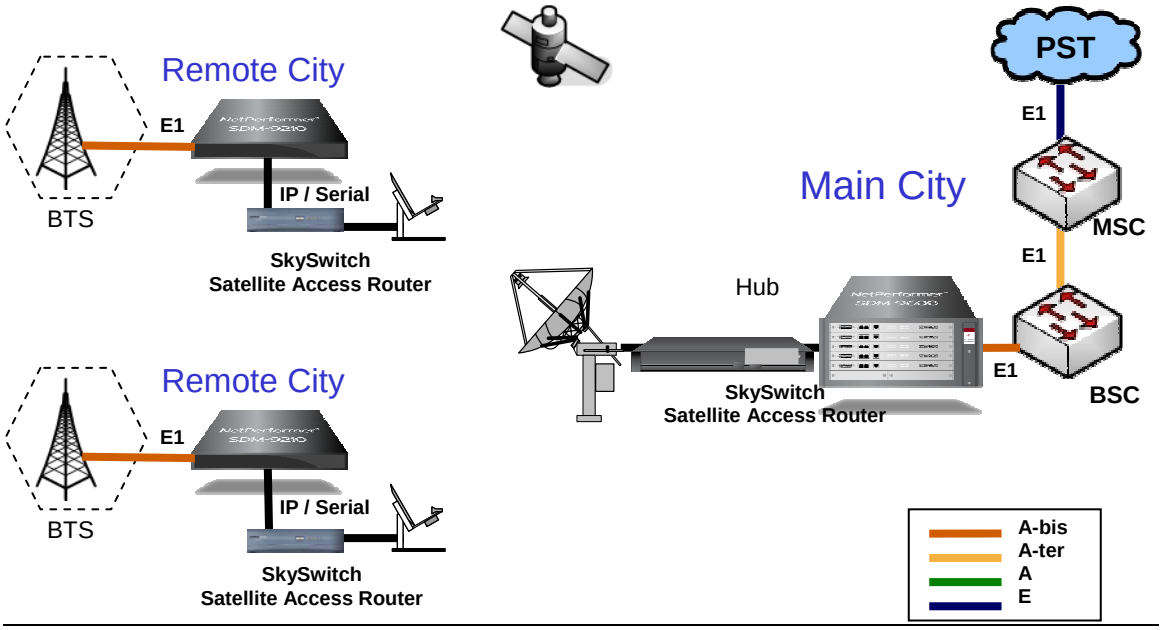
SUBJECT: SkyCell and Economics of SatPath's GSM Abis Solution

1.0 OVERVIEW

The cost of extending the GSM Network terrestrial infrastructure from the Base Station Controller (BSC) and Mobile Service Switching Center (MSC) to isolated Base Transceiver Station (BTS) cell sites most often does not justify the revenue return for the capital investment and its operating costs. Satellite Infrastructure represents the most viable alternative for various reasons including lack of reachable terrestrial backbone infrastructure, time to deploy, simplicity of site equipment etc. However, the GSM operator sooner than later realize that traditional Fractional E1-SCPC and (DVB/TDM)/TDMA VSAT networks' operating cost are either prohibited or do not have a favorable ROI figure, this is mainly driven by the space segment expense.

In view of this market need, SatPath has conducted engineering and system integration design tradeoffs for satellite GSM Networking using its SkySwitch Satellite DAMA/BoD Platform and Verso Netperformer. As a result, SatPath has introduced a GSM backhaul solution that can dramatically reduce the capital investment and its operating costs, without compromising any cellular performance characteristics. The figure below illustrates our proposed network level diagram, based on the results of this effort for the BTS-BSC GSM network expansion. This solution is so powerful and flexible that it can also extend the GSM network over the satellite at the BSC-MSC and the MSC-MSC levels.



SatPath has brand named this solution "SkyCell" which consist of the seamless integration of SatPath's SkySwitch Satellite IP Network system and Verso's Netperformer GSM optimizer. The most important benefit of this solution is the dramatic reduction of Bandwidth expense as compared to other satellite technologies and yet it outperforms them in preserving the functionalities of the GSM Network and the quality of the voice transmission. SkyCell claim to fame statement:

- **50% saving comparing with TDMA VSAT based solution.**
- **20% saving comparing with SCPC-PAMA based solution**
- **50% saving with GSM Optimization**

2.0 Typical Traffic Requirements for a BTS-BSC GSM Network extension

The Abis interface which is used between the BTS and the BSC for GSM cellular networks is inherently bandwidth inefficient. The transmission rate of the Abis interface is 2048 kbps (E1), which is partitioned into thirty-two 64 kbps sub channels. Voice traffic channels on the Abis interface are compressed and four to eight GSM traffic voice channels can be packed into a 64 kbps time slot.

Typically, a BTS supports two to twelve Transmit/Receive modules (TRX), where each TRX consumes two time slots with air voice channels in city areas. Remote cells in rural areas are typically configured with one to four TRXs. In addition to the time slots for compressed air voice, each Abis channel requires an uncompressed time slot for signaling and one uncompressed time slot for O&M signaling/data/transmission control information (optional).

SkyCell system solution works two fold: First, it optimizes the GSM Abis interface to network only actual traffic at the minimum rate over an IP interface using Netperformer Algorithms and Second: it time manages each BTS-BSC links data rate commensurate with actual real time IP traffic thus minimizing transponder bandwidth using the DAMA/BoD SkySwitch System. In addition, the fact that the satellite access scheme is a MCPC/SCPC with dynamic, variable bandwidth using DAMA/BoD SkyCell offers less latency and jitter than competing TDMA solutions and extremely fast set up times.

3.0 Bandwidth Savings for the GSM Abis Optimization/Compression

A number of techniques are used to save Bandwidth at the Abis level. Here the inefficient Abis TDM interface is converted into an efficient IP Packet Based stream prior to satellite transmission. The most important techniques are described as follows:

- Use of PVCR algorithm to group packets with the same destination to reduce overhead

- Silence Suppression 40%, here idle channels and silence are suppressed from the IP Stream.

- Signaling Compression; This takes advantage of the fact that signaling is not a constant stream.

The following table represents the bandwidth savings resulting from the Abis optimization.

Number of TRX	A.bis Voice Channels	Bandwidth Required for A.bis (Kbps)		
		Transparent	Timeslot Grooming	Compressed A.bis (50% avg.)
1	8	2 048	256	*128*
2	16	2 048	448	224
3	24	2 048	640	320
4	32	2 048	832	416
6	48	2 048	1 216	608
8	64	2 048	1 600	800

One can realized that there is 50% average savings prior to satellite transmission. For a Typical Rural BTS the peak traffic will be in the 256-448 Kbps range, whereas the average transmission will be in the 128-224 Kbps range. This values will be taken into consideration in the satellite bandwidth cost analysis to be developed in the next paragraph.

4.0 SkySwitch Bandwidth Savings

With typical lease rates for multi-carrier satellite bandwidth in the range of US $ 3000 per month per MHz, Space Segment represents more than 60% of the operating cost of a typical GSM Satellite Network. Therefore this paper will concentrate on demonstrating how much bandwidth and operating cost SkyCell can provide in a typical GSM satellite Network.

A sample rural expansion of qty 10 BTS will be considered for this analysis. As we implied in the previous paragraph the IP data stream coming out of the BTS Abis Optimized interface is not constant, mainly due to the traffic pattern out of the BTS. This traffic varies between 1-4 TRXs during the day. For example purposes lets say between 2 and 8 TS in a typical BTS. This translates into a large number of voice calls since each TRX will handle between 7-14 calls depending on whether the voice compression is half, full or mixed rate. So the variation granularity may very well be 7 to 56 voice channels. One can characterized and size this traffic using Erlang-B Traffic Loading Tables and Blockage probability. In fact DAMA/BoD works pretty much as a PBX in the

sky, and hence the name SkySwitch. In our Sample Network that represents 70 to 560 calls maximum, one can argue more or less, but for the sake of simplicity lets take a conservative approach of taking 60% of this capacity active on the satellite. Rather than waste transponder capacity using static Bandwidth Assignments to each station, SkySwitch takes advantage of the variable nature of the telephone traffic to size the whole network capacity. As a result, this analysis shows that the equivalent of 24 TRXs worth of satellite capacity should fit the bill for network capacity. Here each BTS can be guaranteed between 0 TRXs to an average of 2-3 TRXs each depending on individual station need. Each station can then ramp up to their maximum capacity of 4 TRXs. This dynamic expanding and contracting of individual BTS-BSC link data rate to handle real time traffic requirements using a shared network bandwidth pool is the heart of the SkySwitch BoD advantage. The mechanism by which a given station goes from idle to active is called DAMA, here the BTS will come into the network with a minimum guaranteed that is programmable between 1-4 TRXs and can ramp up to a maximum peak of 4 TRXs or less (also programmable).

The following table summarizes each individual station capacity and compares costs to a static Bandwidth SCPC solution.

Station	PAMA Capacity TRXs	BoD/DAMA Capacity TRXs	PAMA Bit Rate using Fractional E1 (Kbps)	PAMA Bit Rate using Netperformer Optimizer (Kbps)	DAMA/BoD Bit Rate using Netperformer Optimizer (Kbps)
BSC	40	24	7808	4160	2400.00
BTS #1	4	2	832	416	224.00
BTS #2	4	2	832	416	224.00
BTS #3	4	2	832	416	224.00
BTS #4	4	2	832	416	224.00
BTS #5	4	3	832	416	320.00
BTS #6	4	3	832	416	320.00
BTS #7	4	3	832	416	320.00
BTS #8	4	2	832	416	224.00
BTS #9	4	3	832	416	320.00
BTS #10	4	2	832	416	224.00
Totals	80	48	16128	8320	5024
Total Occupied BW Required *			14600	7532	4548

*Assumes 0.718 TPC, QPSK Modulation, 1.3 Roll Off filtering

Total Savings	48.4%	68.85%
Total Dollar Amount Space Segment Savings in a 60 month contract	$1,272,240	$1,809,360
Additional Savings using DAMA-BoD		$537,120

5.0 SUMMARY

We have demonstrated how the SkyCell can stand behind its claim to fame. SkyCell utilizes the best of SCPC and BoD/DAMA technologies, whereas eliminates the inefficiencies of DVB/TDMA access and the use of SCPC without BoD/DAMA Bandwidth access. The advantages of SkyCell solution can be summarized as follows:

- **Lower equipment cost using SkySwitch VSAT product**
- **Lower operating cost with SkySwitch's Dynamic DAMA & BOD for bandwidth savings**

6.0 Contact Information

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