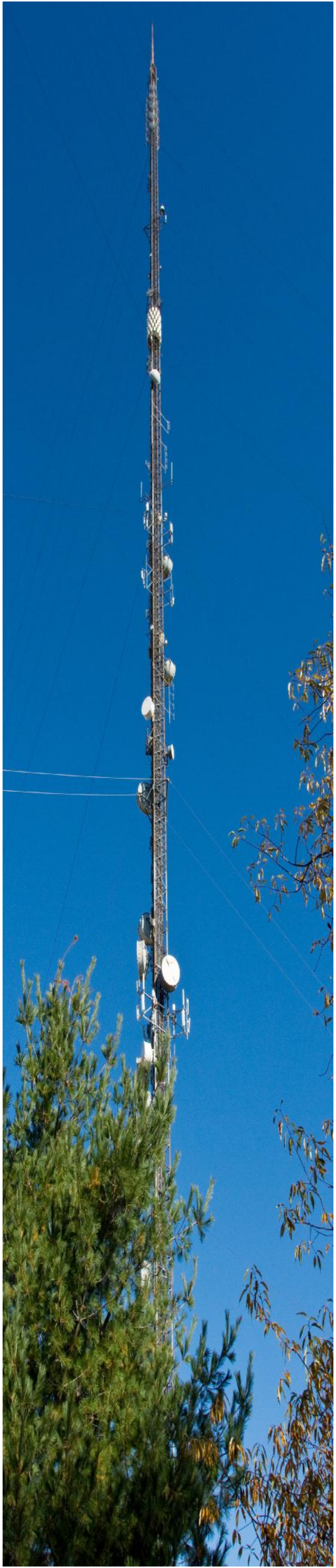

Maximizing Economies of Scale in DTV Transmission Systems

WireIE

From the Office of WireIE's CTO
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Table of Contents

Executive Summary

As the world digitizes over-the-air distribution of broadcast television services, an opportunity is presented to realize significant capital and operational cost efficiencies at the transmitter site. Resources can be shared allowing for dramatic capital and operational cost reduction for every participating broadcaster. The broadcaster can then focus on its core business where competitive differentiation is achieved through program content and station branding.

The concept of transmitter site resource sharing is not new for television stations. For decades stations in many of the world's largest markets have shared a common site. Where technical parameters permit, a single antenna can support multiple stations through the use of a combiner in the transmitter room.

The digital age allows for a giant leap forward in the opportunity for broadcasters to share a common transmission infrastructure. It is estimated capital costs can be reduced by 83% by using a common DTV transmitter infrastructure. In addition, there are many operational savings as a result of less duplication and redundancy of facilities.

Finally, the digitization of broadcast television distribution allows for simplification of repeater sites through the use of digital translators. A translator is essentially a pass-through transmitter with echo cancellation (to address the effects of co-channel signal regeneration). In many cases, this eliminates the need for fiber or microwave to link the remote transmitters. In addition, when a service or feature upgrade is performed on a DTV network transmitter, any translators fed by the transmitter will also enjoy the benefit. It is therefore commonplace for an entire DTV network upgrade to be performed once at one site.

Introduction

The Technical Department of the Bureau Telecommicatie en Post, Curacao is preparing for the digitization of the island's broadcast television services. The DVB-T standard will be adopted in the region. Six sites have been selected with propagation analysis predicting 99.4% of the island population coverage.

While the technical advantages of Digital Television (DTV) are vast, the technology also introduces an opportunity for television station owners (along with their regulatory bodies) to explore new operational models.

This report contrasts the cost benefit of two fundamental operational models. The first is a replication of the traditional analogue model where every program stream is assigned a corresponding RF channel. The second looks at using a single Transport Stream/RF channel for the delivery of 6 standard definition program streams.

Competitive Differentiators in Today's Television Industry

In the early days of broadcast television, signal coverage was regarded as one of several competitive differentiators. At that time, television broadcasters were not inclined to share towers or other transmitter-related facilities.

With the adoption of broadcast distribution (BDU) technologies such as Cable Television in the 1960s, and Direct to Home Satellite services (DTH) in the 1980s, television station availability has become all but ubiquitous in markets where these services are available[i]. As a result of this evolution, program content and station branding have become the primary competitive differentiators of television services in these markets. Put another way, with distribution essentially on an equal footing, the "coverage advantage" is largely nullified.

Television signal distribution "neutrality" achieved through cable and satellite can now be realized over-the-air with digital technologies such as DVB-T (Digital Video Broadcast – Terrestrial). In fact, significant capital and operational cost efficiencies can be realized for broadcasters who wish to take a cooperative approach to TV signal transmission.

Achieving Economies of Scale through Television Transmission Cooperatives

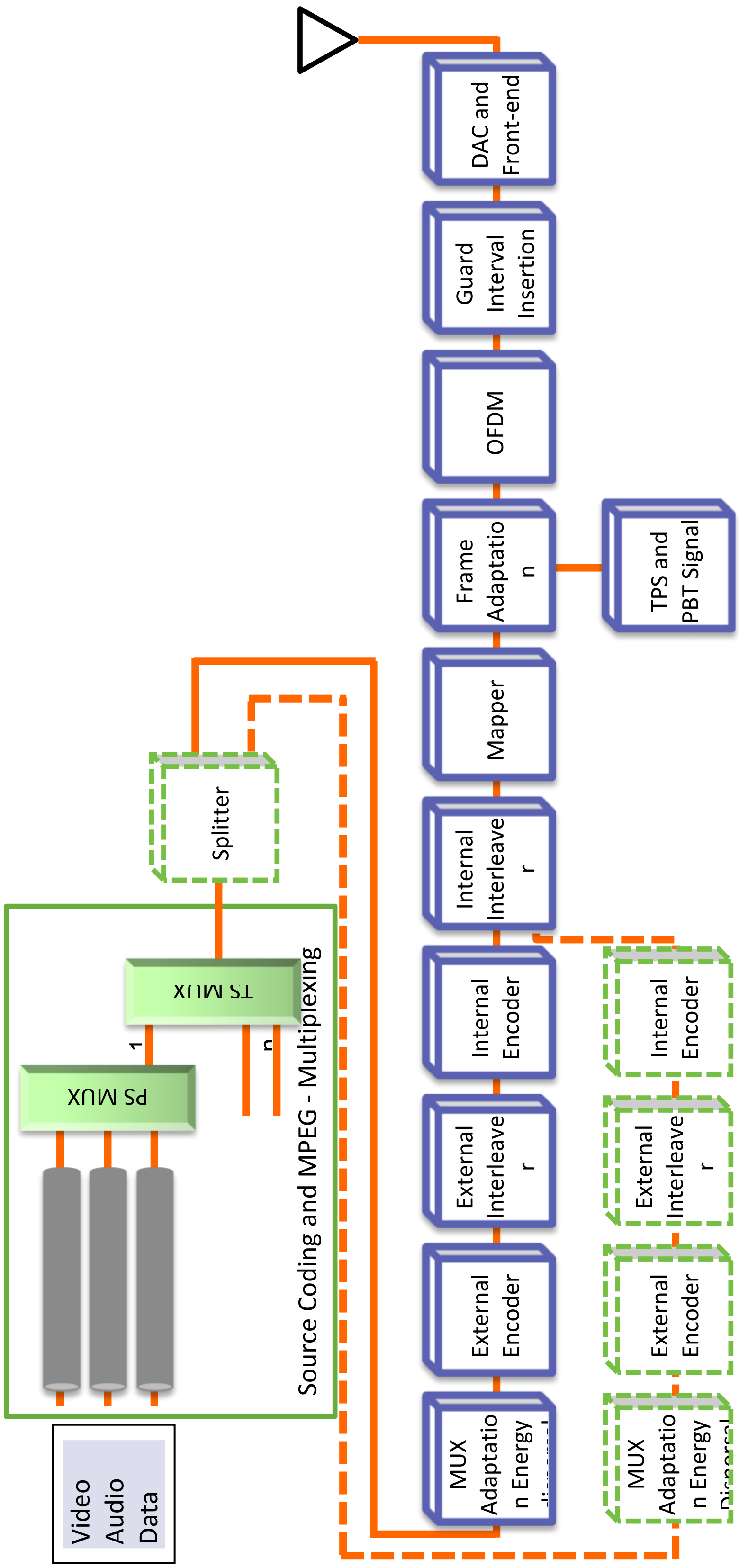
For decades, analogue TV stations in many of the world's largest markets have located their transmitters and antenna at a common site. In many of these cases a single support structure may contain separate antennas for each participating station. If, on the other hand, radiation patterns, polarization and other RF factors align, a single antenna and feed line can be used by several stations at one site. A combiner is installed at the base of the feed line where the transmitter output of each TV station is fed. This allows all participating television stations to enjoy lower capex and opex as result of these very positive economies of scale.

This tower uses three combiners to support 8 DTV channels, along with a single combiner for 12 FM radio stations.

Equally significant, the combined configuration is much simpler with fewer potential points of failure, not to mention a dramatic reduction in mechanical burden on the antenna support structure. Routine maintenance is also simplified. For example, rigging services need only be performed on a single antenna system. Unplanned maintenance, as the result of hurricane damage for example, is performed on a single system, meaning unbudgeted costs, along with time required to fully restore service, are greatly reduced.

As the digitization of broadcast television is contemplated in Curacao, there may be some very useful learning from analogue days.

Digital television broadcast in general, and DVB-T in particular, allows broadcasters to take the concept of sharing common resources at the transmitter site to new levels. To appreciate these capabilities, a high level overview of the DVB-T signal path is useful.


DAC and Front-end
Guard Interval Insertion
OFDM
Frame Adaptation
TPS and PBT Signal
Mapper
Internal Interleaver
Internal Encoder
External Interleaver
External Encoder
MUX Adaptation n Energy
Internal Encoder
External Interleaver
External Encoder
MUX Adaptation n Energy
Splitter
TS MUX
PS MUX
1
n
Source Coding and MPEG - Multiplexing
Video
Audio
Data

The DVB-T standard's Transport Stream (TS) is a container mechanism in which Program Streams (PS) are multiplexed. Each Program Stream represents a discrete virtual television channel. Assuming an 8 MHz RF channel and MPEG2 encoding, the rule of thumb is one high definition, and up to five standard definition program services can be multiplexed into one Transport Stream. In the case of standard definition only, seven Program Streams can be multiplexed on one Transport Stream. Other factors determining the allowable number of Program Streams per Transport Stream include the nature of the programming (e.g.: little motion, verses plenty of motion and transitions), along with the degree of compression the program provider is willing to tolerate. Further, statistical multiplexing allows for instantaneous assignment of Transport Stream bandwidth to the participating Program Streams on a dynamic basis.

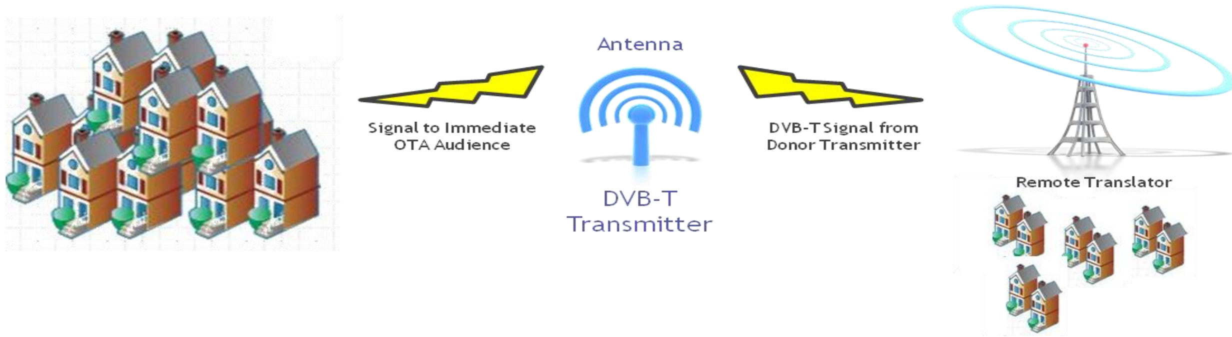
In the event more than one Transport Stream (and corresponding RF channel) is needed, the same economies of scale from the analogue world apply. Multiple DVB-T Transport Streams can be modulated on corresponding RF channels and then fed to an RF combiner and from there into a common antenna/feed line. As with the analogue days, this affords the elegance of a single antenna and feed line per transmitter site regardless of the number of RF channels. When the shared modulator(s) are factored in, significant capex and ultimately opex savings are realized. Again, points of failure – particularly those in dangerous hard to reach places – are dramatically reduced.

The concept of shared Transport Streams (and corresponding RF channels) extends well to a Single Frequency Network (SFN) contemplated by Curacao. The uniformity of service delivery along the entire delivery path simplifies virtually all operational aspects from maintenance to equipment sparing.

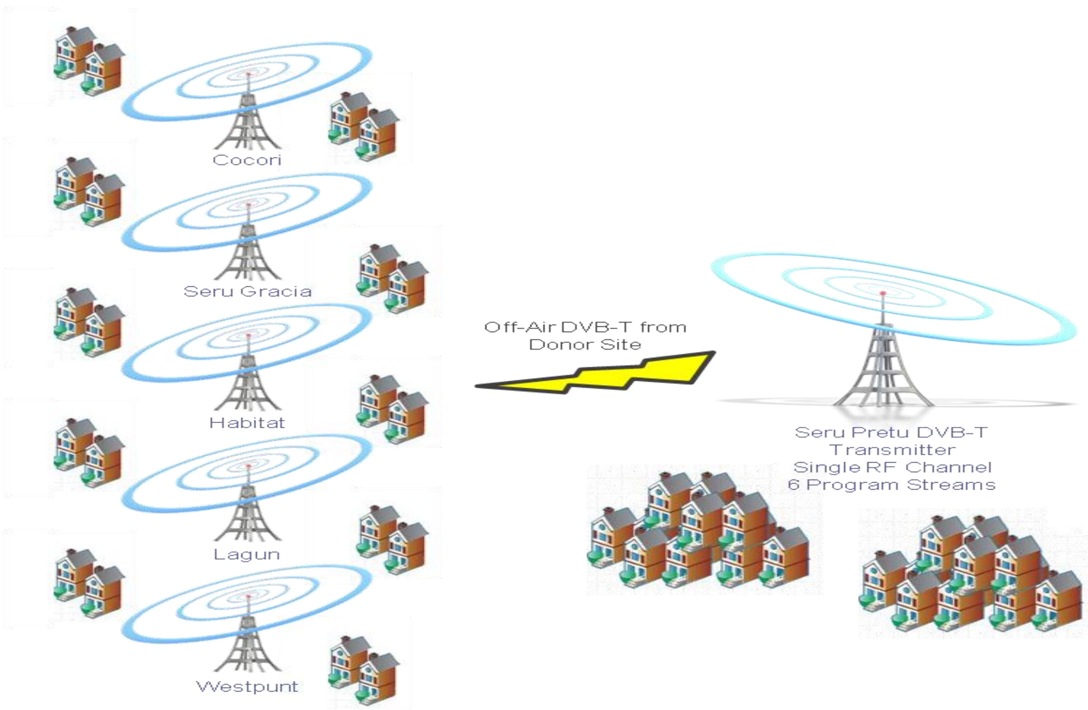
Leveraging Digital Efficiencies Inherent in DTV

Other opportunities for cost efficiency and network simplification are offered through DVB-T. If topology and propagation permit, a single transmitter can be used for the entire Curacao network. The remaining five sites would be equipped with translators.

Translators are a type of DTV transmitter whereby the data stream feeding it is not provided via ASI or other conventional means. Instead the translator accepts the actual off-air data stream from a donor transmitter. This simplifies the network significantly in that encoding occurs once and is merely repeated by the translators.

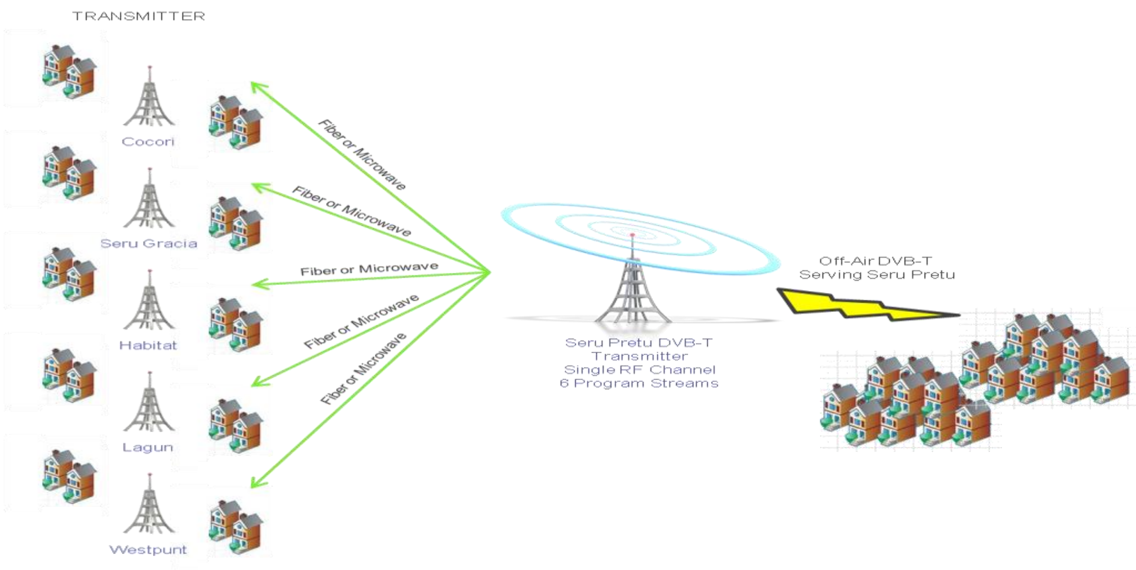


In the configuration below, the remote sites are fed directly off-air by the 'donor' site (Seru Pretu in the example below). Significant capital and long term operational cost savings can be realized with this configuration. The primary advantage is the elimination of the requirement for leased fiber STL/backhaul or dedicated microwave facilities.



In addition, should the broadcasters wish to introduce DVB-H (Digital Video Broadcast - Handheld) at some point in the future, only the main transmitter site need be fitted with the capability. The translators inherit the DVB-H capability as they are merely rebroadcasting the data stream of the donor transmitter. In addition to capex savings with this solution, the requirement for a technician to visit every site for the provision of new services is greatly reduced, potentially eliminated in fact.

As a result of each translator using a common Transport Stream from the donor site, no studio-transmitter link (backhaul) is required. This results in significant operational savings with regards to deploying or leasing fiber facilities, or operating and maintaining a microwave network to support such links.



In the above figure, all locations are transmitters and are fed with costly dedicated links.

In addition, the Transport Stream from the donor site performs double duty. First, it provides a feed to the translators as described above, but it also provides over-the-air service to viewers in the donor's footprint.

Terrain or other factors may not permit all remote sites to be translators. If this is the case, a hybrid network of transmitters and translators is a possibility. Should this be required, the same operational benefits apply albeit to a lesser extent.

Financial Analysis

There are two sets of analysis in this section. In Part One the cost impact of dedicating a single Transport Stream for every Program Stream (1:1 relationship) is contrasted with six standard definition Program Steams multiplexed onto one Transport Stream.

In Part Two, we look at the capital cost savings in using a single transmitter in the network with remaining sites running translators. Please refer to Appendix “A” for unit cost assumptions.

Part One: Contrasting a dedicate Transport Stream for every Program Steam

One Transport Stream Dedicated to Each Program Stream			
QTY	Item	Unit Cost	Total per Item
50 Watt ERP System			
18	DVB-T Transmitter (25 watts)	$ 20,800.00	$ 374,400.00
18	MPEG 2 Encoder	$ 5,500.00	$ 99,000.00
18	5.6 dBd Broadband Antenna	$ 4,900.00	$ 88,200.00
Sub Total			$ 561,600.00
200 Watt ERP System			
18	DVB-T Transmitter (100 watts)	$ 22,800.00	$ 410,400.00
18	MPEG 2 Encoder	$ 5,500.00	$ 99,000.00
18	5.6 dBd Broadband Antenna	$ 4,900.00	$ 88,200.00
Sub Total			$ 597,600.00
Grand Total			$ 1,159,200.00

Single Transport Stream for All Six Program Streams			
QTY	Item	Unit Cost	Total per Item
50 Watt ERP System			
3	DVB-T Transmitter (25 watts)	$ 20,800.00	$ 62,400.00
3	MPEG 2 Encoder	$ 5,500.00	$ 16,500.00
3	5.6 dBd Broadband Antenna	$ 4,900.00	$ 14,700.00
Sub Total			$ 93,600.00
200 Watt ERP System			
3	DVB-T Transmitter (100 watts)	$ 22,800.00	$ 68,400.00
3	MPEG 2 Encoder	$ 5,500.00	$ 16,500.00
3	5.6 dBd Broadband Antenna	$ 4,900.00	$ 14,700.00
Sub Total			$ 99,600.00
Grand Total			$ 193,200.00
Net Savings in Sharing Transport Stream			$ 966,000.00
Percent Savings in Sharing Transport Stream			83%

Assumption: 6 Standard Definition (SD) Program Steams

Please refer to Appendix "A" for unit costs.

Part Two: 1 Transmitter per Site Verses 1 Transmitter and 5 Translators

Single Transport Stream for All Six Program Streams - No Translators			
QTY	Item	Unit Cost	Total per Item
50 Watt ERP System			
3	DVB-T Transmitter (25 watts)	$ 20,800.00	$ 62,400.00
3	MPEG 2 Encoder	$ 5,500.00	$ 16,500.00
3	5.6 dBd Broadband Antenna	$ 4,900.00	$ 14,700.00
Sub Total			$ 93,600.00
200 Watt ERP System			
3	DVB-T Transmitter (100 watts)	$ 22,800.00	$ 68,400.00
3	MPEG 2 Encoder	$ 5,500.00	$ 16,500.00
3	5.6 dBd Broadband Antenna	$ 4,900.00	$ 14,700.00
Sub Total			$ 99,600.00
Grand Total			$ 193,200.00

Single Transport Stream for All Six Program Streams - 1 Transmitter & 5 Translators			
QTY	**Item**	**Unit Cost**	**Total per Item**
50 Watt ERP System			
3	**DVB-T Transmitter (25 watts)**	**$ 20,800.00**	**$ 62,400.00**
1	**MPEG 2 Encoder**	**$ 5,500.00**	**$ 5,500.00**
3	**5.6 dBd Broadband Antenna**	**$ 4,900.00**	**$ 14,700.00**
Sub Total			**$ 82,600.00**
200 Watt ERP System			
3	**DVB-T Transmitter (100 watts)**	**$ 22,800.00**	**$ 68,400.00**
3	**5.6 dBd Broadband Antenna**	**$ 4,900.00**	**$ 14,700.00**
Sub Total			**$ 83,100.00**
Grand Total			**$ 165,700.00**
Net Savings in deploying 1 transmitter and 5 translators			**$ 27,500.00**

Assumptions: 6 Standard Definition (SD) Program Steams.
Terrain and Propagation are conducive to a single transmitter feeding all translators.

Note this cost analysis only factors in capital savings in MPEG 2 encoder hardware. The costs of deploying fiber or microwave Studio-Transmitter Link (STL) backhaul vary by region, transmitter location and distance. Needless to say, these costs are not trivial should any of the sites be located where fiber is not available. Microwave linking is an option but it too is costly and adds a level of complexity to the network.

Conclusion

The DVB-T SFN proposed for Curacao, realizes no benefit by separating Program Streams into their own dedicated Transport Streams (and corresponding RF channels). In fact, as the numbers reveal, capital expenditures can be reduced by $966,000 (US) or 83% by routing the Program Streams into a common Transport Steam.

In addition, with the 1:1 TS/PS approach, either a combiner or multiple dedicated antennas/feed line will be required at each site.

The necessity to introduce individual antennas & support structures further adds a level of duplication where no real advantage is derived. While the use of combiners mitigates this expense to some degree, the end result is the same – that being that transmission equipment is unnecessarily duplicated and complexity unnecessarily increased.

Operating expenditures are increased as a result of the increase in duplicated operational assets. With that, potential points of failure also increase significantly.

APPENDIX

Component Costs

ITEM	DESCRIPTION	COST (US)
1	**50 Watt System**: 25 watt DVB/T-H digital transmitter including colour touch screen display, Ethernet and SNMP control and monitoring system, digital mask filter, isolator. TM600-DVBT/H modulator c/w linear and non linear pre-correction.	$20,800
2	**200 Watt System**: 100 watt DVB/T-H digital transmitter including colour touch screen display, Ethernet and SNMP control and monitoring system, digital mask filter, isolator. TM600-DVBT/H modulator c/w linear and non linear pre-correction.	$22,800
3	MPEG 2 DVB T/H encoder	$5,500
4	OMNI Directional Antenna array, 4 panels, Radom protected broadband including wiring harness, power divider, 5.6 dBd gain, 3.63 x power per channel	$4,900

[i] Specialty channels and premium tiered content are not in this category because they are not broadcast on over-the-air channels and are instead delivered exclusively through cable TV, Satellite and now in many markets, via the Internet.