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Title	**Revision of Scanning, Ranging, and Sleep Mechanism for Mobility Enhancement**	
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Re:	Response to IEEE 802.16e-03_58 (Call for Contributions on IEEE 802.16e/07r5)	
Abstract	Revision of Scanning, Ranging, and Sleep Mechanism for Mobility Enhancement	
Purpose	Stimulate discussion on a more completely defined, flexible model and mechanism for facilitating mobility functionality	
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Revision of Scanning, Ranging, and Sleep Mechanism for Mobility Enhancement

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Observations on Current IEEE 802.16e-03/07r5 Based on Criteria from Assumptions

1. **Scanning, Ranging, and Sleep**

Problem:

The fact that we have created a logical separation/use distinct between 'sleep' mode and 'scanning' mode seems unnecessary. When determining whether differentiating mechanically, I think it best to look at impact on the Serving BS and network when assessing the importance of maintaining a logical distinction. All the network cares is that the MSS is 'unavailable' during the described interval, for whatever reason, and that the Serving BS should not schedule any DL/UL slots addressed to the MSS. What the MSS does during that interval of absence is irrelevant to the Serving BS and network and does not affect the mechanics of the standard.

There is benefit to unifying the two concepts for performance reasons, as well as conceptually. We spent some time at the last meetings talking about re-synchronization on timing for MSS returning from 'sleep' mode. We did not make similar correction for MSS returning from 'scanning' mode. By combining the allocation mechanism for both under the 'sleep' mode rules we effectively eliminate that problem for 'scanning', and any other logical use, as well.

Remedy:

Delete the separate rules allocation for Scanning. Expand the definition and rules for ‘Sleep’ mode to be more flexible and generalized as an MSS ‘Unavailable’ period. Create an appropriate aging timer for Serving BS to consider connection to MSS in ‘Sleep’ mode lost.

Remedy Action 1:

*[Delete **1.4.1.2.1.2 MSS Scanning of neighbor BS** in its entirety.]*

~~**1.4.1.2.1.2 MSS Scanning of neighbor BS**~~

~~A BS may allocate time intervals to MSSís for the purpose of seeking and monitoring neighbor BS suitability as targets for HO. Such a time interval will be referred to as a **scanning interval**.~~

~~An MSS may request an allocation of a scanning interval using the MOB_SCN-REQ MAC message. The MSS indicates in this message the duration of time it requires for the scan, based on its PHY capabilities.~~

~~Upon reception of this message, the BS shall respond MOB_SCN-RSP MAC message. The MOB_SCN-RSP MAC message shall either grant the requesting MSS a scanning interval that is at least as long as requested by that MSS, or deny the request.~~

~~An MSS, upon detection of a MOB_SCN-RSP MAC message addressed to it in the DL-MAP, shall use the allocated interval to seek for neighbor BS. When neighbor BS are identified, the MSS shall attempt to synchronize with their downlink transmissions, and estimate the quality of the PHY connection.~~

~~The BS may buffer incoming data addressed to the MSS during the scanning period, and transmit the data after the scanning period.~~

Remedy Action 2:

*[Delete **6.4.2.3.46 Scanning Interval Allocation Request (MOB_SCN-REQ) message** in its entirety.]*

~~6.4.2.3.46 Scanning Interval Allocation Request (MOB_SCN-REQ) message~~

~~A MOB_SCN-REQ message may be transmitted by an MSS to request a scanning interval for the purpose of seeking neighbor BS, and determining their suitability as targets for HO.~~

~~An MSS shall generate MOB_SCN-REQ messages in the format shown in Table 85e:~~

~~Table 85e—MOB_SCN-REQ Message Format~~

~~Syntax~~	~~Size~~	~~Notes~~
~~MOB_SCN-REQ_Message_Format() {~~		
~~Management Message Type=?~~	~~8 bits~~	
~~Scan duration~~	~~12 bits~~	~~Units are frames~~
~~Start frame~~	~~4 bits~~	
~~}~~		

~~The following parameters shall be included in the MOB_SCN-REQ message,~~

~~**Scan Duration**~~

~~Duration (in units of frames) of the requested scanning period.~~

~~**Start Frame**~~

~~Measured from the frame in which this message was received. A value of zero means that it will start in the next frame.~~

Remedy Action 3:

*[Delete **6.4.2.3.47 Scanning Interval Allocation Response (MOB_SCN-RSP) message** in its entirety.]*

~~6.4.2.3.47 Scanning Interval Allocation Response (MOB_SCN-RSP) message~~

~~A MOB_SCN-RSP message shall be transmitted by the BS in response to an MOB_SCN-REQ message sent by an MSS. In addition, BS may send an unsolicited MOB_SCN_RSP. The message shall be transmitted on the basic CID.~~

~~The format of the MOB_SCN-RSP message is depicted in Table 85f.~~

~~Table 85f—MOB_SCN-RSP Message Format~~

~~Syntax~~	~~Size~~	~~Notes~~
~~MOB_SCN-RSP_Message_Format() {~~		
~~Management Message Type=45~~	~~8 bits~~	
~~For (i=0 ; i<num_CIDs; i++) {~~		~~num_CIDs can be determined from the length of the message (found in the generic MAC header).~~
~~CID~~	~~16 bits~~	
~~Duration~~	~~12 bits~~	
~~Estimated time for hand-over~~	~~8 bits~~	
~~Start frame~~	~~4 bits~~	
~~}~~		
~~}~~		

~~The following parameters shall be included in the MOB_SCN-RSP message:~~

~~**CID**~~

~~Basic CID of the MSS that have sent MOB_SCN-REQ message.~~

~~**Duration**~~

~~Duration (in units of frames) where the MSS may scan for neighbor BS.~~

~~**Estimated time for hand-over**~~

~~Timing (in frames) for the hand-over. A value of zero indicates unknown, a value of one indicates the next frame relative to the frame in which this message is received.~~

~~**Start Frame**~~

~~Measured from the frame in which this message was received. A value of zero means that it will start in the next frame.~~

Remedy Action 4:

*[In **6.4.17 Sleep-mode for mobility-supporting MSS**, **6.4.17.1 Introduction**, page 31, paragraphs 1 thru 10, replace current section with:]*

6.4.17.1 Introduction

Sleep-mode is a mode in which MSS ~~SSs~~ supporting mobility may power down, scan neighbor BS, range neighbor BS, conduct hand-over/network re-entry, or perform other activities for which the MSS will be

unavailable to the Serving BS for DL or UL traffic. Sleep-mode is intended to enable mobility-supporting MSS ~~SSís~~ to minimize their power ~~energy~~ usage and facilitate hand-over decision and operation while staying connected to the network; but sleep-mode use should not be narrowly interpreted. Implementation of sleep-mode is optional.

~~An SS that supports sleep-mode can be in one of two modes:~~

- ~~Awake~~
- ~~Sleep~~

~~When an MSS is in awake-mode, it can receive and transmit PDUs in a normal fashion. When the SS is in a sleep-mode, it does not send or receive PDUs. In sleep-mode the SS may power down.~~

~~Two intervals are defined:~~

~~**Sleep-interval**~~
~~A time duration, measured in whole frames, where the SS is in sleep-mode. During consecutive sleep periods the sleep-interval shall be updated using an exponentially increasing algorithm with adjustable minimum and maximum limits.~~
~~**Listening-interval**~~
~~Length, measured in whole frames, of the listening interval. During this interval the SS shall decide whether to stay awake or go back to sleep based on an indication from the BS.~~

An MSS in sleep-mode shall engage in a sleep-interval, defined as a time duration, measured in whole frames, where the MSS is in sleep-mode. The sleep-interval is constructed of one or more variable-length, consecutive sleep-windows, with interleaved listening-windows, through one or more sleep-window-iterations. During a sleep-window, an MSS does not send or receive PDUs, has no obligation to listen to DL traffic and may power-down one or more physical operation components. During a listening-interval, an MSS shall synchronize with the Serving BS downlink and listen for an appropriate MOB_TRF-IND traffic indication message. The MSS shall decide whether to stay awake or go back to sleep based on a positive MOB_TRF-IND from the Serving BS. During consecutive sleep-windows and listening-windows, comprising a single sleep-interval, sleep-window shall be updated using the algorithm as defined in 6.4.17.2 Sleep-window update algorithm.

Before entering sleep-mode the MSS ~~SS~~ shall inform the BS using MOB_SLP-REQ and obtain its approval. Serving BS shall respond with a MOB_SLP-RSP message. Serving BS may send an unsolicited MOB_SLP-RSP to MSS to initiate MSS sleep-mode. Upon Serving BS transmittal of an affirming MOB_SLP-RSP, Serving BS shall initiate aging timer (MSS Sleep-Aging-Timer, see Table 264a) to coincide with initiation of sleep-interval at start-frame. After receiving an MOB_SLP-RSP message from the BS, an MSS shall enter sleep-mode by beginning sleep-interval at the appropriate frame proscribed by start-frame.

An MSS ~~SS~~ shall awaken ~~awake~~, enter into an interleaved listening-window, according to the sleep-interval and check whether there were PDUs addressed for it. The listening-window parameter defines the maximum number of whole frames the MSS shall remain awake waiting for a MOB_TRF-IND message. Traffic indication message (MOB_TRF-IND) shall be sent by the BS on the broadcast CID during each appropriate MSS listening-window~~when there an MSS in listening interval of sleep-mode~~. If the number of positive indications is zero, the BS sends an empty indication message, that is, MOB_TRF-IND ~~TRF-IND~~ message with num-positive=0. The BS may buffer (or it may drop) incoming PDUs addressed to the sleeping ~~SS~~MSS, and shall ~~a~~ send notification to the MSS ~~SS~~ in its listening-window about whether data has been addressed for it

during a preceding interval~~in itís awakening periods~~. If such PDUs exist, or if listening interval passed but the MSS didn't receive any TRF-IND message, the MSS ~~it~~ shall remain awake, terminating the sleep-interval and re-entering Normal Operation.

~~When its sleep-interval timer expires, the MSS shall awake to listen to the DL transmissions. If, during the listening interval, the MSS receives a TRF-IND message with a positive indication to the MSS, it shall remain awake. If the listening interval passed but the MSS didn't receive any TRF-IND message, it should return to awake state. If, during the listening interval, the MSS received at least one TRF-IND message but there is no positive indication for the MSS, it may return to its sleep-mode. The listening-interval parameter defines the maximum number of frames the SS shall remain awake waiting for the TRF_IND message.~~

An SS may terminate sleep-mode and return to Normal Operation ~~awake-mode~~ anytime (i.e. there is no need to wait until the sleep-interval is over). If a Serving ~~the~~ BS receives a PDU ~~an MPDU~~ from an ~~SS~~ MSS that is supposed to be in sleep-mode, the BS shall assume that the ~~SS~~ MSS is no longer in sleep-mode. Any UL message from the MSS to the Serving BS shall interrupt the sleep-interval, shall signal the Serving BS that the MSS is still active and connected and has not dropped connection during its sleep-interval, and the Serving BS shall terminate the aging timer (MSS Sleep-Aging-Timer, see Table 264a).

Upon completion of sleep-interval, the MSS shall awaken and return to Normal Operation. .

If the intervening interval of MSS absence exceeds the aging timer, then the Serving BS shall assume loss of connection to the MSS and process as if it had received a backbone message announcing another BS becoming the Serving BS for the specified MSS (see section Backbone network HO procedures).

Remedy Action 5:

*[In **6.4.17.2 Sleep-interval update algorithm**, page 38, paragraph 1, replace current paragraph with:]*

An MSS shall use the following algorithm for calculating the sleep-window duration, in whole frames, for performing the sleep-interval:~~enter sleep-mode after receiving an SLP-RSP message from the BS. In the first time it enters sleep-mode, it shall use the initial-sleep window value for the sleep interval. If during the following listening interval the BS has not signaled that traffic has been addressed for the MSS, the MSS shall re-enter sleepmode an double the duration of the sleep-interval. This procedure shall be repeated as long as the resulting sleep-interval does not exceed the final-sleep window value. The following formula defines the calculation of the duration of k^{th} sleep-interval – I_k:~~

$$\begin{cases} I_0 = \text{initial-sleep window} \\ I_k = min\{2 \cdot I_{k-1}, \text{final-sleep window}\} \quad k > 0 \end{cases}$$

$$\begin{cases} I_k = min\{\text{initial-sleep-window} + \text{initial-sleep-window} \bullet \text{sleep-window-factor} \bullet (k-1), \\ \quad \text{final-sleep-window}\} \quad k > 0,\ k < \text{sleep-window-iterations} \end{cases}$$

~~When the MSS has reached the final-sleep window size, it shall continue in sleep mode without further increasing the sleep-interval. The next sleep interval window shall start from the end of the previous one.~~

Upon completion of sleep-interval, MSS and BS shall return to Normal Operation.

Remedy Action 6:

*[In **6.4.2.3.42 Sleep Request message (MOB_SLP-REQ),** replace **Table 85a—Sleep-Request (MOB_SLP-REQ) message format** with:]*

‘**Table 85a—Sleep-Request (MOB_SLP-REQ) message format**

Syntax	Size	Notes
MOB_SLP-REQ_Message_Format() {		
Management Message Type=45	8 bits	
reserved	2 bits	
initial-sleep-window	6 bits	
Sleep-window-factor	4 bits	
final-sleep-window	10 bits	
sleep-window-iterations	10 bits	
listening interval	8 bits	
}		

‘

Remedy Action 7:

*[In **6.4.2.3.42 Sleep Request message (MOB_SLP-REQ)**, paragraph 2, replace current paragraph with:]*

‘Parameters shall be as follows:

initial-sleep-window

Requested start value for sleep-window for the sleep-interval (measured in frames).

sleep-window-factor

Multiplying factor for increasing the sleep-window value through multiple sleep-window-iterations

final-sleep-window

Requested maximum sleep-window value for the sleep-interval (measured in frames).

sleep-window-iterations

Number of iterations of sleep-window to perform prior to completing sleep-interval

listening interval

Requested listening interval (measured in frames) to the MOB_SLP-REQ.’

Remedy Action 8:

*[In **6.4.2.3.43 Sleep Response message (M0B_SLP-RSP),** replace paragraph 1 and **Table 85b—Sleep-Response (MOB_SLP-RSP) message format** with:]*

~~T~~The MOB_SLP-RSP message shall be sent from a Serving BS to an MSS on the ~~MSSís~~ MSS’s ~~basic~~ Basic CID in response to an MOB_SLP-REQ message, or may be sent unsolicited. The MSS shall enter sleep-mode using the parameters indicated in the message. In the case where sleep is denied (After-REQ-action=1), it is recommended that the Serving BS provide unsolicited MOB_SLP-RSP message before the expiration of the time interval specified by the REQ-duration field.

‘**Table 84b—Sleep-Response (MOB_SLP-RSP) message format**

Syntax	Size	Notes
MOB_SLP-RSP_Message_Format() {		
Management Message Type=46	8 bits	
Sleep approved	1 bit	0: Sleep-mode request denied 1: Sleep-mode request approved
Reserved	2 bits	
If (Sleep-approved == 0) {		
After-REQ-action	1 bits	0: The MSS may retransmit the MOB_SLP-REQ message after the time duration (REQ-duration) given by the BS in this message 1: The MSS shall not retransmit the MOB_SLP-REQ message and shall await the MOB_SLP-RSP message from the BS
REQ-duration	4 bits	Time duration for case where After-REQ-action value is 0.
} else {		
Start frame	7 bits	lower byte of the frame number in which the MSS shall enter into sleep-mode
initial-sleep-window	6 bits	
sleep-window-factor	4 bits	
final-sleep-window	10 bits	
sleep-window-iterations	10 bits	
listening interval	8 bits	
SLPID	16 bits	Allowed range: 0..1023
}		
}		

‘

Remedy Action 9:

*[In **6.4.2.3.42 Sleep Response message (M0B_SLP-RSP)**, paragraph 2, replace current paragraph with:]*

‘Parameters shall be as follows:

Sleep approved

Response indication whether or not MSS request to enter sleep-mode has been approved by the BS.

0: Sleep-mode request denied

1: Sleep-mode request approved

After-REQ-action

On MSS request to enter sleep-mode rejected by the BS, indicates recourse action.

0: The MSS may retransmit the MOB_SLP-REQ message after the time duration (REQ-duration) given by the BS in this message
1: The MSS shall not retransmit the MOB_SLP-REQ message and shall await the MOB_SLP-RSP message from the BS

REQ-duration
Waiting value for the MOB_SLP-REQ message re-transmission (measured in frames)

Start-frame
Lower byte of the frame number in which the MSS shall enter into sleep-mode.

initial-sleep-window
Start value for sleep-window for the sleep-interval (measured in frames).

sleep-window-factor

Multiplying factor for increasing the sleep-window value through multiple sleep-window-iterations

final-sleep-window
Maximum sleep-window value for the sleep-interval (measured in frames).

sleep-window-iterations

Number of iterations of sleep-window to perform prior to completing sleep-interval.

listening interval

Requested listening interval (measured in frames) to the MOB_SLP-REQ.

SLPID
This is a number assigned by the BS whenever an MSS is instructed to enter sleep-mode. This number shall be unique in the sense that it is assigned to a single MSS that is instructed to enter sleep-mode. No other MSS shall be assigned the same number while the first MSS is still in sleep-mode.'

Remedy Action 10:

*[In **10.1 Global Values**, **Table 264a—Parameters and Constants**, pages 43&44, append row to table:]*

System	Name	Time Reference	Min. Value	Default Value	Max. Value
BS	MSS Sleep-Aging-Timer	Nominal time for aging of MSS Sleep disconnect.			10500s

Remedy Action 11:

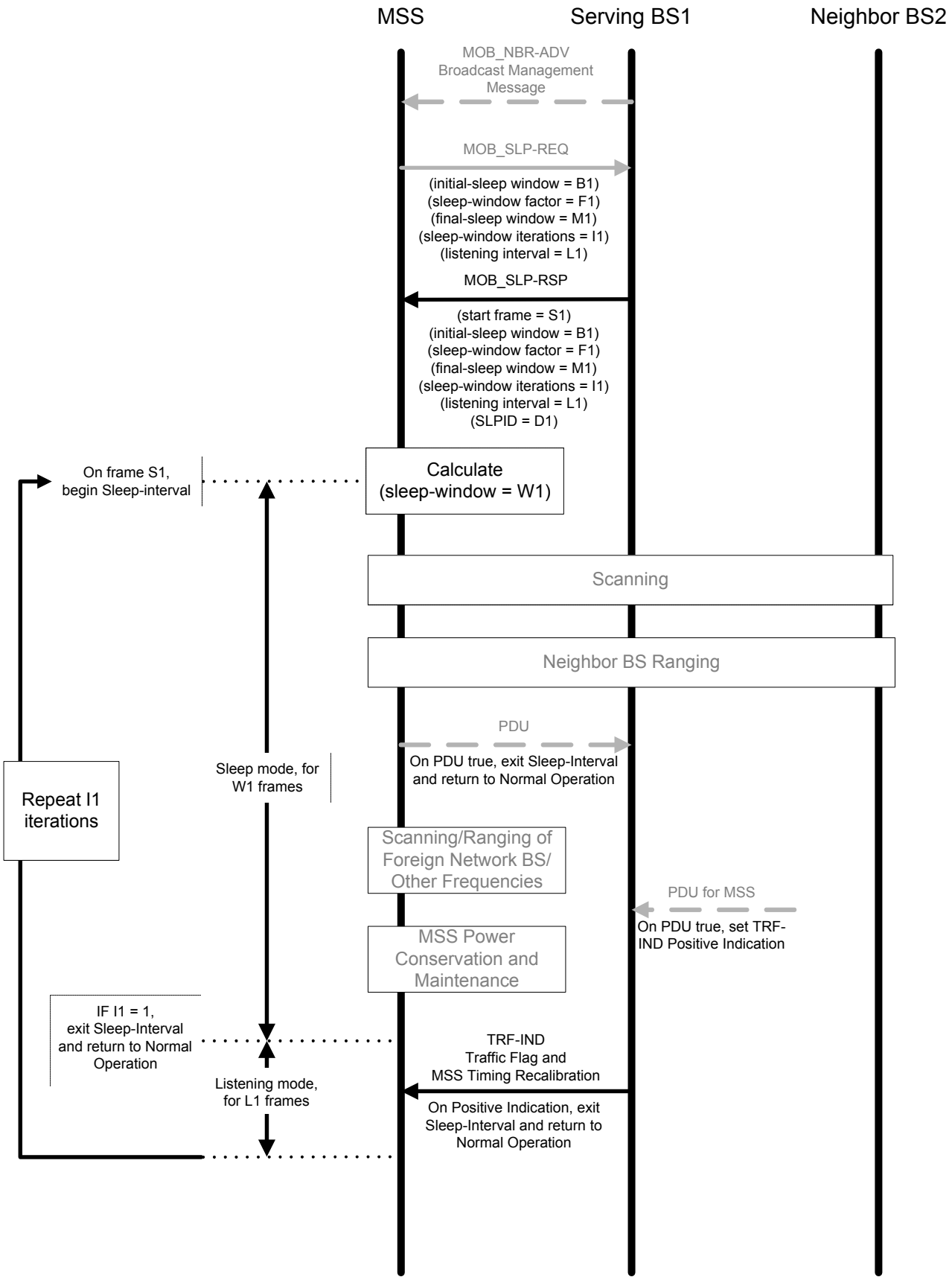
*[In **6.4.17.3 Traffic indication signaling**, page 39, replace current paragraphs with:]*

A BS shall notify each SS in sleep-mode, during its listening-interval, if traffic has been addressed to the MSS during any sleep-window iteration~~it~~. The indication is sent on the MOB_TRF-IND ~~TRF-IND~~ broadcast message. The MSS ~~SS~~ shall examine the frame number from the PHY Synchronization Field during each listening-window and shall verify ~~its~~ synchronization with the BS. If the expected frame number is different than the discovered~~found~~ frame number, the MSS ~~SS~~ shall return into awake mode, Normal Operation. Similarly, if the MSS does not find the expected MOB_TRF-IND broadcast message, the MSS shall return to Normal Operation.

If the SS recives a TRF-IND message with ~~ë~~num-positive~~í~~ field = 0, or no ~~CID~~ SLPID in the TRF-IND message matches the ~~SSís~~ MSS's ~~basic~~ SLPID~~CID~~, it shall consider this as a negative indication and shall continue in sleep mode. For an example of sleep mode operation, see Annex D.

Remedy Action 12:

*[In **Annex D.2**, page 68, replace **Figure D.11** with:]*



Remedy Action 13:

*[In **Annex D.2**, pages 69 & 70, delete **Figures D.12** and **D.13** entirely]*