# INFRARED IMAGING: TECHNOLOGIES, TRENDS, OPPORTUNITIES AND FORECASTS

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-

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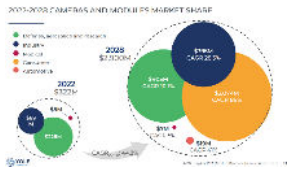
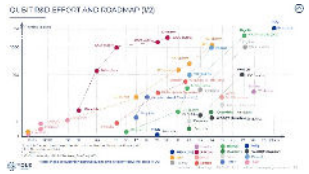
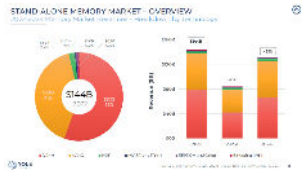
Senior Analyst

YOLE Group

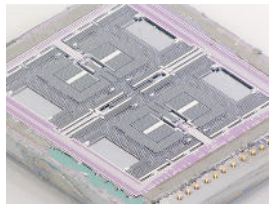
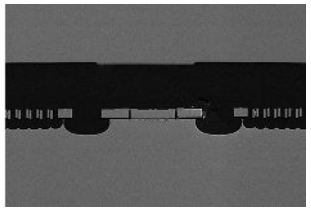
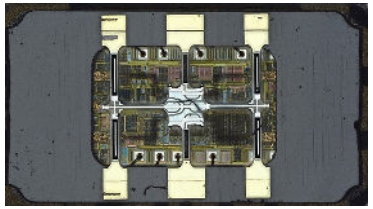
# RESEARCH PRODUCTS

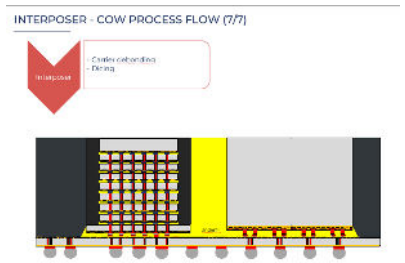
## REPORTS
*Annually with data and 5-yr forecast*

### Market and technology trends analysis

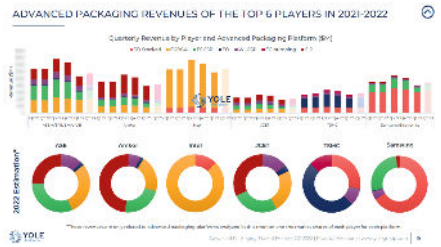




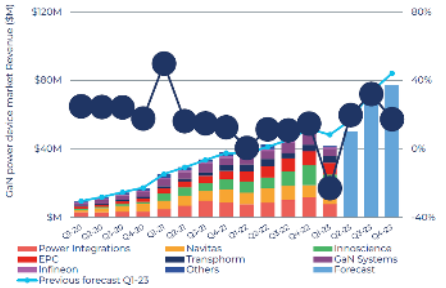
### Reverse engineering & reverse costing

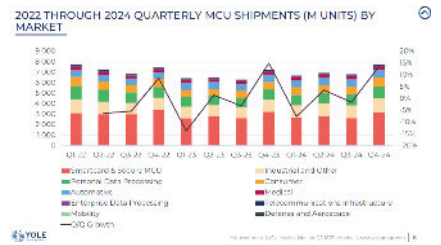





## MONITORS
*Quarterly data and analysis*

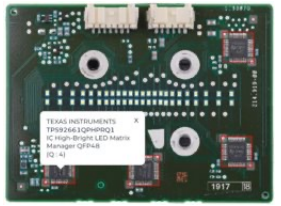


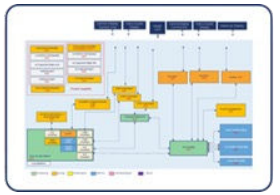




## TEARDOWN TRACKS
*Full BOM costing*

**Dismantling photos**
***from A to Z***



**Detailed PCB**



**Block diagram interactive**

**Bill of materials**

# OUR EXPERTISE

## SEMICONDUCTOR INDUSTRY

- Battery
- Compound Semiconductor
- Computing and Software
- Display
- Electronic Systems
- Global Semiconductor Trends
- Imaging
- Memory
- Photonics and Lighting
- Power Electronics
- Radio Frequency
- Semiconductor Equipment
- Semiconductor Packaging
- Sensing and Actuating

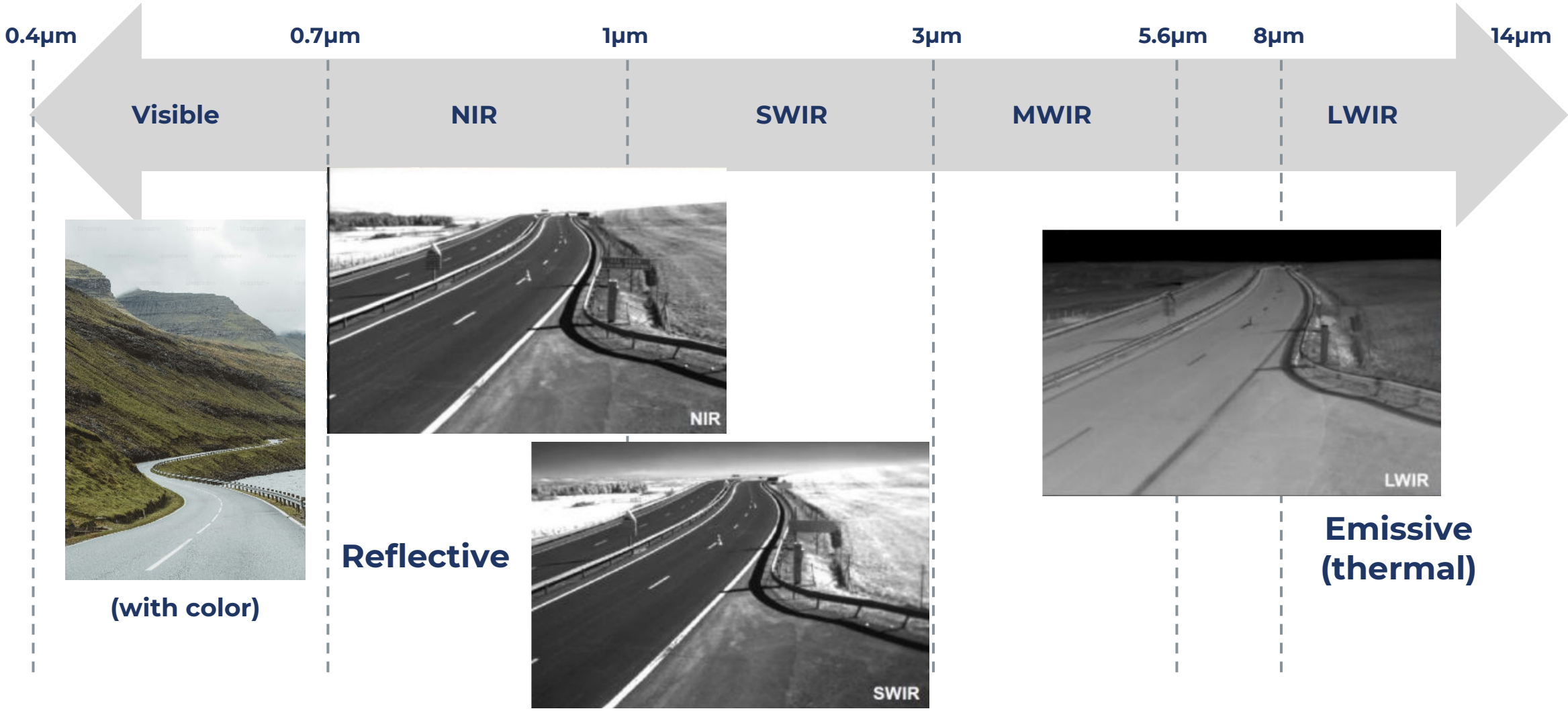
# AGENDA

- General introduction on infrared imaging
- Macro trends impacting demand and supply chain
- Key trends by domain:
  - SWIR
  - Cooled MWIR and LWIR
  - Uncooled LWIR

# General introduction

# OVER THE ELECTROMAGNETIC SPECTRUM…

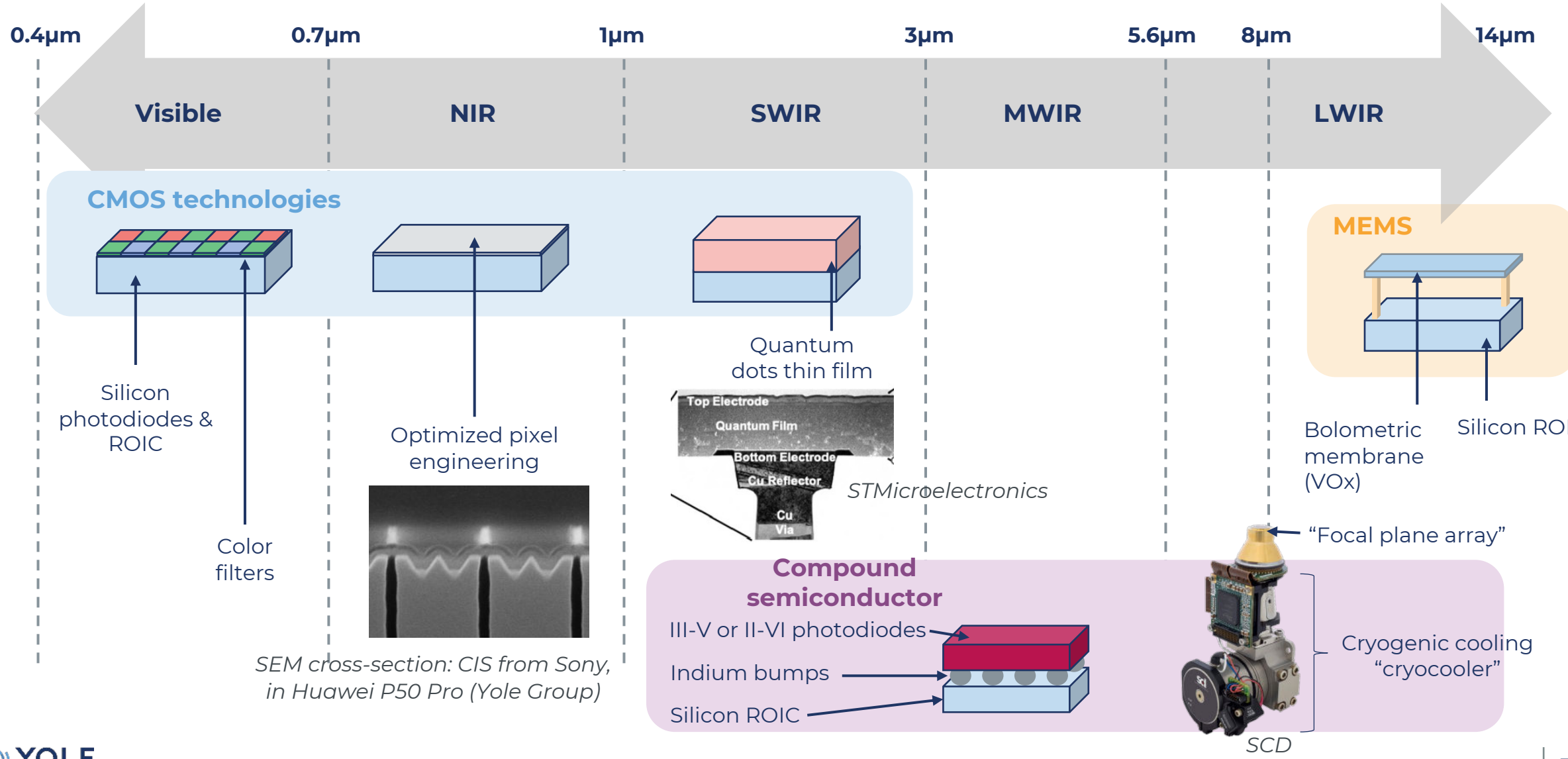
## Type of images




Source: N.Pinchon & al., All-weather vision for automotive safety: which spectral band, VISION SIA, 2016

# OVER THE ELECTROMAGNETIC SPECTRUM…

## Technology platforms



# OVER THE ELECTROMAGNETIC SPECTRUM…

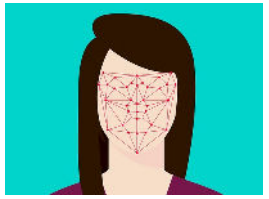
## Applications

***Non-exhaustive***

0.4µm | 0.7µm | 1µm | 3µm | 5.6µm | 8µm | 14µm

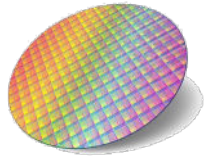
**Visible** | **NIR** | **SWIR** | **MWIR** | **LWIR**

Large span of applications



Biometrics

Robotic navigation



Wafer inspection

Optical sorting

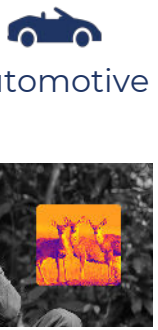
Laser target designation

Vehicle-mounted thermal imaging

Missile seeker

Infantry handheld goggles

Professional thermography



Wildlife observation

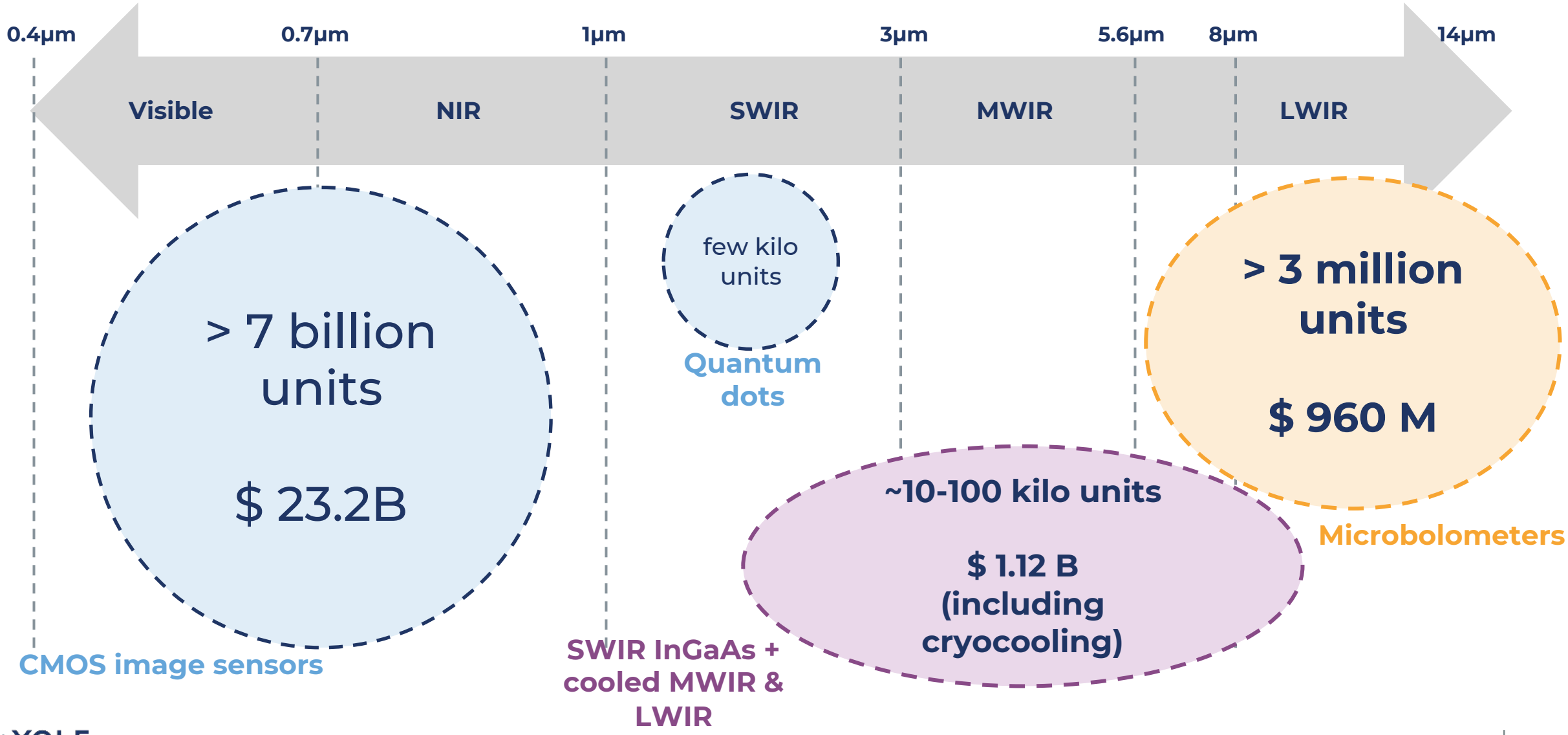
Fire detection and safety

Thermal weapon sights

UAV observation

# OVER THE ELECTROMAGNETIC SPECTRUM…

## Image sensor (focal plane array) market value in 2024



# INFRARED IMAGE SENSOR MANUFACTURERS

## Largest image sensor manufacturers

***Non-exhaustive***


- Fragmented ecosystem with many small contributors.
- Sony has been shaking the ecosystem since 2020.
- Newcomers providing new technologies.

SONY

Newcomers: EMBERION, qurv, onsemi SWIR VISION SYSTEMS, TRIEYE

- U.S-centric ecosystem of vertical players.
- Long-standing players in Europe, Israel and South Korea.

U.S leaders: RTX, L3HARRIS, BAE SYSTEMS, LEONARDO DRS

sci SemiConductor Devices, LYNRED BY SOFRADIR & ULIS, i3system

- China-centric ecosystem of vertical players.
- Long-standing players

Chinese leaders: Raytron, HIKMICRO, GSTiR

TELEDYNE FLIR Everywhereyoulook, Seek thermal, LYNRED BY SOFRADIR & ULIS

**General interest for the MWIR domain**

# Macro trends impacting demand & supply chain

# MACRO TRENDS – END MARKETS

## A recent re-focus on defense


**Defense**

General geopolitical instability leading to increased budgets and investments from governments (long term)

SWIR MWIR LWIR

**Industrial**

Demand for fever detection cameras

LWIR

Post-COVID effect with new CAPEX

SWIR

General slow down and economic downturn

SWIR

**Consumer**

Apple showing interest for usage of SWIR in smartphones

SWIR

Big players stopping mass production projects

SWIR

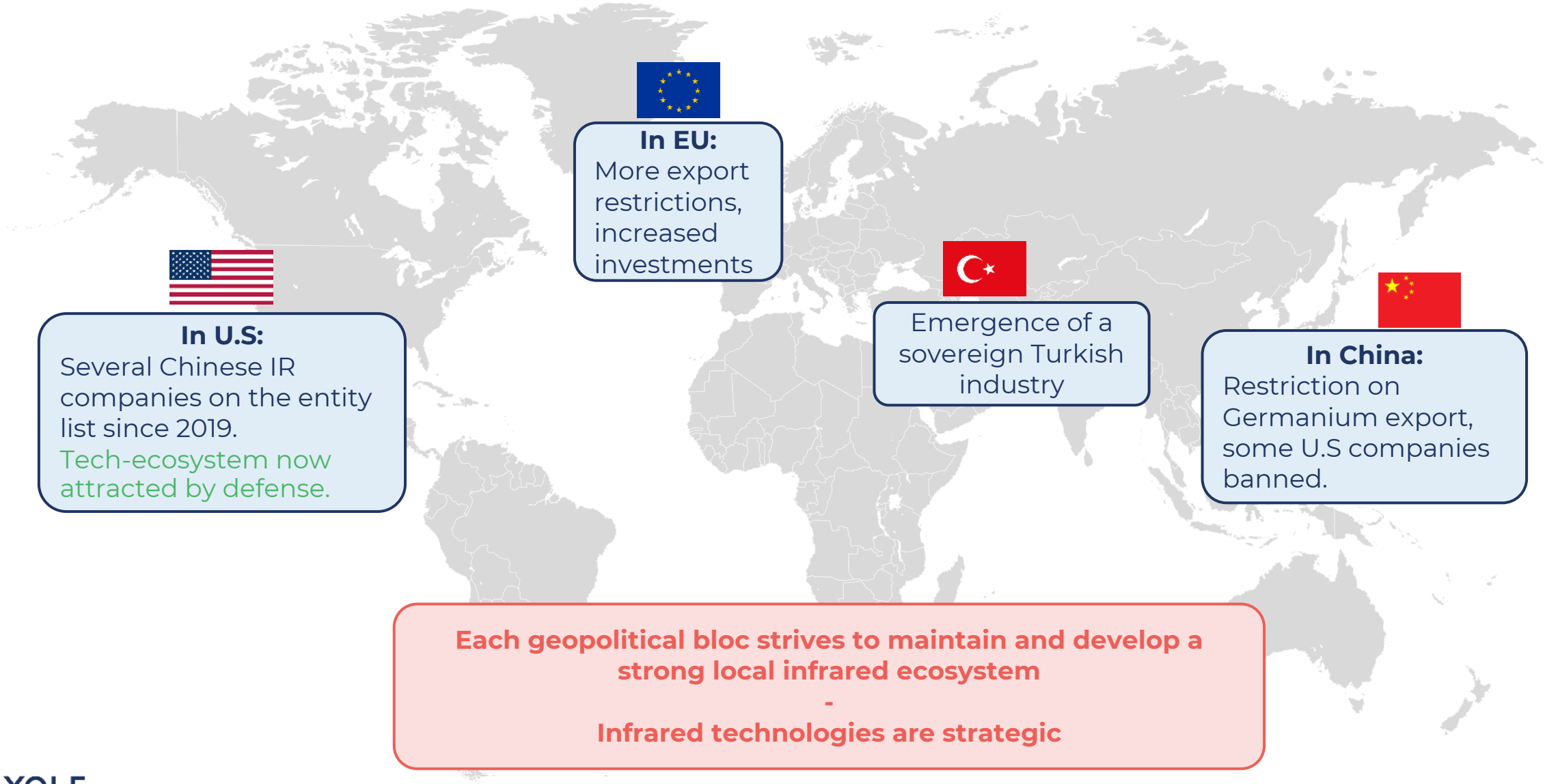
**Automotive**

NHTSA regulation on AEB and interest for thermal cameras

LWIR

# MACRO TRENDS - ECOSYSTEM

## Entering the post globalization era



**In EU:**
More export restrictions, increased investments

**In U.S:**
Several Chinese IR companies on the entity list since 2019.
Tech-ecosystem now attracted by defense.

Emergence of a sovereign Turkish industry

**In China:**
Restriction on Germanium export, some U.S companies banned.

**Each geopolitical bloc strives to maintain and develop a strong local infrared ecosystem**
**-**
**Infrared technologies are strategic**

# MACRO TRENDS - ECOSYSTEM

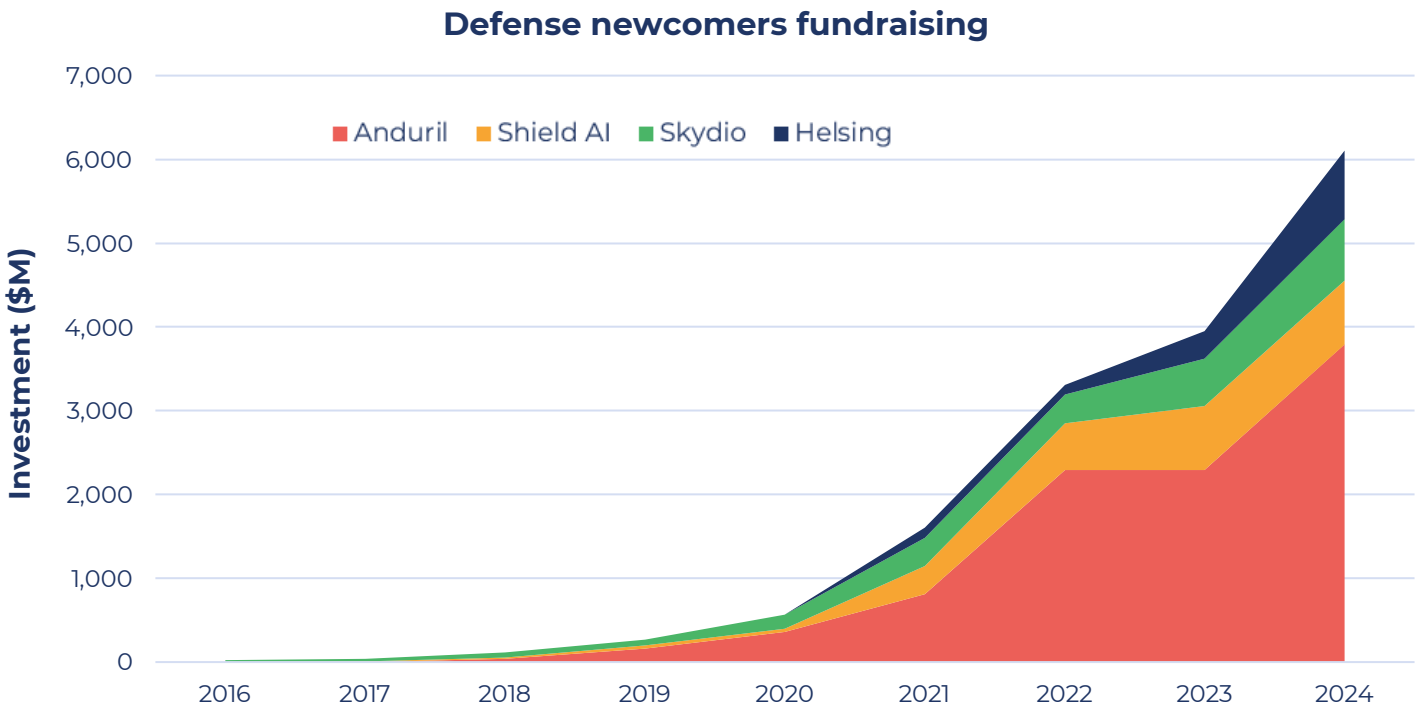
## Entrance of software-defined companies in defense

Software-defined (Tech) newcomers:

ANDURIL
Palantir
Skydio
Shield AI
BAYKAR
Helsing
scale

Legacy defense OEM ecosystem:

RTX
THALES
LEONARDO DRS
LOCKHEED MARTIN
HENSOLDT
L3HARRIS
NORTHROP GRUMMAN
SAFRAN
BAE SYSTEMS
aselsan
TELEDYNE TECHNOLOGIES INCORPORATED
Elbit Systems
Hanwha




**Newcomers are characterized by:**

- Faster development cycles
- Focus on drones and AI-related technologies
- Large and fast fundraising

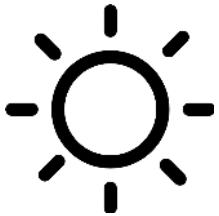
IR technologies are critical in drones and any defense observation technologies.

# Key trends by infrared domains

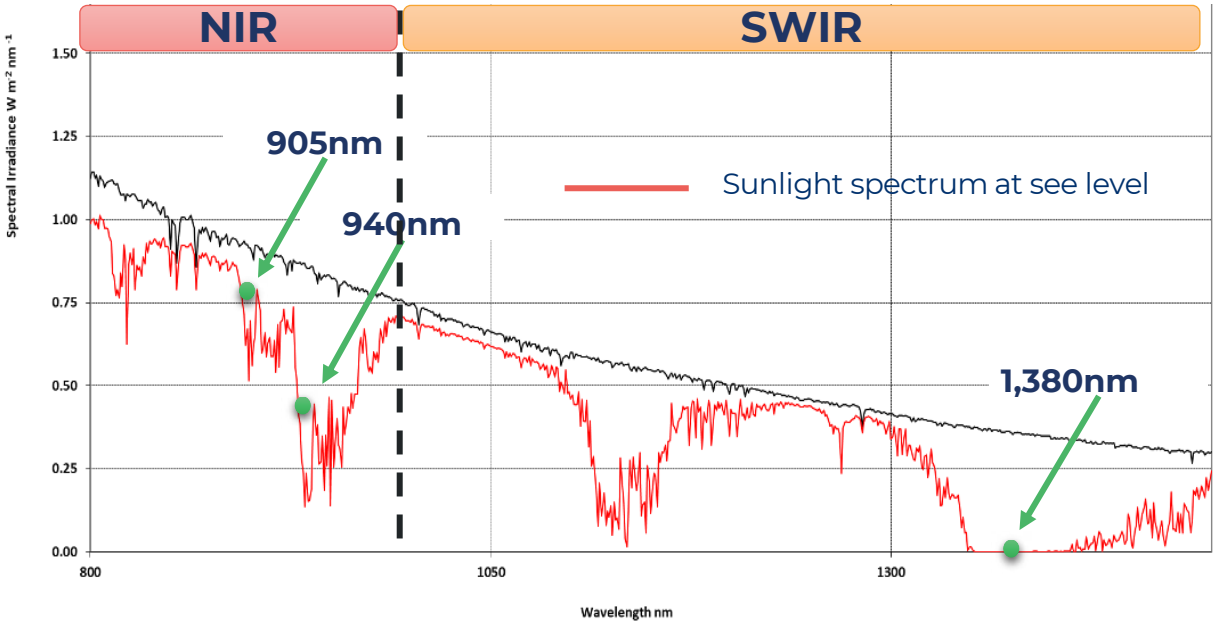
# SWIR

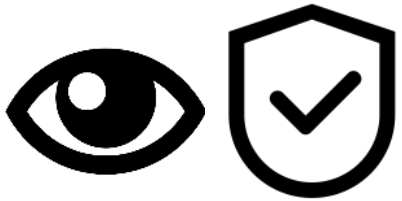
# KEY TRENDS IN SWIR

## Advantage of SWIR for ranging technologies

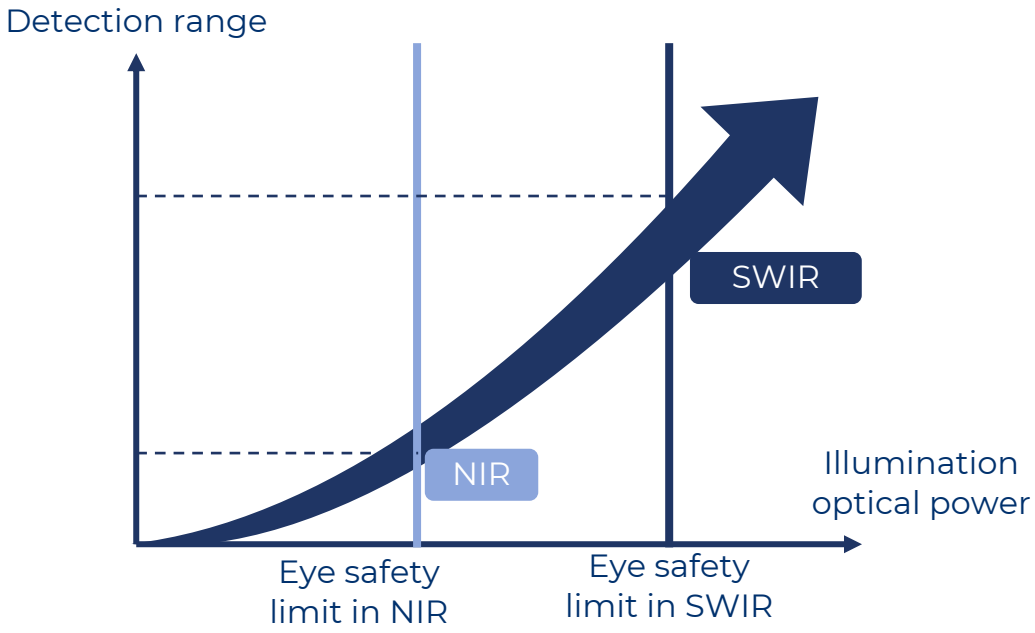


Less parasitic ambient light



More powerful active illumination



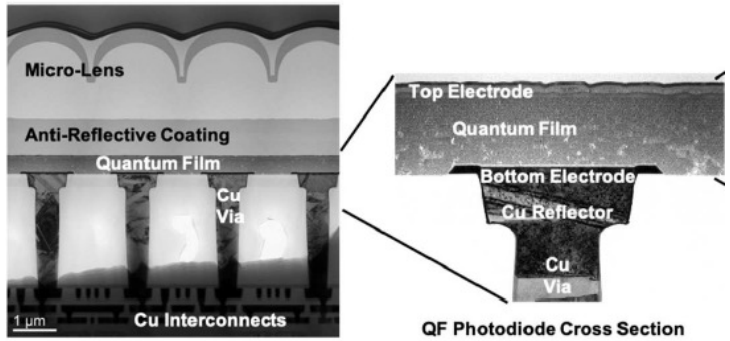
# KEY TRENDS IN SWIR

## 2021-2023: SWIR almost disrupted… almost…

**2021**

- STMicroelectronics presented a paper showing first results of a low-cost SWIR sensors based on quantum dots at IEDM.
- STMicroelectronics is the supplier the CMOS image sensors used in Apple Face ID system…

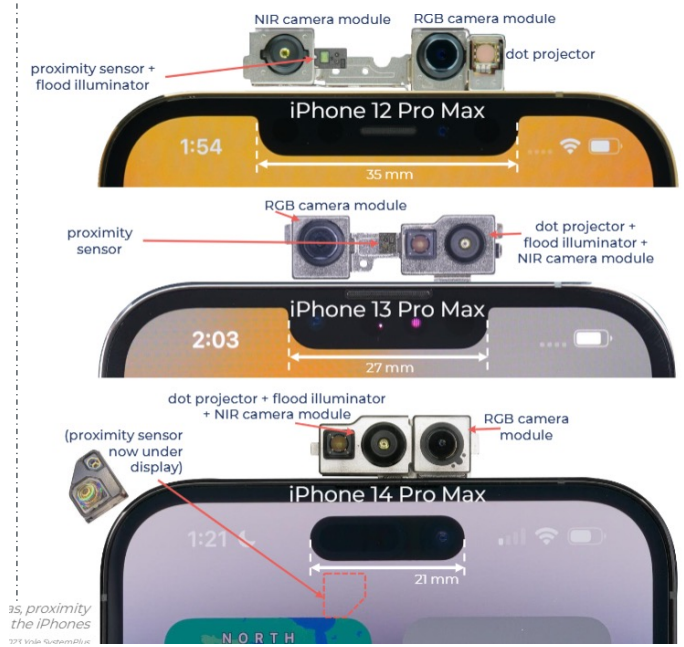
life.augmented

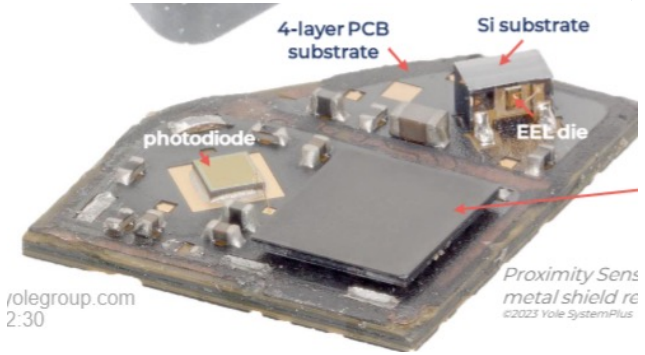


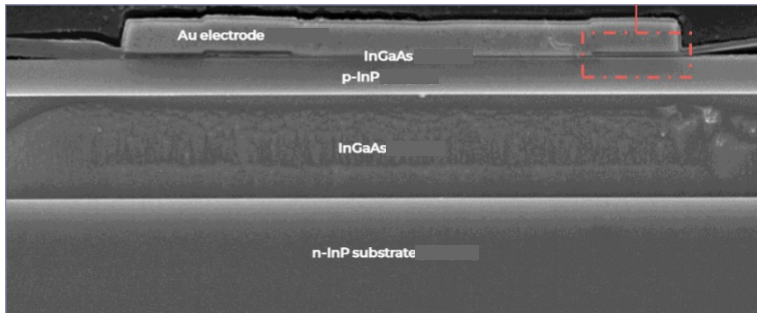

Fully Integrated QF Photodiode Array

**2022**

In 2022, Apple introduced its "dynamic island" moving a proximity sensor under the OLED display. The module operates in SWIR.




*Source: Yole Group's laboratory*

In 2023, Apple removed the SWIR-based solution by optimizing its integration design…

# KEY TRENDS IN SWIR

## Quantum dots and germanium technologies

### Quantum dots in 2024:

**Large consumer-suppliers:**

On hold?

**R&D partner**

Presented R&D results of Pb-free QD sensors at IEDM.

**Start-up ecosystem:**

Focusing on niche defense and industrial market, R&D on Pb-free QD.

### Germanium on silicon in 2024:

- Trieye is refocusing from automotive to industrial and defense.
- Artilux get more involved in datacom.

**Both platforms need to mature, with a cost/performance ratio that is still not good enough for the consumer or the automotive industry (mass markets)**

# KEY TRENDS IN SWIR

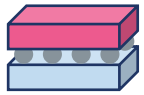
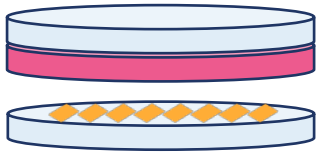
## InGaAs – smaller pitch and new features

- Sony released a first SWIR sensor in 2020.
- It leveraged its extensive sales channels to spread SWIR technology for indutrial applications and is now #1 in volumes.

SONY
**#1 supplier in visible**
**#1 supplier in SWIR**

→ Visible CMOS-based industrial camera makers

SONY

| Die-to-die | Wafer-to-wafer | Monolithic approach? |
|---|---|---|
|  |  |  Aeluma™ |
| Limite pixel pitch: 10µm | Limite pixel pitch: 3.45µm | Limite pixel pitch: ? |

Since 2020 → Long terme?

- The defense requires ALPD feature for laser target designation applications.
- In 2023, SCD introduced a new SWIR event-based sensor that can identify multiple lasers pulses at the same time or very high-speed imaging.

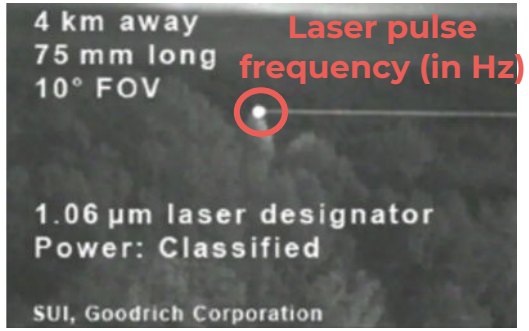
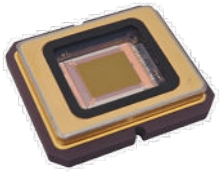
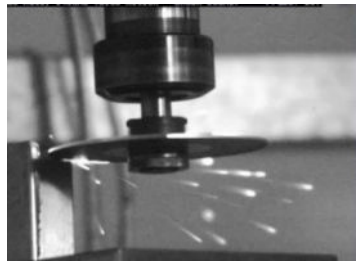



Illustration of a laser designation

SCD



SCD SWIFT-EI



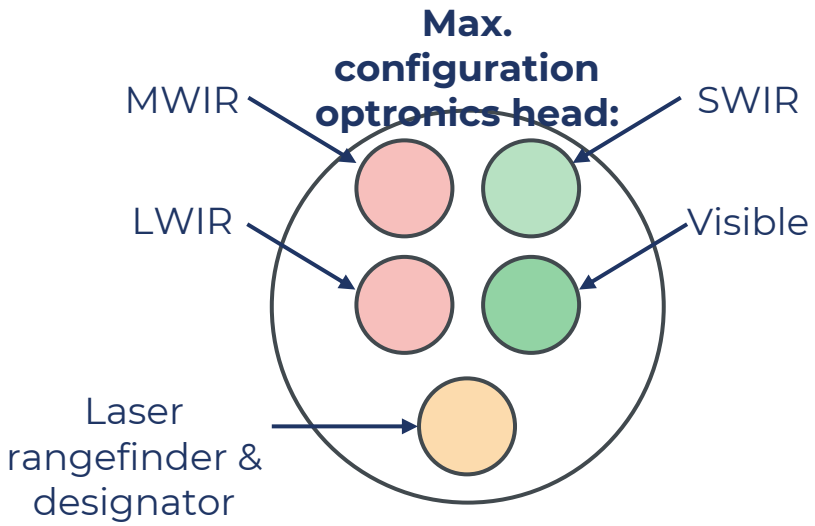
# Cooled MWIR and LWIR

# KEY TRENDS IN COOLED MWIR AND LWIR

## In defense, several channels can be used side-by-side

The choice of the thermal channel depends on the situation. Most of optronics heads found in defense have multiple channels.

| | Cooled MWIR | Cooled LWIR | Uncooled LWIR (microbolo.) |
|---|---|---|---|
| **Resolution** | ✓ | | |
| **Fog / dust penetration** | | ✓ | ✓ |
| **Robustness** | ✓ | ✓ | |
| **Compactness** | | | ✓ |
| **Cost** | | | ✓ |



# KEY TRENDS IN COOLED MWIR AND LWIR

## Towards lower cost systems

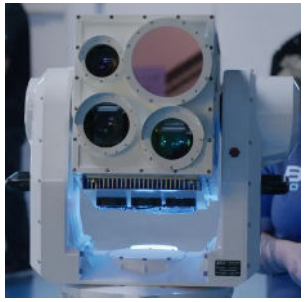
### A brief market insight:

- Cooled technologies are used in defense vehicles and heavy systems.
- Technology lifecycle is very long (~25 years)
- Lastly, demand has been driven by missiles and munitions guiding systems as well as counter-drone systems.

Missile & other munitions guiding

FGM-148 Javelin

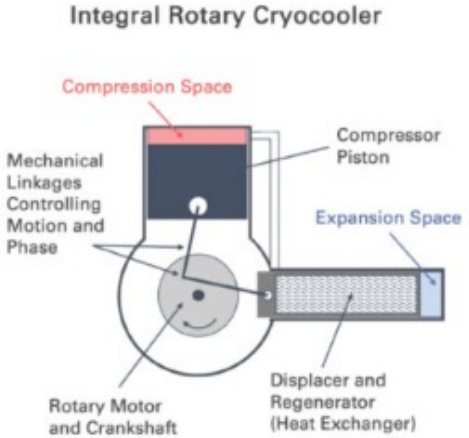
Air defense & counter-drone



Source: Bluehalo

### Technology trends:

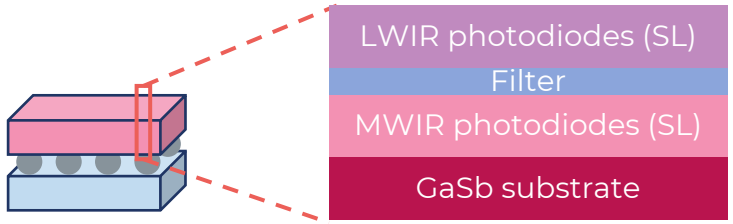
- Towards more compactness and lower cost systems
- Adoption of T2SL technologies




Source: Teledyne

| MCT | T2SL & similar |
|---|---|
| InSb | |
| 0-1Mp | >1Mp |
| 77K | 150K |

Some companies investigate “dual-color” approaches:

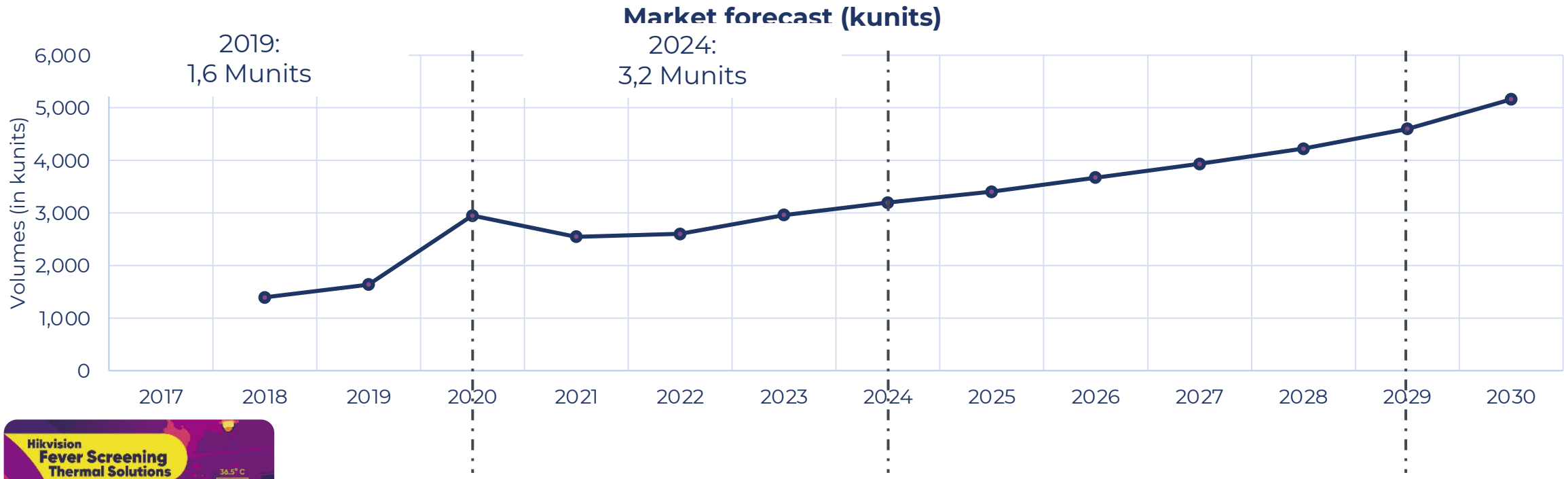



L3HARRIS™ i3system ATTOLLO Engineering

# Uncooled LWIR

# KEY TRENDS IN UNCOOLED LWIR

## The thermal imaging market since 2018






Demand peaked in 2020, in Asia for fever detection cameras in the context of COVID-19 crisis.

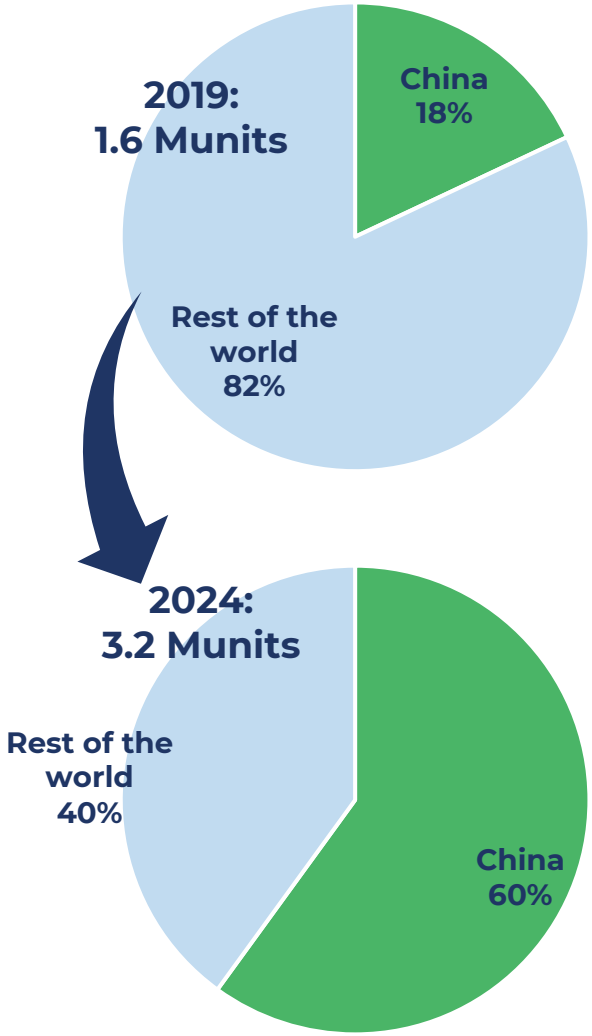
Between 2020 and 2024, record volumes of sensors were sold by the Chinese leading players, for industrial and consumer applications.

Near 2029, more adoption in automotive could contribute to increased volumes.

# KEY TRENDS IN UNCOOLED LWIR

## The COVID crisis triggered the Chinese ecosystem

In 2024, shipments from Chinese companies represented 60% of the global shipments, versus 18% in 2019.




# KEY TRENDS IN UNCOOLED LWIR

## Near a gold rush in U.S for automotive…

In 2024 in U.S, NHTSA voted a new regulation for increased performance of AEB system to prevent pedestrian fatalities.

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

**Some ADAS technologies:**

| | | |
|---|---|---|
| **Visible cameras:** |  | Already integrated |
| **Lighting:** |   | Already integrated |
| **Radar:** |  | Already integrated |
| **LiDAR:** |  | Highly versatile |
| **Thermal cameras:** |  | Passive, good at detecting pedestrians |

The thermal imaging industry wished that this technology would become mandatory as a safety feature in cars.

**Western thermal imaging players:**

TELEDYNE FLIR Everywhereyoulook™
LYNRED BY SOFRADIR & ULIS
Obsidian
SeeK thermal
OWL AI
ADASKY

**U.S automotive market:**

TAM: >10Munits/year

**End of 2024, several automotive companies started a petition against the regulation…**

Infrared industry — Car brands

# KEY TRENDS IN UNCOOLED LWIR

## Meanwhile in Chinese cars…

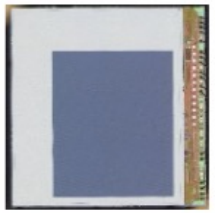
Chinese automotive OEMs are engaged in fierce competition, and new technologies are a key means of differentiation.

Raytron

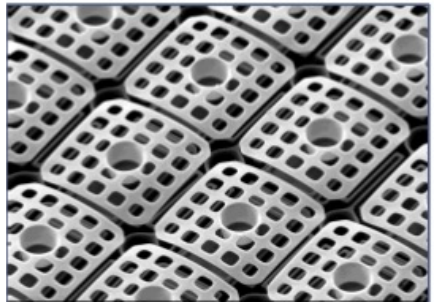
Raytron is the most active thermal camera supplier.

BYD, GEELY, DiDi, tusimple, 智加科技, 踏歌智行

InfiRay NV300



256x192



Source: Yole Group's Laboratory

Will thermal imaging experience the same path as LiDAR?

**A quick look on LiDAR ~~adoption:~~**

**2024:** **1.6 Munits**

**2030:** **17.5 Munits**

**Models equipped with LiDAR in 2025:**

111+ models

**Repartition of volumes by region by 2030:**

93%

Yole Group report: Automotive LiDAR 2025

# KEY TRENDS IN UNCOOLED LWIR

## Light UAV and mixed reality


Light UAVs have been massively used in recent armed conflicts. Most of these systems are consumer-grade products.

**Requirements:**

- **High resolution**
- **Low SWaP and cost**
- **Easy integration**

**IVAS program:**

The program intended to supply the U.S army with mixed reality helmets. A $22B ID/IQ contract has been announced in 2021.

Microsoft → ANDURIL

In 2025, the U.S army has chosen its new trusted partner to takeover the project: Anduril.

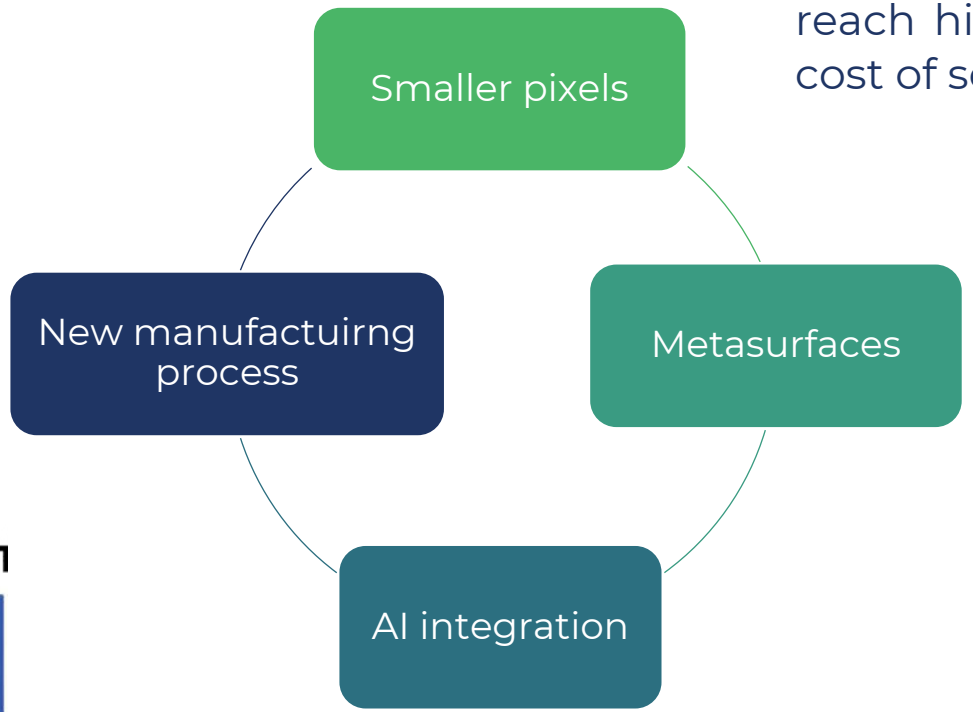
# KEY TRENDS IN UNCOOLED LWIR

## Tehnology trends

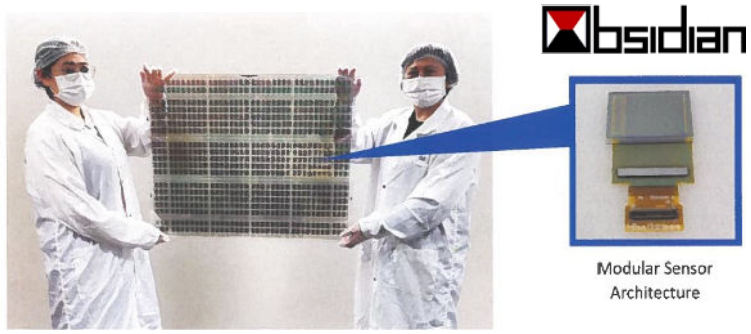
17µm → 12µm → 10µm → 8µm → 6µm

Most of commercial products

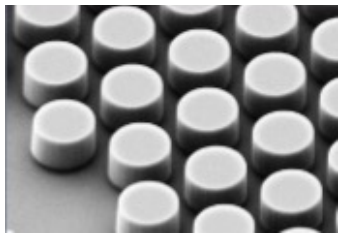
Decreasing pixel pitch allows to reach higher resolution or reduce cost of sensors.




Some companies explore new manufacturing platforms such as glass panels to optimize manufacturing cost.




Micro-pillar patterns are now used on silicon windows in microbolometers for increased sensitivity.

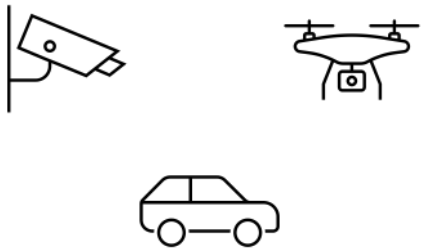


Source: Yole Group's Laboratory

# WHAT ABOUT AI?
## AI in infrared imaging

Two main paths for AI in IR cameras

**Driving segments:**



Hardware "compensation"

- Super-resolution
- Denoising
- Calibration

Scene analytics

- Target identification
- Target tracking

**Infrared being a niche technology, the size of training datasets are more limited than in the visible domain.**

# GENERAL CONCLUSION

- **The infrared domain is a strategic niche within the global imaging industry.**
- **Between 2020 and 2023, infrared technologies were nearly disrupted by potential adoption of SWIR technologies in smartphone.**
- **Amid global geopolitical tensions and challenging market conditions, the industry is refocusing on its primary goal: serving defense applications.**
- **The infrared industry is particularly sensitive to geopolitics, with numerous export restrictions and dependency of critical materials such as germanium.**
- **In uncooled LWIR, Chinese ecosystem is now the unrivaled leader.**
- **Innovation in image sensors continues, driven by the emergence of new technology platforms and ongoing efforts to reduce costs.**

# SOURCES

## Yole Group's related reports


SWIR, MWIR and Cooled Infrared Imaging 2025


Thermal Imaging and Sensing 2025


Automotive LWIR Comparison 2025 (Technology and Cost Comparison)

https://www.yolegroup.com/

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# Thanks for your attention!

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