

Build vs. Buy: The NREN Network Connectivity Dilemma: About Building Research & Education Fibre Networks

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Abstract

National Research and Education Networks (NRENs) typically have the need for interconnecting multiple universities and for off-campus access to connect to telecommunications submarine landing points for the purpose of connecting to other NREN networks such as GÉANT and Internet2 and for access to wholesale commodity internet service providers. As universities and researchers drive the speed requirements for access networks above 1GigE to 10GigE and beyond, NRENs are faced with the decision leasing multiple high bandwidth network connections from carriers or building their own fibre optic network. NRENs that require large capacity network connectivity at a low cost of ownership are now considering building their own fibre networks.

This paper and presentation will examine the options for NRENs and provide a step-by-step implementation plan for what is required to build, operate and maintain a fibre network.

The presentation will review and feature input from representatives the from the NREN and university community as well as an industry representative that have actual experience in deploying networks in the United States and around the world.

Discussion topics to include:

- What are the business model options for acquiring dark fibre?
- What is the payback model for a build versus buy strategy?
- How does a NREN get started deploying a fibre network?
- What are potential sources for seed capital funding
- Learn how incremental cost per Mbps of bandwidth is impacted (i.e. market based cost versus incremental cost)?
- How is network reliability impacted once a fibre network is deployed?

Obligatory Abstract Elements:

Purpose – By writing this paper, I hope to provide emerging NRENs with information on how to evaluate business case parameters and practical experience findings involved in making a decision on migrating from using carrier based bandwidth services to building, operating and maintaining a private fibre network.

Design – I plan to provide information that has been developed from personal professional experience as well as data gathered from being part of the research and education community for over ten years, both as a member and as a vendor serving the community.

Findings – It is my intention to provide emerging NRENs with a beginner’s cookbook for developing a high bandwidth private fibre network for research and education.

Value – This paper should provide emerging NRENs with a “lessons learned” document to refer to when implementing a private fibre network.

Keywords

Network Connectivity Build Buy

1. Background

1.1 US R&E Community Build Their Own Fibre Networks

There is a parallel between the current African developing NRENs and US Regional Optical Networks (RONs) 10-15 years ago. The US RONs recognized that they were paying for limited amount of bandwidth at a market based price. The US RONs took advantage of opportunities to build their own fibre networks and acquire virtually unlimited bandwidth on a marginal cost basis.

Two of the early adopters of this model were Merit Network, a state-wide research and education network in Michigan and MOREnet, a state-wide research and education network in Missouri.

Another early adopter of this model was the University System of Georgia (USG) with owns and Georgia’s PeachNet. The USG previously leased bandwidth from AT&T and small rural carriers. USG now owns & operates its own fibre network

The University Alabama System (UAS) previously leased bandwidth from ITC Deltacom. UAS owns & operates its own fibre network

1.2 Methodology

The methodology for obtaining information for this paper was data obtained from research & education, university community and industry players. This data was gathered over the eight years from participation in the research and education community both as a member of the community and as a member of the private sector providing equipment and services to the community and from personal relationships developed from those experiences. In addition, excerpts from regional optical networks websites will be used to show specific examples of business models and services providing by regional optical networks in order to create a sustainability models.

2. Build vs. Buy

2.1 Case Study

As an example of how to assess whether or not to build a private fibre network or lease bandwidth from a carrier, a case study example has been included. The network application is a data center interconnect design. The network topology includes a diverse fibre route between two data centres.

One leg of the ring is 60Km fibre pair and the other leg of the ring is a 40 Km fibre pair. The customer premise equipment for this model is a load-balanced router/switch interconnect design.

The total initial bandwidth for this model is 38 Gbps, 3x10GigE over the 60Km span and 8x1GigE over the 40Km span.

One of the key components of a private fibre network is that growth can be accomplished relatively easily and quickly on a marginal cost basis. The typical turn-up time for the addition of a 10Gbps channel is only a half-day. The system capacity is 400 Gbps (40 x 10Gbps).

2.2 Business Case Analysis

The first case study shown below is a cash flow analysis for a static network model. From a growth assumptions perspective this is the most conservative model showing no network growth over a five-year period.

The analysis below shows the capital cost of building a fibre network is estimated to be \$207,731 in year-1. There would be no additional capital costs incurred in years 2-5. The estimated operating cost for a fibre network would be \$139,307 per year.

The cost of leasing 8-1GigE circuits at \$19,200 each per year and 3-10GigE circuits at \$96,000 each per year would be \$441,600 per year.

Comparing the total cost of ownership (\$207,731 in year-1 and \$139,307 in years 2-5) with the cost of leasing (\$441,600 per year) shows a savings in year-1 and significant savings in years 2-5.

The build option results in a payback of less than one year.

Network Capacity	Year 1	Year 2	Year 3	Year 4	Year 5
GE	8	8	8	8	8
10GE	3	3	3	3	3
Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5
Total Equipment Cost	\$194,141	\$0	\$0	\$0	\$0
EF&I	\$13,590	\$0	\$0	\$0	\$0
Total DWDM CAPEX	\$207,731	\$0	\$0	\$0	\$0
Opex Non-Recurring Charges					
Network Operations & Technical Support	\$9,707	\$9,707	\$9,707	\$9,707	\$9,707
Dark Fiber Leasing	\$129,600	\$129,600	\$129,600	\$129,600	\$129,600
Total DWDM OPEX	\$139,307	\$139,307	\$139,307	\$139,307	\$139,307
Total DWDM (OPEX + CAPEX)	\$347,038	\$139,307	\$139,307	\$139,307	\$139,307
Leased Line OPEX	\$441,600	\$441,600	\$441,600	\$441,600	\$441,600

Leased Line Assumptions		40Km to 60Km	
Leased Line Cost		Monthly	Annual
GE		\$1,600	\$19,200
10GE		\$8,000	\$96,000

This next case study shows the annual savings of the build over the buy model. It also compares a static growth model with a modest growth model showing the ROI summary over a 5-year period. As indicated below either model results in a significant savings over a 5-year period.

- Static Network Growth – no bandwidth increase over 5 years

Network Capacity	Year 1	Year 2	Year 3	Year 4	Year 5
GE	8	8	8	8	8
10GE	3	3	3	3	3
DWDM ROI	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Savings	\$94,562	\$302,293	\$302,293	\$302,293	\$302,293
DWDM Payback Period (Months)	9				
DWDM 5 Year Savings	\$ 1,303,734				

- Modest Network Growth – add 8xGE and 1x10GE in Year 3

Network Capacity	Year 1	Year 2	Year 3	Year 4	Year 5
GE	8	8	16	16	16
10GE	3	3	4	4	4
DWDM ROI	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Savings	\$94,562	\$302,293	\$506,204	\$551,893	\$551,893
DWDM Payback Period (Months)	9				
DWDM 5 Year Savings	\$ 2,006,845				

Leased Line Assumptions		40Km to 60Km	
Leased Line Cost		Monthly	Annual
GE		\$1,600	\$19,200
10GE		\$8,000	\$96,000

The conclusion for the example above is that it is better to build than to buy. Although that conclusion is a function of the cost of fibre, equipment and bandwidth in any given geographic location.

3. Learning From Other R&E Regional Optical Networks

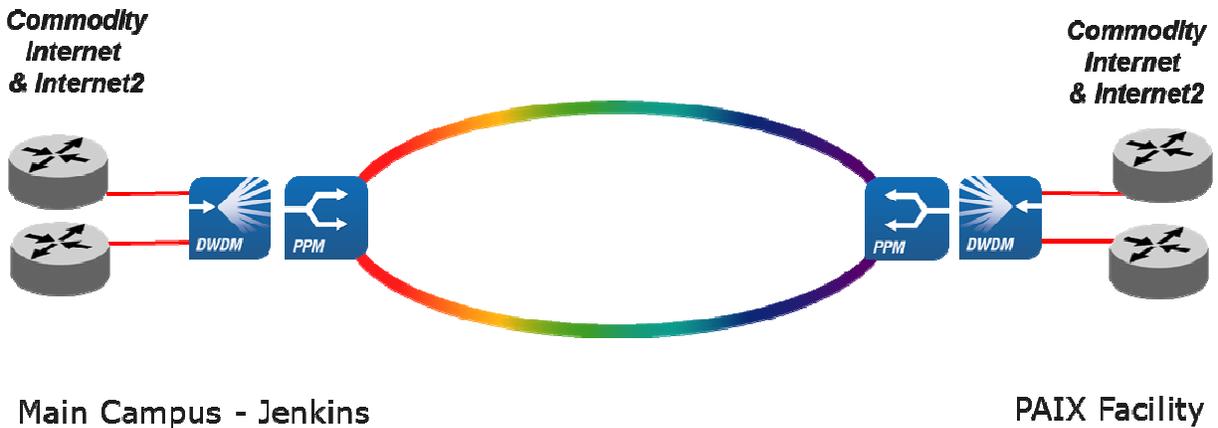
This section will provide examples of US based research and education fibre optical networks from a network topology perspective. It will also examine different initial funding sources and business models for operational cost recovery. The networks are as follows:

- Stanford University
- PeachNET
- Merit Network

- Missouri Research & Education Network (MOREnet)
- University of Alabama System (UAS)

3.1 Stanford University

Stanford University has a diverse fibre ring from their campus to nearest Internet2 / commodity Internet point-of-presence (POP). Their network includes a path protection module that will automatically switch traffic from the working fibre segment to the protect fibre segment in the event of a loss or degradation in the optical power level.



3.2 University System of Georgia (USG) PeachNet1

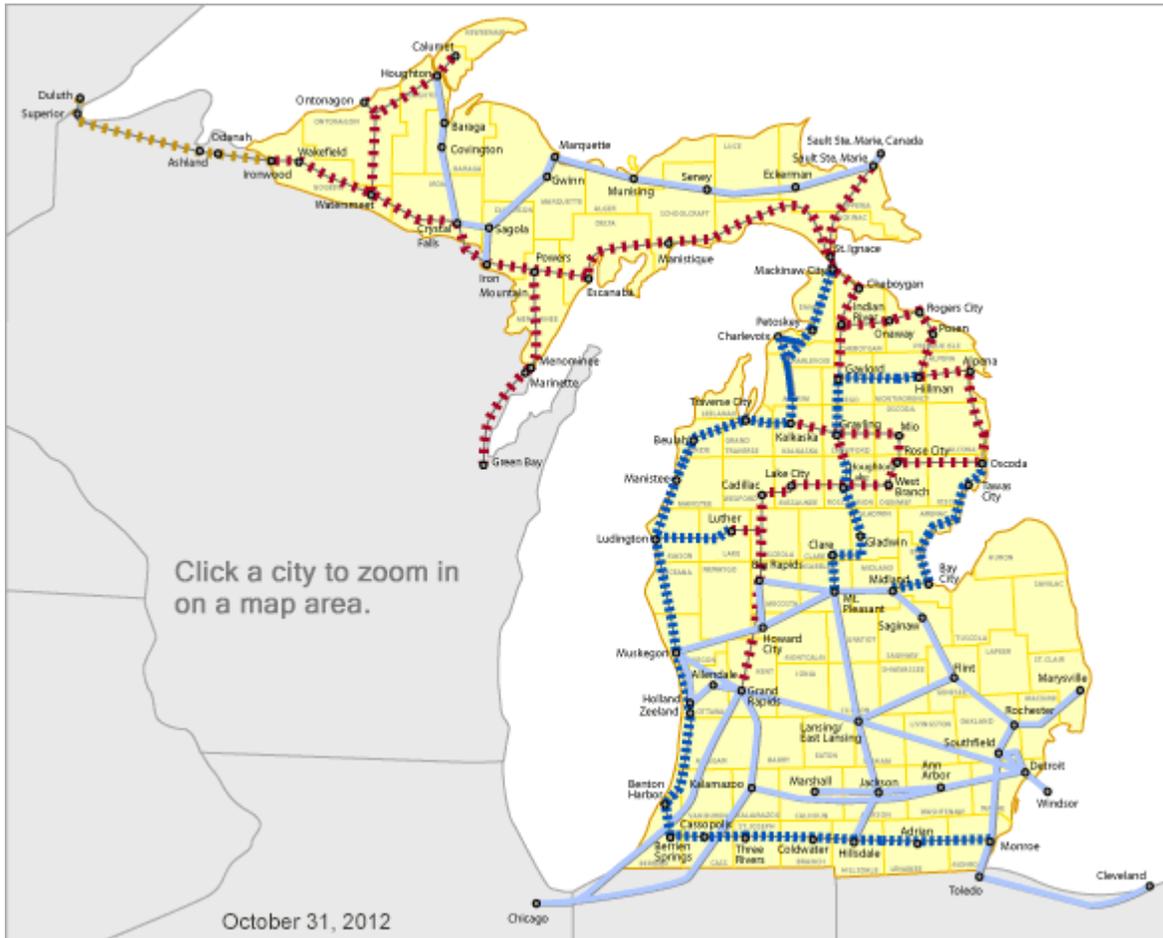


The USG, Information Technology Services (ITS) acquired fibre assets by leasing 1,900 route miles of fibre in 2004 to connect 26 of the 35 USG university institutions, as well as additional USG sites.

The demand for bandwidth continues to rise as USG institutions continually increase their use of technology through online courses, new research connections, web-based tools, and GALILEO services.

By leasing the fibre directly, USG ITS is able to move PeachNet services away from commercial telecommunications services. The result is additional bandwidth and levels of redundancies that were previously cost prohibitive.²

4. Merit Network – REACH-3MC



A summary of the REACH-3MC network and associated network map can be found on the Merit Network website.³

REACH-3MC will build 2,287 miles of open-access, advanced fibre-optic network through rural and underserved communities across Michigan's Lower and Upper Peninsulas.

REACH-3MC is funded by two grants from the Broadband Technology Opportunities Program (BTOP) as part of the American Recovery and Reinvestment Act of 2009 (ARRA), commonly referenced as the Stimulus Package.

REACH-3MC features robust public-private collaboration. Merit Network is working with over 140 community anchor institutions that will receive fibre-optic laterals.

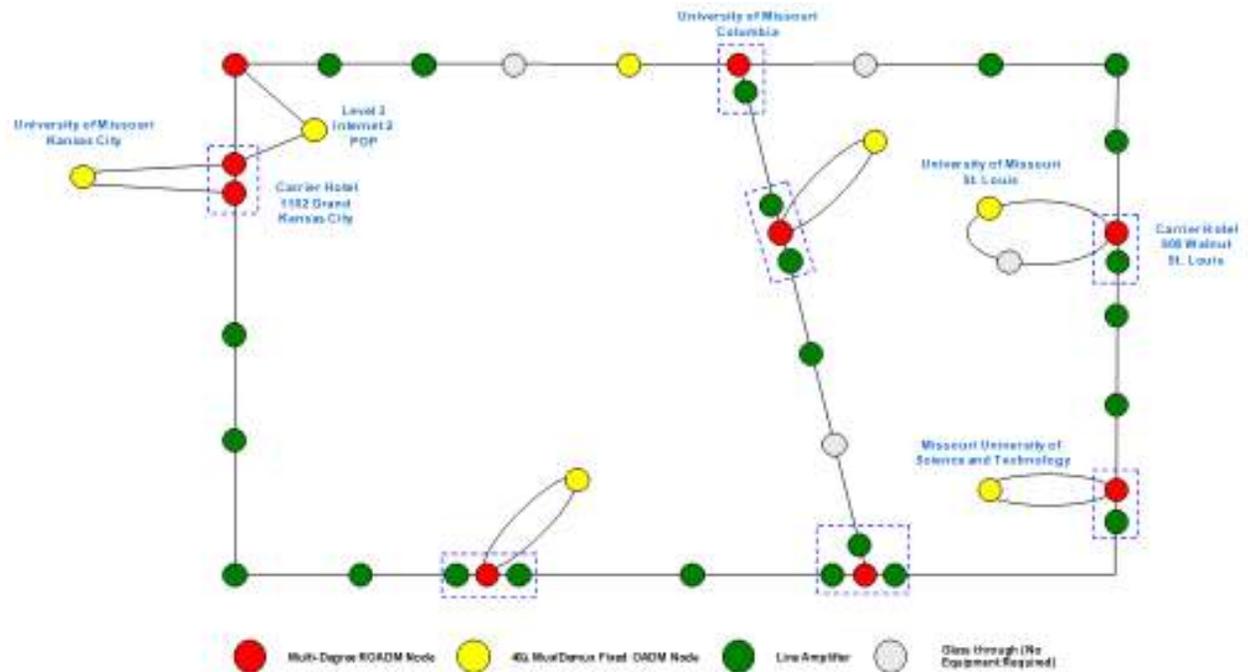
Merit also has engaged three providers from the commercial sector, who are Sub-recipients on REACH-3MC and will offer services to homes, businesses and local ISPs in the project service area.

While the initial capital cost of Merit Network's fibre infrastructure is being paid for by a US government stimulus grant, the on-going operational costs for the network will come from member fees and additional services indicated on their website and summarized below.⁴

4.1 Merit's Family of Services

- Merit Professional Learning
- MeritLicensing Service
- Merit Professional Services
- Merit Town Hall and Services Events
- Merit Cloud Media
- Merit List Manager
- MeritMail Collaboration Suite
- Merit Michigan ID
- Merit RADb - The Routing Assets Database
- MeritVoice
- Merit WebConnect
- Merit Cloud Storage
- Merit Colocation
- Merit VirtualDataCentres
- Merit VirtualDesktops
- Merit Web Contingency
- Merit Connectivity
- Merit Domain Name Services
- Merit Multicast Services
- Merit Network Time Protocol (NTP) Services
- Merit Transport Service
- Merit VPN

4.2 Missouri Research & Education Network (MOREnet)



MOREnet has created an extensive state-wide fibre network in Missouri. This network was provided in part by state funds and in part by federal funding. Operational costs are provided by member institutions and the services provided by MOREnet.

MOREnet's services are displayed on their website and summarized below: 5

Business Continuity / Disaster Recovery

- Colocation
- Network Backup
- Network Storage
- SecondWeb Hosting Service
- Virtual Servers

Connectivity Management

- Black Hole DNS
- Domain Name System
- E-rate Assistance
- E-mail Virus and Spam Filtering
- Good Net Neighbor Phase 1 & 2
- Internet Connection
- Internet Content Filtering
- Internet2
- Microsoft EES Consortium Pricing
- MyMOREnet
- Network Consulting as a Professional Service
- SSL Certificates

- Virtual Servers
- Wireless Assessment Surveys

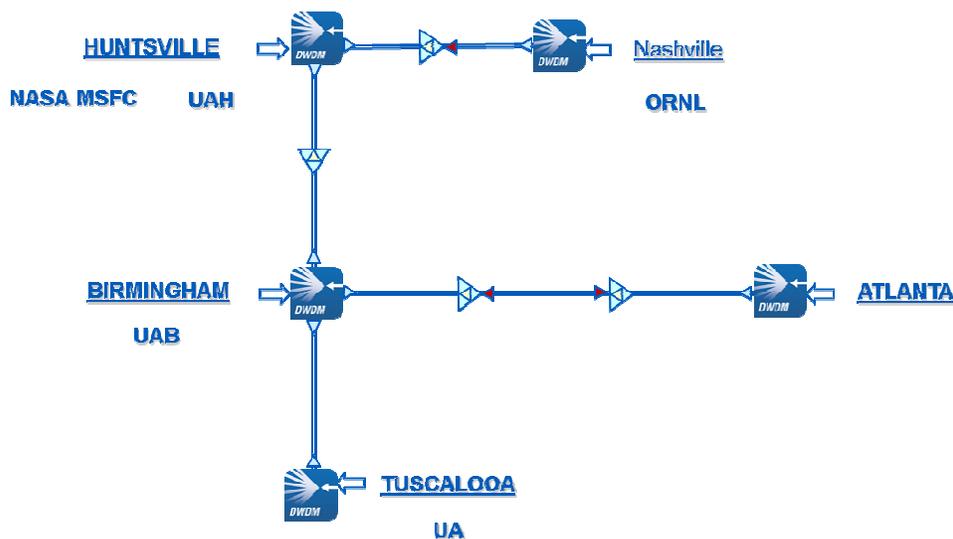
Communications and Collaboration

- Discussion Lists
- E-mail Archiving
- E-mail Hosting
- E-mail Virus and Spam Filtering
- Google Apps for Missouri
- Learning Management System (LMS)
- Live Video Streaming – Originating
- Live Video Streaming – Viewing
- Remote Conference Management
- Mobile Videoconferencing
- Videoconferencing
- Web Hosting

Community Cloud

- E-mail Archiving
- E-mail Hosting
- Learning Management System (LMS) Hosting
- Network Backup
- Network Storage
- SecondWeb Hosting Service
- Virtual Servers
- Web Hosting

4.3 University of Alabama System (UAS)



The University of Alabama System (UAS) network was created in order to provide long-term cost savings over leasing bandwidth. The network interconnects all of University of Alabama System campuses and NASA Marshall Space Flight Center to Internet2 and commodity Internet in Atlanta

The costs for the network were shared by UAS, the National Aeronautics and Space Administration (NASA) Research & Engineering Network (NREN) and Marshall Space Flight Center (MSFC) in Huntsville, AL. NASA paid for the fibre. UAS paid for the optronics. Both NASA and UAS pay for the operational support for the network.

Initially the network will provide MSFC with 10Gbit/s connectivity to NASA's other facilities nationally. I will also provide The University of Alabama System with more affordable commodity Internet connectivity & Internet2 access. The University of Alabama System fibre network will link their campuses in Tuscaloosa, Birmingham and Huntsville, AL. It will provide network services for the scientific community by supporting disaster recovery / business continuity and high-quality, digital-video applications for telemedicine services and distance learning.

Southern Light Rail designed the UAS RON network, acquired the equipment and provided project management and operational support for the network.

5. Models

5.1 Models for Acquiring Dark Fibre

The primary sources for acquiring dark fibre are from telecom carrier or an electric utility.

The primary financial models for acquiring dark fibre are either to lease the fibre and incur a monthly recurring cost or to execute an indefeasible right-of-use agreement and incur an initial nonrecurring cost and a monthly recurring cost.

Another approach is to barter or trade use of the fibre for bandwidth or wavelengths on the network. For example, Uganda Telecom Ltd. (UTL) was to receive one 10Gig wave in return for use of fibre from Entebbe to Kampala on the RENU fibre network.

Yet another potential model is to partner with another institution. One partner procures the fibre and another partner procures the optical equipment. Both parties share the cost of operating and maintaining the network.

5.2 R&E Business Models

There is more to building a network than just evaluating the costs of building a fibre network versus buying bandwidth capacity from a carrier. There are most certain to government and regulatory considerations. In addition, university / National Research and Education Network (NREN) politics will also play a key part in whether or not deploying a fibre network will be successful on a long-term basis.

Sources of initial funding must be identified in advance, whether that will be from loans, grants or member provided internal funding.

Once sources of initial funding have been identified, a sustainability model must be created. This could come from membership dues and/or utilization fees. It is important for NRENs to Drive applications to the network and develop member services as well as teaching and learning opportunities.

5.3 Network Design Considerations

When in the initial planning stages of the building a fibre network, it is important to consider a business model. Determine if it makes sense from a business and operation perspective to build a fibre network or buy bandwidth from a carrier (see Section 3 for more details). It is extremely to not only identify sources of funding for the initial costs for the network but also determine a sustainability model to recover on-going operational costs.

Whenever possible, a NREN should utilize technical resources such as the Network Start-up Resource Center (NSRC) and vendor sponsored workshops and webinars.

A fibre network should be designed to provide diverse facility entries and diverse fibre paths. Hardware such as path protection modules and optical link monitors should be utilized in order to enhance network reliability.

The equipment used to light the dark fibre should have a small rack mount footprint and low power consumption. Whenever possible passive, temperature hardened, equipment should be utilized especially at edge of the network and for short-haul links.

Other considerations for an on-going fibre network operation should include the following:

- Network management software and a network operations center
- In-country spares and a local service partner
- Vendor provided maintenance agreement for all equipment
- Training – vendor provided, both technical and operations

6. Implementation Plan

A step-by-step blueprint for what is required to build, operate and maintain a fibre network

The following items should be considered and be an integral part of a fibre network implementation plan:

- Project Management – make sure to have an internal project manager that understands fibre network deployment or engage a vendor provided resource to provide that service.
- Procure fibre – once fibre is obtained either from a lease, IRU or trade, it is important that the fibre be characterized
 - Characterize fibre (OTDR, optical loss, dispersion, etc.)
- Network design – elements of a proper network design should include the following
 - Design optical network
 - Applications and network integration
 - Rack layout
- Procure optical equipment

- Contract issues – finalize with vendor as soon as possible
- Manufacturing – allow for adequate time to accomplish
 - Production of equipment & spares
 - Staging & system test
- Shipping & Delivery (global logistics - customs) – important for international shipments
- Customer Checklist – this is something that often causes delays if not completed in time
 - Site preparation check list (access, power, fibre jumpers)
- Deployment issues
 - Installation
 - Site access planning
 - Rack & stack
 - Set levels and commission equipment
 - Coordinate with local service partner
- Post- Installation Testing – make sure the equipment vendor’s technical team does this
 - Perform tests at all sites (i.e. OSNR, Res. Sensitivity, Latency)
 - 24 hour BER test
- Training – technical and operational
- Documentation – integral part of every implementation
- Maintenance – a complete package should include access to the following:
 - Remote tech support
 - Spare management
 - Repair & return
 - On-site engineer
- NOC services – this should be provided internally or contracted for

7. Conclusion

First, determine if it make sense from a business and bandwidth perspective to deploy a fibre network. Then learn from / collaborate with other members of the research & education community. Prepare detailed plans based upon other’s experiences that include a dark fibre acquisition plan, business plan, a network design plan and an implementation plan.

References

- ¹<http://www.usg.edu/peachnet/fibre>
- ²<http://www.usg.edu/peachnet/>
- ³<http://www.merit.edu/meritformichigan/>
- ⁴<http://www.merit.edu/services/>
- ⁵<http://www.more.net/content/solution-center>

Biography

Brian Savory is a telecom professional with extensive experience in fibre based transport networks and wireless telecommunications. He has helped research and education (R&E) customers build, operate and maintain private fibre optic networks. Brian currently works for Optelian as Business Development Manager.

Brian is actively involved with Internet2, the NREN consortium led by the US research and education community. He currently serves on the Internet2 Network Architecture, Operations and Policy Program Advisory Group (NAOPpag) as well as the Program Committee.

Brian worked at Georgia Tech assisting in establishing Southern Light Rail, Inc. (SLR), the R&E regional optical network (RON) in the Southeast, US where he served as SLR's President and Executive Director. SLR operates the Internet 2 connector (SoX) in the Southeast. While at Georgia Tech, Brian facilitated the procurement, implementation and operation of the University of Alabama System RON which connects the University of Alabama campuses and NASA Marshall Space Flight Center campus to telecom POPs in Atlanta.

One of Brian's most challenging professional projects was his involvement with IEEAF (Internet Educational Equal Access Foundation), USAID (United States Agency for International Development) and RENU (Research and Education Network of Uganda) on the NREN fibre network in Uganda. This project deployed the first phase of a fibre optic network from Entebbe to Kampala.

Brian graduated from the Georgia Institute of Technology with a Bachelor of Electrical Engineering degree and earned his MBA from Georgia State University.