



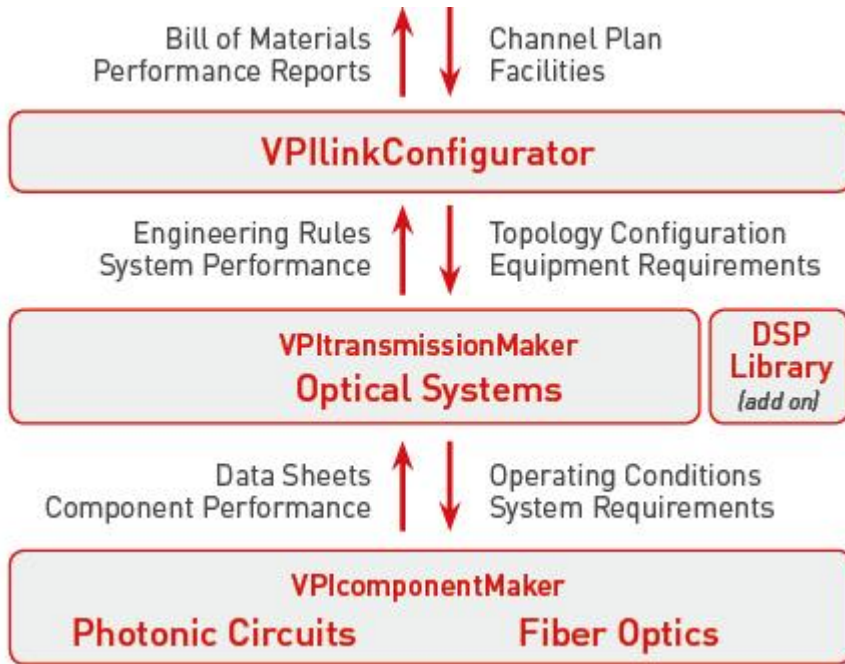
Setting the Standard for Optical Simulation & Design Engineering

Product Overview

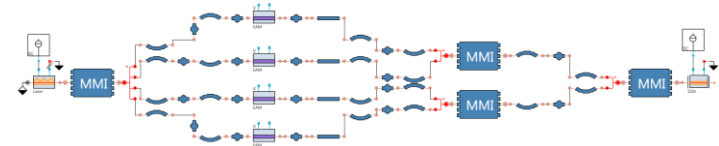
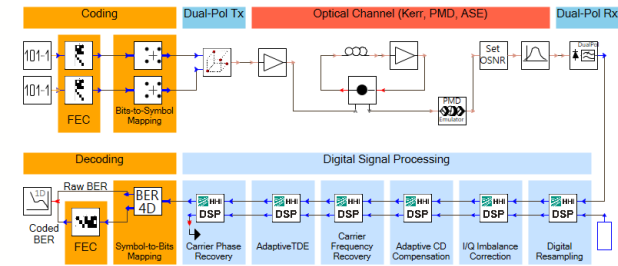
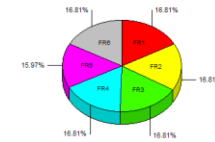
February 2015
Dr. André Richter

- Leading provider of *flexible simulation software and design services* supporting requirements of
 - ✓ active/passive integrated photonics applications
 - ✓ fiber optics applications
 - ✓ optical transmission system and network applications
 - ✓ cost-optimized equipment configuration
- Operations out of Berlin, Germany and Boston, USA; globally distributed network of regional representatives
- A *SaM Solutions* company, with a strong & experienced engineering team driving thought leadership in the industry for over 15 years now

*VPIphotonics - Setting the Standard for
Optical Simulation & Design Engineering*



Breakdown of Fiber Cost by Facility Names



Value proposition

- ✓ Virtual prototyping for faster product development and reduced R&D efforts
- ✓ Research on cutting-edge technologies
- ✓ Teaching optical communications topics

The Standard for industry & academia

- ✓ 140+ public R&D institutions & universities
- ✓ 100+ private companies
- ✓ 1000+ citations in scientific publications

Link Engineering

VPI
Link Configurator

*Application
Programming
Interfaces*

*External Access
for Execution*

*Test &
Measurement
Equipment*

*Standard
Programming
Cosimulation*

*Simulations
scripting
interfaces*

*Electronic Circuit
Design*

*Mask Layout
Design*

Transmission Design

VPI
Lab Expert

VPItransmissionMaker
Optical Systems

DSP Library
(add on)

Component Design

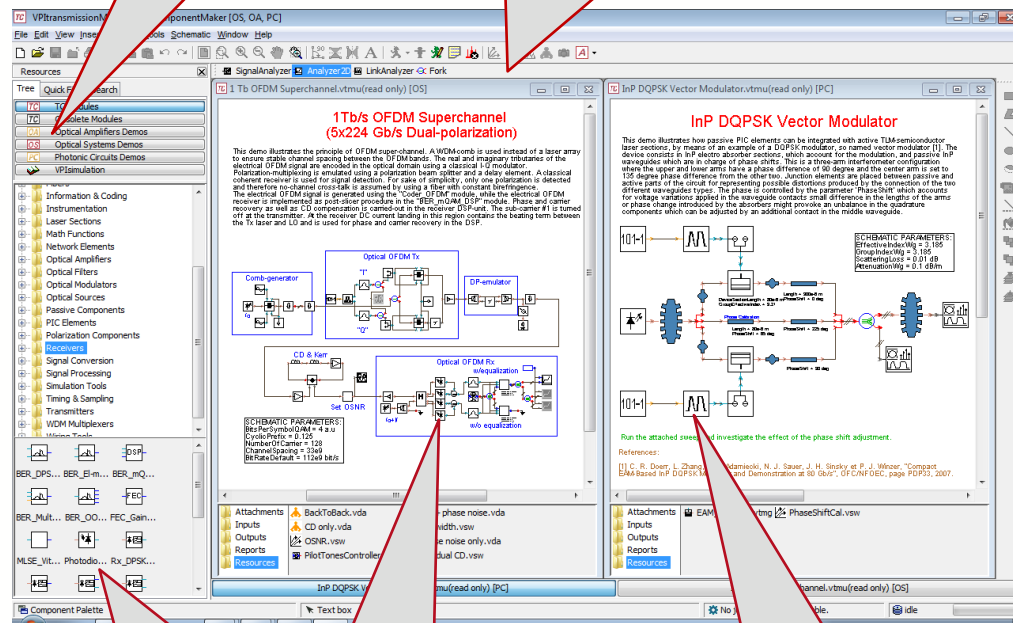
VPIcomponentMaker
Fiber Optics

VPIcomponentMaker
Photonic Circuits

Suite of specialized and interoperable tools
supporting a wealth of design, analysis
and optimization applications

700+ application
examples

Intuitive & powerful
design environment



700+ electrical &
optical modules

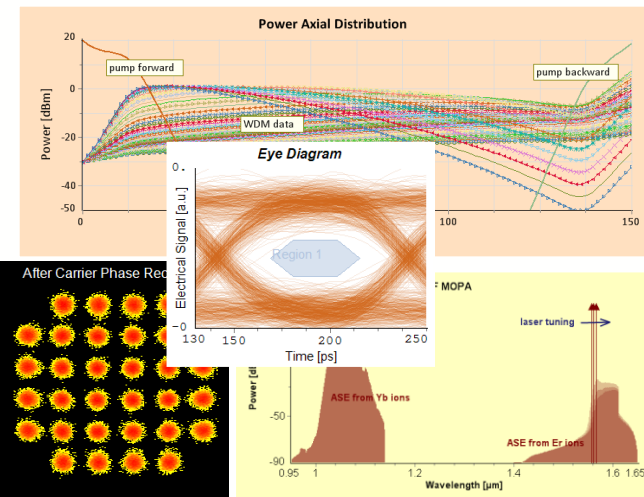
Physical & behavioral
component models

Simple integration of
measurement data

Integration with
3rd party software



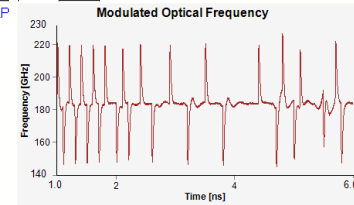
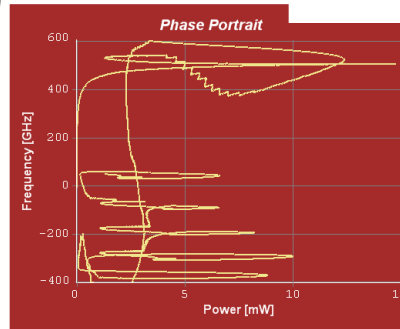
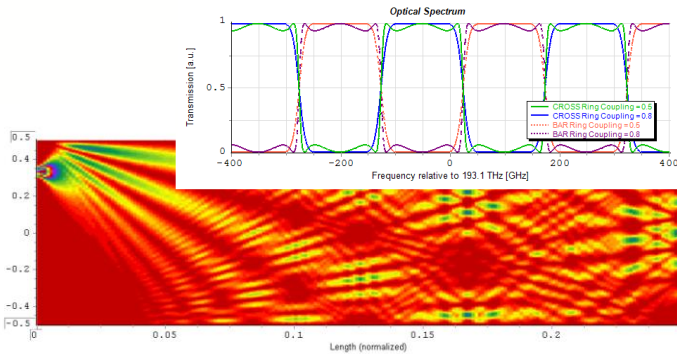
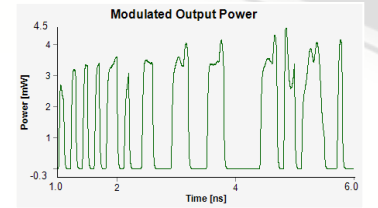
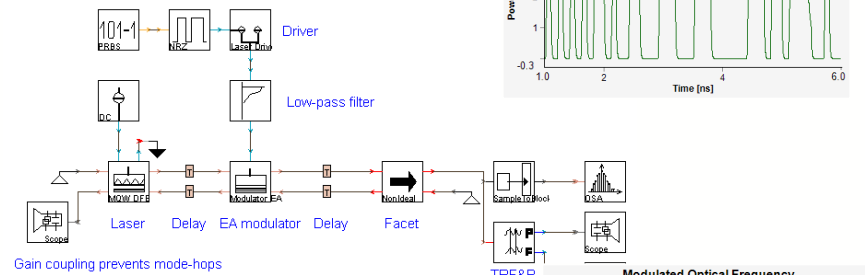
Flexible data
visualization & analysis



- ✓ Bandwidth-efficient WDM systems supporting OOK, DB, APRZ, RZ-DQPSK, (RZ-)DPSK, OFDM
- ✓ High-speed / high-capacity transmission (100Gb ... 1Tb single-/multi-carrier, Dual Pol, mPSK/mQAM, E/OTDM)
- ✓ Electronic equalization and digital signal processing (pre-emphasis, FFE/DFE, MLSE, CMA, MSPE)
- ✓ Dynamic optical networking (ROADMs, amplifier transients, electronic control, design rules)
- ✓ Optical access and short-haul (Video, FTTx, CWDM, PON, OCDMA ,in-house, free-space)
- ✓ Analog transmission and RF over fiber (CATV, wireless backhaul, sensing)
- ✓ Photonic Integrated Circuits (micro-ring resonators, coupled waveguides, integrated transmitters)
- ✓ Ring lasers, multi-section semiconductor lasers, Optical Signal Processing using SOAs
- ✓ Raman and Er/Yb-doped fiber amplifiers and lasers (high-bandwidth/ -power, pump optimization)
- ✓ ... and many more

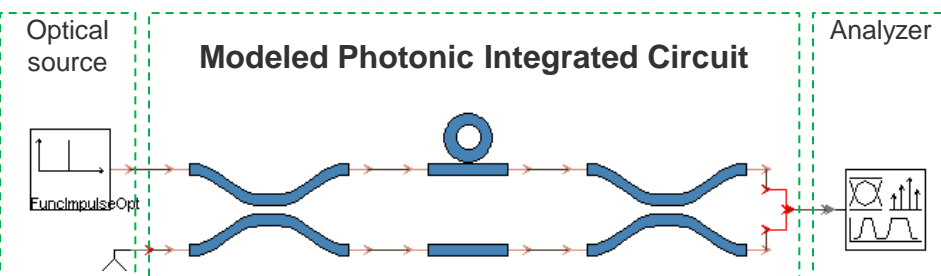
- Photonic Integrated Circuits (integrated transmitters, micro-ring resonators, coupled waveguides)
- Optical Signal Processing using SOAs (regeneration, conversion, routing)
- Semiconductor lasers (ring, multi-section, tunable)

Integrated DFB laser EA-modulator



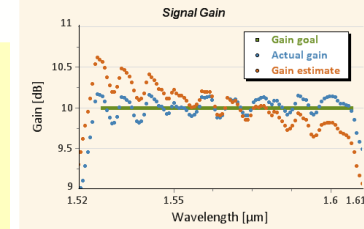
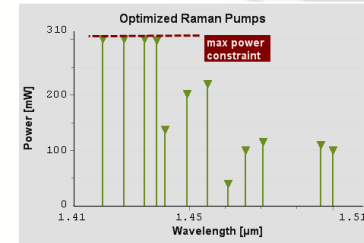
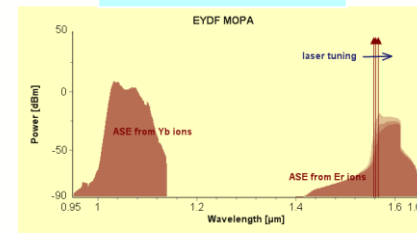
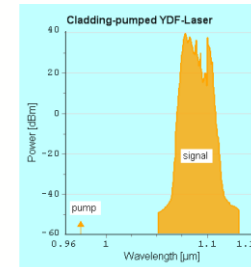
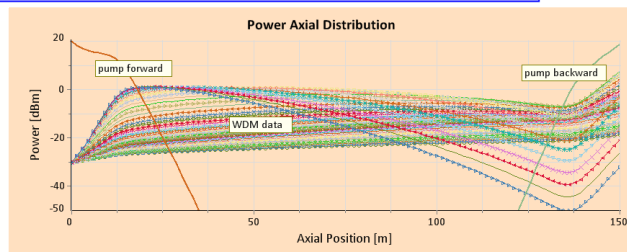
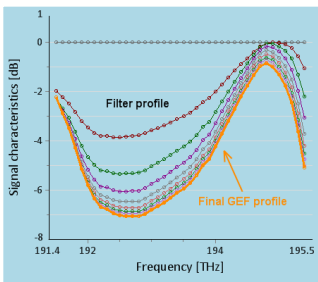
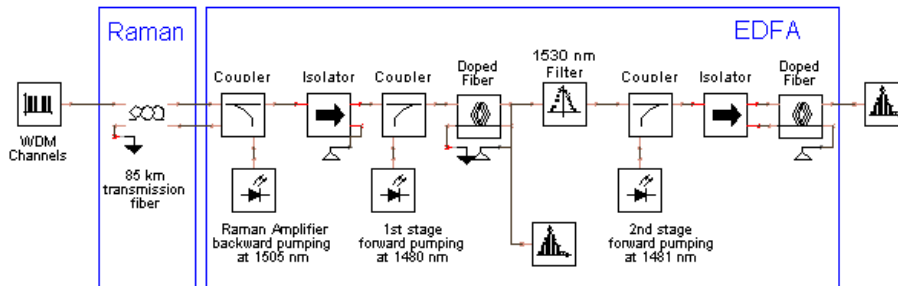
Benefits

- ✓ Fast design & optimization of PICs
- ✓ Investigate birefringence, polarization coupling dispersion
- ✓ Model bi-directional signal and noise processes
- ✓ Investigate large signal dynamics, tuning behavior
- ✓ Find settings for stable laser operation, side-mode suppression



- Er/Yb/Tm/co-doped-fiber amplifiers
- Raman and parametric amplifiers
- CW and pulsed optical fiber sources
- OSP for telecommunication
- High-power and ultrafast applications

Hybrid Distributed Raman (DRA) - EDFA amplifier Link Section



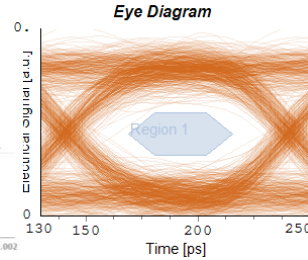
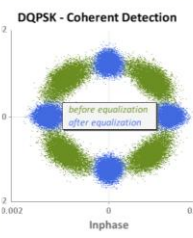
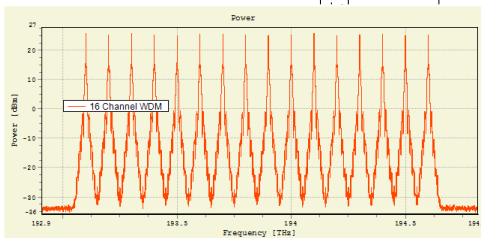
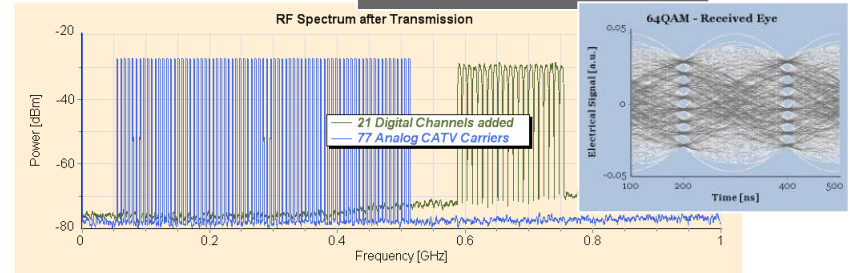
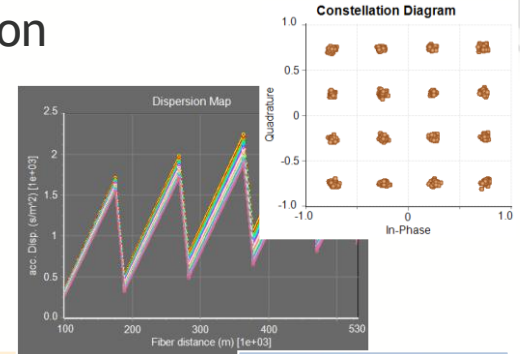
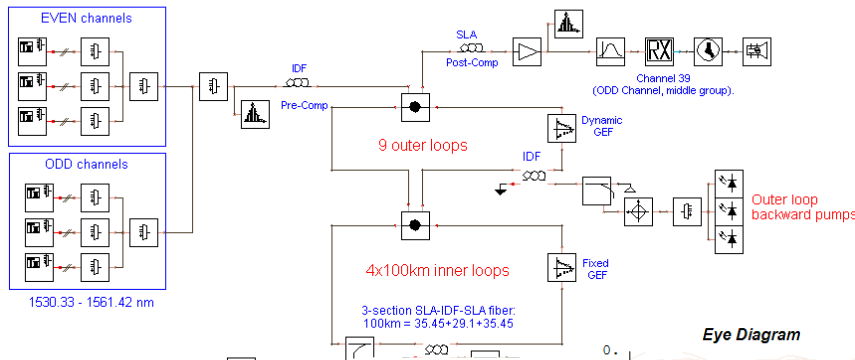
Benefits

- ✓ Design fiber-based lasers, amplifiers and OSP schemes
- ✓ Model ultrafast phenomena in optical fibers
- ✓ Powerful optimization and automation capabilities
- ✓ Identify impact of physical effects in your designs

- Aggregation and metro
- Ultra-long haul WDM
- High capacity, high-speed
- Optical networking
- HFC (analog/digital)
- PON, FTTx distribution
- RoF, Microwave photonics

- Component characterization
- Modulation schemes
- PMD/CD/IMD mitigation
- Raman amplification
- Power transients

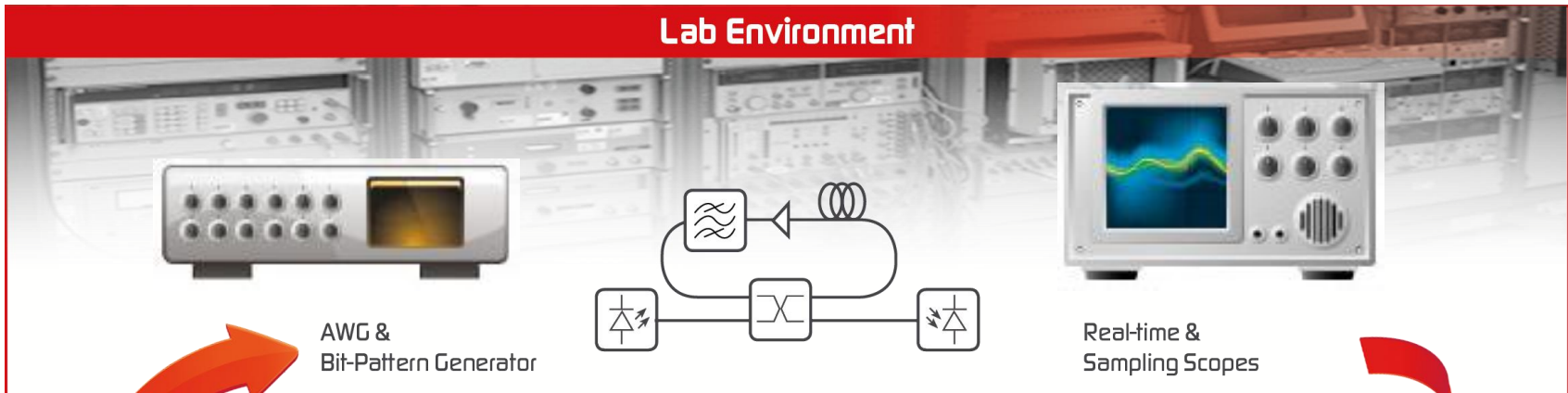
1.6 Tbit/s (40x42.7 Gbit/s) transmission over 3600 km using CSRZ



Benefits

- ✓ Analyze OSNR, Q, BER, ...
- ✓ Optimize amplifier placement
- ✓ Evaluate component performance and impairments
- ✓ Optical Crosstalk analysis
- ✓ Compensate impairments
- ✓ Compare upgrade strategies

*Advanced signal processing
and analysis functions - ready for usage in a lab environment*



- ✓ Virtualize lab equipment by emulating optical and electrical components
- ✓ Develop lab-ready signal processing solutions using simulations
- ✓ Unify methodologies and tools for simulation and lab environments

DSP Library for Coherent Optical Systems

- developed by Fraunhofer Heinrich Herz Institut (HHI)
- pluggable toolkit to *VPItransmissionMaker Optical Systems* and *VPIlabExpert*

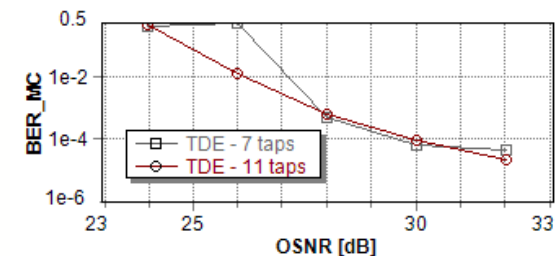
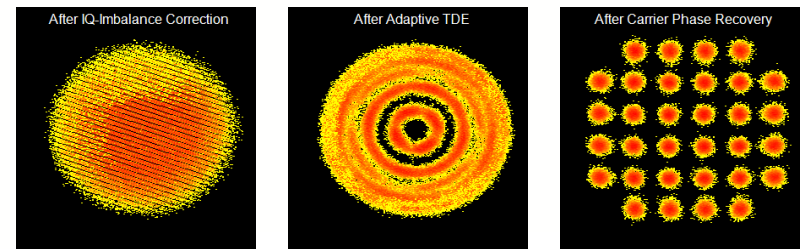


Algorithms

- Resampling*
- I/Q imbalance correction (GSOP)*
- Signal normalization
- CD estimation* and FD CD compensation*
- FFT-based Frequency-Offset correction*
- Clock phase recovery and Clock recovery
- Polarization rotation
- 2x2 adaptive TDE (CMA, PS-CMA, MMA, DD-LMS*)
- Carrier Phase Recovery (Block-based or Sliding-window Viterbi-Viterbi, Blind Phase Search (BPS)*, two-stage BPS/maximum likelihood*)
- Frequency shifter*
- Visualizer* (constellation, time-domain, frequency-domain, SOP)

Modulation formats

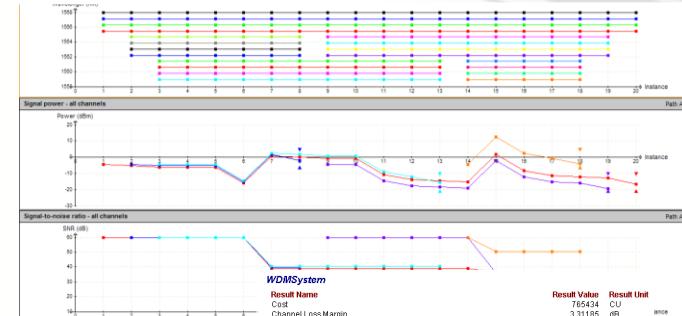
- mQAM
- DP-mQAM (DP-BPSK, DP-QPSK, ...)
- PS-QPSK
- mSP-QAM
- and others



* Modulation-format-independent

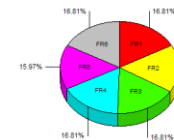
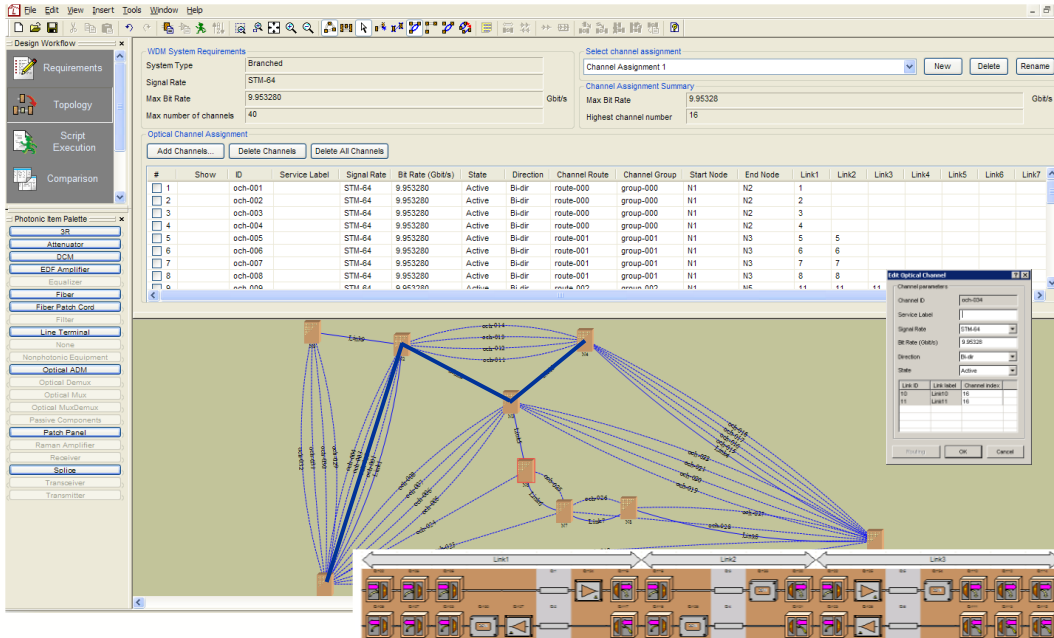
An intuitive software tool for the engineering of links

- Technology agnostic approaches
- Managed equipment libraries & engineering rules (customization mode for experts & application mode)
- Method for handling the engineering process (topology & channel plan ⇒ performance evaluation ⇒ reporting)



Quantity	Instance Ref	Name	Part Number	Total Cost
				761,604.00
Link name:				
Link name: Link1				
1	EDF Amplifier_2484	DA21P	DA21P-1	5,800.00
4	ID 2018	DCM-1842-N100	DCM-1842-N100	6,568.00
	ID 2713			
	ID 2711			
1	ID 2705	EDFA-15P-N	EDFA-15P-N	2,500.00
1	ID 2707	EDFA-21P-N	EDFA-21P-N	2,800.00
1	Line Terminal_2626	LT400G-V2	LT400G-V2	190,300.00
1	Optical ADM_2674	OADM400G-V2	OADM400G-V2	70,500.00

Breakdown of Fiber Cost by Facility Names

#	Show	ID	Service Label	Signal Rate	Bit Rate (Gbit/s)	State	Direction	Channel Route	Channel Group	Start Node	End Node	Link1	Link2	Link3	Link4	Link5	Link6	Link7
1		ech-001	STM-64	9.953280	Active	Bi-dir	route-000	group-000	N1	N2	1							
2		ech-002	STM-64	9.953280	Active	Bi-dir	route-000	group-000	N1	N2	2							
3		ech-003	STM-64	9.953280	Active	Bi-dir	route-000	group-000	N1	N2	3							
4		ech-004	STM-64	9.953280	Active	Bi-dir	route-000	group-000	N1	N2	4							
5		ech-005	STM-64	9.953280	Active	Bi-dir	route-001	group-001	N1	N3	5	5						
6		ech-006	STM-64	9.953280	Active	Bi-dir	route-001	group-001	N1	N3	6	6						
7		ech-007	STM-64	9.953280	Active	Bi-dir	route-001	group-001	N1	N3	7	7						
8		ech-008	STM-64	9.953280	Active	Bi-dir	route-001	group-001	N1	N3	8	8						
9		ech-009	STM-64	9.953280	Active	Bi-dir	route-001	group-001	N1	N3	9	9						

Benefits

- ✓ Optimize node and hut locations, fiber types and equipment
- ✓ Support green & brown fields for SDH&SONET, linear-ADM/OADM, hub-rings and branched networks
- ✓ Evaluate performance limitations
- ✓ Create performance charts, BOM, configuration reports

Cutting edge tools for cutting edge research

- ✓ *Versatile* development and engineering *platforms* for *realistic* photonic equipment *design* and cost-optimized configuration
- ✓ *Very robust* simulation *engines* addressing thousands of modeling applications
- ✓ *Module libraries* with more than *900 items* emulating optical & electrical equipment characteristics, and performing signal processing and supplementary functions
- ✓ *Many adjustable parameters* & *detailed models* allowing to simulate realistic characteristics
- ✓ *Over 700 application examples* providing a tremendous tutorial value
- ✓ *Detailed documentation* about design knowledge, modeling details and usability functions

Cutting edge tools for cutting edge research

- ✓ *Flexible licensing schemes*
(individual/group, time-limited/permanent, local/remote)
- ✓ *Excellent technical support & service team* providing fast and expert-level solutions
- ✓ *Customers* in forward-looking groups, product design and marketing teams from over 100 commercial corporations *across the world*
- ✓ *International University Program* that attracts educators and researchers from over 140 academic institutions
- ✓ *More than 70 technical publications* per year referencing the usage of VPIphotonics' products and services
- ✓ *Active participation* in national and international *R&D projects* and collaborations (SASER, OCEAN, MIRTHE, ...)

- We created the market for professional tools supporting Photonic Design Automation for optical subsystems and systems
- Our strong applications and design team ensures expertise in the field of photonics
- Our strong liaisons with industry and academia allow to stay tuned on market trends
- Our software can dramatically expand learning with interactive and engaging tools that bring current industry practice to the classroom.

VPIphotonics - The Simulation Standard for Optical Transmission Systems and Photonics applications

Thank You!

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