RF and Measurement System Requirements

This document reflects goals and guidelines without considering the restraints imposed by current technology capabilities, budget and personnel resources. The RF and Measurement team will fulfill as many of the goals as possible. There are suggested design approaches in this document. The final design is not restricted to any of these approaches.

1. Pulsed emitter spectra and time-waveform characteristics
    a. The system shall measure the pulse envelope and the following pulse parameters. The pulse width shall be measurable over a range of times from 50 ns to 5 ms. The rise and fall times shall be measurable over a range of times from 12 ns to 100 us. The system shall measure pulses with spectral components contained within 1 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range. The phase linearity shall be of the best quality.
        i. Time domain pulse envelope detection
        ii. Digitization with appropriate processing
    b. The spectral content of a pulsed emitter shall be measurable. The measurements shall determine peak and average power in a bandwidth over a frequency span. The measurement bandwidth shall range from 300 Hz to 20 MHz. The system shall measure pulses with spectral components contained within 1 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.
        i. Stepped measurement: Measurement in which the instrument provides power information within a bandwidth at a single frequency setting as the instrument is stepped across a band, where peak power information is recorded over at least one hit of the main lobe of the emitter. This procedure accommodates wide measurement range requirements by allowing adjustment of the front-end attenuation between frequency steps. The time allotted to record a peak value shall range between 0.1 second and 1 minute.
        ii. Swept measurement: measurement which the instrument provides power vs. frequency information across a span between triggered sweeps.
        iii. Digitized pulses with appropriate processing to determine spectral characteristics. The digitizer shall have a 20 MHz minimum instantaneous bandwidth with a 40 dB instantaneous dynamic range. The data collection and processing shall be capable of producing a minimum spectral data spacing of 300 Hz per point.
    c. The PRF sequence of a pulsed emitter shall be measurable. This is a measurement to determine the pulse spacing characteristic as a function of time (including

stagger, dither, etc.) with possible processing to provide statistical information about the sequence. PRFs from 50 Hz to 10 kHz shall be measured with a maximum sequence length of 2 seconds.

i. Digitized pulse sequence with appropriate processing to determine PRF sequence

ii. Measurements using an instrument dedicated to determining time intervals between pulses to extract PRF sequence information

d. The antenna pattern of a pulsed emitter shall be measurable. The measurement determines the antenna pattern of a pulse emitter by determining the signal power at various azimuth angles of beam direction with an single elevation cut. A statistical analysis of the antenna pattern can be performed (ie. probability statistics in azimuth sectors). The measurement shall accommodate rotation times ranging from 1 to 60 seconds while gathering measurement data ranging from 600 to 1440 samples per rotation. The system shall measure antenna patterns from emitters with spectral components contained within 30 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity of -70 dBm. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range. An 80 dB dynamic range in the antenna pattern is required.

i. Time domain pulse envelope detection

ii. Digitization with appropriate processing

2. Non-pulsed individual emitters

a. A time-domain waveform shall be measurable. This is the acquisition of an emitter's waveform as amplitude (or power) vs. time for the purpose of examining the waveform shape and/or computing statistical metrics. The time period over which the waveform shall be recorded is from 10 ns to 1 second. The system shall measure waveforms with spectral components contained within 100 kHz to 26.5 GHz. The measurement bandwidth shall be at least 30 MHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range. The phase linearity shall be of the best quality.

i. Time domain envelope detection

ii. Digitization with appropriate processing

b. The emission spectra shall be measurable. The measurements shall determine peak and average power in a bandwidth over a frequency span. The spectra shall be measurable in bandwidths ranging from 10 Hz to 30 MHz with a 120 dB amplitude measurement range. The system shall measure emitters with spectral components contained within 100 kHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.

i. Stepped measurement: Measurement in which the instrument provides power information within a bandwidth at a single frequency setting as the instrument is stepped across a band, where peak (average, other statistical metrics) power level is recorded. This procedure accommodates wide measurement range requirements by allowing adjustment of the front-end attenuation between frequency steps. The step time shall range from 50 ms to 1 second with a minimum of 1 step per sweep.
ii. Swept measurement: measurement which the instrument provides power vs. frequency information across a span between triggered sweeps.
iii. Digitized waveform with appropriate processing to determine spectral characteristics. The amplitude spectrum should provide a minimum of 10 Hz per point of resolution.

c. Characterization of the modulation on signals shall be measurable. These are measurements to characterize frequency, amplitude, and phase changes of non-pulsed signals for the purpose of identification and/or quantifying various metrics. Frequency deviation vs. time measurements shall range from a resolution of 1 Hz to a maximum deviation of 200 kHz. Amplitude modulation vs. time measurements shall have a resolution of 1% modulation. Phase modulation resolution shall be 5 degrees. The modulation shall be recordable over time spans ranging from 10 ns to 1 second. The system shall measure modulated signals with spectral components contained within 100 kHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.
i. Digitization with appropriate processing
ii. Modulation analysis instrumentation

3. Multiple bandwidth receiver responses shall be measurable. This is measurements to determine various signal characteristics as a function of received bandwidth. The bandwidths shall vary from 10 Hz to 30 MHz in a 1-3-10 or finer progression and provide both waveform capture and parametric data. The system shall measure responses from signals contained within 100 kHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.
a. Time domain envelope detection
b. Digitization with appropriate processing

4. Absolute field strength of an emitter shall be measurable. These are measurements to determine the absolute field strength as a function of distance and/or position for a frequency span. The field strength shall be resolvable to 1 dBuV/m of resolution. The field strength shall be either an instantaneous value or averaged over a time range of 1 to 60 seconds. The system shall measure field strength of signals with spectral components contained within 100 kHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB

compression point and the upper limit of the spurious free dynamic range.

5. Direction finding: measurements to determine the direction of an emitter
    a. A COTS direction finding system shall be available for frequencies between 100 MHz and 1 GHz. The direction finding system shall have a sensitivity equivalent to a 10 dB noise figure. The system shall have a 1 degree resolution and produce 1 bearing per second.
6. Spectrum occupancy and usage shall be measured. These are measurements to determine whether (occupancy) and how often (usage) transmissions (and/or communications) exist within specified frequencies of the spectrum (frequency, time, and/or code space). The measurement shall be capable of sequentially tuning to a user defined set of frequencies (non-uniformly or uniformly spaced) and changing the bandwidth, sensitivity, and other instrument controls (or ways of processing) at each frequency, tailored to the specific emissions in each channel.
    a. Band-dependent and independent broadband spectrum survey series are measurements to collect data over a large frequency range. Band-dependent measurements are constrained to specific frequency allocations. Band-independent measurements are performed without consideration for any frequency allocations.
        i. The Swept M3 measurement monitors frequencies with either a sample or peak detector. The collected data are processed and graphed to show the maximum, mean and minimum received signal level for each frequency. The minimum channel width that shall be monitored is 1 kHz with a frequency accuracy of 10% of the channel width. The channels shall be scanned at a maximum rate of 480 channels per second. The system shall measure signals with spectral components contained within 30 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.
            (1) Frequency vs. Time using an analog sweep - data downloaded after each sweep and analyzed on computer
            (2) Digitized IF of specific bandwidth combined with post processing.
        ii. The Stepped M3 is similar to the Swept M3 except the data is collected in a stepped mode (see (1)) using a peak detector. The stepped M3 mode shall work with gate times ranging from 2 to 3 ms. The system shall measure signals with spectral components contained within 30 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.
            (1) Maximum, mean, and minimum statistics of multiple maximums, each maximum determined during one gated period (eg. one beam rotation) at multiple narrow bandwidths
                (a) Time domain envelope detection

(b) Digitization with appropriate processing

(2) Digitized with wide bandwidth, triggered at the gated-on time. Multiple acquisitions used to determine maximum, mean, and minimum statistics of maximum power during one gated period.

iii. There shall be a measurement to calculate statistical distributions of a signal property within a specified bandwidth within a channel (e.g,. CCDFs, modulation domain distributions). The measurement bandwidths shall range from 1 kHz to 30 MHz. A frequency deviation distribution shall be measurable up to +/- 200 kHz of deviation with a minimum resolution of 1 kHz per point. An amplitude modulation distribution shall be measurable up to 100% with a minimum resolution of 1% per point. A phase distribution shall be measurable up to 360 degrees of phase difference with a minimum resolution of 5 degrees per point. The recording time to build the distribution shall range from 10 us to 60 seconds. The system shall measure signals with spectral components contained within 30 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.

(1) Amplitude, frequency, and/or phase over time using an analog sweep to build distributions at a specified center frequency

(a) determine within instrument

(b) determined outside instrument

(2) Digitized IF of specific bandwidth combined with post processing to develop distributions of amplitude, frequency, and/or phase.

iv. Percentile usage vs. channel measurements shall be measurable. This is a measurement to determine the percentage of time a signal is present within a channel. A channel as small as 1 kHz shall be measurable with a frequency accuracy of 10% of the channel width. The system shall be able to scan 480 channels per second. 100 visits minimum per channel are required to achieve a 1% resolution in usage. The system shall measure signals with spectral components contained within 30 MHz to 26.5 GHz. These measurements shall be performed with a sensitivity equivalent to a maximum noise figure of 10 dB. The maximum signal level into the system, excluding the antenna, shall be 30 dBm. This signal shall be within the 1 dB compression point and the upper limit of the spurious free dynamic range.

(1) Direct channel signal measurements

(2) Statistics derived from control channel information

7. The system shall support two modes of interference detection as listed in a and b.

a. The first mode is undesired signal detection with alarms. This is spectrum and/or direction scans in which interference sources are detected along with an indication that the detection has occurred. Data recording (i.e., for signal identification) may be instigated by the indicator. For the spectrum scans, 1B plus its subsections and

2B plus its subsections, are the requirements that apply here. In addition, for direction scans, the system shall have 1 degree of pointing resolution to match a minimum antenna azimuthal beamwidth of 2 degree. The directional coverage shall be a minimum of 6 degrees per second.

b. The second mode is spectrograph. This is a measurement to record amplitude vs. frequency vs. time. For the spectrum scans, 1B plus its subsections and 2B plus its subsections, are the requirements that apply here.
   i. Time domain envelope detection
   ii. Digitization with appropriate processing

8. Simulation of a known emitter (whose signal may be desired and/or undesired) to measure system performance and/or compatibility with another system.
   a. The system shall be able to record an emitter and playback the recorded signal. The maximum amplitude for recording shall be 30 dBm and the maximum playback amplitude shall be 10 dBm. The system shall record and playback signals with spectral components contained within 400 MHz to 18 GHz and a maximum 3 dB bandwidth of 40 MHz.
   b. The system shall be able to generate an emitter's signal using the known characteristics of the signal including antenna pattern and/or propagation characteristics. The maximum playback amplitude shall be 10 dBm with a maximum of 30 dB of dynamic range. The system shall generate signals with spectral components contained within 1 MHz to 18 GHz.
      i. Hardware signal reconstruction
      ii. Software signal and receiver simulation
9. Miscellaneous Equipment
   a. G.P.S. with NMEA strings and dead reckoning
   b. Mast rotator with these features:
      i. +/- 180 degree rotation
      ii. Computer control with these commands:
         (1) goto azimuth
         (2) read current azimuth
         (3) set spin rate
   c. Ethernet system
      i. Address translation capability
   d. 0-30 volt, 5 amp, power supplies (three of them)
   e. Antennas
      i. Omnidirectional
      ii. Directional
   f. Drawers
   g. Manually tuneable bandpass filters
   h. Manually tuneable notch filters
10. Equipment Requirements
   a. rack mountable
   b. 120 VAC supply or 12 VDC
   c. Computer connectivity (ethernet preferred)