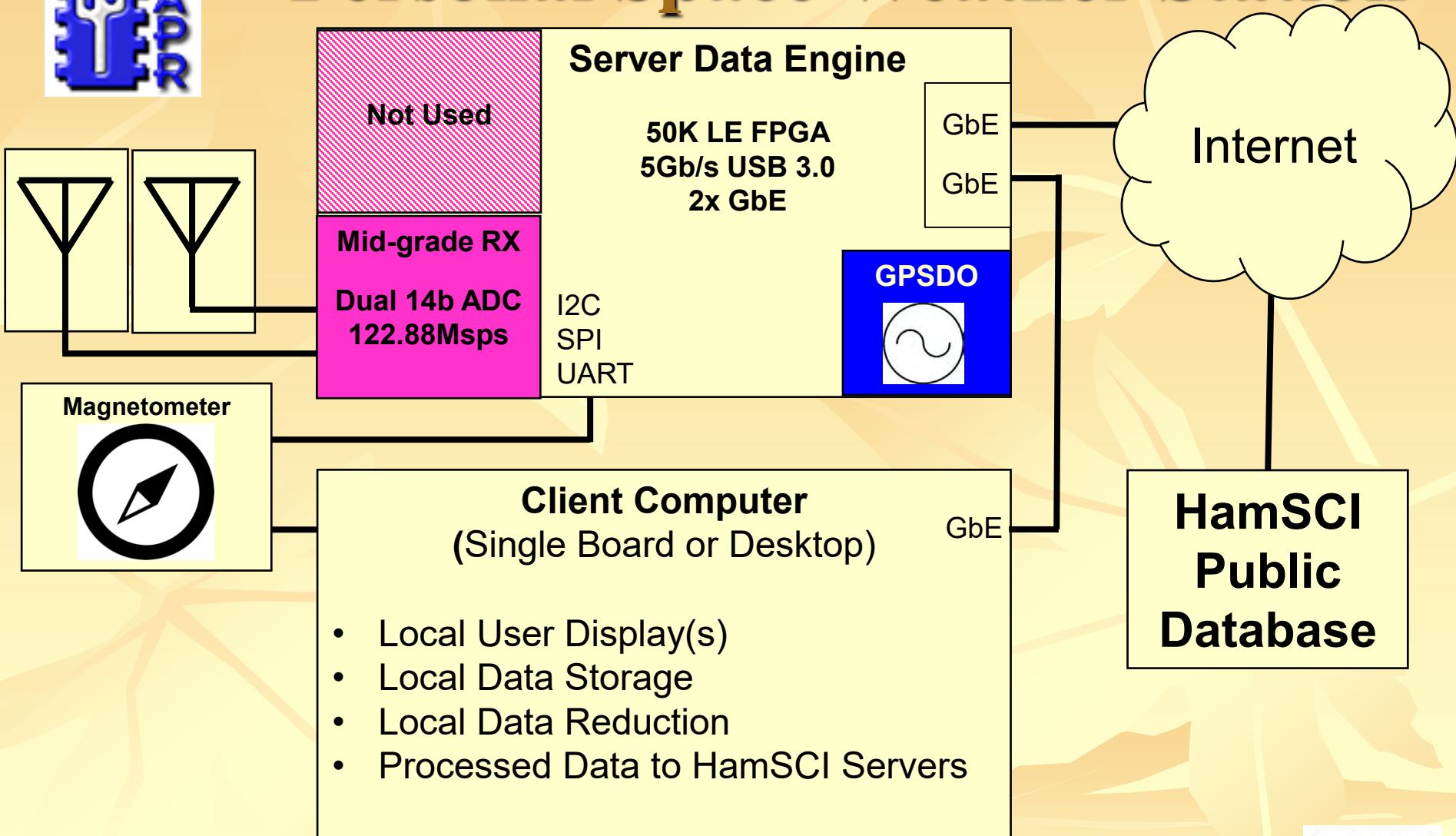
Target Applications

- ❑ HamSCI Personal Space Weather Station (PSWS)
- ❑ Phase 4 Satellite Ground Station (P4G)
- ❑ Academic uses to teach SDR and FPGA techniques
- ❑ Amateur Communications SDR
- ❑ Experimenters' (Amateur and non-Amateur) SDR
- ❑ Remote Ham Radio
- ❑ Others?



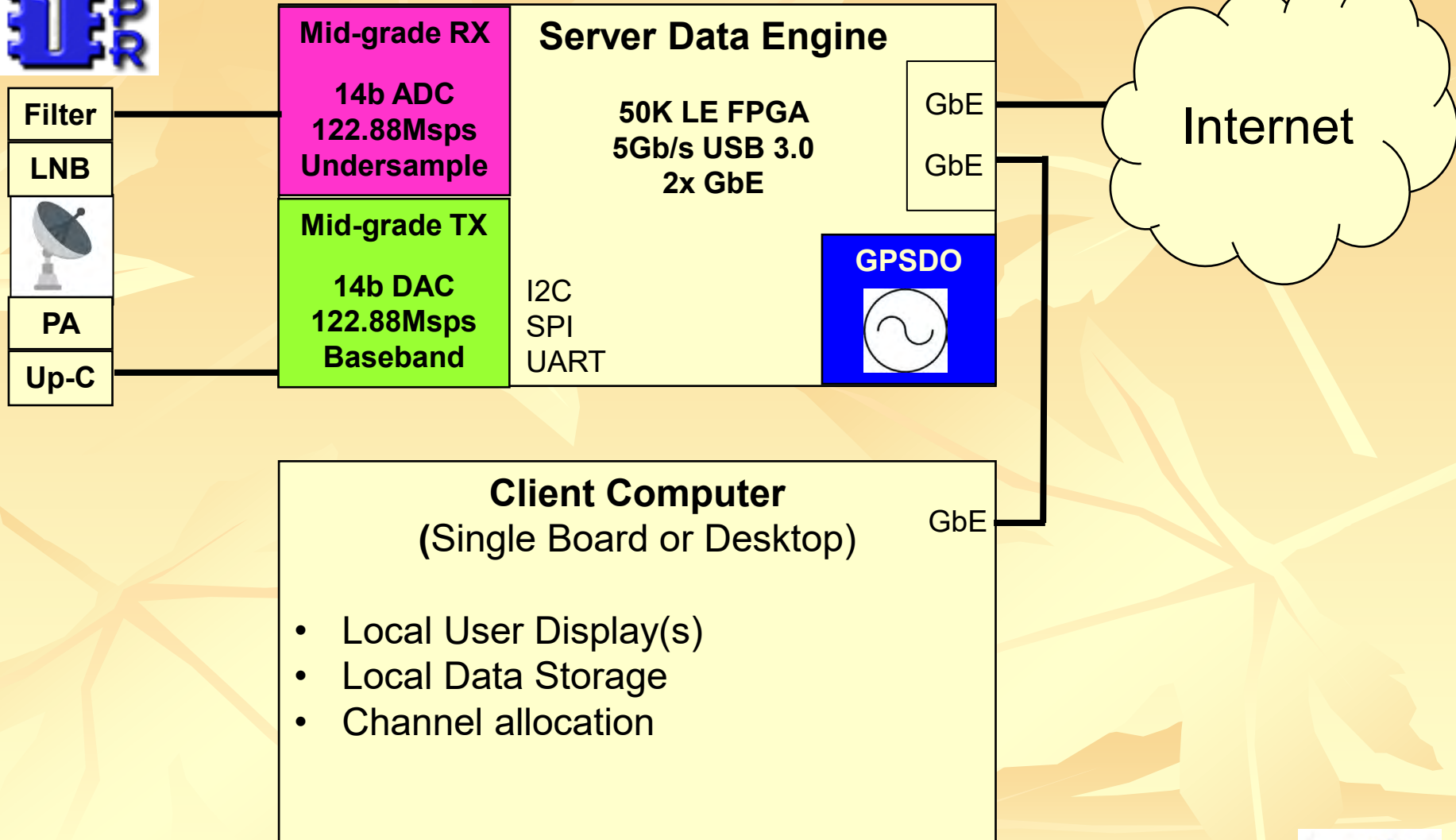


Personal Space Weather Station



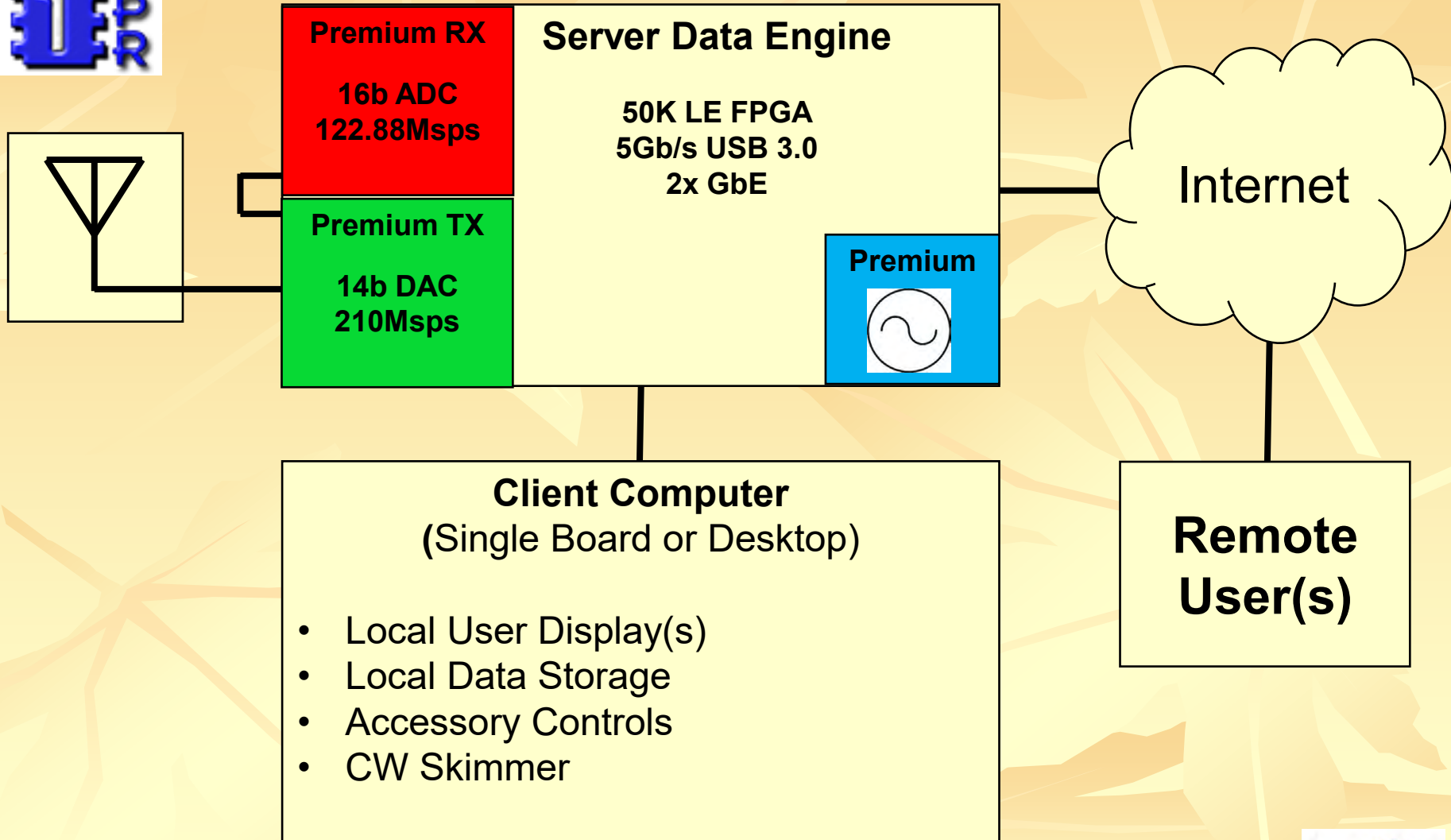


Phase 4B Satellite Ground Station



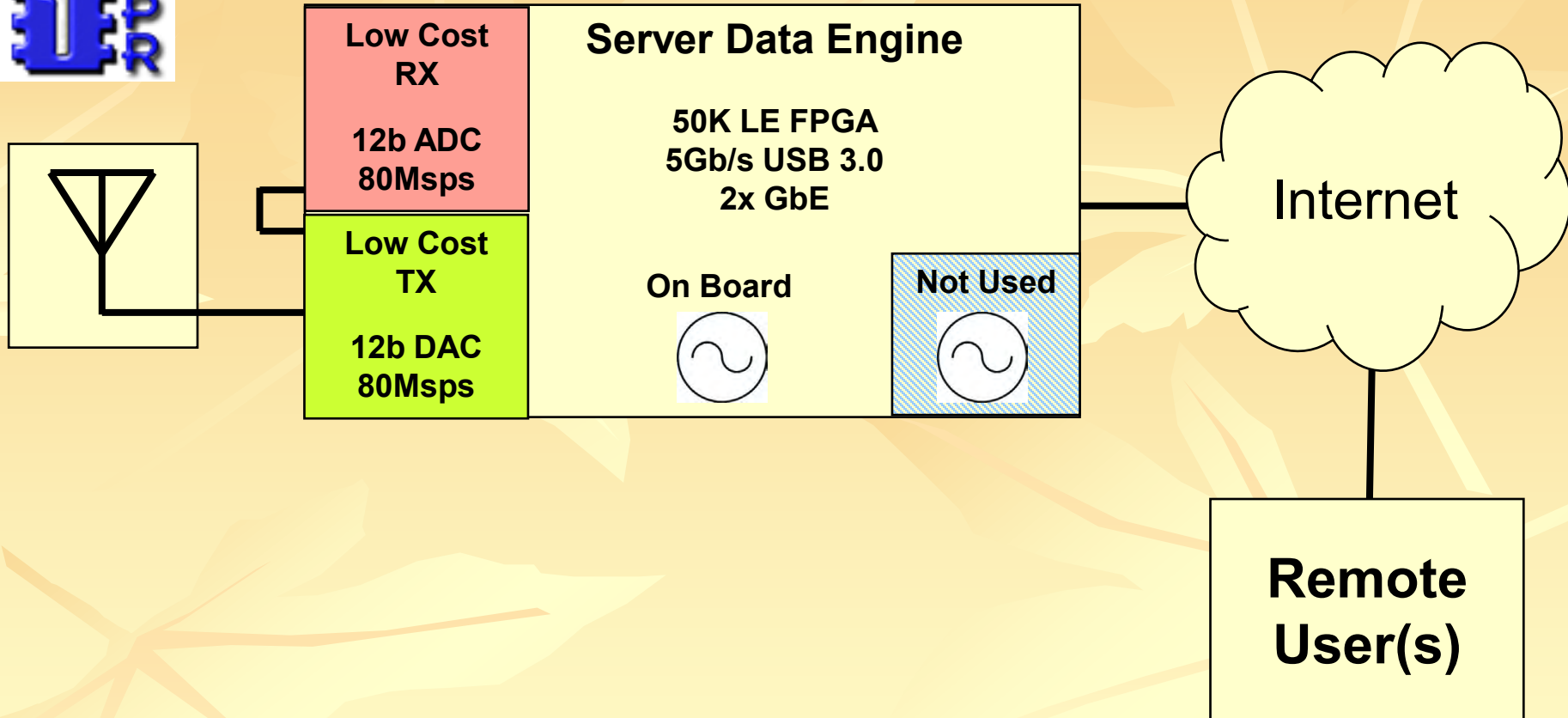


Amateur HF Experimenter

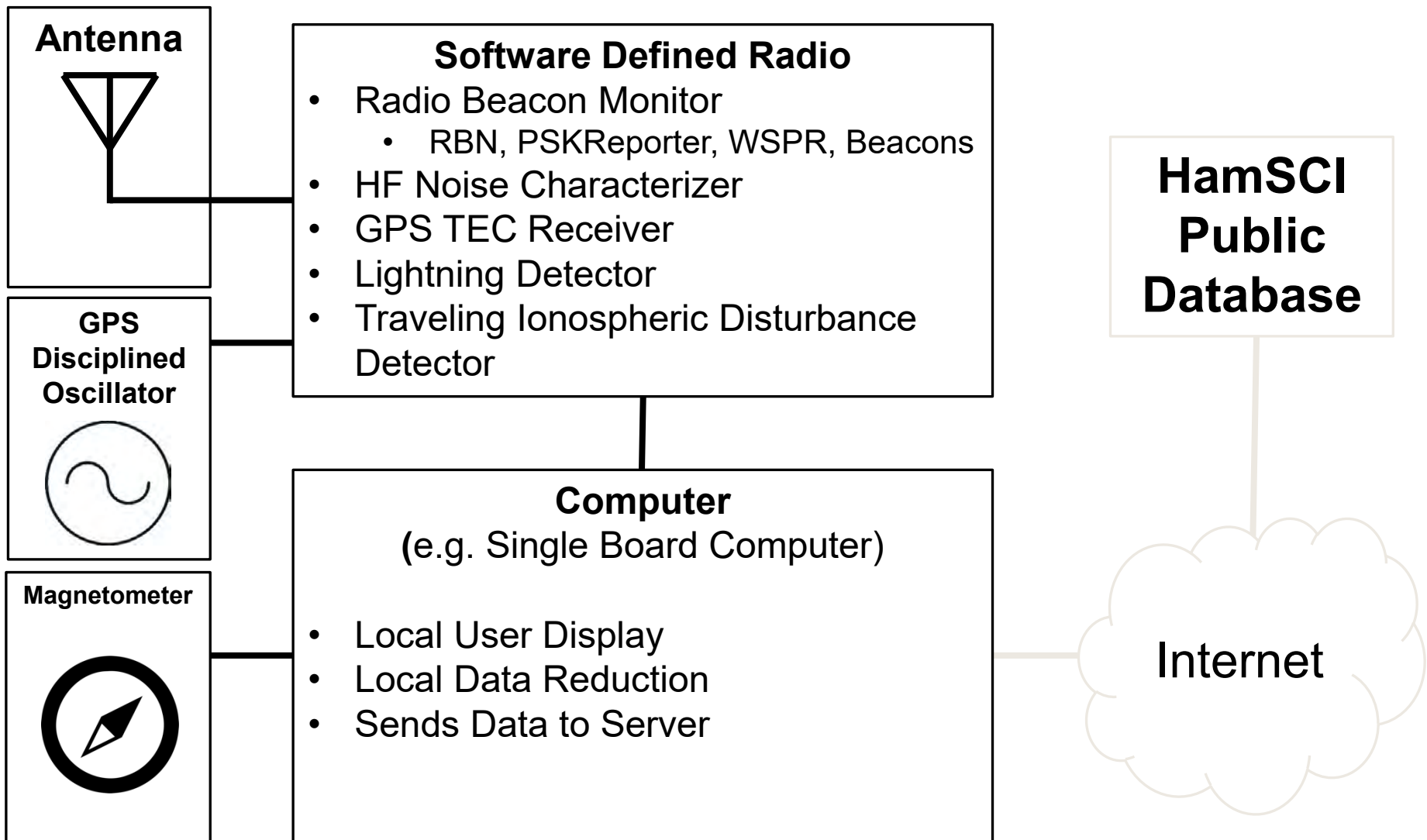




Low Cost Remote Radio



Personal Space Weather Station





Software Features

What can I do with it besides PSWS?

- ❑ WSPR monitor
- ❑ FT8 monitor
- ❑ Simultaneous reception of all bands, *while in use as PSWS*
- ❑ Notifications via e-mail
- ❑ Full digital mode operation once transmit is implemented
- ❑ Server to multiple radio clients on local network

Bill Engelke AB4EJ will give a software demo at 12:20PM today



TAPR's MISSION

Support Digital Radio development with:

R&D funding

- Breadboard prototypes
- Alpha PCBs

Early volume production

- Put leading edge technology into many hands

Result: A growing pool of contributors and experimenters with subsequent advancement of the radio art





Coming Up in September



ARRL/TAPR Digital Communications Conference
September 17-19, 2021
Charlotte, NC



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