

# Towards a Smart Optics Factory: Bridging Design and Manufacturing

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[www.PanDao.ch](http://www.PanDao.ch)





## Optical Products mastering

- (1) digital access to 360 optics manufacturing technologies
- (2) producibility analyses with just one click
  - best manufacturing chain
  - **life cycle analysis**
  - master your supply chain
- (3) substantial cost cuttings
  - **identifies mistakes in early stages of projects**
  - protects your IP
  - **digital communication** between Eng and Prod
- (4) install digital twin of your workshop
  - compare your workshop with the market
  - towards a **smart optics company**





... is **proud member** of:

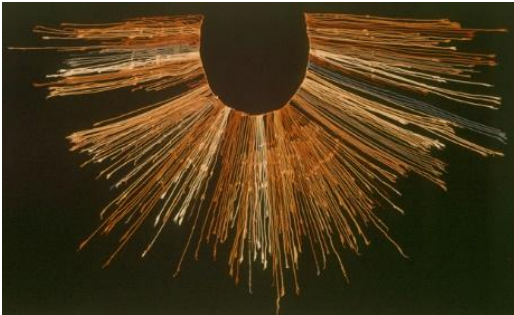


**PhotonHub**<sup>TM</sup>

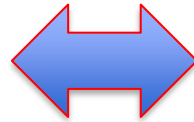


➤ **Find the right language**

- optical system



- fabrication chain



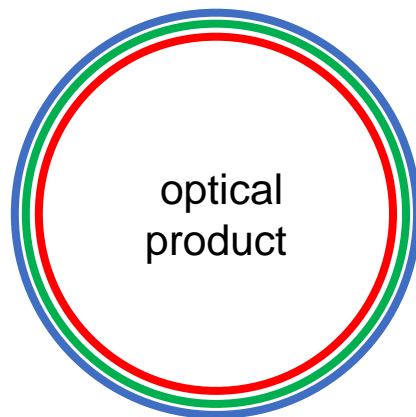
➤ **End-to-End Digital communication**

- Design → Engineering → Manufacturing

➤ **Smart Optics Factory**



*optics products*



## *optics products*



### performance

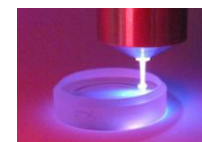
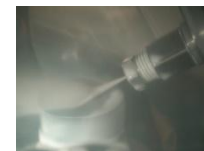
- quality
- throughput
- market price
- PRL
- durability

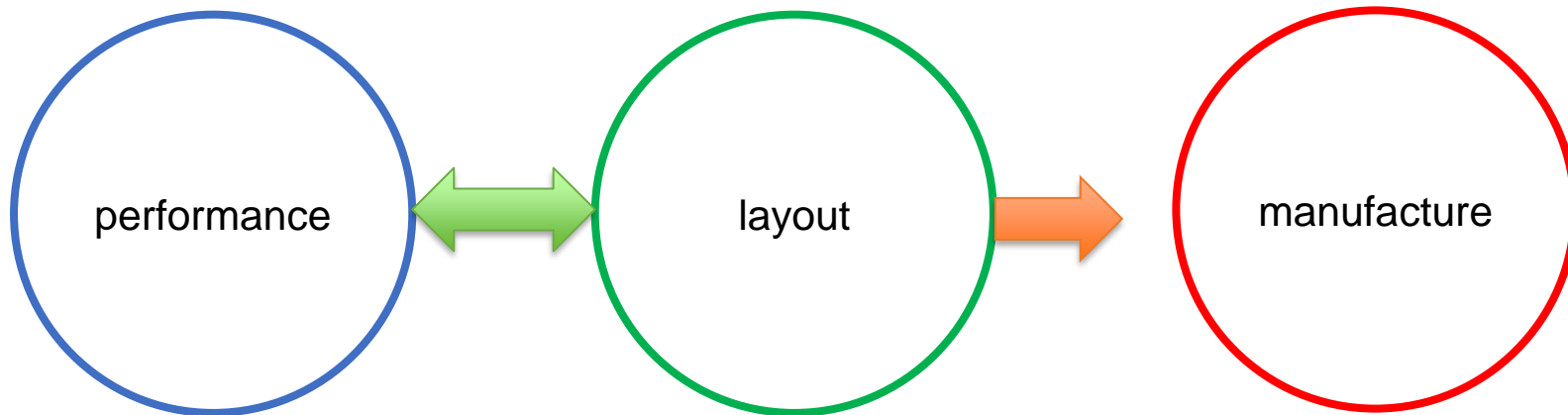
### layout

- type of optics
  - metalens
  - diffractive
  - refractive
  - hologram
- materials
- shape, smoothness, precision
- centering, mounting, coating

### manufacture

- **360 technologies**





**digital communication**

→ optical design software  
(CodeV, Quadoa, Zemax,  
Oslo etc)

**human to human  
communication**



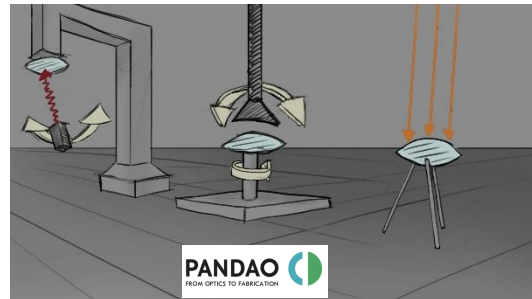
Optical Products mastering by:

Modelling **Complete** Chains

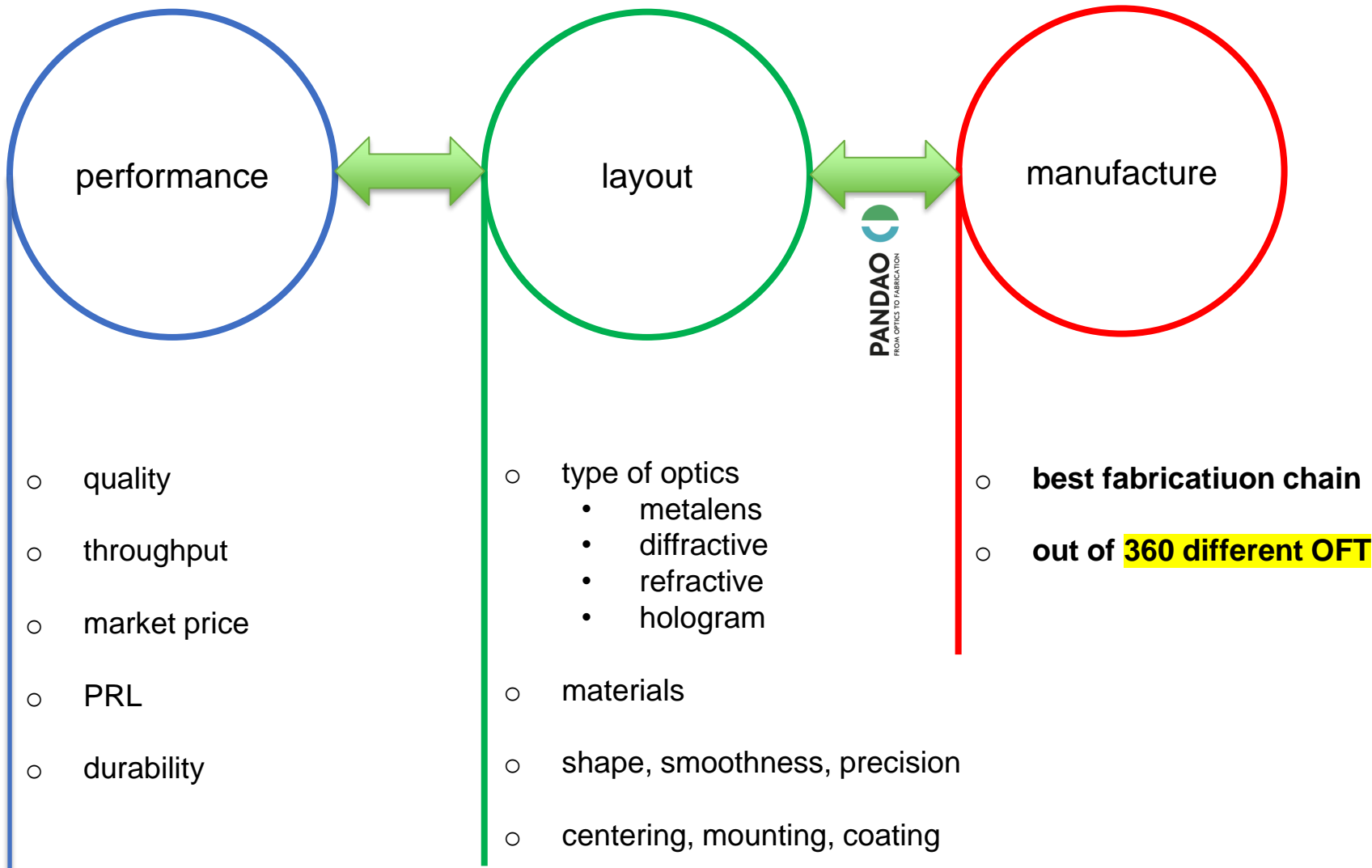
- Instead of single technologies only

**End-to-End digital** communication

- design → engineering → operations









**(1) design**

**(2) producibility analysis**



**(3) optimum fabrication chains**



## INPUT

- ISO10110

CNC  
overarm  
IBF  
MRF  
SPDT  
CCP  
Bonnet  
UPM  
Ductile  
FJP  
3D print  
etc...

**PANDAO**  
FROM OPTICS TO FABRICATION



PGMold  
InjectionMold  
DL  
BowlFeedPol  
FloatPol  
EEM  
PlasmaPol  
LaserPol  
SLE  
Plasma  
etc..

**360 OFTs**

## OUTPUT

- **best fabrication chain**



## (1) INPUT: optical elements

- CodeV, Zemax, Quadoa to PanDao interface

## (2) Pandao Cockpit

- throughput
- TRL level
- yield
- wage level

## (3) OUTPUT: optimum fabrication chain

- technologies required
- optimum fabrication chain @ min cost & risk



- **asphere**, diam 220 mm, N-BK7, 2 lambda PV: 3/3(2)

Name:	Description:	Number of Sides:	Material:
Asphere	Jose Pozo	One	glasses
Batch Size:	Lens Diameter [mm]:	Center Thickness [mm]:	Knoop hardness (HK):
1000	220	30	600
Total Number Of Lenses:	Diameter Tolerance [mm]:	Center Thickness Tolerance [mm]:	Acid resistance (AR):
5000	0.1	0.05	AR1
<input type="checkbox"/> Suited for LIDT	<input type="checkbox"/> Outer cylinder length bigger lens diameter	<input type="checkbox"/> Material suited for precision glass molding	
<b>Side 1</b>			
Shape:	Defect Size(5/)[mm]:	Clear Aperture[mm]:	3/Power[fringes]:
aspheres	0.063	200	3
Roughness:	smallest midspatial wavelength accepted [mm]:	Decenter(4/)[min]:	3/Irregularity[fringes]:
Custom (Sq [nr]	5	Specified:	2
1			
Asphericity[um]:	Smallest Radius Of Curvature[mm]:	Concave parts included?	
100	673	Not Included	
Radius of removal sphere[mm]:	Coating:	Sagitta [mm]:	
660	Antireflex	40	

Resulting most cost-efficient fabrication chain:

Side 1:

- cnc sub aperture rough grinding
- fabrication cost: 8.00€
- cnc sub aperture grinding
- fabrication cost: ~~27.45€~~
- **ccp wheel polishing**
- fabrication cost: 80.26€

Cost 115.71€

Capability factor: 0.999

Chain uniqueness: 1

Total fabrication cost: **115.71€**

Serial batch lead time: 1.9573 days



- asphere, diam 220 mm, N-BK7, 5th lambda PV: 3/1(0.2)

Name: Asphere	Description: Jose Pozo	Number of Sides: One	Material: glasses
Batch Size: 1000	Lens Diameter [mm]: 220	Center Thickness [mm]: 30	Knoop hardness (HK): 600
Total Number Of Lenses: 5000	Diameter Tolerance [mm]: 0.1	Center Thickness Tolerance [mm]: 0.05	Acid resistance (AR): AR1
<input type="checkbox"/> Suited for LIDT	<input type="checkbox"/> Outer cylinder length bigger lens diameter	<input type="checkbox"/> Material suited for precision glass molding	
<b>Side 1</b>			
Shape: aspheres	Defect Size(5/)[mm]: 0.063	Clear Aperture[mm]: 200	3/Power[fringes]: 1
Roughness: Custom (Sq [nr])	smallest midspatial wavelength accepted [mm]: 5	Decenter(4/)[min]: Specified	3/Irregularity[fringes]: 0.2
Asphericity[um]: 100	Smallest Radius Of Curvature[mm]: 673	Concave parts included?: Not Included	
Radius of removal sphere[mm]: 660	Coating: Antireflex	Sagitta [mm]: 40	

**Resulting most cost-efficient fabrication chain:**

Side 1:

- cnc sub aperture rough grinding  
• fabrication cost: 8.00€
- cnc sub aperture grinding  
• fabrication cost: 27.45€
- **ccp wheel polishing**  
• fabrication cost: 80.26€
- **ccp magnetorheological finishing**  
• fabrication cost: 30.50€

Cost 146.21€  
 Capability factor: 1.000  
 Chain uniqueness: 5

Total fabrication cost: **146.21€**  
 Serial batch lead time: 1.9706 days





- asphere, diam 220 mm, N-BK7, 10th lambda PV: 3/1(0.1)

Name:	Description:	Number of Sides:	Material:
Asphere	Jose Pozo	One	glasses
Batch Size:	Lens Diameter [mm]:	Center Thickness [mm]:	Knoop hardness (HK):
1000	220	30	600
Total Number Of Lenses:	Diameter Tolerance [mm]:	Center Thickness Tolerance [mm]:	Acid resistance (AR):
5000	0.1	0.05	AR1
<input type="checkbox"/> Suited for LIDT	<input type="checkbox"/> Outer cylinder length bigger lens diameter	<input type="checkbox"/> Material suited for precision glass molding	
<b>Side 1</b>			
Shape:	Defect Size(5)[mm]:	Clear Aperture[mm]:	3/Power[fringes]:
aspheres	0.063	200	1
Roughness:	smallest midspatial wavelength accepted [mm]:	Decenter(4)[min]:	3/Irregularity[fringes]:
Custom (Sq [nr]	5	Specified:	0.1
1			
Asphericity[um]:	Smallest Radius Of Curvature[mm]:	Concave parts included?	
100	673	Not Included	
Radius of removal sphere[mm]:	Coating:	Sagitta [mm]:	
660	Antireflex	40	

**Resulting most cost-efficient fabrication chain:**

Side 1:

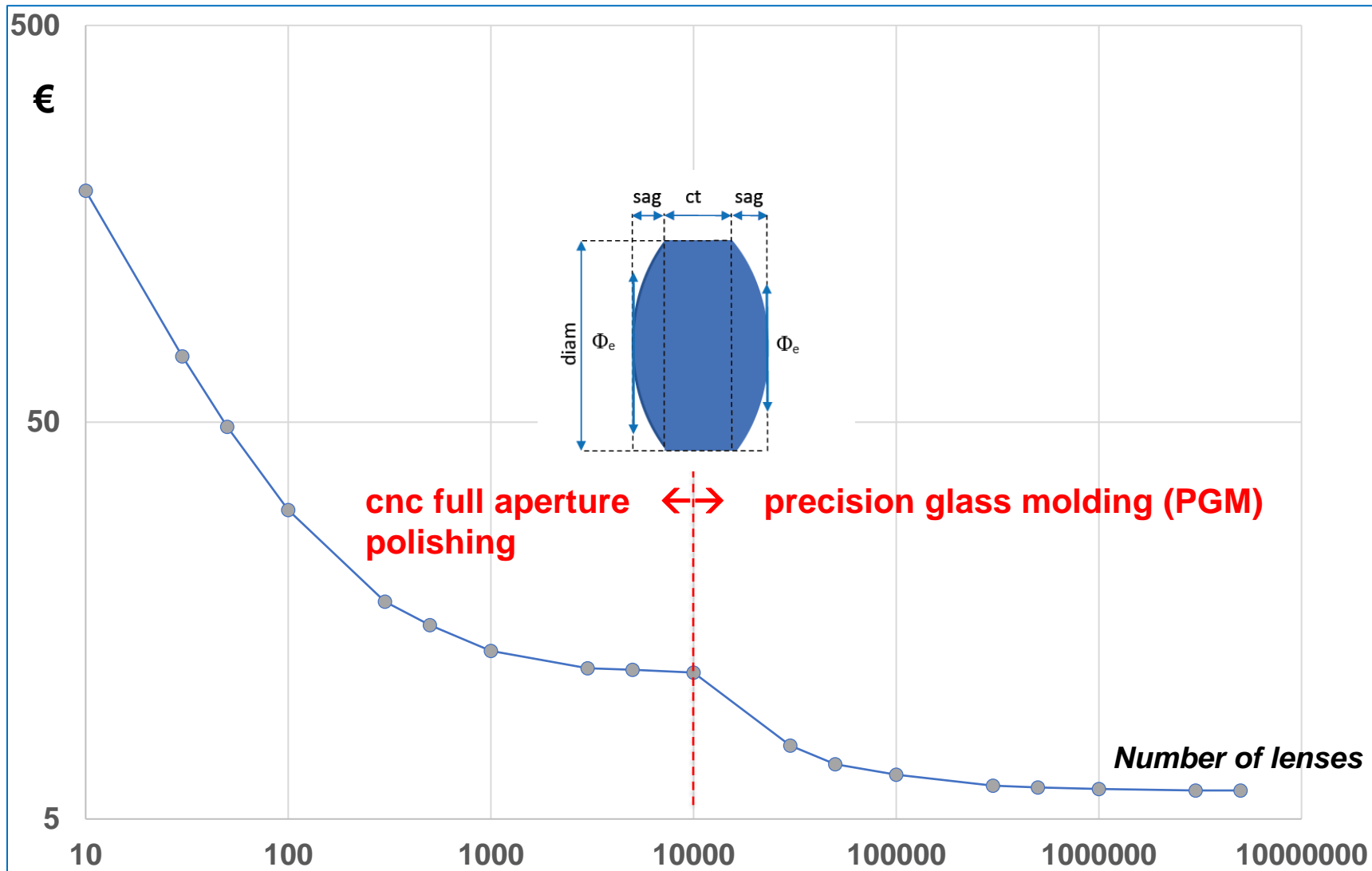
- cnc sub aperture rough grinding  
• fabrication cost: 8.00€
- cnc sub aperture grinding  
• fabrication cost: 27.45€
- **ccp bonnet**  
• fabrication cost: 88.14€
- **ccp ion beam figuring**  
• fabrication cost: 39.54€

Cost 163.12€  
Capability factor: 0.972  
Chain uniqueness: 0

Total fabrication cost: **163.12€**  
Serial batch lead time: 2.0417 days



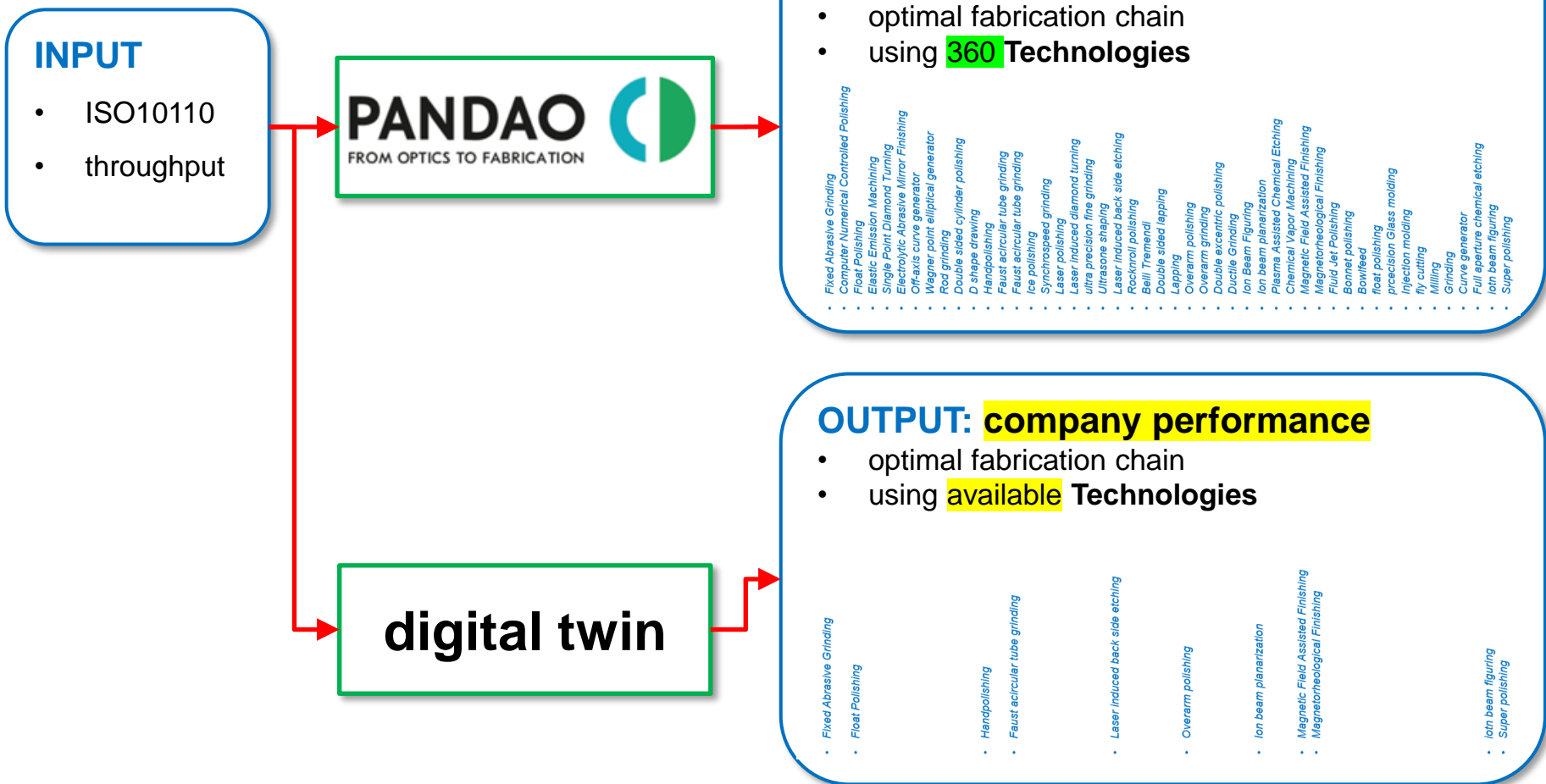
• **product life cycle analysis**

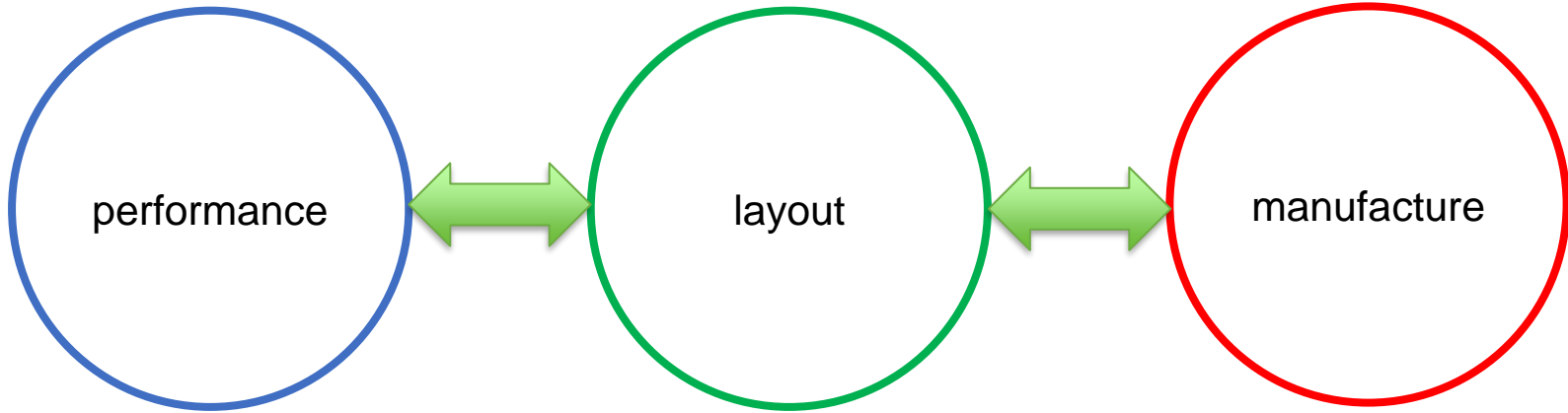






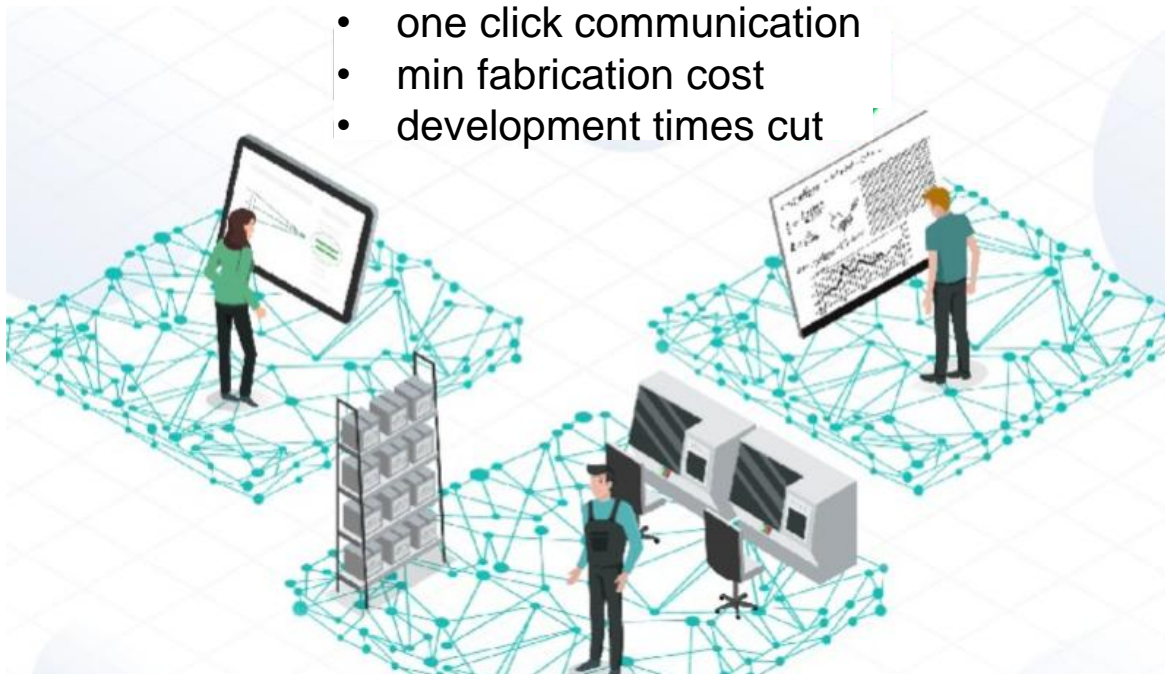
- generate **digital twin** of your workshop
- benchmark your workshop



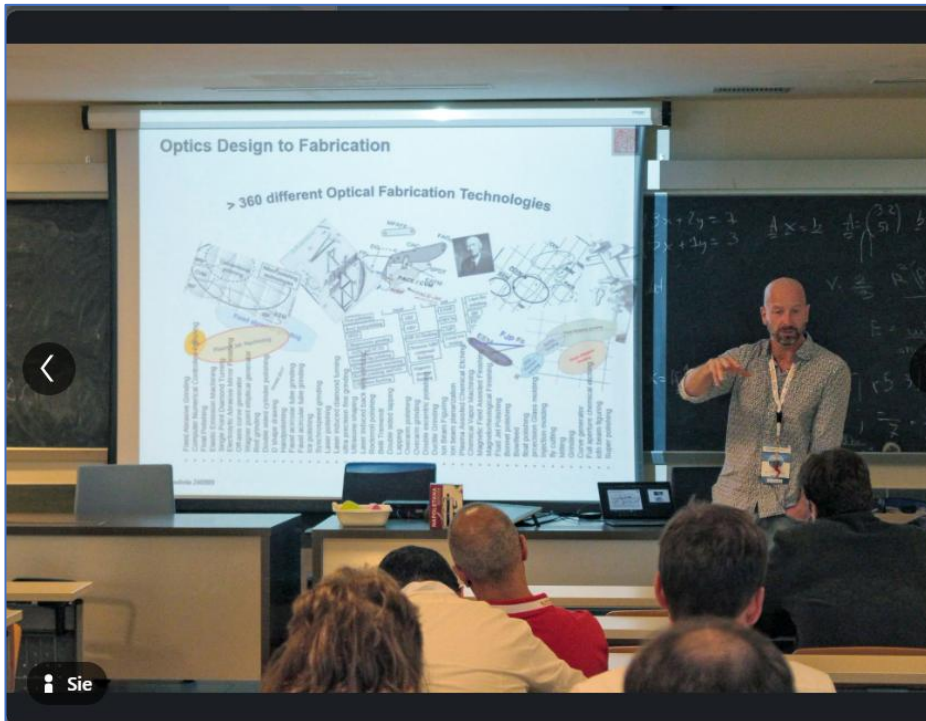


**digital communication**

- one click communication
- min fabrication cost
- development times cut



- annual **University lectures** @ Rochester, Tucson, Joensuu, Jena, Tokyo and Huddersfield
- various tutorials and workshops for EPIC, Optica, EOS
- consortium member of **PhotonHub**





ENABLING TECHNOLOGIES





FROM OPTICS TO FABRICATION



UNIVERSITÄT DER ANGEWANDTEN WISSENSCHAFTEN  
Ernst-Abbe-Hochschule Jena  
University of Applied Sciences

**„CM-Poliervverfahren für optische Freiformflächen mit gezielter Minimierung von SSD-Strukturen“**

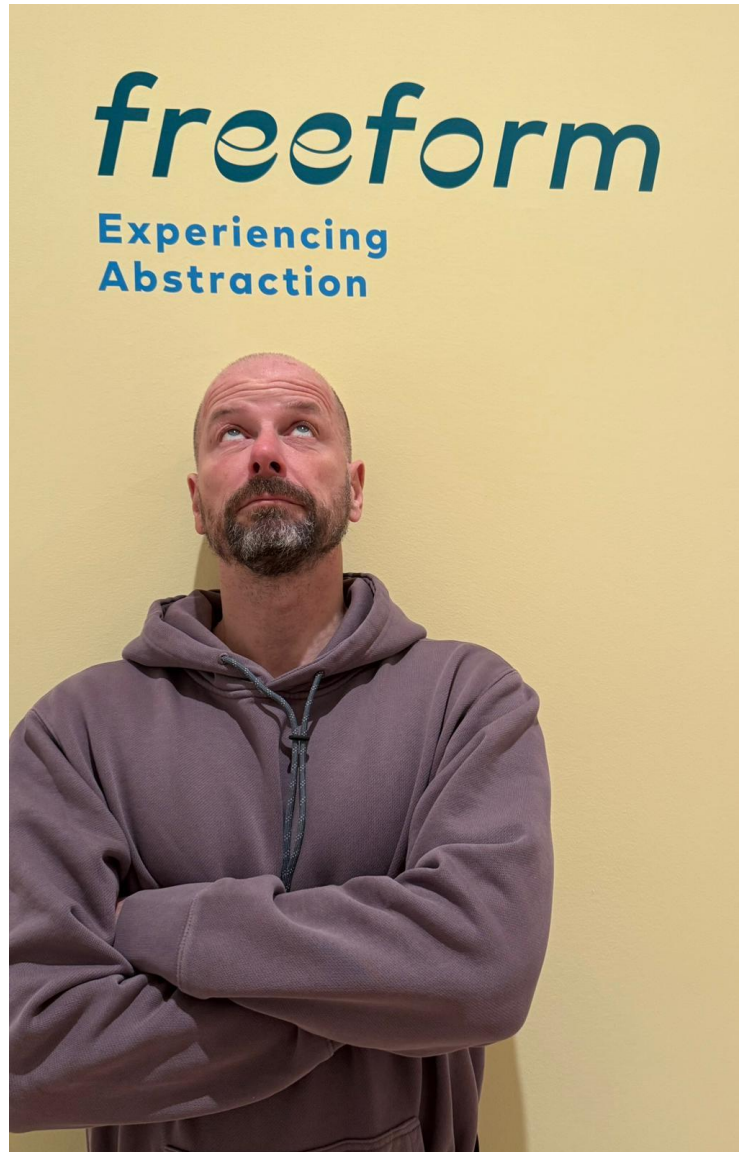
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- *many thx*
- *dōmo arigatō*
- *grazie*
- *dank je wel*
- *dzenkuje*
- *vielen Dank*

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