GROUND ROUTING PROTOCOL FOR USE WITH AUTOMATIC LINK ESTABLISHMENT (ALE) CAPABLE HF RADIOS

ACP193

July 2002

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FOREWORD

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2. ACP193 is effective on receipt for CCEB Nations and when by the NATO Military Committee (NAMILCOM) for NATO Nations and Strategic Commands.

EFFECTIVE STATUS

Publication	Effective for	Date	Authority
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3. All proposed amendments to the publication are to be forwarded to the national coordinating authorities of the CCEB or NAMILCOM.

For the CCEB Principals

[Original Signed]
N. CRAM
Squadron Leader
Permanent Secretary to CCEB

RECORD OF MESSAGE CORRECTIONS

Identification of Message Corrections and Date, Time Group		Date Entered	By whom entered
Msg Corr	**DTG**		

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CHAPTER 1

INTRODUCTION

101. Purpose

(a) This publication defines a text message format for use with automated HF (high frequency, i.e. 1.6-30 MHz) communication systems when automated routing of communication links over ground networks is required. The formatted routing message shall be known as the HF ground routing protocol (HF-GRP).

(b) The HF-GRP is transmitted by mobile HF radio users over HF radio channels to a HF ground station, which is equipped to handle the protocol and automatically perform the specified ground routing function to provide connectivity to a ground-based user. The HF-GRP is designed for direct use with Automatic Link Establishment (ALE) systems and is ideally suited to routing voice communications.

(c) The overall concept is shown in Figure 1-1.

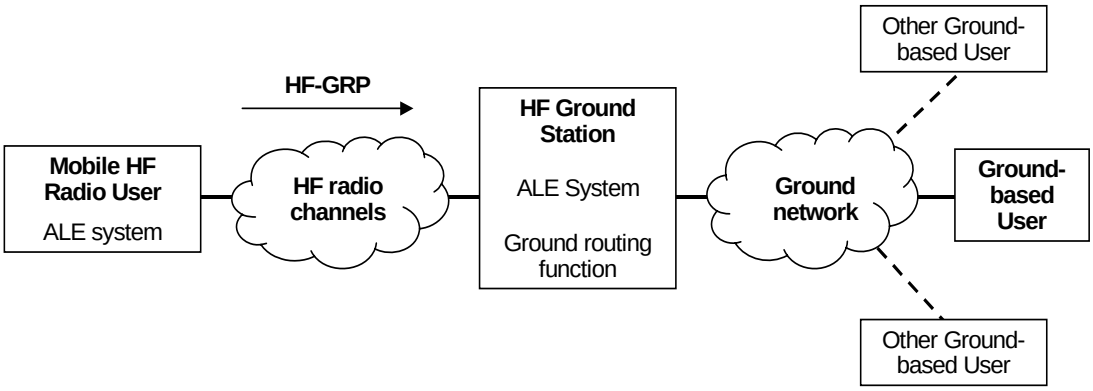

Figure 1-1 Ground Routing Concept

(d) When used in conjunction with radio systems employing Mil-Std-188-141B Appendix A ALE (MS-ALE) [1] the HF-GRP shall be conveyed over radio links using the MS-ALE Automatic Message Display (AMD) function.

102. Scope

(a) The scope of this publication is to specify the requirements to ensure over-the-air interoperability of ground routing requests. The implementation of the routing process at a ground station is not specified in this publication.

(b) Other routing mechanisms may be used in addition or as alternatives to HF-GRP (e.g. to provide advanced data routing functionality).

(c) The information contained within this publication is non-proprietary.

103. Background

(a) Military HF communication systems are being progressively upgraded, and the introduction of new technologies, are delivering much improved capabilities. In relation to the automation of channel selection and link set up procedures, systems are being procured which incorporate MS-ALE. This provides interoperable HF radio link establishment protocols and waveforms to allow radios, which are configured to a common set of operating parameters to automatically negotiate a channel for communications when required by an operator.

(b) When a communications circuit is established from a mobile to a HF ground station there may be the need to extend the link via a ground network (e.g. PSTN landline or similar telecommunications infrastructure) to another connected location. This can be achieved for voice calls via a manual 'phone patch' which is set up by an operator at the receiving HF ground station and routed to a telephone handset at the connected location. Either the mobile radio operator or the telephone user can request this type of circuit. Alongside the automation of the process to establish the radio link, it is desirable to also automate and enhance this process of setting up a phone patch.

(c) This publication defines an interoperable HF ground routing protocol (the HF-GRP) which is to be used over HF radio links to specify the intended destination of a link, which is to be routed from a HF ground radio station via land-line. The protocol takes the form of a formatted text message, which can be conveyed using MS-ALE.

104. Functionality

(a) The HF-GRP defined in this publication provides the following overall functionality:

(1) Provision of an over-the-air protocol (message format) to enable end-to-end automated connectivity from a MS-ALE equipped mobile HF radio user to a user connected to a ground network, via a compatible HF ground radio station.

(b) The detailed functionality is as follows :

(1) Incorporation of message identifiers to distinguish a HF-GRP message from other text messages.

(2) Incorporation of a call dial code, which specifies the required routing destination for a call.

(3) Provision of a call precedence capability.

(4) Allowance for a hand-off traffic service, which may be clear voice, or a data based service.

(5) Provision of mitigation against connection errors and unauthorised access.

(6) Compatibility with mobile HF radios which are compliant with MS-ALE.

(7) Interoperability with the pre-established US Scope Command HF ground routing protocol.

(8) Compatibility with the next generation of ALE systems, which will supersede MS-ALE.

(c) The HF-GRP is used to convey an automated ground routing request from a mobile HF radio user to a compatible HF ground station. The identification of the mobile HF radio user and HF ground station is specified by the user addresses in the associated ALE protocol.

(d) The HF-GRP is not required when establishing a connection from a ground-based user to a mobile HF radio user via a HF ground station. In this case the ground-based user is self-identifying as the initiator of the call, and the mobile radio is identified by the ALE protocol. There is a requirement for a means to enable the ground-based user to indicate to the HF ground station which mobile contact is requested (e.g. via a telephone keypad). The appropriate functionality to support this must be provided at the ground station and is not described in this publication.

CHAPTER 2

DEFINITION

201. Specification of the HF-GRP

(a) A valid HF-GRP message is composed of characters taken from Table 2-1 (plus the comma (‘,’) character if required) to fill message fields according to the following rules and summarised in Figure 2-1.

(1) Field 1

(a) Field name = ‘Call Identifier’.

(b) Size = 4 characters.

(c) Content = ‘CCCC’.

(d) Purpose = Indicates the start of a HF-GRP message.

(2) Field 2

(a) Field name = ‘Call Type’.

(b) Size = 1 character.

(c) Content = ‘P’ or ‘D’ or ‘V’ or ‘W’.

(d) Purpose = Indicates how the ‘Call Dial Code’ field should be interpreted.

(e) Description = ‘D’ specifies a ‘Direct dial call’, ‘P’ specifies a ‘Programmed dial call’, ‘W’ specifies a ‘Self-verified direct dial call’, ‘V’ specifies a ‘Self-verified programmed dial call’.

(3) Field 3

(a) Field name = ‘Call Precedence’.

(b) Size = 0 or 1 character.

(c) Content = ‘P’ or ‘I’ or ‘F’.

(d) Purpose = Used in a ‘Direct dial call’ and a ‘Self-verified direct dial call’ to indicate the precedence associated with the call. Not used in a ‘Programmed dial call’ or a ‘Self-verified programmed dial call’ (i.e. no character present).

(e) Description = In ascending order of precedence: absence of a call precedence character specifies a ‘Routine call’ (the default case), ‘P’ specifies a ‘Priority call’, ‘I’ specifies an ‘Immediate call’, and ‘F’ specifies a ‘Flash call’. See paragraph 203 for further details.

(4) Field 4

(a) Field name = ‘Call Dial Code’.

(b) Size = Between 3 and 25 characters.

(c) Content = User specified characters. Valid characters are limited to those listed in Table 2-1 (plus the comma (‘,’) character).

(d) Purpose = Indicates the required routing destination for the call.

(e) Description = In a ‘Direct dial call’ and a ‘Self-verified direct dial call’ this field contains three or more numerical characters (digits) which are directly interpreted as a routing dial number at the HF ground station. In a ‘Programmed dial call’ and a ‘Self-verified programmed dial call’ this field contains three or more alphanumeric characters that form a programmed routing code which is translated to a routing dial number at the HF ground station. There is also a special ‘hybrid’ version of the ‘Programmed dial call’ and ‘Self-verified programmed dial call’, which includes the flexibility of the direct dial versions. This concatenates an alphanumeric programmed routing code and direct dial digits. See paragraph 204 for further details.

Use of the comma (‘,’) character within this field for ‘hybrid’ and both direct dial call types is reserved for the specification of a two second pause before or between direct dial digits when the HF ground station is dialling into the ground network. It is included in this specification to ensure compatibility with certain old-style telephone exchanges.

(5) Field 5

(a) Field name = ‘Call Verification’.

(b) Size = 0 or 1 character.

(c) Content = Determined by other message fields. A valid character is limited to those listed in Table 2-1.

(d) Purpose = Used in a ‘Self-verified direct dial call’ and a ‘Self-verified programmed dial call’ to detect uncorrected transmission errors which have resulted in corrupted characters in fields 2, 3 or 4.

(e) Description = In a ‘Self-verified direct dial call’ or a ‘Self-verified programmed dial call’ this field contains a checksum character which is calculated from the contents of fields 2, 3 and 4. In a ‘Direct dial call’ and a ‘Programmed dial call’ this field does not contain a character and is not used. See paragraph 205 for further details.

(6) Field 6

(a) Field name = ‘Call EOM’.

(b) Size = 4 characters.

(c) Content = ‘NNNN’

(d) Purpose = Indicates the end of a HF-GRP message (End Of Message).

(b) Table 2-1 defines the valid HF-GRP character set.

Character	Decimal	**Character**	Decimal	**Character**	Decimal
?	0	**B**	12	**N**	24
1	1	**C**	13	**O**	25
2	2	**D**	14	**P**	26
3	3	**E**	15	**Q**	27
4	4	**F**	16	**R**	28
5	5	**G**	17	**S**	29
6	6	**H**	18	**T**	30
7	7	**I**	19	**U**	31
8	8	**J**	20	**V**	32
9	9	**K**	21	**W**	33
0	10	**L**	22	**X**	34
A	11	**M**	23	**Y**	35
				Z	36

Table 2-1 Valid Characters for HF-GRP Messages

(c) Notes on Table 2-1:

(1) This table contains a subset of characters from the expanded 64 ASCII subset, that is used for MS-ALE AMD messages.

(2) Though not included in Table 2-1 the ‘,’ (comma) character may also be entered in field 4 to specify a two second pause during a dialling sequence.

(d) Figure 2-1 shows a summary of the HF-GRP message format.

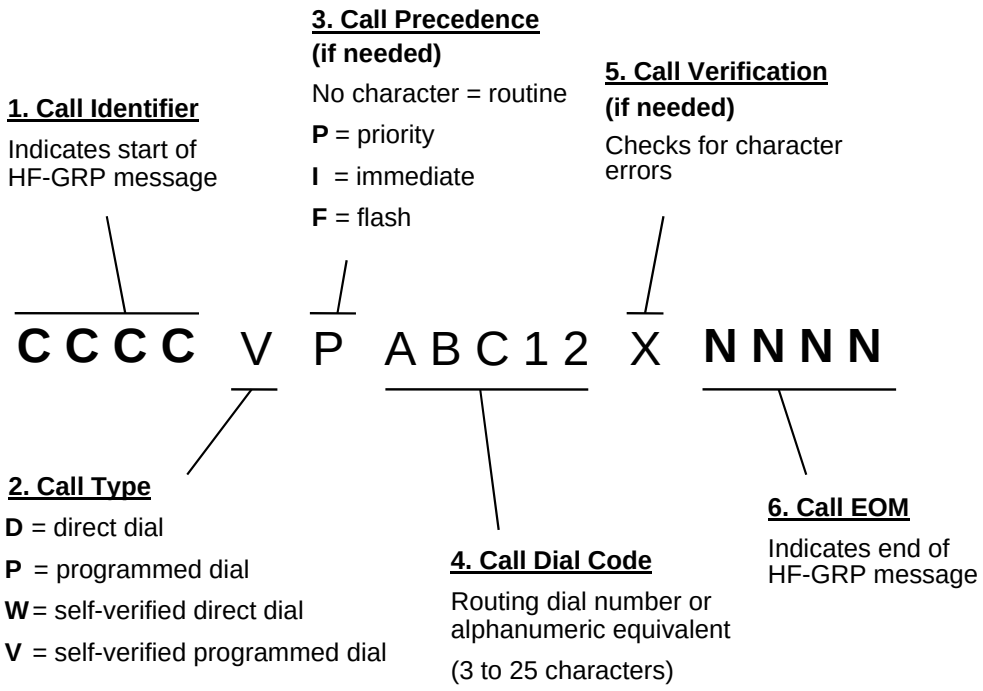

Figure 2-1 Summary Format of HF-GRP Messages

(e) Notes on Figure 2-1:

(1) The characters shown entered in fields 2 to 5 are examples.

(2) There are no spaces in HF-GRP messages (spaces are added here to aid readability).

(3) Field 3 will be omitted (no character) for routine precedence messages and for ‘P’ and ‘V’ call types.

(4) The characters in field 4 are restricted to those specified in Table 2-1 (plus the ‘,’ (comma) character).

(5) Field 5 will be omitted (no character) for ‘D’ and ‘P’ call types.

202. Example HF-GRP Messages

(a) Direct dial call. The first example message (1) specifies a ‘Routine call’ to ‘904563472’. The second example message (2) specifies a ‘Priority call’ to ‘904563895’.

(1) **CCCCD904563472NNNN**

(2) **CCCCDP904563895NNNN**

(b) Programmed dial call. The example message (3) specifies a call to ‘AB1’. The code ‘AB1’ will be translated to a routing dial number via a lookup table at the receiving HF ground station.

(3) **CCCCPAB1NNNN**

(c) Programmed dial call – Hybrid version. The example message (4) specifies a call to ‘904563472’ preceded by the additional dial digits held at the ‘AB2’ lookup table position stored at the receiving HF ground station. E.g. if the ‘AB2’ lookup table position held ‘0044’ then the full code dialled by the receiving HF ground station would be ‘0044904563472’.

(4) **CCCCPAB2904563472NNNN**

(d) Self-verified direct dial call. The first example message (5) specifies a ‘Routine call’ to ‘904563472’. The call verification character ‘9’ will be used to check for character errors after reception at the HF ground station. The second example message (6) specifies a ‘Priority call’ to ‘904563895’. The call verification character ‘7’ will be used to check for character errors after reception at the HF ground station.

(5) **CCCCW9045634729NNNN**

(6) **CCCCWP9045638957NNNN**

(e) Self-verified programmed dial call. The example message (7) specifies a call to ‘UKSIG2’. The call verification character ‘3’ will be used to check for character errors after reception at the HF ground station. The code ‘UKSIG2’ will be translated to a routing dial number via a lookup table at the receiving HF ground station.

(7) **CCCCVUKSIG23NNNN**

(f) Self-verified Programmed dial call – Hybrid version. The example message (8) specifies a call to ‘8017842’ preceded by the additional digits held at the ‘UK2’ lookup table position stored at the receiving HF ground station. For example, if the ‘UK2’ lookup table position held ‘123’ then the full code dialled by the receiving HF ground station would be ‘1238017842’. The call verification character ‘E’ will be used to check for character errors after reception at the HF ground station. Inclusion of the ‘,’ (comma) character in field 4 specifies a two second pause in the dialling between the ‘8’ and the remaining digits.

(8) **CCCCVUK28,017842ENNNN**

203. Call Precedence

(a) The urgency associated with a call, is attributed by the user using the ‘Call Precedence’ (field 3) indicator within the HF-GRP message. The order of precedence is defined as follows.

(1) No character specifies a ‘Routine call’ (lowest precedence – default case).

(2) ‘P’ specifies a ‘Priority call’.

(3) ‘I’ specifies an ‘Immediate call’.

(4) ‘F’ specifies a ‘Flash call’ (highest precedence).

(b) The level of call precedence shall be utilised by the HF ground station equipment to affect the timeliness by which a call is routed – if such facilities are provided.

(c) The ‘Call Precedence’ field is omitted from ‘Programmed dial calls’ and ‘Self-verified programmed dial calls’. For these calls, precedence can be pre-assigned to the alphanumeric programmed routing code, and on receiving the code the HF ground station can determine the precedence via lookup table and then take appropriate action.

204. Routing Destination

(a) The ‘Call Dial Code’ (field 4) contains the information, which is used at the HF ground station to identify the required routing destination.

(b) For programmed dial calls the information is a reference within a private lookup table, which selects the dial number which is recognised by the ground network.

(c) Direct dial calls provide the opportunity to explicitly specify the dial number that is recognised by the ground network. This provides increased flexibility as routing to ad hoc destinations can be achieved with minimal planning. However, use of direct dial calls carries security considerations since the dial number can be intercepted over-the-air.

(d) When using direct dial calls care also needs to be taken to ensure that the direct dial number is valid for the particular HF ground station providing access. It is recommended that direct dial numbers are used which are valid at all HF ground stations which may be available (i.e. assumptions are not made regarding the HF ground station local access point into the ground network). Alternatively, use of ‘hybrid’ programmed dial calls can achieve this, whereby the programmed routing code portion of the call dial code field specifies a region or user group. The associated routing dial number, which is derived via lookup table, may then vary between ground HF stations.

(e) In ‘hybrid’ programmed dial calls the separation of the programmed routing code and numerical direct dial portions is achieved via the associated lookup table for programmed dial codes. The longest sequence of characters at the start of the call dial code that corresponds to a valid programmed dial code is used. Any remaining characters in the call dial code are interpreted as direct dial digits, and may include the ‘,’ (comma) character for dialling pauses.

(f) Care should be taken that there is no risk of ambiguity when defining programmed routing codes for use in ‘hybrid’ programmed dial calls. For example, use of ‘UKSIG1’ and ‘UKSIG11’ as programmed routing codes would be problematic if the call dial code ‘UKSIG1190456’ was meant to be interpreted as ‘UKSIG1’ followed by the direct dial digits

'190456'. The definition requires that this call dial code be interpreted as 'UKSIG11' followed by the direct dial digits '90456'.

(g) Use of the ',' (comma) character provides the capability for specifying dialling pauses before or between direct dial digits when the HF ground station is dialling into the ground network. Certain old-style telephone exchanges require this functionality. Each comma represents a two second pause, but a succession of commas can be used in the HF-GRP message to introduce a longer pause. If pauses are required between dialling digits, which are derived from a programmed routing code, then this information must be held locally at the HF ground station since it is not explicitly conveyed in the HF-GRP message.

205. Call Verification

(a) The call verification character is determined from the checksum which results from the modulo 37 addition of the assigned decimal values of each character in message fields 2, 3 and 4. The mapping of characters to assigned decimal values is defined in Table 2-1 (NB the ',' (comma) character, if used in field 4, should be assigned a decimal zero value). The checksum calculation is performed as follows:

$$\text{Call verification checksum} = \left(\sum_{n=5}^{N-5} val_n\right) MOD_{37}$$

where, n = the position of a character in a HF-GRP message,

$n = 1$ specifies the first character in a HF-GRP message,

$n = N$ specifies the last character in a HF-GRP message and equals the total length of the HF-GRP message,

val_n = assigned decimal value of the character at position n (from Table 2-1),

MOD_{37} = remainder after dividing the argument by 37.

(b) The checksum result equates to the assigned decimal value of the call verification character (in Table 2-1) that is used in the self-verified HF-GRP message. The call verification character is placed immediately before field 6 in the message, i.e. when used, the call verification character position is $N - 4$.

(c) An example of the checksum calculation is shown below.

Content of fields 2, 3 and 4: **WP9,4726**

Checksum value = (33 + 26 + 9 + 0 + 4 + 7 + 2 + 6) MOD_{37} = (87) MOD_{37} = 13

Call verification character decimal value = 13

Resulting call verification character from Table 2-1 = 'C'

HF-GRP message: **CCCCWP9,4726CNNNN**

CHAPTER 3

RULES GOVERNING USAGE

301. Use with MS-ALE

(a) When used with MS-ALE, the HF-GRP shall be conveyed over the radio link using the Automatic Message Display (AMD) function. AMD is a mandatory MS-ALE function which enables text messages of up to 90 characters to be sent and received.

(b) When automatic ground routing is required by a mobile user, an AMD message containing routing information in the HF-GRP format shall be passed during the MS-ALE link establishment handshake, which is used to set up the radio link. This requires a valid routing message to be selected or compiled by the mobile radio operator immediately prior to link establishment.

(c) If likely routing requirements are known in advance, then the MS-ALE radio shall be pre-programmed with AMD messages that contain the routing information in the HF-GRP format (each AMD message containing one HF-GRP message). When instigating a call the radio operator merely has to choose the appropriate AMD message from the list of those available. These are likely to utilise the programmed dial formats with an associated lookup table being held at the ground stations(s).

(d) If advance planning is not possible then the AMD message will need to be constructed prior to link establishment using a suitable radio interface for text entry and following the rules which define the format of HF-GRP messages. Given the information in Table 2-1 it is possible to determine the call verification character needed in a self-verified call by manually calculating the checksum using the formula given in this publication. Where this is not possible for a mobile HF radio user during deployment, the call formats that are not self-verified can be used.

302. Use with Third Generation Automated Systems

(a) Mil-Std-188-141B Appendix C [1] and STANAG 4538 [2] define third generation (3G) automated HF communications management systems that are regarded as the successors to the current MS-ALE systems. The HF-GRP format is compatible with 3G automated systems.

(b) When used with 3G automated systems, the HF-GRP messages shall be conveyed using the 64-byte LDL message transfer function immediately following link set-up. This message transfer function is guaranteed error-free, therefore the self-verified call modes within the routing protocol do not need to be used. The LDL function is used in place of the AMD function, which is provided with MS-ALE.

303. Call Rejection

(a) MS-ALE incorporates coding techniques to detect and correct transmission errors caused by HF channel disturbances. However, not all transmission errors can be corrected this way and received AMD messages are not guaranteed to be error-free. Consequently, a received HF-GRP message may contain errors – in which case the message needs to be rejected (a re-send would then need to be instigated by the mobile radio operator).

(b) A received AMD text message is identified as a HF-GRP message by the character combination 'CCCC' (field 1) at the start of the message. If the message does not start with this character combination then it can be considered that the message is not intended for automatic ground routing and can be interpreted according to local operating procedures. It must also be recognised that a HF-GRP message received with errors in field 1 will also fit this category so additional checks will be needed if it is required to identify this case.

(c) A received HF-GRP message must be rejected if it does not comply with the formatting rules specified under the protocol description, contains an unrecognised or disallowed 'Call Dial Code' value or, in the case of self-verified calls, does not pass the call verification test.

(d) In detail, a received HF-GRP message must be rejected if any of the following conditions apply.

(1) There are characters in the message that are not in Table 2-1 (NB the ',' (comma) is also an allowable character).

(2) There are characters in a message field that are invalid for that particular field.

(3) The length of any of the message fields is invalid.

(4) Characters are present in the message after field 6 (apart from any AMD call 'space' padding characters).

(5) The call dial code is unrecognised or disallowed by the receiving HF ground station.

(6) Additionally, for 'Self-verified direct calls' and 'Self-verified programmed calls' only, the valid 'Call Verification' character must be determined via the checksum calculation using the received characters in fields 2, 3 and 4. If this character does not match the 'Call Verification' character in the received message, then the message must be rejected.

(e) If a message is rejected then no attempt is made to route the link over the ground network. Following the rejection of a message it is recommended that the receiving HF ground station instigates the automatic termination of the ALE link to the mobile. The mobile may then re-attempt a link.

(f) This procedure for identifying and rejecting erroneous HF-GRP messages is intended to prevent calls being routed to the wrong location due to radio transmission errors or message compilation errors. Checks 1 to 5 above will trap most erroneous messages. However, if the HF-GRP is widely deployed and the set of valid call dial codes is large then high reliability against incorrect routing requires the use of the self-verified call format to provide increased protection.

(g) The rejection of erroneous HF-GRP messages following the checks given above is highly reliable but is not absolutely guaranteed. The final mechanism for detecting a false routing is at the start of the traffic phase, when the operators or data systems involved detect the error.

304. Unauthorised Access

(a) If there is a requirement for mitigation against unauthorised call access to a HF ground station, and the associated automated routing of calls, then when MS-ALE systems are being used to convey the HF-GRP the optional Link Protection mode of MS-ALE shall be used at level LP1 or higher.

(b) It should be noted that use of Link Protection results in the scrambling of ALE protocol words used to establish links. This is intended to prevent non-legitimate users from establishing links with legitimate users, since the scrambling key is known only to the legitimate users. The content of AMD messages is not scrambled and therefore can still be decoded via interception. However, this information cannot easily be incorporated into a valid ALE message by a non-legitimate user due to the scrambling of the ALE words which contain user addressing information. The degree of protection against the re-broadcast of intercepted ALE messages by non-legitimate users varies according to the level of Link Protection which is used, increased protection is obtained by using a higher level.

(c) Use of Link Protection requires pre-configuration of radio equipment among users in a network, including distribution of a key and agreement on an absolute time reference. It also requires the availability of MS-ALE equipment which is Link Protection capable (Link Protection is not mandated for MS-ALE compliance).

(d) The Link Protection mode of MS-ALE does not offer any security protection to user traffic.

(e) Link Protection mode is also defined for 3G automated systems and should be used in the same way as described above when HF-GRP is used with 3G systems.

305. Hand-Off Traffic Services

(a) The HF-GRP can accommodate the automatic ground routing of both clear voice links and links for carrying data traffic. This is achieved through the mapping of dial codes to locations which either terminate in voice handsets/telephones or data terminal equipment. Therefore, the traffic service to be carried by the link is transparent to the HF-GRP, which merely provides the end-to-end connectivity between the mobile radio system and the location specified by the call dial code.

306. US Interoperable Mode

(a) A ground routing protocol is implemented in the US Scope Command HF ground system [3]. Currently, this protocol uses a subset of the functionality of the HF-GRP specified in this publication. For interoperability with the US ground routing protocol the following constraints apply when using the HF-GRP.

(1) Self-verified call types are not used, therefore the ‘call type’ (field 2) is either ‘D’ or ‘P’ and no call verification character is needed.

(2) In a ‘Programmed dial call’ the programmed routing code portion of the call dial code field (field 4) has a fixed size of 3 characters. This equates to the call dial code field size, except in the ‘hybrid’ version.

(3) The maximum number of characters in the call dial code field (field 4) is limited to 16.

307. Additional Call Types

(a) The HF-GRP as defined in this publication specifies four-call types, i.e. direct and programmed dial in their standard and self-verified forms. Additional HF functionality (e.g. ALE network management features) could also be supported through formatted message exchange between the mobile radio user and the HF ground station.

(b) Future enhancements to this publication may include the addition of call types which can support this functionality.

CHAPTER 4

REFERENCES

401. Associated Documents

[1] MIL-STD-188-141B. US Military Standard for 'Interoperability and Performance Standards for Medium and High Frequency Radio Systems'.

[2] STANAG 4538. NATO Standard for 'Technical Standards for an Automatic Radio Control System for HF Communication Links'.

[3] Air Force TO31R2-2GRC244-1, Scope Command Lights Out - HF Radio Station with Automatic Link Establishment (ALE), Para 4-11.5 - Automated Phone Patches, page 4-107.

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