BU2 MIDS LVT

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Abstract — *This project studies the considerations, implications and challenges of implementing a block upgrade to the link 16 terminals of several fleets of United States Air Force aircrafts. The block upgrade will try to incorporate several pieces of capabilities, but this report centralizes around the frequency remapping portion, why the frequency has to be remapped and how will this be accomplished.*

Key Terms — *Block Upgrade, Frequency Remapping, Low Volume Terminal, Multifunctional Information Distribution System.*

THE TITLE

When the title of this report is read for the first time, it is impossible to even guess what the report is about if one does not have prior knowledge of the BU2 MIDS LVT program because the title is one long acronym. In the United States Air Force acquisitions world this is always the case because titles and names are so descriptive that for simplicity's sake everything is turned into an acronym. For this reason, this reports starts by literally defining the terms BU2, MIDS and LVT before even getting into the technical aspects of it.

- **BU2**: Block Upgrade 2 is simply a software and/or hardware upgrade package. In our context is a software (and possible hardware) upgrade of the MIDS LVT.[3]
- **MIDS**: The Multifunctional Information Distribution System is a wireless, modular, secure, scalable and jam-resistant digital information system.[4]
- **LVT**: The Low Volume Terminal is one of two (as of January 2015) families of receiver synthesizer line cards available for the MIDS. Right now the two families are the MIDS-LVT and the MIDS-JTRS.[3]

INTRODUCTION

Now that we are familiar with the basic terms we can provide a brief introduction and discuss what this report is going to cover. The BU2 MIDS LVT project's main objective is to retrofit approximately 1,400 Air Force MIDS LVT terminals. The modifications revolve around four main areas, these are; cryptographic modernization, frequency remapping, the addition of an enhanced throughput capability, and other changes proposed by the contractor which are denominated as vendor specific engineering change proposals.

The 1,400 Air Force terminals are designated specifically for the F-15, F-16, B-1, B-2 platforms as well as a handful of ground assets. Even though, the United States Air Force runs its own BU2 program, the lead service for this effort is the United States Navy – The Navy owns the contract and the program management. Also, in order to accelerate the process the terminals will be shipped from the platforms directly to the vendors to implement the upgrade.

THE PROBLEM

We have mentioned the main upgrades that will be included with the block upgrade, but each one of the aforementioned overarching areas that will be upgraded cover a broad spectrum of problems. Since, reporting on the entire block upgrade will require at least three research papers for this report we will only research one, the frequency remapping.

Inside the frequency remapping focus there are three key points that we aim to address. The first issue and the one that drove the entire BU2 effort is an interference problem between the United States Air Force Link 16 terminals and the United States Department of Transportation aviation systems.

The next key point is to honor a memorandum of agreement that was put in place on December 31, 2002 between the Department of Defense and the Department of Transportation. Thirdly is that all of this requirements need to be implemented before the year 2020.

MIDS-LVT

MID is an advanced command, control, computing, communications and intelligence system integrating high-capacity, jam-resistant, digital communication links for exchange of near real-time tactical information, including both data and voice, among air, ground, and sea elements. MIDS was developed to support key theater functions such as surveillance, identification, air control, weapons engagement coordination and direction for all Services.

The MIDS terminal is based on the TDMA (Time Division Multiple Access) data-link technology with 128 time slot per second; during each time slot, only one terminal is allowed to transmit while all the other terminals on the same network are set to receive. To improve the anti-jamming capability signals are spread over 51 frequencies in the 960-1215 MHz frequency band; transmission is inhibited around the two IFF band (1030 and 1090 MHz). Also, The maximum output power of the terminal is 200 Watts, this allows an operational range of approximately 300 miles; the range can be furthered using a capability known as the relay feature.[2]

In Figure 1 we have a picture of a general MIDS-LVT terminal for reference purposes. [5]

Figure 1
MIDS-LVT Terminal

LINK 16

As it can be easily determined the MIDS-LVT is only a terminal and it cannot do anything without waveform cards. Although, there are many different types of waveforms, on this report we are only interested on the Link 16 waveform.

Link 16 is the military tactical data exchange network used by the United States Air Force and the other services as well as every nation that allows the MIDS International Program Office. It is known that its specification is part of the Tactical Data Links hierarchy. Figure 2 illustrates how the Link 16 waveform interacts with the rest of the Air Force and consequently MIDS [5].

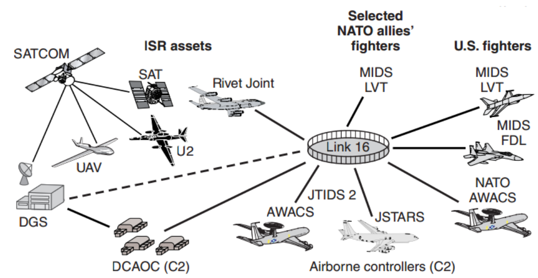

Figure 2
MIDS Correlation with Link 16

With Link 16, military aircrafts as well as ships and ground forces may exchange their tactical picture in near-real time. Link 16 also supports the exchange of text messages, imagery data and provides two channels of digital voice (2.4 kbit/s and/or 16 kbit/s in any combination). Link 16 is defined as one of the digital services of the Joint Tactical Information Distribution system of the MIDS terminal (JTIDS / MIDS) in NATO's Standardization Agreement STANAG 5516. MIL-STD-6016 is the related United States Department of Defense Link 16 MIL-STD.

The diagram depicted below shows the relationships of the Link 16 frequency. We can see the Link 16 frequency sharing inside the 960 to 1215 MHz Band.

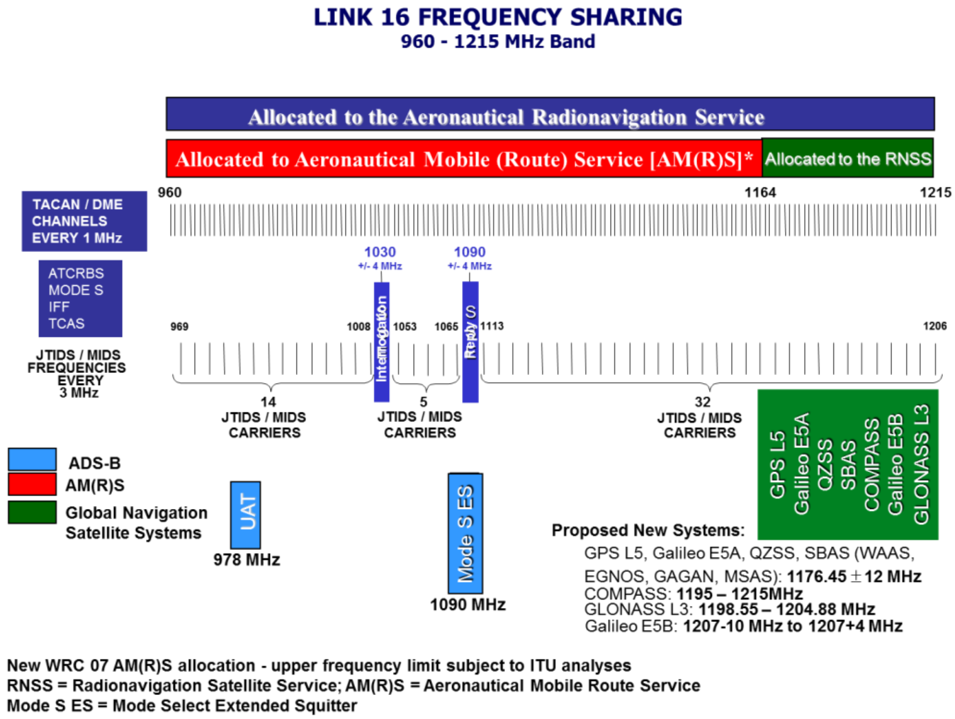

Figure 3
Link 16 Frequency Sharing

From the figure we can note that the higher end of the frequency band is not being used by the Air Force Link 16 terminal as it is allocated to the Radio navigation Satellite Service. The United States Department of Transportation only needs fifteen frequencies, the problem is that these frequencies vary from location to location and it is important to note that Link 16 operates on a 3MHz bandwidth so this could entail the loss of more than 15 frequencies. Fortunately for the United States Air Force remapping frequencies will be needed only inside the United States as the United States Department of Transportation rarely operates outside of United States territories. Because of this, the majority of the time the frequency remapping capability will only be employed on training exercises inside United States territory and should not hinder the mission while over enemy space.

Memorandum of Agreement History

Previously, we briefly mentioned the memorandum of Agreement between the United States Department of Defense and the United States Department of Transportation. The memorandum of agreement between the two departments was signed throughout the months of November and December of the year 2002. The main focus of the memorandum was to establish a baseline on the future management of the 960-1215 MHz band. The National Telecommunication Information Administration updated their manual on May 2003 to accommodate the changes to come and the Federal Aviation Administration recognized their compatibility with the Link 16 waveform.

On March 2004 the new spectrum support certification was approved. This supports the permanent Link 16 frequency assignments for the United States and Possessions.

Later, on 26 April 2005 the Link 16 electromagnetic compatibility features performance specifications were clearly defined and certified by the Department of Defense. The Program Executive Officer for the Command, Control, Communications, Computers and Intelligence was designated as the electromagnetic compatibility features certification authority. In addition, frequency remapping capability would include up to 14 carrier frequencies.

FREQUENCY REMAPPING

In a nutshell what the frequency remapping capability does is that when an unauthorized carrier frequency gets selected for a MIDS pulse transmission the unauthorized carrier will be remapped to an authorized frequency for the pulse transmission in accordance with a remapping algorithm and these calculations are performed in each terminal. Figure 4 gives a simple example on how this is executed.

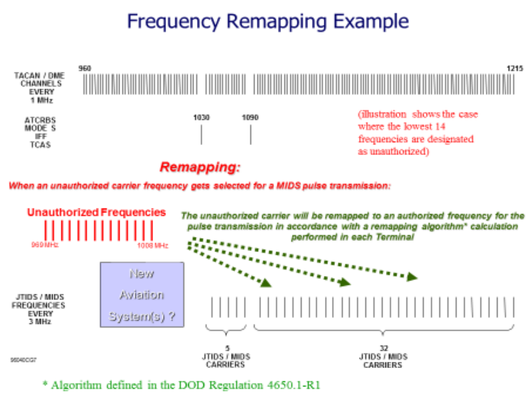

Figure 4
Frequency Remapping Example

The JTIDS/MIDS waveform systems will incorporate a remapping capability for up to 14 carrier frequencies. As we have stated these frequencies can be any 14 among the 51 available and by 2020 all U.S. terminals need to have this capability fielded. Also, any terminal that has been produced after 2007 has this capability already included. Because of this JTIDS will not require a remapping capability, and this is a U.S. requirement only and will not have to be implemented outside of the United States and its possessions. This means that the frequency remapping capability would only be used in peacetime operations: e.g. coordinated exercises within United States and Possessions would cover guest forces with 51 carrier frequencies; The Department of Transportation and the Department of Defense will develop coordination procedures to accommodate Link 16 training exercises involving 51-channel operations.

If necessary carrier frequencies would be remapped to promote compatibility with new aviation systems, this allows the Federal Aviation Administration to identify a portion of the band to implement systems without the absolute burden of being compatible with JTIDS/MIDS. The requirements to remap frequencies would be specified via the NTIA Spectrum Planning Subcommittee (SPS) process and the intent is not to restrict all of the United States and its possessions, but only high density air traffic areas.

POTENTIAL IMPACTS OF FREQUENCY REMAPPING

Figure 5 shows the bit error rate for single pulse non-error coded messages, as a function of the signal-to-noise ratio. Sync reception probabilities are not included in the curves. The “remap 0” case is the reference curve where remapping is not used. When 14 frequencies are remapped, the bit error rate stays above 13% which is unacceptable.

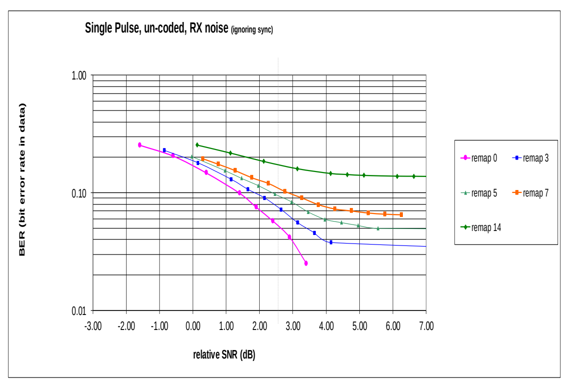

Figure 5
Single Pulse, Un-coded, RX Noise (Ignoring Sync)

The relative signal-to-noise ratio shown on the horizontal axis is the signal-to-noise ratio relative to the signal-to-noise ratio that is required for 1% modulation error ratio for double pulse coded data with 4 frequency sync reception and no remapping. Note that if you were at the point where the bit error rate is 5% with no remapping, it will jump to about 11% if seven frequencies are remapped. The minimum bit error rate will be about 6.5% no matter how much the signal-to-noise ratio is increased. Thus the 5% bit error rate criterion can never be met when 7 frequencies are remapped.

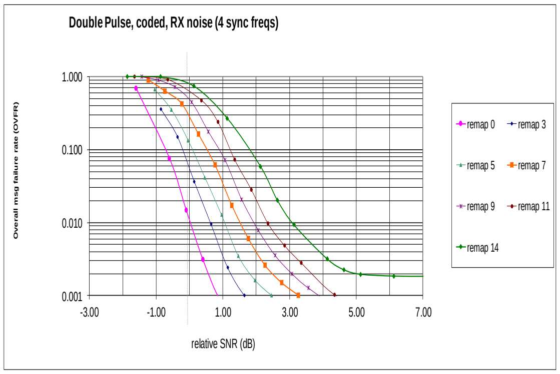

Figure 6
Double Pulse, Coded, RX Noise (4 Sync Freq.)

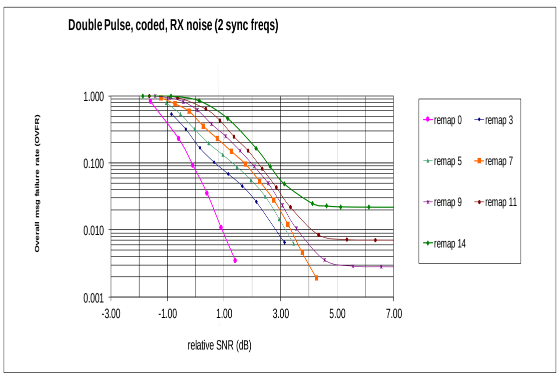

Figure 7
Double Pulse, Coded, RX Noise (2 Sync Freq.)

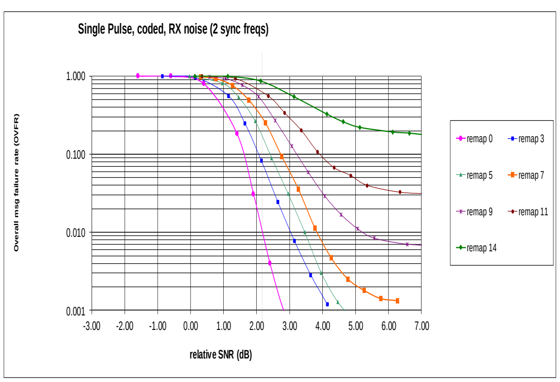

Figure 8
Single Pulse, Coded, RX Noise (2 Sync Freq.)

The last three figures represent other impacts of remapping. We can notice that double pulse waveforms with four synchronization frequencies are least effected. As in any transmission scenario, single pulse waveforms are more susceptible than double pulse waveforms. Also, some studies have indicated that impacts to normal operations will be minimal if no more than seven frequencies are remapped.

Ways to overcome these impacts are still being researched, but some initial approaches include; increasing the required signal to noise ratio to maintain a one percent message error rate for coded signals and a five to ten percent bit error rate for un-coded signals.

The Signal to noise ratio can be increased by reducing the range. Reducing the range will be required to maintain the one percent message error rate or the five to ten percent bit error rate. Moreover, the message formats may need to be limited for coded double pulse waveforms.

FREQUENCY REMAPPING IMPLEMENTATION

To implement the frequency remapping capability two adaptable parameters will be added. The terminal has to process an adaptable parameter that permits or restricts carrier frequency re-mapping. When frequency re-mapping is restricted, the terminal has to select carrier frequencies in accordance to what has been specified in the memorandum of agreement. When frequency re-mapping is permitted, the terminal has to process another adaptable parameter that identifies the frequency numbers required to be re-mapped.

For this to be true we assume that the remapping function will be clear to the user and cannot be restricted in flight by the user except by altering initialization files. Changing to combat mode will not disable the remapping function. It is important to note that the required remapped frequencies will be specified in the frequency assignment. Also, the remapped frequencies will be stored in the network initialization file. And lastly, modifications to the JTIDS network design aid will required.

The remapping capability will be included in new Link 16 capable radio terminals; MIDS-JTRS terminals, AMF JTRS terminals, Joint Strike

Fighter terminal and the Strike common Weapons Data Link Terminal. The frequency remapping capability will be available for incorporating into fielded terminals during routinely depot repair and/or maintenance beginning in December 2009. There is research work currently in process to determine the viability of implementing an enhancement package and deliver the capabilities discussed throughout this project.

CONCLUSION

On this project we discussed the frequency remapping capability which is one of the technologies that will be included with the BU2 MIDS LVT program. We went over what drove this effort and the United States Department of Transportation’s involvement with the program. We discussed some of the impacts that remapping frequencies could bring, but we also saw how to mitigate them and how to implement frequency remapping. Moreover, we researched and explained the military tactical data link used by the MIDS terminal which ultimately employs the frequencies to be remapped. By doing this we established the correlation between Link 16 and MIDS. The BU2 MIDS LVT is a program that is still being developed and researched, but holds a fielding date that is fast approaching. As the time nears we will continue to work to deliver this technology, but only the future will tell us what the final product will be.

REFERENCES

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