



**Nathan Dinning**

Director of Product Management



edge ai + vision  
**ALLIANCE**

## Build vs Buy

Navigating Optical Image  
Sensor Module Complexities

**Prashant Mehta**

Technical Imaging Expert: Sensors & VPUs



[sales@framos.com](mailto:sales@framos.com)

**FSM:GO**



# 40 YEARS OF GLOBAL VISION EXPERIENCE



FRAMOS  
California, USA

FRAMOS  
Ottawa, Canada

FRAMOS HQ  
Munich, Germany

FRAMOS  
Čakovec, Croatia



Ottawa a, Canada



Munich, Germany



Agrate Brianza, Italy



Čakovec, Croatia

## About FRAMOS

190+ Global Employees

Leading Sony image sensor supplier

Optical sensor module manufacturer

Product design solutions and OEM services

Highly skilled teams focused on imaging solutions

- 60+ specialized vision engineers
- Project FAE and AE teams ready to assist



Distribution



Services



Engineering



Manufacturing

# AGENDA



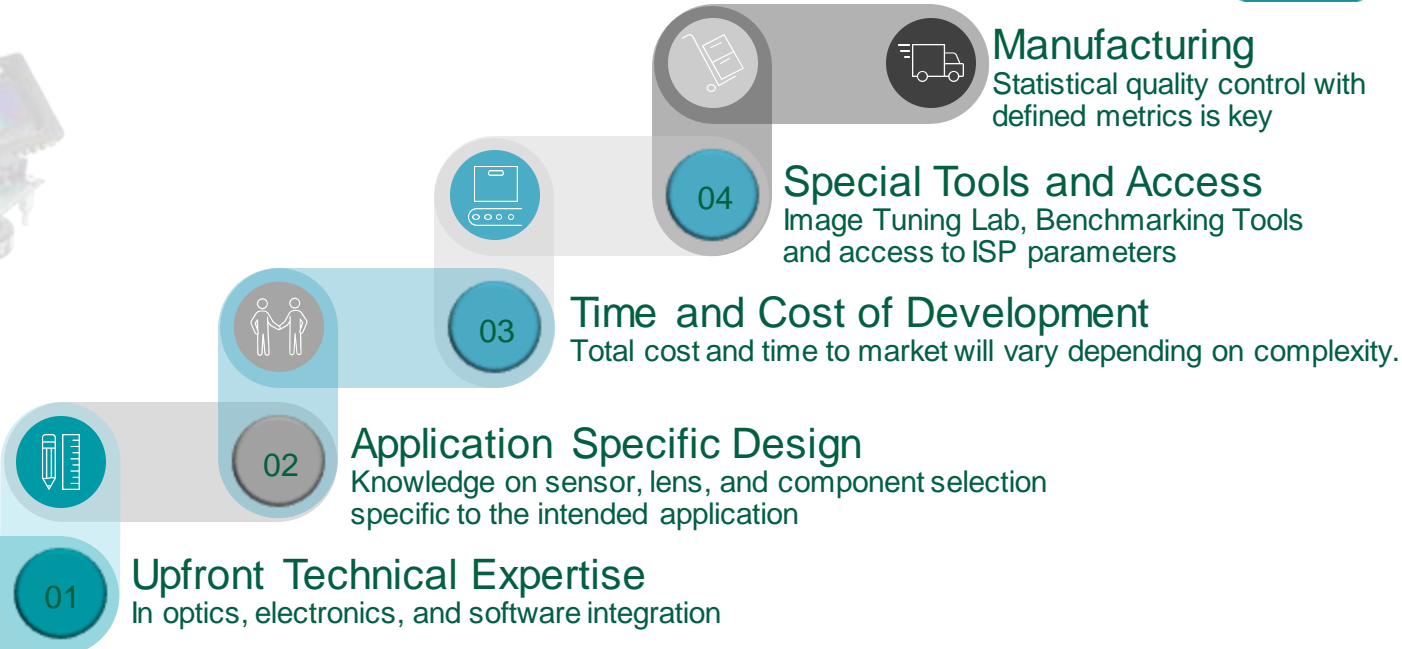
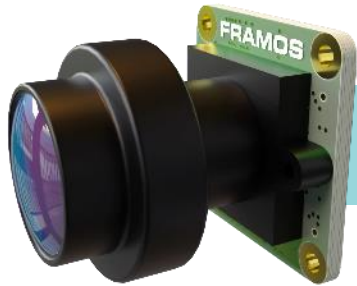
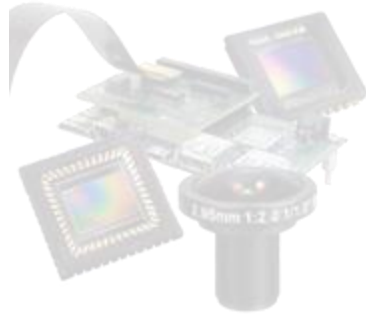
- Imaging aspect of a typical embedded vision system
- Capabilities needed to develop an Optical Sensor Module
- Module Design and application specific considerations
- Use cases Image & color quality, optics selection, production challenges
- **Build** vs. **Custom** development vs. **Buy** OTS modules
- FSM:GO – Field deployable optical sensor modules for your application

# TYPICAL EMBEDDED VISION SYSTEM

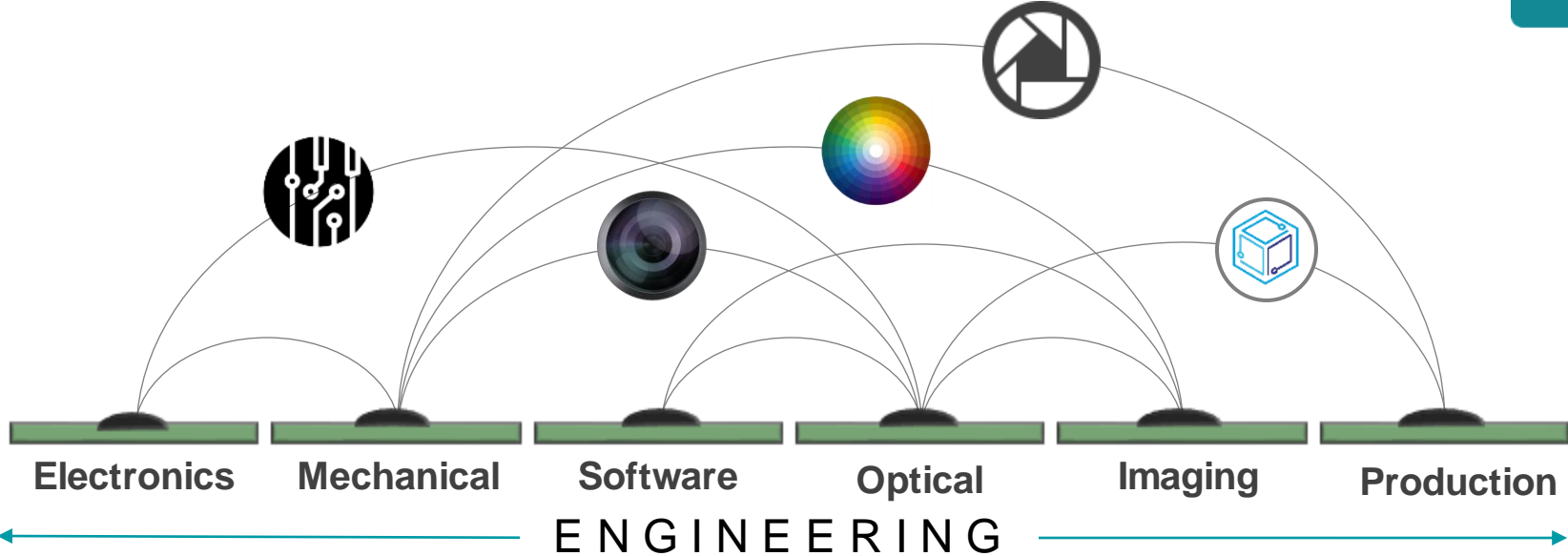


# BUILDING UP THE CAPABILITIES

For a successful sensor module design



# OPTICAL SENSOR MODULE DESIGN CYCLE



Design the electronic circuitry and PCBs to interface and power the sensor module.

Develop the physical mounting, ensuring structural integrity and proper interfacing with other hardware.

Write the **driver** and interface software needed to operate the sensor module and process its data.

Design the optical system, including lens selection and optical path optimization for the sensor module

Focus on the image processing algorithms and the overall performance optimization of the sensor module.

Develop the manufacturing processes, assembly lines, and quality control systems for mass production

# SENSOR MODULE DEVELOPMENT TOOLS



- Electronics Lab for PCB prototyping, soldering stations, oscilloscopes.
- Analog and digital circuit design, PCB layout, signal integrity analysis.

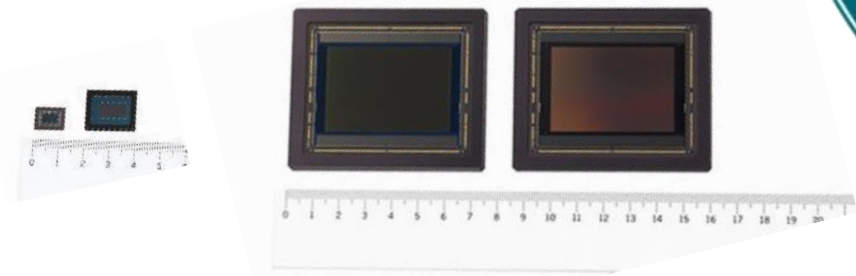
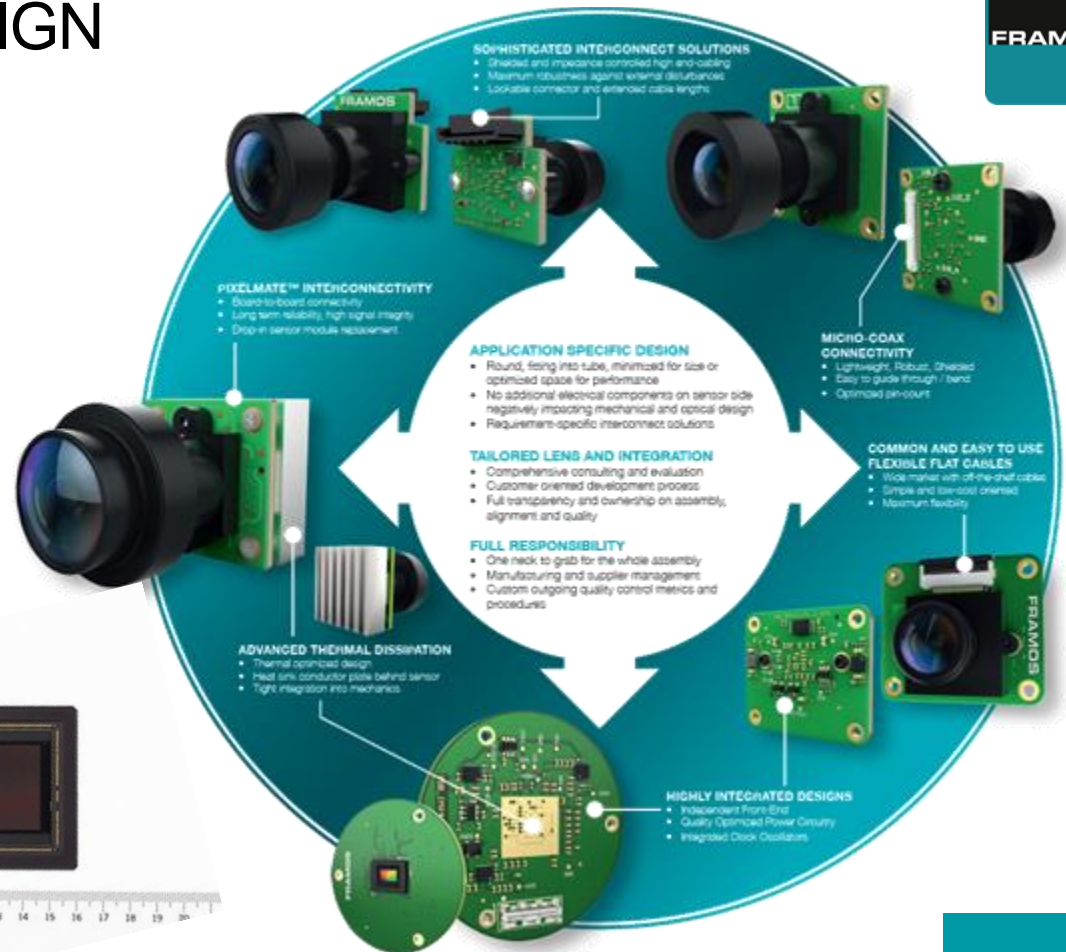
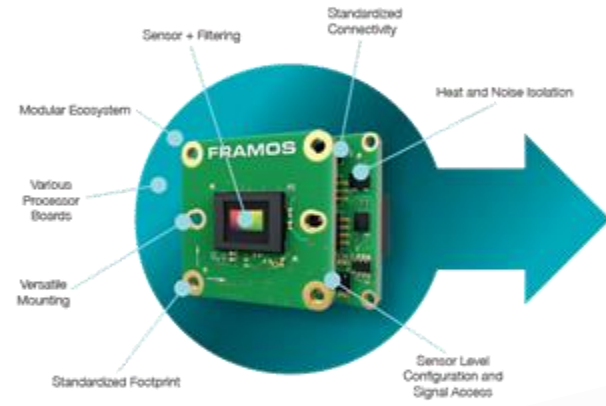


- EMVA1288 is an industry-standard method for characterizing the performance of image sensors.
- It covers parameters such as dark noise, quantum efficiency, and dynamic range.
- The specialized test equipment consists of a tube system with interchangeable optical components including a light source



- Optical Testing Lab equipped
  - optical benches
  - Spectrometers
  - interferometers.
- Optical centering and focusing
- Application specific
  - Pass / Fail criteria
  - Defect detection

# APPLICATION SPECIFIC SENSOR MODULE DESIGN





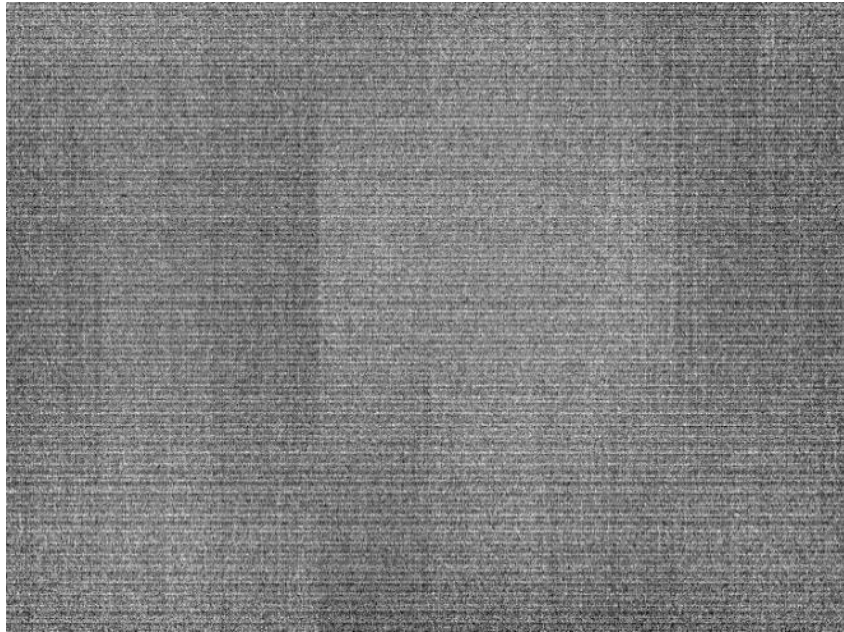
# USE-CASES: TYPICAL CHALLENGES



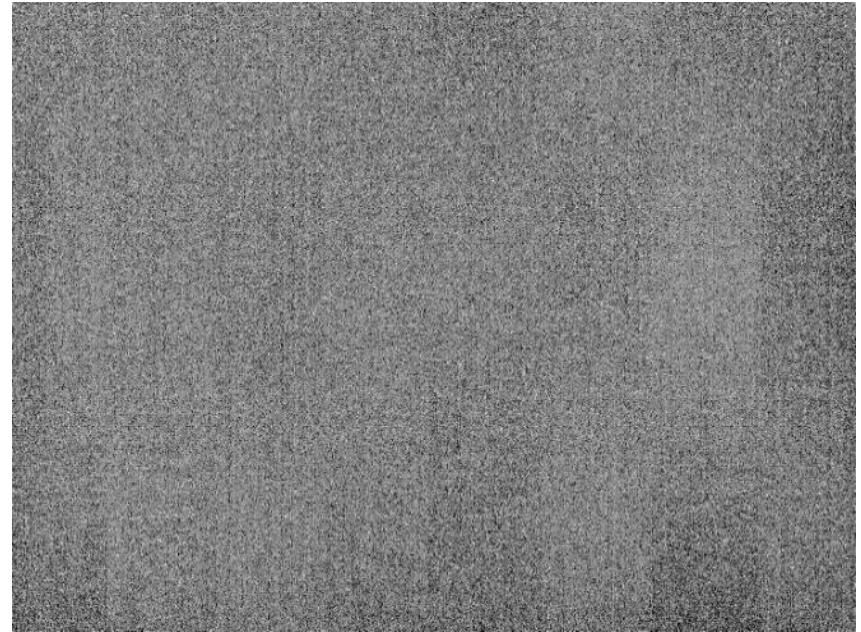
- **Image Quality Tuning:** Tools and know-how required to understand image quality metrics, measure them and make design changes to troubleshoot issues
- **ISP Tuning and Color Reproduction:** Specialized tooling required and tuning access strictly controlled by ISP and Vision Platform providers
- **Optical component selection:** An incompatible lens or filter could adversely affect image quality
- **Optical Alignment in Mass production:** Time and Material Consuming, solution: Active Alignment
- **Production Quality:** Measuring and maintaining production quality

# MEASURE & OPTIMIZE IMAGE QUALITY

Use Case: Dark Signal Non-Uniformities



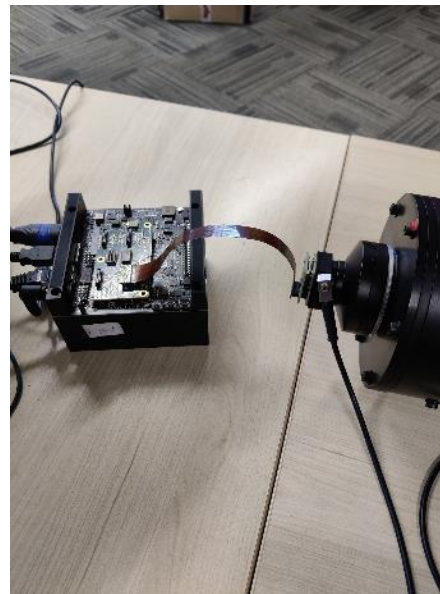
Before Optimization



After Optimization

# MEASURE & OPTIMIZE IMAGE QUALITY

- Characterize the image quality with



<b>Quantum efficiency</b>	
$\eta$	72.7%
<b>Overall system gain</b>	
$K$	0.332 DN/e <sup>-</sup>
$1/K$	3.009 e <sup>-</sup> /DN
<b>Temporal dark noise</b>	
$\sigma_d$	2.38 e <sup>-</sup>
$\sigma_{y,\text{dark}}$	0.84 DN
<b>Signal-to-noise ratio</b>	
$\text{SNR}_{\text{max}}$	106
	40.5 dB
	6.7 bit
$1/\text{SNR}_{\text{max}}$	0.94 %
<b>Absolute sensitivity threshold</b>	
$\mu_{p,\text{min}}$	4.25 p
$\mu_{p,\text{min,area}}$	0.505 p/ $\mu\text{m}^2$
$\mu_{e,\text{min}}$	3.09 e <sup>-</sup>
$\mu_{e,\text{min,area}}$	0.367 e <sup>-</sup> / $\mu\text{m}^2$
<b>Saturation capacity</b>	
$\mu_{p,\text{sat}}$	15409 p
$\mu_{p,\text{sat,area}}$	1832 p/ $\mu\text{m}^2$
$\mu_{e,\text{sat}}$	11200 e <sup>-</sup>
$\mu_{e,\text{sat,area}}$	1332 e <sup>-</sup> / $\mu\text{m}^2$
<b>Dynamic range</b>	
DR	3630
	71.2 dB
	11.8 bit
<b>Spatial nonuniformities</b>	
$\text{DSNU}_{1288}$	0.50 e <sup>-</sup>
	0.17 DN
$\text{PRNU}_{1288}$	0.43 %
<b>Linearity error</b>	
$\text{LE}_{\text{min}}$	-0.19%
$\text{LE}_{\text{max}}$	0.22%
<b>Dark current</b>	
$\mu_{e,\text{mean}}$	$0.21 \pm 0.02 \text{ e}^-/\text{s}$
	0.07 DN/s
$\mu_{e,\text{var}}$	$0.07 \pm 0.02 \text{ e}^-/\text{s}$
$T_d$	— °C

# USE-CASE: COLOR TUNING



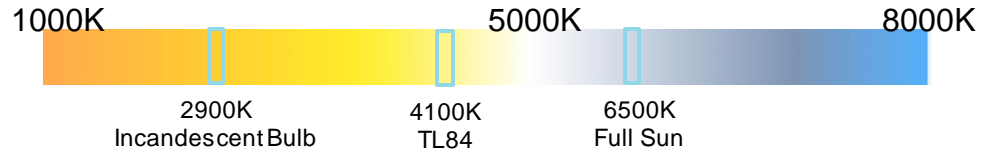
## Brightness of the image

- A change in illumination level results in varying brightness level of the image



## Hue of the image

- The color temperature of the illumination affects the color of the image



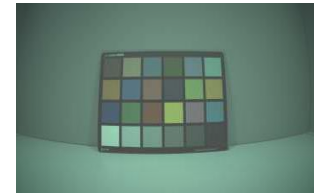
2855K



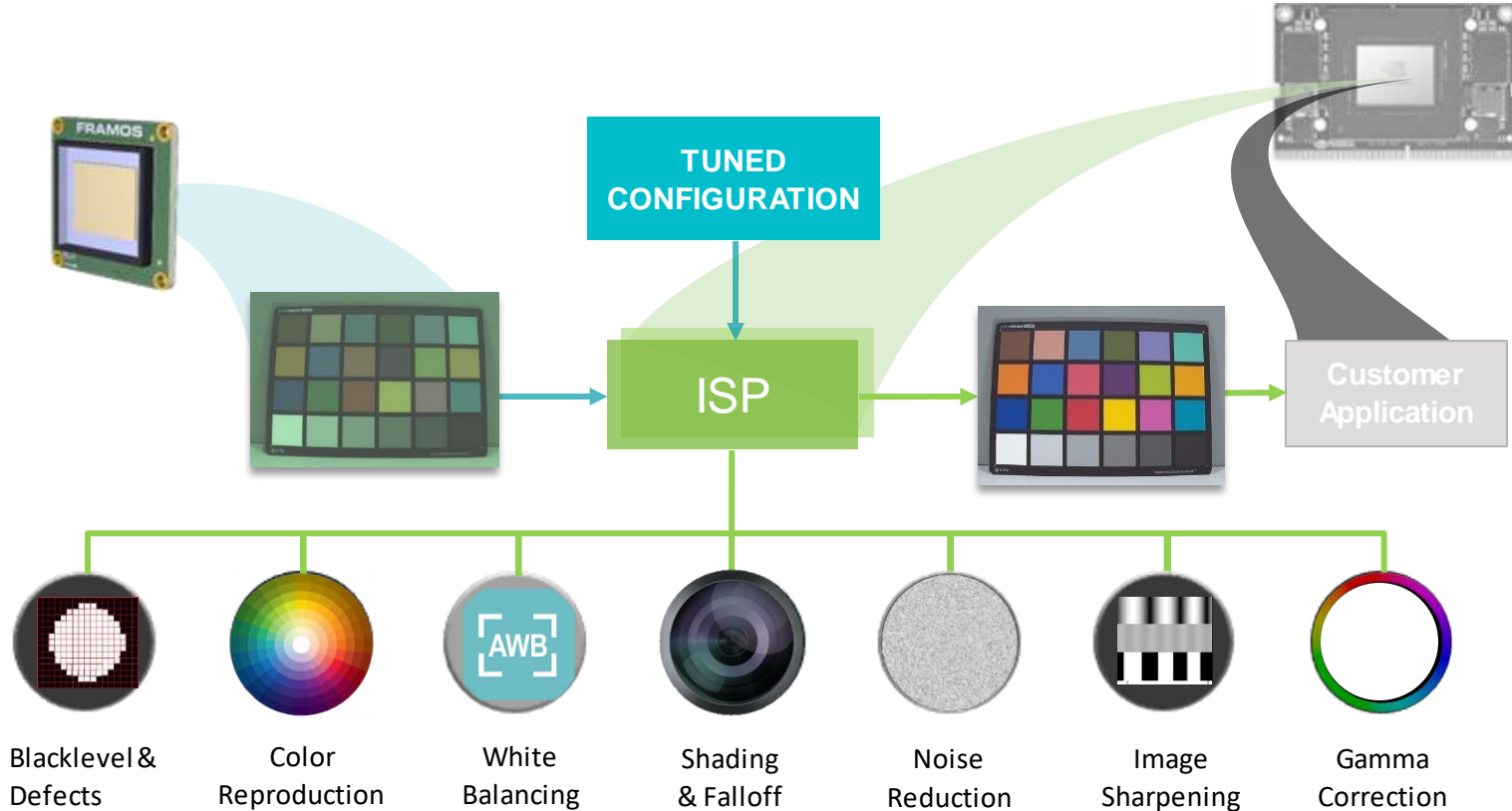
4100K



6500K



# IMAGE SIGNAL PROCESSOR FUNCTIONS



# ISP ACTIVE | BEFORE & AFTER



RAW Image from Sensor, Debayered



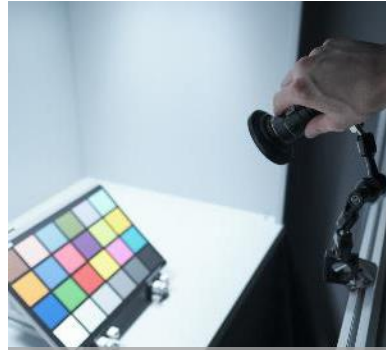
After Color Correction and White Balancing

# SPECIAL TOOLS, LABS AND ACCESS



Precision Calibration Tools

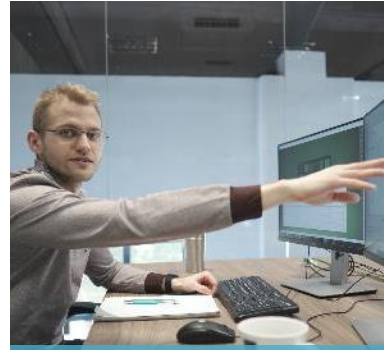
A typical IQ Lab features industry standard measurement systems and proprietary toolchains



ISP-specific IQ tuning

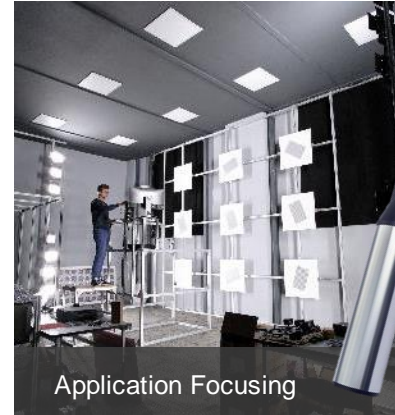
Every lens, sensor and ISP combination is calibrated and tuned in a unique way. Access to the ISP is often closed for most customers.

- Nvidia
- NXP
- ...



Imaging experts

Engineering expertise to optimize the ISP and to improve camera image quality and performance

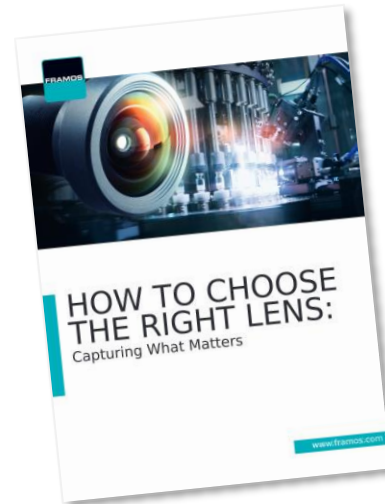
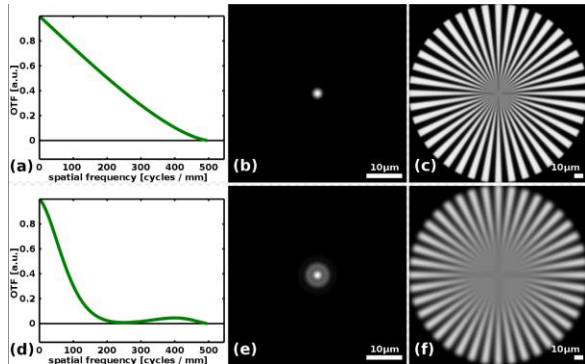


Application Focusing

Tailoring to unique focusing needs may be complex. Be prepared for extensive practical test spaces and specialized collimator equipment for mass production.

# USE-CASE: LENS SELECTION

- ✓ Image circle of the lens matches closely with the sensor size format.
- ✓ The lens has sufficient resolving power comparable to the sensor pixel pitch.
- ✓ The focal length is suitable for desired field of view and working distance.
- ✓ F-Number is optimized for the required depth of field and illumination.
- ✓ Spectral performance is optimized for the intended wavelength of operation.



Download the  
whitepaper here

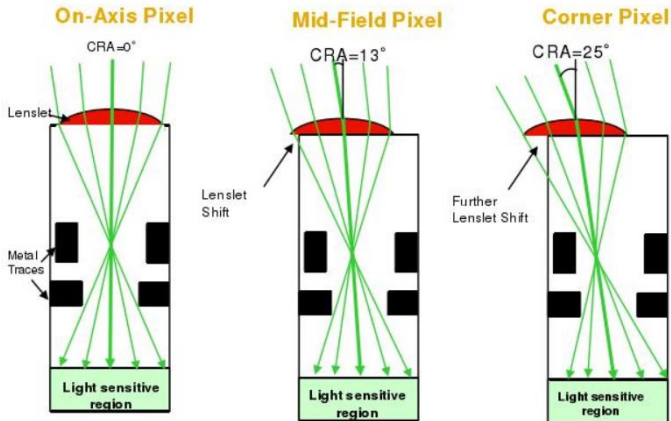




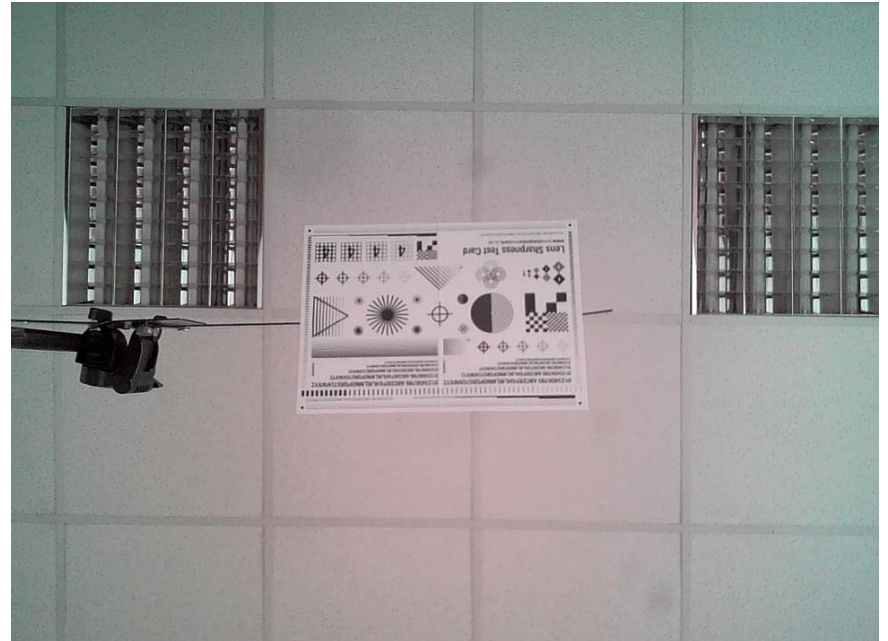
# USE-CASE: LENS SELECTION MATCHING THE CHIEF-RAY-ANGLES



The Chief-Ray-Angles (CRA) need to match up

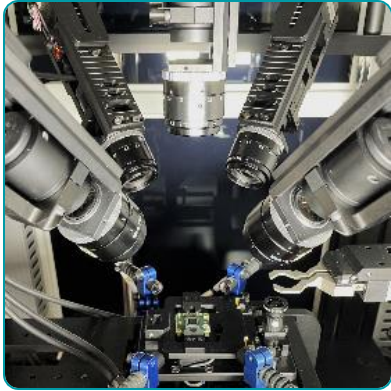


Color gradient due to CRA mismatch.



# ADVANCED IMAGING TOOLS: ACTIVE ALIGNMENT

FRAMOS



## Unique AA Capabilities at **FRAMOS**

- ✓ High-Precision in Alignment (Lateral:  $1\mu\text{m}$ , Axial:  $<1\mu\text{m}$ , Tilt:  $0.002^\circ$ )
- ✓ Wide-Angle Collimator Coverage (Maximum Field of View:  $180^\circ$ )
- ✓ High-speed lens tilt alignment and through focus calculation
- ✓ Possibility to switch between VIS and NIR wavelength ranges
- ✓ High-Flexibility in system configuration and module form factor

## Main Benefits of Active Alignment

### Excellent Image Quality

- ✓ High-resolution with consistent quality
- ✓ Minimal tilting and centering tolerances
- ✓ Sharp image over entire field of view

### Micro-Precision in Assembly

- ✓ Compatibility with high pixel density
- ✓ Consistent quality in MP
- ✓ Minimal operator interaction

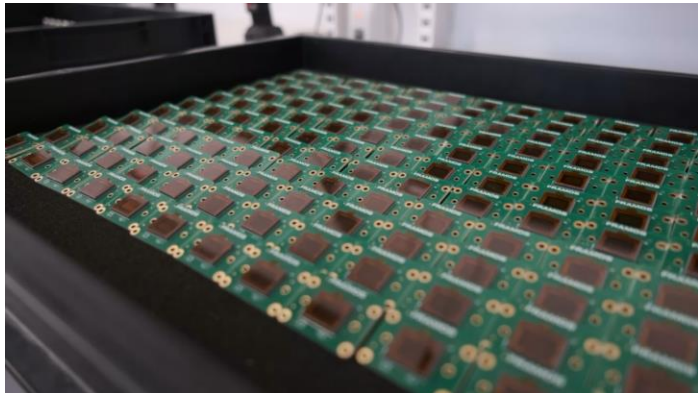
### High Yield & Throughput Rate

- ✓ Reduced error / scrap rate
- ✓ Reduced testing / scrapping time
- ✓ Up to  $\sim 1500$  modules/day

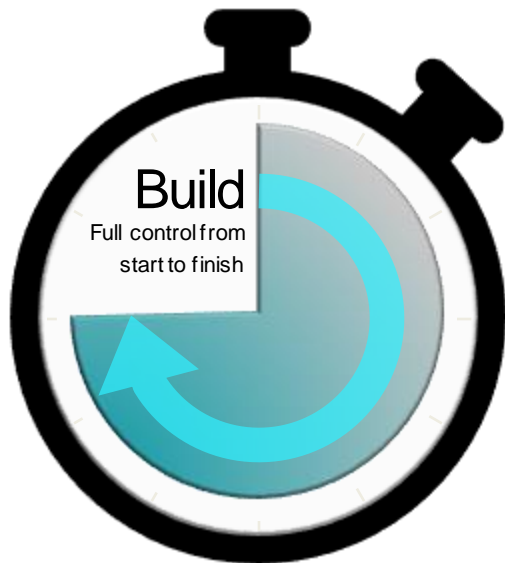
# OPTIMIZING PRODUCTION QUALITY



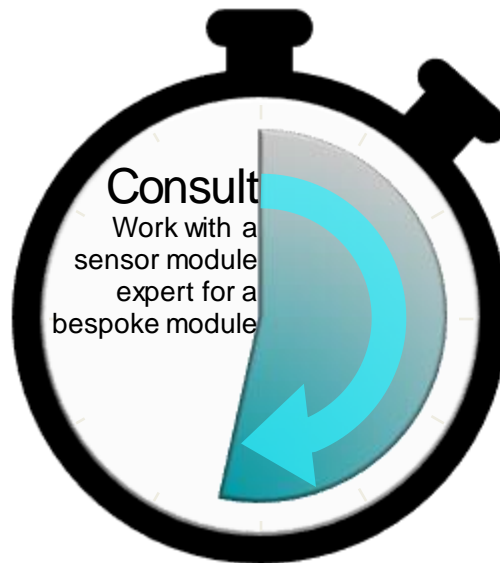
Statistical quality control with defined metrics is required to ensure production quality across large volumes.



# STRATEGIC PATHWAYS FOR PRODUCT DEVELOPMENT



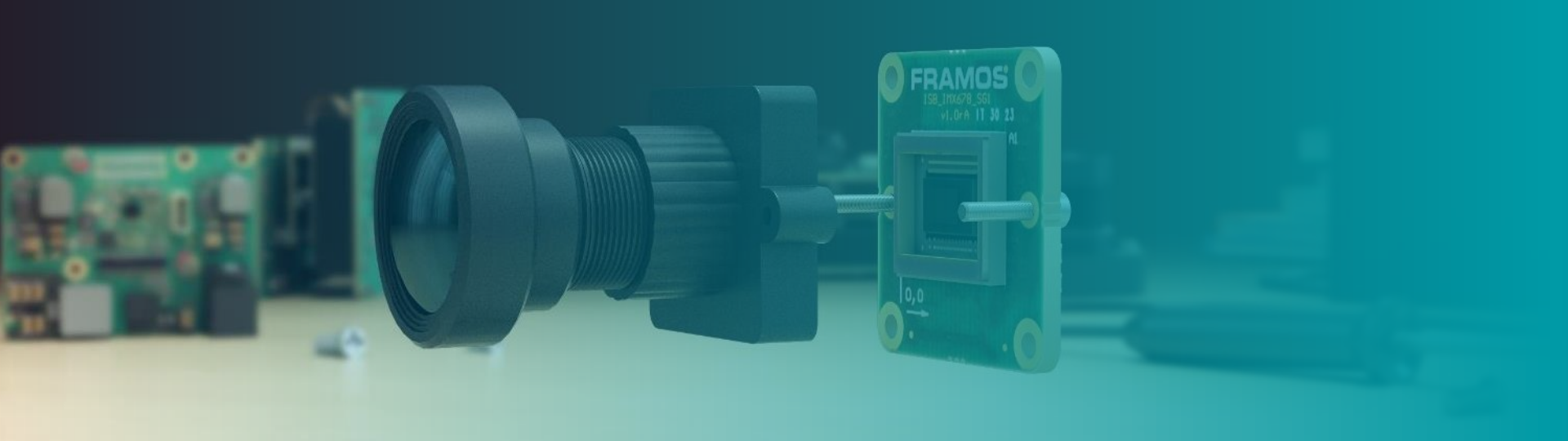
- Full Control
  - Potential for unique innovation
- 
- High Development Costs
  - Special Technical Expertise



- Access to vision experts
  - Your spec backed by guarantee
- 
- Project start dependent on availability
  - Possible NRE costs



- Fastest time to market
  - Turnkey reliability
- 
- Need to be flexible on spec
  - Sacrificing some margin



**FSM:GO**



Simplify Embedded Vision System Deployment

# FSM:GO - Product Line

FSM:GO



FSM:GO offers a curated optical sensor module package starting with the image sensor, seamlessly paired lenses, and precision focus options, ready to GO for your specific vision application.



**Single Board Design**



**Standard Lens Focusing**



**Consistent Quality Guarantee**



**NVIDIA Jetson Family and NXP i.MX8MP Support**



**Lens Options for Various Applications**



**Multiple Interface Options: PixelMate™, GMSL, MicroCoax, FFC**

SONY  
IMX662



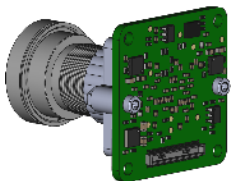
SONY  
IMX678



SONY  
IMX676

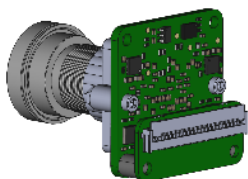


# INTERFACE: FLEXIBLE FOR THE SYSTEM



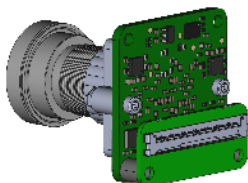
Pixel  
Mate™

- + Simple, Reliable connection
- + Good fit, easy handling
- + All sensor signals
- Limited bending / twisting
- Limited cable length



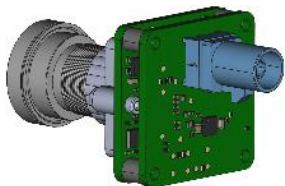
FFC

- + Significantly Cheaper
- + Availability of various lengths
- + Lockable
- EMC / Robustness (not shielded!)
- Limited cable length



MicroCoax

- + Excellent bending and twisting characteristics
- + Good fit, lockable
- Fiddly in production
- Limited cable length



GMSL  
(FAKRA)

- + Cable length (up to 15 m)
- + Robust and lockable
- + Good bending and twisting
- + Easiest to handle, affordable
- Additional power consumption
- Increases size

Small-  
Medium  
Devices

- Handhelds / Scanner
- Web Cameras
- Sports Analytics Cameras
- Drones

**FFC:**

- Wide availability of standard cables.
- Easy adaption of cable length during prototyping
- PixelMate cable recommended for production due to EMC robustness.

Medium  
Sized,  
difficult  
routing

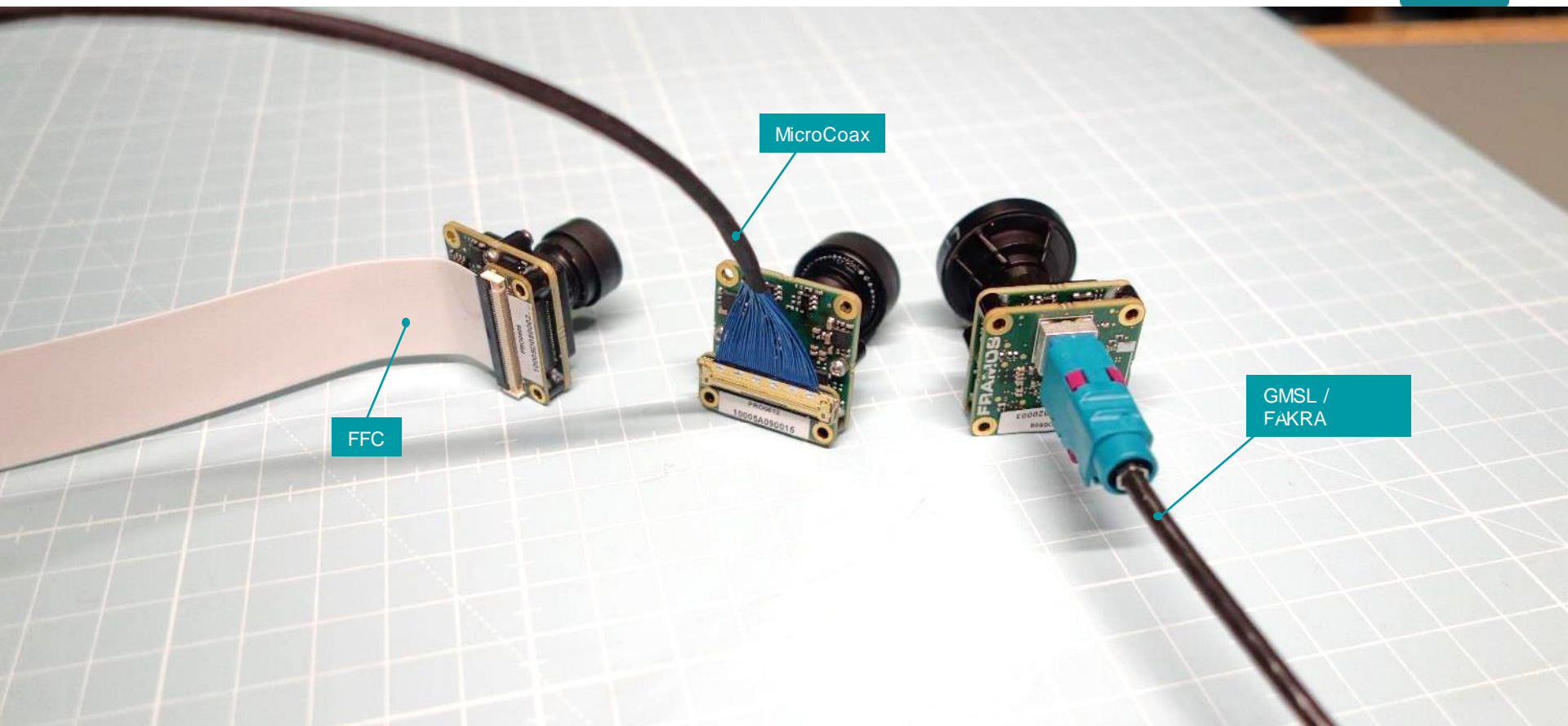
- Stationary / Scanner
- Integrated Robots
- Whitegoods
- Larger Drones

Large  
Machines

- Heavy Robots (Production)
- Vehicles, Machines (AMR, Agriculture, Construction)
- ...

# INTERFACE: FLEXIBLE FOR THE SYSTEM

FRAMOS



FFC

MicroCoax

GMSL /  
FAKRA





[www.framos.com/en/fsmgo](http://www.framos.com/en/fsmgo)




# Configure your FSM:GO

Explore customization options, testing various settings to find the perfect fit for your application.

Best viewed in Chrome

FSM:GO → Application → Select Sensor → Focusing → Interface → Result



Follow this step-by-step guide to assist you in making the right decision when constructing your FSM:GO.

Navigate the steps and choose the necessary vision components to assemble your personalized FSM:GO sensor module.

The images of the components are illustrative and may not accurately depict the actual product.

Click the «**Start**» button to begin.

Start



Thank you for joining

FRAMOS

IMAGING THE FUTURE

# Empowering Product Creators to Harness Edge AI and Vision



The Edge AI and Vision Alliance ([www.edge-ai-vision.com](http://www.edge-ai-vision.com)) is a partnership of 100+ leading edge AI and vision technology and services suppliers, and solutions providers

Mission: To inspire and empower engineers to design products that perceive and understand.

The Alliance provides low-cost, high-quality technical educational resources for product developers

**Register for updates at [www.edge-ai-vision.com](http://www.edge-ai-vision.com)**

The Alliance enables edge AI and vision technology providers to grow their businesses through leads, partnerships, and insights

**For membership, email us: [membership@edge-ai-vision.com](mailto:membership@edge-ai-vision.com)**



edge ai + vision  
ALLIANCE™



# Join us at the Embedded Vision Summit

## May 21-23, 2024—Santa Clara, California



***The only industry event focused on practical techniques and technologies for system and application creators***

- *“Awesome! I was very inspired!”*
- *“Fantastic. Learned a lot and met great people.”*
- *“Wonderful speakers and informative exhibits!”*

### **Embedded Vision Summit 2024 highlights:**

- **Inspiring keynotes** by leading innovators
- High-quality, practical **technical, business and product talks**
- Exciting **demos, tutorials** and **expert bars** of the latest applications and technologies



Visit [www.EmbeddedVisionSummit.com](http://www.EmbeddedVisionSummit.com) to learn more and register





# Nathan Dinning

Director of Product Management



edge ai + vision  
ALLIANCE

Questions ?



# Prashant Mehta

Senior Technical Imaging Expert



[sales@framos.com](mailto:sales@framos.com)

**FSM:GO**

