



CEOI Emerging Technologies Conference:

Latest Detector Developments in UV/VIS & IR

Teledyne e2v Space Imaging

Andrew Pike

# Agenda

## CEOI Emerging Technologies Conference

Teledyne Intro

Short Wave Infrared

Technology & Capability  
Overview

Commercial Space

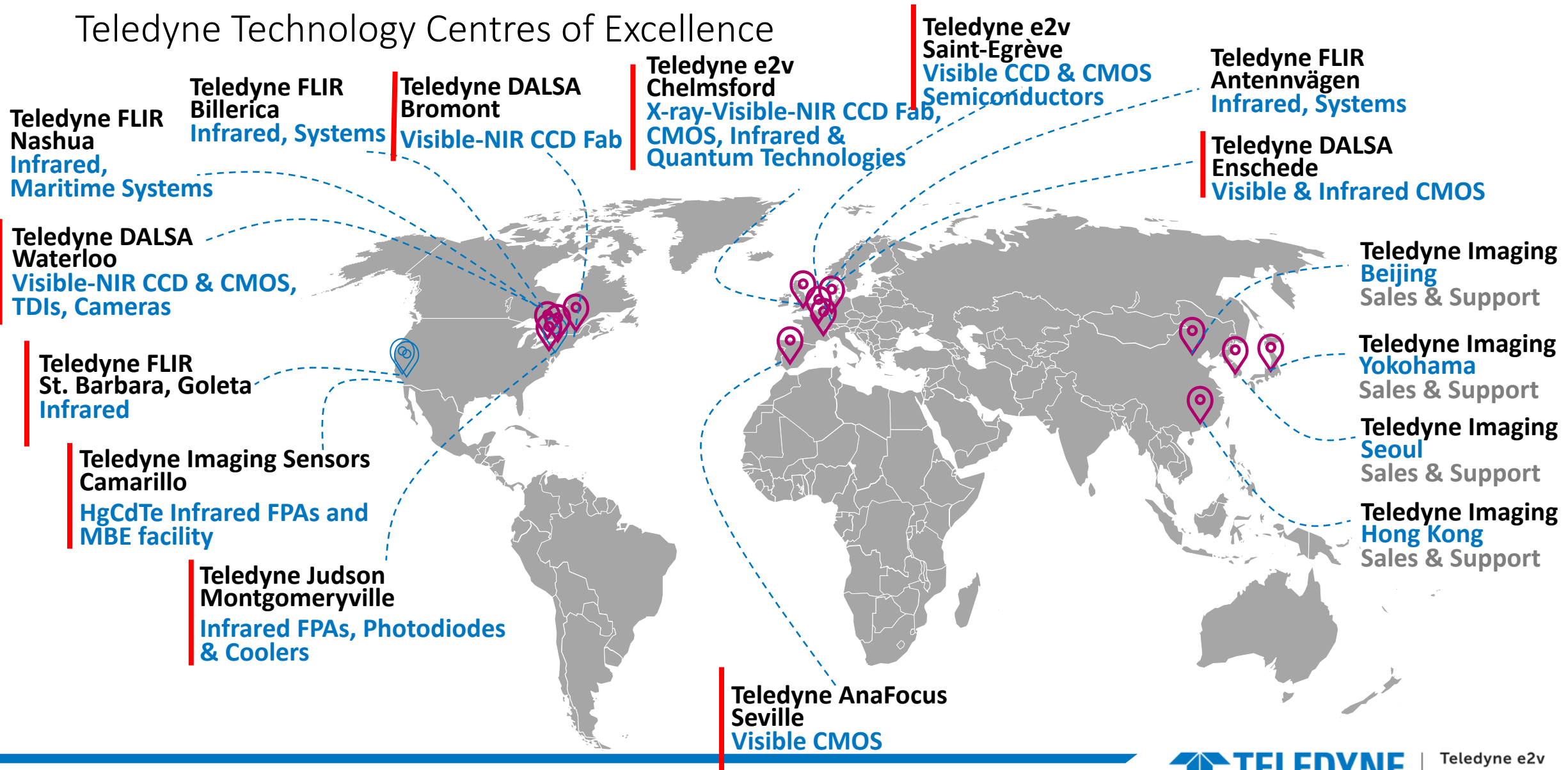
High Resolution Earth  
Observation

Technology Impacts

Large Area CMOS

# Imaging Sensors

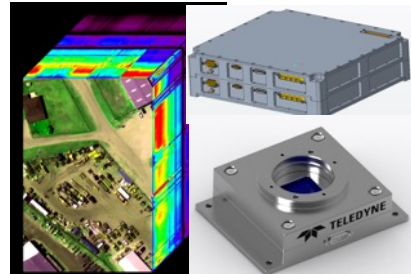
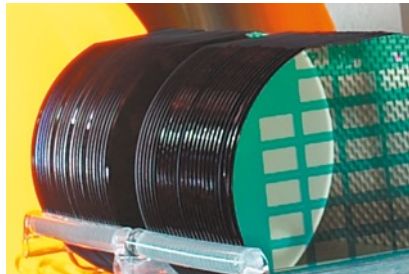
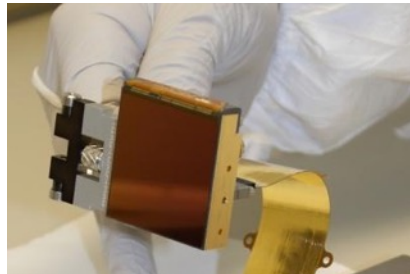
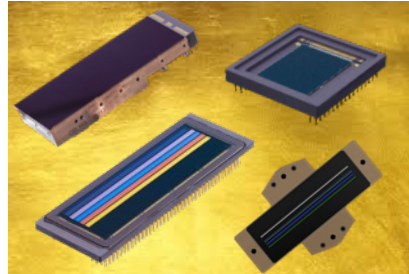
## Teledyne Technology Centres of Excellence



# Teledyne e2v Space Imaging

Imaging technologies from X-ray to Visible to Infrared

Responding to demands for greater electro-optical performance, spatial resolution, spectral resolution and data handling solutions for Earth Observation



## Teledyne Imaging

## CMOS

## Infrared

## Foundries & Coatings

## Semiconductors

## Systems

Technologies available from across Teledyne  
Single point for space imaging solutions in UK

Expanding the CMOS platforms for space  
High performance sensors  
Area | TDI | NIR  
Low Noise

HgCdTe (MCT)  
(US & European)  
Hyperspectral imaging across VIS to SWIR  
ROICs for MWIR/LWIR

X-Ray to NIR  
Backthinning –  
8 inch CMOS  
Coatings - UV to NIR  
Black coating

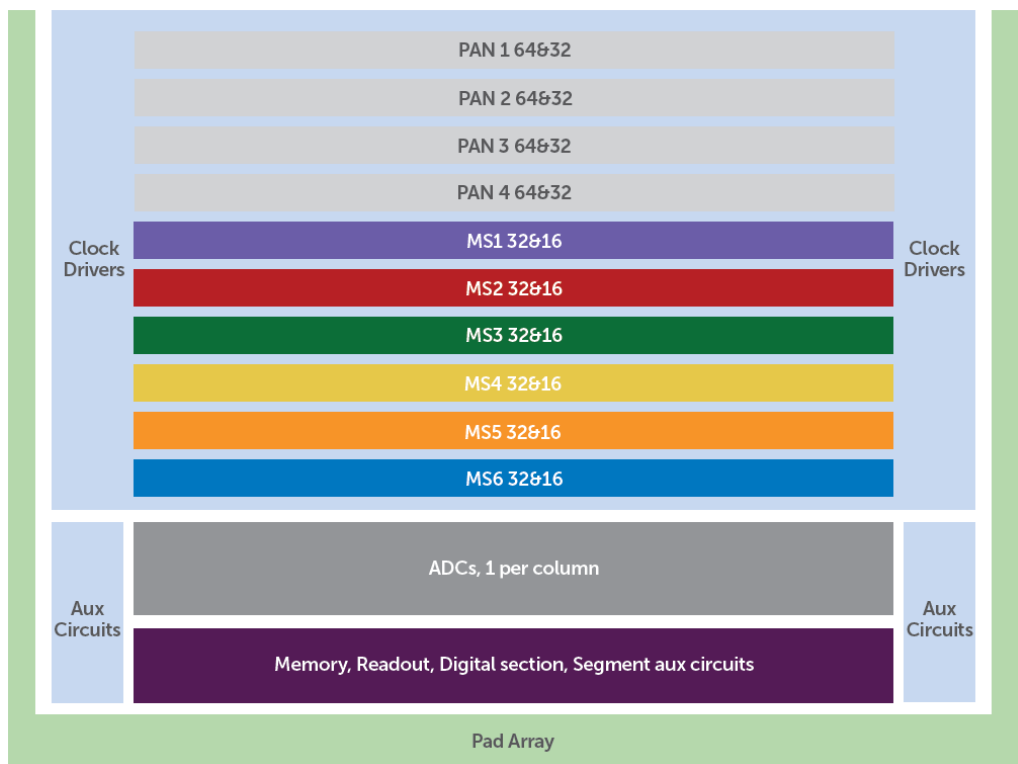
Space Advanced Edge Computing Platforms  
Processors, Memory & Converters

Front-End Electronics  
Data Handling Units  
Focal Planes  
Distributed data processing

# High Resolution Earth Observation Detectors

- Established UK supply chain of CMOS TDI detectors for high resolution EO
- Leveraging latest CMOS blocks from across Teledyne and internal CMOS developments
- Demonstrated CCD-on-CMOS for high performance SNR, FWC & MTF

CMOS TDI CIS125 architecture Block diagram



CMOS TDI CIS125 top level product information

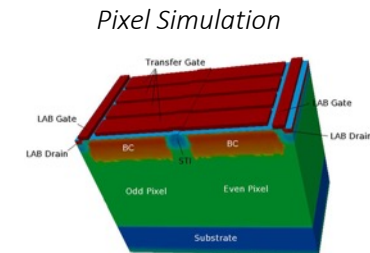
Specification	Front-side illuminated (FSI) and backside illuminated (BSI)
PAN channels	4 Panchromatic bands (P1, P2, P3 and P4, with half pixel offset)
MS channels	6 Multispectral bands with 2 subarrays per band
Pixel pitch	PAN: 5µm x 5µm MS: 10µm x 10µm
Number of columns	PAN: 16k / MS: 8k
Full Well Capacity (per array)	PAN: 30 ke- / MS: 80 ke-
Max. Line Rate	PAN: 40kHz MS: 40kHz Default Operating Mode: 14.7kHz
Read-out speed	40Gb/s (20 parallel 2Gb/s CML channels)
Power Dissipation	≤ 10 W
Other features	Antiblooming, Bidirectional, Radiation Tolerant, Optional Integrated MS Filters
TRL Level	TRL 5: Flight model qualification in progress

# High Resolution Earth Observation Detectors

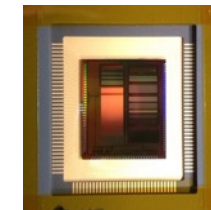
## EO Technology Development

### Design & Development

- CIS123 test chip platform for CMOS TDI CCD-on-CMOS R&D
- Benefits from Industrial-Academic Collaboration with Centre for Electronic Imaging at the Open University – New way of working established
- Standardised electrical interface across Teledyne e2v digital detectors
  - For example, high speed CML data output to simplify interface with Electronics



CIS123 Test Chip



### CEOI funding accelerates product development:

- Product prototype phase (2018 – 2021) and next generation of CMOS TDI pixel (2023 – 2024)

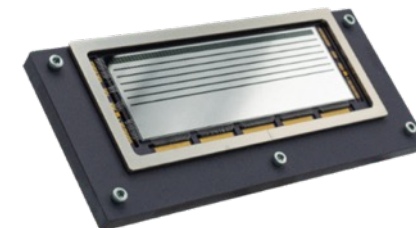
### Manufacturing and test capabilities established:

- New black coating process to minimise straylight
- Multispectral filter integration

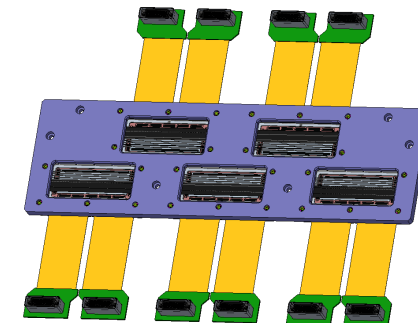
### Next Developments:

- Systems solutions for front-end electronics and focal plane arrays
- Demo kit availability

CIS125 Detector Assembly



Focal Plane Array Concept



# TDI CMOS at a Glance

Space Imaging established as single point of contact for full Teledyne CMOS TDI family

## Impacts of new technologies:

- CIS125 adds high performance detector to CMOS TDI family of products
- Enables next generation of high-resolution earth observation detectors
- Contracts with new and established space Customers
- CIS125 EM & FM product delivery started 2024
- Global pipeline across Asia, Europe and US
- First CIS125 FM launch in 2025



Performance Specifications		IC-49-12K2	IC-51-12K2	IC-51-12K3	IC-52-12K2	CIS125-40
Number of pixels	PAN	12288	12288	12288	0	16000
	MS	3072	6144	6144	12,288	8000
Bands	PAN	2	2	2	0	4
	MS	4	6	6	6	6
Pixel size (µm)	PAN	7	7	7	N/A	5
	MS	28	14	14	7	10
Full Well Capacity (ke-)	PAN	≥ 70	≥ 80	≥ 100	N/A	≥ 30
	MS	≥ 280	≥ 240	≥ 300	≥ 85	≥ 80
Read-out speed at max. line rate (kHz)		2.2 Gb/s via CML interface @ 55MHz input master clock	2 Gb/s via CML interface @ 100MHz input master clock	2 Gb/s via CML interface @ 100MHz input master clock	2 Gb/s via CML interface @ 100MHz input master clock	40Gb/s (20 parallel 2Gb/s CML channels)
Power dissipation (W)		≤ 6	≤ 7.5	≤ 7.5	≤ 10 W	≤ 10 W

# New Area CMOS Detectors

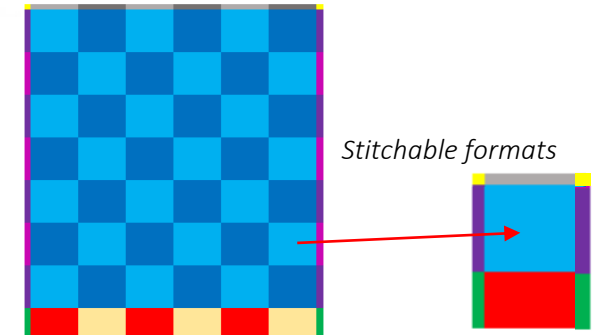
## CIS300 Family for Earth Observation



CIS303/4

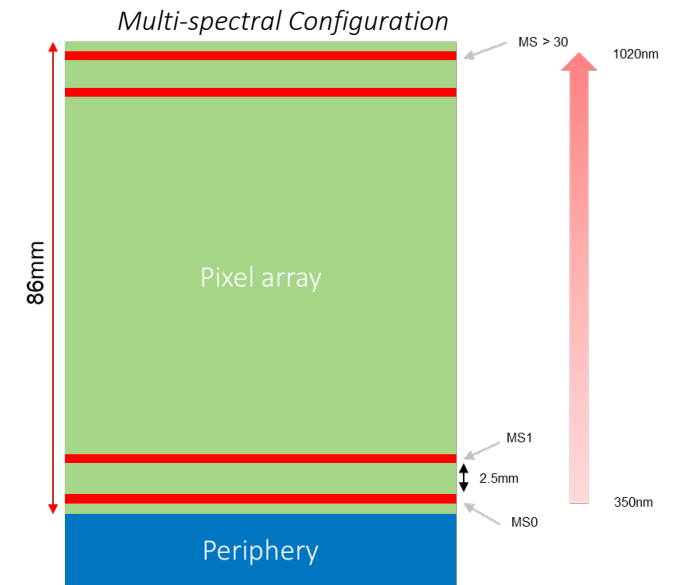
### Flexible large format CMOS imager:

- High electro-optical performance in radiation tolerant platform (low noise, high FWC, dual gain)
- Flexible operation – rolling shutter, global shutter and HDR operation
- Stitchable design enabling different formats
- 10µm pixel pitch baseline – readily scalable to 5µm, 20µm or 40µm with minimal NRE
- Available as standard Si or as CMOS HiRho
- Initial prototypes manufactured in 9k and 4.5k formats



### Mission enablement:

- Baselined for Copernicus next generation missions
- Baselined for GEOXO Lightning Mapper (LMX) for NASA
- Suitable for area imaging or multi-spectral up to 30 channels





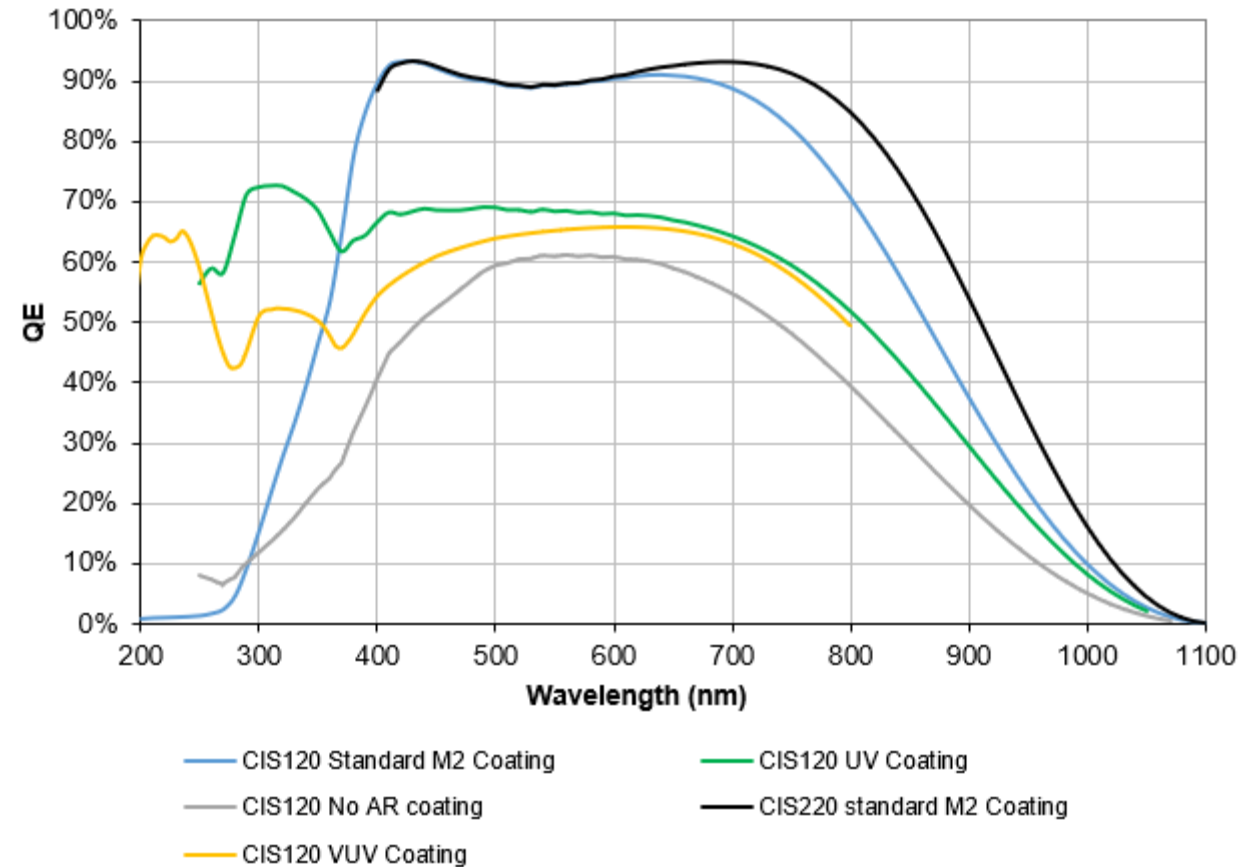
# Spectral Response UV to NIR

## Process and Coatings Development

- Processes developed enable higher performance quantum efficiency across broader range.
- Key technology enablers
  - 8" back-thinning
  - CMOS HiRho for NIR – In collaboration with CEI
  - X-ray variants – In collaboration with CEI
  - UV coatings



High QE on a large spectrum with one silicon



# Short Wave Infrared

## CHROMA-D SWIR MCT

### Technology:

- Teledyne manufactures high performance HgCdTe (MCT) IR material
  - Detection over 400nm (UV) to 14.5um (LWIR) spectral range
  - Fully flexible and precise cut-off wavelength control
  - High EO performance – high QE, low dark signal
- Teledyne hybridise to either analogue or digital output ROICs
  - ROICs are stitchable enabling different format detectors

### Developments:

- Teledyne e2v opened new European supply chain of high-performance SWIR detectors
  - UK development of packaging and test capabilities established
  - Use MCT material with 2.5  $\mu\text{m}$  cut-off on CHROMA-D digital output

### Impacts :

Selected for key missions benefitting science and society:

- Copernicus CHIME mission – Hyperspectral spectrometer to map changes in land cover and sustainable agricultural practices.
- TRUTHS missions – Radiometric calibration for climate measurements



CHROMA-D SWIR 3k x 512



CHROMA-D SWIR 2k x 512  
& 2k x 1k

# From Institutional Space to Commercial Space

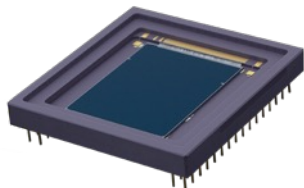
## Bringing Space imaging Experience to Commercial Space

Commercial space market driving new and emerging developments in earth observation

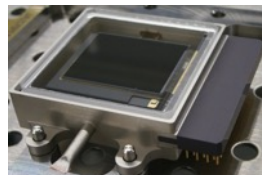
- Simplification and standardisation of radiation hard existing space products
- Upscreening and upgrading of COTS industrial sensors
- Offering sub-system solutions to simplify payload integration

### Teledyne e2v CIS120 general purpose space imager:

- 2k x 2k 10µm format, radiation hard image sensor
- Different variants – Electro-optical, coatings, packages, foundry
  - CIS120<sup>LN</sup> - Low Noise TRL6
  - CIS120<sup>LS</sup> – Large Signal TRL6
  - CIS120<sup>XLS</sup> – Extra Large Signal TRL9
- CIS120 selected for Copernicus CO2M
- CIS120<sup>XLS</sup> variant selected for standardisation



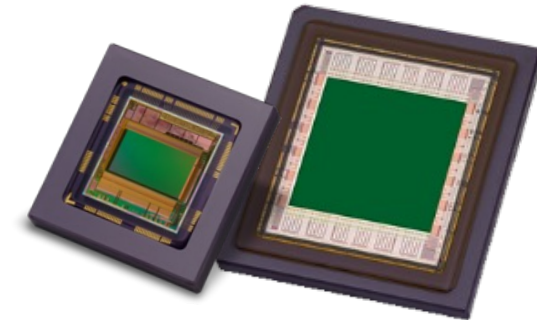
Standard ceramic package



Sealed Peltier package

### Teledyne e2v Machine Vision industrial imagers:

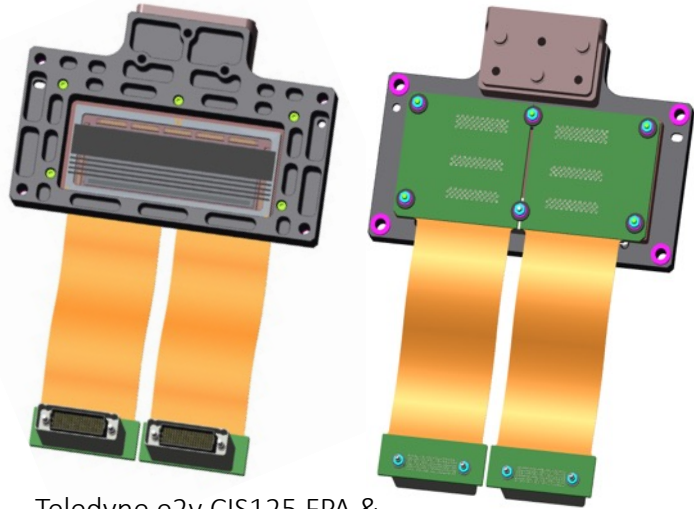
- Specific detectors selected from wide range available
  - Emerald, Emerald Gen2, Ruby5.5
- Produce qualification report (environmental & radiation)
- Batch testing on lots to provide product assurance
- Optional screening LAT as required by Customer



# Sub-System Developments

## Payload Solutions

### Detector & Focal Plane Arrays



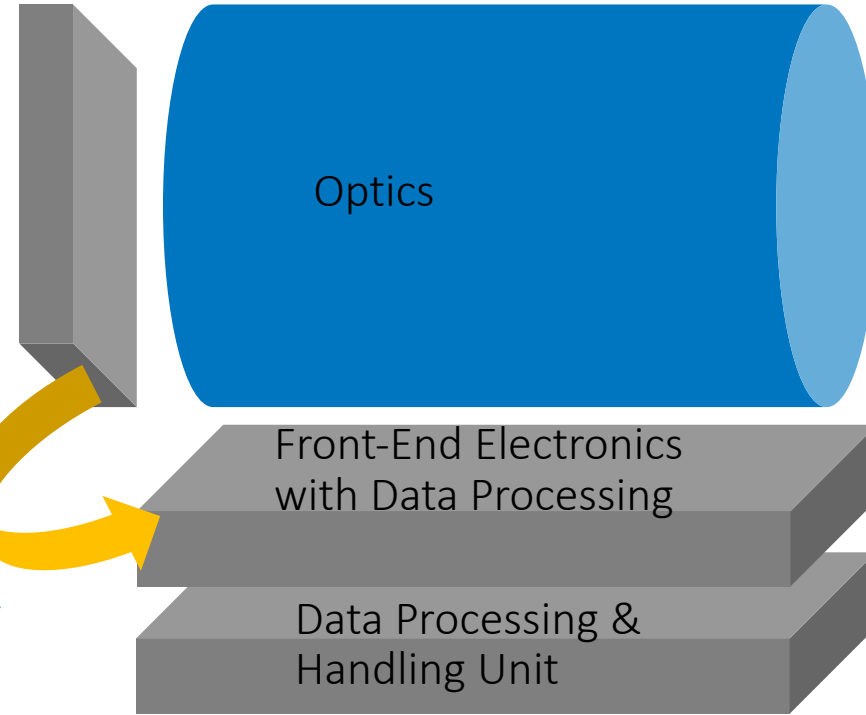
Teledyne e2v CIS125 FPA & harness concept

### Front-End Electronics



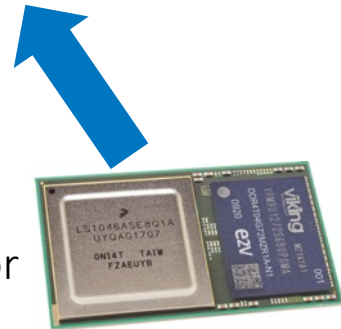
Based on Teledyne e2v FEE roadmap for both institutional and commercial approaches

Compatible with range of Optical Partners



### Data Handling Units

Based on Teledyne e2v Semiconductor processor technology



Qormino Processing Module

# Future Opportunities

## Predicted Impacts of New Technologies

- Enabling New Missions through
  - High performance space detectors
  - High spatial & spectral resolution
  - Commercial space detector solutions
- Global growth in UK export of Earth Observation – institutional and commercial space
- FEE solutions to simplify payload integration
- Distributed data processing solutions
- New solutions through collaboration

