The Business Case for ROADM Technology

Network Strategy Partners, LLC

MANAGEMENT CONSULTANTS TO THE NETWORKING INDUSTRY

www.nspllc.com

August, 2006

Network Strategy Partners, LLC (NSP) — Management Consultants to the networking industry — helps service providers, enterprises, and equipment vendors around the globe make strategic decisions, mitigate risk and affect change through custom consulting engagements. NSP's consulting includes business case and ROI analysis, go-to-market strategies, development of new service offers, pricing and bundling as well as infrastructure consulting. NSP's consultants are respected thought-leaders in the networking industry and influence its direction though confidential engagements for industry leaders and through public appearances, whitepapers, and trade magazine articles. Contact NSP at www.nspllc.com.

Executive Summary

Recent developments in the telecom market are leading to rapid growth of traffic in metro networks. Among the key applications that are driving this growth are:

- Residential triple-play services (IPTV, video-on-demand, VoIP, and high-speed Internet)
- Commercial Carrier Ethernet services

As a result of this growth, service providers are deploying DWDM transport networks in metro areas. One of the key questions facing service providers is:

Should we deploy a Fixed OADM or a Reconfigurable OADM (ROADM) DWDM network architecture in our metro areas?

This paper provides an ROI analysis demonstrating that a Fixed OADM solution could be less expensive than a ROADM on day one. However, in many cases over several years the Fixed OADM is *more expensive* then the ROADM. The higher cost associated with the Fixed OADM is a result of additional CAPEX and OPEX due to inefficient network designs and equipment configurations, inefficient sparing, and increased labor costs. In networks with high growth and uncertainty of future demand, the longer-term cost savings of the ROADM solution is more pronounced.

Our analysis compares both the capital network equipment costs and labor costs of a traditional Fixed OADM network with a Cisco® ONS 15454 ROADM network. In this study we use two approaches to make this cost comparison:

1. **TCO Model** – A total cost of ownership (TCO) model is used that compares two hypothetical networks (a ring and linear topology) for both the Fixed OADM and ROADM systems.

2. **Case Study** – A customer that has already deployed the Cisco ONS 15454 ROADM and has realized CAPEX and OPEX savings was interviewed and the results of that interview are presented.

Our conclusions from this analysis are that the deployment of the Cisco ONS 15454 ROADM system results in both CAPEX and OPEX savings as compared to a traditional Fixed OADM. These savings are realized to a greater degree in networks with:

- Uncertain demand and network changes
- High growth
- High capacity
- Mesh demand characteristics

Network equipment CAPEX savings in ROADM networks are primarily due to more efficient deployments of OADMs and transponders in the network and the reduction of spares.

Labor and OPEX savings are due to the following factors:

- Bandwidth can be turned up on demand without the need for accurate, long-term forecasts.
- More intelligence, automated discovery, automated signaling, and power conditioning functions are used in a ROADM network.
- Circuit provisioning and activation time is significantly faster in a ROADM network.
- Maintenance and network care are improved.
- There is a more efficient deployment of line cards due to any-to-any connectivity.
- Bandwidth can be deployed much more quickly than with fixed DWDM technology.
- With a ROADM network, technicians are only needed at origin and destination points to install line cards – all other provisioning is automatic. In the fixed system, more experienced engineers are needed at each intermediate site (multiple truck rolls) to install wavelength add/drop multiplexers to prepare for uncertain future demand and to manually readjust tuning for power and signal variants resulting from configuration changes.
- Adding additional wavelength channels in Fixed OADM networks is intrusive and service-affecting, and therefore must be done during scheduled maintenance windows.
- Faster provisioning time means faster time to revenue.

In the case study, CAPEX savings were 50% and OPEX savings were 70%. This resulted in a high ROI and a payback of less than 12 months for the Cisco ONS 15454 ROADM.

In addition to CAPEX and OPEX savings, the flexibility of the ROADM provides strategic competitive advantages including:

- Faster time to revenue due to reduced circuit provisioning times
- Reduced churn due to reduced provisioning times and greater flexibility in service offerings
- Ability to win the contract in competitive bidding situations due to increased flexibility and accelerated service deployment

The following sections of this paper present a brief overview of Fixed OADM and ROADM technology, a TCO comparison of these technologies, and a case study of a large cable service provider that has deployed the Cisco ONS 15454 ROADM technology.

Overview of Fixed OADM and ROADM Technology

First- and second-generation DWDM networks were built with Fixed Optical Add/Drop Multiplexer (OADM) technology. While these systems have enormous capacity and are in wide use worldwide, they are complex systems to design, configure, and install. Fixed OADM systems are also extremely complex to change. More recently, Reconfigurable OADM (ROADM) technologies have been introduced to the market, allowing service providers much greater flexibility in network design and installation and, most importantly, have allowed for flexibility in moves, adds, and changes.

Fixed OADM Technology

While there are many different DWDM vendors and system architectures, there are some basic components that are used in all Fixed OADM systems. These components are depicted in Figure 1. In a Fixed OADM system, multiple optical wavelengths are used to create separate optical transport channels. Terminal filters are used at the end points of a linear (point-to-point) network or at the hub of a ring to originate or terminate optical channels. The terminal filters operate at fixed wavelengths and can only originate or terminate optical channels operating at those *fixed wavelengths*. At any point along the ring, channels can be added or dropped by an optical OADM. These OADMs are also *fixed to specific wavelengths* and typically allow add/drop of a *fixed number* of channels. In our TCO model, a fixed OADM system that drops increments of four optical channels is analyzed. Electrical-optical transponders are used to convert standard service interfaces to ITU DWDM optical signals for transport on the DWDM network. Transponders have many service interfaces (Gigabit Ethernet [GbE], 10 GbE, OCn, Fiber Channel, etc.) and come in two fundamental data rates: 2.5 Gigabit and 10 Gigabit transponders. Another fundamental component of all DWDM systems is the Erbium-Doped Fiber Amplifier (EFDA), which is used to amplify the optical signal for medium to long-haul fiber links. In Fixed OADM systems, EFDAs need to be manually adjusted so that the amplification accounts correctly for the number of channels that are added or dropped at a particular site. Manual adjustments need to be made on all EDFAs in the network as new channels are added or dropped.

An example of a Fixed OADM network is illustrated in Figure 2. In the Fixed OADM network, channels are interconnected using fixed filters/OADMs. Because all channels and wavelengths in the network are fixed, it is essential that network planning and engineering account for traffic growth and changes as the network evolves. Adding capacity and/or making changes to the network is difficult and can cause service outages because there is very little flexibility in a Fixed OADM system.

Some of the problems with Fixed OADM systems are:

- Inefficient sparing – A large number of spares are required because each filter and transponder is unique to a specific set of wavelengths.
- Fixed channel filters are unique and require specific part numbers – This makes inventory management quite difficult.
- Dynamic traffic management is not supported – Fixed wavelengths require that channels and transport interconnectivity be fixed.

- Optical span power management is a manual process – As new channels and OADM sites are added, amplifiers and dispersion compensation units (DCUs) need to be manually readjusted.
- Channel balancing is a manual process – Engineers are required at all sites in the network.
- Adding additional wavelength channels is intrusive – This must be done during maintenance windows and it is service-affecting.

While Fixed OADM components are less expensive than ROADM components, the model shows that the TCO can be higher as a result of inefficient configurations, sparing, and operational expenses.

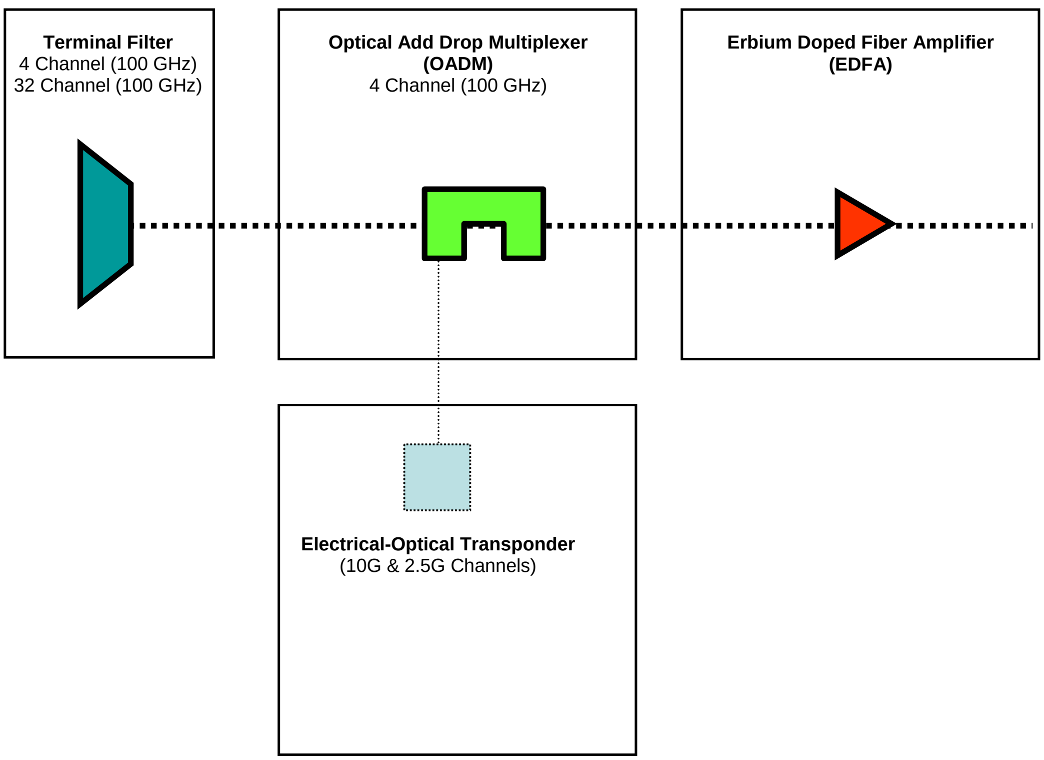

Figure 1
Basic Components of a Fixed OADM Network

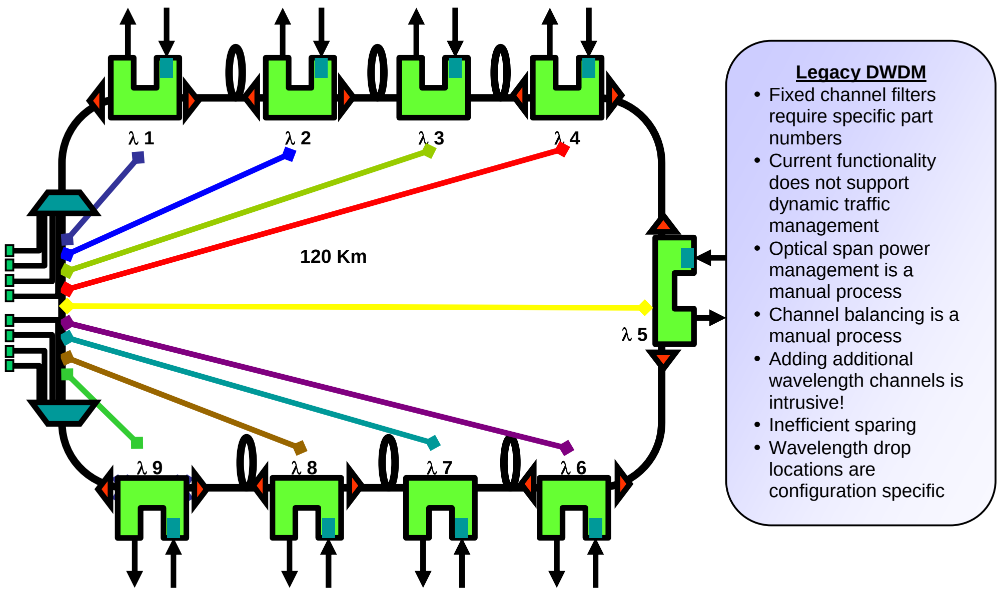

Figure 2
Fixed OADM Network

ROADM Technology

Many of the weaknesses of Fixed OADM technology are addressed in the development of Reconfigurable Optical Add/Drop Multiplexers (ROADMs). While there are several different technology implementations of ROADMs such as Microelectronic Mirrors (MEM) and Planar Lightwave Circuit (PLC), they all provide a similar capability. ROADMs enable flexible network transport design by allowing add/drop of any channel at any ROADM node. ROADMs also automatically adjust the power in the network as channels are dropped or inserted in ROADM nodes. Some ROADMs can also provide the ability to switch wavelengths from one path to another, but that is beyond the scope of this paper.

The basic components of the ROADM are depicted in Figure 3 and a ROADM DWDM network is represented in Figure 4. The fundamental component of a ROADM DWDM system is the Reconfigurable OADM. It typically allows 32-40 channels to be dropped or inserted at any node. As demand in the network changes, additional channels can be dropped or inserted, creating a flexible provisioning system. The ROADM also uses or works with a transponder that is similar in nature to the transponder in the Fixed OADM system. One difference in the Cisco ONS 15454 transponders, however, is that they are tunable and use pluggable optics (SFPs or XFPs) for client (customer-facing) interfaces. This allows for more flexibility in inventory management and more efficient sparing. ROADM nodes also use EDFAs for optical amplification. One of the differences in ROADM networks is that all EDFAs in the network are automatically adjusted to provide the correct transmission power across fiber links. As channels are dropped or inserted, power requirements change. In the fixed network this is accomplished manually while in the ROADM network power is adjusted automatically. The ROADM network also provides per-channel power monitoring for troubleshooting at all sites. This allows technicians to monitor power levels via the management tool. This capability is not available with a Fixed OADM system.

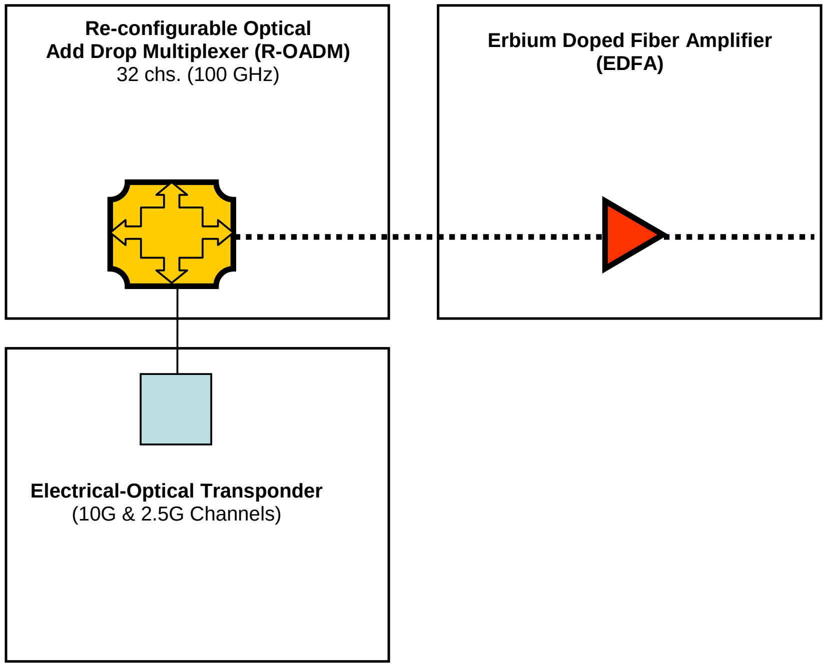

Figure 3
Basic Components of a ROADM Network

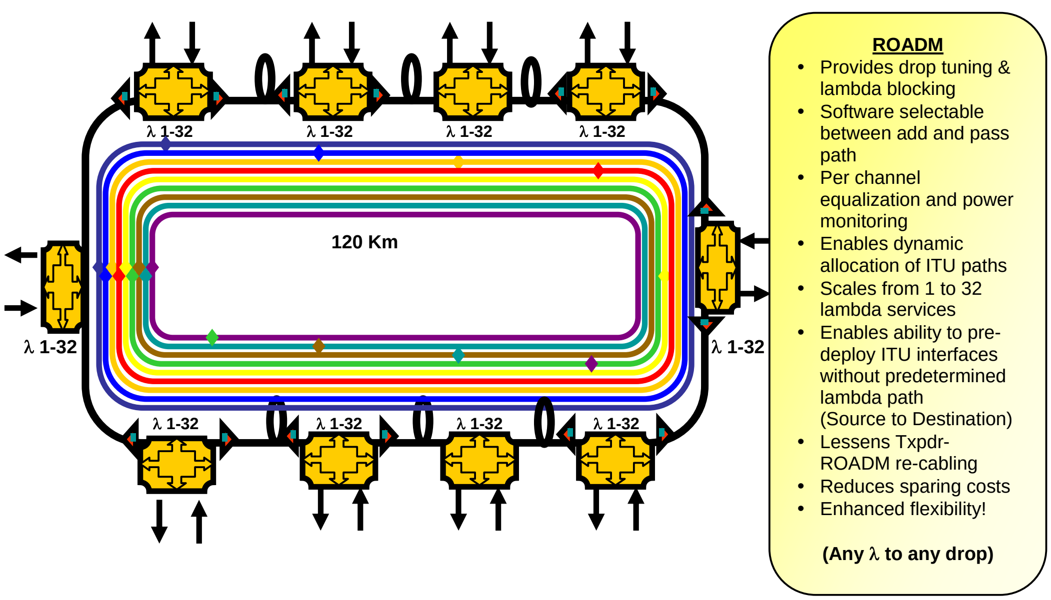

Figure 4
ROADM Network

Some of the benefits of the ROADM network are:

- Provides drop tuning and channel blocking
- Per-channel equalization and power monitoring
- Enables dynamic allocation of ITU-wavelength paths
- Scales from 1 to 32 channel services
- Enables ability to pre-deploy ITU interfaces without a predetermined channel path (source to destination)
- Reduces transponder-ROADM re-cabling
- Reduces sparing costs
- Enhances flexibility

ROADM technology clearly has many benefits. Conventional wisdom is that there is a much higher price tag associated with these benefits. The next section of this paper shows that the costs of ROADM technology can actually be lower then the costs of Fixed OADM technology.

A TCO Comparison of Fixed OADM and ROADM

In this section, two hypothetical metro networks are analyzed and the TCO of a Fixed OADM system is compared with the TCO of a ROADM system. The first network is a ring topology and the second network is a linear topology. Both examples demonstrate that when all costs (including spares, engineering, and installation) are considered, the cost of the ROADM network is competitive with the Fixed OADM network. In the metro ring network the ROADM is significantly less expensive than the Fixed OADM. In the linear network the expenses of the ROADM are not significantly different than the Fixed OADM expenses.

In both examples (ring and linear) a set of demand matrices are specified for transport services over a three-year period and two networks are designed based on that demand:

1. A network using an industry-standard, low-cost Fixed OADM system
2. A network using the Cisco ONS 15454 ROADM system

A TCO model is used to compare the costs of the Fixed OADM[1] design and the Cisco ONS 15454 ROADM design. The costs that are compared in the model are:

- Capital equipment costs (OADMs and transponders)
- Engineering and network design costs
- Installation and test costs

Because chassis and common equipment, amplifiers, and DCUs are considered to be roughly the same price for both fixed and reconfigurable systems, these costs were not considered in the comparisons[2].

---

[1] The cost of this system is based on a major Fixed OADM vendor with a cost-competitive solution.
[2] In the ring network the Fixed OADM system exhausted all 32 channels and therefore required a second ring. In this example the cost of the extra chassis, amplifiers, and dispersion compensation units were counted because these costs were costs that were *not* incurred by the ROADM system which satisfied all the demand on 32 channels.

The following sections present the demand matrices and compare the total costs for the Fixed OADM and Cisco ONS 15454 ROADM systems.

Metro Ring Topology

In the first example we consider a metro ring topology. In this network there are five sites connected by a fiber ring in a metro area. In the following sections we present the circuit demand assumptions and the network equipment expenses, labor expenses, and TCO associated with both the Fixed OADM design and the Cisco ONS 15454 ROADM design.

Circuit Demand Assumptions

The transport requirements for this hypothetical DWDM network are specified over a three-year period. In the first year of operation it is assumed that the DWDM network will need to carry traffic from:

1. An existing OC48 SONET network
2. A new 10 GbE Carrier Ethernet network

The SONET and the Carrier Ethernet transport demand is illustrated in Figure 5. The SONET network is an OC48 ring that is overlaid on the DWDM network. To support the SONET network, 2.5G channels are required between each node on the ring. The Carrier Ethernet network uses Cisco 7600 Series Routers and has hub locations in sites 4 and 5. The Cisco routers at sites 1-3 are dual-homed to sites 4 and 5 and are interconnected with 10 GbE circuits. These circuits are unprotected because SONET uses UPSR or BLSR protection and Metro Ethernet uses Layer 2 switching protection.

In years 2-3 it is assumed that there is demand for 2.5G and 10G *protected* private lines. This demand is assumed to be randomly distributed across all five sites.

The complete details of the three-year circuit demand are specified in the demand matrices depicted in Figure 6. The upper right-hand half of the matrix specifies the number of circuits between two sites. For example, in the matrix that specifies 10G protected circuits in year 2, there are two circuits[3] between site 1 and site 3 and one circuit[4] between site 3 and site 4.

[3] The number of circuits between site 1 and site 3 can be found in the row of site 1 and the column of site 3.
[4] The number of circuits between site 3 and site 4 can be found in the row of site 3 and the column of site 4.

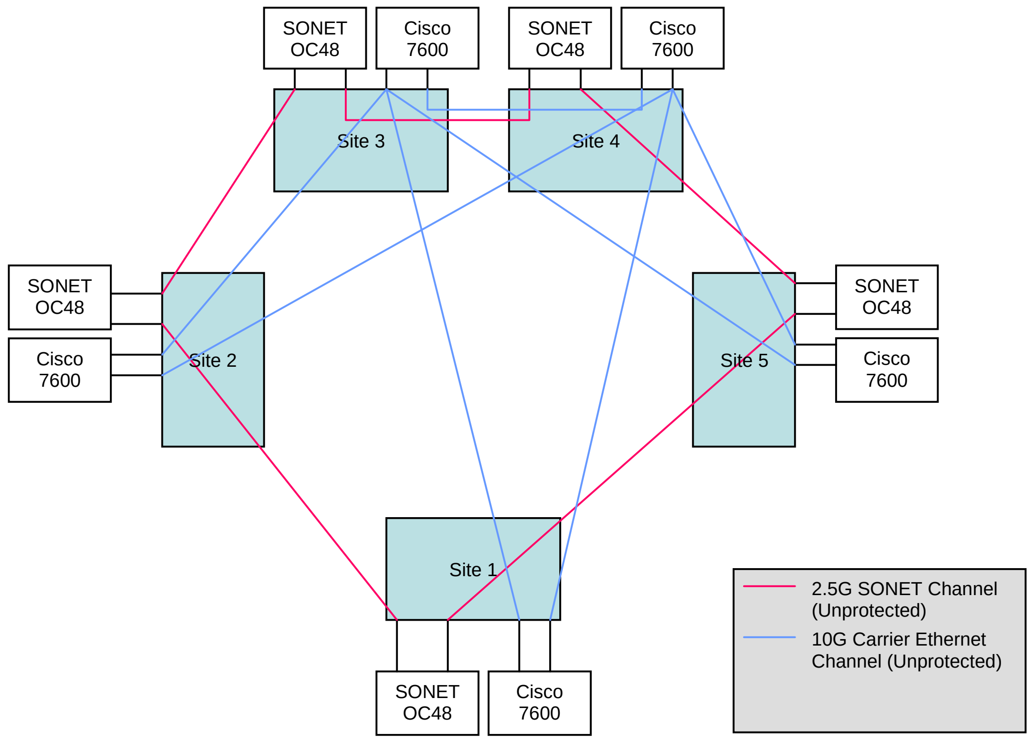

Figure 5
SONET OC48 and 10 GbE Carrier Ethernet Demand in Year 1

	SONET 2.5G Circuits in Year 1 (Unprotected)					
	Site 1	Site 2	Site 3	Site 4	Site 5	Row Total
Site 1	N/A	1	0	0	1	2
Site 2	N/A	N/A	1	0	0	1
Site 3	N/A	N/A	N/A	1	0	1
Site 4	N/A	N/A	N/A	N/A	1	1
Column Total		**1**	**1**	**1**	**2**	**5**

	Carrier Ethernet 10G Circuits in Year 1 (Unprotected)					
	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
Site 1	N/A	0	1	1	0	2
Site 2	N/A	N/A	1	1	0	2
Site 3	N/A	N/A	N/A	1	1	2
Site 4	N/A	N/A	N/A	N/A	1	1
Column Total		**0**	**2**	**3**	**2**	**7**

	Private Line 2.5G Protected Circuits in Year 2					
	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
Site 1	N/A	1	1	0	0	2
Site 2	N/A	N/A	0	0	0	0
Site 3	N/A	N/A	N/A	1	0	1
Site 4	N/A	N/A	N/A	N/A	1	1
Column Total		**1**	**1**	**1**	**1**	**4**

	Private Line10G Protected Circuits in Year 2					
	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
Site 1	N/A	0	2	1	1	4
Site 2	N/A	N/A	0	1	0	1
Site 3	N/A	N/A	N/A	1	1	2
Site 4	N/A	N/A	N/A	N/A	0	0
Column Total		**0**	**2**	**3**	**2**	**7**

	Private Line 2.5G Protected Circuits in Year 3					
	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
Site 1	N/A	1	2	0	0	3
Site 2	N/A	N/A	1	0	1	2
Site 3	N/A	N/A	N/A	1	1	2
Site 4	N/A	N/A	N/A	N/A	0	0
Column Total		**1**	**3**	**1**	**2**	**7**

	Private Line10G Protected Circuits in Year 3					
	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
Site 1	N/A	1	0	0	1	2
Site 2	N/A	N/A	0	1	0	1
Site 3	N/A	N/A	N/A	1	0	1
Site 4	N/A	N/A	N/A	N/A	1	1
Column Total		**1**	**0**	**2**	**2**	**5**

Figure 6
Ring Topology Circuit Demand over Three-Year Period

TCO Comparison

Using the demand assumptions specified above, network designs were developed for both a Fixed OADM network and a Cisco ONS 15454 ROADM network. Figure 7 shows the network equipment expense for the metro ring network over a three-year period. The network equipment consists primarily of OADMs, ROADMs, and transponders. While Fixed OADM systems are cost-effective for small networks with predictable demand, the fixed systems are complex to configure as demand grows and are not well suited to random mesh-traffic demands. Therefore, deployment of OADMs is inefficient and subsequent capital expenses are incurred as a result of this inefficiency. In this example the Cisco ONS 15454 ROADM network was able to serve all the circuits specified in the demand matrix on a single 32-channel ring. In contrast, the fixed OADM system exhausted all 32 channels in year 1 and, therefore, *a second fiber ring was required in years 2 and 3*. This necessitated a second set of chassis and common equipment at each site. The additional Fixed OADM chassis, common equipment, amplifiers, and DCUs at each site were added to the equipment expenses because this expense was not incurred in the Cisco ROADM design. Additionally another dark fiber on the ring was burned; however, this expense was not accounted for in the model. (This is because the cost of dark fiber is not easily quantifiable. If dark fiber is abundant it is virtually free, however, if it is in short supply the cost could be significant).

Another important factor driving the differences in equipment costs is the high cost of spares for the Fixed OADM architecture. The breakdown of network equipment costs and spares is illustrated in Figure 8 and Figure 9. The reason for the high cost of spares in the Fixed OADM network is that many spare transponders and filters are needed. In the fixed OADM network each transponder is tuned to a single wavelength. Therefore, for each pair of transponders operating on a single wavelength, a spare is required. In contrast, the Cisco ONS 15454 has 10G transponders that are tunable to 82 different wavelengths, thus greatly reducing the number of spares required. The Cisco 2.5G transponder is tunable to four wavelengths, therefore less spares are required than a single wavelength transponder. Also, the fixed OADM system uses fixed 4-channel filters to drop and insert wavelengths. One spare for each pair of filters also is required because filters are fixed to wavelengths. In contrast, the Cisco ONS 15454 32WSS Card (ROADM) is tunable to 32 channels. Therefore, one spare card can serve all the nodes in the network. These differences in sparing costs are reflected in the overall equipment expenses.

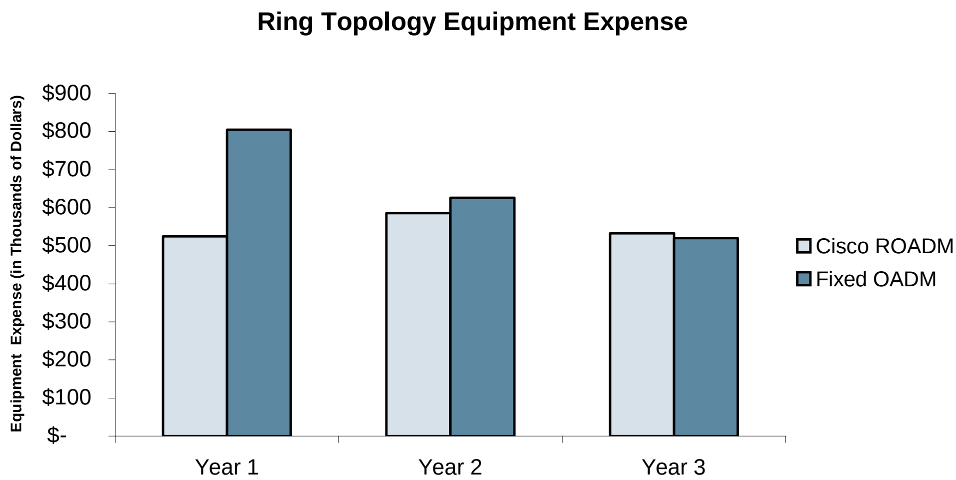

Figure 7
Ring Topology Equipment over Three-Year Period

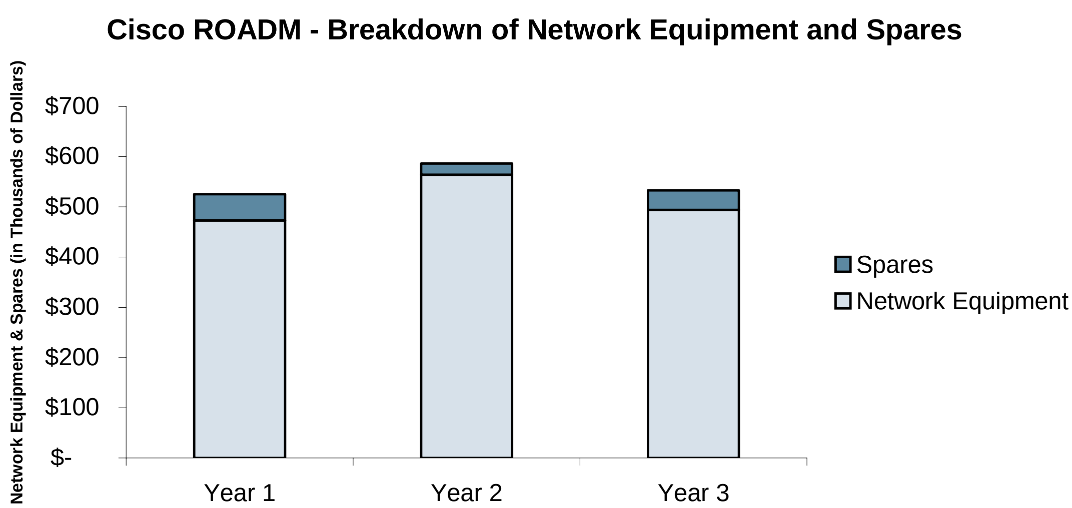

Figure 8
Cisco ROADM – Breakdown of Network Equipment and Spares

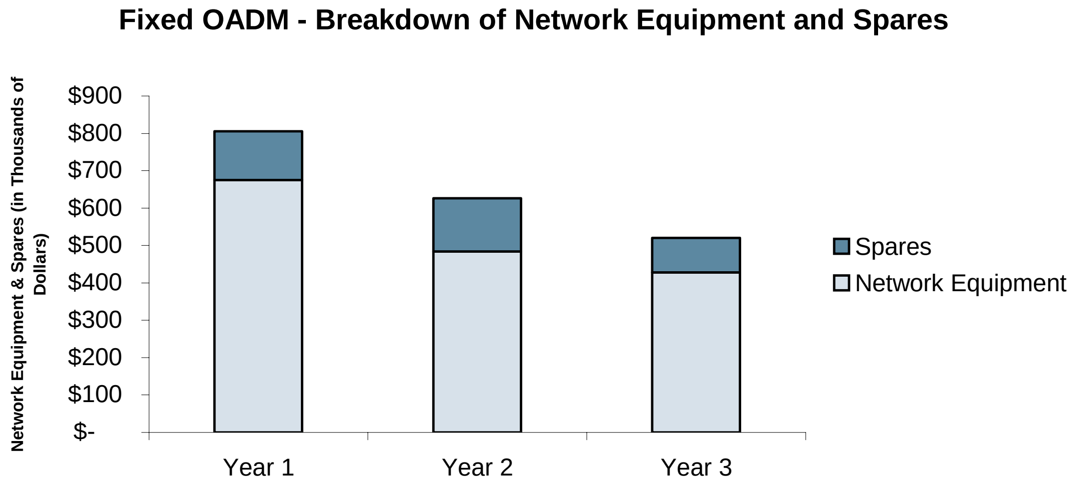

Figure 9
Fixed OADM – Breakdown of Network Equipment and Spares

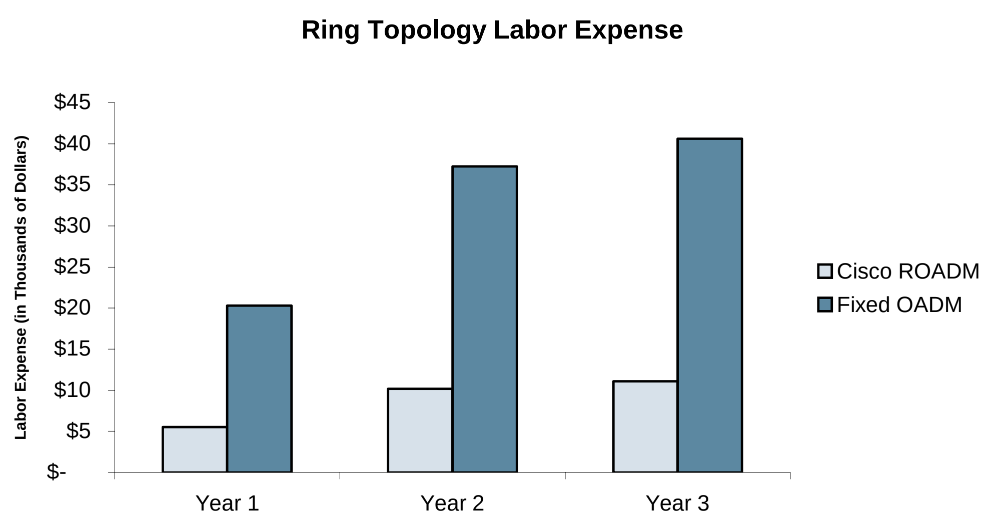

Figure 10
Ring Topology Labor Expense over Three-Year Period

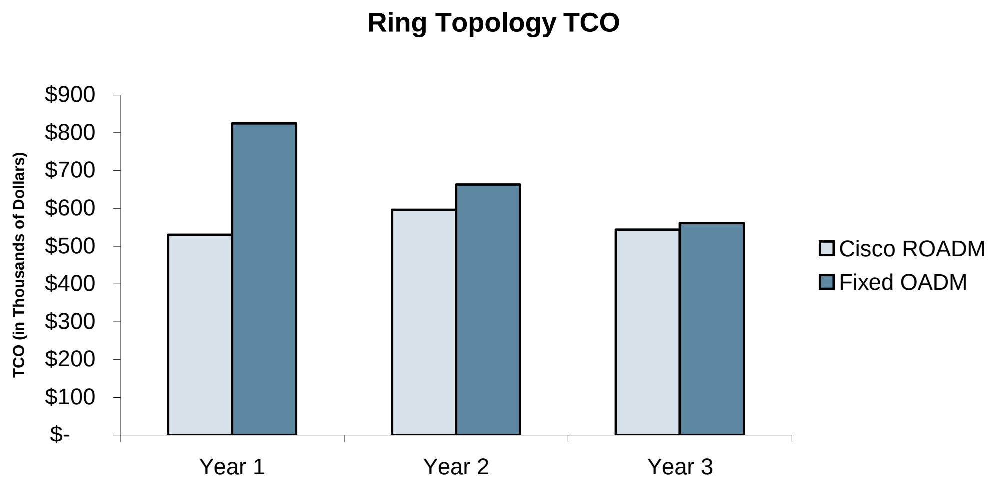

Figure 11
Ring Topology TCO over Three-Year Period

In addition to equipment expenses, there are also labor expenses associated with network engineering, design, installation, maintenance, and testing. Labor expenses also reflect installation and testing of additional wavelengths as demand grows. These expenses are presented in Figure 10 and the key assumptions[5] used to calculate these expenses are presented in Table 1. The Fixed OADM network results in a significantly more complex network design, installation, maintenance, and test process. These expenses are also reflected in Figure 10.

The combination of the equipment capital expenses and the labor expenses is defined as the total cost of ownership (TCO), reflected in Figure 11. Because of the reduced network complexity and efficient sparing, the Cisco ONS 15454 ROADM design results in a lower overall TCO.

	Cisco ONS 15454 ROADM	Fixed OADM
Engineering Hours per Site, per Wavelength	1	3
Installation Hours per Site, per Wavelength	4	16

Table 1
Labor Expense Assumptions

[5] The assumptions used to calculate labor expenses are based on field engineering experience with optical networks.

Linear Topology

In the second example we consider a metro linear topology (Figure 12). In this network there are five sites connected by a linear fiber span in a metro area. In the following sections we present the circuit demand assumptions and the network equipment expenses, labor expenses, and TCO associated with both the Fixed OADM design and the Cisco ONS 15454 ROADM design.

Demand

The transport requirements for this hypothetical linear DWDM network are specified over a three-year period. In the first year of operation it is assumed that the DWDM network will need to carry traffic from:

1. An existing linear OC48 SONET network
2. A new linear 10 GbE Carrier Ethernet network

The SONET and the Carrier Ethernet transport demand is illustrated in Figure 12. The SONET network is an OC48 linear network that is overlaid on the DWDM network, requiring 2.5G channels between each network node. Each site also has a Cisco 7600 Series Carrier Ethernet node that interconnects to a hub node at site 1. All connections are *unprotected* because the network is a linear topology.

In years 2-3 it is assumed that there is demand for 2.5G and 10G *unprotected* private lines. This demand is assumed to be randomly distributed across all five sites.

The complete details of the three-year circuit demand is specified in the demand matrices depicted in Figure 13. The upper right-hand half of the matrix specifies the number of circuits between two sites.

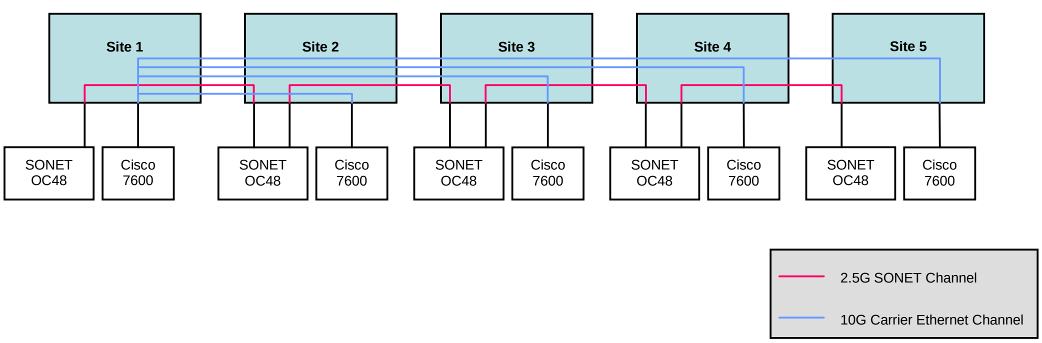

Figure 12
SONET OC48 and 10G Carrier Ethernet Demand in Year 1

	Site 1	Site 2	Site 3	Site 4	Site 5	Row Total
	SONET 2.5G Circuits in Year 1 (Unprotected)					
Site 1	N/A	1	0	0	0	1
Site 2	N/A	N/A	1	0	0	1
Site 3	N/A	N/A	N/A	1	0	1
Site 4	N/A	N/A	N/A	N/A	1	1
Column Total		**1**	**1**	**1**	**1**	**4**

	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
	Carrier Ethernet 10G Circuits in Year 1 (Unprotected)					
Site 1	N/A	1	1	1	1	4
Site 2	N/A	N/A	0	0	0	0
Site 3	N/A	N/A	N/A	0	0	0
Site 4	N/A	N/A	N/A	N/A	0	0
Column Total		**1**	**1**	**1**	**1**	**4**

	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
	Private Line 2.5G Unprotected Circuits in Year 2					
Site 1	N/A	0	0	0	1	1
Site 2	N/A	N/A	0	0	0	0
Site 3	N/A	N/A	N/A	0	0	0
Site 4	N/A	N/A	N/A	N/A	0	0
Column Total		**0**	**0**	**0**	**1**	**1**

	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
	Private Line10G Unprotected Circuits in Year 2					
Site 1	N/A	0	0	0	1	1
Site 2	N/A	N/A	0	0	0	0
Site 3	N/A	N/A	N/A	0	0	0
Site 4	N/A	N/A	N/A	N/A	0	0
Column Total		**0**	**0**	**0**	**1**	**1**

	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
	Private Line 2.5G Unprotected Circuits in Year 3					
Site 1	N/A	1	1	0	0	2
Site 2	N/A	N/A	1	0	1	2
Site 3	N/A	N/A	N/A	1	0	1
Site 4	N/A	N/A	N/A	N/A	0	0
Column Total		**1**	**2**	**1**	**1**	**5**

	Site 1	Site 2	Site 3	Site 4	Site 5	Total Circuits
	Private Line10G Unprotected Circuits in Year 3					
Site 1	N/A	1	0	0	0	1
Site 2	N/A	N/A	0	0	0	0
Site 3	N/A	N/A	N/A	1	0	1
Site 4	N/A	N/A	N/A	N/A	1	1
Column Total		**1**	**0**	**1**	**1**	**3**

Figure 13
Linear Topology Circuit Demand over Three-Year Period

TCO Comparison

Network designs were developed for both a Fixed OADM linear network and a Cisco ONS 15454 ROADM linear network using the demand assumptions specified in Figure 13. Figure 14 shows the network equipment expense for the metro linear network over a three-year period. The network equipment modeled consists of OADMs, ROADMs, and transponders. In the case of the linear topology, there is not much difference in the equipment expenses over the three-year period. All network circuits are unprotected and the demand is less complex than in the metro ring. As a result the inefficiencies of the Fixed OADM network bring the equipment cost up to the same levels of the ROADM[6]. In the linear topology the high cost of spares is also a factor driving up the cost of the Fixed OADM design (See the discussion of sparing inefficiencies in the section about the ring topology).

In addition to equipment expenses, there are also labor expenses associated with network engineering, design, installation, and testing. These expenses are presented in Figure 15 and the key assumptions used to calculate these expenses are presented in Table 1. The Fixed OADM network results in a significantly more complex network design, installation, and test process. These expenses are reflected in these results.

The combination of the equipment capital expenses and the labor expenses is defined as the TCO, reflected in Figure 16. Because of the reduced network complexity and efficient sparing, the Cisco ONS 15454 ROADM design results in a lower overall TCO.

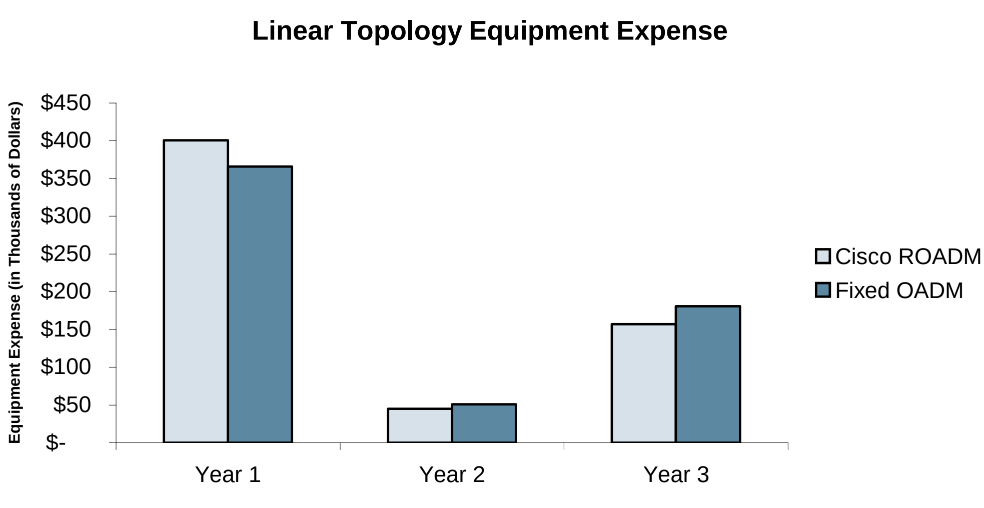

Figure 14
Linear Topology Network Equipment Expense

[6] In simple networks with a small number of channels and small growth, the Fixed OADM systems are less expensive than the ROADM systems. The linear network is an example of a network with a medium level of complexity and the equipment cost is therefore similar to the ROADM network. As demand increases growth and complexity, the ROADM network becomes less expensive as illustrated in the ring topology.

Figure 15
Linear Topology Labor Expense (Engineering, Installation, and Testing)

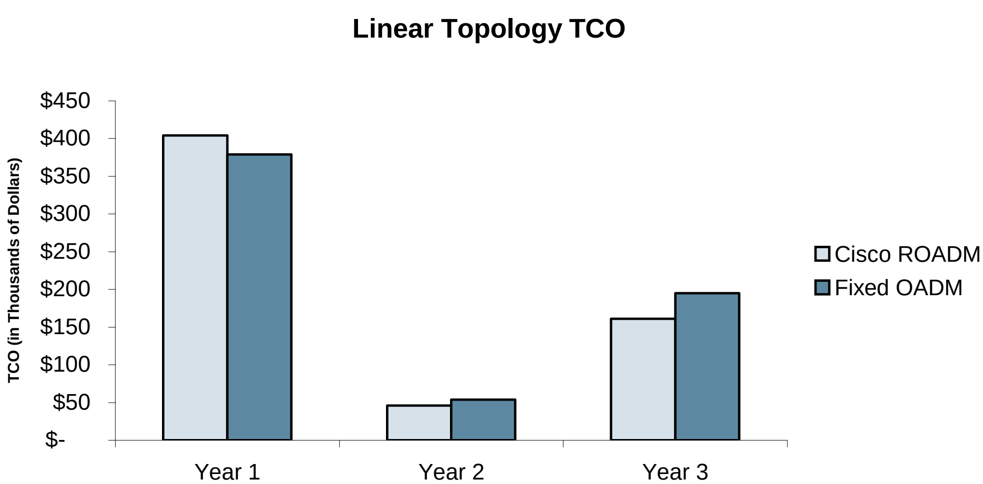

Figure 16
Linear Topology TCO (Equipment and Labor Expenses)

Case Study – A Large Cable Network Operator

Some of the benefits highlighted in the hypothetical networks described earlier are reinforced by the actual experience of a large cable network operator that serves both residential triple-play and commercial customers.

This service provider has a wide range of requirements across its network footprint and provides service to different types of customers including:

- High-income residential
- Low-income residential
- Commercial

The key services offered by this provider are:
- Video
- High-speed Internet
- Voice
- Commercial services

Commercial services include:
- Layer 2/Layer 3 Ethernet-based services
- Private-line services provisioned across 10 G wavelength
- Data rates up to a protected 10 Gigabit private line are offered

Network traffic demand is highly unpredictable and the service demand has a mesh characteristic. The salient features of traffic management are:
- High growth in network traffic (20% to 40% per year)
- The ability to provision bandwidth as demand grows is critical
- Demand growth is uncertain

As a result of these network and traffic requirements, this service provider was able to realize substantial CAPEX and OPEX savings after migrating to Cisco ONS 15454 ROADM technology. The savings in CAPEX was primarily due to the fact that ROADM cards and transponders are now *only needed at sites that originate or terminate circuits*. In the older Fixed OADM system, this provider dropped and inserted all channels at all sites and *required transponders at all sites*. This was necessary due to the growth and uncertainty in traffic demand as well as the mesh patterns of traffic demand. Because of the ROADM flexibility and efficiency, this service provider had a 50% savings in OADM cards and transponders by deploying the Cisco ONS 15454 ROADM.

Disaster recovery of head-ends is a strategic initiative for this service provider. With the Cisco ONS 15454 ROADM solution, a redundant head-end can be easily added and connected to all nodes in the network. Without the ROADM, many more add/drop wavelengths and transponders would need to be added into the network whether they are needed or not. This has resulted in significant CAPEX savings in the disaster recovery program.

The Cisco ONS 15454 ROADM deployment also has produced a 70% reduction in OPEX. The key areas of operational improvement are:

- More intelligence, automated discovery, and other automation is used.
- Circuit provisioning and activation time is reduced (in some cases from 2 weeks to 2 days).
- Maintenance and network care is improved.
- There is more efficient deployment of line cards due to any-to-any connectivity.
- Bandwidth can be turned up as needed without requiring accurate long-term forecasts.
- Bandwidth can be deployed much more quickly than with fixed DWDM technology.
- With the ROADM engineers are only needed at origin and destination to install line cards – all other provisioning is automatic. In the fixed system, engineers were needed at each intermediate site (multiple truck rolls) to install wavelength add/drop to prepare for uncertain future demand.
- Faster provisioning time means faster time to revenue.

Overall the ROI on the ROADM investment resulted in a payback period of less then 12 months for this service provider and the capacity and flexibility of the optical DWDM network have been dramatically improved.

Conclusion

In this paper an ROI Model and a Case Study are used to demonstrate that deployment of the Cisco ONS 15454 ROADM system results in both CAPEX and OPEX savings as compared to a traditional Fixed OADM. These savings are realized to a greater degree in networks with:

- Uncertain demand
- High growth
- High capacity
- Mesh demand characteristics

Savings in both network equipment and labor costs are directly proportional to increases in these factors. The Case Study demonstrates that installation of a ROADM network produces a positive ROI and provides a scalable and flexible network essential to sustained competitive success.