# *PERSONAL SPACE WEATHER SYSTEM*

# *LOCAL HOST*

# FUNCTIONAL SPECIFICATIONS

Version Number: 0.4

Version Date: June 4, 2019

# VERSION HISTORY

| Version Number | Implemented By | Revision Date | Approved By | Approval Date | Description of Change |
|---|---|---|---|---|---|
| 0.1 | W. Engelke | *5/10/2019* | | | |
| 0.2 | W. Engelke | 5/13/2019 | | | Added unattended restart |
| 0.3 | W. Engelke | 5/24/2019 | | | Changed text to consider that the Tangerine includes both the DE and the SBC; added more functionality and notes from Dayton 2019 meeting. Elaborated 2 use cases. |
| 0.4 | W. Engelke | 6/4/2019 | | | Added section numbers; added reference to TangerineSDR Requirements doc. |
| 0.5 | W. Engelke | 7/9/2019 | | | Added mention of throttling, personal propagation monitoring, magnetometer |
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# 1. INTRODUCTION

This Functional Specification describes the capabilities of the Local Host computer (typically a Single Board Computer, or SBC) which works together with the Radio (single board SDR including ADC, FPGA and Data Engine (DE)) to form the Tangerine. The Tangerine is the local (primarily a receiver/data collector) subsystem for the Personal Space Weather System (PSWS). Within the Tangerine, the Local Host communicates with the Radio portion through a Gigabit switch (GbS) built into the DE.

In the PSWS, the Tangerine collects spectrum data (in general I&Q) and uploads it to a target system for storage and/or analysis. The target system in the typical PSWS will be the Local Host; but optionally could be a server if sufficient bandwidth is available. Refer also to *TangerineSDR Requirements* document.

## 1.1. SYSTEM OVERVIEW

There is more than one way to for the DE to save or upload data; the Local Host connection is one of them; this specification documents the capabilities of that Local Host. An overview of the system in this configuration is shown in Figure 1.

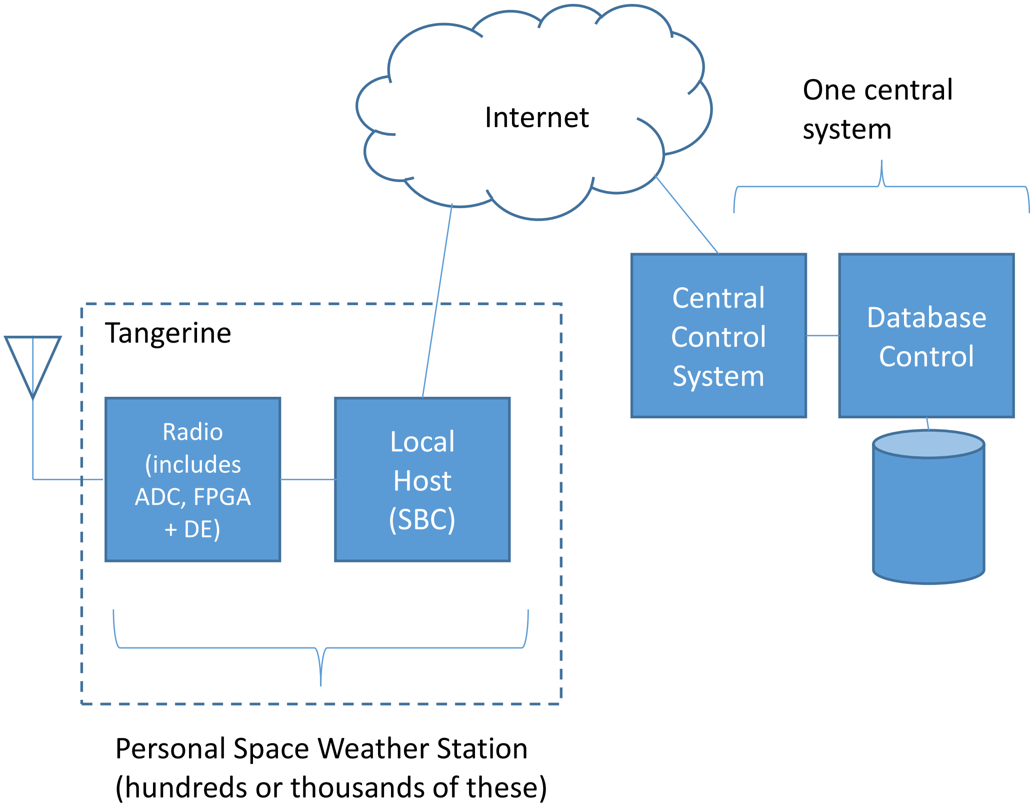
Internet
One central system
Central Control System
Database Control
Tangerine
Radio (includes ADC, FPGA + DE)
Local Host (SBC)
Personal Space Weather Station (hundreds or thousands of these)

***Figure 1. Conceptual Overview.***

USE CASE 1. Spectrum data collected by the DE is uploaded to the Local Host which maintains a ring buffer of 24 hours' worth of observations. The Central Control System is able to send the Local Host a request to upload selected observation data.

The Local Host configuration is to allow an individual PSWS to participate in crowd-sourced data collection in spite of a low-bandwidth Internet connection, and also to provide some local signal analysis and propagation reporting for the individual PSWS owner. In this case, the Local Host initiates communication with the DE.

USE CASE 2. In an alternate configuration the DE uploads directly to a remote server. This is intended for use in institutional settings where the local area network is high bandwidth and locally attached computers are very fast and can handle the full stream of data being collected.

# 2. FUNCTIONAL REQUIREMENTS

Functional requirements capture and specify intended behavior of the system being developed. They define things such as system calculations, data manipulation and processing, user interface and interaction with the application, and other specific functionality that show how user requirements are satisfied.

## 2.1. GENERAL REQUIREMENTS - OVERVIEW

Requirements and capabilities of the overall PSWS system are described in a separate document. This Functional Specification covers only the Local Host, which shall have the following capabilities:

- Can connect to exactly one DE
- Send commands to the connected DE
- Provide a web browser and web-based interface for user interaction
- Receive uploaded spectrum (I&Q) data from connected DE
- Save uploaded spectrum data to a ring buffer for 24 hours
- Connect to Central Control System
- Respond to commands from the Central Control system to upload data
- Provide a variety of propagation and band-opening information of interest to the radio amateur, including reporting to WSPR, RBN, and PSK networks and email notification when selected (digital) stations are heard (details TBD)
- Can be updated from the Central Control System
- Is able to push firmware updates to the DE for loading into the FPGA [??Need to understand how to do this; doesn't this require a USB Blaster?]

### 2.1.1. Operating Environment

The Local Host is distributed as an image to be burned to a SD or micro-SD card using an imaging utility such as Balena Etcher. The user is expected to supply a SBC compatible with [ Ubuntu (?...] Support will be provided only for the [ Odroid?];

users electing to install and use the system on other types of hardware are on their own.

The SBC should have the minimum features as follows:

- USB-3 port for attached high speed disk or SSD
- Gigabit Ethernet (GbE)
- Quad-core, 2GHz
- 4 GB RAM
- .
- .

### 2.1.2. Assumptions and Dependencies

The assumptions and dependencies for the project are as follows:

- User-provided equipment includes the SBC, micro-SD card, attached USB-3 hard drive with at least 4 TB capacity (QQQQ need to determine required speed), GbE switch, Internet connectivity with user-configurable router, ability to burn image to micro-SD card
- The Local Host will be on a local network behind a router and not exposed to the public Internet (i.e., it does not need to have a built-in firewall)
- The user will provide a workstation (i.e. a HDMI compatible monitor, keyboard, and mouse) either directly connected to the Local Host or on another PC on the same network as the SBC and Tangerine
- Dependencies for the DE/FPGA documented elsewhere

## 2.2. USER INTERFACE REQUIREMENTS

### 2.2.1. Guiding Principles

- This system is intended for use by both amateurs and professionals, so it should have default configurations and easy-to-use settings to enable startup of the base use case system by a non-expert; but allow access to advanced functionalities by experts
- Security (access) features roughly equivalent to a modern desktop PC shall be provided (see Assumptions and Dependencies), e.g., a User-ID and password for access, where the system is delivered with standard defaults and the user has the option to change these
- Configurations will be saved in logically named files containing human readable settings.
- System functions will be logged for debugging, and the user will have the option to turn off logging or select circular logging to avoid using up all space
- Major functions and settings will be settable through a web interface
- The same system logos will be used for the Local Host and Central Control System so it will be clear to users that the systems are part of a whole
- Conventions used in related projects (HPSDR, GNUradio, etc.) should be used so users familiar with those systems will have a reduced learning curve

### 2.2.2 A User-friendly Interface

- The user should not have to remember things the computer knows. For example, whenever possible, choices should be shown as a drop-down list (rather than requiring user to key in).
- When the user attempts any action, the system must advise the user whether the action was successful or not, and if not, attempt to provide some useful information for troubleshooting.

# 3. MAJOR FUNCTIONALITIES

## 3.1. CONFIGURATION AND SETUP

The Local Control System (as distributed and burned to SD card) will be preconfigured so that the simplest default configuration should be workable after simply connecting the system (assuming the user has procured the recommended hardware and connected it according to plan).

The user has two interface options:

1. Connect a HDMI-compatible monitor, keyboard and mouse directly to the SBC or
2. Use an existing PC on the same network and browser, and enter the URL of the SBC (which can be determined based on the MAC address of the SBC Ethernet interface).[??]

Once the user has a browser connected via http, they will see the welcome screen of the Local Host with default User id (UID and password (PW).

## 3.2. STARTUP AND CONNECTING TO THE DATA ENGINE

In the initial Local Host web screen, the user will have a button to connect to the DE. When clicked, this button will trigger code which will handshake with the DE and receive DE status.

QQQQ NOTE:

?? - here we need to decide on the default operation – should it be automatic monitoring of WWV on 2.5, 5, 10, 15 and 20 MHz, with data going to the ring buffer?

Connection of DE directly to a server – details documented elsewhere QQQQ

## 3.3. CONNECTING TO THE CENTRAL CONTROL SYSTEM

The user will use a browser with Internet access to connect to the Central Control system. (This activity is independent from configuring and controlling the Local Host, and serves to let the user make themselves known to the Central system and get an authentication token; complete documentation on this is in another document QQQQ). The user will create an account, be issued a token, and then copy their (unique) token to the Local Host. This will identify the Local Host to the Central

Control system. Once the token is entered, the user will have a button to click which checks in with the Central Host and advises the user if the Host connection is complete.

## 3.4. CENTRAL REQUEST / RESPONSE / UPLOAD (USE CASE 1: DATA COLLECTION)

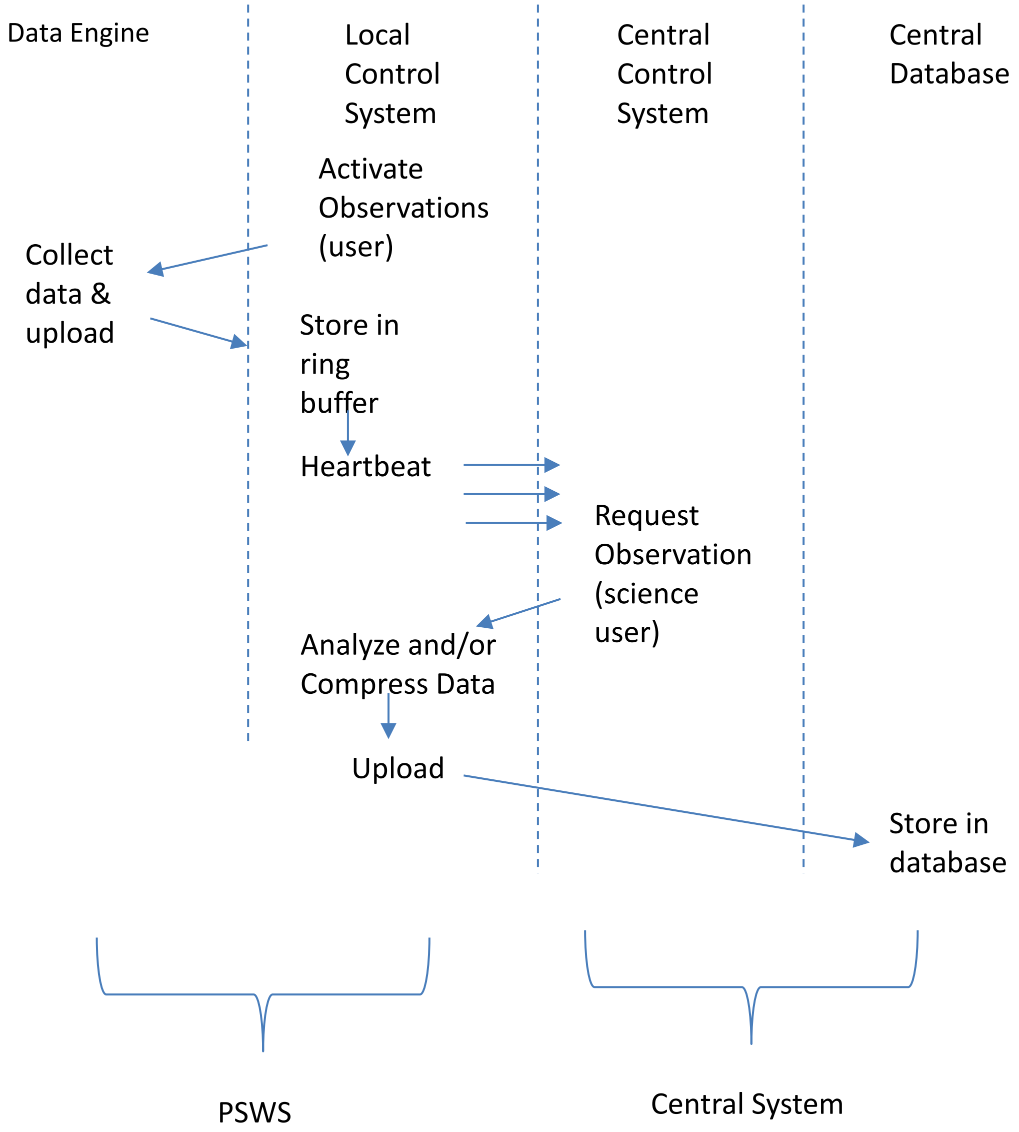

*Figure 2. Use Case 1. Request/Response process model.*

Refer to Figure 2.

1. Once everything is configured (including user account established, token issued and entered into Local Host configuration), the user Activates Observations (thru the Local Host web interface).

2. The Local Host starts sending heartbeats to Central Control. The user can look at their profile on Central Control and see that their Local Host is connected to Central. The heartbeat includes data to tell the Central System that the Local Host is up, whether the DE is connected, whether data is being uploaded from DE to Local Host.
3. The Local Host triggers the DE to start sending observations.
4. The Local Host receives I&Q data and stores into its ring buffer.
5. A science user triggers a data collection event. Central Control sends a command to active PSWS systems.
6. The Local Host selects the data as requested from the ring buffer, compresses and uploads.
7. Uploads must be able to start again from where they left off in case of interruption.

### 3.4.1. Heartbeat

When the Local Host is connected to Central Control, it will send a status message to Central every XX seconds QQQQ. The status message will include data on the Local Host's connection to the Tangerine, whether the Tangerine is actively uploading spectrum data, data availability in the ring buffer, etc. (Documented separately – the status of a user's PSWS will be reflected in real time by status information in the user's profile in Central Control).

## 3.5. LARGE LOCAL SERVER DATA COLLECTION (USE CASE 2: FIREHOSE)

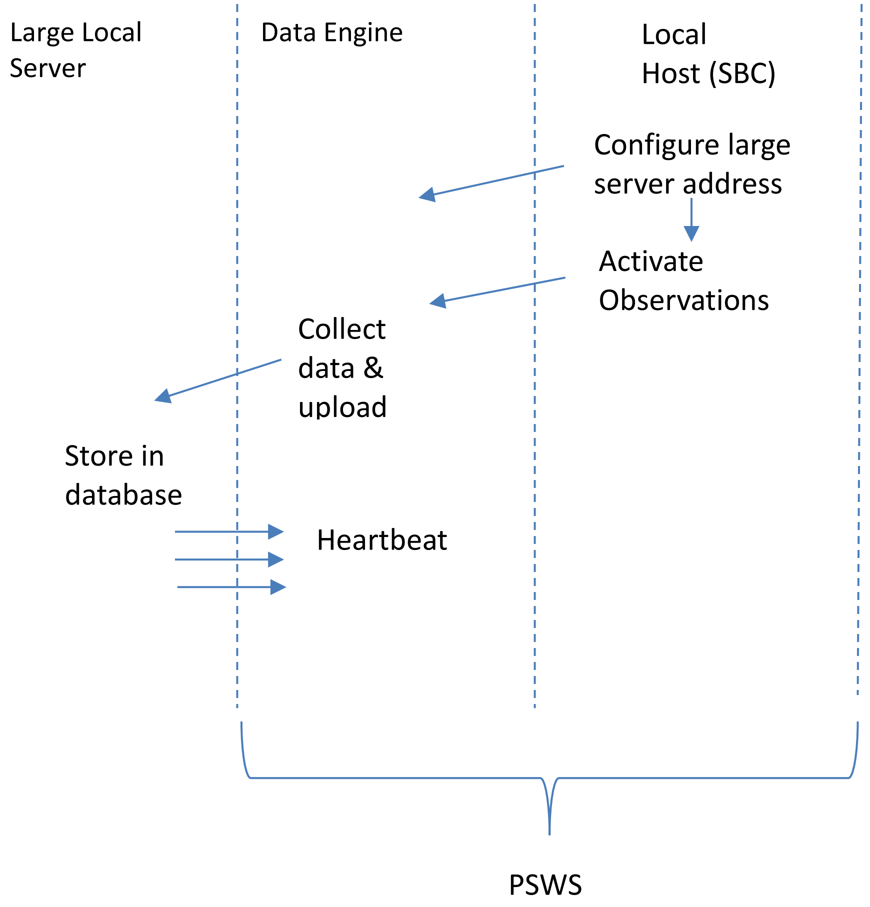

*Figure 3. Use case 2, Firehose.*

1. Once everything is configured, the user enters the address of the large local server to receive data. (This is a server-to-server case, where the Tangerine acts as a spectrum data server to the large local data collection and analysis server).
2. The SBC shakes hands with the large local server.
3. The SBC sends a command to the DE including the large local server's address and data collection parameters.
4. The DE starts sending data directly to the large local server. Note that this bypasses the SBC and no data is stored to the ring buffer.
5. The large local server heartbeat (every QQQQ msec) maintains the DE in continuous data upload mode.
6. QQQQ NOTE: there may be an additional functionality or use case where Tangerines are discoverable on the network. If so, need to determine the security aspect of that.

## 3.6. LOCAL SIGNAL PROCESSING AND USER NOTIFICATIONS

**(Additional Local Host capabilities TENTATIVE/OPTIONAL)**

- Ability to manually run GNURadio on SBC and process signals up to capacity of SBC
- Standard GNURadio function to run FFT on I&Q data from Tangerine; upload FFT data (?)
- Ability to set SBC to copy and upload WSPR, RBN, PSK (one at a time) on up to 8 (??) bands at once (+ CW Skimmer?)
- Ability to set SBC to watch for a specific callsign to be copied (or perhaps a list of up to 10 callsigns) (on digital mode. CW??) to be copied (previous item) and send an email to selected email address when call is detected
- Ability to define a rule (rule set?) for user notification when a band opens (need to define what constitutes "open" and how to detect it)
- Personal Propagation Monitoring: Ability to run a multi-band receiver to support one or more of the following
  - FT8 signal copying and reporting to PSKreporter
  - WSPR signal copying and reporting to WSPRNet
  - Watch aggregate noise level to determine when a band might be open
  - Plug-in for CW Skimmer (?)
- Monitoring of locally connected magnetometer (need to develop details on this)
- Ability to "throttle" upload so as to manage bandwidth consumption, especially of interest to home stations

## 3.7. LOGGING

Local Host software will optionally output logging information to a configurable location. Each major step in operation will output to the log.

## 3.8. HELP

Describe how Help will be available to user

### 3.9. LOCALIZATION

Localization allows an application to respond to the user's location, language, and similar factors that affect how the application should respond.

SUGGEST TO MAKE THIS A PHASE 2 REQUIREMENT

### 3.10. REMOTE SYSTEM UPDATES

Need to define what system must be able to do here – e.g., possibly – on startup, handshake with Central Control; if an update package is available, download and install. (Security requirements here) – what level of control should the user have over this? This should be supported only for a standard SBC and O/S – QQQQ

Need to determine/define what type of updating (if any) the Local Host is able to do to the Data Engine – (seems like an easy way to brick the system) – reflashing of the FPGA(?)

### 3.11. Accessibility

If federally funded, there may be some requirements for use by the disabled, i.e., user interfaces to trigger narrator or other voice response, high contrast display option, etc. Check on this

## 4. TECHNICAL NOTES

Notes from discussions at Dayton, May 2019. To be incorporated into Detailed Design Specification.

- The plan is to store data into the ring buffer using the Digital _RF HDF5 module from MIT. (Note that it still needs to be determined that this package can handle all the metadata we have in mind. )
- The DE will have a certain data packet type to transfer metadata to the SBC.
- Once a metadata variable's content is transferred to the SBC, it will be stored associated with the following signal data, until a new value for that variable is received from the DE.
- The signal data is called the payload, and is planned to be transferred from the DE to the SBC in blocks of 1024 bytes. This number is chosen to make it convenient to combine data for FFT, which requires the input data length to be a power of 2.
- Data will be transferred and handled as I & Q pairs.
- Time stamps. Each data block will contain the time stamp of the first pair of IQ samples in the payload. (Unix time) (This is metadata and is not included in the 1024 byte payload).
- Data format. Tentatively, the plan is for the payload data to be in 16-bit integers (of these, 14 bits used). QQQQ Must decide on the Endian-ness of these data. ??

**--------------------------------------------------------------------------------**

Remaining sections are standard Functional Spec stuff, may not be needed for this project

# 5. LOGICAL DATA MODEL

*[Include the Logical Data Model as an appendix.]*

See Appendix E - <Project Name> Logical Data Model.

# 6. REQUIREMENTS TRACEABILITY MATRIX

*[Include the Traceability Matrix as an appendix. In the Requirements Analysis phase, the matrix is populated with requirements identified in the Requirements Definition. It is a living document that should be populated with information throughout design, construction, and test phases, etc.]*

See Appendix F - <Project Name> Requirements Traceability Matrix.

# 7. Appendix A: Functional Specifications Definition Approval

The undersigned acknowledge that they have reviewed the ***<Project Name>*** **Requirements Definition** and agree with the information presented within this document. Changes to this **Requirements Definition** will be coordinated with, and approved by, the undersigned, or their designated representatives.

*[List the individuals whose signatures are desired. Examples of such individuals are Business Owner, Project Manager (if identified), and any appropriate stakeholders. Add additional lines for signature as necessary.]*

Signature: ______________________________ Date: ____________

Print Name: ______________________________

Title: ______________________________

Role: ______________________________

Signature: ______________________________ Date: ____________

Print Name: ______________________________

Title: ______________________________

Role: ______________________________

Signature: ______________________________ Date: ____________

Print Name: ______________________________

Title: ______________________________

Role: ______________________________

# APPENDIX B: REFERENCES

The following table summarizes the documents referenced in this document.

| Document Name | Description | Location |
|---|---|---|
| *Tangerine SDR Requirements V0.3.pdf* | *System requirements* | *https://tangerinesdr.com/TangerineSDR_documents/* |
| | | |
| | | |

# APPENDIX C: Business Process Model

The Business Process Model is attached as a separate document. (Master Flow diagram to be included and/or flow charts from EFOTM).

# APPENDIX D: Logical Data Model

The Logical Data Model is attached as a separate document.

# APPENDIX E: Requirements Traceability Matrix

*The Requirements Traceability Matrix is attached as a separate document.* (Refer to following spreadsheets):

1. Combined Use Case List for Intervention Release 1-8-10.xls
2. MCA - Intervention Business Requirements and Rules 12-29-09.xls