NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD

MILITARY AGENCY FOR STANDARDIZATION (MAS)
BUREAU MILITAIRE DE STANDARDISATION (BMS)
1110 BRUSSELS

Tel : 707.42.82

8 July 1999 MAS/873-C3/5065

STANAG 5065 C3 (EDITION 1) - MINIMUM STANDARDS FOR NAVAL LOW FREQUENCY (LF) SHORE-TO-SHIP SURFACE BROADCAST SYSTEMS

Reference:
ANCA/97/SEC/34 dated 14 March 1997 (Edition 1) (Ratification Draft 1)

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in page iii is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

3. AAP-4 should be amended to reflect the latest status of the STANAG.

ACTION BY NATIONAL STAFFS

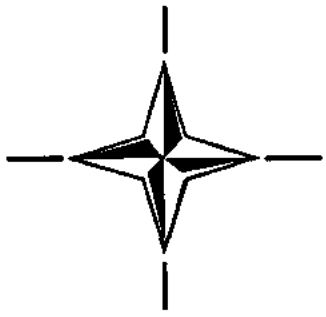
4. National staffs are requested to examine page iii of the STANAG and, if they have not already done so, advise the NHQC3S through their national delegation as appropriate of their intention regarding its ratification and implementation.

for A. GRØNHEIM
Major General, NOAF
Chairman MAS

Enclosure:
STANAG 5065 (Edition 1)

STANAG No. 5065
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)



MILITARY AGENCY FOR STANDARDIZATION
(MAS)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: MINIMUM STANDARDS FOR NAVAL LOW FREQUENCY (LF) SHORE-TO-SHIP SURFACE BROADCAST SYSTEMS

Promulgated on 8 July 1999

Col Lena Bekkum

A. GRØNHEIM
Major General, NOAF
Chairman, MAS

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "In NATO Standardization, the fulfilment by which a member nation formally accepts, with or without reservation, the content of a Standardization Agreement" (AAP-6).

5. Implementation is "In NATO Standardization, the fulfilment by a member nation of its obligations as specified in a Standardization Agreement" (AAP-6).

6. Reservation is "In NATO Standardization, the stated qualification by a member nation that describes the part of a Standardization Agreement that it will not implement or will implement only with limitations" (AAP-6).

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page iii gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page iv (and subsequent) gives details of reservations and proprietary rights that have been stated.

FEEDBACK

8. Any comments concerning this publication should be directed to NATO/MAS - Bvd Leopold III - 1110 Brussels - BE

NATO STANDARDIZATION AGREEMENT

Minimum Standards for Naval Low Frequency (LF) Shore-to-Ship Surface Broadcast Systems

ANNEXES

A. Terms and Definitions
B. Mimimum Standards for Naval LF Broadcast Transmitting (Shore Station) and Receiving (Ship Station) Systems
C. Baseband Processing and Channelization
D. Baseband Description of MSK (for information only)

RELATED DOCUMENTS

STANAG 4481 Minimum Technical Equipment Standards for Naval HF Shore-to-Ship Broadcast Systems

STANAG 5031 Minimum Standards for Naval HF, MF, and LF Shore-to-ship Broadcast Systems

ACP 167 Glossary of Communications-Electronics Terms

CCIR 329-6 Spurious Emissions part III.

INTRODUCTION

AIM

1. The aim of this agreement is to define the minimum technical standards required for Naval shore-to-ship surface broadcast (shore transmitting and ship receiving) equipment that will permit interoperable communication using LF transmission and appropriate baseband modulation/demodulation techniques.

AGREEMENT

2. Participating nations agree to introduce equipment for naval shore-to-ship broadcasts to meet the minimum standards set out in the Annexes B and C, stating which of the baseband modulation techniques they will adopt for transmission.

IMPLEMENTATION

3. The STANAG is considered to be implemented when a Nation's Naval shore-to-ship broadcasts meet the minimum standards set out in Annexes B and C and appropriate receiving equipment has been installed in ships.

ANNEX A to
STANAG 5065
(Edition 1)

TERMS AND DEFINITIONS

Bandwidth, occupied

The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage B/2 of the total mean power of a given emission. Unless otherwise specified by the CCIR for the appropriate class of emission, the value of B/2 should be taken to be 0.5 percent.

Bandwidth, necessary

For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under the specified conditions.

Broadcast

A method of transmitting messages wherein no acknowlegement for the message is required.

Carrier

An oscillator or wave, usually periodic, some characterstic of which is intended to be constrained by modulation to follow the variations of a signal or of other oscillation.

Frequency, display

The frequency indicated on the dial settings of RF equipment.

Fibonacci bits

Deterministic unencrypted bits used by the KW-46 cryptographic equipment to provide synchronization defined by the polynomial $y_o = x_{31} + x_3 + 1$.

Low frequency (LF)

For the purposes of this STANAG, LF is defined to be the frequency band from 50 kHz to 160 kHz.

Mark

A condition of the modulated signal corresponding to a binary 1 (condition Z).

Radio teletype (RATT)

The system of communication by teletypewriter over radio circuits. This term is used in this STANAG to describe any system which provides message based communication using the ITA No. 2 alphabet.

Space

A condition of the modulated signal corresponding to a binary 0 (condition A).

Telegraphy

A form of telecommunications which is concerned [sic] in any process providing transmission and reproduction at a distance of documentary matter, such as written or printed matter or fixed images or the reproduction at a distance of any find of information in such a form. Unless otherwise stated, telegraphy shall mean a form of telecommunicaiton for the transmission of written matter by the use of a signal code.

v_d

Ratio of RMS to mean absolute value of atmospheric noise in dB.

Wagner code

An error coding scheme that utilizes a single parity bit per block of N information bits. This code is intended to be decoded with a "soft decision" demodulation process: if a received codeword does not pass the parity check, the least reliable bit is inverted. The size of the Wagner code word is designated by a (N+1, N) prefix.

MINIMUM STANDARDS FOR NAVAL LF SURFACE BROADCAST TRANSMITTING (SHORE STATION) AND RECEIVING (SHIP STATION) SYSTEMS

FREQUENCY RANGE

1. Designated ranges in the LF band from 50 kHz - 160 kHz.

TUNING

2.(a) Transmitter and receiver equipment shall tune to integral multiples of 10 Hz, starting at 50 kHz.

(b) The frequency of the carrier shall be the reference frequency ($\omega_o = 2\pi f_o$) as designated in Annex C, paragraph 3.

FREQUENCY TOLERANCE

3.(a) The radio frequency carrier shall have an absolute accuracy of 10^{-7}. The accuracy means that at any instant, the carrier shall be within 10^{-7} of the specified value. The radio frequency carrier shall have a stability of 10^{-8} or better over a period of one day.

(b) When FSK modulation is used, the frequency of the generated FSK tones shall be within +/- 1 Hz of the frequency specified in Annex C.

RF BANDWIDTH

4.(a) The transmitter system (transmitter, aerial tuning unit and aerial) shall have a minimum 3 dB response bandwidth of 180 Hz at 50 kHz for 300 bps MSK operation. For use with 75 bps FSK, the 3 dB bandwidth of the transmitter system shall be a minimum of 150 Hz.

(b) The amplitude response of the transmitter system including the antenna shall be linear +/- 1.0 dB over +/- 90 Hz centred on the carrier frequency.

5. Phase linearity. Deviation in phase response in the complete LF transmitter complex (including the antenna) shall not exceed 13° from the linear over +/- 90 Hz about the reference frequency.

6. Phase stability. The phase jitter of all radio frequencies shall not be greater than +/- 1.0 degree in a 200 Hz bandwidth when averaged over one hundred 20 ms sample periods.

7. Spurious Emissions. Spurious emissions from the transmitter shall be in accordance with CCIR 329-6 Spurious Emissions part III.

EMISSION CHARACTERISTICS

8. Emission characterstics are shown in Table B-1. For FSK emissions, the occupied bandwidth shall be within the limits established by the Radio Regulations of the ITU. For 300 bps MSK, the occupied bandwidth is 360 Hz (measured).

Table B-1. Emission Characteristics

Description	Designation	Occupied Bandwidth	Description
Single Channel RATT MSK (300 bps)	180HG1BCN	360 Hz	Minimum shift keying; telegraphy
Single Channel RATT FSK (75 bps)	177HJ2BBN	235 Hz	Frequency modulation; telegraphy

MODULATION

9. LF transmitters shall provide the emissions as given at Table B-1. LF receivers shall be compatible with 300 bps MSK and 75 bps FSK as defined in Annex C of this STANAG.

BASEBAND INTERFACE CHARACTERISTICS

10. If a baseband (audio) interface to an external demodulator is used, it shall have the following characteristics:

(a). The baseband audio signal output shall be centred on 975 Hz.

(b) The variation in audio frequency output amplitude of the receiver over the range 800 Hz to 1200 Hz shall be within +/- 1 dB of the response at 975 Hz.

(c) Differential Delay Distortion. The maximum differential envelope (group) delay distortion over 80% of the band from 800 Hz to 1200 Hz must not vary by more than 0.5 ms.

RECEIVE SYSTEM PERFORMANCE REQUIREMENTS

11. The minimum signal-to-noise performance of the receive system for a character error rate of 10^{-3} (including KWR-46) shall be as specified in Table B-2.

Table B-2. Receive System Performance Requirements

Modulation (data rate)	Required SNR (dB)*	Required SNR (dB)**
MSK (300 bps)	- 7.0	+ 5.0
FSK (75 bps)	+ 4.0	+ 5.0

* Noise is atmospheric with v_d = 10 dB measured in 1000 Hz bandwidth.
** Noise is Gaussian measured in 1000 Hz bandwidth.

BASEBAND PROCESSING AND MODULATION

OVERVIEW

1. LF transmit equipment conforming to this STANAG may be used to transmit information at 300 bps using MSK modulation and the baseband processing described below. LF receive equipment conforming to this standard will be able to receive 300 bps MSK and 75 bps uncoded FSK as described below. The 75 bps FSK capability is required for backward interoperability with existing LF broadcast transmissions until they are upgraded to the 300 bps MSK.

SINGLE CHANNEL USING FSK MODULATION

2. Single channel RATT employing 75 bps FSK (J2B) shall use two sinusoids of different frequencies to distinguish between a MARK and a SPACE. The frequency shifts shall be +/- 42.5 Hz centred about the carrier frequency. The upper frequency shift shall represent a SPACE.

SINGLE CHANNEL USING MSK MODULATION

3. MSK is a form of phase shift keying. This modulation technique will allow transmission of 1.6 bits per Hz of radio frequency bandwidth as defined at the 3 dB points. The transmitted signal shall appear as a phase-continuous frequency-shift-keyed signal of constant amplitude. The frequency shift shall be +/- 75 Hz and shall occur at the bit rate. This corresponds to a modulation index (m) of 1/2. The intelligence (mark or space) is contained in the phase shifts and is not consistent with the frequency shifts. The intelligence shall be related to the phase shifts in the following manner. Two subchannels of binary data, $b_o(t)$ and $b_e(t)$, which are formed from alternate bits from the input data sequence b(t) as shown in figure C-1, shall modulate the phase of two sinusoidally weighted components of the reference signal in accordance with the following expression:

$$\upsilon_{MSK}(t) = A\, b_e(t)\sin(\omega_o t)\cos(\omega_f t) + A b_o(t)\cos(\omega_o t)\sin(\omega_f t)$$

where

A is the constant amplitude of the MSK signal

ω_o is the angular frequency of the reference signal (carrier frequency), which must be an integral multiple of 1/4 of the data rate - that is, $\omega_o = m\pi 150$, with m an integer.

ω_f is the angular frequency of the sinusoidal weighting functions and is equal to $\pi/2T$

$b_o(t)$ and $b_e(t)$ shall each be at 150 bps (half the input data rate). Bit period boundaries for $b_o(t)$ shall be at the zero crossings of $\cos(\omega_f t)$ and bit period boundaries for $b_e(t)$ shall be at zero crossings of $\sin(\omega_f t)$.

T is equal to the bit period of the input binary data

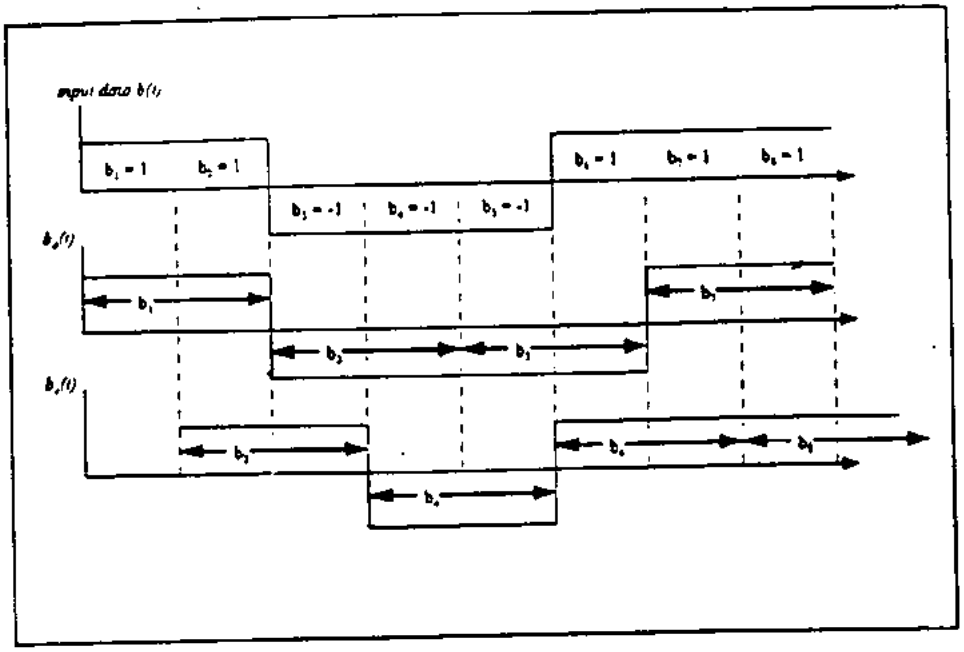


Figure C-1. Relationship of $b_o(t)$ and $b_e(t)$ to input bit sequence

BASEBAND PROCESSING

The following baseband processing is defined for the LF broadcast using the 7.0-unit START-STOP ITA No. 2 (Baudot) code as shown in Table C-1.

4. Encryption and decryption shall be provided by KW-46 interoperable cryptographic equipment. The equipment shall be operated in the 6.0 Stepped Digital mode.

5. In MSK mode, when provided with the encrypted data from the KWT-46 equipment, the LF transmit site shall encode encrypted data into a (13,12) Wagner code described in section 8. The encrypted and encoded data shall then be applied to the MSK modulator as described in section 3.

6. The coding of the message input into the KW-46 equipment shall be coded in the 7.0 unit START-STOP ITA No. 2 alphabet as shown in Table C-1.

7. Encryption by the KWT-46 equipment operating in the 6.0 Stepped Digital mode will result in bits 1 through 6 being encrypted and bit 7 (STOP) being replaced with an unencrypted and deterministic Fibonacci bit. This form is shown in Figure C-2 (b).

8. The encoding of channel bits for LF transmission at 300 bps MSK shall include blocking the information into two character groups, substituting a parity bit for every second Fibonacci bit to form a (13,12) Wagner odd parity code block (odd number of 1s) over the information bits (Fibonacci bit excluded). The resulting form is shown in Figure C-2 (c).

9. Pre-decryption processing of the received MSK signal includes performing error correction (using the Wagner code) and replacing the parity bit with the proper Fibonacci bit so that the signal applied to the receiving KWR-46 equipment is in the same form as that generated by the transmit KWT-46 equipment.

10. Decryption by the KWR-46 equipment results in the clear text message in 7.0 unit START-STOP ITA No. 2 code as shown in Figure C-2. A block diagram of the overall conversion, encryption, and Wagner codec processes is also shown in Figure C-2.

11. Baseband processing for 75 bps FSK operation shall not include Wagner encoding and decoding.

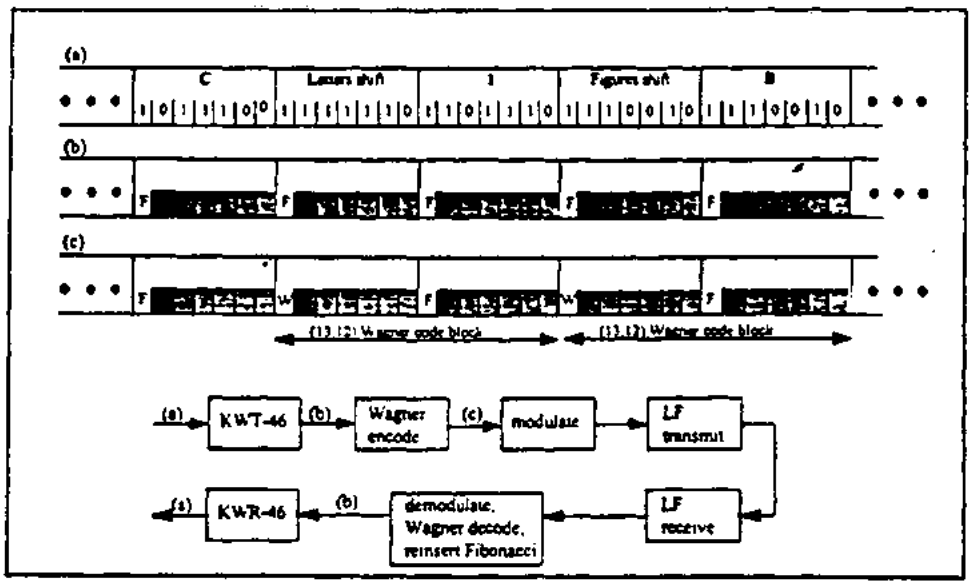


Figure C-2. Baseband Processing and Modulation for 300 bps MSK Operation

Notes:
1. F = Fibonacci bit
2. W = Wagner parity check bit
3. Shading represents encrypted data
4. The bit sequence shown at (c) is the input bit sequence to the 300 bps MSK modulator

Table C-1. 7.0 Unit START-STOP ITA No. 2

Bit Numbers 7 6 5 4 3 2 1	Letters case	Figures case
1 0 0 0 0 0 0	[No action]	[No action]
1 0 0 0 0 1 0	E	3
1 0 0 0 1 0 0	[Line feed]	[Line feed]
1 0 0 0 1 1 0	A	-
1 0 0 1 0 0 0	[Space]	[Space]
1 0 0 1 0 1 0	S	[apostrophe]
1 0 0 1 1 0 0	I	8
1 0 0 1 1 1 0	U	7
1 0 1 0 0 0 0	[Carriage return]	[Carriage return]
1 0 1 0 0 1 0	D	[WRU]
1 0 1 0 1 0 0	R	4
1 0 1 0 1 1 0	J	[Audible signal - bell]
1 0 1 1 0 0 0	N	, [comma]
1 0 1 1 0 1 0	F	[Unassigned]
1 0 1 1 1 0 0	C	:
1 0 1 1 1 1 0	K	(
1 1 0 0 0 0 0	T	5
1 1 0 0 0 1 0	Z	+
1 1 0 0 1 0 0	L	)
1 1 0 0 1 1 0	W	2
1 1 0 1 0 0 0	H	[Unassigned]
1 1 0 1 0 1 0	Y	6
1 1 0 1 1 0 0	P	0
1 1 0 1 1 1 0	Q	1
1 1 1 0 0 0 0	O	9
1 1 1 0 0 1 0	B	?
1 1 1 0 1 0 0	G	[Unassigned]
1 1 1 0 1 1 0	[Figures]	[Figures]
1 1 1 1 0 0 0	M	. [period]
1 1 1 1 0 1 0	X	/
1 1 1 1 1 0 0	V	=
1 1 1 1 1 1 0	[Letters]	[Letters]

Notes:
1. Transmission order is bit 1 first - bit 7 last.
2. Bit 1 is a START bit and shall be a 0 (space).
3. Bit 7 is a STOP bit and shall be a 1 (mark).
4. Explanatory or descriptive (non-printing) entries in the table are shown in [brackets].

ANNEX D to
STANAG 5065
(Edition 1)

BASEBAND DESCRIPTION OF MSK
(for information only)

This Annex is provided to clarify implementation of LF receivers and MSK demodulators with baseband interfaces (as described in Annex B, part 10 of this STANAG).

The MSK waveform has been described in Annex C as a form of phase shift keying, produced by direct modulation of an RF carrier. The same waveform can be described in a different way, which is also interoperable. This annex will describe MSK as an FSK waveform[1]; the FSK description will then be used to further explain the signal that is required at baseband interfaces to radio equipment(as described in Annex B, part 10 of this STANAG).

The FSK description of the MSK waveform is:

$$\upsilon_{MSK}(t) = A\left[\frac{b_o(t)+b_e(t)}{2}\right]\sin(\omega_o+\Omega)t + A\left[\frac{b_o(t)-b_e(t)}{2}\right]\sin(\omega_o-\Omega)t$$

where

$$\Omega = \frac{2\pi}{4T_b} = 2\pi\left(\frac{f_b}{4}\right)$$

f_b = 300 bps; $T_b = 1/f_b$

and $b_o(t)$ and $b_e(t)$ are shown in relation to the input bit stream $b(t)$ in figure C-1. Thus, depending on the value of bits b_o and b_e in each bit interval, the transmitted signal is at angular frequency $\omega_H = (\omega_o + \Omega)$ or $\omega_L = (\omega_o - \Omega)$ as in FSK and the amplitude is constant.

The two frequencies $f_H = \omega_H/2\pi$ and $f_L = \omega_L/2\pi$ are chosen such that the two possible signals are orthogonal over the bit interval T_b. This results in a subcarrier frequency f_o that is an integral multiple of $f_b/4$, or 75 Hz.

For the baseband interface to LF radio equipment receiving the 300 bps MSK broadcast, f_H, f_L and f_o shall be:

f_H = 1050 Hz, f_L = 900 Hz, and f_o = 975 Hz.

This is equivalent to a sideband receiver with an carrier offset 975 Hz from the occupied or assigned frequency.

---

[1] The figures, description, and discussion of MSK are from Taub and Schilling, "Principles of Communication Systems", 1986, McGraw Hill

RATIFICATION AND IMPLEMENTATION DETAILS
STADE DE RATIFICATION ET DE MISE EN APPLICATION

NATION	NATIONAL RATIFICATION REFERENCE DE LA RATIFICATION NATIONALE	NATIONAL IMPLEMENTING DOCUMENT/ DOCUMENT NATIONAL DE MISE EN APPLICATION	IMPLEMENTATION/MISE EN APPLICATION					
			INTENDED DATE OF IMPLEMENTATION/ DATE PREVUE POUR MISE EN APPLICATION			DATE IMPLEMENTATION WAS ACHIEVED/ DATE REELLE DE MISE EN APPLICATION		
			NAVY MER	ARMY TERRE	AIR	NAVY MER	ARMY TERRE	AIR
BE	ZSP/OTAN 96.1822 dtd 29/07/96	No implementation Pas d'application						
CA	2441-5065(DNR 6-2) dtd 17/06/97	STANAG 5065	2000 /2001					
DA	MA204.69-S5065/MAM3-12495 dtd 30/05/97	STANAG	2002 +					
FR								
GE	BWB-ATIII4-AZ03-51-60/5065 dtd 30/06/98	STANAG	+ 4	+ 4	+ 4			
GR	060.5020/1/97 dtd 20/01/97	STANAG 5065	01/06 /97			01/09 /98		
IT								
LU								
NL	NATO/21569-043/97 dtd 14/10/97					TBD +		
NO	MAS-104/97 dtd 29/05/97	STANAG 5065	TBD					
PO								
SP								
TU								
UK	D/DPol(ICS)28/15/43/4 dtd 17/07/97	Self-imple-menting	N/A	1998	1998	N/A	1998	1998
US								

* See reservations overleaf/Voir réserves au verso
\+ See comments overleaf/Voir commentaires au verso
X Service(s) implementing/Armées mettant en application

STANAG 5065
(Edition 1)

COMMENTS

DENMARK: Intended date of implementation is depending on the approval of BRASS CP.

NETHERLANDS
1. This STANAG will only be implemented by the RNL NAVY.
2. There are no LF-BCST stations in The Netherlands. The STANAG will be applicable on board Dutch-frigates, submarines, a submarine support ship, AOR's and the Amphibious Transport Ship.

NORWAY
1. Norway is suggesting that Receiving Performance Requirements in Annex B stated as minimum signal to noise ration (SNR) requirements in terms of character error rates also should be stated in minimum E_b/N_o versus bit error rates and in minimum SNR versus bit error rates.
2. Implementation depending on modification on LF-antenna.

COMMENTAIRES

DANEMARK La date prévue pour la mise en application est fonction de l'approbation du PC BRASS.

PAYS-BAS
1. Ce STANAG sera mis en application par la RNL NAVY seulement.
2. Il n'y a pas de station LF-BCST aux Pays-Bas. Le STANAG sera d'application à bord des frégates hollandaises, des sous-marins, du bateau d'appui au sous-marin, du bateau AOR et du bateau de transport amphibie.

NORVEGE
1. La Norvège suggère que les performances requises à la réception, reprises dans l'annexe B comme un rapport signal bruit minimum en fonction du taux de caractères erronés, devraient aussi être exprimées par un rapport minimum Eb/No en taux d'erreurs binaires et par un rapport signal bruit minimum en taux d'erreurs binaires.
2. La mise en application est fonction des modifications de l'antenne LF.