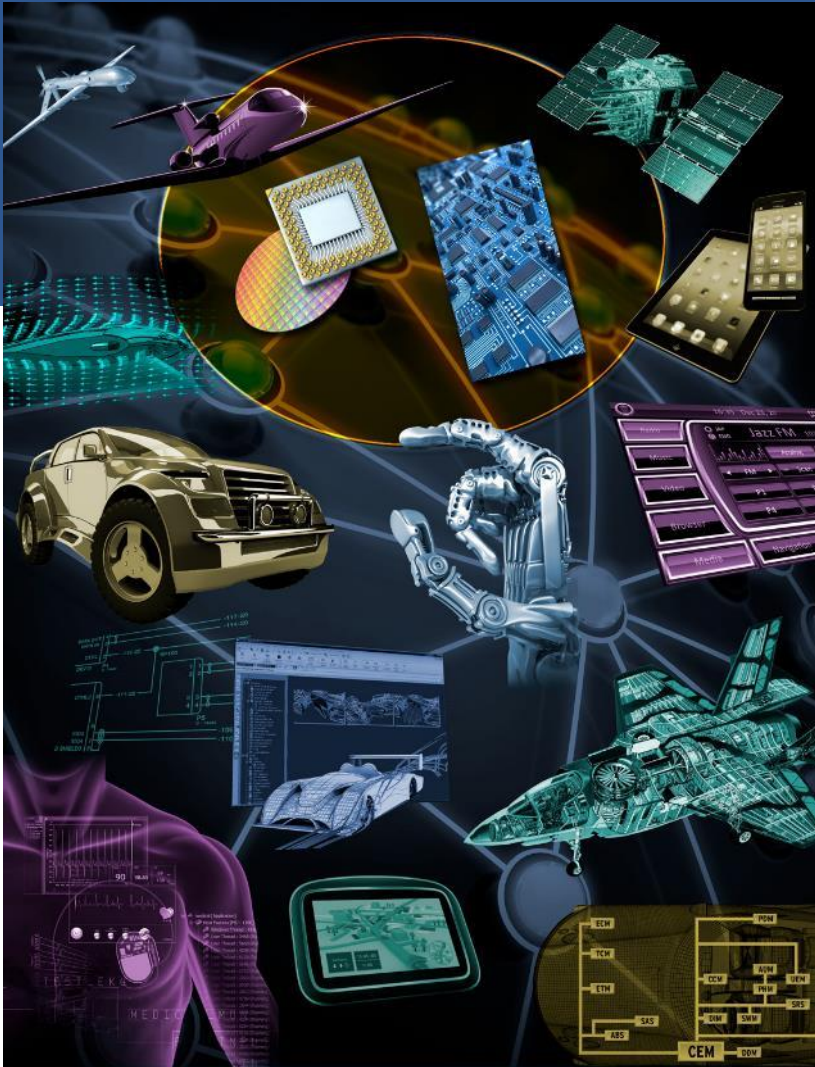


# Adding Curves to an Orthogonal World

Extending the EDA Flow to Support Integrated Photonics

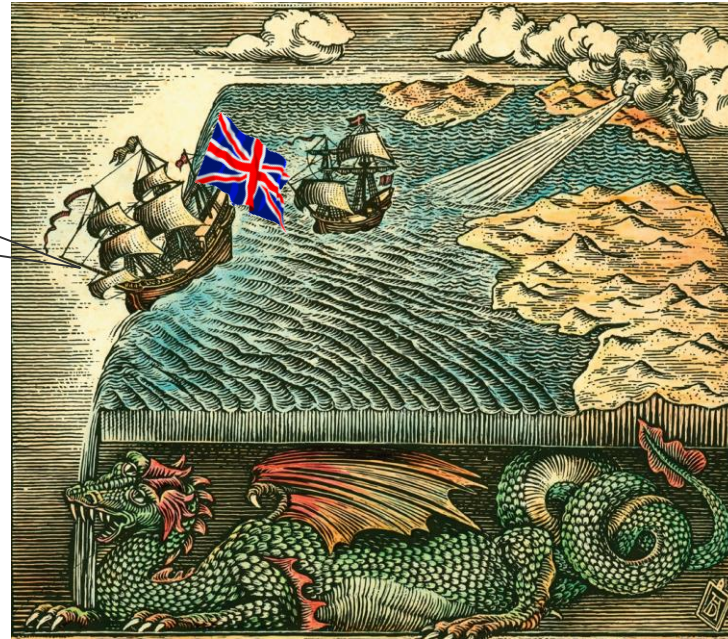
Paul Double

July 2018



# Traditional IC Design

"BREXIT AHOY!"

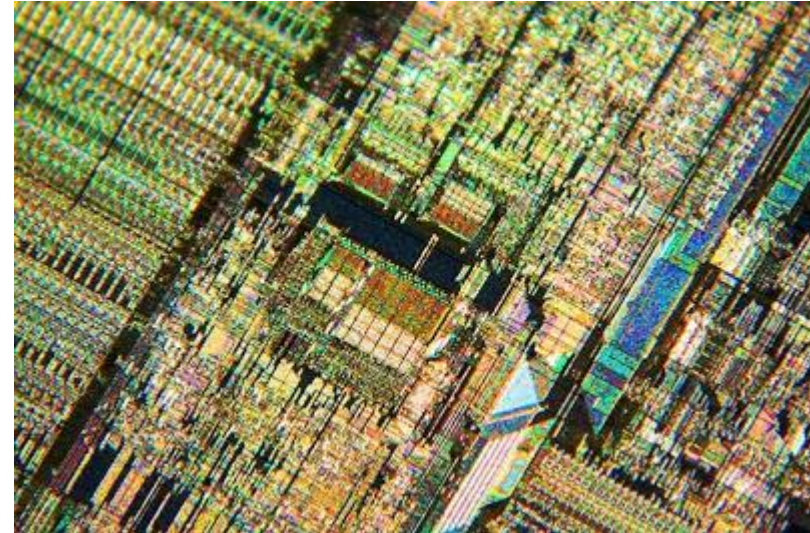


- Designers & tool developers have lived in a orthogonal world for 60 + years
- EDA tools
  - Thousands of man years developing software
  - Representing 100's of millions lines of code
- MEMS and photonics have changed this

# Simplified Integrated Circuit Design Flow

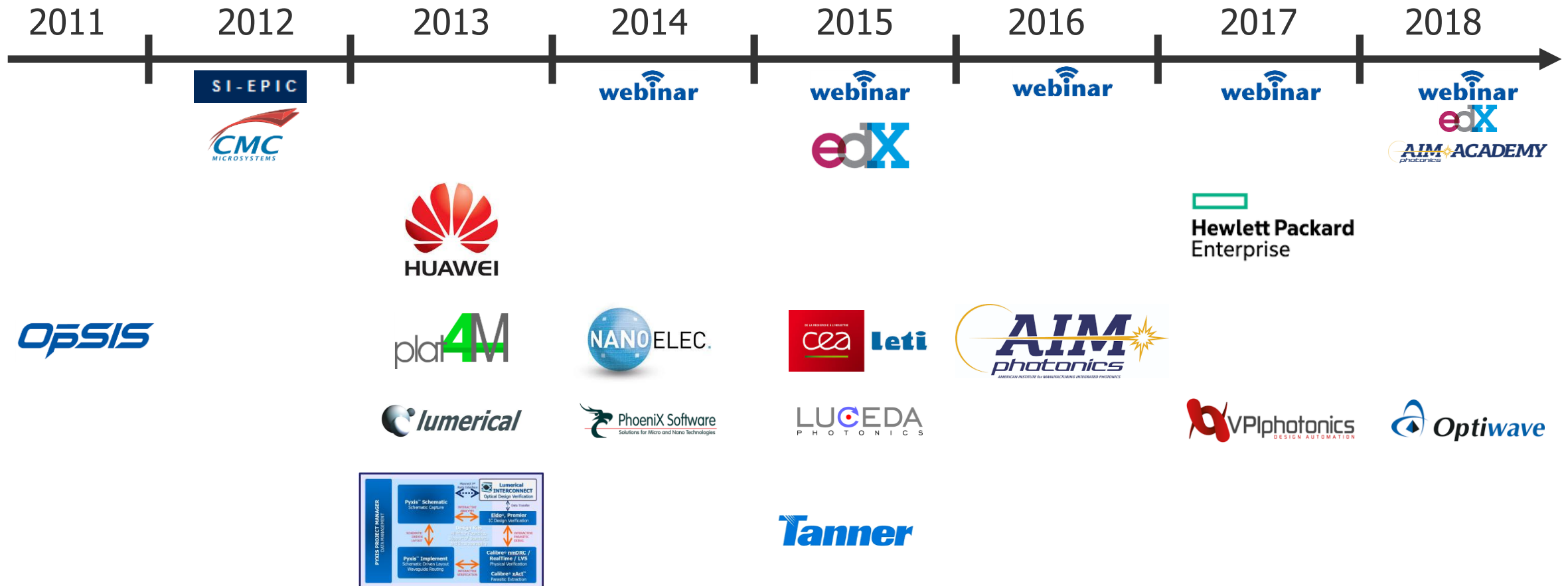
- Create an abstraction
- Create an implementation
- Verification
- Prepare for manufacturing
- Make Mask
- Fabrication
- Packaging and Testing

**Modifying the tools and flows to support photonics**



# Integrated Photonics

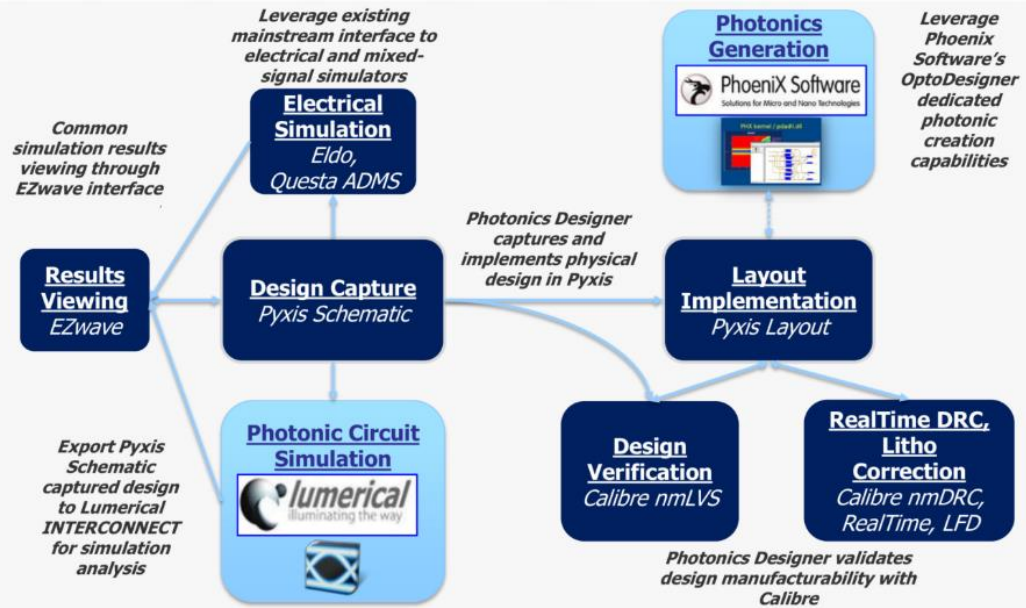
## ICDS History



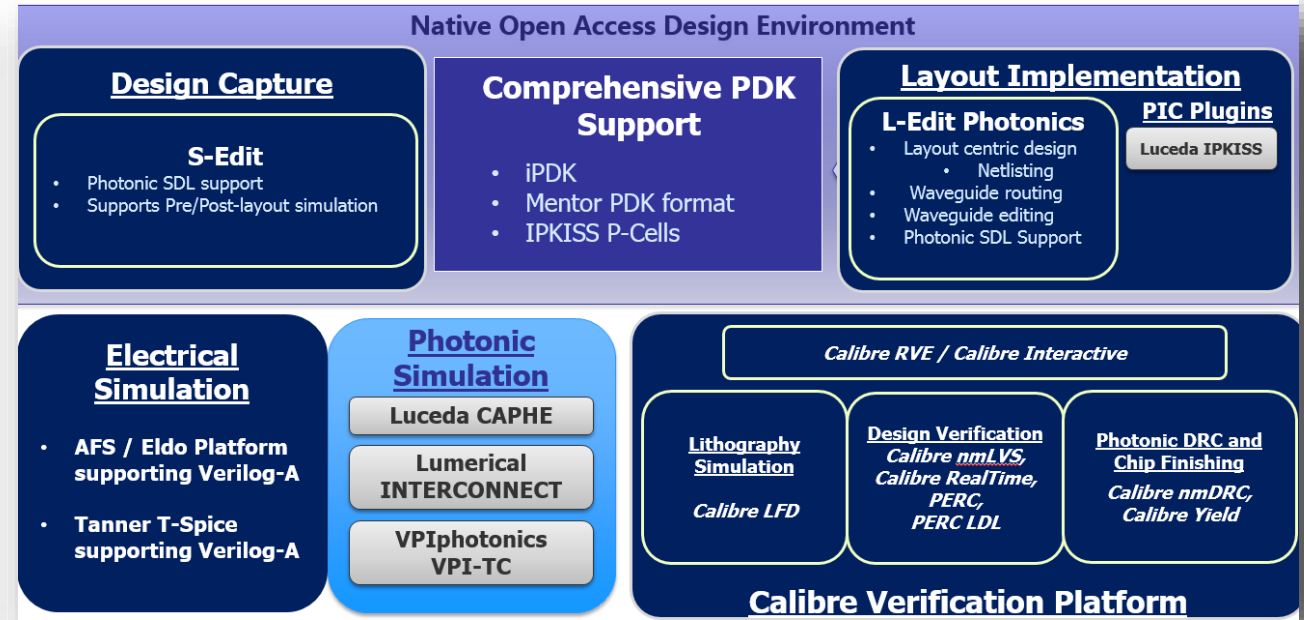
# Mentor's Photonic Design Flows

## Supporting Two Flows - Pyxis and Tanner

### Pyxis Flow



### Tanner Flow



- Focusing new customer on Tanner

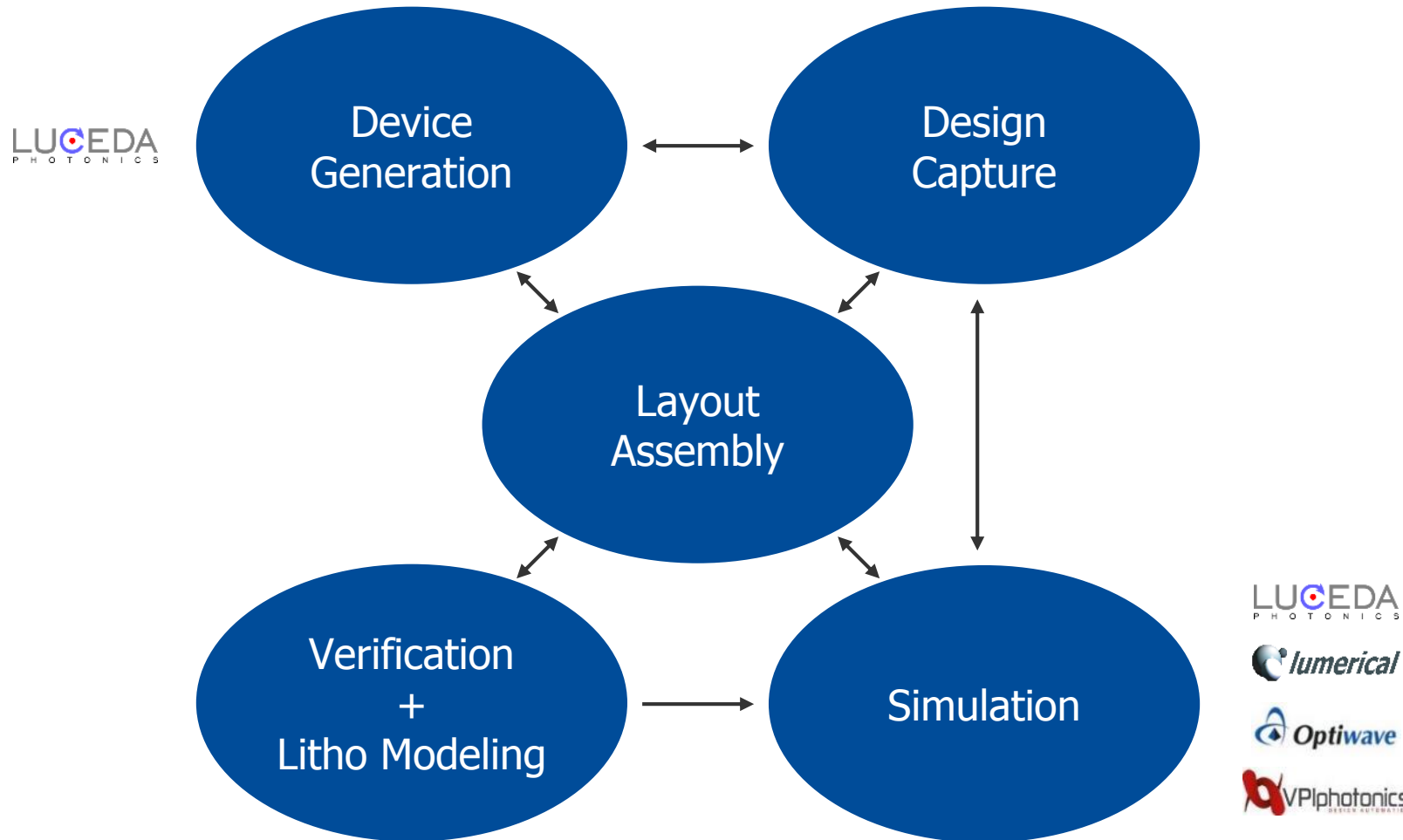
- Support both flows:

- support OpenAccess

- share the same PDK

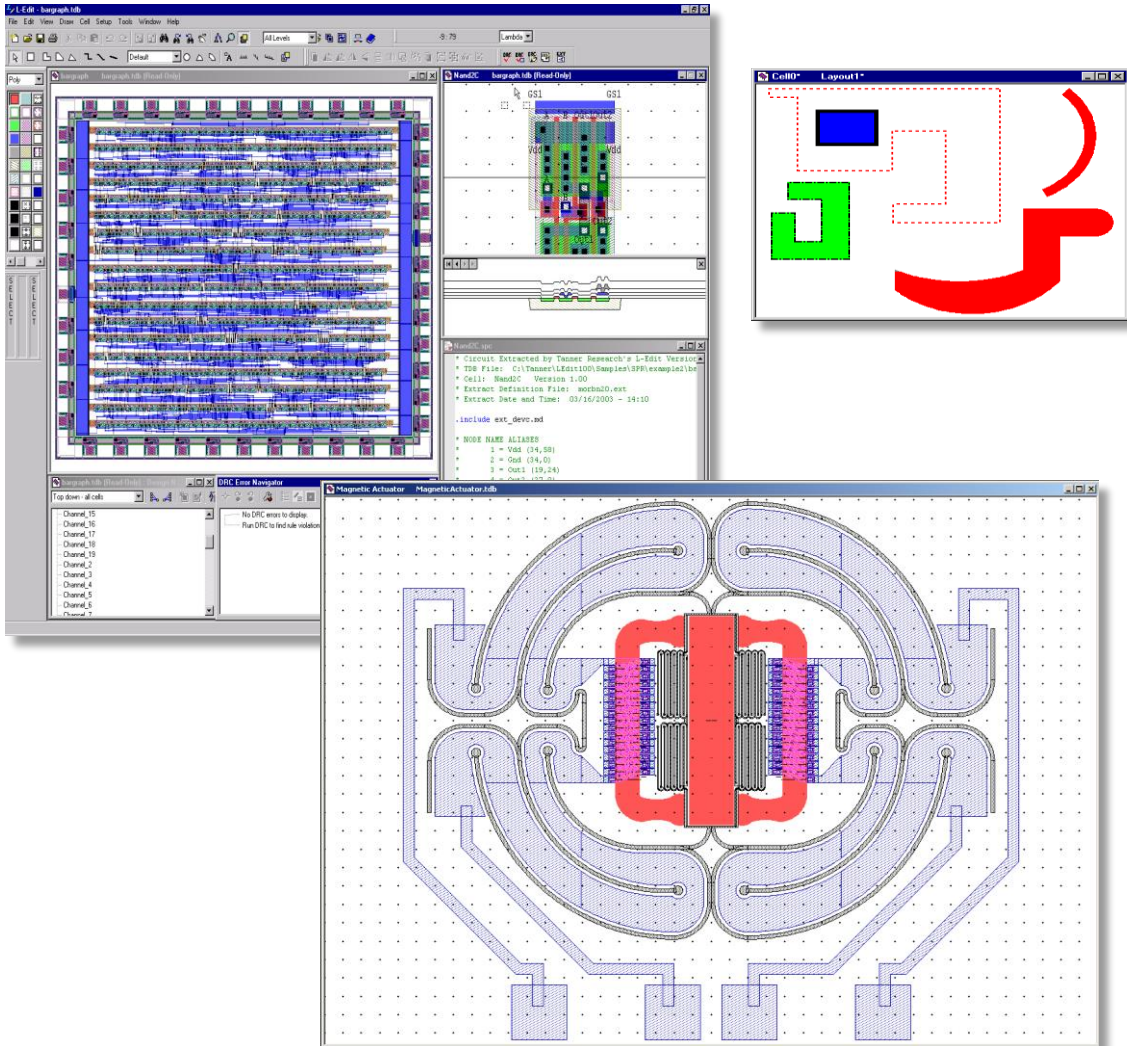
- interface to Mentors simulation and verification tools - Calibre® & Eldo

# Integrated Photonics Tanner Design Flow



# Layout Assembly

## L-Edit

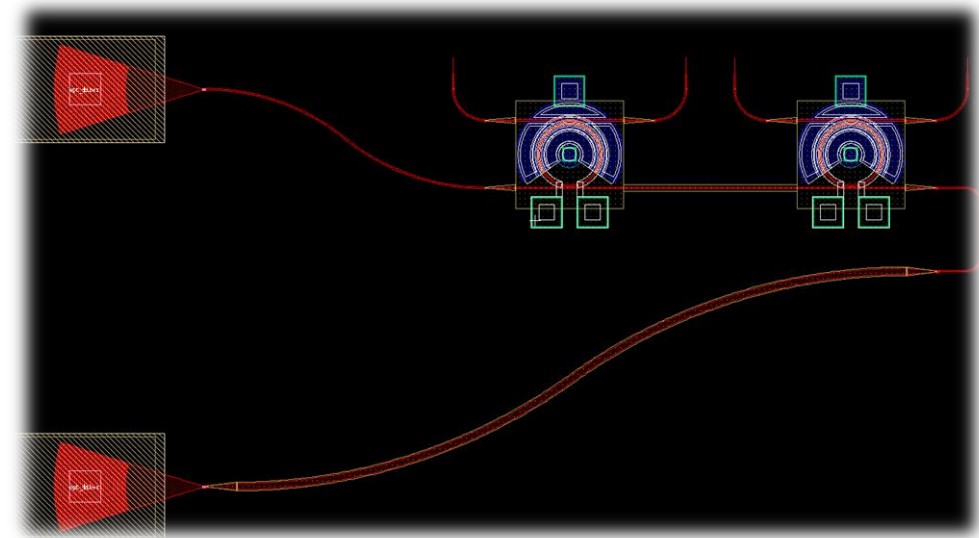


- The only tool developed specifically for MEMS, IC design and now integrated photonics
- Easy to use, easy to install, programmable physical layout engine with true curvilinear support
  - Full function layout editor with Schematic Driven Layout
  - Built-in support for curvilinear shapes
  - Dynamic scripting capability
  - OpenAccess
  - iPDK support
  - Interfaces to all MGC physical and electrical verification tools

# Layout Assembly

## Announcing L-Edit Photonics

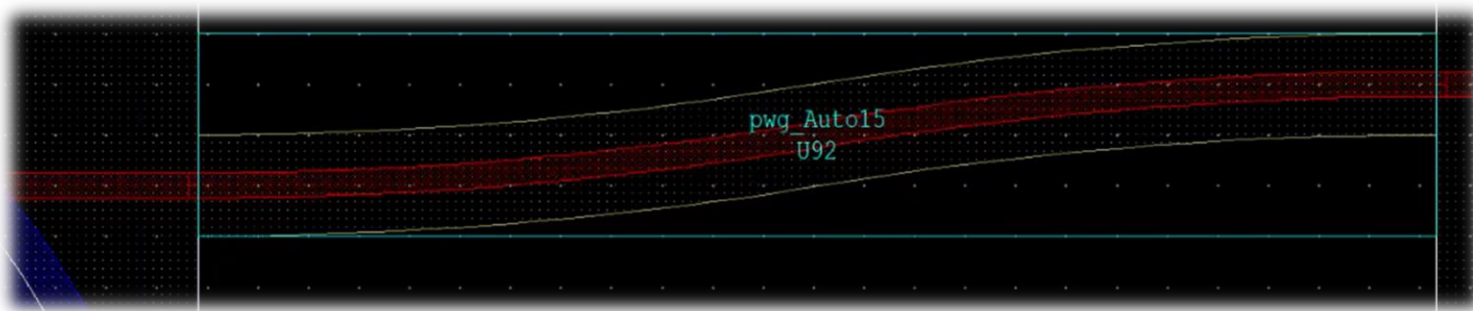
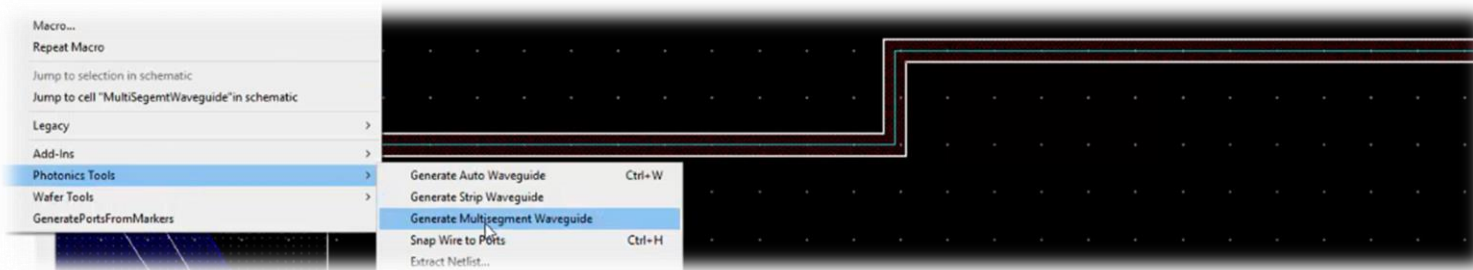
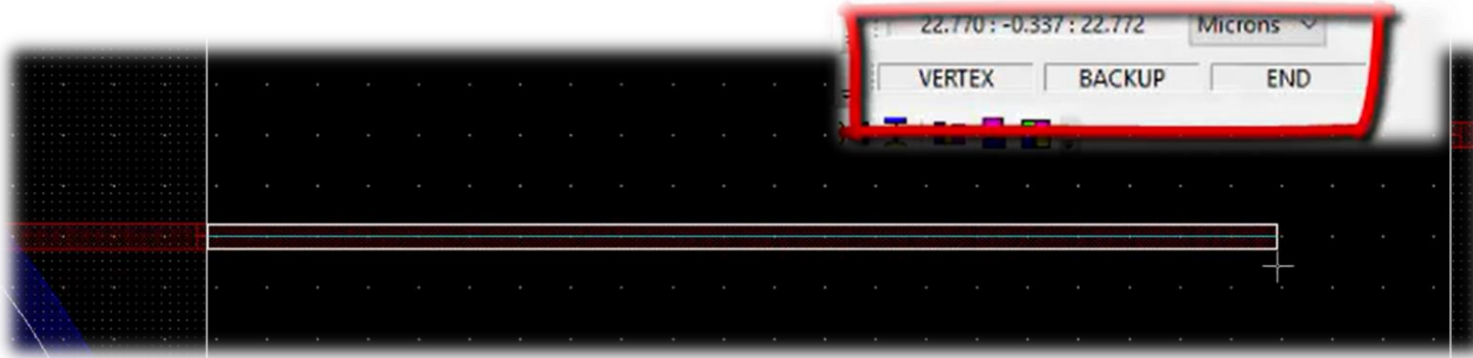
- Stand alone photonic design with L-Edit
  - Available July 31
- New functionality added to L-Edit
  - Waveguide creation and editing
  - Crossing insertion
  - Netlisting





# Layout Assembly

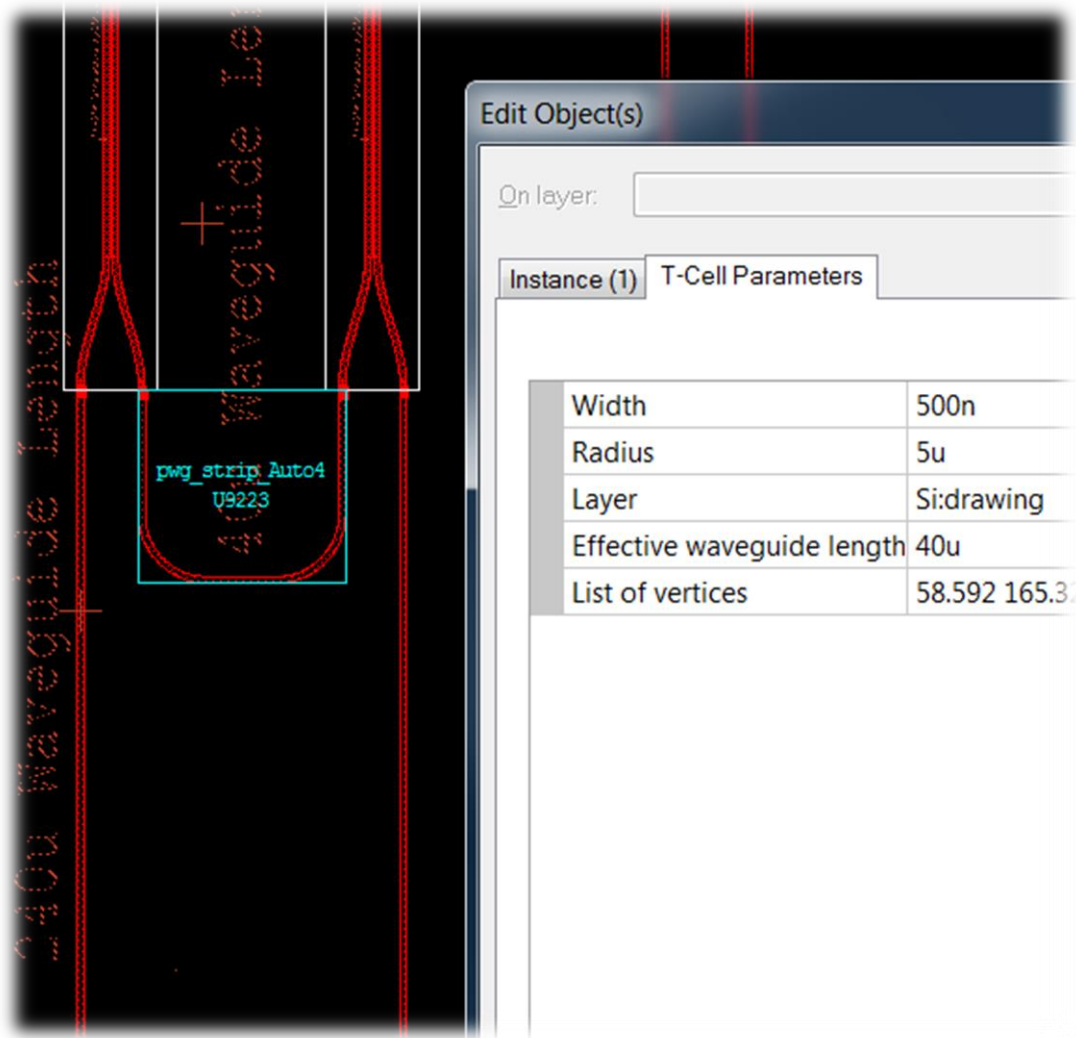
## Interactive Waveguide Routing



- Route waveguide wires interactively in L-Edit
  - Users have complete control of wires
  - Alignment to pins
- Waveguide conversion
  - Menu, hotkey driven
- Completed waveguide
  - Configurable
  - Supports multiple waveguide types

# Layout Assembly

## Edit Waveguide Parameters

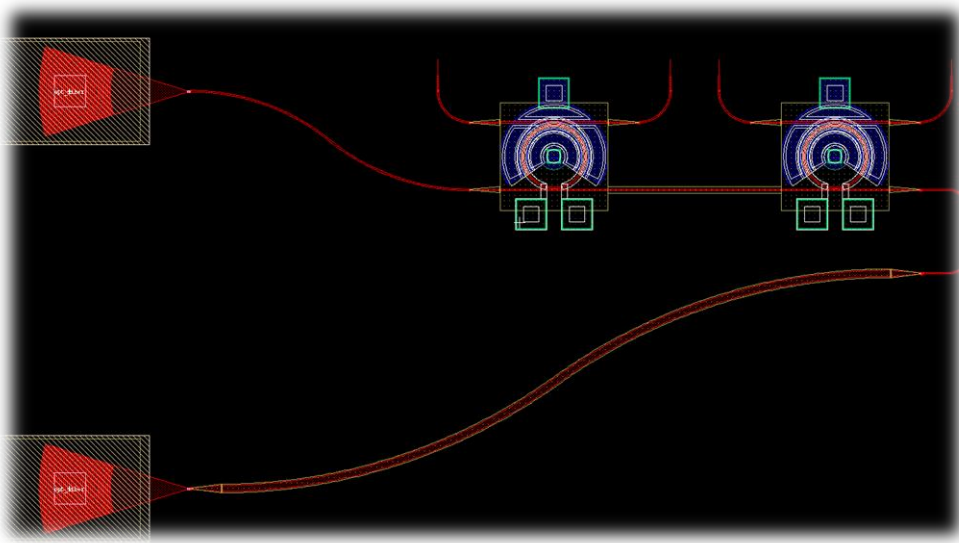


- Edit waveguide parameters including the effective length
- Enables designers precision control over coherent waveguides to perform MZI based design

# Layout Assembly

## Layout Centric Flow

- Layout is the golden design database
- No need for a schematic
- Netlist can be generated directly from L-Edit Photonics



```
* Header file: C:\projects\Github_UBC\SiEPIC_IME_Library\SiEPIC_IME_Tanner_Library\GSiP_2018_14_0FC\EBeam_cells_shor
.subckt ebeam_gc_te1550 opt_fibre opt_wg
.ends

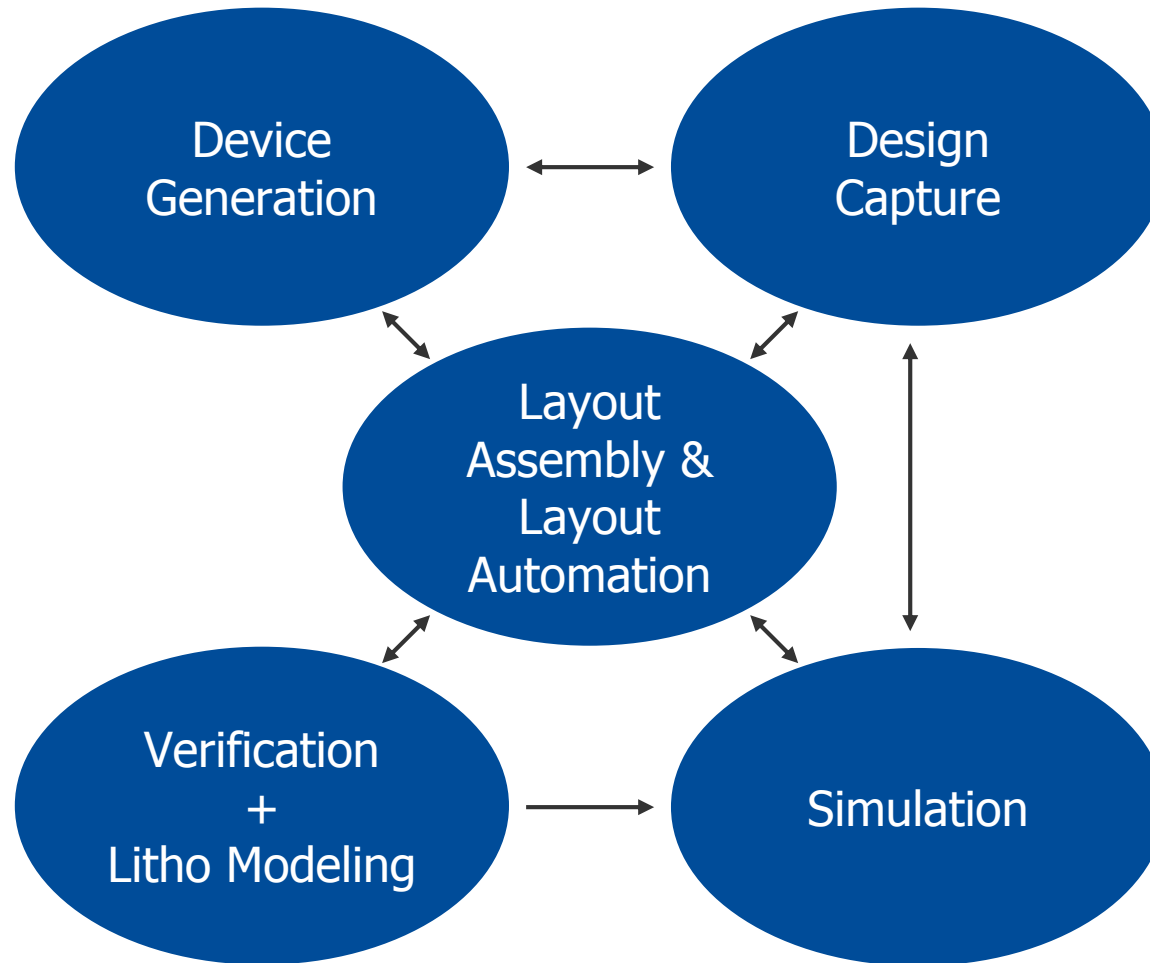
.subckt ebeam_gc_te1550 opt_a1 opt_b1 opt_b2
.ends

.subckt ebeam_wg_integral_1550 A B
.ends
* End of header file: C:\projects\Github_UBC\SiEPIC_IME_Library\SiEPIC_IME_Tanner_Library\GSiP_2018_14_0FC\EBeam_cells_shor

.subckt EBeam_interferometer opt_TOP opt_BOTTOM
*L-Edit Mirror=True, L-Edit Rotation Angle=0
XGC1 opt_BOTTOM N1 ebeam_gc_te1550 library="Design kits/EBeam" lay_x=1.65e-05 lay_y=0 sch_x=1.65e-00 sch_y=0
*L-Edit Mirror=True, L-Edit Rotation Angle=0
XGC2 opt_TOP N3 ebeam_gc_te1550 library="Design kits/EBeam" lay_x=1.65e-05 lay_y=0.000127 sch_x=1.65e-00 sch_y=0
XU9105 N7 N8 ebeam_wg_integral_1550 library="Design kits/EBeam" layer="Si:drawing" points="[[22.25,92.2],[22.25,92.2],[22.25,92.2],[22.25,92.2],[11.58,31.715],[11.58,31.715],[11.58,55.411],[22.25,55.411],[22.25,34.8]]" r=5u w=0.5u wg_length=184.741u lay_x=-47e-00 sch_r=0 sch_f=True
XU9106 N5 N6 ebeam_wg_integral_1550 library="Design kits/EBeam" layer="Si:drawing" points="[[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8],[27.75,34.8]]" r=5u w=0.5u wg_length=184.741u lay_x=-47e-00 sch_r=0 sch_f=True
XU9107 N3 N4 ebeam_wg_integral_1550 library="Design kits/EBeam" layer="Si:drawing" points="[[25,107],[25,127],[25,107],[25,107],[25,107],[25,107],[25,107],[25,107],[25,107],[25,107]]" r=5u w=0.5u wg_length=184.741u lay_x=-47e-00 sch_r=0 sch_f=True
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XVB2 N4 N8 N5 ebeam_y_1550 lay_x=-2.5e-05 lay_y=9.96e-05 sch_x=-2.5e-00 sch_y=9.96e-00 sch_r=90 sch_f=False
.ends
```

# Integrated Photonics Design Flow

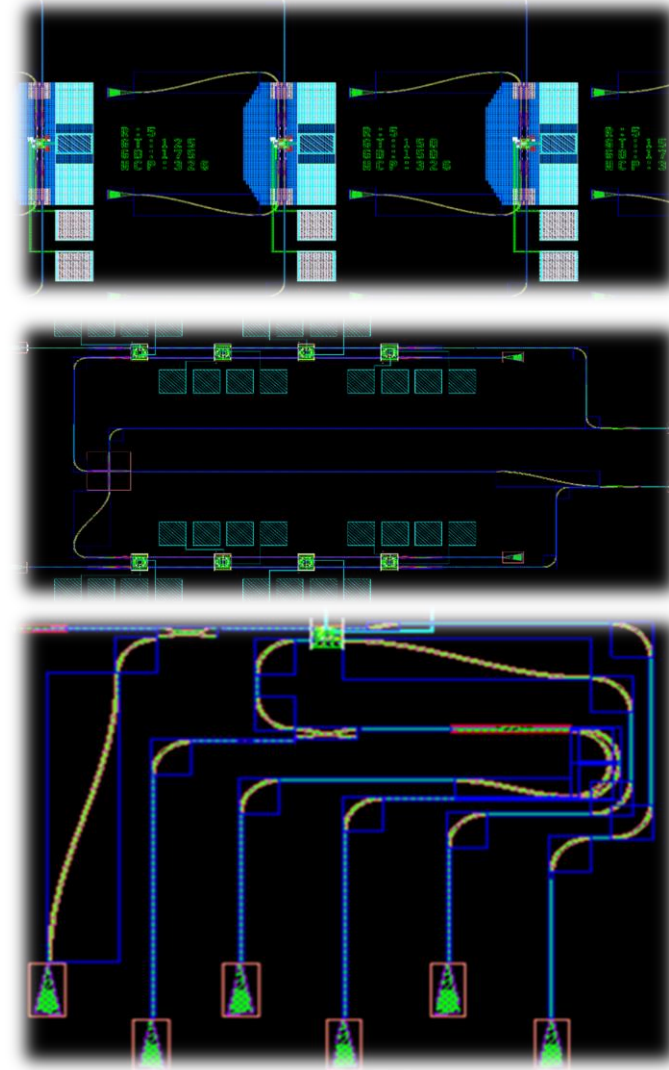
## Adding Automation



# Layout Automation

**New Product Coming September 2018**

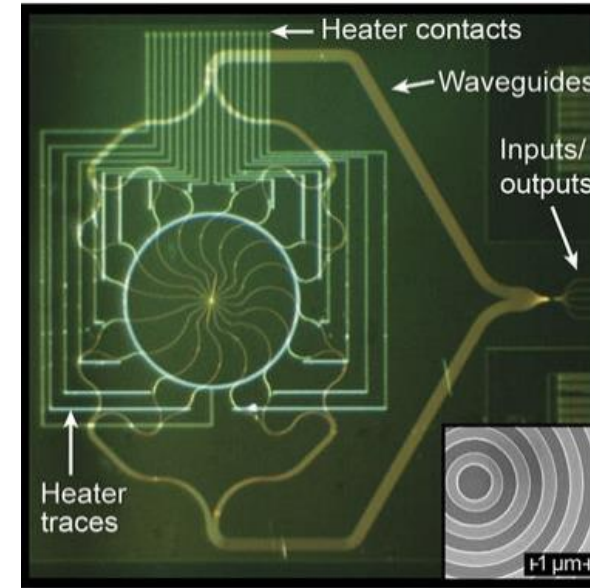
- Industry's first integrated photonic layout automation tool
  - Native on OA
  - Python is the extension language
- Simultaneous auto routing of both photonic waveguides and electrical nets
  - Placement – Netlist and user defined
  - Enables “what if” and scalability of designs
- **C**orrect **B**y **C**alibre
  - Using foundry provided SVRF file



# Photonic Automation

## Simultaneous Routing

- Photonic structures optimally work at a fixed temperature
- Heater elements are incorporated within the PCell to maintain a fixed temperature
- Removes the need place the bond pads and perform electrical routing in L-Edit or another layout editor



# Layout Automation

## Example in the Design Flow

Define  
Connectivity

Place Schematic  
Symbols

Connect  
Symbols

Photonic  
Layout

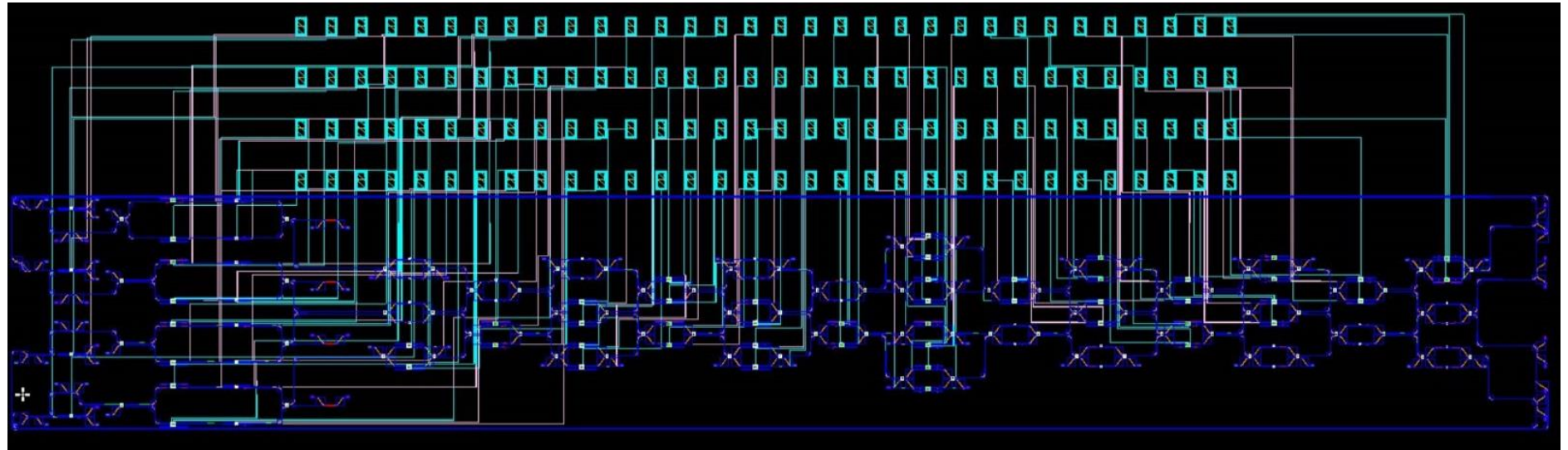
Place photonic  
components

Place Electrical  
Components

Simultaneous  
Photonic and  
Electrical Routing

C  
A  
P

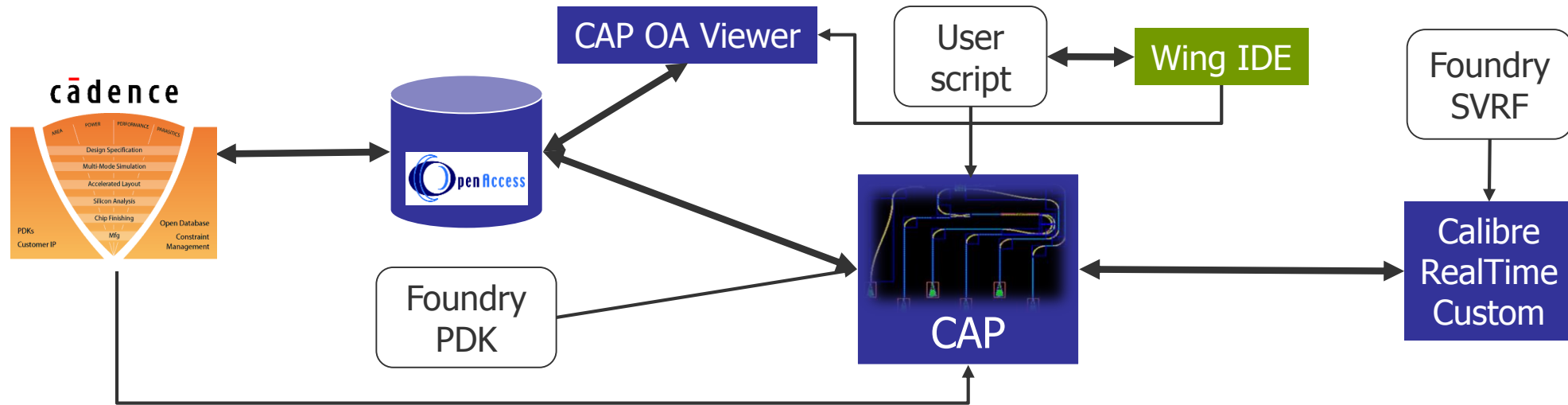
Calibre - Final  
Verification



- Ising machine – designed to solve the “Travelling Salesman” problem
- ~250 photonic components & 130 bond pads
- Placed & routed - DRC clean
- **~9 minutes**

# Layout Automation

## Use Model



- “Interactive” use model
  - User interacts with Wing IDE
  - Commands are entered with results seen visually in OA Viewer
- Calibre RealTime Custom runs in the background
- Flow enhanced by a 3<sup>rd</sup> Party IDE such as Wing or PyCharm



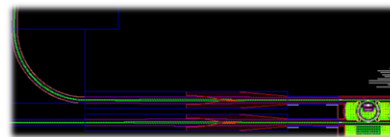
# Layout Automation

## First Tape Out Successful

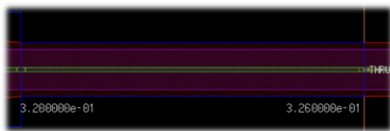
- Automated Silicon Photonic Circuit Layout and Design using a CMOS-Compatible photonics PDK
- Joint HPE/ST paper
  - U2U Munich, November, 2017
- Partnership with PDK development and design teams

### Photonic Routing Challenge with Ring Based PCells

- Sample routing results using CAP generated waveguide using the PP2P routing mode
  - Using photonic P2P routing mode
  - Trapeze taper insertion to match ring waveguide width
  - Waveguide type insertion to match optical I/O waveguide type



Waveguide routing using S-Bend, Bend90, waveguide type taper and trapezoid taper



Trapezoid taper to match pin dimensions



Joint HPE/ST paper, U2U Munich, November 2017

USER2USER U2U 2017

# **PHOTONIC FOUNDRY SUPPORT**

# Foundry Support is Key

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## Supported Today

- AIM
- Cornerstone
- CEA-Leti
- Fraunhofer HHI
- IMEC

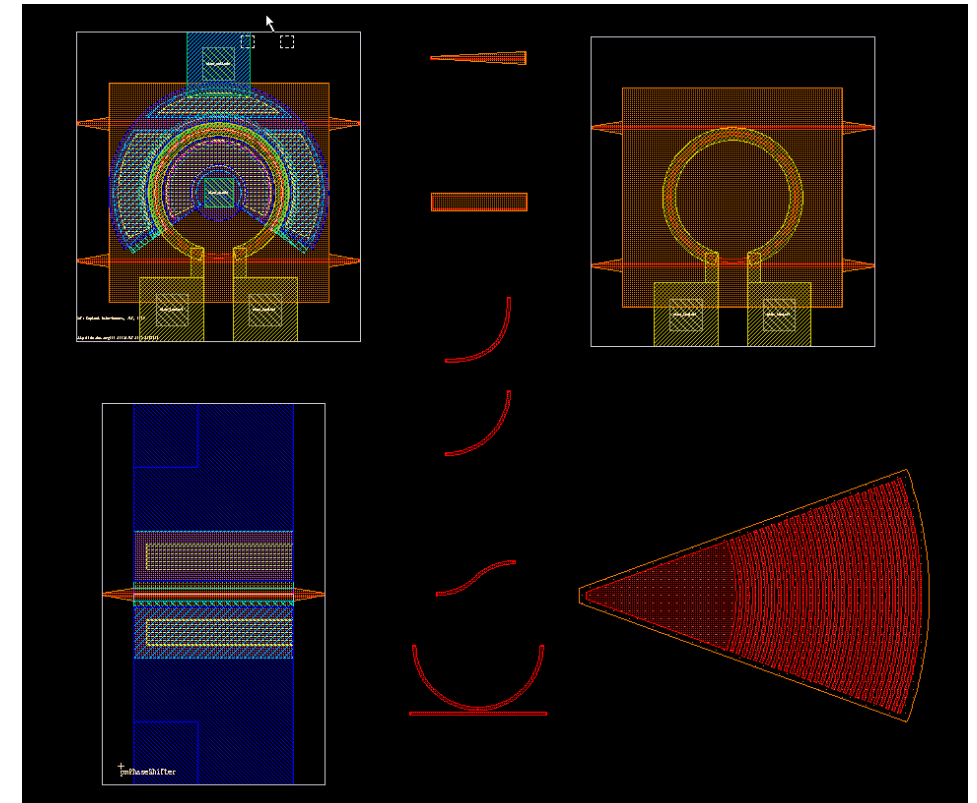
## Work in Progress

- AMF (IME)
- Silterra
- SMART Photonics
- TowerJazz
- IHP
- Ligentec

# GSiP PDK

## Generic Silicon Photonic PDK

- Passive components
  - Waveguides
    - Bends, S-bend, Sticks, crossings
    - Tapers
  - Y-branches, MMI, directional coupler
  - Grating couplers
- Active components
  - Ring modulators
  - Phase shifters for MZI design
- Need for training and demo's
- Can be used as a starting point for building a PDK



# Come Join Us at ECOC 2018

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- Join us at stand 436
- For demos of both CAP and L-Edit Photonics
- Discussion on how Mentor can help improve your photonic design productivity

# Summary

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- First layout automation product for integrated photonics
  - Enables “what if” design exploration
    - Too time consuming with manual layout
  - Correct by Calibre
  - Successful teacher customer
  - Unique product differentiator
- Flows for all design sizes
- Complete flow with third party providers
- Growing photonics foundry support
  - Mentor PDK
  - iPDK

**Mentor**<sup>®</sup>  
A Siemens Business

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