DEPARTMENT OF DEFENSE
UNITED STATES STRATEGIC COMMAND

Reply to:
USSTRATCOM/J66
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NOV 19 20

MEMORANDUM FOR THE DEFENSE INFORMATION SYSTEMS AGENCY

Attention: Integrated Waveform (IW) Project Manager – Mr. Ronald Williams

Subject: Request for Time Division Multiple Access (TDMA) Waiver for AN/PSC-5C Terminal

1. References:

a. Request for IW Certification Waiver AN/PSC-5C Ultra-High Frequency (UHF) Satellite Communications (SATCOM) Terminal, Defense Information Systems Agency, 02 May 2012.

b. AN/PSC-5C (RT-1672C(c)/U) IW Conditional Test Certification Waiver Recommendation, UHF Consolidate SATCOM Systems Expert (C-SSE) Office, 09 Nov 2012.

c. Memorandum of Understanding Between the Joint Staff and the United States Strategic Command (USSTRATCOM) for transfer or Functions and Associated Resources, Joint Staff and the USSTRATCOM, 27 Nov 11.

2. Reference (a) requests a lifetime certification waiver for the AN/PSC-5C (RT-1672C(c)/U). The UHF C-SSE office has evaluated the request and supporting documentation and recommended a two year waiver be granted for test and evaluation purposes only until legacy DAMA capabilities are assessed and accepted as per reference (b). As per the C-SSE recommendation, USSTRATCOM grants a two-year waiver from the date of this memorandum for test and evaluation purposes only as per authorities granted in reference (c).

3. The UHF C-SSE office must be notified of any subsequent planned hardware/software upgrades or changes to the tested configuration of the terminal prior to use over the satellite implementation. Upon receipt of the modification details, the UHF C-SSE will review and assess the proposed terminal changes to provide guidance regarding steps necessary to maintain the associated waiver.

4. POC is Maj James A. Conway, Narrowband Strategic SATCOM Manager, conwayj@stratcom.mil, Commercial (402) 232-2494, DSN 272-2494.

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U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND
U.S. ARMY STRATEGIC COMMAND
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REPLY TO
ATTENTION OF

SMDC-ISS-N

November 09, 2012

MEMORANDUM FOR USSTRATCOM/J66

SUBJECT: AN/PSC-5C (RT-1672C(c)/U) INTEGRATED WAVEFORM CONDITIONAL TEST CERTIFCATION (WAIVER) RECOMMENDATION

1. References.

a. Joint Interoperability Test Command (JITC) Assessment 11-35047.6-8994, subject: Integrated Waveform (IW) Military Standard (MIL-STD) Conformance Assessment of the Raytheon AN/PSC-5C (RT-1672C(c)/U).

b. Integrated Waveform Project Office Memorandum, 02 May 2012, subject: Request for IW Certification Waiver for the AN/PSC-5C UHF SATCOM terminal.

c. CJCSI 6251.01C, Narrowband Satellite Communications Time Division Multiple Access Requirements, 15 August, 2009.

d. Memorandum of Understanding between the Joint Staff and the United States Strategic Command for Transfer of Functions and Associated Resources, 27 Sep 2011.

2. Background. JITC assessed the AN/PSC-5C (RT-1672C(c)/U) for full compliance with applicable Integrated Waveform (IW) MIL-STD requirements (ref 1a). Testing found that with one exception, all deviations (total of 23 deviations) were "non-critical," having minimal impact to operational usage. The one item identified as having a "major," but not "critical" deficiency relates to a subset of the phase shift keying (PSK) modulation options in which the terminal cannot successfully operate without exceeding the limits for how much radiated power a terminal can transmit outside of its channel. In consequence to JITC's test findings, the IW Project Office requested a MIL-STD waiver from USSTRATCOM/J66 to install, test, and operate the terminal (ref 1b). JITC noted in their assessment that this version of the AN/PSC-5C has legacy Demand Assigned Multiple Access (DAMA) operational capabilities. The legacy DAMA software component has not been tested for certification as part of the complete terminal system.

3. UHF C-SSE Evaluation. In accordance with provisions and precedents identified by ref 1c and 1d, the Military Ultra High Frequency (UHF) C-SSE evaluated DISA's waiver request.

a. The one item identified as having a "major," but not "critical" impact involves adjacent channel emissions (ACE) on an older modulation scheme. IW terminals use this modulation scheme when operating in "backwards-compatible" communications with legacy DAMA terminals. USASMDC/ARSTRAT does not foresee a requirement to use this mode during IW testing.

b. USASMDC/ARSTRAT considers all remaining deficiencies as minor in nature. While those failures may degrade user communications, no examples or evidence was noted of any potentially spurious transmissions, signal bleed, or other issues that could possibly impact non-IW users who would be using the satellite simultaneously during operation.

c. JITC noted that the Phase 2 IW PSC-5C & -5D software has not been assessed against legacy DAMA requirements. This IW / Legacy DAMA functionality must be tested before any final lifetime or more comprehensive waiver recommendation can be made.

4. Terminal Waiver Recommendation. The Military UHF C-SSE recommends granting an IW conditional waiver with the following conditions:

a. This terminal shall be used for IW testing purposes only to expire no later than September 2014.

b. This terminal shall not use the 3840 symbols per second (sps) PSK modulation option when interoperating with other IW terminals or for "backwards-compatible" communications with legacy DAMA terminals.

This recommendation may be cancelled or revoked at any time if it becomes apparent that the use of the terminal(s) creates a detrimental impact on other Narrowband users during IW operation. The UHF C-SSE office must be notified of any subsequent planned hardware/software upgrades or changes to the tested configuration of the terminal prior to actual implementation.

5. Point of Contact. Mr Kenneth Wright, Narrowband Engineering and Integration Section, Narrowband Branch, SATCOM Division, USASMDC/ARSTRAT G-6, DSN (312) 692-6274/CML (719) 554-6274, kenneth.c.wright30.civ@mail.mil .

11/9/2012

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IN REPLY REFER TO NSE13

02 May 2012

MEMORANDUM FOR USSTRATCOM J-66

SUBJECT: Request for IW Certification Waiver for the AN/PSC-5C UHF SATCOM terminal

Reference: Chairman of the Joint Chiefs of Staff Instruction 6251.01C

1. Purpose. The Integrated Waveform Project Office requests a Demand Assigned Multiple Access (DAMA) Certification Waiver for the Raytheon AN/PSC-5C Ultrahigh Frequency (UHF) Satellite Communications (SATCOM) terminal in accordance the relevant Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6251.01C. Testing by the Joint Interoperability Test Command (JITC) found that the AN/PSC-5C passes the testable requirements of all pertinent MIL-STDs, except for the following that are explained below.

2. Previously-waived Failures. All requirements failures described in the JITC Assessment Letter, with the exceptions of paragraphs 10b/c/d and 12a, 10i/j, and 10k/m are identically the same as issues that were reported previously as "non-critical" failures during the IW Phase I testing process, and which previously received lifetime waivers. Thus DISA reasonably requests that the Phase II terminal and software be granted the same waiver for these same failures, especially now that Phase I operation has further confirmed what was initially expected, i.e., that they have no adverse impacts.

3. Adjacent Channel Emissions (ACE) Failures. The non-conformance found in testing of the IW Phase II terminal about which JITC expresses the most concern is described in paragraphs 10b, 10c, 10d, and 12a of the JITC Assessment. Here the JITC determined a failure to meet requirements 23, 24, and 25 of MIL-STD-188-181C, and requirement 17 of MIL-STD-188-183B. Because of overlap between the various MIL-STDs and between multiple requirements within a single MIL-STD, these four failures all reduce to but a single terminal deficiency and failure to meet a single ACE requirement (Reqt. #24), namely, the narrowband ACE EIRP requirements when the output EIRP is less than 18dBW. Even here, the failures are found in only three of the PSK modulation options as shown in Table 1, which compiles the relevant JITC ACE results from the enclosures. Essentially, JITC found that in these specific cases, the AN/PSC-5C cannot possibly be operated without exceeding the limits in the pertinent MIL-STDs for how much radiated power a UHF terminal can transmit outside of its own channel. From Table 1 it is clear that only a subset of the modulation options used for narrowband multiple-access are

nonconforming (shaded). Furthermore, the MIL-STD requires ACE compliance at four "checkpoints" offset from the carrier frequency out to 20kHz, and the non-compliances only extend out to 10kHz from the center frequency. Now, the vast majority of UHF SATCOM narrowband channels are spaced 10kHz apart, so this failure cannot be dismissed outright, but to assess the impact one must first understand the precise nature of the ACE requirement that the AN/PSC-5C failed.

Table 1. JITC ACE Findings for Narrowband Multiple-Access

	Frequency Offset (Δf)			
Modulation (Coding)	±5 kHz	±10 kHz	±15 kHz	±20 kHz
2400sps CPM	Meets requirement			
3000sps CPM	Meets requirement			
3600sps CPM	Meets requirement			
4000sps CPM	Meets requirement			
4800sps CPM	Meets requirement			
3000sps SOQPSK (R=1/2)	Meets requirement			
3000sps SOQPSK (R=7/8)	Meets requirement			
3840sps SOQPSK (R=1/2)	Meets requirement			
3840sps SOQPSK (R=3/4)	Fails by 1.22 dBc	Fails by 1.78 dBc	Meets requirement	Meets requirement
3840sps SOQPSK (R=7/8)	Meets requirement	Fails by 0.58 dBc	Meets requirement	Meets requirement
3840sps SOQPSK	Meets requirement	Fails by 0.49 dBc	Meets requirement	Meets requirement

a. The MIL-STD requirements for ACE and the associated method JITC uses to test and report compliance are rather complicated. (Note: This complexity results mostly because the requirements are levied on EIRP, not simply power, and this means JITC must account for the gain of the antenna assembly, which makes compliance a function of the antenna being used.) But in short, there is both an absolute and a relative ACE requirement. The first is the most important in terms of performance impact on neighboring channels. It requires that transmitters keep their absolute amount of ACE EIRP below limits that prevent users on adjacent channels from being impacted in a adverse way. Focusing then only on the area of failures, i.e., narrowband PSK ACE at 5KHz and 10kHz offsets, Table I of MIL-STD-188-181C reflects the determination that, for the transponder sizes and modulations in question, these limits are 4dBW at 5kHz away from center, and –16dBW 10kHz away from center. No matter how much power a terminal has or how big its antenna, these are the physical limits that cannot be exceeded without beginning to affect other users/systems. Note that per the JITC assessment, the AN/PSC-5C does not fail the absolute part of this requirement. JITC only notes correctly that operational training and discipline is required to ensure that users know what power settings and antenna gains can be used without exceeding system ACE limits. But Table I of MIL-STD-188-181C also contains a second limit on the amount of transmitted EIRP ACE relative to the peak carrier power. This requirement ensures that vendors are not free to totally neglect ACE simply because the terminal is not being used at higher power

settings. The relative requirement stipulates that even at lower powers, i.e., any value less than +18dBW (or 63 Watts), the terminal must still keep its ACE EIRP to –14dB relative to the carrier power (dBc) at a 5kHz offset, and –34dBc at a 10kHz offset. It is this relative requirement that JITC failed for certain modulations as shown in Table 1.

b. JITC is doing its due diligence and correctly testing and reporting the requirements as written. But from the standpoint of operational impact, the terminal is in fact passing the requirement that matters most to the user in the adjacent channel, which is obviously the absolute requirement. It is of no importance to an operator whether the amount of interference from a neighbor is small relative to its maximum transmit power. What matters for performance is the absolute amount of energy entering the victim band. To see this, consider that the relative nature of the requirement means that even if the terminal is set to its lowest possible power output of 0.2W, it would still fail the requirement, although at power levels this low certainly no adverse impact to anyone would be possible. But the key point here is that even though JITC has determined a failure to meet the relative ACE requirement of (P_{max} – 14dB) at 5KHz and (P_{max} – 34dB) at 10kHz, respectively, because the maximum output power of the AN/PSC-5C is only +13dB, far less than the +18dB at which point the absolute requirements apply, this means that the terminal still has significant margin before it begins to exceed the requirements set on absolute ACE. This is illustrated in Figure 1, which shows the JITC data with the important context of comparing the relative numbers to the absolute ACE requirements. This makes it clear that even though three modulations exceed the relative limit at the 10kHz offset and one modulation exceeds the relative limit at the 5kHz offset, in every case, the ACE values are as much as 3–5 dB below the absolute limits at which point users on adjacent channels will begin to be impacted. This margin is important because the peak output power of the AN/PSC-5C is 3dB less than the minimum required EIRP of 16dB, and therefore an antenna of at least 3dB is needed to meet this requirement (see para. 10a of the JITC assessment letter). So, for example, the worst-case nonconforming modulation is 1.78dB above the allowed ACE limit at 10kHz. But setting the radio to its peak power of +13dBW, adding a 3dB antenna for +16dB EIRP should result in a 10kHz ACE of (+16 – 34 = –18dBW.) Yet, the additional 1.78 dB only takes the ACE to –16.22, which is still 0.22dB below the absolute MIL-STD limit of –16 dB. Note also that even these "absolute" limits were designed with built-in margin.

c. Consider further that IW terminals do not use these 3840 sps SOQPSK modulation options when inter-operating with other IW terminals. Rather, this is an older modulation that IW terminals use only when operating in "backwards-compatible" comms with legacy (DAMA) terminals that do not have the IW upgrade. Even then, these modulations are used only when the DAMA terminals are using a 5-kHz (narrowband) channel (all wideband, i.e., 25-kHz transmissions comply with ACE requirements). Also, the nonconforming modulations arise only in the case of multiple-access, i.e., the terminal is assigned to a timeslot and not an entire channel. Even in this case however, other PSK modulation options exist that are ACE-compliant and which could be used for the provisioning of networks that host both DAMA and IW terminals.

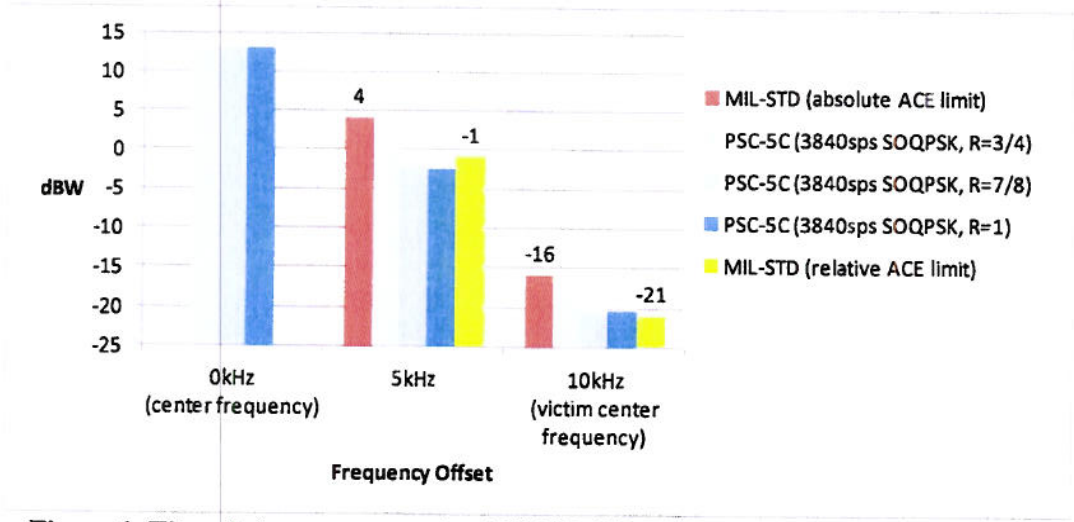

Figure 1. Though in some cases the AN/PSC-5C exceeds the relative ACE limits (yellow), it always keeps below the more critical absolute ACE limits (red).

d. Techniques do in fact exist that could meet this requirement with changes to the software to implement additional filtering. However, irrespective of the cost of development and testing spirals, these changes are not desirable anyways because such a filtered waveform, when it hits the non-linear UHF transponder, produces inter-modulation products on the downlink which results in a problem much worse than the initial nonconformance since these are less predictable as to where in the band they will occur. Thus, a "loophole" in the existing system requirements means that vendors who pass this requirement often must do so at the expense of other UHF MILSATCOM users. Note that the AN/PSC-5C passed these same ACE requirements when Phase I testing was performed in 2009. This, coupled with the fact that no changes to the relevant portions of the code were done when adding the Phase II update, means that the true reason for the failure this time is that the hardware is aging, and that therefore the only valid option for resolving this nonconformance is by making hardware modifications to the thousands of fielded radios, along with the corresponding testing and fielding costs. Note also that this supplies evidence against there being an adverse operational impact. That is, since the issue is hardware age, the currently-fielded AN/PSC-5Cs used in IW Phase I also have this same issue, yet there have been no known reports of any problems. In conclusion then, given that the scenario under which the ACE non-compliant modulations would even be used will occur only extremely rarely if ever (and even then the impact should be negligible if any), and given the significant cost and effort required to bring the terminal into compliance, DISA recommends that the nonconformance simply be accepted.

5. Phase Noise Failures. In paragraphs 10 i/j, JITC determined a failure to meet requirements 35 and 36 of MIL-STD-188-181C, which both pertain to requirements concerning phase noise, or the terminal's ability to accurately maintain the frequency and phase of transmitted signals within allowable limits.

a. According to the terminal vendor, this is simply the result of the radio hardware showing its age. Again, this is confirmed by the fact that the AN/PSC-5C passed the

same test in 2009 when it underwent Phase I testing. Moreover, to prove that this behavior was not introduced by software modifications made since then, note that the PSC-5D, which shares the same code as the AN/PSC-5C, did in fact meet this requirement in JITC testing.

b. The nature of this noncompliance makes it difficult to conceptualize, but to show that it has little if any impact, note that if the performance measured by JITC had adverse impact, it would have caused failures in other areas, such as the very accurate and stringent waveform structure tests. Yet, as the JITC assessment states, the "excessive phase noise did not significantly affect the transmitted signal or the terminal's ability to synchronize with other network terminals." DISA thus concurs with the JITC assessment that this results in a mere "minor" operational impact.

6. No Support for Option 16 Failures. In paragraphs 10k/m, JITC determined a failure to meet requirements 44 and 116 of MIL-STD-188-181C. Both of these trace to the fact that the AN/PSC-5C does not support mandatory modulation option 16, i.e., 6000bps CPM for single access operation.

a. This same failure was present in the AN/PSC-5C since Phase I, but unfortunately was not noticed by JITC at that time when it might have been more easily addressed. Rather, it was discovered so late in the development and testing cycle that it was deemed not prudent to take the risk of making the necessary alterations to core portions of the software in order to address a failure with such minimal operational impact.

b. DISA concurs with the JITC assessment that this causes a mere "minor" operational impact, but offers the following justification. For one thing, these impacts are minimal because this failure only affects single access (SA) operation, which, using Phase I experience as a guide, is rarely if ever used since multiple access (MA) operation is much more efficient and commonplace. Even then this limitation is only encountered when operating on 5kHz channels and when the desired data rate is 6000 bps. Even granting however that this exact scenario should occur, the only impact would be that without Option 16, planners would have to assign either Option 13, which provides superior BER performance, albeit at a slightly reduced data rate (4800bps), or Option 18, which provides 7200 bps, but per MIL-STD-188-181C needs 1.0 dB better link quality in order to maintain BER less than the 1E-5 threshold for data traffic. Note however that according to experimental data collected for DISA on a satellite simulator that is an exact replica of the filters of the UFO satellites, as shown in Figure 2, the AN/PSC-5C implementation of Option 18 out-performs the MIL-STD requirement for BER=1E-5 by about 0.8dB. Therefore, any user who would be assigned Option 16 for 6kbps data transfer can use Option 18 and receive a higher data rate with negligible performance impact (0.2 dB) to data transfers. From the figure it is clear that this translates to receiving about 1.5E-5 BER instead of the desired 1.0E-5. This is certainly on par with the BER deviations that have been granted waivers for this and other terminals, and demonstrates that Option 18 is a very adequate substitute for the missing Option 16.

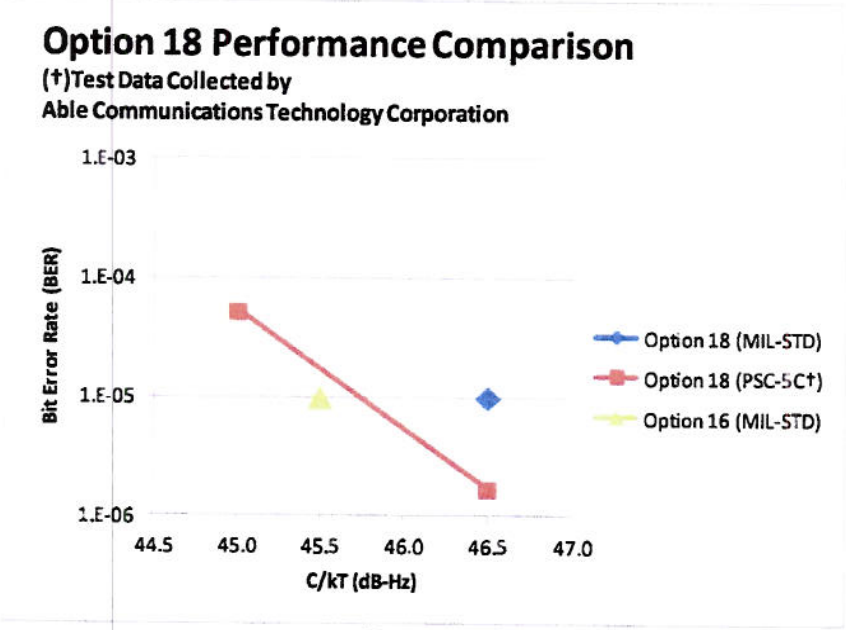

Figure 2

7. Conclusion. For these reasons then, DISA believes that all MIL-STD requirement failures reported by JITC are "non-critical" in their nature, and, in accordance with the Instruction, requests that this radio be granted a full certification waiver for the lifetime of the terminal.

Ronald E. Williams

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2 Enclosures:
JITC Assessment for AN/PSC-5C
JITC_Test_Data_for_ACE_Tests.xls

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