Boeing Technology
Information Technology

Next Generation Backbone for the Boeing Company

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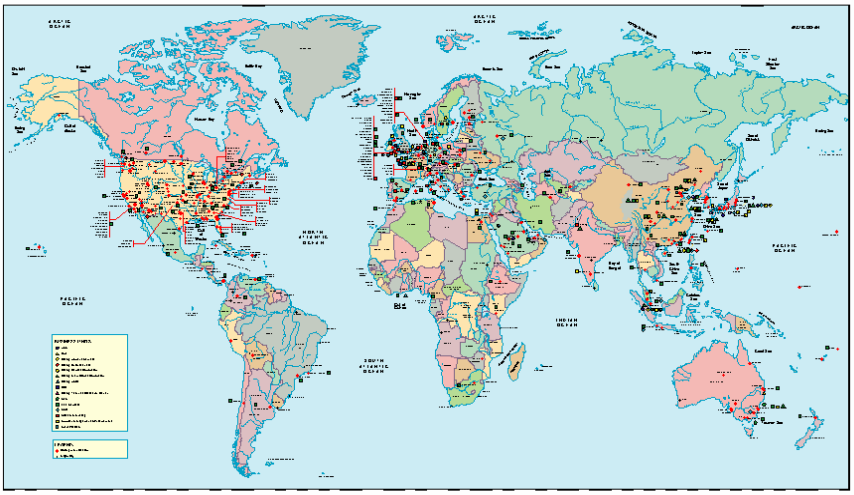
Boeing Background

- **Boeing Company employment approx 154,000 (Jan 06)**
- **Boeing Locations**
  - In CONUS approx 85 locations with populations ranging from 50 to 20,000 each
  - Hundreds of locations with smaller numbers of employees worldwide
  - Numerous large Boeing sites outside CONUS
- **Military and civilian aerospace, defense systems integration, mobile networking, space systems and launch services**
- **IT support, including network, provided by a central organization – Boeing Information Technologies (BIT) Computing and Network Operations (CNO)**
- **Major IT trends**
  - Consolidation of Data Centers
  - Virtual work groups
  - Extensive collaboration with Customer/Partner/Supplier relationships with companies throughout the world

Boeing Locations Worldwide

Boeing Locations supported across 62 countries



Old Architecture

- **Old national backbone (CONUS) was ATM/Frame Relay based**
  - Hub and spoke architecture
    - Interconnected individual sites and clusters of sites in metro areas
    - Two large metropolitan areas – Puget Sound and Los Angeles
      - DWDM (POS) and ATM connected (metro speeds T-3 to OC-48)
  - National backbone port speeds range from T-1 to OC-12
  - Boeing used ATM and Frame Relay for about eight years
- **Three perimeter locations provide firewall, filtering, and services for external access**
  - Internet access
  - External and international locations
    - Separate network services supported these connections
  - Policy enforcement for ingress/egress between internal and external networks
- **Approx 800 routers, 5000+ LAN Switches**

Hub and Spoke Backbone Model

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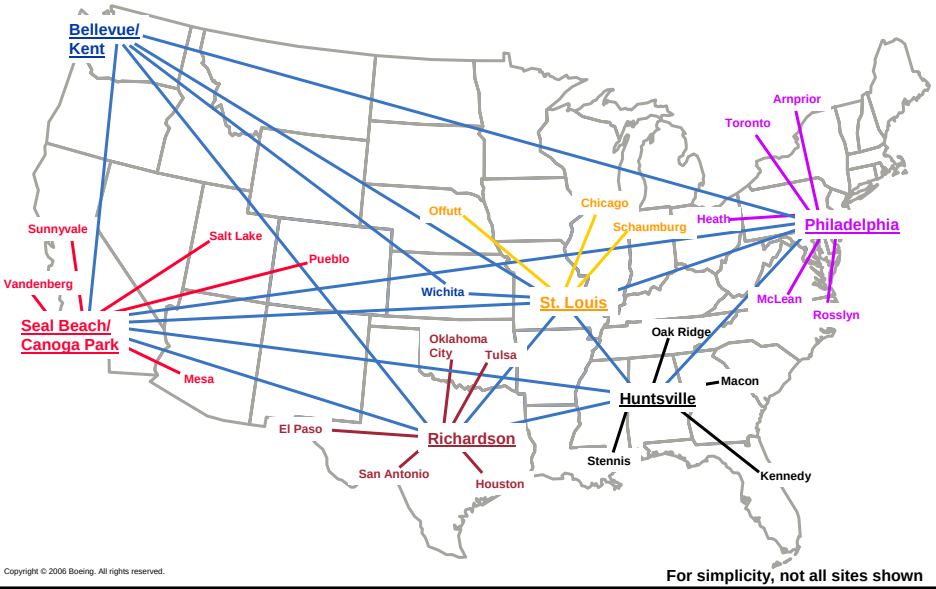

For simplicity, not all sites shown

Regional Routing Processes with BGP Core

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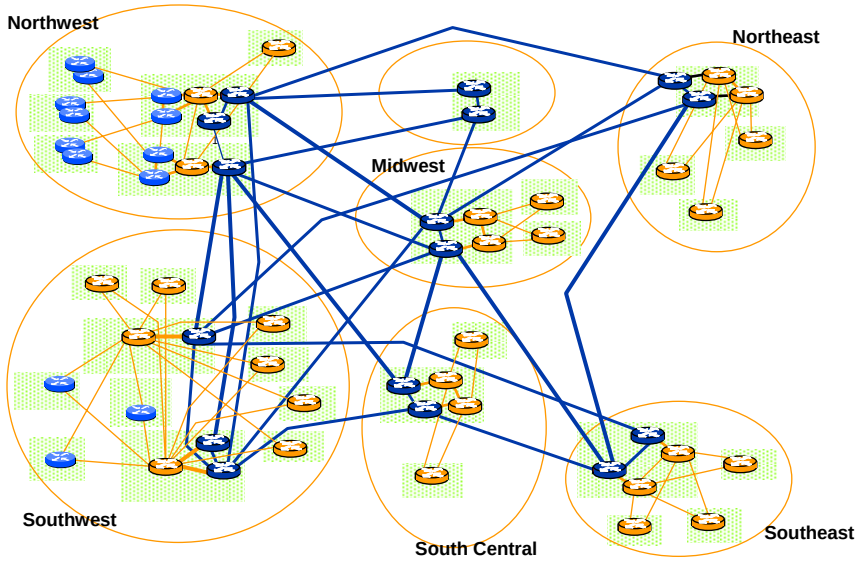

Security Perimeter and External Connectivity

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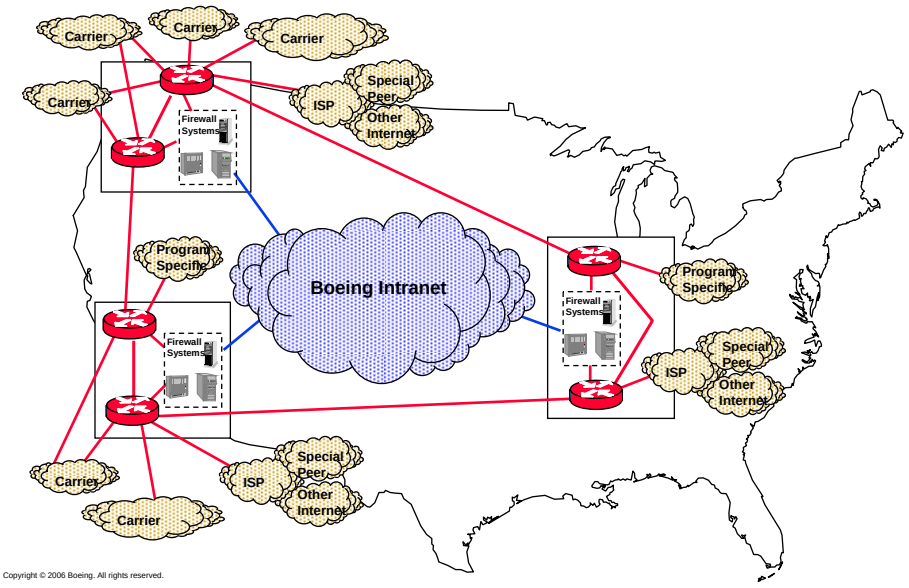

Extranet via MPLS VPN Over ATM Backbone

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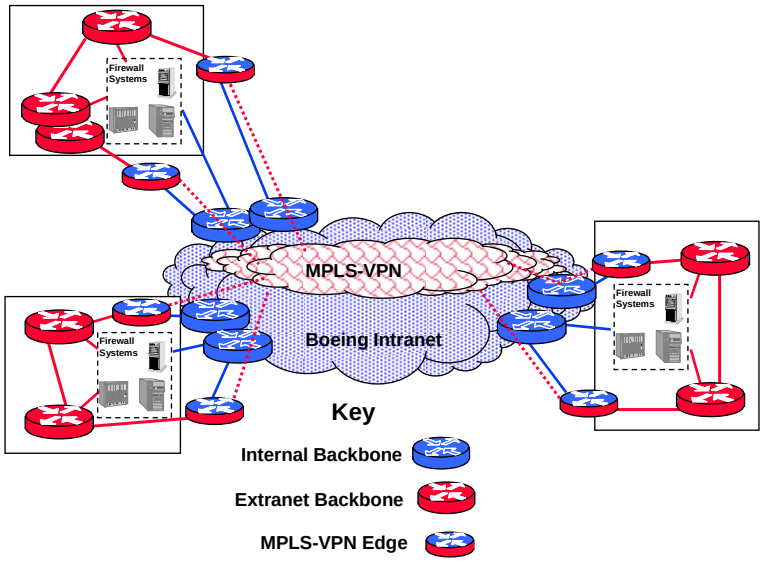
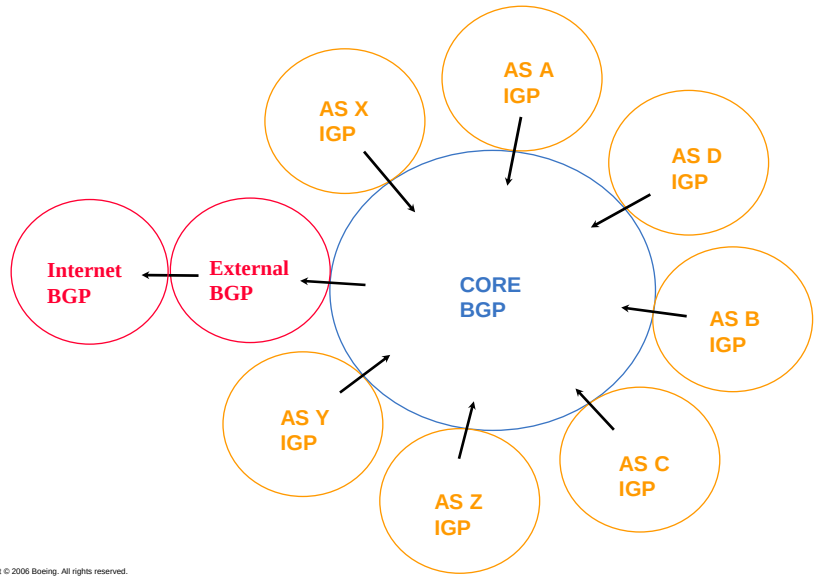


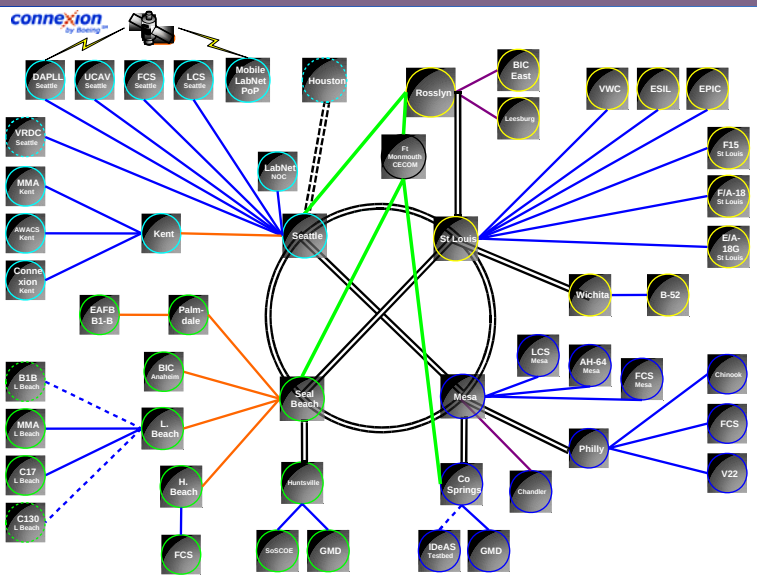
Old Routing Hierarchy



Services and Operations

- **Backbone currently carries approximately 32,000 terabytes per month (and growing)**
- **Backbone supports Protocol Independent Multicast (PIM)**
  - Large multicast video events (town hall meetings)
    - Largest event to date approximately 6000 participants
  - Manufacturing production control applications
- **Quality of Service (QoS)**
  - Five traffic classes supported
- **Extensive deployment of Voice and Video Over IP**
  - Approx 500,000 minutes per month on corporate backbone
- **In-house design, install, Network Management**
- **Special purpose networks for program specific requirements (simulation and product development)**

Special Purpose Network - LabNet



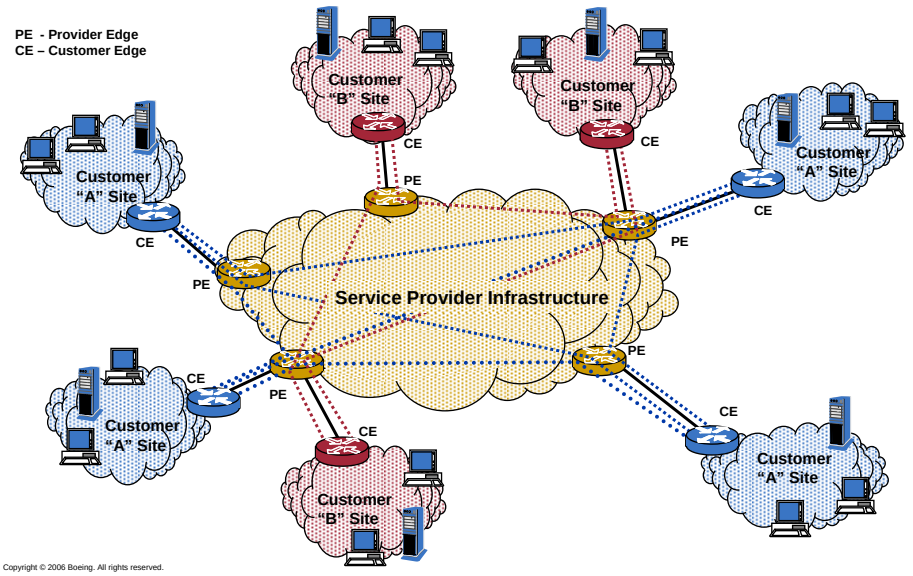
Why Did Boeing Consider MPLS?

- **Objectives**
  - Provide increased capacity, respond to customer requirements
    - Growth in traffic
    - Increasing demand for special purpose networks
    - Sensitivity of applications to latency
    - Data Center consolidations
  - Simplify operation of the backbone, routing processes
    - Design and maintenance of backbone
  - Maintain services and features currently provided
  - Maintain stability of the network
  - Make no decision that would force change in Boeing security policies
  - Lower the price point
- **Examination of MPLS services and architecture**
  - Discussions with 12 carriers (services) and Cisco (equipment)
  - Described features and services Boeing required
  - Determined which type of MPLS service to pursue - L2 vs. L3 VPN

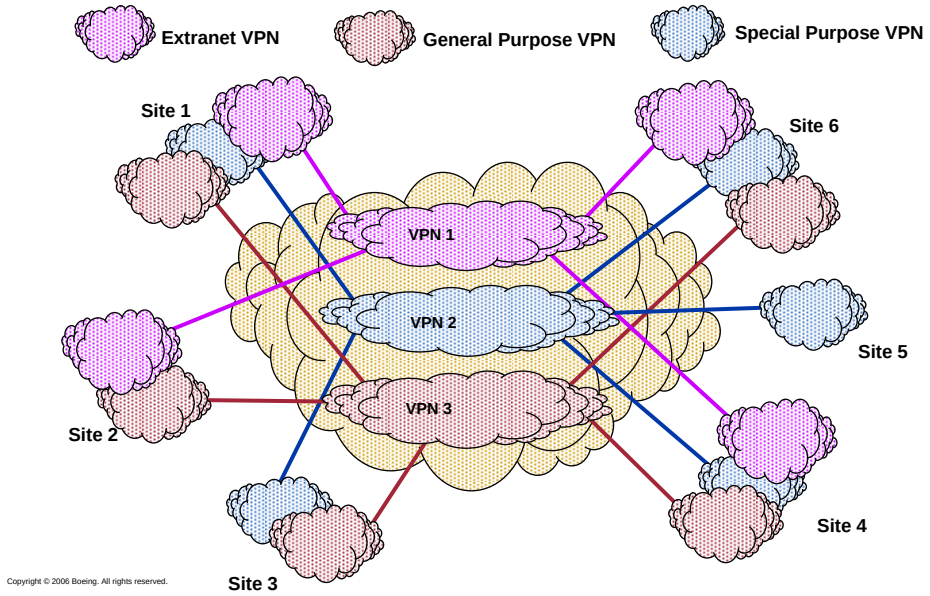
MPLS Implementation Timeline

• Conceptualization and socialization	3Q 02 – 2Q 04
• Evaluation of MPLS service providers	4Q 03 – 1Q 04
• Opportunity evaluation	2Q 04
• RFP	3Q 04 – 1Q 05
• Prep for MPLS (Renumbering)	4Q 04 – 2Q 05
• Labs	4Q 04, 1Q 05
• Business case development	4Q 04 – 1Q 05
• Provider selected and contract negotiation	1Q 05
• Network conversion	2Q 05 – 1Q 06

L3VPN – Service Provider View



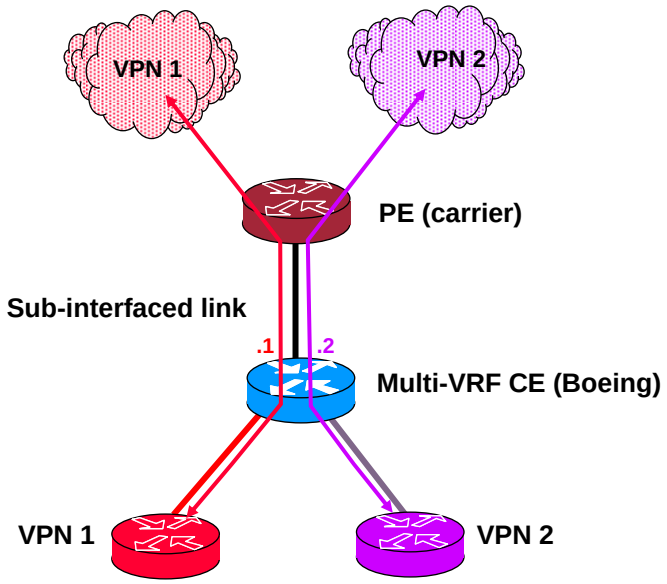
L3VPN – Boeing View



Boeing MPLS Architecture

- **Each site has at least one port to the provider MPLS net**
  - Boeing owns and implements the CE
  - Some locations implemented with two access circuits and ports for redundancy
  - Port sizing based on aggregate traffic to/from the site (including all VPNs)
- **One or more VPNs established at each site**
  - Each VPN is separated (air gap) from other VPNs on a campus
  - VPNs:
    - General Purpose VPN supports the internal network
    - Perimeter Interconnect VPN supports perimeter services
    - External VPN supports connectivity to non-Boeing locations
    - LabNet VPN
    - Other VPNs established as required
  - Boeing implemented Cisco Multi-VRF CE to access multiple VPNs over a single access circuit
    - Reduced access cost
  - "Soft Limit" for capacity management and QoS allocations
- **Fully meshed infrastructure within each VPN**
  - Connections amongst <u>all</u> sites are direct (from a routing point of view)
  - The L3VPN model eliminated the hub and spoke construct

Multiple VPNs Through a Single Access



Boeing MPLS Architecture (cont)

- **External customers, suppliers, partners can join specified VPNs**
- **Interconnect between any two VPNs must traverse perimeter systems**
- **Access Speeds and Protocols**
  - T-1 PPP
  - NxT-1 - Parallel circuits and MLPPP
  - T-3 PPP
  - OC-3 through OC-48 POS
- **Routing**
  - PE to CE routing - E-BGP
  - Link addressing and ASNs assigned by Boeing
  - Each location advertises a summarized site range(s) to the VPN
    - Control the number of routes advertised into each VPN
  - Routing advertisements from the VPN to the site could vary from the full table, to a default address, to a filtered set of networks
    - Boeing chose to take the full routing table

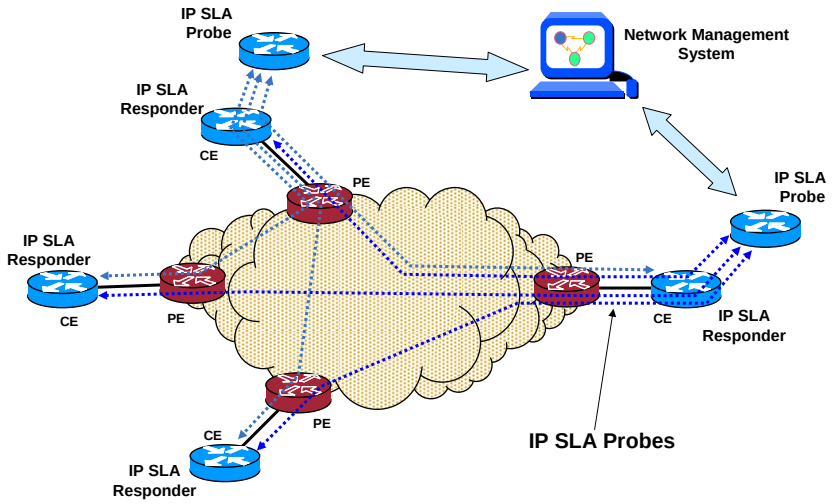
Services

- **Multicast services**
  - Carrier implemented “Rosen draft”
    - Default and Data Multicast Distribution Trees (MDTs) implemented
  - Transparent to Boeing multicast infrastructure
  - Satisfactory service to date
- **QoS**
  - Expedited Forwarding, Assured Forwarding, and Best Effort supported
  - Boeing QoS structure supports more classes than offered by most carriers
    - Boeing traffic is “compressed” into fewer classes in the backbone
  - Several carriers offered queuing at edge only
  - QoS allocations often based on “configuration templates”
  - Some carriers didn’t offer queuing at all
    - “High bandwidth” approach

Preparation for Deployment

- **Addressing**
  - Service providers limit the number of networks advertised to the VPN
    - Limitations weren’t considered restrictive, but did provide the opportunity to introduce some discipline
  - Re-numbered sites and metro areas to summarized address boundaries
- **Design and documentation tools**
  - Design processes were unchanged, except in the details
  - Home-grown address management tool updated to address characteristics of MPLS
    - Assigning and controlling the address ranges, Autonomous System Numbers, etc, for each site
- **Development of a performance measurement system utilizing Cisco IP SLA feature**
  - Integrated IP SLA into the existing tools/applications to generate performance reports, etc
    - Measurement of packet delivery, jitter, errors, etc for each traffic class
  - Close observation of performance of the carrier

IP SLA Architecture



Consequences of the New Architecture

- **Dramatically reduced costs**
  - Elimination of over-capacity and redundancy at hubs
  - Simplified operations
  - Lower price point for the service
- **Simplified design and maintenance**
  - Backbone routing is essentially eliminated
    - Local/metropolitan routing processes only
  - No maintenance of backbone links
    - Responsibility of the carrier
    - Boeing no longer maintains the core backbone connectivity and sizing
      - Ports and QoS allocations based on ingress and egress traffic only
      - Consideration of failure scenarios in core no longer responsibility of Boeing
- **Routing processes at individual sites are isolated from one another**
- **No national backbone hubs**
  - Dependency on hub transit is eliminated
  - Latency determined by carrier backbone only
    - Boeing architecture won't induce additional routing hops

Experience So Far

- **Implementation**
  - •Transition simple
    - Initial deployments approached cautiously
      - "Burn-in before cutting traffic
    - Eventually confidence gained to cut traffic at port acceptance
  - Typical issues with LEC access circuits during implementation
- **Multicast working well**
- **QoS - Latency and jitter measurements are nominal**
- **Routing is straightforward and stable**
- **"Soft failure" scenario**
  - Separation of core transport from Boeing edge (no physical or link layer relationship between core transport and Boeing routers)
    - Physical or Link Layer faults would be detected by Boeing router and path removed from routing table
  - Fault on MPLS side of PE not detected by PE to CE routing processes

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