THERMAL IMAGING OPTICS FOR DEFENSE APPLICATIONS

YOUR OPTICS PARTNER FOR MISSION SUCCESS

DECADES OF PARTNERSHIP WITH LEADING DEFENSE OEMs

Leading Provider of Defense Thermal Imaging with NATO Country-Based Production Site

MKS Ophir brand is at the forefront of innovation in the field of advanced defense thermal imaging, with state-of-the-art manufacturing facilities in Romania, a NATO member country, as well as Israel. Our commitment to excellence is evident in our high-performance IR optical elements and assemblies, meticulously crafted to meet the rigorous demands of defense and security applications.

Decades of Experience and Unmatched Partnerships

With 50 years of experience in the field of electro-optics, shaped by extensive collaborations and strategic partnerships with leading defense OEMs, we are a trusted partner for our customers, providing innovative solutions based on unrivalled capabilities and expertise that support major defense platforms worldwide.

One-Stop-Shop Solutions Provider

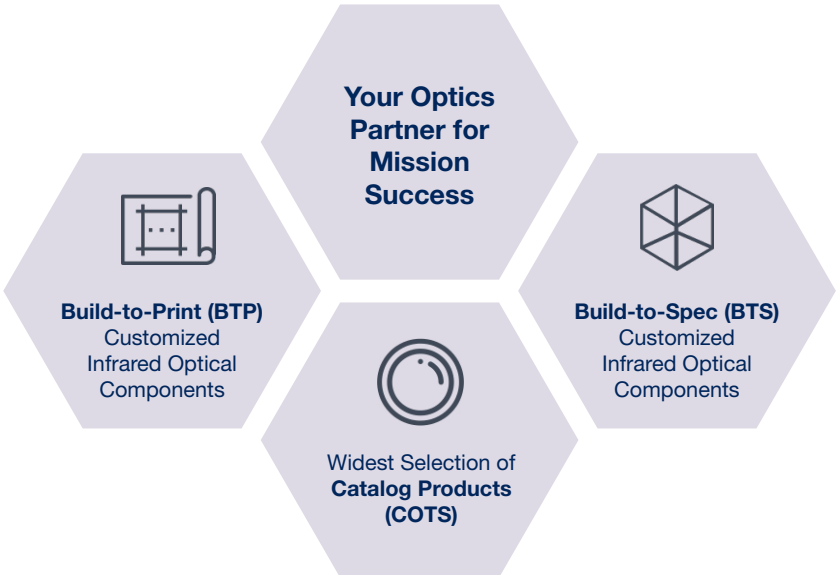
With a track record of designing and supplying thousands of thermal imaging optics for various defense applications, we have earned recognition as one of the world's leading one-stop-shop providers of infrared thermal imaging components for defense OEMs.

Collaborative R&D Approach

Our dedicated R&D engineering team collaborates closely with defense customers, leveraging their extensive experience to develop, design, and deliver high-performance optics tailored to meet the stringent requirements of high precision and environmentally challenging defense applications. This collaborative approach ensures that Ophir IR Optics product lines align perfectly with the evolving needs of defense customers, facilitating the deployment of today's most advanced aerospace and defense solutions.

Applications Served

- **Ground-based:** Anti-drone IR systems (C-UAS), Enhanced Vision Systems (EVS), Driver Vision Enhancement (DVE), Situation Awareness Systems (SAS), Remote Controlled Weapon Stations (RCWS), Tank Gunner/Commander Sight, Thermal Goggles, Thermal Weapon Sight (TWS), Hand-Held Thermal Imagers (HHTI)
- **Airborne:** Unmanned Aerial Vehicles (UAV), Payloads and Forward-Looking IR Cameras (FLIR)
- **Naval:** Surveillance, Targeting
- **Missiles:** Optical build-to-print components for IR guided missiles, including domes, mirrors and Cassegrain telescopes
- **High Energy Laser (HEL) Systems:** directed-energy and defense laser platforms



Widest IR Assemblies Product Range

Our range of long-lasting products includes IR complex lens assemblies with various focus mechanisms:

- Fixed
- Manual
- Motorized focus
- Continuous zoom

From LWIR, MWIR to SWIR, we excel in production of the following product configurations:

- Single Field-of-View (FOV)
- Multiple FOV
- Zoom

Our knowledge and experience in motorized continuous zoom lens systems is recognized by customers around the world.

Build-to-Spec (BTS) & Build-to-Print (BTP) Expertise

Advanced optical design technologies and innovative engineering are applied to our build-to-specification (BTS) development processes, allowing us to reach efficient design results with fewer elements, lighter components, and reduced-cost.

These same advanced capabilities and expertise are combined with cutting-edge manufacturing technologies such as MRF technology, diamond-turning machines, CNC generators and polishers, automated coating chambers, and advanced metrology and test equipment, to create our build-to-print components and assemblies, including aspheric, diffractive and spherical lenses, mirrors, domes, windows and prisms.

Meeting Strict Defense Market Demands

We harness innovative designs to provide the largest portfolio of products with field-proven performance, answering the strict demands of global defense customers for:

- Lightweight, compact designs answering the strict SWaP restraints
- Rugged design for durability in harshest environmental conditions
- Outstanding detection, recognition, and identification (DRI) ranges
- Constant F-number and Line-of-Sight (LOS) retention throughout the zoom range
- High precision optics with MTF close to the diffraction limit
- Focal length ranges from 1.8mm to 1350mm
- Rigorous QA precess, MIL STD compliant

GERMANIUM-REDUCED OPTICS FOR VGA UNCOOLED LWIR 10-12 µm DETECTORS

Complete H-FOV Coverage for VGA 12 µm Detectors

Product Number	Focal Length (mm)	F/#	H-FOV (deg)*
680582	15-75	f/1.2	29.9° (WFOV) 5.8° (NFOV)
680596	5.5	f/1.2	86°
680310	8.7	f/1.0	50°
680258	9.0	f/1.4	49°
680407	9.2	f/1.0	50°
680269	9.3	f/1.3	48°
680412	13.6	f/1.0	32°
680312	19.8	f/1.2	21.7°
680602	24.0	f/1.0	18°
680193	50.0	f/1.2	8.8°
680603	73.1	f/1.05	6°

*H-FOV values are calculated for a 12 µm, 640×480 LWIR detector.

OPHIR® KAMU MWIR SXGA INFRARED CAMERA SERIES

High-performance, integration-ready, SXGA MWIR f/4 thermal camera series pairs continuous zoom optics with advanced video processing, consistent thermal performance, and MIL-STD-810-class ruggedization

- SXGA MWIR cooled sensor (1280x1024, 10 µm)
- Constant f/4 at 0.6° (NFOV) to 47.8° (WFOV)
- Digital Outputs & streaming H.264/H.265, HD SDI, HDMI
- Advanced NUC & calibration 2-point NUC, optional 1 point
- Open-frame and MIL-STD-810 qualified configurations available
- Multiple zoom configurations: 21-420mm/ 30-600mm/ 35-690mm/ 45-900mm/ 60-1200mm

Figure 1: The Ophir Kamu 900mm open-frame, and the Ophir Kamu 900mm MIL-STD-810 qualified configuration

STRICT QUALITY ASSURANCE (QA) PROCESSES

Figure 2: QA process throughout product manufacturing cycle

New! AquaShieldIR Lens Coating: Long-lasting Protection, Enhanced IR Lens Capability for Maritime Environments

AquaShieldIR

Knowing firsthand the unique challenges posed by wet, humid, and salty coastal environments, we have meticulously crafted the new AuqaShieldIR lens coating to tackle the challenges of maritime environments head-on.

With its advanced hydrophobic properties, the AquaShieldIR lens coating provides unparalleled protection and boosts the performance of your IR imaging system for the long run.

Lasting Key Capabilities & Benefits:

- Exceeds MIL-STD 810 for durability testing in salt fog and salt solution
- Creates a water-repellent surface on IR imaging lenses
- Enables high performance in wet conditions, including rain and fog
- Provides clear imaging and reliable performance in maritime environments

CUSTOM OEM COMPONENT MANUFACTURING PER ANY SPECIFICATION

Vast Versatility

- Manufacturing large size mirrors, lenses, mirrors, domes, windows, and prisms, supporting multispectral optics and emerging applications
- VIS to LWIR wavelengths
- Spherical, aspherical, diffractive, flat, and free-form shapes
- Doublets and triplets
- Substrates: Germanium, Silicon, Zinc selenide, Zinc sulfide (IR & multispectral), Calcium fluoride, Chalcogenide materials such as IG materials

Core Capabilities

- In-house, cutting-edge manufacturing technologies:
  - MRF
  - Lupho Scan Profilometers
  - Diamond turning
  - CNC polishing
  - Coating
  - Metrology
- Highest development standards including Design for Manufacturability and Assembly (DFMA) as well as highest production standards including risk analysis.
- Complete control of production processes
- Statistical Process Control (SPC) over full production cycle
- Innovative engineering
- Large volume high-end production capabilities
- Manufacturing sites in Israel and Europe (Romania) with a clean room the coating, inspection and packing processes

Superior Components Manufacturing

- MRF strict irregularity
- Large optics up to 400mm dia
- Dual A-spherical elements
- Freeform (non-radial or matrix)
- Off axis parabolas
- Special truncated shapes
- Doublets and triplets
- Prisms of all types
- Mass production of low-cost IR small lenses

Figure 3: Ophir components: mirrors, domes, truncated shapes, prisms

Tolerances (typical | high-end):

	Windows	Lenses		Mirrors
Dimensional	± 0.05mm | ± 0.01mm	± 0.05mm | ± 0.01mm		± 0.05mm | ± 0.01mm
Surface Figure (P-V)	Flatness 0.5 | 0.2Fr Irregularity 0.2 | 0.1Fr	**Spherical** Power 2Fr | 1Fr Irregularity 0.5Fr | 0.2Fr	**Aspherical** Radius tolerance 0.1% | 0.05% Irregularity 1Fr | 0.5Fr	Flatness 0.5Fr | 0.2Fr
Parallelism	3 | 5 arc sec.	3 | 5 arc sec.		3 | 5 arc sec.
Surface Quality (S-D)	80-50 | 10-5	80-50 | 10-5		80-50 | 10-5
Roughness nm, RMS	2 | 0.5	2 | 0.5		2 | 0.5

Our in-house testing tools encompass all required specifications and include the following:

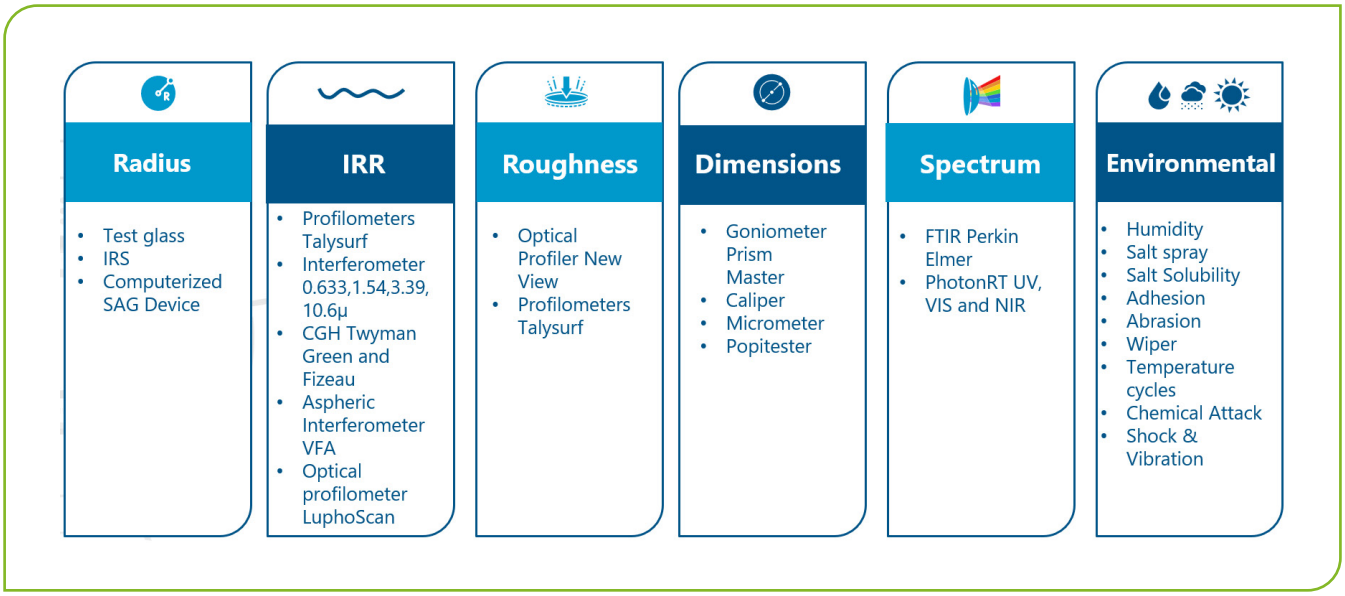


Figure 4: QA testing tools per specification requirements

Standard Compliance

- AS9100 Rev. E and ISO 9001:2015 certified
- US and European military standards compliant with:
  - DIN 3140
  - IPC 620
  - MIL-PRF 13830
  - MIL-PRF 85285
  - MIL-STD-810
  - MIL-C-48497
  - MIL-C-48616
  - ISO 10110 sections 1-19, ANSI\ASQ Z1.4

Advanced Infrared Optics Coatings

Coating Types:

- Anti-reflective (AR), mirrors and filters
- UV, VIS, NIR, SWIR, MWIR, LWIR
- Multispectral coatings
- High efficiency and high durability coatings
- DLC (HC) coatings and Low Reflectance HC (LRHC)
- Laser coatings YAG and CO_2

Coating Performance:

- Broadband AR:
  - Ref < 0.5% to 0.2%
  - Tra > 98% to 99%
- Broadband mirror: Ref > 98% to 99%
- Windscreen Wiper Test TS1888 / P 5.4.3 – DLC coatings

LARGE REFLECTIVE OPTICS FOR MULTISPECTRAL IMAGING SYSTEMS

Large reflective optics are essential for high-performance multispectral imaging systems in defense, surveillance and aerospace applications.

Our expertise lies in producing and assembling precise, large reflective optics available in spherical, aspherical, parabolic, and freeform shapes, fabricated from materials such as aluminum, silicon, germanium, and copper.

With strict accuracy and surface quality standards, Ophir's reflective optics meet the rigorous demands of multispectral imaging applications across visible, UV, and IR wavelengths.

High-end Specifications

- Diameter up to 700 mm
- On or off-axis mirrors
- Radius tolerance of 0.05%
- Irregularities less than 0.5 Fr P-V, 0.1 Fr RMS at 0.633µ
- Roughness less than 40 Å RMS

Advanced Optical Coatings

Coating types:

- Anti-reflective (AR), Mirrors and
- Filters
- UV, VIS, NIR, SWIR, MWIR,
- LWIR
- Multispectral coatings
- High efficiency and high durability coatings
- DLC (HC) coatings and Low Reflectance HC (LRHC)
- Laser coatings YAG and CO2
- EUV coatings

Coating performance:

- Broadband AR: Ref<0.5% to 0.2% Tra>98% to 99%
- Broadband mirror: Ref>98% to 99%
- Windscreen Wiper Test TS1888 / P 5.4.3 – DLC coatings

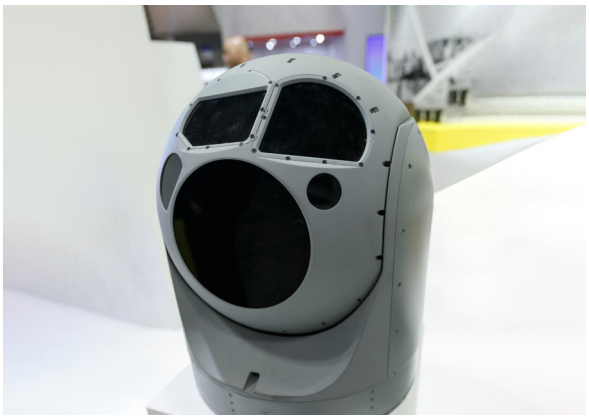


Figure 5: Multi-spectral electro-optical/infrared (EO/IR) system. Image credit: Alamy.

HIGH ENERGY LASERS FULL SCALE SOLUTIONS

Ophir® Precision Engineered Optics for High-Energy Laser (HEL) Systems

Mission critical custom optics & coatings

Custom optics and coatings for mission-critical HEL systems.
Optimized for 100kW directed-energy platforms with ultra-low-loss performance.

Optical Component Capabilities

- Fused Silica (7980, 7979), Sapphire, Optical Glass
- Mirrors, Windows, Lenses, Dichroics, Beam Splitters, Filters
- Surface Accuracy: <λ/10
- Up to Ø400mm components diameter, Ø600mm coating diameter

Coating Technologies

- Ion Beam Sputtering (IBS)
- Spectral ranges: VIS, NIR, SWIR
- Coating types: HR, AR, Dichroic, Beam Splitter

Coating Technologies

- Absorption < 3 ppm (PCI)
- Reflectance > 99.9%
- Total Optical Loss < 0.1%

The Complete Ecosystem for High-Energy Laser Success

TRACK. DELIVER. MEASURE.

	1. TRACK: Thermal Imaging	2. DELIVER: HEL Optics	3. MEASURE: Power Analysis
Product	Thermal channel 900mm f/4 SXGA	Custom HEL components	150kW Calorimetric Sensor
The role	Long-range target acquisition and tracking for DEW platforms	Ultra-low-loss beam delivery and combining for up to 100kW	Precision measurement and calibration of high-power beams
Key spec	Continuous zoom with 45-900mm capability	< 3 ppm absorption with IBS coatings	Water-cooled for extreme power densities

Advanced High-Energy Lasers Optical Coating

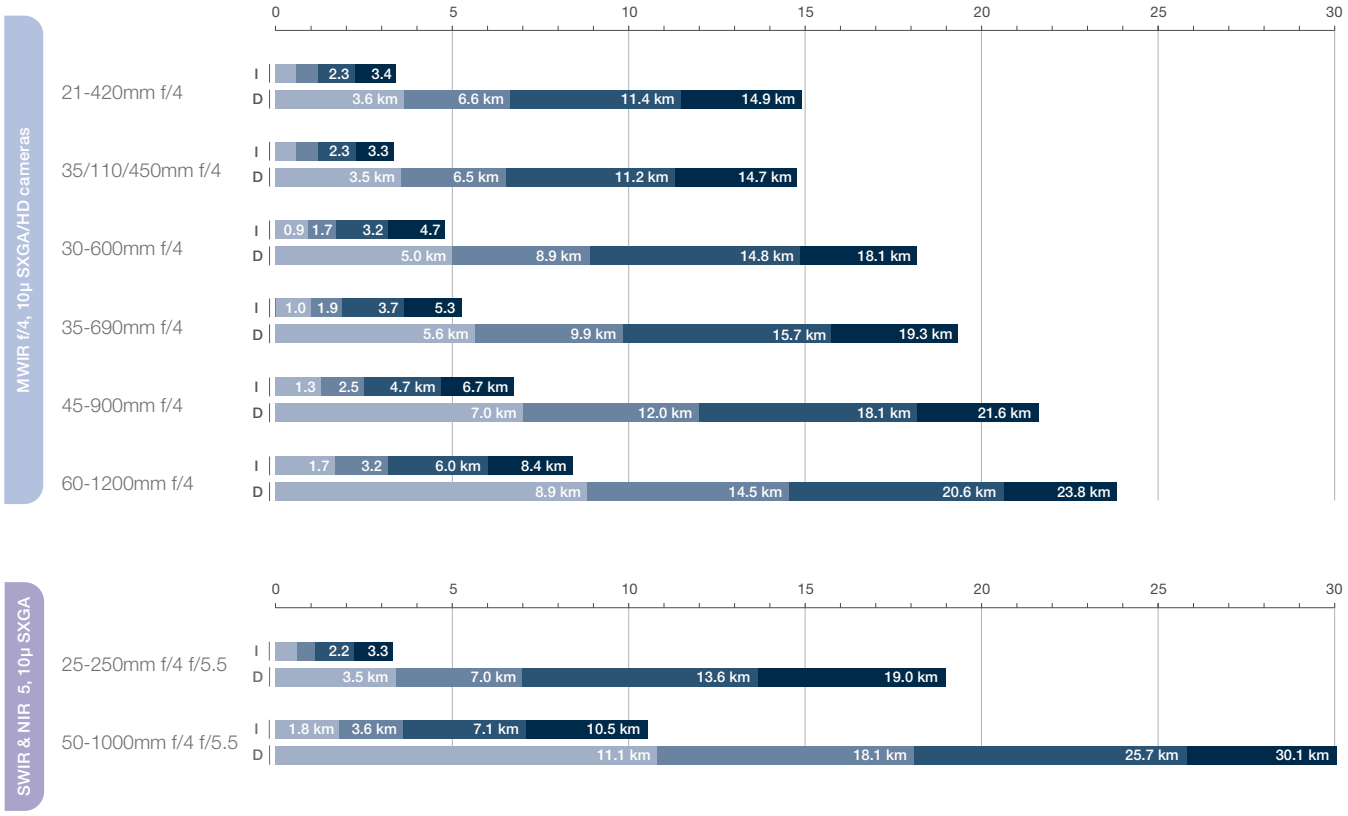
Optical Component Capabilities

- Materials: Fused Silica (7980, 7979), Sapphire, Optical Glass
- Components: Mirrors, Windows, Lenses, Dichroics, Beam Splitters, Filters
- Surface Accuracy: < λ/10
- Component Diameter: Up to Ø400 mm
- Coating Diameter: Up to Ø600 mm
- Absorption: < 3 ppm (PCI Measurement)
- Reflectance: > 99.9% (PhotonRT Spectrophotometer)
- Total Optical Loss: < 0.1% (Cavity Ring Down)

Coating Technologies

- Ion Beam Sputtering (IBS)
- Spectral Ranges: VIS, NIR, SWIR
- Coating Types: HR, AR, Dichroic, Beam Splitter

ZOOM LENSES IDENTIFICATION AND DETECTION RANGES FOR COUNTER-DRONE SYSTEMS



I = Identification
D = Detection

Micro Quadcopter 20x20cm

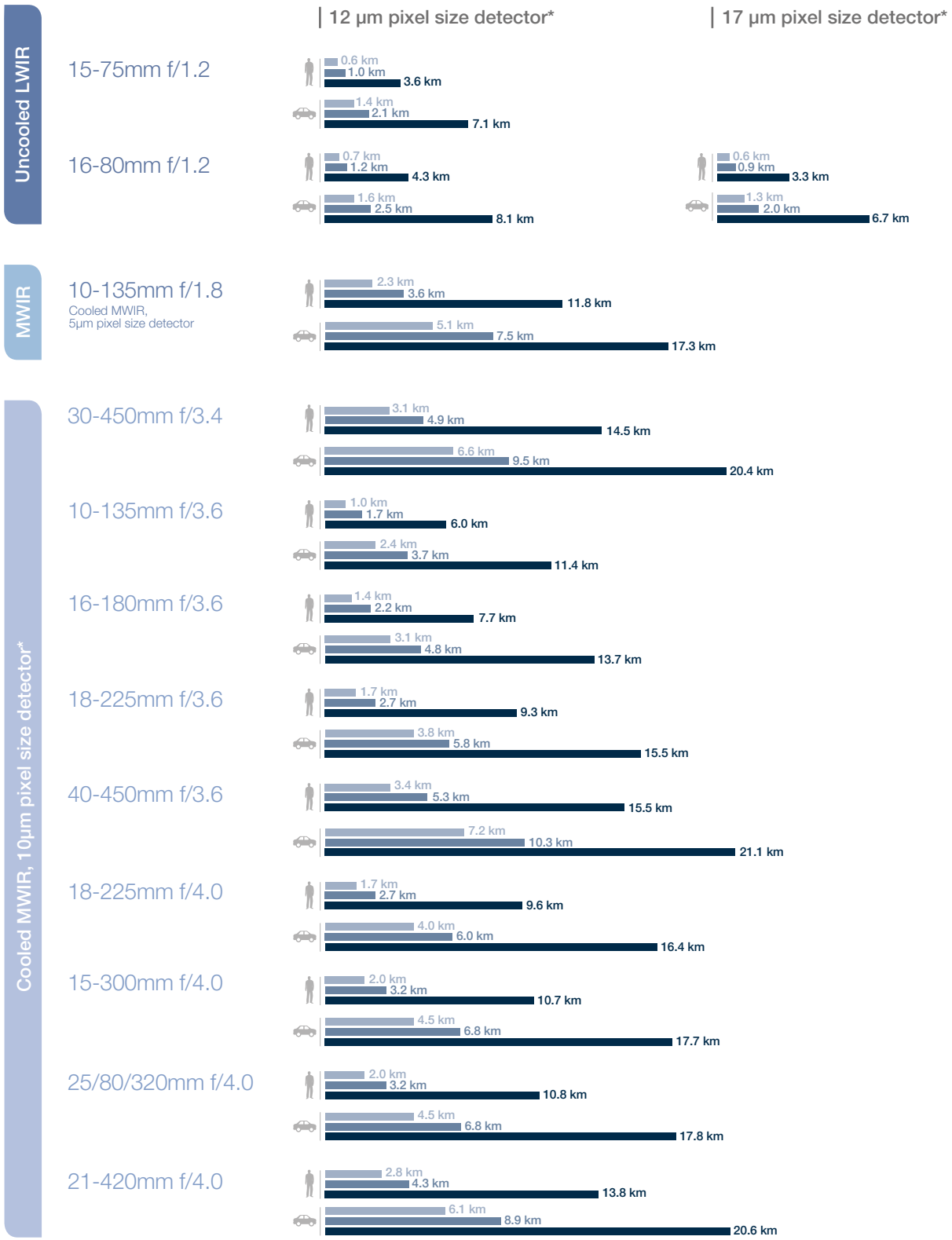
Quadcopter 40x40cm

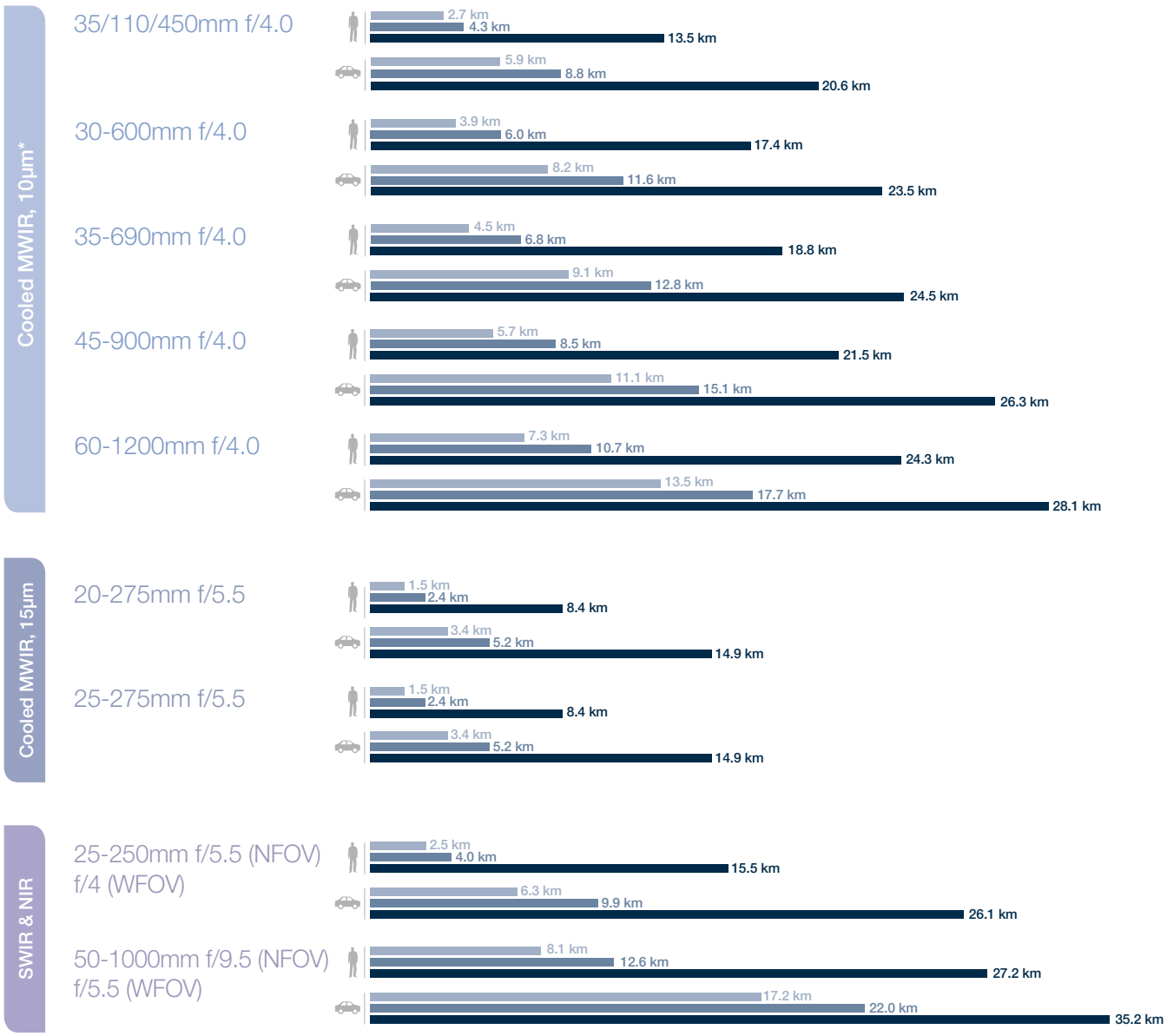
Hexacopter 80x80cm

Octocopter 120x120cm

Assumptions: NETD MWIR (f/4) 23mK | 2°C target ΔT | 30Hz frame rate MWIR | 25Hz frame rate SWIR at 0.7µm to 1.7µm spectral range, day mode TRM4 model, 10µm pitch Cardinal 1280 detector, overcast daylight irradiance | 0.2km^{-1} atmospheric attenuation coefficient | 50% detection probability | 0.2 path radiance factor | 250m drone altitude (above ground) | 50% drone reflectivity | 15% background reflectivity

ZOOM LENSES DETECTION, RECOGNITION & IDENTIFICATION (DRI) PERFORMANCE





Identification
Recognition
Detection

Vehicle size 2.3m x 2.3m

Human size 1.7m x 0.5m

Note: Calculations used are based on “Johnson Criteria” | Real world performance may vary depending on the weather conditions

* Assumptions: 49mK NETD at f/1.8 for MWIR detectors | 23mK NETD (f/4 & f/5.5) for MWIR cooled detectors | 35.5mK NETD (f/3.4) | 32mK NETD (f/3.6) | 50mK NETD (f/1.0) for LWIR uncooled detectors | 30Hz frame rate | 50% detection probability | 0.2km^{-1} atmospheric attenuation coefficient | human ΔT = 5°C | vehicle ΔT = 2°C

** SWIR assumptions: 1280 detector | TRM4 model | Day mode | 0.7µm to 1.7µm spectral range | 25Hz frame rate | Overcast daylight irradiance | 0.2 path radiance factor | 0.2km^{-1} atmospheric attenuation coefficient | 50% detection probability | Human and vehicle target 50% reflectivity | 15% background reflectivity

mks | Ophir

About Ophir an MKS Inc. Brand

With five decades worth of knowledge and experience, MKS's Ophir Infrared Optics product line is a world leading designer and manufacturer of high-performance IR thermal imaging systems and optics for SWIR, MWIR & LWIR imaging. Using advanced technologies and innovative engineering we provide a global solution for homeland security, surveillance, defense and commercial applications: infrared thermal imaging cameras, complex lens assemblies and components.

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