The Business Case for Carrier Ethernet over MSPP SONET Networks

Network Strategy Partners, LLC

MANAGEMENT CONSULTANTS TO THE NETWORKING INDUSTRY

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TABLE OF CONTENTS

Executive Summary

Telecom networks today are undergoing a radical transformation from circuit switched and legacy data networks to converged Ethernet transport and IP/MPLS networks. While there is universal agreement that the path towards the future is over Ethernet, many service providers are struggling to find the optimum business model for Carrier Ethernet to ensure profitable growth of new services as legacy cash cow services are retired. In this paper we compare two approaches to building Carrier Ethernet networks:

1. Deploy an overlay Carrier Ethernet network directly over fiber or DWDM transport
2. Provide Carrier Ethernet transport over an existing MSPP SONET or SDH network

This paper will examine both these options and show that the optimal approach is to use existing SONET/SDH networks for Carrier Ethernet in smaller cities and to build an overlay Ethernet network in Tier 1 cities. *A key success factor for service providers implementing this strategy is a partnership with a vendor that offers an integrated solution with both of these approaches*.

One of the reasons that the first approach makes sense for small cities is that these cities already have existing SONET networks deployed for TDM traffic. In these cities Carrier Ethernet services can be implemented quickly and cost effectively using Ethernet cards on MSPP SONET nodes. Because smaller cities do not have sufficient fiber connectivity, density, and demand they do not justify the rollout of a separate Carrier Ethernet network in the short-term[1].

On the other hand, Tier 1 cities do have sufficient fiber connectivity, density, and demand to justify a separate Ethernet overlay network. These networks are typically built with scalable L2/L3 Ethernet switches in Central Offices (COs) and Metro DWDM transport rings.

This paper uses North American market research and US census data to build a network demand, engineering, and ROI model comparing these two solutions for three cities:

- Springdale, AR (Tier 3)
- Stockton, CA (Tier 2)
- Boston, MA (Tier 1)

In both the Tier 1 and Tier 2 cities the MSPP Ethernet approach is less expensive then the dedicated Ethernet network. In Springdale the dedicated Ethernet network is 250% the

[1] This study analyzes the business case for Carrier Ethernet over a five year period. Over this period we found that Ethernet over SONET in Tier 2 and 3 cities makes more sense then a separate Ethernet overlay network. However, it is possible that over a longer period with more growth in demand that an overlay network could be cost justified.

cost of the MSPP Ethernet network. In Stockton price difference between the approaches is 210%. However, in Boston the dedicated network is less expensive then the MSPP approach.

One key exception to this finding is that if service providers are deploying Video-on-Demand (VoD) services to residential customers then bandwidth requirements could be *much larger* than those calculated in this ROI model and it is prudent for service providers to build overlay networks in *all cases* that VoD services are offered. This model assumes that residential triple play traffic consists of High Speed Internet, Voice-over-IP, and IPTV, *not* VoD.

Based on this analysis we show that it is a smart business strategy for service providers to leverage their existing SONET MSPP networks to deploy Ethernet services quickly and cost effectively in smaller cities where VoD services are *not* offered, while building out dedicated Ethernet networks in larger metro areas and *all areas* where VoD service are offered. Service providers should work with a vendor that can provide an integrated solution with both MSPP Ethernet and dedicated Carrier Ethernet products.

This paper is organized as follows. First, we give an overview of Carrier Ethernet services and applications, next we provide background on the assumptions for demand, traffic, and network architecture in our ROI model, and finally we present the results of this economic analysis.

Carrier Ethernet Services and Applications

Most service providers and vendors are in agreement that Ethernet transport networks will carry much of the future IP traffic. Ethernet is currently being used for transport between Internet and MPLS routers, Ethernet DSLAMs and OLTs, and commercial Carrier Ethernet services and it is expected that Carrier Ethernet will grow by an order of magnitude over the next five years. In this section we provide an overview of *what* Carrier Ethernet transport is and how it *differs* from Enterprise Ethernet.

Carrier Ethernet's capabilities are built upon the Metro Ethernet Forum's Ethernet Line (E-Line) and Ethernet LAN (E-LAN) service types. They are defined as:[2]

- E-Line – An Ethernet service type that is based on a Point-to-Point Ethernet Virtual Connection. Two E-Line services are defined:
    - EPL (Ethernet Private Line) – This is a very simple point-to-point service characterized by low Frame Delay, Frame Delay Variation and Frame Loss Ratio. No service multiplexing is allowed and other than a Committed Information Rate (CIR) no CoS (Bandwidth Profiling) is allowed.

[2] See MEF 6 – Ethernet Service Definitions – Phase I, Metro Ethernet Forum, June 2004 for the technical specification of E-Line and E-LAN service types.

  - EVPL (Ethernet Virtual Private Line) – This is a point-to-point service wherein service multiplexing (More than one Ethernet Virtual Circuit) is allowed. The individual Ethernet Virtual Circuits can be defined with the rich set of Bandwidth Profile and Layer 2 Control Protocol Processing methods defined by the Metro Ethernet Forum.

- E-LAN – An Ethernet service type that is based on a Multipoint-to-Multipoint Ethernet Virtual Connection. Service multiplexing—more than one Ethernet Virtual Circuit at the same UNI—is permitted, as is the rich set of performance assurances defined by the MEF such as CIR with an associated Committed Burst Size (CBS) and Excess Information Rate (EIR).

These Metro Ethernet Forum (MEF) service definitions (and their associated technical implementations) are key to helping service providers profitably migrate their customers from existing TDM/PDH and Frame Relay services to next-generation services delivered over a much higher speed converged network infrastructure. The MEF definitions maintain and extend desirable characteristics of these older services including:

- Performance guarantees – The MEF CoS mechanisms and Layer 2 Control Processing methods provide guaranteed performance of such parameters as delay variation, information rates and information loss recovery mechanisms.

- Security – Layer 2 networks that employ virtual circuits such as Frame Relay and Point-to-Point private lines such as T1/E1 are considered to be highly secure. The MEF E-LAN and E-Line services are equivalently secure.

By contrast, Enterprise Ethernet is based on a much simpler layer 2 switching network with little or no QoS capabilities or security. While Enterprise Ethernet is not an appropriate technology for service provider transport networks, Carrier Ethernet products have been designed specifically for service providers and are optimally suited to next generation IP packet transport.

Demand and Pricing Assumptions

The economic analysis in this paper is based on a set of assumptions regarding traffic demand, service pricing, and network architecture. This section of the paper provides an overview of the data used in forecasting demand and our service pricing assumptions.

In order to compare the business case for Carrier Ethernet over the MSPP transport network versus a dedicated Carrier Ethernet network, we forecasted network traffic for three cities: Springdale, AR, Stockton, CA, and Boston, MA. These three examples are representative of Tier 3, Tier 2, and Tier 1 cities respectively. Table 1 presents US Census data for number of households and the number of business establishments for each of these cities.

City	Households	Establishments
Springdale, AR	16,962	552
Stockton, CA	91,313	2,012
Boston, MA	239,528	8,135

Table 1
Households and Business Establishments based on US Census Data

For each of the cities studied the number of households is used to calculate residential triple play traffic (HSI, VoIP, and IPTV) and the number of business establishments is used to calculate commercial Carrier Ethernet traffic. The traffic calculations use the census numbers as well as assumptions for service penetration rates and port distributions. These penetration rate and port distribution assumptions are based on current market research data.

Commercial Carrier Ethernet Service Forecasts

For the smaller cities (Springdale and Stockton) the penetration of commercial Carrier Ethernet services is expected to be lower then in the large metro areas. In these smaller cities the penetration rates are for commercial Carrier Ethernet services are specified in Table 2.

Service	Year 1	Year 2	Year 3	Year 4	Year 5
E-Line (EPL)	0.5%	0.9%	1.6%	2.6%	4.4%
E-LINE (EVPL)	0.4%	0.7%	1.2%	2.0%	3.4%
E-LAN	0.5%	1.0%	1.7%	2.9%	4.8%
Total	**1.3%**	**2.5%**	**4.5%**	**7.5%**	**12.6%**

Table 2
Penetration Rates for Commercial Carrier Ethernet in Tier 2 and 3 Cities

For the larger cities (Boston) the penetration rates are expected to be larger as illustrated in Table 3.

Service	Year 1	Year 2	Year 3	Year 4	Year 5
E-Line (EPL)	0.9%	1.8%	3.2%	5.3%	8.4%
E-LINE (EVPL)	0.7%	1.4%	2.4%	4.1%	6.5%
E-LAN	1.0%	1.9%	3.4%	5.7%	9.1%
Total	**2.6%**	**5.0%**	**9.0%**	**15.0%**	**24.0%**

Table 3
Penetration for Commercial Carrier Ethernet in Tier 1 Cities

Carrier Ethernet port distributions (10Mbps, 100 Mbps, and 1 Gbps) are expected to be similar for all cities. Market research data was used to generate the port distributions specified in Table 4.

The final piece of the puzzle is the pricing assumptions for Carrier Ethernet which are specified in Table 5. These assumptions are based on tariffs and Network Strategy Partners' work with service providers and vendors in the telecommunications industry.

Service	Year 1	Year 2	Year 3	Year 4	Year 5
10 Mbps	68%	70%	74%	76%	78%
100 Mbps	26%	23%	19%	16%	14%
1 Gbps	6%	6%	7%	7%	8%

Table 4
Five Year Forecast of Carrier Ethernet Port Distributions

Service	Port Speed (Mbps)	CIR (Mbps)	Monthly Price
E-Line (EPL)	10 Mbps	10	$ 1,000
	100 Mbps	100	$ 1,800
	1 Gbps	622	$ 4,500
E-Line (EVPL)	10 Mbps	1	$ 750
	100 Mbps	10	$ 900
	1 Gbps	200	$ 2,000
E-LAN	10 Mbps	1	$ 750
	100 Mbps	10	$ 900
	1 Gbps	200	$ 2,000

Table 5
Carrier Ethernet Monthly Pricing Assumptions

Residential Triple Play Service Forecasts

Another key driver of Ethernet transport infrastructure is residential triple play service. All next generation DSLAM, OLT, and CMTS access devices use GbE ports as gateways to the aggregation network. Triple play traffic can be a major consumer of bandwidth in the network. In this model we consider traffic associated with High Speed Internet (HSI), Voice over IP (VoIP), and IPTV. We do not consider Video-on-Demand (VoD). *Deployment of VoD will drive network bandwidth requirements to much higher levels. If VoD service is offered a separate Carrier Ethernet overlay network is recommended.*

Our assumptions for the five year penetration rates for residential triple play services are specified in Table 6 and our assumptions for monthly pricing are listed in Table 7.

Service	Year 1	Year 2	Year 3	Year 4	Year 5
IPTV	2%	6%	8%	12%	15%
VoIP	2%	6%	8%	12%	15%
High Speed Internet	25%	30%	35%	40%	50%

Table 6
Forecast of Penetration Rates for Residential Triple Play Services

Service	Monthly Price
SDTV	$ 60
HDTV	$ 65
VoIP	$ 30
High Speed Internet	$ 25

Table 7
Monthly Pricing Assumptions for Residential Triple Play Services

TDM Demand Forecast

All SONET and SDH networks today are dominated by traditional TDM traffic consisting of TDM voice, private lines, Frame Relay, ATM, and other legacy services. In order to calculate the bandwidth on the SONET ring(s) that is available for Ethernet services it is necessary to determine the bandwidth used by traditional TDM services. It is assumed that over time the bandwidth used by TDM services will decrease due to VoIP, MPLS, and Pseudo Wire services. Our assumptions for TDM penetration rates over the five year period are specified in Table 8. We also assume that for business establishments

that have T1 or DS3 circuits that there are on average 1.5 DS1's and 1 DS3 per establishment.

Service	Year 1	Year 2	Year 3	Year 4	Year 5
DS1	85%	85%	80%	75%	70%
DS3	2%	1%	1%	1%	1%

Table 8
Five Year Forecast for TDM Penetration Rates

Network Architecture Assumptions

The primary focus of this paper is a business case comparison of Carrier Ethernet services transported on a MSPP network versus on a dedicated L2/L3 network. Figure 1 characterizes the MSPP network architecture. For each of the cities modeled in our study (Springdale, Stockton, and Boston) we have used MSPP aggregation and access rings to connect central offices to a core IP/MPLS network. Ethernet traffic consists of residential traffic from DSLAMs and commercial Carrier Ethernet traffic from business establishments. The MSPP network also is used for all legacy TDM transport (T1 and DS3).

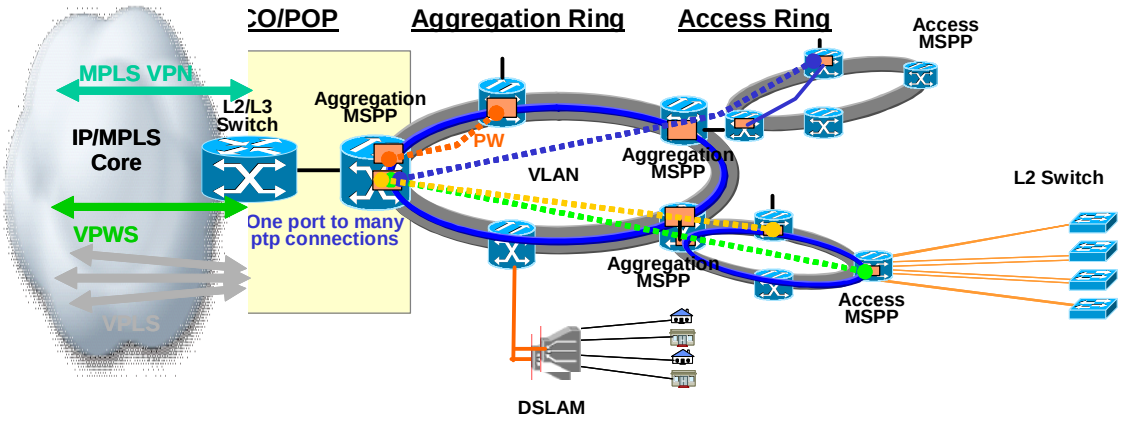

Figure 1
MSPP Carrier Ethernet Network Architecture

Figure 2 specifies the dedicated Carrier Ethernet network architecture. This approach uses L2/L3 Ethernet switches directly connected to fiber to build a Carrier Ethernet aggregation ring. In the access rings lower cost L2 switches are used for Carrier Ethernet services. Ethernet traffic consists of residential triple play traffic aggregated from DSLAMs and commercial Carrier Ethernet traffic from business customers.

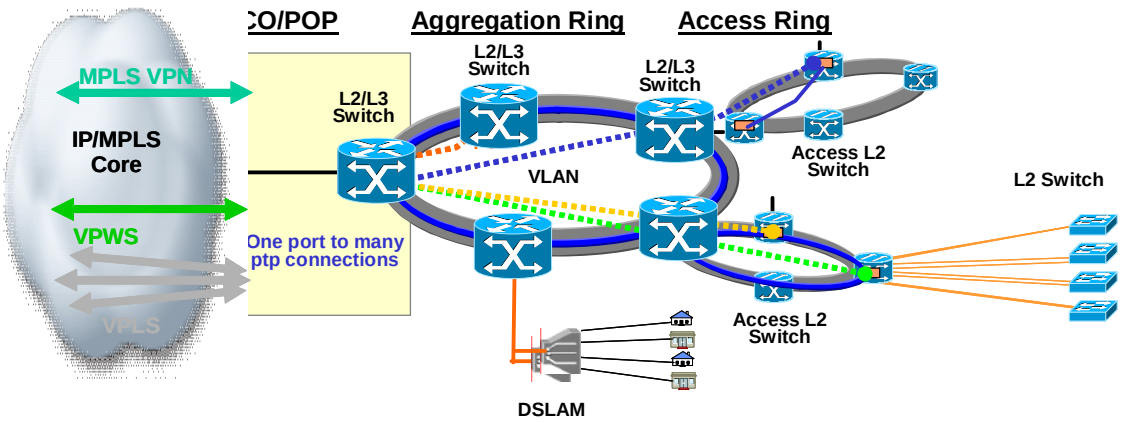

Figure 2
Dedicated Carrier Ethernet Network with L2/L3 Switches

Business Case Results

For each of the three cities studied in this paper we have used a model to forecast demand, design networks, and calculate financials for both MSPP Ethernet and Ethernet overlay architectures. We have analyzed scenarios for each city assuming that a SONET network is already installed and is carrying TDM traffic. Additionally, for one city, Stockton, we have assumed that there is no existing SONET network in place and a SONET extension from a neighboring network is required. The results and conclusions from each of these examples are presented in the following sections.

Springdale, AR

Springdale, with 16,962 households and 552 business establishments, is representative of a Tier 3 city. Using the demand assumptions specified earlier, we have projected total network traffic over a five year period which is represented in Figure 3. In year 1 most of the traffic is TDM, over the five year period we see a significant growth in Carrier Ethernet traffic until it dominates the network in year 5. Because Springdale is a smaller city the total traffic can be carried on a single OC192 ring.

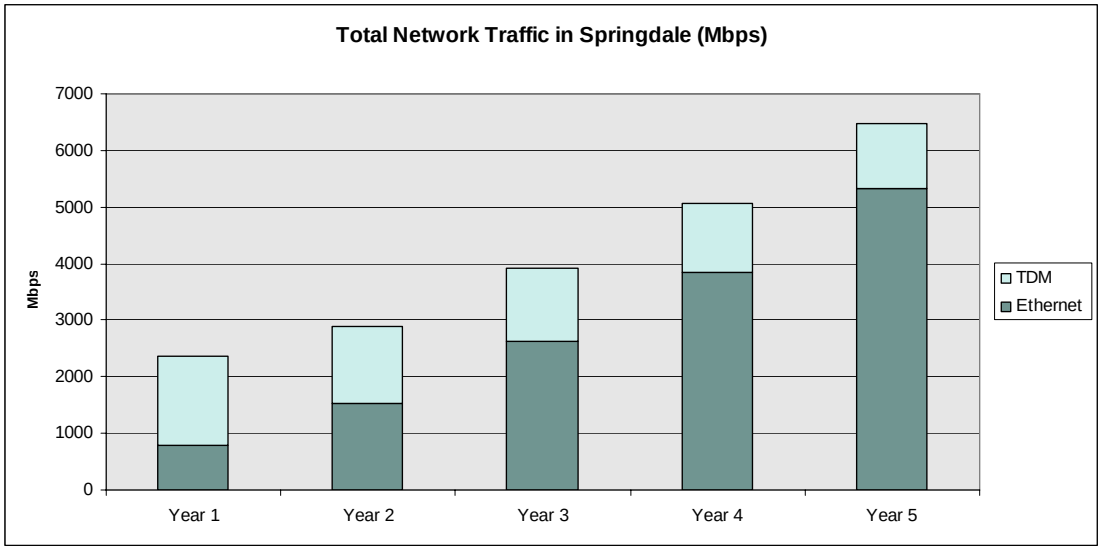

Figure 3
Total Network Traffic Demand in Springdale, AR

Given the traffic forecast we designed networks using both the MSPP approach and the dedicated Carrier Ethernet approach. We also assumed that there is an existing MSPP SONET network in Springdale so only Ethernet cards for the MSPP are needed to provide Ethernet service as compared to a dedicated network that requires new chassis in all locations. Revenues were calculated using pricing and penetration assumptions, capital expenses were calculated from the network configurations, and operations expenses were calculated using the assumption that the cost of revenue is 35% and SG&A is 24% of revenue. The cash flow analysis for the MSPP and dedicated solutions are presented in Table 9 and Table 10. Over the five year period there is a positive Net Present Value (NPV) for both capital investments, however, the MSPP approach is more cost effective and, therefore, has a shorter pay back period, higher IRR, and higher NPV then the dedicated network.

Financial Statements - Ethernet over MSPP

	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Revenue					
EPL	$ 22,375	$ 81,663	$ 144,933	$ 240,442	$ 407,775
EVPL	$ 20,078	$ 38,661	$ 69,437	$ 115,964	$ 196,525
ELAN	$ 28,258	$ 54,411	$ 97,726	$ 163,209	$ 276,591
DS1	$ -	$ -	$ -	$ -	$ -
DS3	$ -	$ -	$ -	$ -	$ -
Standard Definition TV	$ 11,971	$ 29,316	$ 29,316	$ 36,644	$ 36,644
High Definition TV	$ 265	$ 7,940	$ 21,172	$ 39,698	$ 59,547
Voice over IP	$ 6,107	$ 18,322	$ 24,430	$ 36,644	$ 45,806
High Speed Internet	$ 63,619	$ 76,343	$ 89,066	$ 101,790	$ 127,238
Annual Revenue	**$ 152,672**	**$ 306,655**	**$ 476,079**	**$ 734,393**	**$ 1,150,125**
Cumulative Revenue	**$ 152,672**	**$ 459,326**	**$ 935,405**	**$ 1,669,798**	**$ 2,819,923**
Operations Expenses					
Cost of Revenue	$ 53,435	$ 107,329	$ 166,628	$ 257,037	$ 402,544
Sales, General & Administrative Expense	$ 36,641	$ 73,597	$ 114,259	$ 176,254	$ 276,030
Annual Operating Expenses	**$ 90,076**	**$ 180,926**	**$ 280,887**	**$ 433,292**	**$ 678,574**
Capital Cost					
Aggregation MSPP	$ 126,508	$ 12,344	$ -	$ 38,832	$ 23,381
Access MSPP	$ 10,075	$ 25,188	$ 10,075	$ -	$ -
L2/L3 Switch	$ 25,968	$ -	$ -	$ -	$ -
Annual Capital Cost	**$ 162,551**	**$ 37,531**	**$ 10,075**	**$ 38,832**	**$ 23,381**
Cumulative Capital Cost	**$ 162,551**	**$ 200,082**	**$ 210,157**	**$ 248,989**	**$ 272,370**
Annual Cash Flow	**$ (99,955)**	**$ 88,197**	**$ 185,117**	**$ 262,269**	**$ 448,171**
Net Present Value	**$ (99,955)**	**$ (16,750)**	**$ 148,004**	**$ 368,209**	**$ 723,203**
IRR	**142%**				
Payback	**3.57**				

Table 9
Cash Flow Analysis for Carrier Ethernet over an MSPP Network

Financial Statements - Ethernet over Dedicated Network

	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Revenue					
E-Line	$ 22,375	$ 81,663	$ 144,933	$ 240,442	$ 407,775
E-LAN	$ 20,078	$ 38,661	$ 69,437	$ 115,964	$ 196,525
MPLS VPN	$ 28,258	$ 54,411	$ 97,726	$ 163,209	$ 276,591
DS1	$ -	$ -	$ -	$ -	$ -
DS3	$ -	$ -	$ -	$ -	$ -
Standard Definition TV	$ 11,971	$ 29,316	$ 29,316	$ 36,644	$ 36,644
High Definition TV	$ 265	$ 7,940	$ 21,172	$ 39,698	$ 59,547
Voice over IP	$ 6,107	$ 18,322	$ 24,430	$ 36,644	$ 45,806
High Speed Internet	$ 63,619	$ 76,343	$ 89,066	$ 101,790	$ 127,238
Annual Revenue	**$ 152,672**	**$ 306,655**	**$ 476,079**	**$ 734,393**	**$ 1,150,125**
Cumulative Revenue	**$ 152,672**	**$ 459,326**	**$ 935,405**	**$ 1,669,798**	**$ 2,819,923**
Operations Expenses					
Cost of Revenue	$ 53,435	$ 107,329	$ 166,628	$ 257,037	$ 402,544
Sales, General & Administrative Expense	$ 36,641	$ 73,597	$ 114,259	$ 176,254	$ 276,030
Annual Operating Expenses	**$ 90,076**	**$ 180,926**	**$ 280,887**	**$ 433,292**	**$ 678,574**
Capital Cost					
L2/L3 Aggregation Switch	$ 449,183	$ -	$ -	$ -	$ 29,250
L2 Access Switch	$ 48,406	$ 242,028	$ -	$ -	$ -
Annual Capital Cost	**$ 497,588**	**$ 242,028**	**$ -**	**$ -**	**$ 29,250**
Cumulative Capital Cost	**$ 497,588**	**$ 739,616**	**$ 739,616**	**$ 739,616**	**$ 768,866**
Annual Cash Flow	**$ (434,993)**	**$ (116,299)**	**$ 195,192**	**$ 301,101**	**$ 442,301**
Net Present Value	**$ (434,993)**	**$ (544,709)**	**$ (370,988)**	**$ (118,178)**	**$ 232,166**
IRR	**19%**				
Payback	**5.00**				

Table 10
Cash Flow Analysis for Carrier Ethernet over a Dedicated Ethernet Network

The capital expenditures for the two approaches are compared in Figure 4. The CAPEX graph shows that there is a significant amount of capital expense for the dedicated network in years 1 and 2. This is because an entire Carrier Ethernet network needs to be deployed at many of the central offices throughout the city. After this network is deployed there are only modest expenditures required in the subsequent years because the network has sufficient capacity to handle new demand. Since the MSPP network is already deployed, the only capital expense required is for MSPP Ethernet line cards and installation.

The Net Present Values for the two approaches are compared in Figure 5. These charts show a positive business case for both investments, but a much stronger case for the MSPP approach. The MSPP NPV hits zero[3] in the middle of year 2. It does not hit zero until late in year 4 for the dedicated network solution. The NPV is also significantly higher for the MSPP approach.

In summary, a city the size of Springdale is a good place to use an existing MSPP network to deploy Carrier Ethernet services as long as there is no plan to offer VoD services to residential customers.

[3] The NPV calculates the future value of an investment accounting for the time value of money (discounting). An NPV of zero indicates that the investment does not lose or make any money. It breaks even. A negative NPV indicates that an investment loses money and a positive NPV indicates that an investment makes money. The higher the value of the NPV the better the investment.

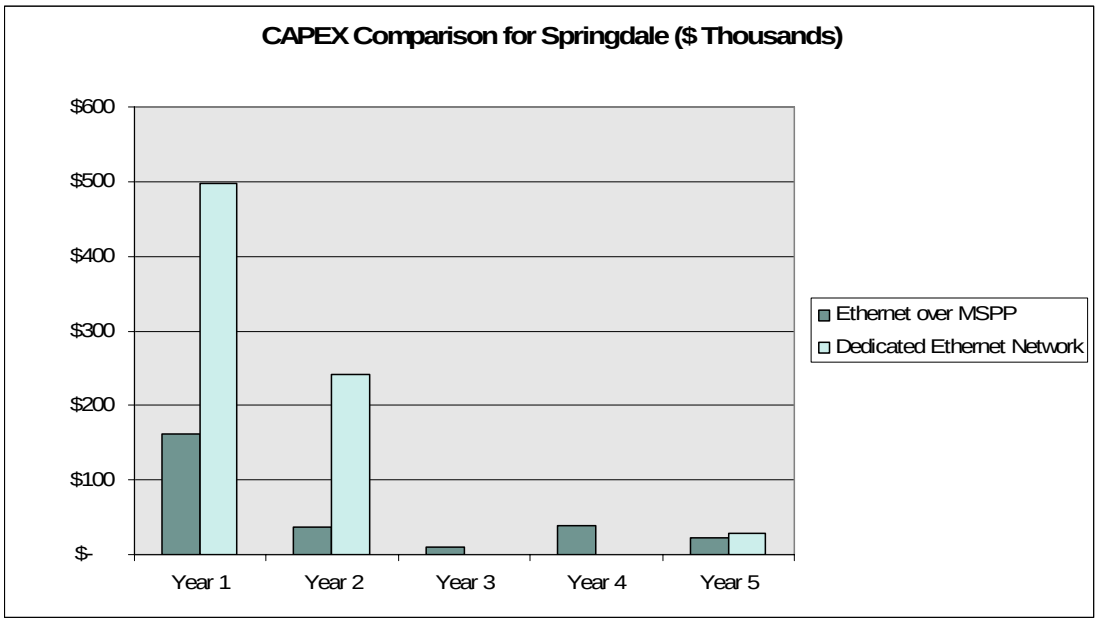

Figure 4
CAPEX comparison between the MSPP and Dedicated Network for Springdale

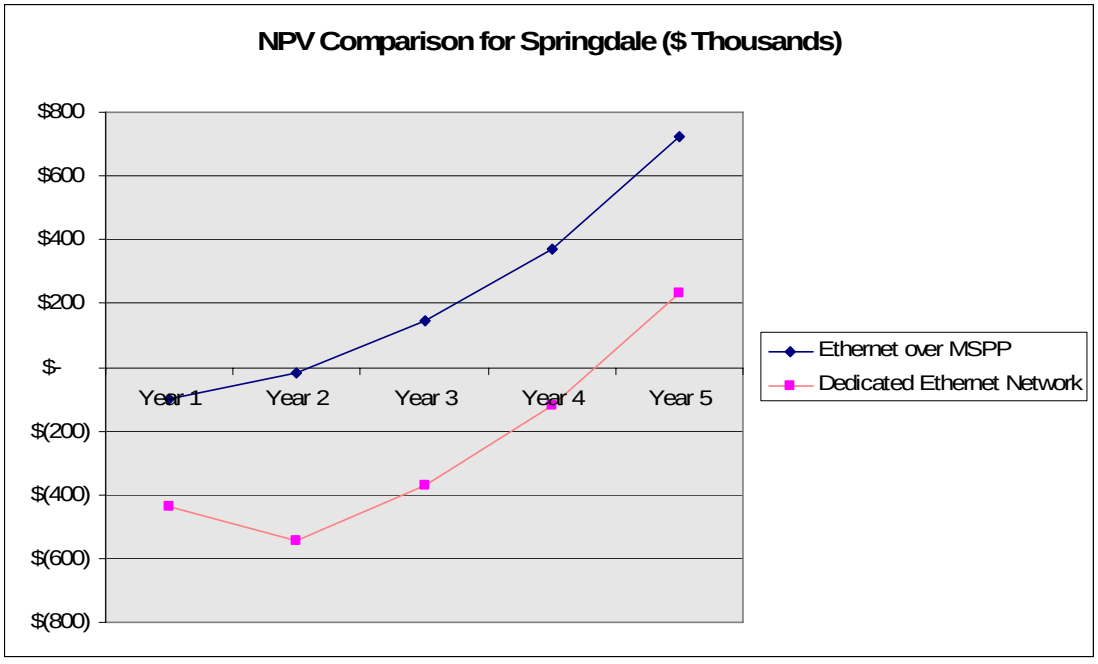

Figure 5
Net Present Value Comparison of MSPP and Dedicated Network for Springdale

Stockton, CA

Stockton, with 91,313 households and 2,012 business establishments, is representative of a Tier 2 city. The same methodology described for Springdale also was employed for Stockton. The total traffic in Stockton is presented in Figure 6. As in the Springdale model, Carrier Ethernet starts as a small percentage of the traffic in year 1 and over the five year period dominates the network. Because Stockton is a larger city then Springdale the magnitude of network traffic is greater. All Stockton's traffic can be supported by two OC192 rings.

The key financial metrics for the two approaches are compared in Table 11 and comparisons of five year capital spending and the NPV of both approaches are provided in Figure 7 and Figure 8. The total cumulative capital spending for the MSPP network is roughly half the cost of the dedicated network and most of the spending for the dedicated network is required in year 1. There is more revenue associated with both commercial and residential services in Stockton than Springdale, however, because Stockton is a larger city. The increased revenue results in the NPV curves coming together more closely for the two alternatives in Stockton then in Springdale. However, the breakeven, NPV, and IRR for the MSPP solution are still superior to the dedicated network.

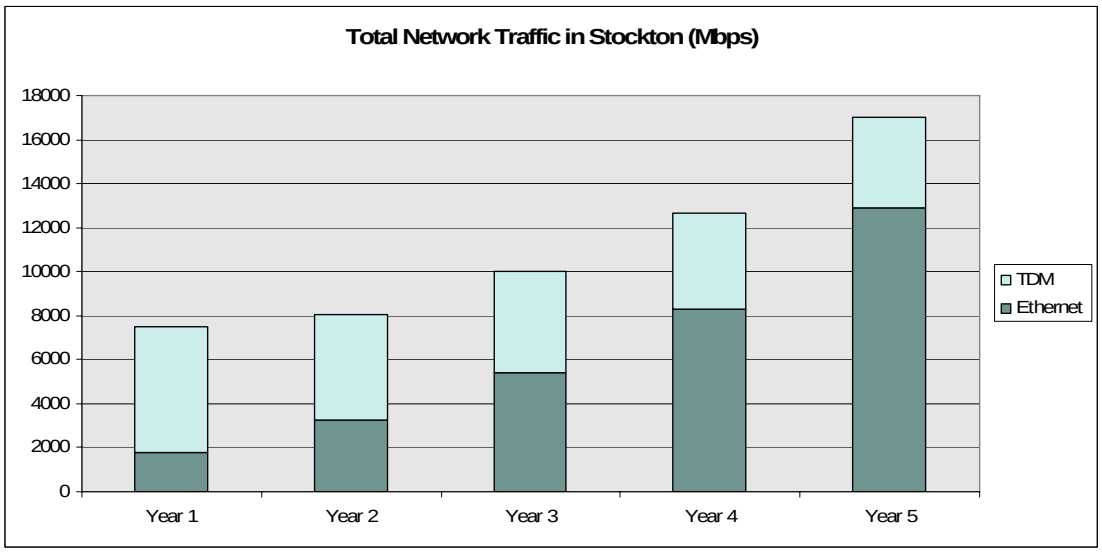

Figure 6
Total Network Traffic for Stockton in Mbps

	MSPP	Dedicated Ethernet Network
Cumulative CAPEX	$ 812,399.25	$ 1,718,421.25
NPV	$ 2,956,222.98	$ 2,021,695.94
Payback (Years)	2.5	4.7

Table 11
Key Financial Parameters for Stockton

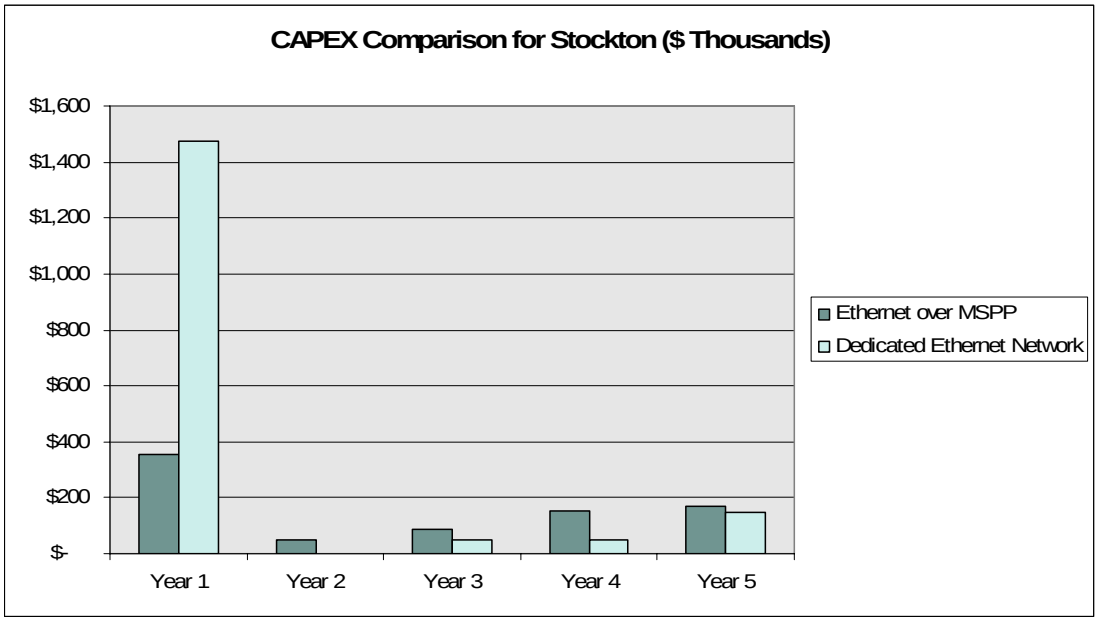

Figure 7
CAPEX Comparison of the Two Approaches for Stockton

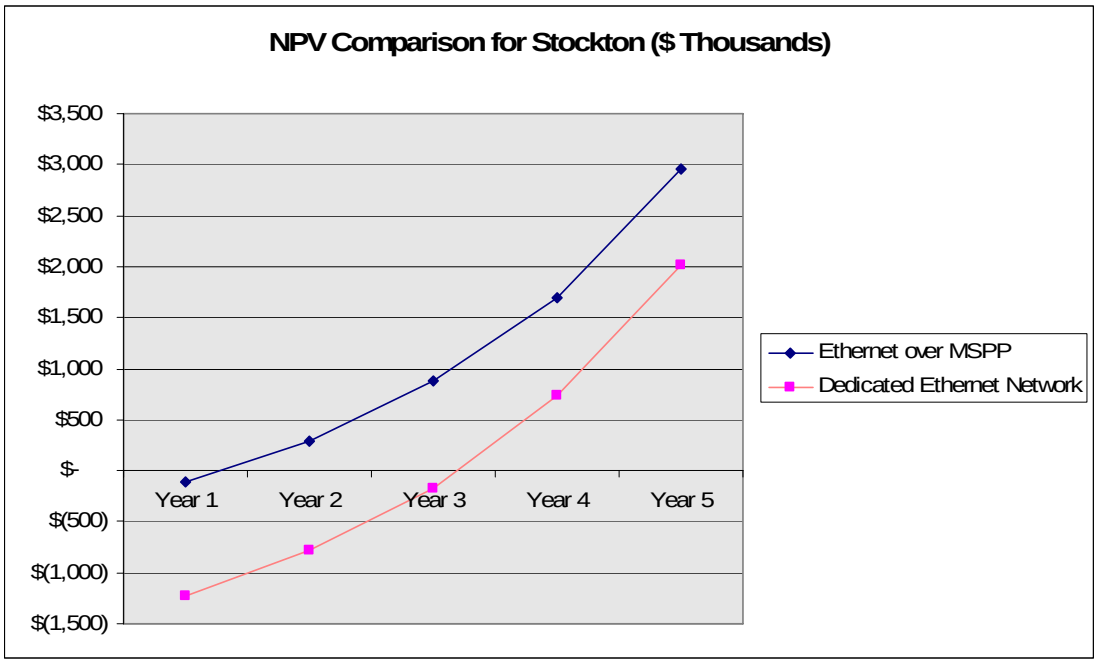

Figure 8
NPV Comparison for Stockton

In summary, a city the size of Stockton is also a good place to use an existing MSPP network to deploy Carrier Ethernet services as long as there is no plan to offer VoD services to residential customers.

Boston, MA

Boston, with 239,528 households and 8,135 business establishments, is representative of a Tier 1 city. The same analysis methodology described earlier was employed for Boston. Figure 9 depicts the total network traffic in Boston., The total network demand is significantly higher in Boston because it has a much higher population and business establishment density than Springdale or Stockton. The key financials presented in Table 12 show that the dedicated network is a less expensive approach in Boston then the MSPP network. The business case for the dedicated network in Boston is further supported by the five year CAPEX and NPV comparisons presented in Figure 10 and Figure 11. Furthermore, in a city the size of Boston, service providers are much more likely to deploy VoD services[4] to residential customers. The additional traffic generated by VoD only will strengthen the business case for the dedicated Carrier Ethernet network. Clearly, in Tier 1 metro areas it makes a great deal of sense to build a separate Carrier Ethernet infrastructure for Ethernet transport. This approach is more cost effective and more scalable then offering Ethernet services on the existing MSPP infrastructure.

[4] VoD services are not considered in this analysis because it is assumed that if VoD services are deployed, then the traffic created will automatically justify the deployment of a dedicated Carrier Ethernet network.

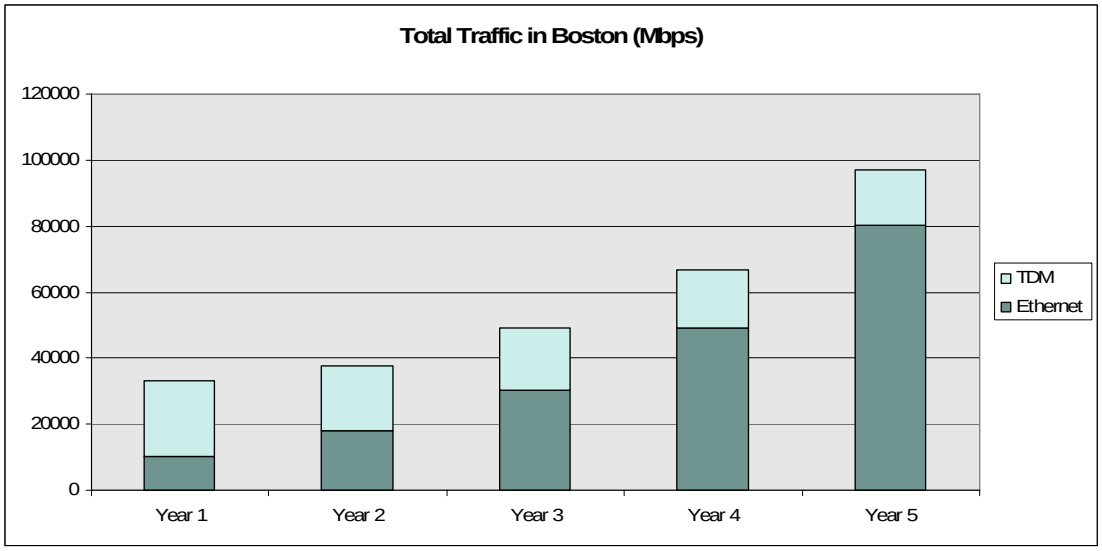

Figure 9
Total Network Traffic in Boston (Mbps)

	MSPP	Dedicated Ethernet Network
Cumulative CAPEX	$ 4,998,461	$ 4,500,652
NPV	$ 21,492,549	$ 21,911,780
Payback (Years)	1.9	1.8

Table 12
Key Financials for Boston

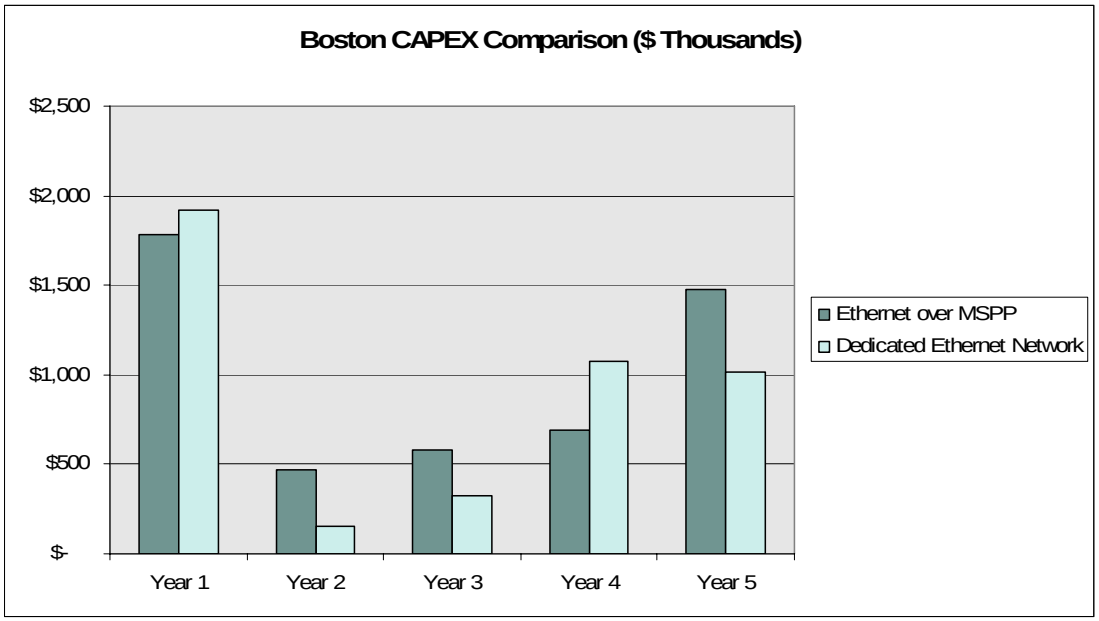

Figure 10
Boston CAPEX Comparison of the MSPP Approach to a Dedicated Network

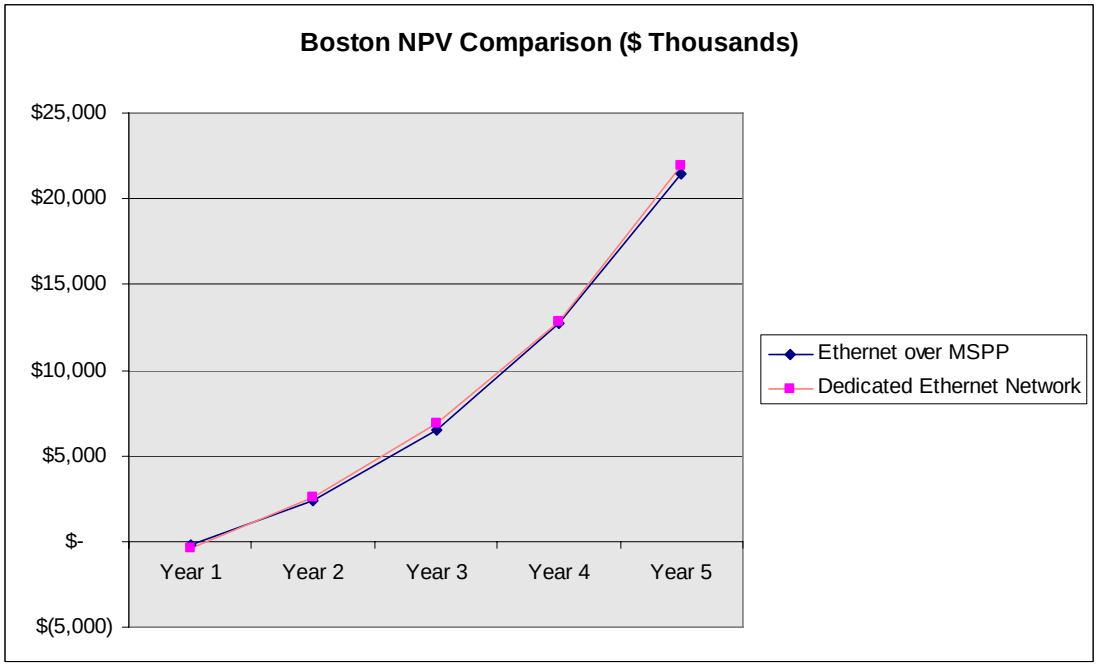

Figure 11
Boston NPV Comparison between the MSPP and Dedicated Ethernet Networks

SONET Extension Network

All of the cases analyzed above have assumed that there is an existing SONET network in place allowing Carrier Ethernet services to be offered by simply adding Ethernet cards to the existing MSPPs. In this section we consider the case in which there is *no existing SONET network* and a SONET extension from a neighboring ring is required. In this example we only consider the cost of the network equipment and *not* the cost of fiber, as construction costs are the same for the both the MSPP and dedicated Ethernet approaches. For this analysis we use Stockton, which represents a Tier 2 city. We also assume that the TDM demand requirements must be met by both alternatives. Therefore, if a dedicated Ethernet network is used, a SONET network must also be implemented to support the TDM demand (specified earlier in this paper).

Table 13 provides a summary of the key financials. The results demonstrate that in a Tier 2 city with no VoD requirements, an integrated MSPP network is more cost effective then a separate SONET (for TDM demand) and Carrier Ethernet network (for Ethernet demand). This is because the population and business establishment densities are not high enough to justify the deployment of two networks. This is supported further by the five year CAPEX and NPV charts in Figure 12 and Figure 13. It should be noted, however, that the NPVs for the two alternatives are much closer than in the earlier case considered where there was an existing network in place. It also should be noted that in a Tier 3 city the business case is stronger for an MSPP extension because there is lower population and commercial business density.

From this analysis we conclude that a MSPP SONET extension for combined TDM and Ethernet services makes sense in Tier 2 and Tier 3 cities *if* there is Ethernet and TDM demand *and* there are no VoD services offered to residential customers.

	MSPP	Dedicated Ethernet Network
Cumulative CAPEX	$ 1,444,394	$ 2,304,933
NPV	$ 18,721,488	$ 17,832,444
Payback (Years)	0.3	0.8

Table 13
Key Financial Results for the SONET Extension in Stockton, CA

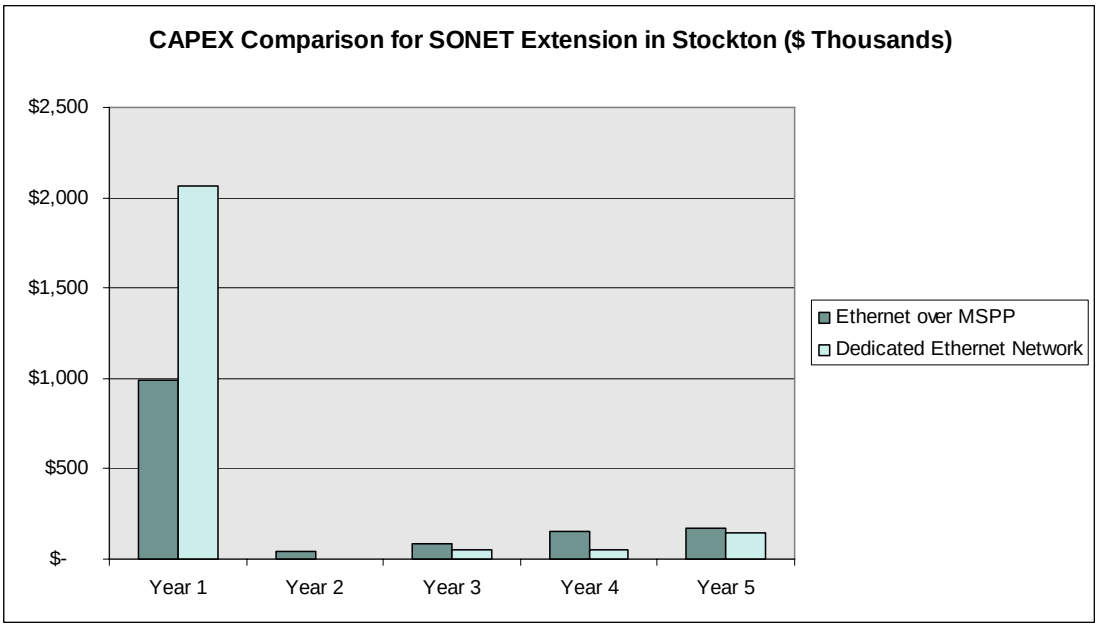

Figure 12
CAPEX Comparison for SONET Extension in Stockton

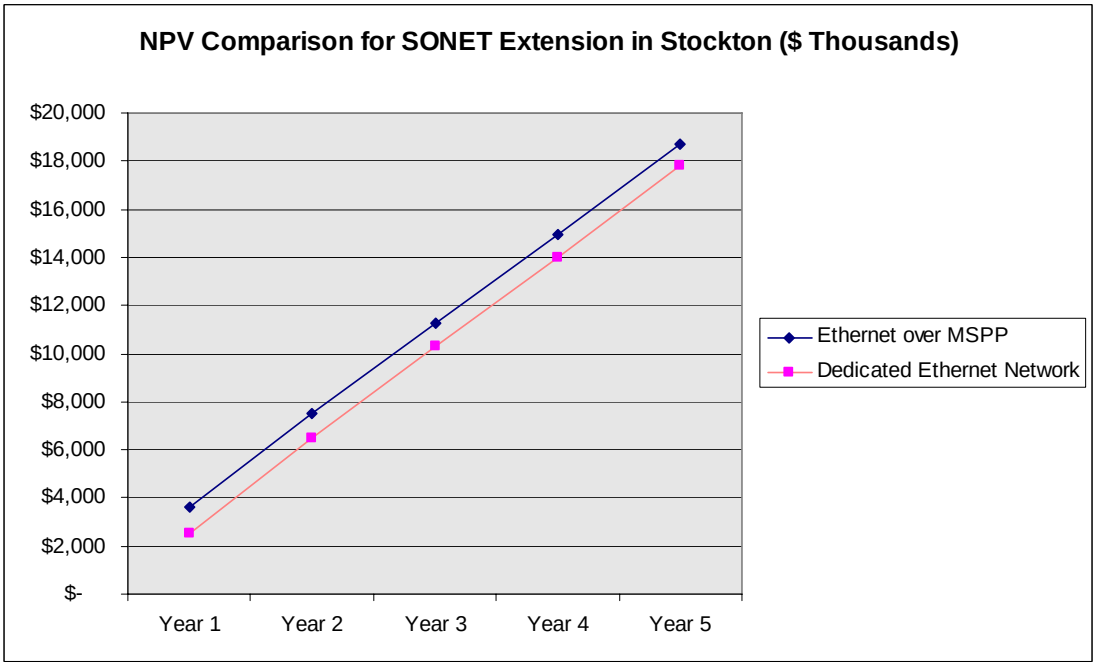

Figure 13
NPV Comparison for SONET Extension in Stockton

Conclusion

We have analyzed and compared two approaches for Carrier Ethernet:

1. Deploy an overlay Carrier Ethernet network directly over fiber or DWDM transport

2. Provide Carrier Ethernet transport over an existing MSPP SONET and SDH networks

These approaches have been analyzed for three cities: Boston, MA, Stockon, CA, and Springdale, AR (these are representative of Tier 1, 2, and 3 cities). The summary of our findings is:

- *If service providers are deploying commercial Carrier Ethernet and residential triple play services (HSI, VoIP, IPTV) then there is a strong business case for using an existing MSPP SONET network for Carrier Ethernet services in Tier 2 and 3 cities*

- *Even if there is no existing SONET network, there is also a business case for building out a new SONET extension in Tier 2 and 3 cities for Carrier Ethernet services*

- *In Tier 1 cities the demand justifies the deployment of a dedicated Carrier Ethernet network*

- *In all cities that are offering VoD, service providers should consider using a dedicated Carrier Ethernet network to handle potentially large amounts of VoD traffic*