Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Review of Part and other Parts of the	)	ET Docket No. 01-278
Commission's Rules	)	RM-9375
	)	RM-10051
	)	

COMMENTS OF SAVI TECHNOLOGY, INC.

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SUMMARY

Savi Technology, Inc. herein submits comments strongly supporting the adoption of the Commission's proposal to permit expanded use of the 425 to 435 MHz and 13.56 MHz bands for advanced radiofrequency identification ("RFID") products. Savi has endeavored to provide detailed technical information about its current products and its anticipated use of future products. Savi only requires a relaxation of very stringent duty cycle requirements under Part 15 of the Commission's rules to permit better wireless data gathering for its RFID product lines. Savi has conducted a series of tests and interference analysis to demonstrate that the existing Amateur Radio Service operations in the 425 to 435 MHz band will not be adversely affected by the relaxation of the duty cycle requirements. Savi urges the Commission to rapidly complete its efforts and adopt the changes proposed to Part 15 of its rules.

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Savi Technology, Inc. ("Savi") hereby submits these comments in response to the *Part 15 NPRM* released October 15, 2001.[1] Savi restricts its comments to proposals concerning radio frequency identification systems ("RFID"). Specifically, Savi strongly supports the Commission's tentative conclusions to permit minor changes to Part 15 of its rules to enable use of the 425 to 435 MHz and 13.56 MHz bands for RFID products. As will be discussed in more detail in these comments, Savi has endeavored to clearly describe the changes to Part 15 to appease the Amateur Radio community. Further, Savi has conducted several tests between Amateur and Savi devices. Through this testing, and due to the fact that the Savi RFID product currently operates in the 433 MHz band in Federal Government locations, a relaxation of the overly strict duty cycle requirements in Part 15 for the 433 MHz band is clearly in the public interest. Removal of these restrictions will better enable our nation's homeland security efforts by tracking contents of containers throughout the United States.

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[1] *See Review of Part 15 and other Parts of the Commission's Rules*, ET Docket No. 01-278, *Notice of Proposed Rule Making and Order*, FCC 01-290 (October 15, 2001) ("*Part 15 NPRM*").

I. INTRODUCTION

Savi filed a petition for rule making on November 22, 2000, seeking a relaxation of the duty cycle requirements of Part 15 for its devices.[2] As discussed in this petition, Savi's RFID system has had a variety of uses, including, among other applications, the control of material for the Bosnia peacekeeping deployment. The RFID system has proven effective for tracking, tracing, and controlling the flow of supplies on a cost-effective basis for both government and commercial applications. Savi products fall into two broad categories: active tags and interrogators. The active tags are battery operated and contain a simple processor, 128 kilobytes of memory, and a radio transceiver operating in the 433 MHz band. These tags are designed to be attached to freight containers with the memory unit programmed with the contents of the containers. In typical military forward deployment applications, a particular container may contain a dozen different products needed by field personnel. In industrial and commercial applications, on the other hand, typical shipping containers house only one or two types of products.

As the Savi system currently operates, the tags only transmit information on specific items within the container back to the interrogator. Given the limited data provided by the tags, all transmissions can be completed within the 1 second limitation of Section 15.231(e) with a 10-to-1 duty factor, which allows the tags to operate under Section 15.35[3] with a peak power necessary to achieve a 100-meter range. In complying with these requirements, the field strength limit for a device operating in the 420 to

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[2] *See* Petition for Rule Making of Savi Technology, Inc; Amendment of Part 15 to Permit Broader Data Transmission Capabilities, RM-10051, rec. November 22, 2000.

[3] *See* 47 C.F.R. § 15.35.

450 MHz band would be 110,000 µV/m at 3 meters, with a limitation on the duty cycle of operation. While this field strength limit allows effective operation of RFID products, it unnecessarily limits the amount of data that can be conveyed by such systems.

The *Part 15 NPRM*, in recognition of these stringent limitations on duty cycles, agreed with Savi that changes to Part 15 to allow more advanced RFID systems in the 433 MHz band would serve the public interest.[4] The Commission proposed, therefore, to create a new section that would allow operation of such devices in the 425-435 MHz band, with a maximum field strength of 11,000 microvolts per meter measured at 3 meters, using measurement equipment (in accordance with Section 15.35 of the Commission's rules) with an average detector function. The maximum peak level permitted would be 110,000 microvolts per meter measured at 3 meters, which is exactly the same as the current rule limits. Most importantly, the Commission proposed to allow transmissions to last 120 seconds, with a 10 second latency period.

Additionally, the *Part 15 NPRM* proposed to permit the use of RFID products in the 13.56 MHz band.[5] This was to be accomplished by relaxing the emission restrictions into the adjacent, restricted bands and by modifying Section 15.225 of the Commission's rules.

II. AUTHORIZATION OF ADVANCED RFID PRODUCTS WILL PROVIDE OBVIOUS PUBLIC BENEFITS

As noted by the Commission and Savi, previous commenters are in agreement with Savi that relaxation of the Part 15 duty cycle limitation on data transmissions for the 425 to 435 MHz band will

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4 *See Part 15 NPRM* at 27.

5 *See Part 15 NPRM* at 20.

provide meaningful public benefits and allow for seamless tracking of material throughout the supply chain.[6] Currently, Savi operates its tags and interrogators in compliance with Section 15.231(a) and 15.231(e) of the Commission's rules.[7] In accordance with these requirements, Savi limits its interrogators to a 110,000 microvolts/meter field strength at 3 meters, with an effective radiated power ("ERP") of 3.6 milliwatts, with its tags limited to a 43,980 microvolts/meter field strength at 3 meters and an effective ERP of 0.6 milliwatts.[8] Savi has currently deployed its RFID products in commercial locations and Federal Government sites throughout the continental United States, Europe and Asia. As Savi has done previously for the Commission, attached as Appendix A to these comments is a continental United States map that demonstrates the current system deployment of Savi's products. As such, Savi has implemented significant systems throughout the country and now only seeks Commission approval to enhance this existing product for higher volume data applications.

The public interest benefits are many to increasing the RFID duty cycle for the 425 to 435 MHz band. UPS notes that "…there exists a need to store greater amounts of data on the tags and a need for the capability to transfer that data via RF."[9] Oracle asserts that "Increasing the Part 15 duty factor, while maintaining the same field intensity of the existing system, increases the utility of the Savi system

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[6] *See e.g.*, Comments of United Parcel Service ("UPS"); Comments of Oracle Corporation ("Oracle"); Comments of Cynthia Barnhart, Massachusetts Institute of Technology ("MIT"); Comments of H. Donald Ratliff, CEO of Velant ("Velant").

[7] *See* 47 C.F.R. § 15.231(a).

[8] Taking advantage of the averaging provisions of Section 15.35 of the Commission's rules, with a 7 millisecond pulse train that is utilized by Savi, the field strength limit at 3 meters for the 433 MHz band can be interpolated to be 110,000 microvolts/meter.

[9] *See* UPS Comments at 1.

while maintaining the same operating range."[10] MIT states that "New and more robust services can now be using the full capabilities of a Savi RFID system. The result will be lower costs throughout the supply chain."[11]

In addition to these clearly stated benefits, the increased need for national homeland security in light of the terrorist actions of the past year can be accommodated by Savi's RFID system. Savi's product, as enhanced by the requested rule changes, will greatly enable law enforcement and other homeland security authorities to track containers and their cargo throughout the supply chain. More crucially, material that is shipped into and out of national defense locations, such as military bases and seaports, will be more efficiently logged and determined prior to entry.

In light of these public benefits, Savi again encourages the Commission to act expeditiously and favorably upon its requested changes to Part 15 of its rules. Further, Savi supports the Commission's efforts to modify Section 15.225 of its rules to enable additional advanced RFID products to be brought to the public. Through these modifications to its currently restrictive rules, the Commission will enable a variety of RFID products that will provide the American public with extended security and tracking of material throughout the country.

III. THE AMATEUR RADIO SERVICE STILL MISUNDERSTANDS SAVI'S REQUEST

Despite repeated attempts by Savi to discuss its RFID product, and a variety of tests run in cooperation with the Amateur community, Savi's minor change to the Commission's rules continues to

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[10] *See* Oracle Comments at 1-2.

[11] *See* MIT Comments at 2.

be stubbornly opposed by this radio user group. To date, numerous Amateur Radio Service licensees have filed comments opposing Savi's proposal, primarily reiterating the same objections raised by the ARRL, the National Association for Amateur Radio ("ARRL"). From review of these comments, it appears the only new issue raised is about the "weak signal" service and the effect that Savi's system would have on this service.

Herein, Savi again addresses each of the Amateur community's concerns, and have included a summary of testing conducted with Warren Bruene, a longtime Amateur radio user and equipment developer, that details his belief that Savi's system will not adversely affect Amateur operations. In addition, Savi conducted a series of tests with a weak signal system operator, to demonstrate the lack of interference present to Amateur operations from Savi's system. Finally, Savi addresses *ex parte* comments of the ARRL concerning the technical operating characteristics of Savi's products. Savi believes that it is clear that its system, operating with extremely low power, should not present any interference concerns for the Amateur service.

A. Part 15 Permits Power Levels Utilized By Savi

In a continuing thread, the Amateur commenters steadfastly argue that Savi is seeking an increase in the permitted field strength for its products.[12] Savi again states that it has not, and does not require *any* increase in the field strength limits for successful operations. Rather, Savi seeks, and the Commission has tentatively concluded to adopt, an increase in the duty cycle permitted under Part 15 of the Commission's rules.

To repeat detailed information concerning its system, Savi uses an interrogator, operating at an

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[12] *See e.g.*, Comments of Bryan Alan King at 1; Comments of Michael J. Linden at 1.

ERP of 3.6 milliwatts, to query tags as part of its system. The tag does not go "active" until interrogated by the interrogator. The tag is limited to an ERP of 0.6 milliwatts. Due to the constraints of Section 15.35(c) and 15.231(e), Savi limits the pulse train length of its data messaging to 7 milliseconds ("ms"). With a train of 7 ms pulses, Savi may take advantage of the averaging provisions of Section 15.35(c) and is permitted to emit a signal with a field strength of 110,000 microvolts/meter at 3 meters. Savi is confident that its system complies with the requirements of Sections 15.35(c) and 15.231(e) due to the fact that its equipment has been issued Commission equipment authorization.[13]

Rather than increase its power, and therefore its field strength, Savi seeks a relaxation of the duty cycle limitations of Section 15.231(c). Savi would not alter its power levels or emissions, it simply requires additional transmission time to download 128 kilobytes of data in a reasonable amount of time. Savi currently complies with these packet size limitations, which forces any large data transfer to take almost 30 minutes to download. While the limitations were workable when only a tag number was relayed via an RF link (approximately 8 kilobytes), new applications required by the Department of Defense and commercial entities are leading to a need for greater amounts of data to be transferred via the RF link. For example, a computer database is used with the Savi product to match the tag number to the actual contents of a container. With the present system, if the computer database is not in place, a user would be unable to determine what material is within a container. However, if a user were able to occasionally query a container for its full contents, on an as needed basis, the need for the computer database would be less significant. There are other examples of system requirements, including the loading of container data from the computer database to the tag using the RF link, that require more

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[13] *See e.g.*, FCC ID KL7-410R-V1, FCC ID KL7-410T-V1, FCC ID KL7-HHI-V3.

robust data streams than 8 kilobytes. Furthermore, although the current rules permit the downloading of significant amounts of data, the duty cycle limitation effectively precludes any sort of timely downloading (or uploading) of large amounts of data. It is therefore critical to allow further flexibility to Savi's operations in the 433 MHz band to promote efficient, seamless material tracking.

B. Savi Operations Are Limited to Commercial/Industrial Environments That Severely Restrict Propagation

Several Amateur commenters reiterate ARRL arguments that due to the itinerant/mobile nature of RFID tags, interference between Amateur Radio and Savi could not be mitigated once devices are deployed.[14] This point is tied to the incorrect assumption that Savi tags are utilizing power levels to produce a field strength of 110,000 microvolts/meter at 3 meters, that tags transmit continuously, and that the tags are in "uncontrolled" environments.

As discussed above, Savi tags actually are limited to an ERP of 0.6 milliwatts, which produces a field strength of 43,980 microvolts/meter at 3 meters. Again, these tags are currently deployed throughout the continental United States at these operating powers, and have yet to be cited for harmful interference to the Amateur community.

Notably, the Savi tag does *not* operate unless instructed to do so by the interrogator. As discussed in the introduction of these comments, interrogators are located at fixed locations or in the warehouse or other commercial environment. Therefore, Savi communications between tags and interrogators can only occur in very controlled circumstances. Savi's product is utilized only in commercial and industrial areas such as ports, military bases and warehouses. They are not broadly

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[14] *See e.g.*, Comments of Jeffrey Peter Kershaw at 1; Comments of Richard Lourette at 1.

used throughout the country and remain inactive until interrogated by an interrogator. With the controlled bursts of data that flow from Savi tags limited to commercial and industrial areas, the potential for interference to Amateur operations would be remote at best.

C. The 433 MHz Band Is Appropriate and Necessary for Savi's Operations

Several commenters suggest that Savi should not operate in the 425 to 435 MHz band, but should use other allocated bands for its RFID products.[15] To the contrary, Savi carefully chose the 433.92 MHz frequency to ensure the proper operation of its system, to make certain its Federal government and commercial customers could both deploy the system, and to ensure that the costs of the product were economical.

The initial demand for Savi's RFID product was from the Department of Defense to handle logistics tracking. Recognizing the challenging RF environment faced in commercial ports and warehouses, Savi tested a variety of spectrum bands for propagation characteristics, researched international allocations, and reviewed current technology available at a reasonable cost. As an initial matter, the 900 MHz band was certainly reviewed as part of this process and rejected due to the nature of the containers to be tracked. As can be seen in Appendix B of these comments, at 433 MHz a typical metal container in the direct path of the signal introduces 25 dB of losses, which could be even higher if the tag is not physically attached to a metal container. At 900 MHz, this effect is even more acute, rendering the 900 MHz band useless for tracking of containers in a commercial/industrial setting unless the RFID tag happens to have clear line of sight to the interrogator. More crucially, at 433 MHz a skin current is developed when the tag is attached to a metal container that enables the tag to be read

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[15] *See e.g.*, Comments of Brian James Jarchow at 1; Comments of David A. Merriweather at 2.

even when on the opposite side of the container from the interrogator. At higher frequencies, this effect is greatly reduced, requiring line of sight linkage between the Savi tag and interrogator. In light of this, Savi focused its attention on the 433 MHz band as the next logical point of deployment.

As the need for material tracking was derived from Department of Defense requirements, it was critical to choose a frequency that would not only be available domestically, but also internationally wherever the military is deployed. After an exhaustive review of international allocations, Savi determined that the 433.92 MHz frequency was available domestically, in Europe and Asia. Domestically, the 420 to 450 MHz band is allocated to the Federal government on a primary basis for radiolocation. Internationally, the frequency is allocated for use on an unlicensed basis as well, without the strict limitations found domestically. Therefore, contrary to Amateur allegations, Savi's choice of frequency was carefully considered and planned prior to its implementation.

A final consideration to any Department of Defense or commercial product is cost considerations. The Federal government is not in a position to pay inordinate amounts of taxpayer money to support an RFID product that could be deployed more cost effectively. Further, commercial entities certainly desire a low cost solution to their material tracking needs that was not being met by current products employed at 900 MHz. Savi is able to provide a workable product at 433 MHz that provides all these economic benefits to the Federal government and commercial users, a critical point of consideration when choice of appropriate operating frequency was decided.

D. Use of the 433 MHz Band Will Not Introduce Harmful Interference to Amateur Operations

Amateurs suggest that Savi's operations in the 425 to 435 MHz band will cause interference to

weak signal systems, as well as disrupt the many Amateur FM voice repeaters in the band.[16] On January 31, 2002, the ARRL also filed an *ex parte* presentation concerning Savi's system claimed to be an "interference study" that showed harmful effects to Amateur services greater than 1000 meters from Savi operations.[17]

In response to these contentions, attached in Appendix B is a link budget for the existing Savi system. This link budget demonstrates the nature of the RF environment faced for material tracking. Containers used for shipping material are typically steel that, at 433 MHz, when in the direct path of the Savi tag/interrogator transmission introduces 25 dB of losses. Additionally, Savi has found that 20 dB is also lost due to fading and antenna nulls. From practical experience in the field, Savi has been able to calculate that on average the overall losses due to these effects are approximately 30 dB. Therefore, even with an interrogator operating at the current 3.6 milliwatts ERP, Savi only has a margin of 17.8 dB at 100 meters. The tags, operating at 0.6 milliwatts ERP, only have margin of 9.8 dB at 100 meters. This link budget clearly demonstrates the necessity of Savi utilizing the ERP that it does (and the corresponding field strength as measured at 3 meters). If a second container even partially is in the direct path between the tag and interrogator, the link margin is completely overwhelmed.

Savi also considered the effects on the primary and secondary users of the 425 to 435 MHz band. The tag is inactive until interrogated, which greatly reduces the time that a tag is actually transmitting. Further, Savi uses FSK modulation for its system. Because Amateurs in the 420 to 450

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16 *See e.g.*, Comments of Howard Malone at 1; Comments of Melvyn Louis Bernstein at 1.

17 *See* Comments of the ARRL, filed January 31, 2002.

MHz band use FM modulation, it is highly unlikely that Savi's low power, FSK signal would capture the FM discriminator of an Amateur receiver during an Amateur transmission. To buttress this contention, Savi participated in a test with Warren Bruene. Mr. Bruene, call sign W50LY, has been a licensed Amateur Radio operator since 1935. More importantly, he has had over 45 years of experience at Collins Radio and its successor companies developing single sideband equipment used in the Amateur Radio service. As such, he certainly is an expert in the field and has experience that is relevant to determining what interference effects might be caused by Savi operations. As provided in more detail in his *ex parte* filing in this docket,[18] Mr. Bruene found that adoption of the Commission's proposal concerning Savi's system would not result in interference with the Amateur Radio operations in the 430 to 440 MHz band. Savi has attached as Appendix C to these comments, a summary of the test conditions for the tests conducted with Mr. Bruene.

Additionally, Savi participated in tests with a weak signal system in the Dallas, Texas area. The particular parameters of these tests are attached as Appendix D to these comments. During operations of the Earth-Moon-Earth ("EME") Amateur station, the station was able to operate normally in the 432 to 433 MHz band in both the CW and SSB mode during Savi interrogator and tag transmissions, even within 30 meters of the station. Additionally, this testing demonstrated that clear line-of-sight from a Savi tag and interrogator link is necessary for the EME station to detect the link. Again, this testing demonstrates that Amateur Radio service is not, and would not be, disrupted by the operations of Savi facilities.

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[18] *See* Comments of Warren B. Bruene, filed January 30, 2002.

Finally, Savi has analyzed the January 31, 2002 *ex parte* presentation of the ARRL, which alleges that harmful interference will occur to Amateur operations even more than 1000 meters from Savi operations. A detailed analysis of this filing is contained in Appendix E to these comments, however, it is clear that the "interference study" submitted by ARRL is not an interference analysis. ARRL failed to analyze the effects of the Savi signal on a desired, Amateur signal. Moreover, ARRL has incorrectly characterized the Savi signal levels. Finally, the ARRL signal strength curves for Savi operations at various distances are off by 30 dB.

In spite of these inaccuracies, Savi has performed an interference analysis based on the parameters provided by ARRL. From this analysis it is clear that at 1000 meters from Savi's tags, the Amateur operations defined by ARRL would have an interference protection margin of 63 dB and 53 dB from Savi's interrogators. At 100 meters, the tag margin would be 31.5 dB and interrogator margin would be 23.5 dB. This level of margin would allow the FM discriminator of the Amateur FM receiver to capture the desired Amateur receiver and to suppress any signal present from a Savi tag or interrogator. The testing performed by Savi has also shown that the Savi system will not "open" the squelch of the Amateur FM receiver, meaning that the Amateur receiver will not be able to "hear" the undesired Savi signal. Therefore, Amateur operations would not be adversely affected by the introduction of Savi operations.

Finally, Savi performed extensive research into the use of the 420 to 450 MHz band before selecting the 433.92 MHz frequency for operation. From review of the ARRL licensed repeaters, it was apparent that only a small number of Amateur systems operated at this frequency, used for auxiliary and repeater links, leading Savi to determine it to be the most appropriate frequency for use.

Savi believes it has developed a low power, RFID product that presents insignificant risks of harmful interference to either Federal government or Amateur systems. As noted herein, this system has been deployed commercially and by the Federal government throughout the United States and has yet to have any reported event of interference from other users. Additionally, the operating frequency and bandwidth of the system were carefully selected to mitigate any effects that could potentially arise with respect to the licensed users of the 425 to 435 MHz band.

IV. CONCLUSION

Savi applauds the Commission's recognition of the vast public benefits that advanced RFID technology can provide. Savi urges the Commission to rapidly complete its rule making efforts to permit the modification to the duty cycles for Savi's product line in the 425 to 435 MHz band and to permit expanded use of the 13.56 MHz band. A reduction in the duty cycle restrictions, without any modification to the existing power levels that may be employed, will permit Government and commercial users of RFID products to have better visibility for transportation containers and their contents throughout the transport system. This will result in immense benefits to the nation as it attempts to ensure the secure transport of goods throughout the country.

Respectfully submitted,

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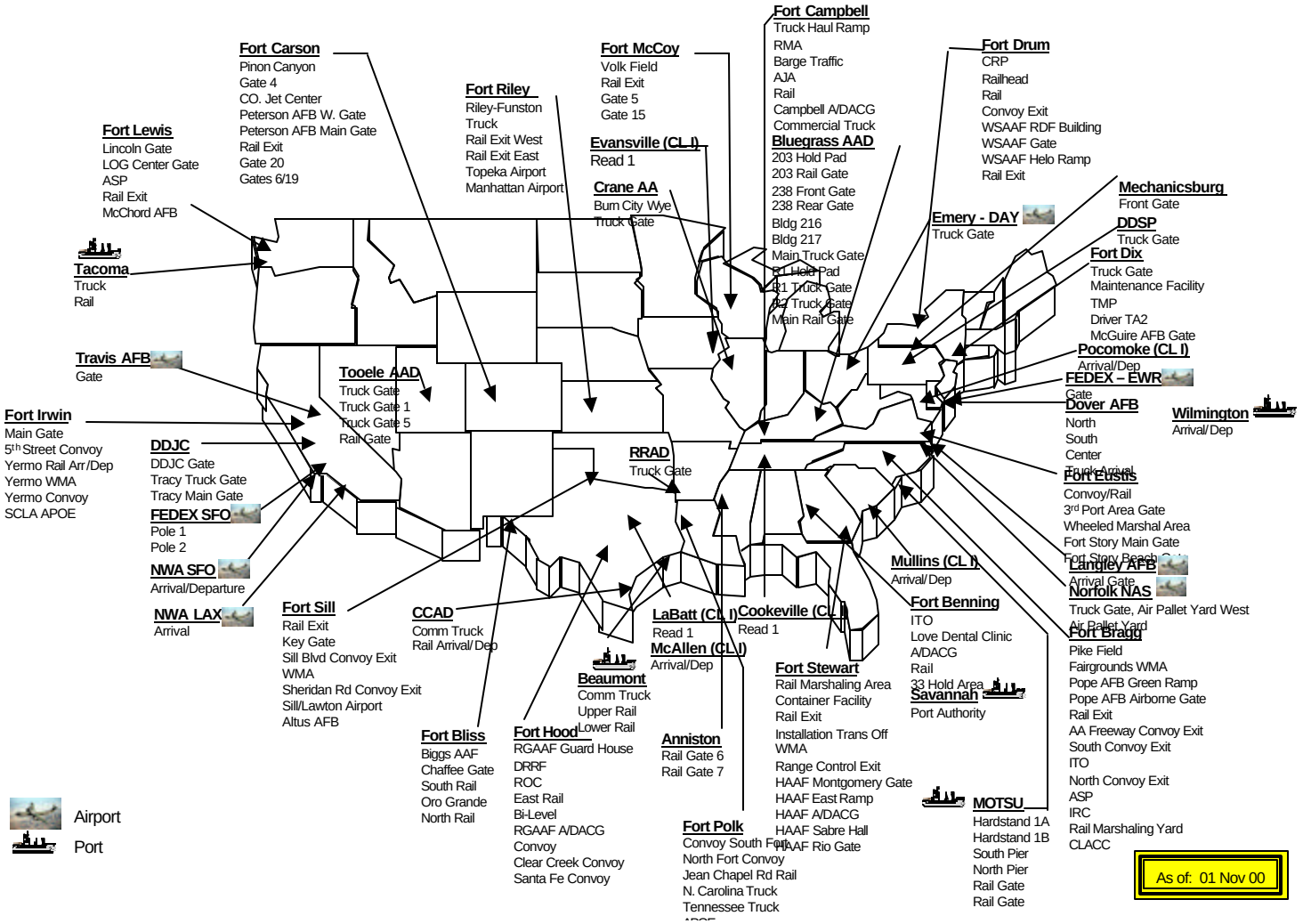
CONUS RFID Read Stations



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APPENDIX B

SAVI
TAG – INTERROGATOR

LINK BUDGET/MARGIN

RECEIVER PARAMETERS

Receiver Antenna Aperture:	0.175 meter	
Receiver Sensitivity:	1 microvolt	-107.0 dBm
Receiver Threshold:	5 microvolts	-93.1 dBm

TRANSMITTER PARAMETERS

Transmitter Field Intensity at 3 meters: 110,000 microvolts/meter (interrogator)

43,980 microvolts/meter (tag)

BLOCKAGE AND FADING LOSSES

Single metal container blocking direct path:	**-25 dB**
Fading and antenna nulls:	**-20 dB**
RSS of path losses:	**-30 dB**

RECEIVED RECEIVER SIGNAL (50 ohm input port) with –30 db path losses at distances of: (interrogator/tag)

100 meters	38.6/15.4 microvolts	-75.3/-83.3 dBm
300 meters	18.4/7.4 microvolts	-81.7/-89.7 dBm
1 km	8.3/3.3 microvolts	-88.6/-96.6 dBm

LINK MARGINS with –93.1 dBm threshold at distances of: (interrogator/tag)

100 meters	**17.8/9.8 dB**
300 meters	**11.4/3.4 dB**
1 km	**4.5/-3.5 dB**

APPENDIX C

70CM Band Test Report

70 CM Test: January 11, 2001

Location: W5OLY QTH, Dallas, Texas

Equipment:
Savi Mobile Interrogator and Savi 400 Series Tags
Savi Interrogator and Tag operating frequency: 433.92MHz

Amateur Equipment:
Icom IC-T7A Dual Band FM Transceiver
Operating frequency range: VHF TX 144-148 MHz UHF TX 440-450 MHz
RX 118-174 MHz RX 400-470 MHz

Receiver System: Double conversion superhetrodyne,
First IF 45.15 MHz and Second IF 450 kHz.

Receiver and Squelch Sensitivity: Less than 0.16 microvolts, 12 dB SINAD

Selectivity: Greater than 15 kHz at –6 dB and less than 30 kHz at –30 dB

Test Frequencies:
Savi TX/RX: 433.92 MHz
IC-T7A: 420-435 MHz.

Test Results:
The IC-T7A was tuned to 433.92 MHz and placed less than 3 meters from the Savi interrogator and tags. The interrogator requested all tags present and reported that the three tags present had reported their unique recognition code ID's. The contents of the reported tags memory was requested and down loaded to the interrogator.

During the interrogator and tags exchanges the IC-T7A squelch remained close and did not detect the FSK interrogator and tags transmissions. The IC-T7A squelch was manually defeated and the only the receiver high frequency noise (hiss) and a very low level of data transmission just above the noise could be discerned.

This test clearly indicates that the Savi system would not cause inference to normal amateur communication that would occur on the Savi operating frequency.

Further consideration of the characteristics of FM receivers provide why these test were successful

considering the close proximity of the amateur FM receiver and the Savi interrogator and tags.

FM receivers have good noise suppression characteristics due to their use of limiting IF amplifiers and FM discriminator detectors. It is well known that the limiter and discriminator stages in a FM receiver can eliminate a good deal of amplitude noise. This and several other characteristics of the FM receiver work in favor of not having the Savi systems cause interference to the amateur FM receivers (auxiliary and repeater links) that operate at this frequency.

The FM receiver has a characteristic known as capture effect where the strongest FM signal received will suppress the weaker signal and is the only signal demodulated. FM receivers sensitivity is specified in terms of signal required to produce a given amount of quieting, usually 12 dB and have sensitivities in the 0.15 to 0.5 microvolts range.

Another factor in the operation of a FM receiver that works in favor of the two systems is the squelch function that "opens the audio gate" and allows the transmitted signal to be heard when a FM carrier is detected. This function operates on the principle of the noise quieting that occurs when a FM carrier is present.

The narrow bandwidth of the amateur FM receivers, 15 kHz down to 6 kHz for narrow band FM, as compared to the 100 kHz wide FSK signal also reduces the Savi transmitted energy in the amateur receiver by 8 to 12 dB.

These test results demonstrate that the Savi interrogator and tags are not harmful to the FM amateur receiver operation due to the low operating power of the Savi system, Savi's FSK modulation and the characteristics that are intrinsic in the FM amateur receiver.

APPENDIX D

EME/Weak Signal Test Report
and
ARRL 425-435 BAND PLAN

Introduction

The following is the ARRL band plan for the 425-435 MHz frequency range, the Savi operating frequency and test results obtained while operating the Savi system co-located with a 70 cm EME (Earth-Moon-Earth) amateur station.

The EME station was able to receive the co-located (30 meters) Savi interrogator and tags when tuned to their operating frequency while in the SSB mode of operation. The EME station was not able to receive the signals while in the FM mode unless the receiver squelch was defeated and it was not able to receive the Savi system signals when a truck blocked the line of sight (LOS).

The EME station was able to operate normally in the EME/weak signal band segment (432.00-433.00 MHz) in both the CW and SSB mode during Savi interrogator and tag transmissions

425-435 MHz

425.00-432.00	ATV repeater or simplex.
432.00-432.07	EME (Earth-Moon-Earth)
432.07-432.10	Weak-signal CW
432.10	Calling Frequency
432.10-432.30	Mixed-mode and Weak-signal
432.30-432.40	Propagation Beacons
432.40-433.00	Mixed-mode and weak signal
433.00-435.00	Auxiliary/Repeater links

* Weak Signal band segment: 432.00-433.00 MHz

Savi Interrogator and Tag operating Frequency: 433.92 MHz

EME Test Report

EME Test: January 26, 2002

Location: K5GW EME Station 45 miles North East of Dallas, Texas

Equipment:
Savi Mobile Interrogator and Savi 400 Series Tags
Savi Interrogator and Tag operating Frequency: 433.92 MHz

EME Station K5GW
Antenna Array : 64 X 10 element with 30-dB gain.
Preamp: 25 dB gain, 0.2 dB Noise Figure
Exciter/Receiver: Yaesu FT-736
Power Amplifier: 1500 Watts
Test Frequencies: TX/RX 432.00-432.07 MHz
RX 433.92 MHz

Test Results:

- EME Station in the SSB detection mode and tuned to 433.92 MHz and Savi Interrogator and three Tags placed 30 meters from front of antenna array indicated a received signal strength of S9 (~50 microvolts).
- During EME station transmissions the Savi Interrogator reported no tags found when activated and during tag data transmissions the link was lost by the interrogator and the system ceased data transmissions.
- The 433.92 MHz signal was lost by the EME station during the time that a truck was placed between interrogator and tags and the EME antenna array. This indicated that line of sight (LOS) is required for signal reception.
- The EME Station was not able to receive either Interrogator or Tag transmissions when operating at the ARRL band plan EME/Weak signal frequencies of 432.00-433.00 MHz.
- The EME Station was also operated in the FM receive mode on 433.92 MHz and it was observed that the Interrogator and Tags did not break the squelch of the Yaseu FT-736 receiver.

APPENDIX E

Savi's Analysis
Of
ARRL's Ex Parte Presentation
To the
FCC Office of Engineering and Technology
On
January 14, 2002

A review of the subject Ex Parte presentation has been conducted and the following are observations and findings.

- The study is not an interference analysis in that it does not analyze the effects of an undesired received signal level on a desired signal level.

- The signal levels from the undesired signal sources are incorrectly defined. The corrected field intensity levels at the distance of 3 meters are as follows:

Interrogator	110,000 microvolts/meter peak
Tag	43,980 microvolts/meter peak

- The ARRL curves for signal strength at various distances also appear to be in error by 30 dB. The vertical axes of the figures are labeled as dBW. Either the label is wrong or the data is incorrect.

- The correct signal levels at 3 meters when converted to dBm is as follows where, P (dBm) = -77 + 20log E (in microvolts) - 20log F (MHz).

Interrogator	-28.17 dBm or -58.17 dBW
Tag	-36.13 dBm or -66.13 dBW

- The undesired received signal levels (Interrogator or tag source) at 1 Km and 0.1 Km is as follows:

Interrogator	-142.57 dBW and -122.57 dBW
Tag	-150.53 dBW and -130.53 dBW

- The radio horizon and the received FM amateur signal (desired signal) varies according to the antenna height, thus LOS as follows:

The desired RSL is in the range of –89 dBW to –99.4 dBW for antenna heights of 20 to 200 feet.

- The C/(N+I) ratio, (desired signal to noise plus undesired signal ratio), at 1 Km from the undesired signal source is 63 dB for a Savi tag source and 53 dB when the undesired signal source is a Savi interrogator.

- The C/(N+I) ratio at 0.1 Km (edge of a Savi system deployment) is 31.5 dB when the undesired source is a tag and 23.5 dB when the source is a Savi interrogator.
- Conclusion

  The C/(N+I) ratios for typical amateur FM operations is sufficient to activate the amateur FM receiver squelch and capture the FM detector while suppressing any signal that might be present from a Savi Tag or Interrogator.

  The nature of the Savi FSK signals does not cause the receiver's squelch to activate.

  The Savi Tags and Interrogators are weak signal devices and do not cause harmful interference to amateur FM operations.