AtlanticWave + Americas Lightpaths: Enhancing Research Connectivity between North and South America with Open Lightpath Exchanges and 100G Waves

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OpenWave 100G project

- OpenWave is a project (award# 1341895) under NSF IRNC ProNet AmLight award for U.S.-Latin America connectivity
- OpenWave will deploy an experimental 100G alien wave between the U.S. and Brazil
- OpenWave is an experiment consisting of 2 major goals:
  - Understand how to deploy a 100G trans-oceanic alien wave on a highly constrained operational undersea cable system
  - Understand how to operate a 100G alien wave with a total span of approximately 10,000km
- Broader Impacts:
  - Impact is the potential of introducing a novel approach for upgrading production undersea optical fiber systems
  - Facilitating academic access to submarine spectrum
  - Brings a new resource to science and education, preparing for future science demands, such as the Large Synoptic Survey Telescope (LSST), which is expected to push to the limits of 100Gb/s network connections, bridging the southern and northern hemispheres.

OpenWave Project Partners

- NSF and the IRNC program
- Florida International University via the AmLight Project
- Brazil via the ANSP and RNP
- PadTec, optical equipment manufacturer in Brazil
- Latin American Nautilus, submarine cable system operator
- Florida LambdaRail (FLR)
- Internet2

OpenWave Challenges

- 100G alien wave technology has not been field tested in this type of environment
- Complexity of LAN's undersea cable system
  - Real-world submarine cable system that is 14+ years old with many amplifiers
  - Complex overlays using multiple digital modulation schemes
    - 10G waves with Non-return-to-zero (NRZ) modulation at 100GHz, 50GHz and 33GHz spacing
    - 40G & 100G waves in an overlay using BP & QPSK modulation at 50GHz spacing
  - Overcoming non-linear phase noise effects
    - Optical Signal to Noise Ratio (OSNR), Bit Error Rate (BER), Chromatic Dispersion, etc.

OpenWave and AmLight Topology

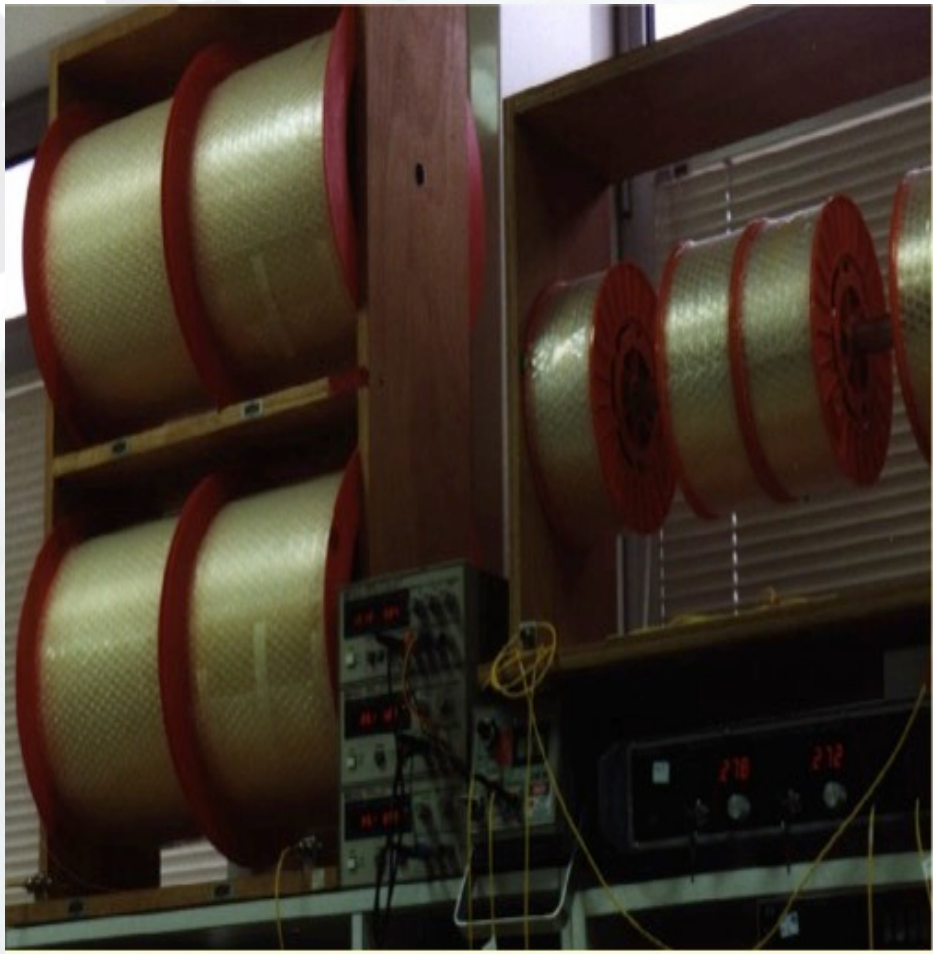
- 4 100G segments (future):
  - St. Croix (STX)-Fortaleza 4,200km
  - Fortaleza-Rio, 3,500km
  - Rio-Santos, 400km
  - Miami-STX, 2,400km
- ANSP: 2x 10G links
  S Paulo – Miami
  - (W) via Santiago (LAN)
  - (E) direct (Telefonica)
- RNP: 2x 10G links
  S Paulo – Miami
  - (W) direct (Telefonica)
  - (E) via Rio de Janeiro & Fortaleza (LAN)
    (+ redundant terrestrial links)

OpenWave System Characteristics

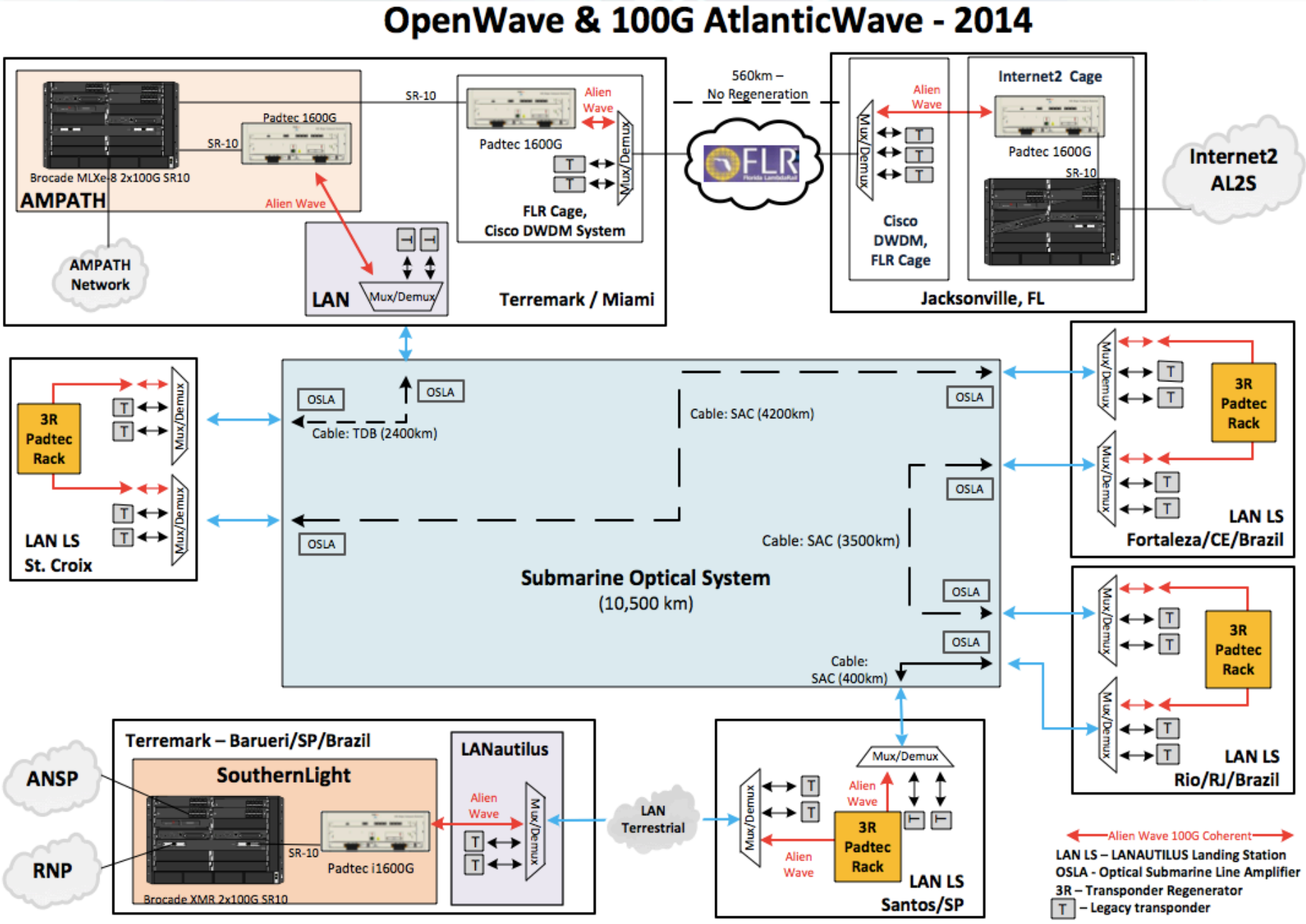
- Four spans in the path; longest measured at 4,200km
- 100G Alien Wave will be deployed using Padtec's devices with LAN's hybrid Ciena SLTE and Alcatel repeatered line
  - New Alien Wave deployment in SAC cable
  - Differential Quadrature Phase Shift Keying (DQPSK)
  - Coherent Detection technology
- Use of a 50GHz channel, plus some guard channels of 50Ghz
  - Number of guard channels depends on results of simulation and lab tests
  - Prevents Non Linear Effects on production waves

Methodology

- Separate the Miami – São Paulo path into 4 spans:
  a. Miami to St. Croix (2,400km)
  b. St. Croix to Fortaleza/BR (4,200km)
  c. Fortaleza to Rio de Janeiro (3,500km)
  d. Rio de Janeiro to Santos (400km)
- Modeling span (b): (approx. 30 days)
  - (b) is the longest span
- Simulation of (b): (approx. 30-45 days)
- Laboratory tests of (b): (approx. 30 days)
- Repeat for (a), (c), (d) and (e) – (up to 15 days each)
- Evaluation of the results by all partners
- Deploy the 100G in the SAC cable



OpenWave Network Design



Critical Success Factors

- Overcoming non-linear phase noise effects
  - Bit Error Rate (BER)
  - Sensitivity to Optical Signal-to-Noise Ratio (OSNR)
  - Chromatic Dispersion
- Q-value performance margin
  - How well the wave is performing in relation to BER and OSNR
  - Must account for aging and faults on the fiber
- St. Croix – Fortaleza span is most challenging
  - 4,200km
  - Experiment hinges on success with this span

Timeline

- Padtec has provided LAN with specs of their Coherent technology
- LAN has provided Padtec with characteristics of its submarine system
- Simulation of the wave
  - Results estimated by end of April 2014
- Laboratory tests
  - Results estimated by end of June 2014
- Documentation Analysis and Approval
  - Completion estimated by mid August 2014
- Field Trial
  - Projected for August – November 2014

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