RF PRODUCTS, INC.

Authoring the Requirements for a Non-Stovepiped Reconfigurable Transmit/Receive Multi-Mode, Multi-Band RF Distribution System (M3B RFD) part of a Modern, M3B, Software-Defined Radio System with Collocated M3B Radios.

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Contents

1 Introduction.

This document defines the requirements for the procurement of a Multi-Mode, Multi-Band RF Distribution System (M3B RFD). The procurement is in two stages:

1. Initial proposal (technical and price) provides all details of the proposed M3B RFD design based on requirements and platform technical information provided by the requirements author and/or assumed by the M3B RFD supplier.

2. After agreement between Government/Military and the M3B RFD supplier on the baseline proposal (technical and price), the M3B RFD supplier shall be funded for a Requirements Definition Stage (RDS). In the RDS the M3B RFD supplier shall have access to additional technical information that defines the intended platform (e.g. ship, aircraft, land system) from the Government/Military. In the RDS, the M3B RFD supplier shall have access to the intended platform to take RF measurements. The RDS concludes with an updated proposal (technical and price) to be agreed upon between the M3B RFD supplier and the Government/Military. The RDS includes and concludes with the System Requirements Review (SRR). The production contract release immediately follows RDS.

An M3B RFD is required because a modern radio system is to be installed that utilizes Multi-Mode, Multi-Band (M3B) radios (also called Software Defined Radios, SDR) which achieves significant benefits for the warfighter through reduced logistics costs and through increased and flexible mission capability.

Replacement of old single-band radios, without any changes to the RF infrastructure (i.e. everything else between the radios and the antennas), is required to achieve the benefit of substantial logistics savings because one radio part number replaces many different radio part numbers, and obsolete radio part numbers are deleted. However, the installation of modern M3B radios on a military platform (e.g. ship, air or land system) also provides the opportunity to significantly increase the mission performance for the warfighter, broaden the mission capabilities (i.e. Concept of Operations - CONOPS) for the system, and enable the warfighter and the platform to be able to quickly address emergencies during a mission, while at the same time addressing both hostile and humanitarian activities.

In a system with single-band stovepiped radios, the combination of bands and modes available to the warfighter was fixed depending on how many of each type of radio were on the platform. The number of radios that could operate simultaneously in each band and mode was fixed to the maximum number of each radio type installed. Adding to what is now an obsolete design approach with reliance on manual patch panels, these stovepiped radio systems also had little opportunity to quickly switch paths between radios and antennas, such as when an antenna fails for any reason. To make changes took planning, time and mission capability interruption to reconnect RF cables between radios and antennas.

The mission benefits that are possible with M3B radios are dependent on being able to be quickly and easily rearrange the overall radio/antenna system, both before and during a mission, for different combinations of simultaneous operation (SIMOP), and for increased SIMOP in the different modes and bands of which each radio is capable.

Achievement of this ability to reconfigure a platform's radio system greatly increases the return on investment in the new M3B radios significantly beyond logistics savings. More valuable than money-savings, being able to quickly and easily reconfigure an M3B radio population increases the platform's mission capability and ensures the lives and safety of warfighters and civilians involved in the missions.

Exploitation of this overall platform external communications capability is dependent on installing the new M3B radios with a modern, non-stovepiped, holistic, reconfigurable, scalable M3B RF Distribution System (M3B RFD).

With a reconfigurable M3B RFD, military forces, teams, services, and even coalition countries, can each deploy with radio bands and modes in a configuration that meets their special needs, yet each are assured of interoperability when they come together in joint exercises or live missions, including emergency situations in which connectivity emphasis changes during a mission.

When M3B software defined radios and a non-stovepiped M3B RFD design are the basis for the overall radio system, defining a radio system for each band or mode separately can create shortfalls, ambiguities, and loopholes in the tenders, in the proposals and in the contract specifications that can become obstacles to ensuring that the best, achievable non-stovepiped capability is delivered to the warfighter. Due to these loopholes in either RFT or contract requirements, platform capabilities will be reduced via interpretation and negotiation, both before and after contract award. This shall not be allowed to happen.

The purpose of this document is to identify, define and quantify the parameters that define an M3B RF Distribution system. This document includes discussion for eyes of the Government's requirements author that need not be included in the published requirements finalized for a specific project. Some of this discussion is in blue italicized font.

2 Applicable Documents

To be determined by requirements author.

3 Requirements

The proposing M3B RFD supplier shall have responsibility for providing a proposal that meets the following requirements.

3.1 Non-Stovepipe Requirements.

A non-stovepiped M3B RFD includes each of the following requirements at minimums defined elsewhere in this document. M3B RFD suppliers are encouraged to propose performance above the minimums and to the maximum extent possible based on cost tradeoffs.

1. The M3B RFD must enable radio transmit and receive operation in each band and mode of which the radio models are capable, and meeting the required Non-Stovepipe Score.
2. The M3B RFD must minimize antenna population. The antenna population applies to antenna physical locations/radomes/housings, not antenna elements.
3. The M3B RFD must enable sharing of main transmit/receive antennas by multiple radios.
4. The M3B RFD must enable backup paths for radios for transmit/receive operation of bands/modes on an alternate transmit/receive antenna without the use of manual patch panels. Changes must be fast, easy and from either the M3B RFD Remote Control Unit (RCU), or from the main communications control computer via the M3B RFD RCU.
5. The M3B RFD must be easily reconfigurable during a mission to change Same-Band and Multi-Band SIMOP, with no manual patch panel changes. Changes must be fast, easy and from either the M3B RFD Remote Control Unit (RCU), or from the main communications control computer via the M3B RFD RCU.
6. The M3B RFD must be holistic and provide all RF and remote control interface connections between the intended radios and the intended antennas as required in this document. There shall be no other RF or remote control interface connections between the radios and the antennas that are not through the M3B RFD.
7. The M3B RFD shall be locally controlled by a Remote Control Unit (RCU) that is located in the same racks as the M3B RFD equipment. The RCU shall be remotely controllable from the main Communications Control Computer. The RCU shall have a front panel keypad and display so that it can be used as a backup to the main Communications Control Computer.
8. The M3B RFD shall include built-in growth to increase Same-Band or Multi-Band SIMOP of existing radios, and/or increase number of radios without negatively impacting operation of the overall radio system or the antenna population.

9. The M3B RFD shall include built-in extra RF ports for special mission carry-on radios.
10. The M3B RFD shall allow use of different radio models with minimal-to-no impact to overall RF distribution architecture. M3B RFD architecture shall be radio-agnostic.
11. The M3B RFD shall enable radios with a built-in separate guard receive capability to have a path to an antenna for guard receive function.
12. The M3B RFD shall include the High Power Amplifiers (HPA). HPA output power shall be controlled automatically by the M3B RFD's RCU to default settings for optimized prime power efficiency and cosite interference efficiency.
13. A Requirements Definition Stage shall be conducted that includes and concludes with System Requirements Review.

3.2 Radio Band/Mode Utilization.

Non-stovepiping requires that to the maximum extent practical, radios connected to the M3B RFD shall be able to operate alternatively in each band and mode of which it is capable.

The "maximum extent practical" is defined as meeting or exceeding the minimum Non-Stovepipe Score required in this document.

"Each band and mode of which a radio is capable" is defined by the requirements author providing a table for the required/desired radio model or by the M3B RFD supplier providing this table for their respective proposed alternative radio model. The M3B RFD supplier must provide detail explanations on the benefits of using a proposed alternative radio in place of designated radios.

The sample table below lists all of the bands/modes/waveforms embedded in the RT-1990/ARC-210 radio designated to be used in the proposal. There can be multiple radios designated for use with the M3B RFD and there would be a table for each radio model. Other capabilities built-into the radio, such as encryption modes, are not required in this table because they typically are not a factor in the M3B RFD design.

The table includes three columns filled in by the requirements author:

Required: Each of the radios must be able to alternatively operate in these bands/modes/waveforrms which could be all of or a subset of the radio's full list of embedded capability.

Desired: The requirements author has determined that not all of the radio's embedded capability is required. Some of the capabilities can be checked under this Desired column. The proposal can offer any or all of this desired capability as included in the proposal baseline, or as an option.

Not Required: The requirements author has determined that the checked capabilities are not required and would not be used on the ship/aircraft. Therefore if for some reason the proposal includes these "Not Required" capabilities, it will not be considered as a bonus on the baseline capabilities.

Sample - TRANSCEIVER RT-1990A(C)/ARC-210 Band/Mode/Waveform Non-Stovepipe Requirements.			
Band/Mode/Waveform	**Required**	**Desired**	**Not Required**
Line-of-Sight (LOS):			
VHF 30-88 MHz close air support	X		
VHF 108-118 MHz navigation		X	
VHF 118-137 MHz air traffic control	X		
VHF 137-156 MHz land mobile		X	
VHF 156-174 MHz maritime	X		
UHF 225-512 MHz military/homeland defense	X		
UHF 806-824, 851-869, 869-902, 935-941 MHz (public safety bands)	X		
Link 11	X		
SINCGARS	X		
HaveQuick	X		
HaveQuick II	X		
Link 4A		X	
SATURN	X		
MIL-STD-188-220 B/C (Tactical Internet specification)		X	
Scan (4 channel)		X	
LOS: AM voice/data	X		
LOS: FM voice/data	X		
ATC (8.33 kHz channels)	X		
ATC (25 kHz channels)	X		
CASS/DICASS	X		
Standard 121.5 MHz guard channel (via Aux Receiver)	X		
Standard 243 MHz guard channel (via Aux Receiver)	X		
MIL-STD-188-220D Notice 1 – Combat Net Relay		X	
BEAM Line of Sight Technology (BLT)		X	
SATCOM:			
MIL-STD-188-181B (dedicated)	X		
MIL-STD-188-182A (5 kHz)	X		
MIL-STD-188-183 (25 kHz)	X		

A second table is provided by the requirements author (see below). This table lists modes and/or waveforms for which the radios will be used but are not embedded in the radios themselves. Ancillary equipment to be used with the radios to provide these capabilities, require that the respective M3B RFD paths are compatible with these modes and/or waveforms.

Other Band/Mode/Waveform Non-Stovepipe Requirements, Not embedded in TRANSCEIVER RT-1990A(C)/ARC-210			
Band/Mode/Waveform	**Required**	**Desired**	**Not Required**
TO BE COMPLETED BY REQUIREMENTS AUTHOR.	**X**		
	X		

Notwithstanding the above tables, the M3B RFD supplier is required to ensure M3B RFD performance compatibility with any other related standards or specifications referenced as applicable by the requirements author.

3.2.1 Radio Band/Mode Utilization Non-Stovepipe Scoreboard.

A Radio Band/Mode Utilization Non-Stovepipe Scoreboard is required in the M3B RFD supplier proposal.

The Scoreboard is a table in which all of the radios are listed in the left hand column and all of the bands/modes built into each radio are listed across the top row.

Other modes or waveforms that are enabled by ancillary equipment used with the radio, are not included in the Scoreboard top row because these modes or waveforms are expected to be enabled 100%, based on a one-to-one addition of the ancillary equipment. In other words, if the ancillary mode/waveform is not to be used on a particular radio, then there is no need to have the respective ancillary equipment installed with that radio.

An “X” is put into each band/mode/waveform box that is enabled for each radio based on the proposed M3B RFD design.

If a band/mode/waveform is built-into a radio but not enabled by the radio/M3B RFD/antenna system design, then an “O” is put in that band/mode box.

If different radios are used within the same overall system design, then NA (Not Applicable) is used in band/mode boxes for which that band/mode is not embedded in the different radio.

The goal is to enable each radio to operate in each band/mode of which it is capable. However often times there are cost and/or physical constraints that cause a compromise in the radio/M3B RFD/antenna system design so that a score of 100% is not practical or possible.

A sample Scoreboard is shown below. In this example there are 12 radios, 3 different radio models and each covers a different frequency range as listed. X's, O's and NA's are in each of the boxes depending on the capability of each radio and on the capability of the overall M3B RFD/antenna system design.

For convenient reference, although not required in this table or for the Band/Mode Utilization Score, the bottom row shows the Same-Band SIMOP provided by the M3B RFD/antenna system design for each of the bands/modes listed in the top row. The requirements author can change the list of bands/modes. But the list must match the full built-in capability of the radios, regardless of what is enabled by the M3B RFD/antenna system design.

By ignoring the NA's, adding all the X's, and dividing by the total number of X's + O's, the Band/Mode Utilization Score for this example equals 76 / 98 = 77.6 %.

Radio Band/Mode Non-Stovepipe Scoreboard – Sample XYZ Platform

	BAND / MODE :	30-88 Tac FM	108-174 Nav., ATC, Land Mobile, Maritime	225-400 HAVE QUICK	225-400 NON HOP	400-512 Civilian	Guard 121.5	Guard 243	SATCOM 225-400	806-941 Civilian	L-Band, SRW 1-2 GHz
1	Radio B 30-512 MHz	X	O	X	X	X	X	X	O	NA	NA
2	Radio B 30-512 MHz	X	O	X	X	X	X	X	O	NA	NA
3	Radio B 30-512 MHz	X	O	X	X	X	X	X	X	NA	NA
4	Radio B 30-512 MHz	X	O	X	X	X	O	O	O	NA	NA
5	Radio B 30-512 MHz	X	X	X	X	X	X	X	O	NA	NA
6	Radio A 30-941 MHz	X	X	0	X	X	X	X	X	X	NA
7	Radio B 30-512 MHz	X	X	X	X	O	X	X	O	NA	NA
8	Radio C 30 MHz – 2 GHz	X	X	O	X	X	X	X	X	X	X
9	Radio C 30 MHz – 2 GHz	X	X	X	X	X	X	X	O	0	X
10	Radio C 30 MHz – 2 GHz	X	O	X	X	O	O	O	X	X	O
11	Radio C 30 MHz – 2 GHz	X	X	X	X	X	X	X	O	X	X
12	Radio Carry-On 30-88 MHz	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Same Band SIMOP, each up to:	4	4	4	11	2	11	11	4	2	2

Band/Mode Non-Stovepipe Score = 76 / 98 = 77.7%.
A Measurement of Return On Investment in M3B Software Defined Radios.

3.3 Antenna Population.

The goal for the M3B RFD supplier is to meet all M3B RFD requirements with a minimal antenna population on the ship.

An “antenna” is defined as any “packaged antenna system” within a radome/shell regardless of whether it contains a single antenna element or many antenna elements each in a different frequency range.

This definition is used because the goal of minimizing antenna population relates to physical space and other installation parameters as a constraint, and not the number of antenna elements.

The proposed system shall minimize antenna population by having each antenna (as defined above) shared by multiple radios.

Alternate RF path connections shall be available for each radio to an alternate antenna for backup transmit/receive operation should the main antenna fail. The alternate antenna shall be another "antenna" as defined above.

The radio system shall have a receive-only antenna to which any or all of the M3B radios can be connected through the M3B RFD for simultaneous alternate receive operation. Transmit operation shall be continued on the main transmit/receive antenna while the respective radio has receive operation on the alternate receive-only antenna.

3.4 SIMOP

The M3B RFD shall enable multiple collocated radios to operate at the same time in accordance with the following Simultaneous Operation (SIMOP) minimum requirements. Increase of SIMOP over the minimum requirements is desirable but dependent on affordability. SIMOP capability is dependent on the M3B RFD design. There are two types of SIMOP: Same-Band SIMOP and Multi-Band SIMOP.

Unless there is some particular case that must be addressed in the intended installation, the requirements author must be careful that requirements do not specify the SIMOP per antenna which is a hardware box specification, and doing so would unnecessarily constrain the creativity of the proposing radio system supplier. SIMOP is a platform requirement; it is not a "box" spec. It is up to the cleverness of the proposing contractor to determine the best approach to achieving the platform SIMOP requirements. But it is up to the requirements author to accurately and completely specify overall system constraints (if any) such as limitations on antenna population (don't forget the definition of an "antenna" in the previous paragraph).

Same-Band SIMOP and Multi-Band SIMOP includes the following requirements as minimums. M3B RFD suppliers are encouraged to propose performance above the minimums and to the maximum extent possible based on cost tradeoffs.

3.4.1 Same Band SIMOP

The M3B RFD shall enable Same-Band SIMOP, as a minimum, in accordance with the following table.

Same-Band SIMOP is the number of transceivers in the radio/M3B RFD/antenna system that are enabled by the M3B RFD to operate simultaneously within the same frequency band (for example in 30-88, or in 225-400 MHz etc.) in any combination of transmit and receive modes. *A Same-Band SIMOP number should be listed by the requirements author for each of the bands/modes/waveforms of which the radios are capable.*

If the proposed Same-Band SIMOP numbers for each band/mode/waveform exceed the minimum requirements, this increase is desired albeit not required. The proposer shall state and explain the increased Same-Band SIMOP capability above the minimum requirements.

Notwithstanding the prudent design of the initially installed M3B RFD, there is future potential SIMOP growth built into a non-stovepiped system. Future increased SIMOP in any band that does not already have Same Band SIMOP maxed out is possible by adding more cosite interference reduction equipment to the design which would convert Secondary paths to Primary paths. See the paragraph titled "Primary and Secondary Paths through the M3B RFD". And this upgrade can be achieved without having to replace the M3B RFD, thereby making the M3B RFD initial purchase an even safer investment.

Required Same Band SIMOP		
Frequency Range	**Description**	**Same Band SIMOP**
30-88 MHz	Tactical FM & SINCGARS	4
118-137 MHz	ATC	3
137-156 MHz	Land Mobile	2
156-174 MHz	Maritime	2
225-400 MHz	Have Quick	4
225-400 MHz	Non-Hop	11
400-512 MHz	Civilian/Public Agencies	2
121.5 MHz	Guard, International Air	11
243 MHz	Guard, Military Air	11
225-400 MHz	SATCOM	4
806-941 MHz	Civilian/Public Agencies	2
1 – 2 GHz	L-Band, SRW	2

3.4.2 Multi-Band SIMOP

The M3B RFD shall enable Multi-Band SIMOP, as a minimum, in accordance with the following table. Multi-Band SIMOP shall reconfigurable and shall be all possible combinations of individual Same-Band SIMOP numbers, recognizing that in operation the total cannot exceed the number of radios.

Multi-Band SIMOP is the number of transceivers that are enabled by the radio/M3B RFD/antenna system to operate simultaneously but in different frequency bands (e.g. 3 radios in 30-88, and 4 radios in 108-174, and 8 radios in 225-400).

Because the M3B RFD is non-stovepiped and reconfigurable, Multi-Band SIMOP must not be specified as a fixed number or a fixed combination. Therefore, Multi-Band SIMOP shall be any combination of the Same-Band SIMOP numbers, as long as the total does not exceed the number of radios.

The total of all Same Band SIMOP numbers shall exceed the total number of radios, which of course is not realizable in actual operation.

If the proposed Same-Band SIMOP numbers for each band/mode/waveform exceed the minimum requirements, the related increase in Multi-Band SIMOP is desired albeit not required. The proposer shall state and explain the increased Multi-Band SIMOP capability above the minimum requirements.

Required Multi-Band SIMOP – Sample XYZ Platform			
Frequency Range	**Description**	**Same Band SIMOP**	**Multi-Band SIMOP Requirement**
30-88 MHz	Tactical FM & SINCGARS	4	It is required that any combination of the Same Band SIMOP numbers shall be possible, but the combination shall not exceed the total number of M3B radios which is 11.
108-174 MHz	Navigation, ATC, Land Mobile, Maritime	4	
225-400 MHz	Have Quick	4	
225-400 MHz	Non-Hop	11	
400-512 MHz	Civilian/Public Agencies	2	
121.5 MHz	Guard, International Air	11	
243 MHz	Guard, Military Air	11	
225-400 MHz	SATCOM	4	
806-941 MHz	Civilian/Public Agencies	2	
1 – 2 GHz	L-Band, SRW	2	

3.4.3 SIMOP Mix Reconfigurability.

An overall communications control management system is required to manage the communications plans for the overall platform. The M3B RFD operation is a subset of the communications plans.

The proposed M3B RFD to be able to store and quickly implement changes to the RF paths through the M3B RFD RCU, either as path maps or as individual paths.

3.5 ASSET-SIMOP Table.

An ASSET-SIMOP Table shall be provided as part of the proposal.

When the proposal is for an upgrade to an existing ship/aircraft, the requirements author shall provide an ASSET-SIMOP Table for the existing design as part of the solicitation documents. ASSET-SIMOP Table is a summary to compare “before/after” radio system designs.

The proposal shall include an ASSET-SIMOP Table of the proposed design and a review of the proposed non-stovepiped, reconfigurable M3B RFD as defined by the proposed ASSET-SIMOP Table.

See the following sample table. There are three lists in the table:

1. A list of the radios to be used. Again this could be specified by the requirements author or proposed by the M3B RFD supplier.

2. A list of the antennas used with the radio/M3B RFD system. The antennas could be specified by the requirements author and/or proposed by the M3B RFD supplier.

3. A list of the maximum Same Band SIMOP possible for each of the bands/modes. This list is developed from the M3B RFD supplier’s radio/M3B RFD/antenna system design.

ASSET-SIMOP Table – Sample: XYZ Platform			
Radio / Antenna Population		Each Up To:	Baseline SIMOP
5	Radio B 30-512 MHz	4	30-88, Tactical FM
2	Radio A 30-941 MHz	4	108-174, Navigation, ATC, Land Mobile, Maritime
4	Radio C 30 MHz-2 GHz	4	225-400 Have Quick
1	Radio Carry-On 30-88 MHz	11	225-400 Non-Hop
		2	400-512 Civilian
12	TOTAL RADIOS	4	225-400 SATCOM
		2	806-941 Public
2	30-400 MHz	2	1-2 GHz L-Band, SRW
2	30-512 MHz		
2	108-1000 MHz	33	SIMOP TOTAL is a Comms Multiplier which is the Qualifying Quality Factor of the Non-Stovepiped Design. Multi-Band SIMOP is any combination of the above individual Same-Band SIMOP numbers as long as the total is less than then number of radios, in this case 12.
2	225-2000 MHz		
8	TOTAL ANTENNAS		

The Asset-SIMOP Table is straight-forward in its contents but there are important implications for the evaluation of proposed radio/M3B RFD/antenna system designs:

- Because an M3B RFD is reconfigurable, the total of all Same-Band SIMOP numbers exceeds the total number of radios which of course is impossible.

- However, this total (33 in above example) is a useful indicator as a qualifying quality factor of a non-stovepiped design.
  - In the above example, the total number of radios is 12. Yet the Non-Stovepipe SIMOP total is 33. This is an almost 3 to 1 “force multiplier” of the radio population.
  - This more than anything shows the increased mission capability and flexibility being given to the platform.
  - This more than anything shows the return on investment in the M3B software defined radios. (Logistics costs savings is important, but mission capability life saving is most important.)

- Also important is that Multi-Band SIMOP for the platform must not be specified as a fixed number or a fixed combination. The requirements author should also not try to list the many possible multiple-radio combinations of radio band/mode connections. The list of possible Multi-Band SIMOP combinations via an M3B RFD is only limited by each individual maximum Same Band SIMOP capability design and by the total number of multi-band radios connected to the m3B RFD. Therefore the requirements author can take advantage of these limits to be designed into the M3B RFD by each bidding radio system supplier, and simply state the Multi-Band SIMOP requirements as:

  “Multi-Band SIMOP shall reconfigurable and shall be all possible combinations of individual Same-Band SIMOP numbers, recognizing that in operation the total cannot exceed the number of radios.”

3.6 Adjacent Channel Separation (ACS) Rules.

Adjacent Channel Separation (ACS) is the separation between the frequency settings of different radios in any combination of transmit and receive. This mostly applies to radios operating within the same frequency range (Same-Band SIMOP), for example in 225-400 MHz.

However there are some situations in which an ACS specification applies to radios operating in different frequency ranges (i.e. Multi-Band SIMOP) that are contiguous such as when one radio is operating near to 30 MHz in the HF 1 to 30 MHz range and a second radio is operating near 30 MHz in that VHF 30 to 88 MHz range. In this multi-band contiguous-ranges situation, an ACS may need to be specified between the two ranges which would be implemented with a radio in each range is near the 30 MHz end.

Another example is when a 225-400 transceiver and a 400-512 transceiver are both operating close to 400 MHz. This is also a case of Multi-Band SIMOP that also requires an ACS number.

The requirements author can state a required Multi-Band ACS number or can request the M3B RFD supplier to state the best Multi-Band ACS number based on the proposed M3B RFD design.

Typically, increased SIMOP is more important to achieve than tighter ACS, except where a tight ACS is required for a particular waveform operation. Tighter ACS (with no Architecture change) is usually possible but at increased cost, therefore ACS should not be required tighter than necessary.

Minimum ACS must tight enough to enable operation in accordance with waveform requirements. However when ACS is part of the overall radio system frequency management configuration plan, cost tradeoffs should be considered and not make ACS unnecessarily tight.

The ACS specifications are stated by the requirements author only at the platform level. Which combinations of radios are used to enable the frequency selections to achieve specified minimum ACS is determined by and is part of the detailed design of each M3B RFD supplier. The M3B RFD supplier's responsibility includes ensuring that the M3B RFD's Remote Control Unit programming provides automated management of the path/frequency combinations resulting in reduced operator workload and operator error.

Because a non-stovepiped M3B RFD is holistic and reconfigurable across radios and bands/modes, the requirements author must state the ACS requirements in one table. An example of the ACS table of requirements is shown below.

Same-Band and Multi-Band SIMOP Minimum Adjacent Channel Separation (ACS) Requirements Sample							
Frequency Ranges	30-88 MHz	108-174 MHz	225-400 MHz	400-512 MHz	806-941 MHz	1-2 GHZ	UHF SATCOM
30-88 MHz	5 MHz						
SINCGARS	Waveform Compliant						
108-174 MHz		5 MHz					
225-400 MHz			5 MHz	5 MHz			5 MHz
Have Quick			Waveform Complaint	5 MHz			
400-512 MHz			5 MHz	5 MHz			5 MHz
806-941 MHz					10 MHz		
1-2 GHZ						10 MHz	
UHF SATCOM			5 MHz				Waveform Compliant

3.6.1 ACS Management and Rules Enforcement.

The ACS rules are a design feature of the M3B RFD RF performance. The ACS rules are used in the main communications control computer to prevent a transmitter from operating too close in frequency to a receiver, both in the mission planning stage and in operations when unplanned changes to frequencies of individual radios are attempted.

The M3B RFD design shall include an embedded look-up table required for ACS Management and Rules Enforcement by the overall communications control computer.

Preliminary ACS rules shall be provided with the M3B RFD supplier's initial proposal including justification on which the proposed ACS performance is based:

- Antenna isolation table
- Transmit EIRP table
- Cosite interference reduction table
- Radio receiver susceptibility
- Radio transmit noise characteristics
- And other radio system performance factors as determined by M3B RFD supplier.

The above system performance factors are finalized during the RDS, which in turn will finalize the ACS rules.

3.7 RFD Path Deconfliction.

A feature of an M3B RFD is that an antenna is shared by multiple radios. Therefore use of an RF path through the M3B RFD to an antenna may be on a first come, first serve basis: For example if any 3 of 6 radios could be connected to an antenna. However if 3 radios are already connected, an operator's attempt to connect a 4th radio to that antenna will result in a "path conflict".

The M3B RFD shall provide RF Path Deconfliction. The M3B RFD must have the capability to automatically detect path conflicts, prevent operator error, notify selection error on RCU and on main communications control computer, and enable correction of the conflict.

3.8 Non-Stovepiped, Holistic Block Diagram.

The M3B RFD supplier's proposal shall include a detailed radio/M3B RFD/antenna block diagram. Because it is non-stovepiped and reconfigurable, by definition of an M3B RFD, there cannot be separate block diagrams for different frequency bands. For example, there cannot be a block diagram for the "VHF system", and another block diagram for the "UHF system".

The M3B RFD supplier's block diagram must include:

- All RF and control interface connections to each M3B RFD box.
- The quantity and type of radios, with part numbers.
- The quantity and type of antennas, with part numbers.
- The quantity and type of RFD boxes, with part numbers.

3.9 M3B RFD Includes HPA's.

The M3B RFD shall include the main multi-band 100 watt HPA's and any additional specific frequency range HPA's which shall be automatically controlled by the M3B RFD to optimize prime power efficiency, cosite interference reduction and SIMOP performance.

The main multi-band 100 watt HPA's shall match the main frequency ranges of the main M3B radios to be used with the M3B RFD. For the RT-1990, the main HPA's shall cover the frequency ranges from 30 to 512 MHz.

The additional specific frequency range HPA's shall be included as separate components within the M3B RFD to match any additional transmit power requirements as indicated initially in the M3B RFD supplier proposal, and/or finalized in the RF Analyses performed during the RDS. Additional specific frequency range HPA's for the RT-1990 for example could be for 806-941 MHz, or for UHF SATCOM.

The HPA transmit power shall be automatically adjusted by the M3B RFD to a default power level to meet all required link ranges for each path through the M3B RFD, as part of the M3B RFD path selection.

The M3B RFD shall enable operator override (password protected if required by requirements author) of the automated transmit power level of each HPA. The HPA output shall be adjustable in 0.1 dB increments up or down from the automated default HPA output of any path. The measured power from the HPA compared to the commanded power shall have a maximum tolerance of +/- 0.5 dB.

To support the M3B RFD requirement for scalability and spares commonality across ship classes, even with different radios and antennas, the HPA is required to adaptable for different radios with different RF connector configurations to the M3B RFD and different control interfaces to the M3B RFD. Regardless of these differences, the HPA shall be the same part number useable across different ship classes.

3.10 Primary and Secondary Paths through the M3B RFD.

The M3B RFD shall include RF paths through the M3B RFD to provide:

- Paths which operate during SIMOP,
- Paths which enable backup antenna operation but not necessarily in SIMOP,
- Paths for future growth, and
- Paths for carry-on radios.

The paths that meet SIMOP requirements are called Primary Paths. The paths that meet transmit/receive link range but not during SIMOP are called Secondary Paths.

The M3B RFD supplier shall list all paths as either Primary or Secondary paths.

The result is that beyond enabling Same-Band SIMOP and Multi-Band SIMOP of each radio in accordance with the SIMOP requirements, each radio will have additional RF paths through the M3B RFD that will meet link range requirements but will not meet SIMOP requirements. The main reason that these additional paths through the M3B RFD will not operate during SIMOP is because of cost considerations. Another purpose of Secondary paths is to meet built-in-growth requirements for future growth of Same-Band SIMOP.

3.11 Link Ranges.

The M3B RFD shall enable all link ranges to be met in all frequency ranges in all Same-Band SIMOP and Multi-Band SIMOP combinations.

Because cosite interference is worse at maximum transmit power levels, as stated elsewhere in the paper, when a radio's RF path through the M3B RFD is switched, the M3B RFD shall set the HPA for the radio to the power level required to meet the maximum required link range through that M3B RFD path and associated antenna.

Depending on the RF Analysis, the HPA's could meet maximum required link ranges at power levels below the full output of the 100 watt HPA's. The operators shall be able to override the M3B RFD's HPA default power level for greater link ranges but this could be at the sacrifice of SIMOP.

3.11.1 Line of Sight Link Range.

The M3B RFD shall provide sufficient power to the antennas to meet the following Line Of Sight Link Ranges. The HPA power output shall default to the power level required for each M3B RFD path to meet all link ranges within each band.

The following table is required from the requirements author for the initial M3B RFD proposal and for the RDS.

Line of Sight Link Ranges			
Frequency Range	**Ship to Ground**	**Ship to Air**	**Ship to Ship**
30-88 MHz			
108-118 MHz			
118-137 MHz			
137-156 MHz			
156-174 MHz			
225-400 MHz			
400-512 MHz			
806-941 MHz			
1-2 GHZ			

3.11.2 SATCOM Link Margin.

The M3B RFD shall meet the following SATCOM wave form requirements

3.12 Overall Radio System RF Analyses.

The M3B RFD supplier's proposal shall include detailed radio/M3B RFD/ antenna system design and performance characteristics which must be confirmed and modified if determined necessary during a Requirements Definition Stage (RDS). After the M3B RFD supplier is selected, a pre-production-release stage shall be contracted so that a detailed RF analysis can be performed using accurate (measured if possible) RF data either from the existing ship, or from the new construction ship's shipbuilder design information.

The M3B RFD supplier would perform the RF Analyses working with the Ship integrator/installer and, if required, a top side modelling/analysis subject matter expert.

It is critical for the M3B RFD supplier to perform and or be involved in the overall RF analyses of the ship because all M3B RF paths from the transceivers operate through the M3B RFD. And because all cosite interference reduction equipment are contained with the M3B RFD. The M3B RFD supplier's intimate knowledge of both the overall RF analysis and of the M3B RFD component performance, enables the M3B RFD supplier to ensure an accurate RF analysis and to very quickly develop solutions to any RF problems that might be identified during the analysis.

Notwithstanding the above described M3B RFD supplier's involvement in the RF analysis, the responsibility for installed performance on the ship remains with the company/organization designing and performing the installation, integration and interconnections on the ship. During and at the conclusion of RDS, the M3B RFD supplier will share all RF analysis calculations, methods and fudge factors with the integrator, top side modeler and the Government-customer.

In the RDS, the M3B RFD supplier shall reconfirm antenna performance at specific top side locations, antenna coupling, multi-paths, etc. so that the overall radio/RFD/antenna system design can be confirmed and updated/upgraded where necessary. Although the proposed design yields a low risk achievable non-stovepiped architecture, the RF Analysis with measured data from the ships is required to ensure optimized RF performance of the radio systems in all configurations enabled by the M3B RFD. Results of the RF Analysis include finalization of the antenna and AIA designs, required transmit and receive amplification levels, and insertion of additional cosite interference equipment into the M3B RFD. The additional cosite interference equipment (if and where needed) yields the best compromise between cost and Same-Band SIMOP and Multi-Band SIMOP in the final design prior to release for production and installation.

After the proposed M3B RFD designs and RF performance confirmed in RDS, any changes requested by the Government and/or determined during the RDS will be accommodated wherever possible, and options quoted by the M3B RFD supplier if required.

The RDS RF Performance Study shall produce an RF analysis model of the Top-side and M3B RFD to support the design process and forecast RF performance prior to production release.

The RDS RF Performance Study shall cover the transmission path through the M3B RFD; through the platform projected antenna solution over the air to a receiving system equal to that of the transmitting platform and a typical aircraft.

When the RDS study is performed prior to construction of a new ship, the RDS study will continue under the main production release contract to verify the projected M3B RFD RF Performance and will establish:

a. Interference reduction performance of the M3B RFD.
b. Real-world platform antenna to antenna performance.
c. If any additional further design activity is necessary to increase margins and provide for failure paths, the M3B RFD supplier will review and comment on the calculation approaches and provide quotations for options.

The Prime contractor is responsible for the overall ship fit/installation performance of the system.

The M3B RFD supplier shall provide information and assistance to support the performance study including the performance trials.

The M3B RFD supplier shall perform, for the M3B RFD, a "per-path" analysis of the M3B RFD System.

The results of the analysis will be presented in the Co-Site Interference Analysis Report (CSIAR) required as a deliverable from the RDS contract. To support the ship integrator and/or top side modeller in meeting the Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) requirements, and to demonstrate the proposed system's suitability to be integrated into the Platform, the CSIAR will contain:

d. Identify Mutual Interference between components of the M3B RFD System.
e. If required as an additional task, identify interference between components of the M3B RFD System and the Ship’s other platform radiators and susceptible in-band receivers.
f. The M3B RFD supplier shall assist in analysis of system performance degradation due to electromagnetic interference.
g. Identify co-site interference mitigation solutions or strategies.
h. Recommend Interference mitigation solutions or strategies.

The CSIAR is used to identify any EMI/EMC issues and propose suitable mitigations to address these issues. It will be used by the Government-customer to assess the Electromagnetic Environmental Effects (E3) program and any potential EMI/EMC issues, and propose mitigations prior to M3B RFD production and to integration of the system into the First of Class (FOC) Platform.

3.13 Guard Channel Operation.

The M3B RFD shall provide for operation of the radios for guard receive based on the capability of the respective radio model. Guard operation shall be on either the main transmit/receive antenna or on the alternate receive-only antenna.

3.14 Backup Paths through the RFD and/or Backup antennas.

The M3B RFD shall provide a backup path for each radio to an alternate antenna such as in case the main antenna for the radio is damaged. Switching from a main antenna to an alternate antenna shall not be by manual patch panel. It shall be via path selection via the M3B RFD RCU.

3.15 Special Mission Carry-On Radios.

The M3B RFD shall be designed to enable addition of special mission carry-on radios.

The M3B RFD must include spare RF ports so that carry-on radios can be connected into the M3B RFD and operated without the need to add antennas to the platform.

Connection of special mission carry-on radios into the M3B RFD HPA's and/or remote control interfaces, is not required. It is expected that special mission radio operators will bring on board with the carry-on radios, the required HPA's, cosite interference reduction equipment, and local control of the special mission assets directly by the special mission operator.

The requirements author must specify the number of additional ports and frequency ranges to be provided in the M3B RFD for carry-on radios. If at all possible the requirements author should provide model numbers or part numbers representative of the typical carry-on radios expected to be used with the proposed design.

Minimum Requirements for Spare RF Ports for Special Mission Carry-On Radios	
Frequency Range	**Minimum Frequency range coverage of the required 4 Spare Ports.**
30-88 MHz	3 of the 4 spare ports.
108-118 MHz	0 of the 4 spare ports.
118-137 MHz	0 of the 4 spare ports.
137-156 MHz	1 of the 4 spare ports.
156-174 MHz	1 of the 4 spare ports.
225-400 MHz	4 of the 4 spare ports.
400-512 MHz	1 of the 4 spare ports.
806-941 MHz	2 of the 4 spare ports.
1-2 GHZ	2 of the 4 spare ports.

3.16 Built-in-Growth

The requirements author should specify the Built-in-Growth desired for the M3B RFD. This could be specified as a percentage or a fixed number. If the intended platform is the rare case for which no future growth is required, then the requirements author should state that in the requirements.

The M3B RFD requires built-in-growth for:

3.16.1 Built-In Growth Same-Band SIMOP:

The M3B RFD shall enable an increase of at least 25% minimum Same-Band SIMOP Growth through the addition of cosite interference reduction equipment into the proposed M3B RFD architecture, as fitted-for-but-not-with capability.

3.16.2 Built-In Growth M3B RFD Control.

The M3B RFD shall be designed for a System growth capacity of at least 25% growth capacity for voice and data circuits including management of these circuits. The M3B RFD control equipment shall be provided with at least 25% spare processing and memory capacity, when at maximum load.

3.16.3 Built-in-Growth Radios.

Built-in-Growth Radios is defined as the number of additional RF ports within the M3B RFD so that additional radios can be connected in the future without the need to add antennas.

For M3B RFD proposal purpose, the future radios shall be the same part number as the M3B radios that form the baseline of the proposed M3B RFD design.

These additional M3B RFD RF ports for future radios need not include the connection to M3B RFD functions including: transmit amplification, receive amplification, Same-Band cosite interference reduction, or remote control via the M3B RFD RCU. The M3B RFD shall be shown to be designed for but not with the necessary connections for the aforementioned M3B RFD functions.

3.16.4 Built-in-Growth Antennas.

Built-in-Growth Antennas is defined as the number of additional antennas that could be connected to the M3B RFD should antennas be added to the platform in the future. The requirements author could specify the intended frequency range or ranges of the future antennas and if possible, the intended transmit power handling of the antennas. Or the M3B RFD supplier can propose antenna types and capability based on the M3B RFD design.

If the requirements author specifies M3B RFD spare ports for future antennas, it should be noted that this does not include RF cabling outside of the room in which the M3B RFD is contained. If the requirements author wants the RF cabling for future antennas pre-run, then that would have to be specified for the overall radio system integrator.

3.17 System Interlocks.

The internal control structure of the M3B RFD shall enable control interlocks to be used for EMCON and path integrity by breaking control paths that inhibit RF transmission. The M3B RFD shall verify that the control of the interlock contacts are functioning properly. Inhibiting of the RF transmission is outside the M3B RFD.

The status of the On Air condition shall to be reported to the main communications control computer via the M3B RFD’s Remote Control Unit (RCU).

The Path Interlock (PI) status shall be reported via the M3B RFD’s RCU to the main communications control computer.

3.18 Remote Control of the M3B RFD.

The M3B RFD shall include its own Remote Control Unit (RCU) that shall be mounted in the same racks as the M3B RFD equipment. The RCU accepts a serial interface directly from the main communications control computer. The RCU performs most of the M3B RFD control and management functions so that the RCU can provide local control of the M3B RFD when the M3B RFD, for any reason, is not being controlled by the main communications control computer. The RCU shall be sufficiently robust to perform as a backup to the main communications control computer, and not be a high-risk single point of failure.

The RCU provides all RF, control and status connections to the individual M3B RFD boxes.

Each of the radios can also provide a remote control interface to the M3B RFD.

3.19 Configuration Scalability and Spares Commonality Across Ship Classes.

The M3B RFD shall enable sharing of spares at both the M3B RFD box level and the box module level between ship classes even when the M3B RFD configuration, radio models and antenna population are different between ship classes.

The M3B RFD shall mostly use common building blocks (i.e. same part number boxes) across differently configured radio/antenna populations on different ship classes. This provides savings in both initial production stages as well as life cycle costs.

Spares commonality shall be at least 75% of the M3B RFD box population.

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