Multi-Band EGNOS File Format Description Document

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APPROVAL

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CHANGE LOG

Reason for change	Issue Nr.	Revision Number	Date
First issue of the document	1	0	06/04/2018
Update after comments from TCB#11	1	1	13/07/2018
Update after first comments from user community	1	2	24/10/2018
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Added missing items in list of abbreviations. Changed year padding to '%02d' to make it consistent with other date fields. Clarified message type padding.	1	4	09/10/2020

CHANGE RECORD

Issue Number 1			Revision Number 4
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Update after comments from TCB#11	13/07/2018	All pages	1, 2, 3
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Added missing items in list of abbreviations. Changed year padding to '%02d' to make it consistent with other date fields. Clarified message type padding.	12/10/2020	6, 7, 9	1.4, 2,2

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1   INTRODUCTION

1.1   Background

The European Satellite-Based Augmentation System (SBAS) EGNOS (European Geostationary Navigation Overlay Service), tailored to the needs of the aviation community, provides correction and integrity information for NAVSTAR GPS and, since 2011, is certified for use in Safety-of-Life (SoL) applications. Owned by the European Commission, EGNOS in its current design (v2.x) is supporting reliable and precise positioning while using GPS L1 frequency over the European Civil Aviation Conference (ECAC) area. EGNOS correction and integrity messages are broadcast as Navigation Overlay Frames (NOF) through geostationary (GEO) satellites for real-time use with a Time-to-Alert of six seconds.

For offline analysis and non-SoL/non-real-time applications, familiarization with the system or general research, the European Space Agency (ESA) has developed the EGNOS Message Server (EMS) file format. EMS is a well-known file format that this capturing, per GEO and epoch, the NOF broadcast to single-frequency L1 users. EMS file format is not limited to EGNOS but can contain NOF from any RTCA MOPS DO-229 compliant SBAS.

In future major system upgrades (V3.x), EGNOS will also provide information to dual-frequency and multi-constellation (DFMC) users (more specifically, receivers using both L1/E1 and L5/E5a frequencies of GPS and Galileo). To support this evolution, new standards such as the DFMC SBAS MOPS and message formats (such as this Multi-Band EGNOS File Format) are currently created to serve a larger user community and benefit from increased processing on user side.

1.2   Scope of the document

This document defines the interfaces of the new Multi-Band EGNOS File Format in terms of file format. In this context, band shall be understood as both the SBAS downlink bands as described in [DFMC_MOPS] as well as alternative dissemination means (such as terrestrial), potentially also broadcasting experimental messages not covered by current standards.

Section 1 (this section) provides background information and describes the scope of the document and its content.

Section 2 introduces the new Multi-Band EGNOS File Format containing the optional flag to distinguish between different MOPS message encodings while maintaining backwards compatibility for legacy toolkit users.

Section 3 summarizes the Multi-Band EGNOS File Format.

1.3   Reference Documents

ID	Title	Reference
[MOPS_DO-229D]	Minimum Operational Performance Standards for Global Positioning System / Wide Area Augmentation System Airborne Equipment	RTCA MOPS DO-229D Change 1 (February 1st 2013)
[DFMC_MOPS]	Minimum Operational Performance Specification for Galileo / Global Positioning System / Satellite Based Augmentation System Airborne Equipment	ED259A v0.6 (August 2020)

1.4   List of Abbreviations

ASCII   American Standard Code for Information Interchange
BOM   Byte Order Mark
CRLF   Carriage Return Line Feed
DFMC   Dual-Frequency Multi-Constellation
ECAC   European Civil Aviation Conference
EGNOS   European Geostationary Navigation Overlay Service
EMS   EGNOS Message Server
ESA   European Space Agency
GAL   Galileo
GEO   Geostationary Earth Orbit
GPS   Global Positioning System
GPST   GPS Time
LF   Line Feed
MOPS   Minimum Operational Performance Standards
MSB   Most Significant Bit
NOF   Navigation Overlay Frame
PRN   Pseudorandom Noise
SBAS   Satellite-Based Augmentation System
SF   Single Frequency
SFSC   Single-Frequency Single-Constellation
SoL   Safety-of-Life
RTCA   Radio Technical Commission for Aeronautics
UTF   Unicode Transformation Format

2   MULTI-BAND EGNOS FILE FORMAT DESCRIPTION

The Multi-Band EGNOS File Format is an ASCII-encoded representation of SBAS correction and integrity information (the NOF). Each NOF (and additional information as described below) is stored in an individual line as a record, followed by a line feed.
The information (fields represented by blue boxes) stored in each record is shown in Figure 1. Details on the fields, formats and the allowed delimiters/line feeds are provided below.
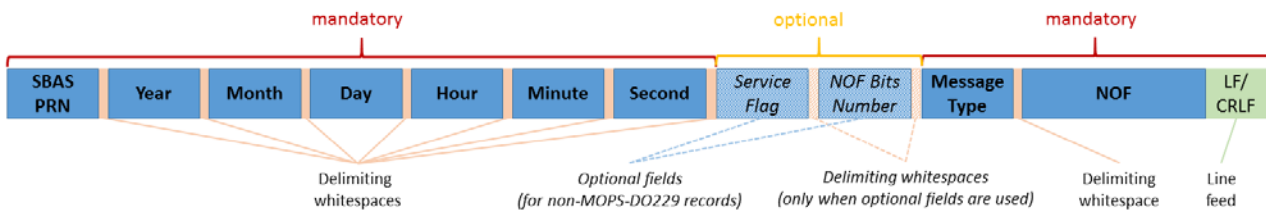

Figure 1 - Information encoded in a Multi-Band EGNOS File Format data record

2.1   General format requirements

The following general format requirements shall apply:
- All files shall be **UTF-8** encoded, the BOM shall not be used. Furthermore, all characters shall be single-byte only, i.e. ASCII characters.
- Each field, represented by a blue box in Figure 1, shall be **separated** from the others by a single **whitespace** (U+0020), represented in orange color.
- Each record shall end with an **end-of-line**, represented in green color, which shall directly follow the NOF field without preceding whitespace. End-of-line can follow Unix or Windows definition as **line feed** (LF, U+000A) or a **carriage-return line feed** (CRLF, U+000D U+000A) respectively regardless of the underlying OS.

2.2   Multi-Band EGNOS File Format field definition

The fields of a Multi-Band EGNOS File Format record are defined as follows. The GPST timestamp included in each record shall be valid at **reception of last bit of message**.

1. **SBAS PRN**: SBAS PRN (e.g. GEO, alternative broadcast means) from which NOF has been received (%03d[1], **mandatory** zero-padded 3 digits integer, range 0...999)

2. **Year**: truncated year from receiver local timestamp (%02d, **mandatory** zero-padded 2 digits integer, range 0...99)

3. **Month**: month from receiver GPST timestamp (%02d, **mandatory** zero-padded 2 digits integer, range 0...12)

4. **Day**: day of month from receiver GPST timestamp (%02d, **mandatory** zero-padded 2 digits integer, range 0...31)

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[1] All format specifiers contained in the document are given according to C convention, e.g. Brooks, D. (1999). C Programming: The Essentials for Engineers and Scientists. New York, NY: Springer New York.

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5. **Hour**: hour from receiver GPST timestamp (%02d, **mandatory** zero-padded 2 digits integer, range 0...59)

6. **Minute**: minute from receiver GPST timestamp (%02d, **mandatory** zero-padded 2 digits integer, range 0...60)

7. **Second**: second from receiver GPST timestamp (**mandatory**)
    a. For MOPS DO-229 (optional fields not set): %02d, zero-padded 2 digits integer
    b. For other (optional fields set): %9.6f, zero-padded 8 digits float (6 decimal places)
    for both: range 0...60[2]

8. **Band Flag**: Flag indicating how SBAS NOF is encoded (%2s, **optional** 2 characters string)
    The optional **Band Flag** shall be either of the following values:
    a. For RTCA MOPS DO-229: **not included** (fully backwards compatible) *or*
    b. For DFMC SBAS MOPS: **L5** *or*
    c. For non-standard message encoding (i.e. experimentation) or alternative broadcast means: **any 2 character string** where the first character is any character which is not a hexadecimal character[3] (i.e. not 0...9 or A...F) and the second character is any ASCII character
    Recommended first characters:
        i. For other GEO downlink bands: L
        ii. For experimentation: X
        iii. For terrestrial broadcast: T
        iv. For broadcast through internet: I

9. **NOF Bits Number**: Number of useful bits (i.e. excluding padding) that are used to encode message (%4i, zero-padded 4 hexadecimal representation of integer, to be **included only[4] when Band Flag is set**)
    Depending on the Band Flag, the **NOF Bits Number** field shall be either:
    a. *When Band Flag is not set (RTCA MOPS DO-229): **not included** *or*
    b. When Band Flag is set to L5 (DFMC SBAS MOPS): **00FA** (250) *or*
    c. When Band Flag is set to any other value (non-standard message encoding or alternative broadcast means): **any 4 characters hexadecimal integer**, range 0001...FFFF (1... 65535)

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[2] Range set as 0...60 to allow for leap seconds. Leap seconds are normally introduced as 23:59:59 → 23:59:60 → 00:00:00 on either June 31st or December 31st although they may be introduced on any last day of a month. Actual implementation varies and may also be a repetition of the last time step (i.e. 23:59:59 ... 23:59:59 ...00:00:00).

[3] This character can be used to distinguish between legacy (SF) and other message encoding.

[4] This means that each record shall have **either 9** (for MOPS DO-229) **or 11 fields** (for all other cases), i.e. in any Multi-Band EGNOS File Format record, either **both** optional fields (Service Flag and NOF Bits Number) **or none** shall be included.

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10. **Message Type**: SBAS message type identifier as decoded from corresponding NOF (**mandatory**)
    a. For MOPS DO-229 (optional fields not set): non-padded integer (%d)
    b. For other (optional fields set): zero-padded integer (%02d)

11. **NOF**: %0s, zero-padded hexadecimal stream (each hexadecimal digit being represented by one UTF-8 character) of SBAS messages with leftmost bit of each character being the MSB[5] (**mandatory**)
    a. For MOPS DO-229 (optional fields not set): 64 characters hexadecimal string
    b. For DFMC SBAS MOPS (Band Flag set to L5): 64 characters hexadecimal string
    c. For others (Band Flag set $\neq$ L5): Hexadecimal string with arbitrary length representing the number of bytes as $2 \cdot ceiling \left(\frac{NOF\ Bits\ Number}{8} \right)$

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[5] In 2.3 example A (NOF 536A...), the MSB is the leftmost bit (0) of the binary representation of 5 (0101).

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2.3   Example records in valid files

Examples formatted according to Multi-Band EGNOS File Format record definition (see above), respectively compliant to MOPS DO-229 (A.), DFMC SBAS MOPS as GEO (B.) and terrestrial (C.) broadcast, and experimental message encoding (D.), are presented below:

A. RTCA MOPS DO-229 compliant (no flag, Windows like end-of-line):

120 18 03 26 11 08 31 4 536A500BA03B01C00DC06E03701B80E007203C01F00FBFDFFEF02F0036897580\CR\LF

B. DFMC SBAS MOPS compliant (flag L5 and NOF Bits number 00FA, Unix line end-of-line):

136 18 03 26 11 08 31.844986 L5 00FA 36 391EEE777EE7777EEEE777E777777EEEE77EEE7000000000000000001DA24400\LF

C. DFMC SBAS MOPS compliant (terrestrial broadcast, flag T1 and NOF Bits number 00FA, Windows like end-of-line):

019 18 03 26 11 08 05.028361 T1 00FA 36 391EEE777EE7777EEEE777E777777EEEE77EEE7000000000000000001DA24400\CR\LF

D. Experimental message structure (flag X2 and NOF Bits number 0108 for NOF length 264 bits, Unix line end-of-line):

123 18 03 26 11 08 31.844986 X2 0108 75 62FACEECD8B8D029E38A0C85E0EA5296437A92B6192E0C031C09679886E9D7FC7B60\LF

2.4 Versatility of file

The definition of Multi-Band EGNOS File Format records as described above (with both optional fields set) allows a Multi-Band EGNOS File Format file to contain NOF from any number of days, hours of the day, SBAS PRN and message encoding/broadcast means.

The following excerpt is an example of a Multi-Band EGNOS File Format file[6] highlighting its versatility:
- Change of month leading also to change of hour
- Two SBAS PRN
- MOPS DO-229D on L1 and DFMC SBAS MOPS on L5

```
...
120 18 03 31 23 59 58 4 C611C003FC0003FF4000000000000000000000000039797BB80000017CA1640\LF
120 18 03 31 23 59 58.844986 L5 00FA 36 A91EEE7E7EE7777EEEE777E777777EEEE77EEE70000000000000000000234C75C0\LF
136 18 03 31 23 59 58 2 C60AC000000003FCC003FFC000013FF8000000000003BB97BB9BBBBB805CAC40\LF
136 18 03 31 23 59 58.795325 L5 00FA 36 391EEE7E7EE7777EEEE777E777777EEEE77EEE70000000000000000000350A9F40\LF
120 18 03 31 23 59 59 3 530CC003FD8003FDC003FFBFF4003FE8003FFBFF7FEB979B9579B9954CC09780\LF
120 18 03 31 23 59 59.844982 L5 00FA 31 C7EBF377C00000000000047FFF60000000000000000000000000002C5EBB80\LF
136 18 03 31 23 59 59 27 536C0040F46EC0A0A200000000000000000000000000000000000000253DC840\LF
120 18 04 01 00 00 00 2 9A09C000000003FCC003FF8000013FF8000000000003BB97BB9BBBBBA49CF600\LF
120 18 04 01 00 00 00.844979 L5 00FA 40 6A14A0014000000000000000000000000000000000000014CD0000000003F15D40\LF
136 18 04 01 00 00 00 4 9A10C003FC0003FF40000000000000000000000039797BB8000003267D780\LF
136 18 04 01 00 00 00.795328 L5 00FA 31 97EBF377C00000000000047FFF60000000000000000000000000000322DD640\LF
120 18 04 01 00 00 01 25 C664C2AFB013FCFFDE56FE00FFA0461E740B04010044567F8121380BA4A52740\LF
120 18 04 01 00 00 01.844976 L5 00FA 39 59E80000000000000000A1C800000000000000000000000000000001E38B6C0\LF
136 18 04 01 00 00 01 3 C60EC003FDC003FDC003FFBFF4003FEC003FFBFF7FEB979B9579B99540F24BC0\LF
136 18 04 01 00 00 01.795331 L5 00FA 40 AA14A0014000000000000000000000000000000000000014CD000000000BC4DA00\LF
...
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[6] No message received or message from PRN 136 lost at 23:59:59 on March 31st 2018.

3   SUMMARY

In this document, the Multi-Band EGNOS File Format, a standard format used for the exchange of SBAS NOF complying to either MOPS DO-229 or DFMC SBAS MOPS, is introduced.

Within the new Multi-Band EGNOS File Format, all SBAS correction and integrity information can be efficiently encoded, while maintaining full backwards compatibility with current toolset. The format of a Multi-Band EGNOS File Format record is presented in detail, including the definition of each field and the corresponding formatting. For both MOPS available today, an example record is included to show valid Multi-Band EGNOS File Format records created on different operating system (Windows and Unix).

-    END OF THE DOCUMENT -

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