6. Optimisation of the VSAT Network

6.1. General Remarks

The traffic analysis and the topology considerations as presented in chapters 5.1 and 5.2 reflect the situation at the end of the first 3 years. The layout of the system must allow to operate all stations in this challenging environment although at the beginning of the realization the traffic will be much lower.

The system optimization with regard to the capabilities of the hardware to be procured has to meet the requirements for the phase of full deployment.

The optimization has been done for the final configuration and thereafter a possible rollout scenario has been developed together with AVU. This will allow to identify the start-up conditions for the first year and the growth potential for the second year.

6.2. Full Deployment

For the final configuration the optimization has been done for the two satellite systems namely NSS-7 and IS 901.

The results for NSS-7 can be summarized as follows:

To carry the total traffic at least two full 54 MHz transponders are required. But even then the total outbound of 90.4 Mbit/s cannot be loaded to the two transponders. Additional capacity would be needed to provide the missing 8 Mbit/s. However, after having gained sufficient experience during the first two years of operation the decision can be made on that.

The following Tables show the summaries of the link budgets:

NSS –7 Link Summaries

Outbound Optimisation (Full Transponder for year 3)

Hub: 6,5 m SFD: -90 dBW/m²

Satellite				VSAT Characteristics						Link Characteristics			
Name	BW MHz	EIRP dBW	G/T dB/K	Antenna m	G/T dB/K	Eb/No dB	FEC	RS	Sym. max Mbaud	Sym. requ. Mbaud	Data rate Mbit/s	PW margin dB	Hub TX pw Watt
NSS -7	54	38	-5	1,8	15	3,9	0,50	X	45	45,0	39,7	2,92	440
				1,8	15	5,1	0,75			45,0	59,0	0,00	
				2,4	17,5	6,4	0,88			45,0	69,4	0,13	

The solution with the 1.8m VSAT antenna and an FEC of ¾ has been selected as first approach to maintain the cost of the antenna as low as possible. The single transponder could then carry with the selected transmission parameters 59 Mbit/s.

Shared Transponder Optimisation (year 3)

Type A: Remote to Hub
Type B: Remote to Remote
Type C: Hub to Remote

Satellite					VSAT Characteristics						Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB	G/T dB/K	Service Type	Antenna m	TX bit rate Mbit/s	Eb/No dB	FEC	RS	VSAT TX Power/W	EIRP/carrier dBW	Sites active	Total sat EIRP/dBW	Occupied BW/MHz	Total BW MHZ
NSS -7	54	38	4,2	-5	A	1,8	0,2	7,7	0,75	-	5,9	9,2	100,00	29,16	0,18	18,00
						2,4	1,2	7,7	0,75	-	20,5	17,0	1,00	17,03	1,04	1,04
						2,4	0,03	7,7	0,75	-	0,5	0,9	53,00	18,16	0,03	1,59
					B	2,4	0,256	7,7	0,75		12,5	14,9	4,00	20,92	0,23	0,92
												Total Inbound:		30,27		21,55
					C	6,5	16,4	3,9	0,50	X	73,0	31,3	1,00	31,26	24,22	24,22
												Total:		33,80		45,77
NSS -7	54	38	3,0	-5	A	1,8	0,2	7,7	0,75	-	6,6	8,7	100,00	28,74	0,18	18,00
						2,4	1,2	7,7	0,75	-	22,1	16,5	1,00	16,52	1,04	1,04
						2,4	0,03	7,7	0,75	-	0,6	0,5	53,00	17,74	0,03	1,59
					B	2,4	0,256	7,7	0,75		14,6	14,7	4,00	20,74	0,23	0,92
												Total Inbound:		29,87		21,55
					C	6,5	23,6	4,5	0,66	X	145,3	33,4	1,00	33,40	26,40	26,40
												Total:		35,00		47,95

NSS-7 Summary

The table with the shared transponder optimization shows two different approaches with regard to the selected output backoff (OBO) of the transponder. With an OBO of only 3 dB the remaining outbound traffic is some 7 Mbit/s higher than with an OBO of 4.2 dB. The price to pay for that is an increased power demand for the VSAT transmitter of about 10%. This slight increase is justified by the increase in transmit capacity. The summary for the total outbound traffic is the following:

Full transponder at saturation:	59	Mbit/s
Shared transponder:	23.6	Mbit/s
Total	82.6	Mbit/s

INTELSAT 901

For the Intelsat 901 type of satellite the situation is compared with the NSS-7 different. IS 901 has a lower EIRP (36 dBW only and lower G/T (-7dB/K). There are two types of transponders some with a bandwidth of 36 MHz and others with 72 MHz bandwidth.

To carry the total traffic 3 36 MHz or 3 72 MHz transponders are required for the phase of full deployment. But similar as for the NSS-7 three transponders would not allow the full outbound as some Mbit/s are missing.

The details of the IS 901 link budgets is given in the following tables:

Outbound Optimisation (Full Transponder for year 3)

Hub: 6,5 m SFD: -90 dBW/m²

Satellite				VSAT Characteristics						Link Characteristics			
Name	BW MHz	EIRP dBW	G/T dB/K	Antenna m	G/T dB/K	Eb/No dB	FEC	RS	Sym. max Mbaud	Sym. requ. Mbaud	Data rate Mbit/s	PW margin dB	Hub TX pw Watt
IS 901	36	36	-7	1,8	15	3,9	0,50	X	45	35,8	31,5	2,00	440
				1,8	15	5,1	0,75			28,4	37,5	0,00	
				2,4	17,5	6,4	0,88			29,6	45,6	0,00	
IS 901	72	36	-7	1,8	15	3,9	0,50	X	45	45,0	39,6	1,03	440
				1,8	15	5,1	0,75			28,4	37,5	0,00	
				2,4	17,5	6,4	0,88			29,6	45,6	0,00	

For both transponder types the 1.8 m antenna has been selected. In case of the 36 MHz transponder FEC ¾ has been selected which provides a throughput of 37.5 MHz. For a 72 MHz transponder the FEC of ½ is more efficient.

Shared Transponder Optimisation (year 3)

Type A: Remote to Hub
Type B: Remote to Remote
Type C: Hub to Remote

Satellite					VSAT Characteristics						Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB	G/T dB/K	Service Type	Antenna m	TX bit rate Mbit/s	Eb/No dB	FEC	RS	VSAT TX Power/W	EIRP/carrier dBW	Sites active	Total sat EIRP/dBW	Occupied BW/MHz	Total BW MHZ
IS 901	36	36	4,2	-7	A	1,8	0,2	7,7	0,75	-	9,1	9,2	100,00	29,18	0,18	18,00
						2,4	1,2	7,7	0,75	-	30,7	17,0	1,00	16,96	1,04	1,04
						2,4	0,03	7,7	0,75	-	0,8	0,9	53,00	18,10	0,03	1,59
					B	2,4	0,256	7,7	0,75		18,8	14,8	4,00	20,85	0,23	0,92
												Total Inbound:		30,27		21,55
					C	6,5	5,31	3,9	0,50	X	37,3	26,5	1,00	26,52	7,84	7,84
												Total:		31,80		29,39
IS 901	36	36	3,0	-7	A	1,8	0,2	7,7	0,75	-	10,2	8,9	100,00	28,86	0,18	18,00
						2,4	1,2	7,7	0,75	-	34,8	16,6	1,00	16,64	1,04	1,04
						2,4	0,03	7,7	0,75	-	0,9	0,6	53,00	17,86	0,03	1,59
					B	2,4	0,256	7,7	0,75		24,1	15,1	4,00	21,08	0,23	0,92
												Total Inbound:		30,02		21,55
					C	6,5	10,03	4,5	0,66	X	100,5	30,0	1,00	29,96	11,22	11,22
												Total:		33,00		32,77

IS 901 Summary

The table shows the same effect as the one for NSS-7. Also in this case the slight increase in the VSAT transmit power would justify the selection of the lower OBO of 3 dB. It is worth to mention that the EIRP requirement of the VSAT´s is significantly higher as in the case of the NSS-7. This is the result of the lower G/T of IS 901 as compared to NSS-7. The summary of the total outbound traffic gives the following results:

36 MHz transponders:

2 fully saturated transponders:	75 Mbit/s
1 shared transponder	10.03 Mbit/s
Total	85.03 Mbit/s

72 MHz transponders:

2 fully saturated transponders	79.2 Mbit/s
1 shared transponder	10.03 Mbit/s
Total	89.23 Mbit/s

6.3. Partial Deployment

As the deployment of the system will take place in several steps a rollout scenario has been discussed and agreed by AVU. The planning for the first three years could be the following:

Rollout Plan: years 1-3

Year	Learning Centres				COE		Parliament					
	Sites	PC/site	Total PC´s	Video Chan.	Sites	Video TX Mbit/s	Sites	PC/site	Total PC´s	activity	Video Conf.	Audio Conf.
1	30	50	1500	2	4	1	25	40	1000	0,3	2	1
2	65	75	4875	4	6	1	53	40	2120	0,3	4	2
3	100	100	10000	4	9	1	53	50	2650	0,3	4	2

For the first year the optimization shows for NSS-7 the following results:

Shared Transponder Optimisation (year 1)

Type A: Remote to Hub
Type B: Remote to Remote
Type C: Hub to Remote

Satellite					VSAT Characteristics						Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB	G/T dB/K	Service Type	Antenna m	TX bit rate Mbit/s	Eb/No dB	FEC	RS	VSAT TX Power/W	EIRP/carrier dBW	Sites active	Total sat EIRP/dBW	Occupied BW/MHz	Total BW MHZ
NSS -7	54	38	4,2	-5	A	1,8	0,1	7,7	0,75	-	3,0	6,2	30,00	21,01	0,09	2,70
						2,4	1,2	7,7	0,75	-	20,5	17,0	1,00	17,03	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,5	-0,3	25,00	13,72	0,03	0,75
					B	2,4	0,256	7,7	0,75		12,5	14,9	2,00	17,91	0,23	0,46
												Total Inbound:		24,18		4,95
					C	6,5	16,4	3,9	0,50	X	73,0	31,3	1,00	31,26	24,22	24,22
Power BW:	36,0											Total:		32,04		29,17
NSS -7	54	38	3,0	-5	A	1,8	0,1	7,7	0,75	-	3,5	6,0	30,00	20,75	0,09	2,70
						2,4	1,2	7,7	0,75	-	22,1	16,5	1,00	16,52	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,5	-0,2	25,00	13,76	0,03	0,75
					B	2,4	0,256	7,7	0,75		14,6	14,7	2,00	17,73	0,23	0,46
												Total Inbound:		23,92		4,95
					C	6,5	16,4	3,9	0,50	X	92,0	31,4	1,00	31,41	24,20	24,20
Power BW:	27,8											Total:		32,12		29,15

Summary for NSS-7:

For both cases the total traffic can be loaded to a single transponder. For the 4.2 dB OBO system the required power determines the required transponder bandwidth of 36 MHz. With an OBO of 3 dB the required bandwidth is actually determined by the occupied bandwidth (29.15 MHz).

For IS 901 the results are:

Shared Transponder Optimisation (year 1)

Type A: Remote to Hub
Type B: Remote to Remote
Type C: Hub to Remote

Satellite					VSAT Characteristics						Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB	G/T dB/K	Service Type	Antenna m	TX bit rate Mbit/s	Eb/No dB	FEC	RS	VSAT TX Power/W	EIRP/carrier dBW	Sites active	Total sat EIRP/dBW	Occupied BW/MHz	Total BW MHZ
IS 901	36	36	4,2	-7	A	1,8	0,1	7,7	0,75	-	4,6	6,2	30,00	20,94	0,09	2,70
						2,4	1,2	7,7	0,75	-	30,7	17,0	1,00	16,96	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,6	-0,3	25,00	13,71	0,03	0,75
					B	2,4	0,256	7,7	0,75		18,8	14,8	2,00	17,84	0,23	0,46
												Total Inbound:		24,12		4,95
					C	6,5	15,43	3,9	0,50	X	104,0	31,0	1,00	30,98	22,77	22,77
Power BW:	35,9											Total:		31,79		27,72
IS 901	36	36	3,0	-7	A	1,8	0,1	7,7	0,75	-	5,6	6,1	30,00	20,83	0,09	2,70
						2,4	1,2	7,7	0,75	-	34,8	16,6	1,00	16,64	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,7	-0,3	25,00	13,71	0,03	0,75
					B	2,4	0,256	7,7	0,75		24,1	15,1	2,00	18,07	0,23	0,46
												Total Inbound:		24,06		4,95
					C	6,5	16,40	3,9	0,50	X	132,0	31,2	1,00	31,15	24,20	24,20
Power BW:	28,1											Total:		31,93		29,15

IS 901 Summary:

With an OBO of 3 dB the total traffic (16.4 Mbit/s outbound) can be loaded to single transponder with still some margin.

For the second year the optimization shows the following results:

In case of an OBO of 4.2 dB about 1 Mbit/s of outound capacity is missing.

Shared Transponder Optimisation (year 2)

Type A: Remote to Hub
Type B: Remote to Remote
Type C: Hub to Remote

Satellite					VSAT Characteristics						Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB	G/T dB/K	Service Type	Antenna m	TX bit rate Mbit/s	Eb/No dB	FEC	RS	VSAT TX Power/W	EIRP/carrier dBW	Sites active	Total sat EIRP/dBW	Occup. BW/MHz	Total BW MHZ
NSS -7	54	38	4,2	-5	A	1,8	0,15	7,7	0,75	-	4,6	8,0	65,00	26,13	0,13	8,45
						2,4	1,2	7,7	0,75	-	20,5	17,0	1,00	17,03	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,5	-0,3	53,00	16,98	0,03	1,59
					B	2,4	0,256	7,7	0,75		12,5	14,9	4,00	20,92	0,23	0,92
												Total Inbound:		28,02		12,00
					C	6,5	21,6	3,9	0,50	X	73,0	32,5	1,00	32,46	31,80	31,80
Power BW:	53,9											Total:		33,80		43,80
NSS -7	54	38	3,0	-5	A	1,8	0,15	7,7	0,75	-	5,2	7,7	65,00	25,87	0,13	8,45
						2,4	1,2	7,7	0,75	-	22,1	16,5	1,00	16,52	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,5	-0,2	53,00	17,02	0,03	1,59
					B	2,4	0,256	7,7	0,75		14,6	14,7	4,00	20,74	0,23	0,92
												Total Inbound:		27,78		12,00
					C	6,5	27,6	3,9	0,50	X	92,0	34,1	1,00	34,08	28,40	28,40
Power BW:	53,9											Total:		35,00		40,40

The required outbound capacity at the end of year two is 48 Mbit/s. The loading of a full 54 MHz wide NSS-7 transponder would just allow putting 21.6 Mbit/s or 27.6 Mbit/s on that shared transponder. The missing capacity has to be loaded on another shared transponder of NSS-7. The results are shown below:

Hub: 6,5 m **SFD: -90 dBW/m²**

Satellite											Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB		G/T dB/K	Antenna m	Eb/No dB	FEC	RS	S max Mbaud	S requ. Mbaud	Data rate Mbit/s	Occ. BW MHz	Sat EIRP dBW	Power BW MHz	Hub power Watt
NSS -7	54	38	4,2		-5	1,8	3,9	0,50	X	45	30,0	26,4	38,9	33,33	48,46	117
	54	38	3,0			1,8	3,9	0,50	X		30,0	26,4	38,9	33,24	36,01	140
	54	38	4,2			1,8	3,9	0,50	X		23,2	20,4	30,1	32,21	37,44	90
	54	38	3			1,8	3,9	0,50	X		23,2	20,4	30,1	32,12	27,82	108

For the second year the optimization shows the following results:

NSS-7 Summary:

Shared Transponder Optimisation (year 2)

Type A: Remote to Hub
Type B: Remote to Remote
Type C: Hub to Remote

Satellite					VSAT Characteristics						Link Characteristics					
Name	BW MHz	EIRP dBW	OBO dB	G/T dB/K	Service Type	Antenna m	TX bit rate Mbit/s	Eb/No dB	FEC	RS	VSAT TX Power/W	EIRP/carrier dBW	Sites active	Total sat EIRP/dBW	Occup. BW/MHz	Total BW MHZ
NSS -7	54	38	4,2	-5	A	1,8	0,15	7,7	0,75	-	4,6	8,0	65,00	26,13	0,13	8,45
						2,4	1,2	7,7	0,75	-	20,5	17,0	1,00	17,03	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,5	-0,3	53,00	16,98	0,03	1,59
					B	2,4	0,256	7,7	0,75		12,5	14,9	4,00	20,92	0,23	0,92
												Total Inbound:		28,02		12,00
					C	6,5	21,6	3,9	0,50	X	73,0	32,5	1,00	32,46	31,80	31,80
Power BW:	53,9											Total:		33,80		43,80
NSS -7	54	38	3,0	-5	A	1,8	0,15	7,7	0,75	-	5,2	7,7	65,00	25,87	0,13	8,45
						2,4	1,2	7,7	0,75	-	22,1	16,5	1,00	16,52	1,04	1,04
						2,4	0,024	7,7	0,75	-	0,5	-0,2	53,00	17,02	0,03	1,59
					B	2,4	0,256	7,7	0,75		14,6	14,7	4,00	20,74	0,23	0,92
												Total Inbound:		27,78		12,00
					C	6,5	27,6	3,9	0,50	X	92,0	34,1	1,00	34,08	28,40	28,40
Power BW:	53,9											Total:		35,00		40,40

To carry the missing outbound capacity another full transponder of Is 901 has to be used as shown below.

Outbound Optimisation (Full Transponder for year 2)

Hub: 6,5 m SFD: -90 dBW/m²

Satellite				VSAT Characteristics						Link Characteristics			
Name	BW MHz	EIRP dBW	G/T dB/K	Antenna m	G/T dB/K	Eb/No dB	FEC	RS	Sym. max Mbaud	Sym. requ. Mbaud	Data rate Mbit/s	PW margin dB	Hub TX pw Watt
IS 901	36	36	-7	1,8	15	3,9	0,50	X	45	35,8	31,5	2,00	440
				1,8	15	5,1	0,75			28,4	37,5	0,00	

Summary for the rollout of years 1 and 2:

Year 1:

NSS-7:	OBO 4.2 dB:	36 MHz of the 54 MHz transponder
	OBO 3 dB:	29.15 MHz of the 54 MHz transponder
IS 901:	OBO 4.2 dB:	36 MHz of the 36 MHz transponder
	OBO 3 dB:	28.1 MHz of the 36 MHz transponder

Year 2:

NSS-7:	OBO 4.2 dB:	54 MHz +36 MHz
	OBO 3 dB:	54 MHz + 27 MHz
IS 901	OBO 4.2 dB:	2 transponder
	OBO 3 dB:	2 transponder

7. AVU Network Design

The AVU traffic requirements are not yet very well defined. The difference between assumed and real traffic could be in orders of magnitude. It is also not very clear, which services will really be implemented into the AVU network.

As already pointed out in the chapters above, the hardware and space segment costs of the AVU network are strongly influenced by the chosen inroute (or Return Channel) system. The inroute system has also a major impact to the overall quality of service of the whole network system.

To realize the AVU network different return channel systems from different vendors could be chosen. But: especially the very attractive shared inroute systems based on TDMA technology have to be examined very carefully not to select a system with serious drawbacks or, vice versa, not to implement an oversized and therewith very expensive network system.

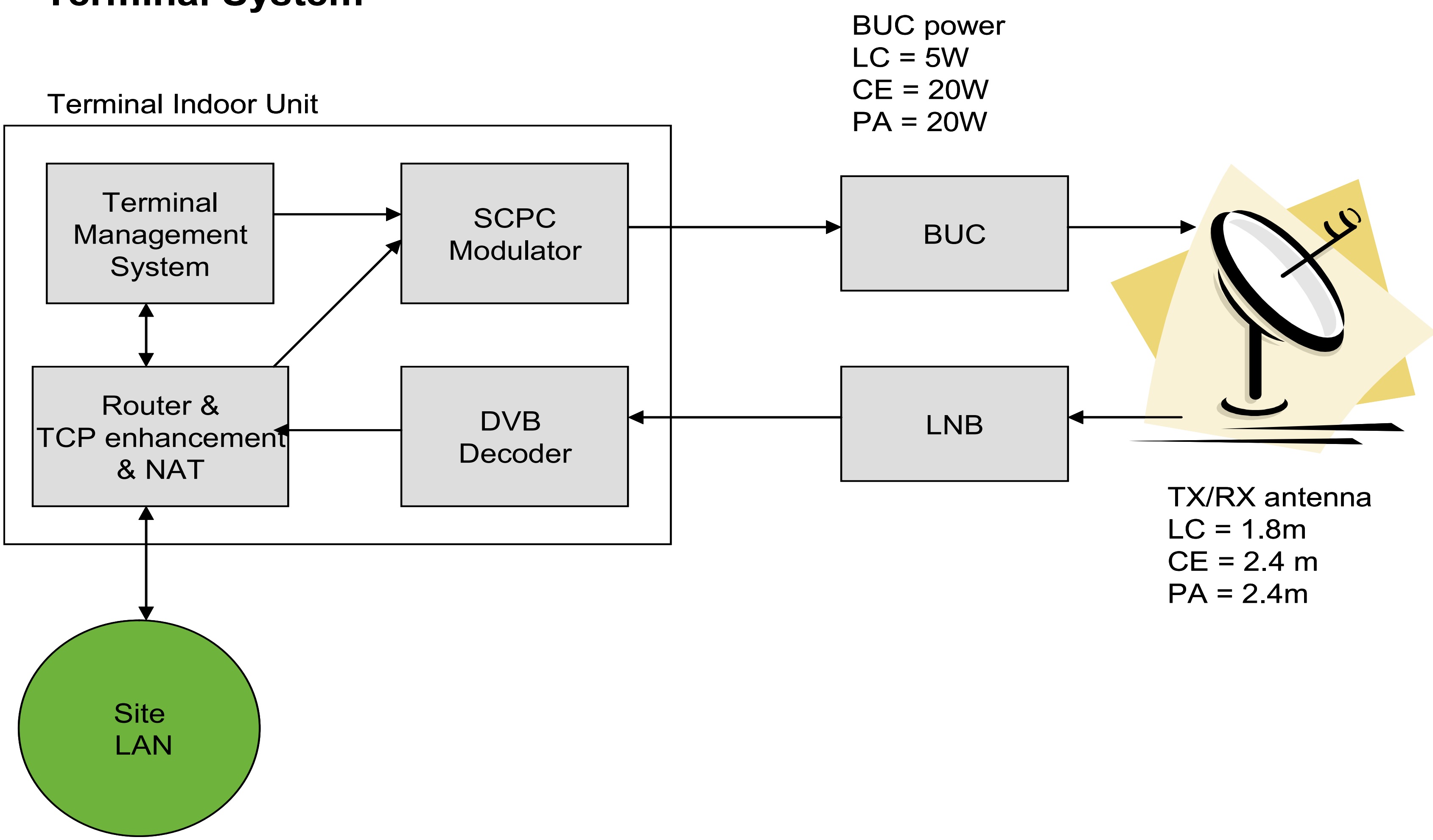
To avoid such problems and to provide a maximum of flexibility together with moderate cost (CAPEX and OPEX) it is recommended to choose a network system, consisting of an IP-over-DVB outroute system (Hub to Terminals) and a SCPC DAMA (Bandwidth on demand) inroute system.

This solution would give to AVU the following possibilities:

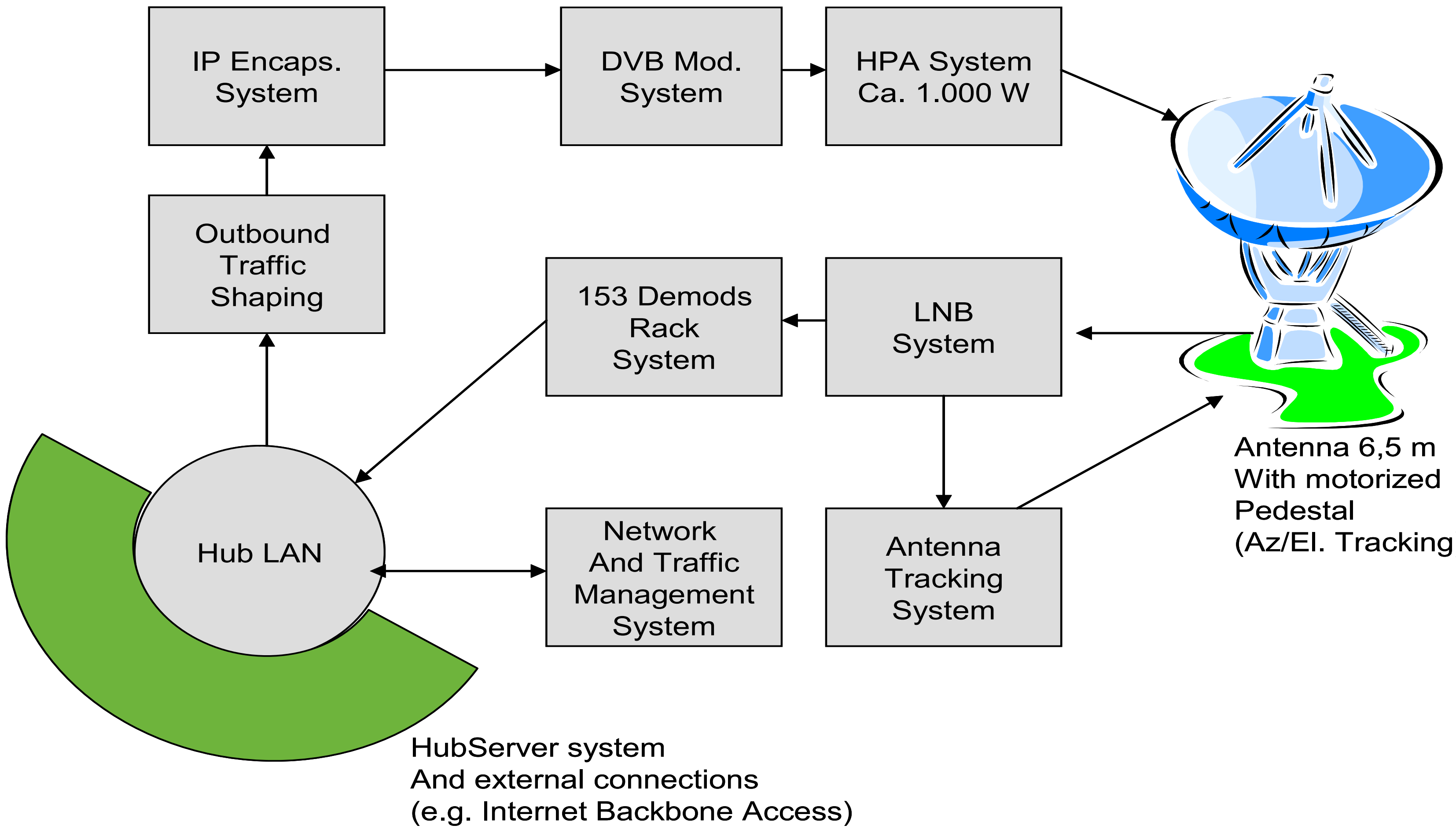
1. The DVB outroute could be used by Receive Only terminals with terrestrial return channel system. So in case an AVU LC/CE/PA has reliable terrestrial access to the Internet, a hybrid network could be established, using terrestrial Internet channels as return channels to the AVU service center (hub).
   This approach gives also to the AVU the possibility for a given implementation period to use in parallel the existing receive only equipment at the existing sites or to connect some "low cost/ low service level" sites with r/o capabilities only.
2. The SCPC DAMA inroutes would guarantee without any further difficult engineering and traffic analysis a CIR (committed information rate), which provides together with standard routers and well-proven IP standards a high level of QoS for actual and future services.
3. The SCPC DAMA approach will automatically adapt the inroute carrier size to the requirements of each terminal. The AVU can start with a relative small amount of inroute space segment pool. When the network

grows (by number of terminals and by traffic) AVU will gain more and more data about the real traffic requirements and can adapt the inroute space segment pool accordingly.

Terminal System



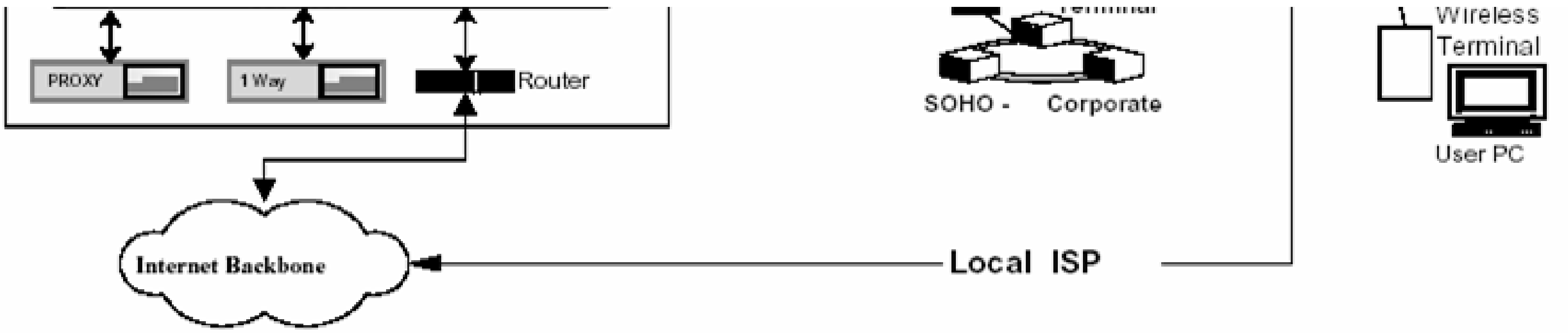
Hub System

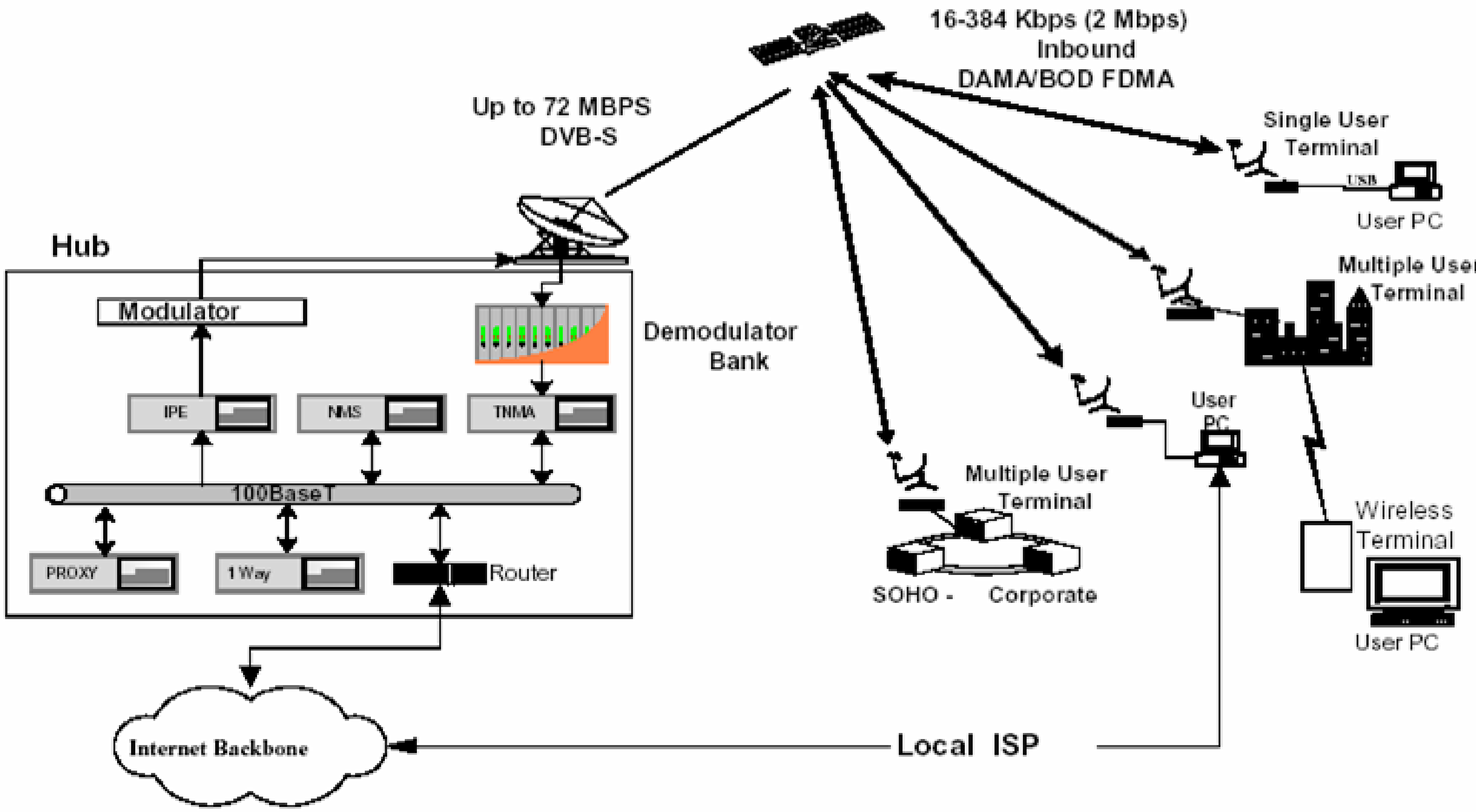

IP Encaps. System
DVB Mod. System
HPA System Ca. 1.000 W
Outbound Traffic Shaping
153 Demods Rack System
LNB System
Hub LAN
Network And Traffic Management System
Antenna Tracking System
Antenna 6,5 m
With motorized
Pedestal
(Az/El. Tracking)
HubServer system
And external connections
(e.g. Internet Backbone Access)

In principle, the proposed solution could be build up on the basis of a usual DBV-S outbound system, as offered by several vendors (Radyne/Comstream, ComtechEfdata, NDsatcom, Shiron, Skystream and others) with an additional SCPC-based inbound system.

From our point of view the solution offered by Shiron (under the brand InterSky) seems to be the best compromise. The InterSky system includes already both the DVB outbound system and the SCPC DAMA inbound system. The InterSky offers easy handling features, allowing AVU the operation of its own system. The InterSky system is already well introduced in Africa (e.g. service providers in Nigeria and Africa-Services from Redwing Satellite Solutions with hub in the UK).

The big advantage of the InterSky system is the fact, that the InterSky terminal includes already the router function and, very important for IP over satellite, a complete TCP-enhancement solution, to overcome the well-known throughput problems of TCP satellite connections (due to the “interferences” of the satellite time delay and the TCP slow start algorithm).


PROXY
1 Way
Router
SOHO - Corporate
Wireless
Terminal
User PC
Internet Backbone
Local ISP


16-384 Kbps (2 Mbps)
Inbound
DAMA/BOD FDMA
Up to 72 MBPS
DVB-S
Single User
Terminal
USB
User PC
Hub
Multiple User
Terminal
Modulator
Demodulator
Bank
IPE
NMS
TNMA
100BaseT
User
PC
Multiple User
Terminal
PROXY
1 Way
Router
SOHO - Corporate
Wireless
Terminal
User PC
Internet Backbone
Local ISP

A similar solution is offered by RadyneComstream with its IPSat terminal system. Unfortunately, the IPSat solution requires additional routers at each terminal site and does not provide an automatic inroute bandwidth adaptation function. So the bandwidth adaptation of the inroutes has to be done by the hub operator manually.

Optionally the hub could contain a MPEG MUX and MPEG Encoders. This gives to the AVU the possibility to send within the outbound also non-IP video content and therewith to use further the already existing LC equipment installed during the phase 1 of the AVU service implementation. Unfortunately this approach requires additional space outbound segment and do not solve the problem of content delivery from the content providers (Universities in USA, Canada, Europe and Australia) to the AVU hub. Therefore we recommend to use such an approach only like an intermediate solution up to the moment, the existing LC's are equipped with IP-based video content servers/systems.

The hub can be additionally equipped with a traffic shaping system, to improve the QoS functionality on the outbound direction. As the spectrum of services provided by AVU is relatively small, during the implementation period of the network the traffic shaping or better traffic priority functionality of the IP-encapsulator and the hub router will be powerful enough to fulfil these basic requirements. As the AVU network fills up with traffic and with additional services a reengineering of the AVU network, based on the collected traffic data, could be provided and at that time could be made a decision about additional traffic shaping and traffic compression devices.

A very important question for the overall costs and the reliability of the AVU network is the hub location. To implement the required network solution the hub should be within Africa.

One of the core functions of the AVU network is to bring Broadband Internet Access to the AVU members. The overall Internet Access requirement is about 80..90 Mbps. An appropriate Internet Backbone access could be provided today and also during the next future by an access to the SAT3/SAFE fiber optic cable system only.

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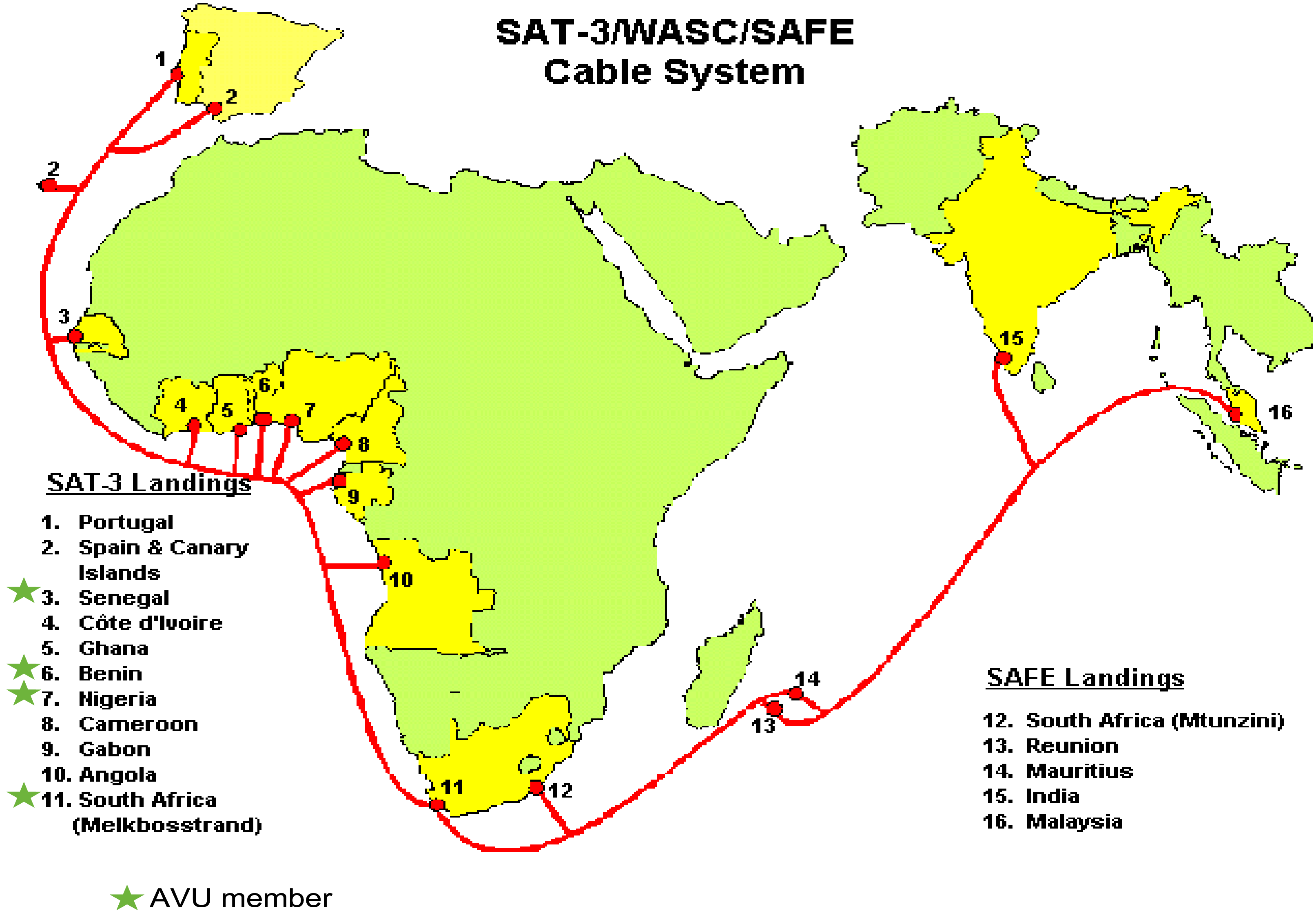
Detecon&Diebold Consultants



The graphic above shows the SAT3 landing point within Africa. SAT3 is directly connected to the European Fiber Optic Cable system (Portugal and Spain) and further with the North American cable systems.

Taking into account

- the political situation (stability, position of AVU)

- the regulatory situation (licenses, access to the landing point)

- the cable distance to the Internet Backbone (TIR One providers in Europe or USA)

Senegal seems to be a good choice for the installation of a hub.

The management system of the AVU network could be operated from any terminal within the AVU network or even from any point within the Internet. In principle at the hub only hardware maintenance and Internet access maintenance is required. Existing teleport/antenna serving e.g. NSS7 or Intelsat 901 and having broadband (at least 45Mbps) Internet Backbone Access could be used as a hub. In case such a teleport could be found in Africa, AVU could install the AVU hub equipment and using the teleport maintenance service.

7.1. Technical specification of the AVU VSAT system

The AVU network and service requirements are described in chapter “5. Revised AVU Requirements”. The text of that chapter could be the basis for the technical part of a RFP.

The hub and terminal parameters below are based on the assumption, that NSS7 standard C-band hemi beam east with SFD = -90dBW/m2 is used and that the hub station is located within Africa.

In case other space segment is used or proposed by the system vendor the appropriate station parameters (HPA power of hub and terminals, frequency range, antenna diameter) have to be adapted to the available satellite/space segment.

7.1.1. Hub system

1. antenna 6.5m with complete motorized mount and automatic tracking system, circular feed and OMT system with wave guides to the indoor HPA system, inclusive of wave guide dehydration system.
2. 1:1 redundant rack mounted 1 kW HPA system
3. 1:1 redundant LNA system
4. 1:1 redundant upconverter (140MHz to C-band) system
5. 1:1 redundant DVB-S modulator (140MHz)
6. 1:1 redundant IP-encapsulator system with guaranteed IP throughput of at least 40Mbps, inclusive of complete MPEG traffic management system
7. 1:1 redundant outdoor LNA system
8. inroute demodulator system for 153 terminals
9. 1:1 redundant IP router system with a reliable data throughput of at least 90 Mbps IP data in both directions: to/from the terminals and to/from the Internet Backbone.
10. A network management system, based on SNMP, giving full control to all network elements (hub and terminals) and the space segment use. The NMS should contain a carrier monitoring system (spectrum analyzer, could be PC based).

    The NMS should provide remote control functionality, either by WEB access or by special remote control PC software. The network operator should be able to control and maintain the whole network (inclusive of carrier monitoring) from any terminal of the AVU network and/or from any Internet Access point.
11. The UPS system of the hub should guarantee at least 1h power backup time. To decrease the power consumption during the power backup time the redundant hub elements could be (automatically) switched off in case of power supply failure.

As an option the whole hub indoor equipment should be integrated into an air-conditioned, transportable housing (container), which could be located next to the hub antenna system. At least two hub operators should be able to work inside the housing in a usual office environment.

7.1.2. LC terminal

1. antenna 1,8m with non-penetrating mount and circular feed/OMT system

2. BUC/HPA with 5W transmitter power
3. LNB
4. IF between ODU and IDU can be 70MHz or L-band or any system specific frequencies
5. ODU should be powered from the IDU
6. the IDU should contain the following subsystems:
   - DVB-S decoder with IP demux
   - inroute (return channel) transmission system up to 200 kbps
   - TCP/IP enhancement system
   - NAT
   - traffic shaping functionality for the inbound channel
   - IP-Router to connect the IDU system directly to the LAN (Ethernet 10/100)
7. UPS for 15 minutes back-up time
8. the complete terminal system should be managed by IP/SNMP and should provide local management access by extra management port
9. the terminal should guarantee a data throughput of at least in receive direction of 5Mbps and in transmit direction of 200 kbps IP data.

7.1.3. CE Terminal

1. antenna 2,4m with non-penetrating mount and circular feed/OMT system
2. BUC/HPA with 10W transmitter power
3. LNB
4. IF between ODU and IDU can be 70MHz or L-band or any system specific frequencies
5. ODU should be powered from the IDU
6. the IDU should contain following subsystems:
   - DVB-S decoder with IP demux
   - inroute (return channel) transmission system up to 1.200 kbps
   - TCP/IP enhancement system
   - NAT
   - traffic shaping functionality for the inbound channel

- IP-Router to connect the IDU system directly to the LAN (Ethernet 10/100)

7. UPS for 15 minutes back-up time
8. the complete terminal system should be managed by IP/SNMP and should provide local management access by extra management port
9. the terminal should guarantee a data throughput of at least in receive direction of 5Mbps and in transmit direction of 1.200 kbps IP data.

7.1.4. PA terminal

1. antenna 2,4m with non-penetrating mount and circular feed/OMT system
2. BUC/HPA with 10W transmitter power
3. LNB
4. IF between ODU and IDU can be 70MHz or L-band or any system specific frequencies
5. ODU should be powered from the IDU
6. the IDU should contain following subsystems:

- DVB-S decoder with IP demux
- SCPC Modulator and 4 SCPC demodulators (256kbps data rate, with SNMP management system)
- inroute (return channel) transmission system up to 1.200 kbps
- TCP/IP enhancement system
- NAT
- traffic shaping functionality for the inbound channel
- IP-Router to connect the IDU system directly to the LAN (Ethernet 10/100), the router should also transmit/receive the videoconference data to from the SCPC modulator/demodulators

7. UPS for 15 minutes back-up time
8. the complete terminal system should be managed by IP/SNMP and should provide local management access by extra management port
9. the terminal should guarantee a data throughput of at least in receive direction of 3Mbps and in transmit direction of 50 kbps IP data and additional 256kbps transmission and 4x256kbps receive of videoconference data.

All terminal outdoor equipment should be able to work under the climatic conditions in Africa. Especially for the BUC/HPA the operating temperature should be at least 50°C and the terminal ODU should be able to work at 100% humidity and under heavy rain conditions.

8. Cost Assessment

8.1. Estimated Hardware Cost

The following cost estimations are related to the above-described AVU network solution. The costs may differ significantly for different system vendors.

The table below shows the estimated average hardware costs for the different terminal types of the AVU network

.

Termi-nal type	Anten-na	Antenna price	BUC power (W)	BUC price	IDU price	VC modem price	other HW costs	*total per terminal*
LC	1,8	1.000	5	2.000	3.350		1.000	*7.350*
CE	2,4	3.000	10	6.000	7.400	0	1.500	*17.900*
PA	2,4	3.000	10	6.000	3.350	14.000	3.500	*29.850*

The prices are EXW and do not contain expenses for transport, delivery, installation/commissioning, import and license fees and taxes.

The prices also do not include any servers/routers dedicated to the LAN and services at the remote sites (LC/CE/PA).

The table below shows the minimal cost for the hub:

Subsystem	Elements	price	remarks
Antenna system	6,5m antenna	120.000	
	Motorized pedestal mount		
	tracking system		
	civil works		
	Installation		
HPA	Redundant 1 KW TWTA with redundancy switch system and upconverter	200.000	
Inbound system	Inbound system for 55 inbound channels, complete with NMS and TMS, inclusive of installation	320.000	additional inbound channel ca. 1.500
Total hub	**for first year, but HPA for full network (153 terminals)**	**640.000**	

The hub costs could be decreased by 100.000 US$ by starting with a HPA of lower power (e.g. 400 W). Such a HPA would be powerful enough to fulfil the network requirements of the first year (up to one transponder). If during the second or third year it would be necessary to increase the outbound to more than one transponder the HPA power could be increased either by changing the HPA by a more powerful or to add an additional HPA together in a Phase Combined scheme with a 2…3:1 redundancy scheme. What approach would be the best (full HPA power from the start on or increase of HPA power step by step) has to be negotiated with the potential vendors

The total investment costs per year for the first 3 years implementation period are shown in the table below.

The investment of the first year is influenced mostly by the initial hub costs, especially by the hub elements: antenna, HPA and DVB uplink system. In case

AVU could manage to use an existing DVB uplink system the investment for the first year could be reduced by at least by 400.000 US$. All other investment costs are related to the terminals, which could be purchased by the LC/CE/PA'a.

Year	No. Of Termnials			CAPEX	
	LC	CE	PA	cumulative	per year
1	26	4	25	1.648.950	1.648.950
2	59	6	53	2.889.100	1.240.150
3	99	9	53	3.322.800	433.700

In comparison to the estimated space segment costs (see next chapter) the hardware CAPEX is very low.

If taking into consideration, that the hardware can be used at least for 5 years (terminals) and up to 10 years (hub), the yearly reinvestment rate at the end of year three (full network implementation) will be about 800.000 US$ or lower than 20% of the estimated space segment costs.

8.2. Cost Assessment for the Spacesegment.

As there were no responses from the two satellite operators (Intelsat and Newskies) the prices are based on available public information. We have assumed the following prices:

NSS-7: full transponder: 2.6 Mio US$/year, shared: 4,000 US$/MHz/month

IS 901: full transponder 1.6 Mio US$/year, shared. 4,000 US$/MHz/month.

Year	NSS-7 in Mio US$	IS 901 in Mio US$
1	1.4	1.4
2	3.9	3.2
3	5.2	4.8

The costs are based on the most economic usage of the space segment (3 dB OBO for the shared transponders.

The high spacesegment cost necessitates some further optimization of the overall system. A sensitivity analysis regarding the size of the VSAT antenna diameter and the total Internet traffic volume has to be done and is presented in the next chapter.

9. Sensitivity Analysis

9.1. General Remarks

Several input parameters used in the above analysis are based on best guess assumptions. The major contribution to the overall traffic is the Internet access from the various sites. At the time being AVU has no sound statistical basis for the traffic generated by the Learning Centers. On one site the total number of sites is not yet known and on the other site the total number of active PC´s per site are also not known. In view of this uncertainty and the serious impact on the overall space segment cost as shown in the last section, we have varied the total number of active PC´s in the network over large range.

To limit the number of possible scenarios we have taken the total number of sites as 100 and varied the number of active PC´s from 10 to 100 per site. The required transponder capacity will not vary in case the number of uplink carriers would change in a certain range.

The results could be used to allocate the total number of active PC´s to any number of sites. The only impact would be the requirement for flexible transmission rates of the VSAT´s at the different sites (DAMA configuration).

All the other traffic will be considered as constant (video channels, video conferencing, audio conference and video uploading.

In the first step the general impact of the antenna diameter of the LC´s will be addressed.

9.2. VSAT´s with 1.8m Antenna

For this analysis the following assumptions have been taken:

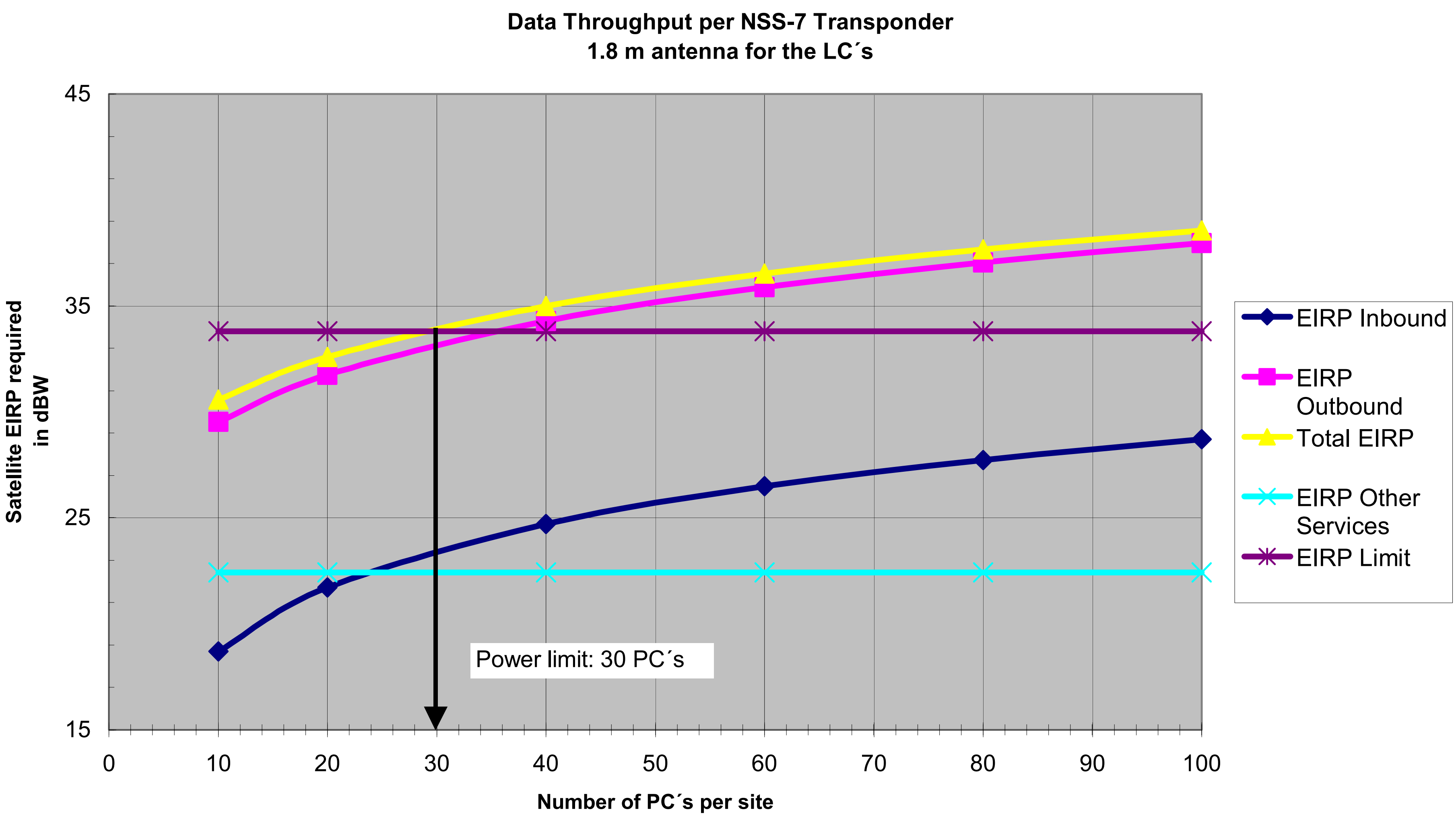
Antenna: 1.8 m antenna

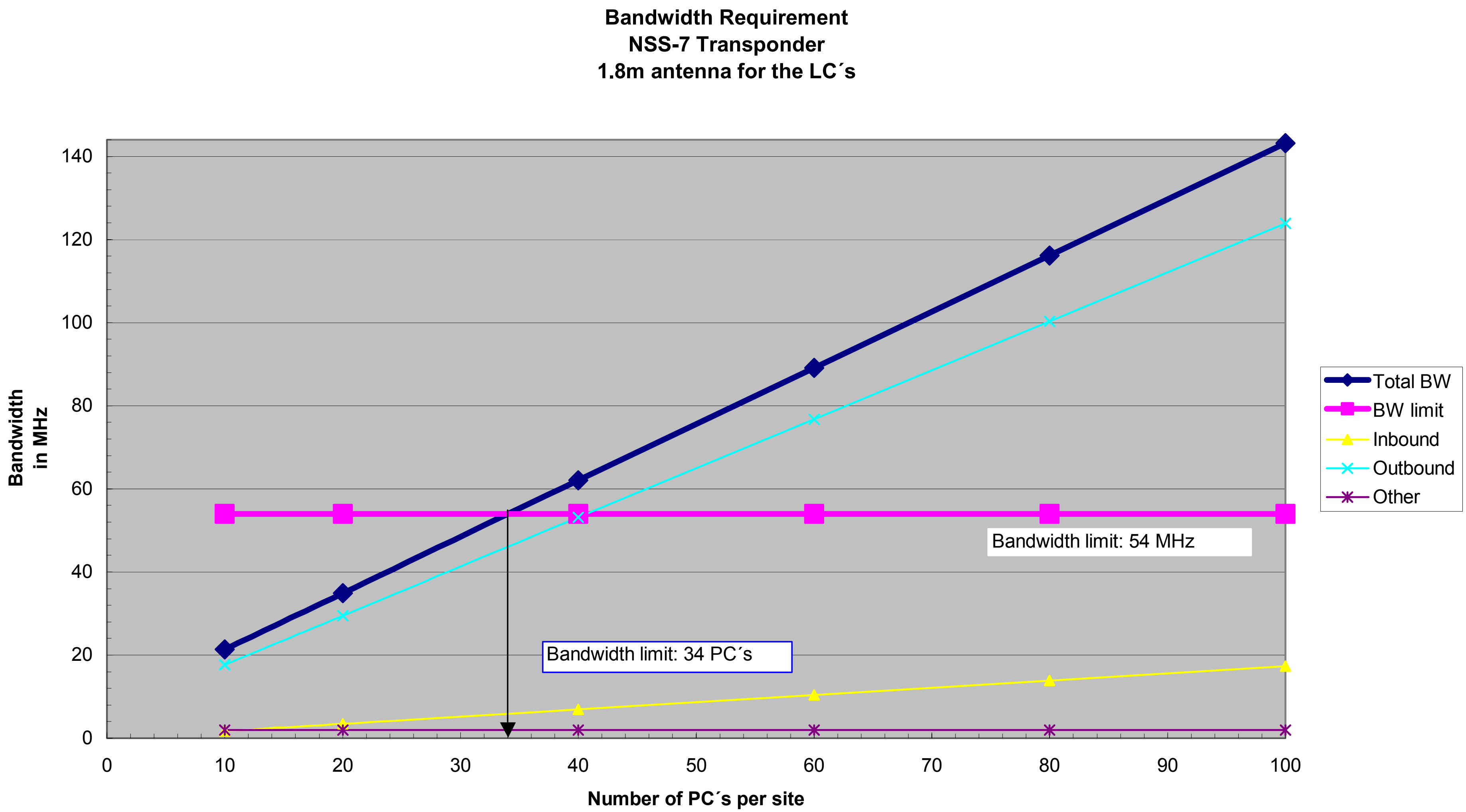
Outbound: DVB-S with QPSK, Eb/No=3.9 dB and FEC=1/2

Inbound: SCPC with QPSK, Eb/No= 7.7 dB and FEC=3/4

For the Centers of Excellence and the Houses of Parliament 2.4m antenna are considered due to the high transmission bitrate (CoE) and the interconnectivity requirement (PA).

The results are shown for a shared NSS-7 transponder with 54 MHz bandwidth.


Data Throughput per NSS-7 Transponder
1.8 m antenna for the LC´s
Satellite EIRP required in dBW
45
35
25
15
0
10
20
30
40
50
60
70
80
90
100
Number of PC´s per site
Power limit: 30 PC´s
EIRP Inbound
EIRP Outbound
Total EIRP
EIRP Other Services
EIRP Limit


Bandwidth Requirement
NSS-7 Transponder
1.8m antenna for the LC´s
Bandwidth
in MHz
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Number of PC´s per site
Bandwidth limit: 54 MHz
Bandwidth limit: 34 PC´s
Total BW
BW limit
Inbound
Outbound
Other

The link budgets have been calculated for an output backoff of 4.2 dB to give some margin with regard to the intermodulation products. As long as a transponder has to be shared with other users the satellite operator will define the exact OBO to be applied.

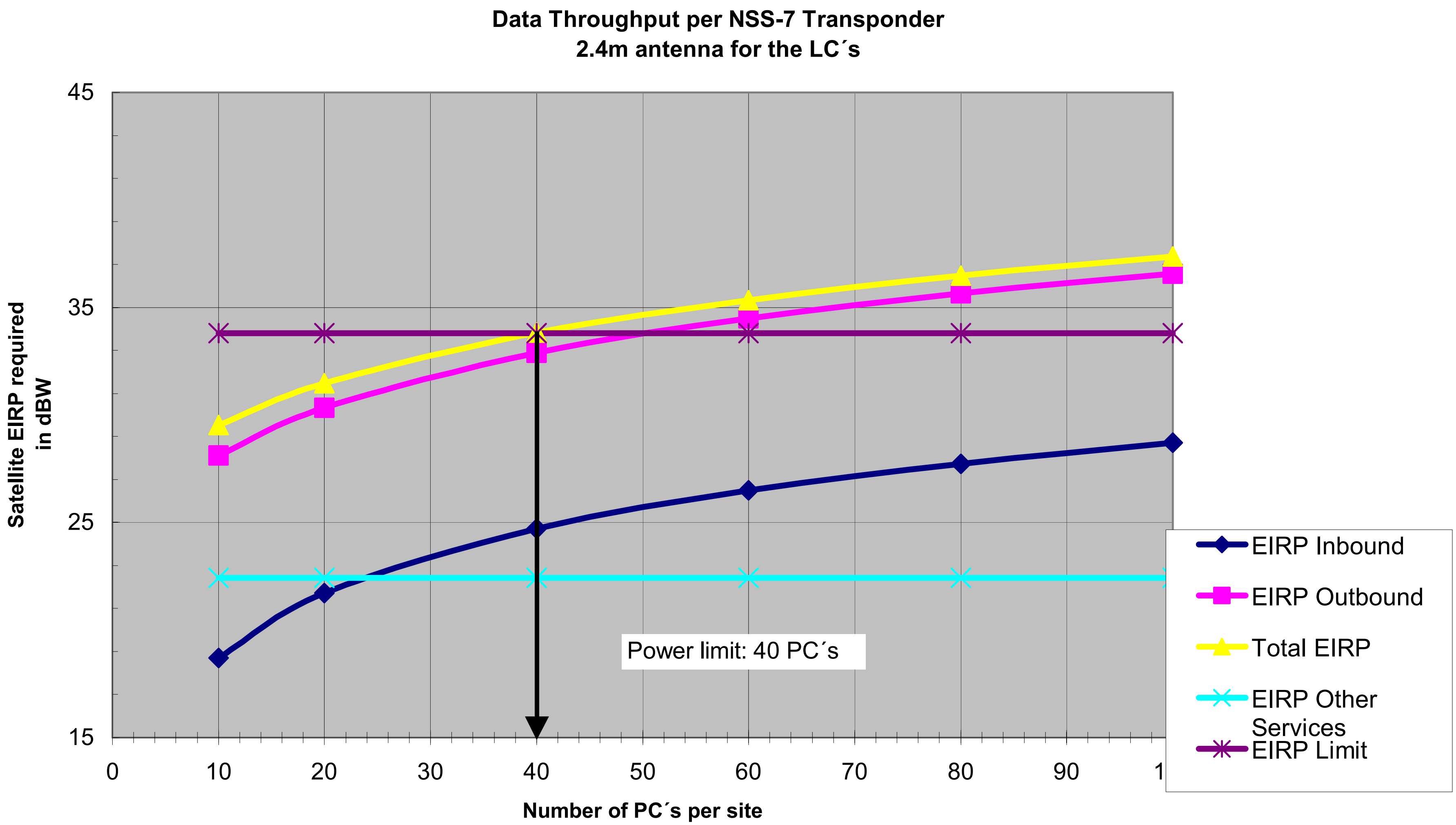
The results show that the 54 MHz transponder could support 30 PC´s per site or 3000 PC´s in total. The system is power limited. The available bandwith would allow to transmit the equivalent of 34 PC´s per site or 3400 in total.

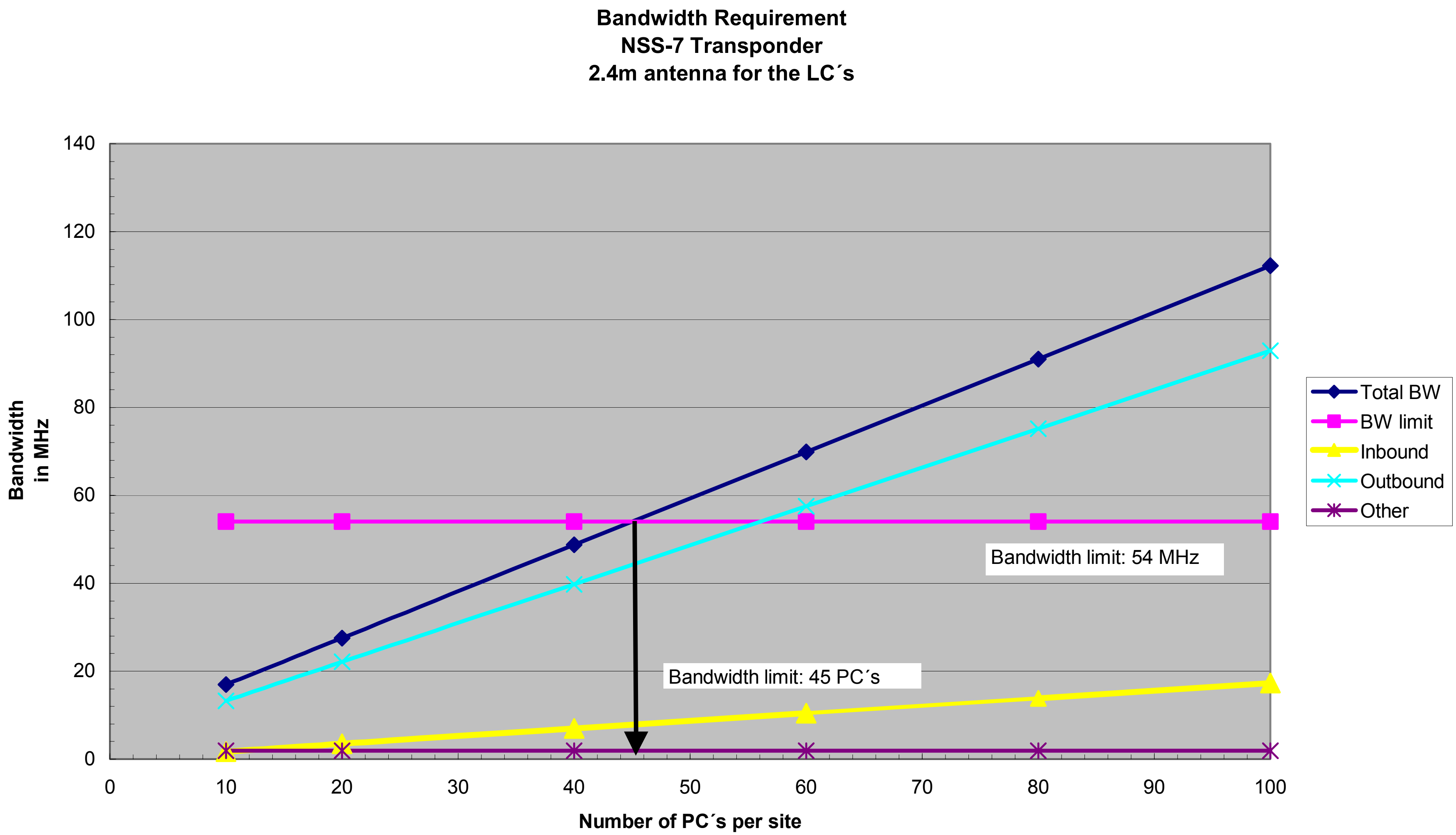
9.3. VSAT´s with 2.4m Antenna

In this configuration all VSAT´s would use the 2.4m antenna. Beside this change on optimization regarding the FEC could be done to allow more outbound traffic.

Outbound: DVB-S with QPSK, Eb/No=4.5 dB and FEC=2/3

All other parameters are the same as for the case of the 1.8m antennas. The budgets show the following results:


Data Throughput per NSS-7 Transponder
2.4m antenna for the LC´s
Satellite EIRP required in dBW
45
35
25
15
0
10
20
30
40
50
60
70
80
90
Number of PC´s per site
Power limit: 40 PC´s
EIRP Inbound
EIRP Outbound
Total EIRP
EIRP Other Services
EIRP Limit


Bandwidth Requirement
NSS-7 Transponder
2.4m antenna for the LC´s
Bandwidth in MHz
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Number of PC´s per site
Total BW
BW limit
Inbound
Outbound
Other
Bandwidth limit: 54 MHz
Bandwidth limit: 45 PC´s

As expected the transmission capacity of the54MHz transponder could be improved by more than 30%. With the increase of the antenna diameter from 1,8m to 2,4 m 40 PC´s per site or 4000 in total can be supported. Also this configuration is power limited.

A rough analysis shows that from a purely economical point of view the 2.4m scenario is much cheaper than the 1.8m solution.

For the outbound the following calculation can be done:

Assumption:	shared transponder fully loaded
Additional traffic carried by 2.4m:	1000*0.008Mbit/s = 8Mit/s
Occupied Bandwidth (FEC=1/2):	11.8 MHz
Additional cost per year:	11.8 *4000*12 = 566,400.00 US$
Additional cost of the 2.4m antenna:	100*2000 = 200,000.00 US$

The above analysis was just for a single shared transponder. As it is quite obvious that the 2.4m solution is the cheaper one a next step is performed to show how the cost will develop in case a second transponder has to be used.

9.4. Cost Assessment for the 2.4m Antenna

The shared transponder is at its saturation with the equivalent of 40 PC´s per site. To carry additional traffic it is assumed that all the outbound traffic is loaded to the existing transponder with a single carrier to allow optimal use of the available EIRP of the satellite. The total inbound traffic is loaded on an additional shared transponder.

To make the best use of the power the transmission scheme for the outbound is further optimized:

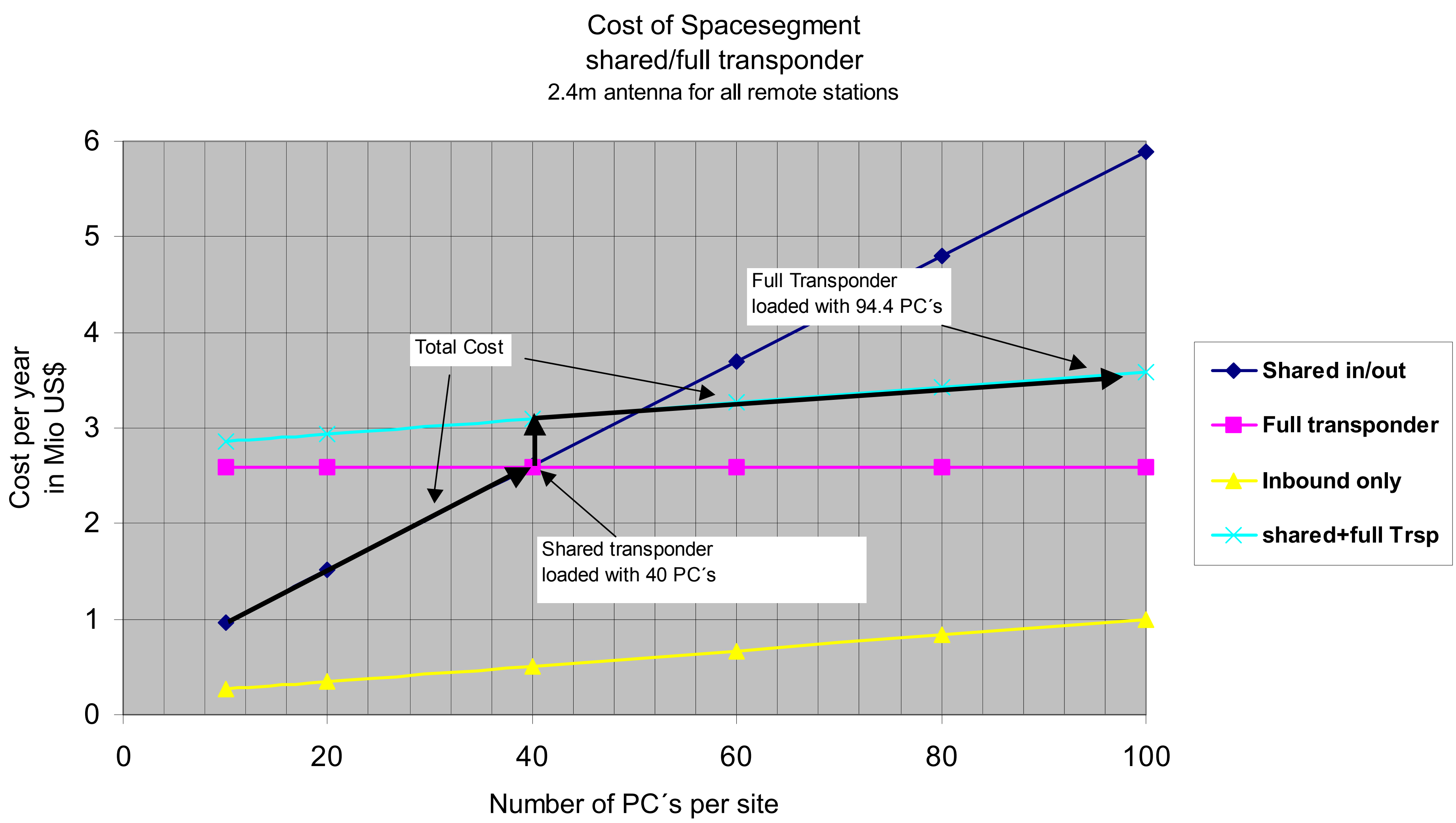
Outbound: DVB-S with 8PSK, Eb/No=6.5 dB, FEC=2/3

All other parameters remain unchanged.

The assumed transponder costs are those as mentioned above:

4,000.00 US$/MHz/month

The evolution of the cost can be seen from the following diagram:


Cost of Spacesegment
shared/full transponder
2.4m antenna for all remote stations
Cost per year in Mio US$
Number of PC´s per site
0
1
2
3
4
5
6
0
20
40
60
80
100
Full Transponder
loaded with 94.4 PC´s
Total Cost
Shared transponder
loaded with 40 PC´s
Shared in/out
Full transponder
Inbound only
shared+full Trsp

In this diagram the effect of adding a second transponder to the network can be clearly seen. With 40 PC´s per site in the network the second transponder has to be used. However, it can also be seen that the slope is kept much lower than in the first part. This is due to the effect that with the change to a single carrier operation of one transponder the additional outbound traffic can be handled without any additional cost. This is valid up to the point where the transponder carrying the outbound traffic is also fully loaded. However, as this occurs only with an equivalent of 94 PC´s per site it would make only sense to load some traffic on the shared transponder if there is a strong request to do so.

Such analysis could be done for any other satellite (e.g. INTELSAT 901). Although the EIRP and the bandwidth are different the results would be similar and instead of only two transponders 3 transponders have to be used.

10. Recommendations

Detecon recommends to AVU the following strategy for the upgrading of the existing network:

1. Definition of the traffic requirements

During the discussion with AVU Detecon got the impression that the real traffic requirements are not yet well defined. There are large uncertainties in the traffic projections resulting in significant cost impacts for the CAPEX as well as OPEX (specifically the space segment). It is mandatory to have an agreed traffic projection and rollout plan.

2. Identification of available spacesegement

Due to the modification of the requirements Detecon did not succeed in getting sound information from the two C-band satellite operators with regard to availability and cost. AVU should approach both INTELSAT and NewSkies to get the information on the identified satellites.

3. Definition of the operational mode

AVU should decide whether they intend to operate the VSAT network by themselves or whether they would like to outsource the services to a VSAT service provider. This should also be considered for issuing any RFP for the network.