

ETSI TS 101 851-2-1 V2.1.1 (2008-01)

Technical Specification

Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 2: Multiplexing and channel coding; Sub-part 1: G-family (S-UMTS-G 25.212)

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Reference

RTS/SES-00298-2-1

Keywords

interface, MES, MSS, radio, satellite, UMTS

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is specifying the Satellite Radio Interface referenced as SRI Family G at ITU-R, in the frame of the modification of ITU-R Recommendation M.1457 [10]. This modification has been approved at SG8 meeting in November 2005.

The present document is part 2, sub-part 1 of a multi-part deliverable covering Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; G-family, as identified below:

Part 1: "Physical channels and mapping of transport channels into physical channels";

Part 2: "Multiplexing and channel coding";

Sub-part 1: "G-family (S-UMTS-G 25.212)";

Sub-part 2: "A-family (S-UMTS-A 25.212)";

Part 3: "Spreading and modulation";

Part 4: "Physical layer procedures";

Part 5: "UE Radio Transmission and Reception";

Part 6: "Ground stations and space segment radio transmission and reception".

Introduction

S-UMTS stands for the Satellite component of the Universal Mobile Telecommunication System. S-UMTS systems will complement the terrestrial UMTS (T-UMTS) and inter-work with other IMT-2000 family members through the UMTS core network. S-UMTS will be used to deliver 3rd generation Mobile Satellite Services (MSS) utilizing either low (LEO) or medium (MEO) earth orbiting, or geostationary (GEO) satellite(s). S-UMTS systems are based on terrestrial 3GPP specifications and will support access to GSM/UMTS core networks.

NOTE 1: The term T-UMTS will be used in the present document to further differentiate the Terrestrial UMTS component.

Due to the differences between terrestrial and satellite channel characteristics, some modifications to the terrestrial UMTS (T-UMTS) standards are necessary. Some specifications are directly applicable, whereas others are applicable with modifications. Similarly, some T-UMTS specifications do not apply, whilst some S-UMTS specifications have no corresponding T-UMTS specification.

Since S-UMTS is derived from T-UMTS, the organization of the S-UMTS specifications closely follows the original 3rd Generation Partnership Project (3GPP) structure. The S-UMTS numbers have been designed to correspond to the 3GPP terrestrial UMTS numbering system. All S-UMTS specifications are allocated a unique S-UMTS number as follows:

S-UMTS-n xx.yyy

Where:

- The numbers xx and yyy correspond to the 3GPP numbering scheme.
- n (n = A, B, C, etc.) denotes the family of S-UMTS specifications.

An S-UMTS system is defined by the combination of a family of S-UMTS specifications and 3GPP specifications, as follows:

- If an S-UMTS specification exists it takes precedence over the corresponding 3GPP specification (if any). This precedence rule applies to any references in the corresponding 3GPP specifications.

NOTE 2: Any references to 3GPP specifications within the S-UMTS specifications are not subject to this precedence rule.

EXAMPLE: An S-UMTS specification may contain specific references to the corresponding 3GPP specification.

- If an S-UMTS specification does not exist, the corresponding 3GPP specification may or may not apply. The exact applicability of the complete list of 3GPP specifications shall be defined at a later stage.

1 Scope

The present document describes the characteristics of the Layer 1 multiplexing and channel coding used for family G of the satellite component of UMTS (S-UMTS-G).

It is based on the FDD mode of UTRA defined by TS 125 211 [6], TS 125 212 [7], TS 125 213 [8] and TS 125 214 [9] and adapted for operation over satellite transponders.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
 - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

- [1] ETSI TS 101 851-1-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 1: Physical channels and mapping of transport channels into physical channels; Sub-part 1: G-family (S-UMTS-G 25.211)".
- [2] ETSI TS 101 851-3-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 3: Spreading and modulation; Sub-part 1: G-family (S-UMTS-G 25.213)".
- [3] ETSI TS 101 851-4-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 4: Physical layer procedures; Sub-part 1: G-family (S-UMTS-G 25.214)".
- [4] ETSI TS 125 302: "Universal Mobile Telecommunications System (UMTS); Services provided by the physical layer (3GPP TS 25.302)".
- [5] ETSI TS 125 215: "Universal Mobile Telecommunications System (UMTS); Physical layer; Measurements (FDD) (3GPP TS 25.215)".

2.2 Informative references

- [6] ETSI TS 125 211: "Universal Mobile Telecommunications System (UMTS); Physical channels and mapping of transport channels onto physical channels (FDD) (3GPP TS 25.211)".
- [7] ETSI TS 125 212: "Universal Mobile Telecommunications System (UMTS); Multiplexing and channel coding (FDD) (3GPP TS 25.212)".
- [8] ETSI TS 125 213: "Universal Mobile Telecommunications System (UMTS); Spreading and modulation (FDD) (3GPP TS 25.213)".
- [9] ETSI TS 125 214: "Universal Mobile Telecommunications System (UMTS); Physical layer procedures (FDD) (3GPP TS 25.214)".
- [10] ITU-R Recommendation M.1457 (2006): "Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Transmission Gap (TG): consecutive empty slots that have been obtained with a transmission time reduction method

NOTE: The transmission gap can be contained in one or two consecutive radio frames.

Transmission Gap Length (TGL): number of consecutive empty slots that have been obtained with a transmission time reduction method $0 \leq TGL \leq 14$

NOTE: The CFNs of the radio frames containing the first empty slot of the transmission gaps, the CFNs of the radio frames containing the last empty slot, the respective positions N_{first} and N_{last} within these frames of the first and last empty slots of the transmission gaps, and the transmission gap lengths can be calculated with the compressed mode parameters described in TS 125 215 [5].

TrCH number: transport channel number which identifies a TrCH in the context of L1

NOTE: The L3 transport channel identity (TrCH ID) maps onto the L1 transport channel number. The mapping between the transport channel number and the TrCH ID is as follows: TrCH 1 corresponds to the TrCH with the lowest TrCH ID, TrCH 2 corresponds to the TrCH with the next lowest TrCH ID and so on.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$\lceil x \rceil$ round towards ∞ , i.e. integer such that $x \leq \lceil x \rceil < x + 1$

$\lfloor x \rfloor$ round towards $-\infty$, i.e. integer such that $x - 1 < \lfloor x \rfloor \leq x$

$|x|$ absolute value of x

$\text{sgn}(x)$ signum function, i.e. $\text{sgn}(x) = \begin{cases} 1; & x \geq 0 \\ -1; & x < 0 \end{cases}$

N_{first} The first slot in the TG, located in the first compressed radio frame if the TG spans two frames.

N_{last} The last slot in the TG, located in the second compressed radio frame if the TG spans two frames.

N_{tr} Number of transmitted slots in a radio frame.

Unless otherwise is explicitly stated when the symbol is used, the meaning of the following symbols is:

i TrCH number

j TFC number

k	Bit number
l	TF number
m	Transport block number
n_i	Radio frame number of TrCH i
p	PhCH number
r	Code block number
I	Number of TrCHs in a CCTrCH
C_i	Number of code blocks in one TTI of TrCH i
F_i	Number of radio frames in one TTI of TrCH i
M_i	Number of transport blocks in one TTI of TrCH i
$N_{data,j}$	Number of data bits that are available for the CCTrCH in a radio frame with TFC j
$N_{data,j}^{cm}$	Number of data bits that are available for the CCTrCH in a compressed radio frame with TFC j
P	Number of PhCHs used for one CCTrCH
PL	Puncturing Limit for the uplink. Signalled from higher layers
RM_i	Rate Matching attribute for TrCH i . Signalled from higher layers

Temporary variables, i.e. variables used in several clauses with different meaning.

x, X
 y, Y
 z, Z

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BCH	Broadcast CHannel
BER	Bit Error Rate
CCPCH	Common Control Physical CHannel
CCTrCH	Coded Composite Transport CHannel
CFN	Connection Frame Number
CRC	Cyclic Redundancy Check
DCH	Dedicated CHannel
DL	DownLink (Forward link)
DPCCH	Dedicated Physical Control CHannel
DPCH	Dedicated Physical CHannel
DPDCH	Dedicated Physical Data CHannel
DTX	Discontinuous Transmission
FACH	Forward Access CHannel
FDD	Frequency Division Duplex
FER	Frame Error Rate
GEO	Geostationary Earth Orbit
GF	Galois Field
LEO	Low Earth Orbit
MAC	Medium Access Control
MEO	Medium Earth Orbit
MSS	Mobile Satellite Services
PCCC	Parallel Concatenated Convolutional Code
PCH	Paging CHannel
PhCH	Physical CHannel
PRACH	Physical Random Access CHannel
RACH	Random Access CHannel
S-CCPCH	Secondary Common Control Physical CHannel
SF	Spreading Factor
S-UMTS	Satellite Universal Mobile Telecommunication Systems
TF	Transport Format
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TG	Transmission Gap

TGL	Transmission Gap Length
TPC	Transmit Power Control
TrCH	Transport CHannel
TTI	Transmission Time Interval
UL	UpLink (Reverse link)
USRAN	UMTS Satellite Radio Access Network
UTRA	UMTS Terrestrial Radio Access

4 Multiplexing, channel coding and interleaving

4.1 General

Data stream from/to MAC and higher layers (Transport block/Transport block set) is encoded/decoded to offer transport services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting, rate matching, interleaving and transport channels mapping onto/splitting from physical channels.

4.2 General coding/multiplexing of TrCHs

This clause only applies to the transport channels:

- DCH;
- RACH;
- BCH;
- FACH; and
- PCH.

Other transport channels which do not use the general method are described separately below.

Data arrives to the coding/multiplexing unit in form of transport block sets once every transmission time interval. The transmission time interval is transport-channel specific from the set {10 ms, 20 ms, 40 ms, 80 ms}.

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see clause 4.2.1);
- transport block concatenation and code block segmentation (see clause 4.2.2);
- channel coding (see clause 4.2.3);
- radio frame equalization (see clause 4.2.4);
- rate matching (see clause 4.2.7);
- insertion of discontinuous transmission (DTX) indication bits (see clause 4.2.9);
- interleaving (two steps, see clauses 4.2.5 and 4.2.11);
- radio frame segmentation (see clause 4.2.6);
- multiplexing of transport channels (see clause 4.2.8);
- physical channel segmentation (see clause 4.2.10);
- mapping to physical channels (see clause 4.2.12).

The coding/multiplexing steps for uplink and downlink are shown in figures 1 and 2 respectively.

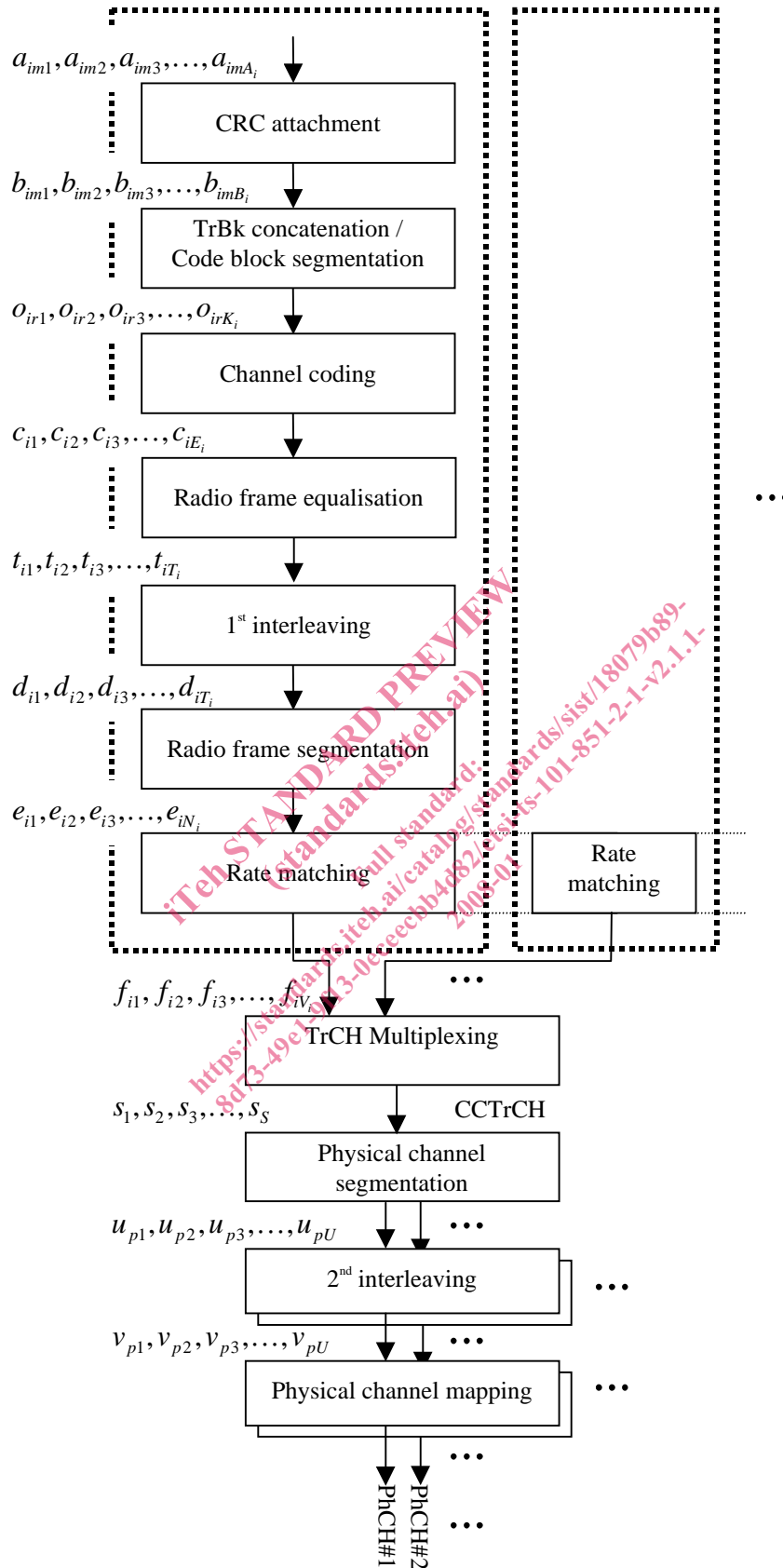


Figure 1: Transport channel multiplexing structure for uplink

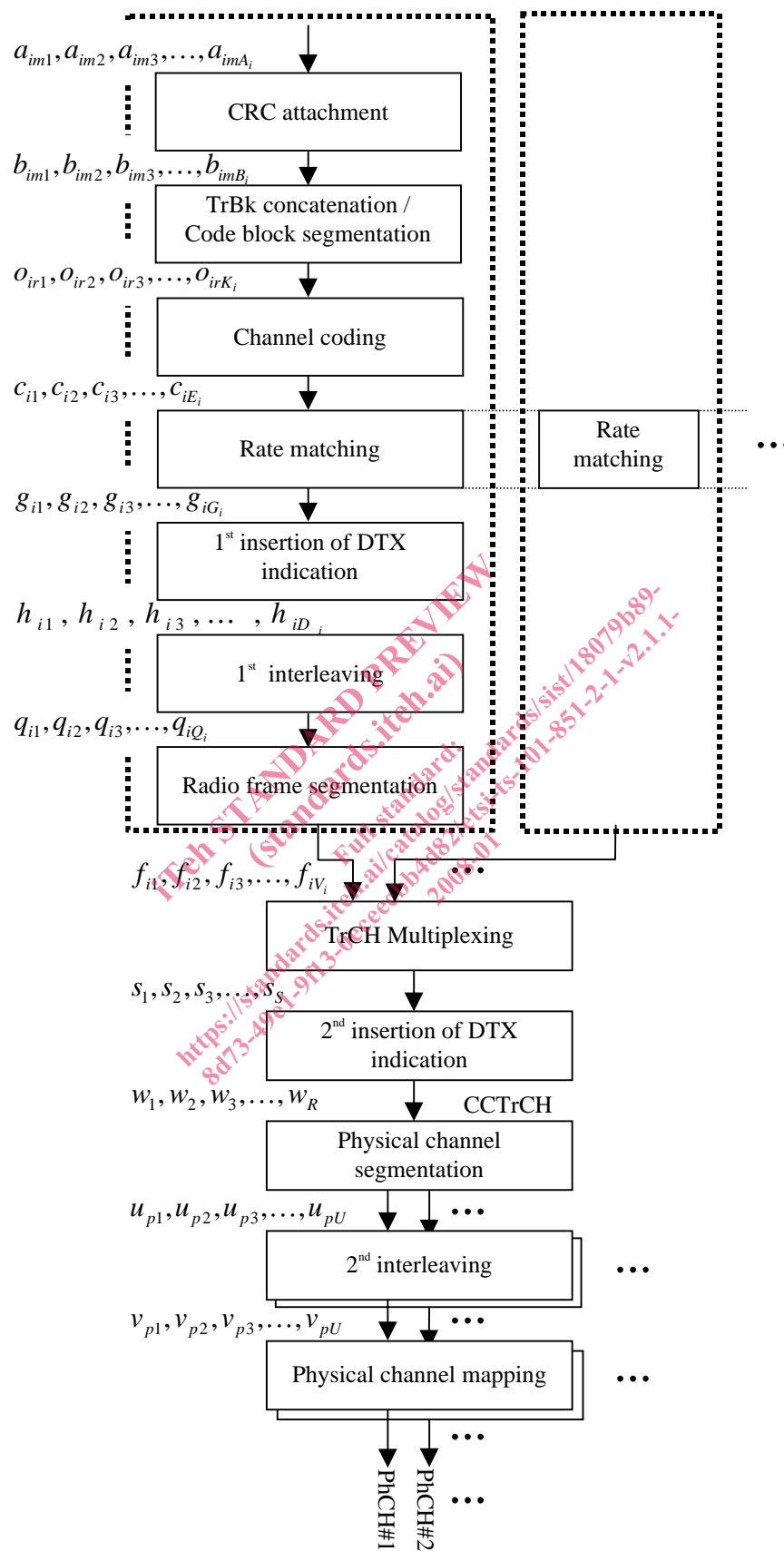


Figure 2: Transport channel multiplexing structure for downlink

The single output data stream from the TrCH multiplexing, including DTX indication bits in downlink, is denoted *Coded Composite Transport Channel (CCTrCH)*. A CCTrCH can be mapped to one or several physical channels.

4.2.1 CRC attachment

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 24 bits, 16 bits, 12 bits, 8 bits or 0 bit and it is signalled from higher layers what CRC size that should be used for each TrCH.

4.2.1.1 CRC Calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

- $g_{\text{CRC24}}(D) = D^{24} + D^{23} + D^6 + D^5 + D + 1;$
- $g_{\text{CRC16}}(D) = D^{16} + D^{12} + D^5 + 1;$
- $g_{\text{CRC12}}(D) = D^{12} + D^{11} + D^3 + D^2 + D + 1;$
- $g_{\text{CRC8}}(D) = D^8 + D^7 + D^4 + D^3 + D + 1.$

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \dots, a_{imA_i}$, and the parity bits by $p_{im1}, p_{im2}, p_{im3}, \dots, p_{imL_i}$. A_i is the size of a transport block of TrCH i , m is the transport block number, and L_i is the number of parity bits. L_i can take the values 24, 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_{im1}D^{A_i+23} + a_{im2}D^{A_i+22} + \dots + a_{imA_i}D^{24} + p_{im1}D^{23} + p_{im2}D^{22} + \dots + p_{im23}D^1 + p_{im24}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC24}}(D)$, polynomial:

$$a_{im1}D^{A_i+15} + a_{im2}D^{A_i+14} + \dots + a_{imA_i}D^{16} + p_{im1}D^{15} + p_{im2}D^{14} + \dots + p_{im15}D^1 + p_{im16}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC16}}(D)$, polynomial:

$$a_{im1}D^{A_i+11} + a_{im2}D^{A_i+10} + \dots + a_{imA_i}D^{12} + p_{im1}D^{11} + p_{im2}D^{10} + \dots + p_{im11}D^1 + p_{im12}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC12}}(D)$ and polynomial:

$$a_{im1}D^{A_i+7} + a_{im2}D^{A_i+6} + \dots + a_{imA_i}D^8 + p_{im1}D^7 + p_{im2}D^6 + \dots + p_{im7}D^1 + p_{im8}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC8}}(D)$.

If no transport blocks are input to the CRC calculation ($M_i = 0$), no CRC attachment shall be done. If transport blocks are input to the CRC calculation ($M_i \neq 0$) and the size of a transport block is zero ($A_i = 0$), CRC shall be attached, i.e. all parity bits equal to zero.

4.2.1.2 Relation between input and output of the CRC attachment block

The bits after CRC attachment are denoted by $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$$\begin{aligned} b_{imk} &= a_{imk} & k &= 1, 2, 3, \dots, A_i \\ b_{imk} &= p_{im(L_i+1-(k-A_i))} & k &= A_i + 1, A_i + 2, A_i + 3, \dots, A_i + L_i \end{aligned}$$