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Agenda Item:	**Release 2000 items**
Source:	**Mitsubishi Electric Trium-RD**
Title:	**Reinforced Synchronisation Interval (RSI interval)**
Document for:	**Discussion**

1 Introduction

This contribution proposes to enhance cell search on surrounding cells.
This paper issues the problem of cell search acquisition time, due to the low (10%) SCH duty cycle. We propose to increase the duty cycle of this channel on some occasions, called hereafter Reinforced Synchronisation Interval (RSI). If cell search is performed on these occasions, the UE gather a lot of SCH symbols, making the measure much more efficient in terms of required time, quality, complexity, and power consumption.

We foresee to apply this scheme when a UE has to synchronise on a cell and can get some information about this cell, which is the case e.g. in selection mode or handover preparation. We also propose to use the scheme for positioning and we propose two different methods adapted from current IPDL [1] [2] and TA-IPDL [3].

We insist on the fact that this has a slight impact on the standard, we just had a bit more synchronisation signal and that this is fully compliant with R'99 UE which can still operate as now.

References:

[1] Tdoc SMG2 UMTS-L1 327/98 Method for downlink positioning (IP-DL), Ericsson
[2] TSGR1#4(99)346 Recapitulation of the IPDL positioning method, Ericsson
[3] TSGR1#7(99)b79 Time Aligned IP-DL positioning technique, Motorola
[4] TSGR1#9(99)L61 Draft liaison statement on the inclusion of IPDL in the layer 1
[5] TSGR2#R2(99)h93 discussion on Signalling for Time-Aligned IPDL, Motorola

2 RSI Description

The basic idea is to intensify the synchronisation channel signals (primary and secondary) on some occasions called RSI. These occasions can be periodic or follow a pseudo-random pattern. The pseudo-randomness minimises systematic collision between RSI of different cells. The RSI frequency can be set constant or an operator parameter, a typical value can be, e.g. in the order of 100ms.

The RSI should be long enough to allow a synchronisation with a single RSI and short enough not to be too disturbing. To achieve this, we propose to use 15 SCH symbols in the RSI (as in a frame).

There are many ways of arranging SCH symbols in the RSI. We suggest to follow two basic principles: keep the current SCH structure unchanged and make the order simple. Therefore, within the RSI, the SCH symbols that already exist from the current SCH structure (i.e. the 256 first chips of each slot) are transmitted unchanged. These SCH symbols are called hereafter *basic* SCH symbols. Regarding the others SCH symbols of the RSI, hereafter called *auxiliary* SCH symbols, the order in the RSI is proposed to be chosen as a simple one to one correspondence with the order of the basic SCH symbols order in the frame.

Figure 1 and 2 represent a 1 ms long RSI with 15 SCH symbols. On both figures, the current SCH structure is represented above, then the SCH+RSI structure and the SCH symbols order in the RSI is shown. Figure 1 is illustrative, Figure 2 is more in accordance with the specs representation.

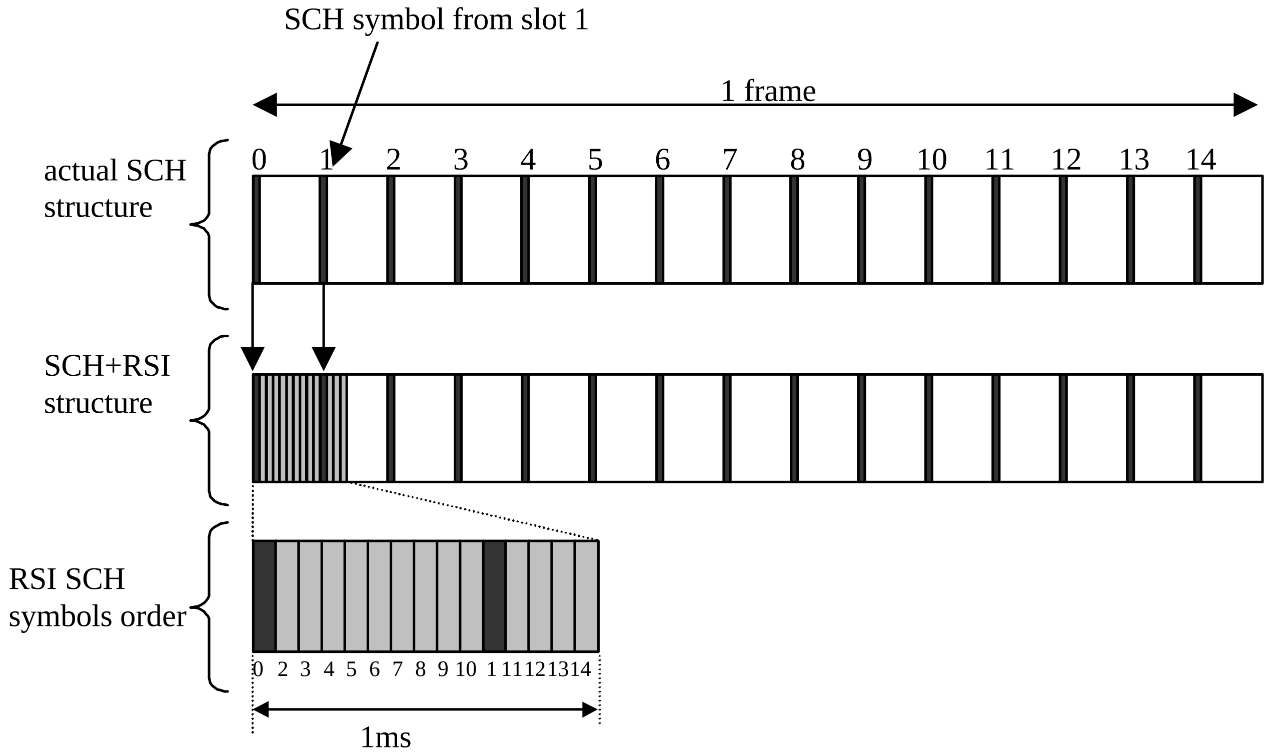


Figure 1: RSI of 15 SCH symbols

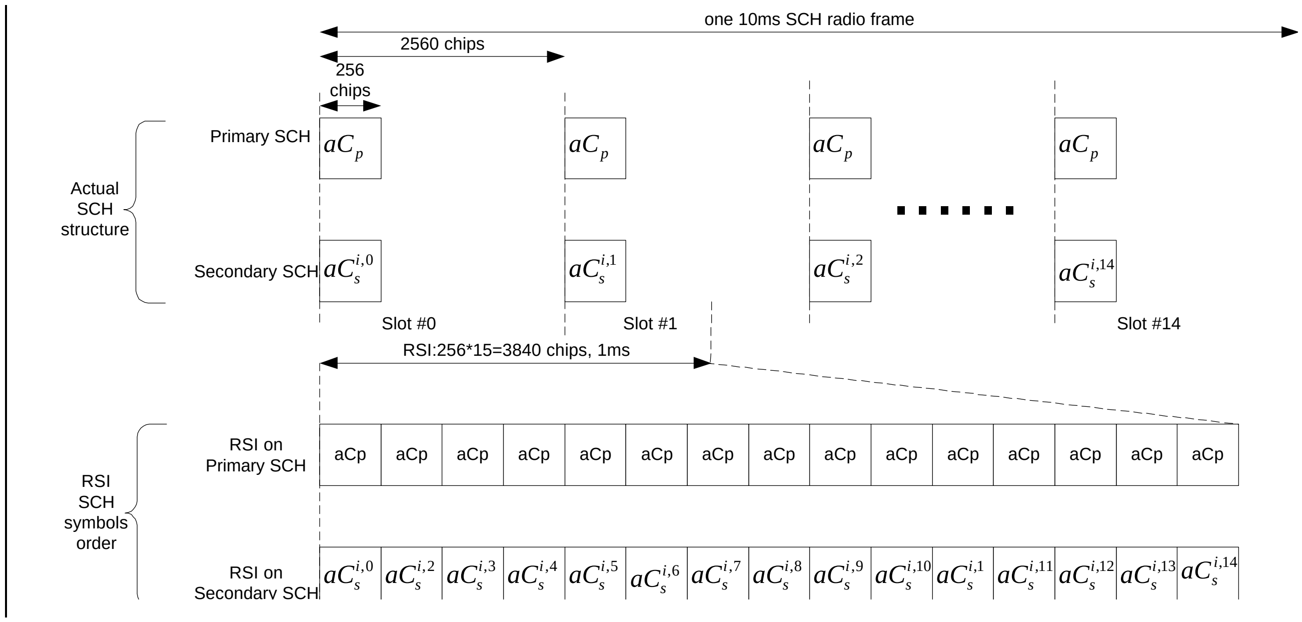


Figure 2: RSI of 15 SCH symbols

Depending on its period, the RSI can start at any place in the frame. In figure 1 it starts on slot 0, in figure 3 on slot 4.

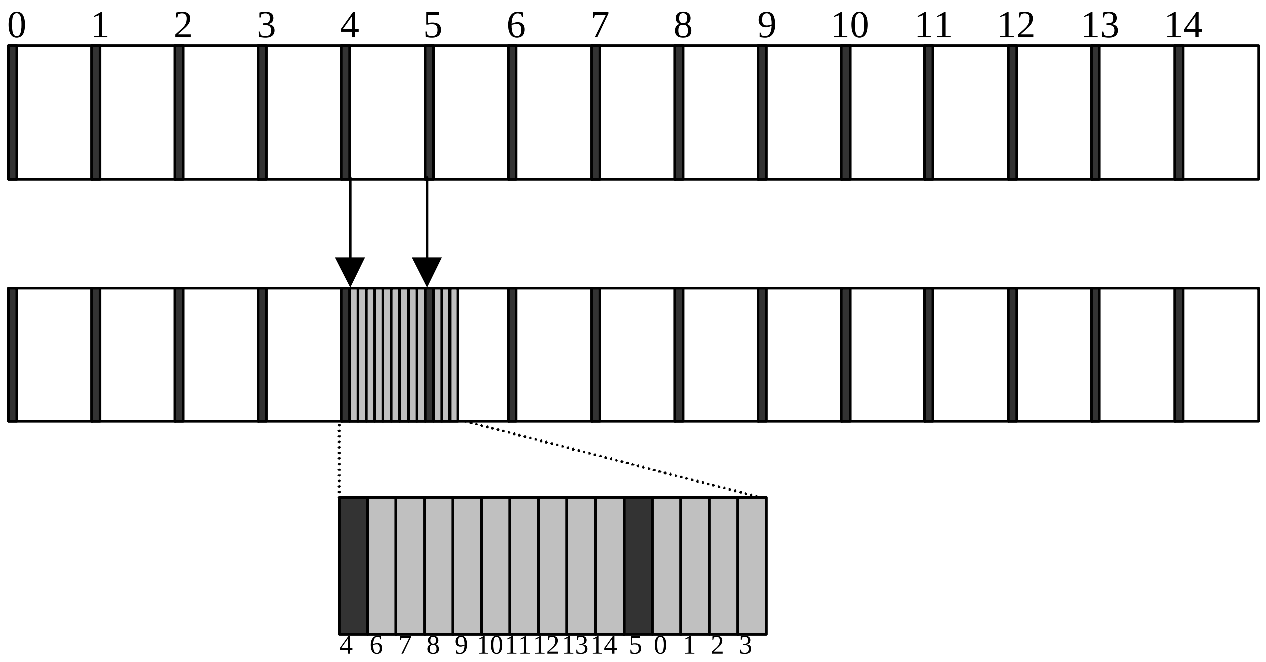


Figure 3:RSI of 15 SCH symbols on slot 4

3 Processes benefiting from the RSI

First we think about all processes where a UE synchronises on a neighbouring UMTS cell. These occur in different situations as listed in table 1

Situation	mode	Serving cell type	Target cell type	Same carrier frequency
1	connected	UMTS-FDD	UMTS-FDD	yes
2		UMTS-FDD		no
3		GSM		no
4	idle	UMTS-FDD		
5		GSM		

Table 1

Measurement time is variable depending on the situations. In situations 1,2 and 3 the UE is free to arrange it as it wants. In situation 2, the measurement time is the Transmission Gap Length. In GSM connected mode, UE measure between downlink and uplink slots and between uplink and downlink slots, if the RSI falls in an idle frame the UE has the full frame.

Positioning can be improved using the RSI. Currently positioning is preferably based on the CPICH [1], [2], [3]. SCH is not of great interest because, at best, a single SCH symbol is detected every idle period. Scanning neighbouring cells timing based on the SCH symbols of the RSI is more efficient than using CPICH symbols. Another alternative is to first use the RSI and then refine or confirm the timing with the CPICH.

4 RSI requirements and functionality

In all previous situations, to detect a RSI, the UE must be aware when it is about to happen (a continuous blind detection would remove the benefits from the scheme). This can be easily achieved by network signalling. This signalling can be carried along with the neighbouring cell list transmitted via the BCH or DCH, this signalling can be compared to the signalling required in IPDL [2], [4].

4.1 requirements on the network

- Node B need to know the relative timing of surrounding cells. This issue has already been addressed [1], [2], [5].
- Some signalling is required for the UE to predict approximately RSI occasions.
  We propose to signal RSI parameters together with other information relative to synchronisation on the neighbouring cell list like i.e. scrambling code number of surrounding cells.
  Let t_0 be the time of transmission of the first RSI in the SFN cycle of the serving cell, t_n the time of transmission of the n^{th} RSI, T the RSI mean period. Then for a periodic RSI $t_n = t_0 + n\times T$, for a pseudo-random RSI $t_n = t_0 + n\times T + \Delta T_n$.
  ΔT_n is related to a known pseudo-random law, so no need to be signalled if the law is common to all Node B (where t_0 is different).
  T has to be signalled only if this is an operator parameter. t_0 shall be signalled.
  Again, signalling t_n is very similar to signalling idle periods patterns in IPDL and TA-IPDL.
  An other parameter to be signalled is the slot number [0-14] of the first RSI (at t_0) in the target cell. This parameter is useful for SCH symbols reordering.

4.2 Network functionality

- Concerning cell search, on the network side, the only functionality is to signal RSI parameters of surrounding cells. In situation 2, the network has to set Transmission Gap so that RSI falls in it.
- Regarding positioning, we propose two techniques, close to the IPDL and TA-IPDL, taking advantage of the RSI. The idea is again to set RSI of adjacent cells during the transmission gaps of the serving cell.

4.2.1 RSI cell planning

This technique applies to networks where cell Node B's are synchronised between them, i.e. the Node B's time bases are controlled to avoid clock drift between Node B's.

The idea is to have a cell planning with N cells, so that RSI occurs successively within the same cell set and simultaneously within the corresponding cells of the different sets. The technique can be complemented by a similar dual planning of transmission gaps. Such planning can be easily achieved e.g. via the planning of a time offset of a same repeated pattern, as shown in the below figure.

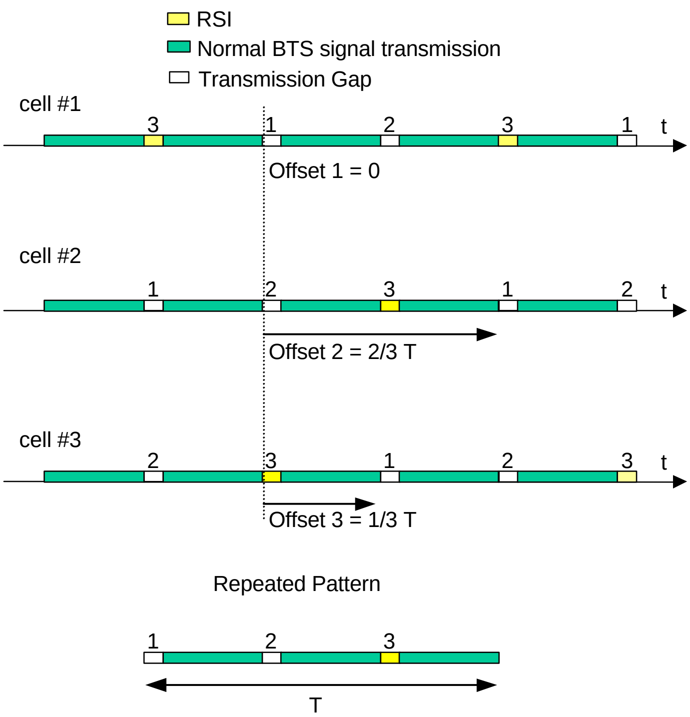


Figure 4: RSI and transmission gap Planning via repeated patterns (N=3).

Figure 4 and 5 represent a set of N=3 cells. The 3 different situations are illustrated. The shaded cells mean that they transmit their RSI and the non-shaded ones mean that they are off i.e. in idle period. Shaded cells for idle period and non-shaded cells for RSI is another alternative depending on operator choice.

This technique is expected to give good positioning performance, it is easy to set and is conflict-free but implies a synchronised (not necessarily synchronous) network.

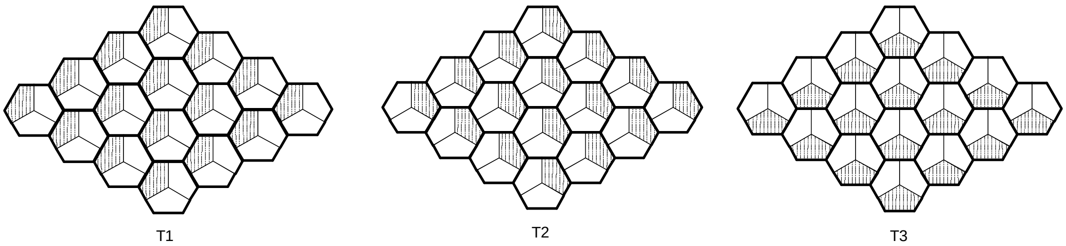


Figure 5: example of cell planing (N=3)

The idea can be extended to a planning of Node B, the areas represented above are then Node B having e.g. 3 three cells. This can be seen as a particular case of a cell planning.

4.2.2 RSI master and idle period slave

This technique applies to networks where Node B are not necessarily synchronised between them, i.e. the Node B's time bases drift.

In IPDL and TA-IPDL Node B keep silent according to a pseudo-random or a periodic pattern. The pseudo-randomness minimises systematic collisions. Instead of using a pattern of silence, we propose to use a pattern of RSI which is pretty much the same. When a RSI happens in a cell, surrounding cells are off. We propose that the Node B switch off all signals except their RSI. This should limit harmful conflicts effects, i.e. two simultaneous RSI. Indeed the near-far effect caused by the RSI of the serving cell shouldn't prevent from detecting the RSI from the neighbouring cell, especially since the others surrounding Node B are silent.
On figure 6, 3 Node B are successively off according to surrounding cells RSI. They are not off for each RSI to avoid too much idle period on a Node B.

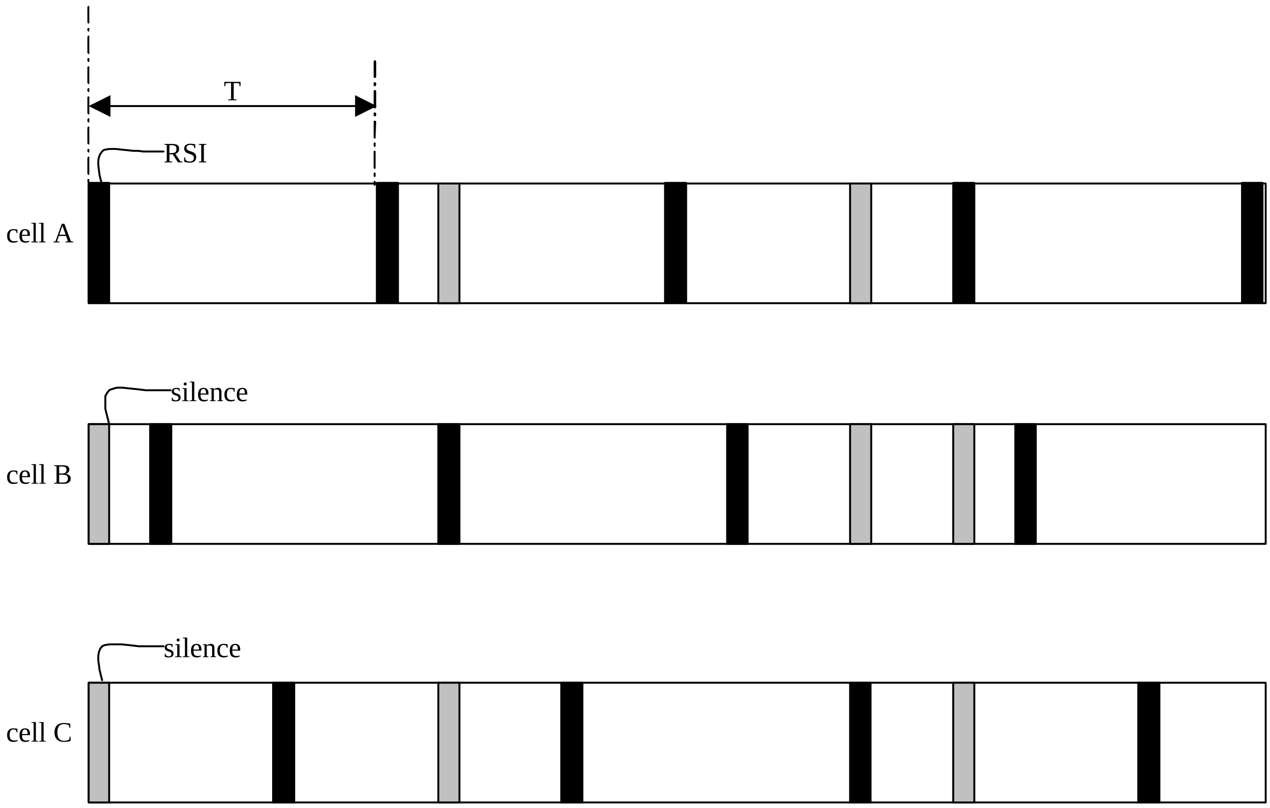


Figure 6: example of RSI and corresponding silences for 3 Node B

4.3 Requirements on the UE

The UE should be able to get the RSI parameters and then derive the next RSI occasion. It should also be able to detect the RSI and deduces the timing information, which is pretty similar to current cell search. The only difference is for step1 the circular integration is carried out on a 256 chip basis instead of 2560chips, and for step2, once the code word decoded, it should perform a simple reordering.

4.4 UE functionality

UE functionality is pretty simple: first get the RSI parameters of neighbouring cells and then detect RSI when it happens.

5 Benefits

As a complete RSI should, in many cases, be enough for a reliable synchronisation, a single measurement window is needed. Benefits are thus

1. **Speed up measurements procedures**
   This comes directly from the reduced measurement windows (in length or in number) and particularly because if a single one is required, no more need to gather SCH symbols over several discontinuous measurement windows.

2. **Resource saving.**
   Using less measurement windows frees space for other measurements.
   For instance, UMTS cell search for GSM UE is less “measurement time consuming”, leaving some extra time for others measurements, e.g. on GSM cells.
   Compressed modes TGL can be shorten, considering that a current 14 slots gap contain less SCH symbols than a 3 slots gap including a RSI.

3. Reduced complexity.
   No more need to monitor SCH symbols coming from several measurement windows.
   Moreover, as far as positioning is concerned, using the SCH instead of the CPICH is much more appropriate for correlation complexity.
   With a shorter measurement time, buffering for off-line correlations is more easily achievable.

4. Reduced power consumption.
   Because measurement time is shorter, thus less correlation (only for first synchronisation step which is the more resource consuming).

5. Improved measurement quality for a given measurement time.
   For instance, considering compressed mode with 7 gaps, the number of SCH symbols is increased from 7 to 20 (without taking into account the PLL locking time). Concerning positioning, after synchronisation with the RSI, the measure can be then refined with the CPICH.

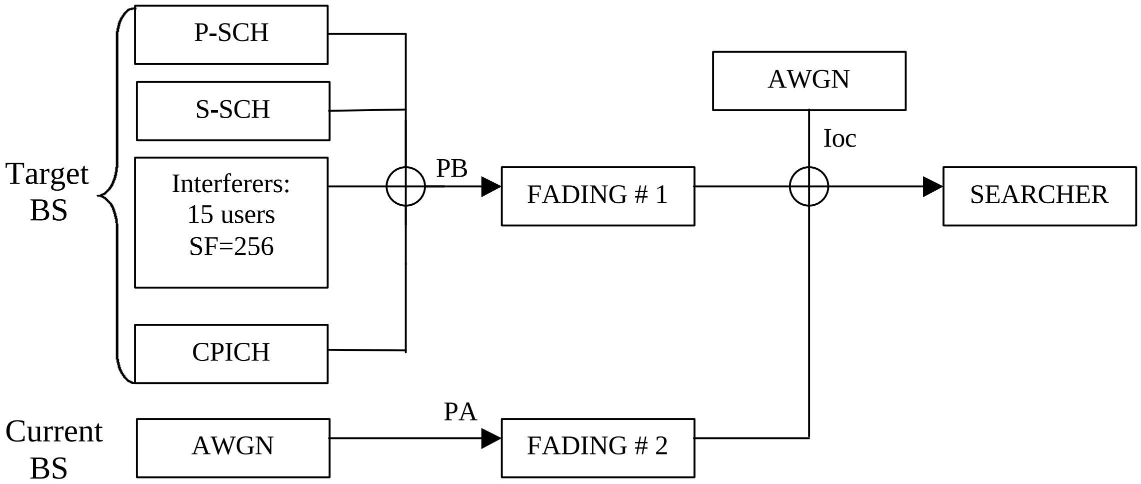
6 Simulation results

For a first evaluation of RSI performances, we focus on the gain in term of Transmission Gap Length.
Simulations conditions are those of handover. However, more generally than handover scenario, simulations goal is to see how much acquisition time can be shorten through the RSI. For this reason last synchronisation step (CPICH) is not considered here, Transmission Gaps occur in consecutive frames (i.e. TG pattern are not taken into account) and candidate cell list has a single element.

As previously explained, the RSI brings auxiliary SCH symbols improving target cell search performances. To evaluate RSI benefits, we have simulated the mean Transmission Gap Length needed for a correct target cell search.

Four cases have been considered:
1. basic SCH i.e. current SCH structure with TGL=14
2. basic SCH structure with TGL=5
3. basic SCH+RSI structure with TGL=5
4. basic SCH+RSI structure with TGL=3

Simulations conditions are depicted above.



Parameters	Values
P-SCH power	5 % of total base station power
S-SCH power	5 % of total base station power
CPICH power	10 % of total base station power
DPCH power modeled by 15 users with Spreading Factor of 256	80 % of total base station power
Channel model	Single path Raleigh fading
Vehicular speed	3 km/h
Oversampling	2
Target cell power / Primary cell power = PB/PA	-6 dB
PA/Ioc	-8dB to –2dB
Number of SCH symbols per RSI	15

Results are reported in figure 7.

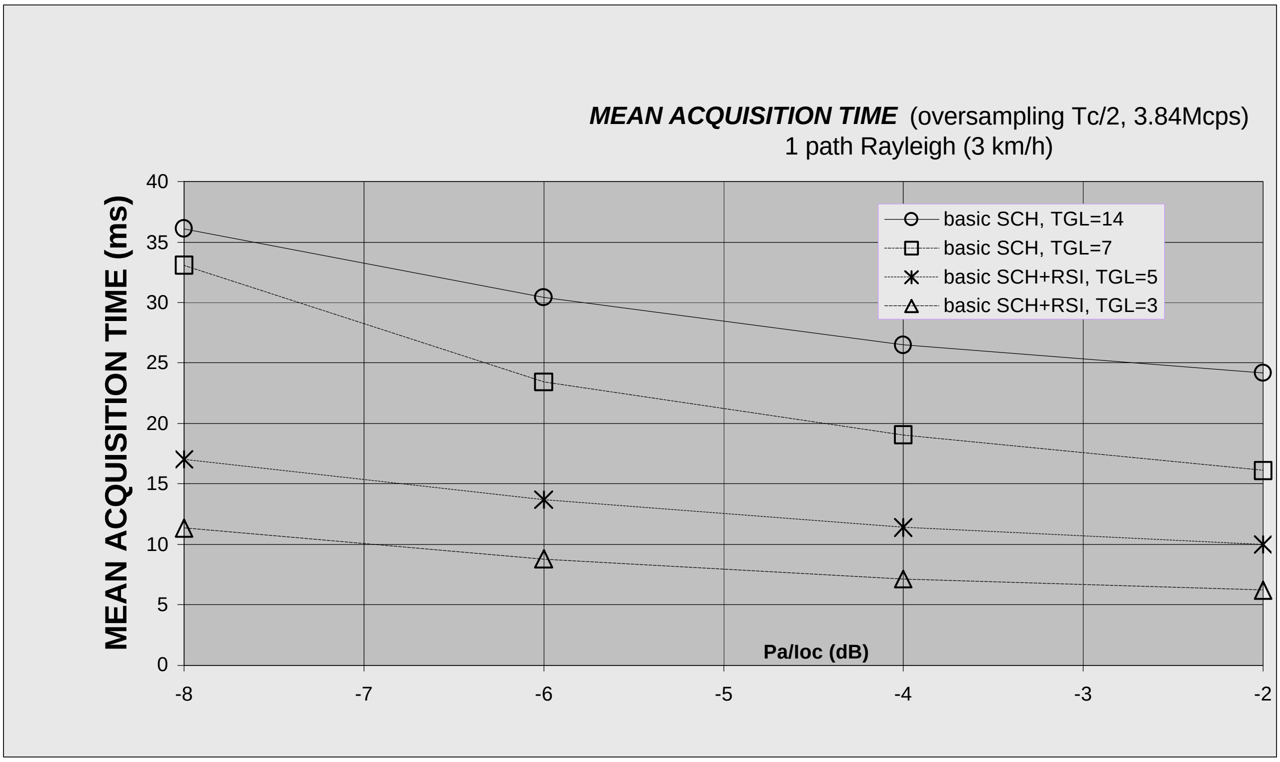


Figure 7: mean acquisition time performance

It can be seen that using a TGL of three slots improves significantly mean acquisition time.

7 Impacts on the standard

From Layer 1 point of view, an extension to the SCH structure should be added, describing the RSI.
Higher layers signalling is required.

7 RSI parameters are adaptive

RSI parameters and configurations can evolve according to what seems to suit best.
For instance, RSI can be periodic or pseudo-random. The number of SCH symbols in a RSI can be increased or decreased. SCH symbols in a RSI are not necessarily packed together, some chips can space them out. Others codes than classical SCH codes can be adopted (except those at the beginning of the slots to keep the current SCH structure unchanged).

8 Conclusion

We propose to intensify the synchronisation channel signals on some occasions. This has few impacts on the standard but improves cell search and positioning.