

THERMAL IMAGING OPTICS FOR DEFENSE APPLICATIONS YOUR OPTICS PARTNER FOR MISSION SUCCESS





DECADES OF PARTNERSHIP WITH LEADING DEFENSE OEM'S

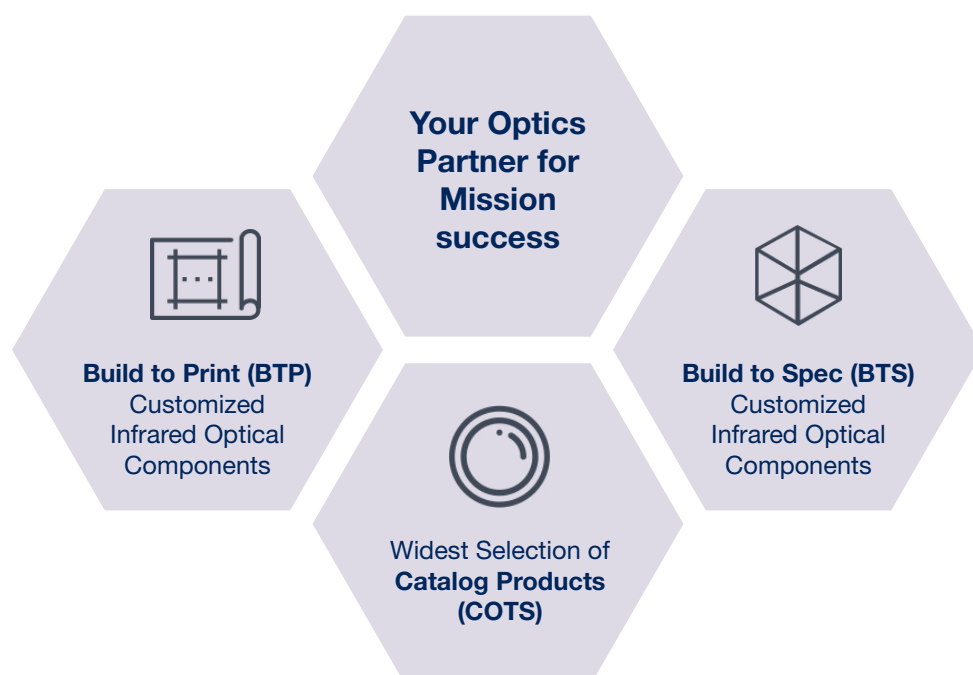
Ophir IR Optics is a leading provider of high-performance IR optical elements and assemblies for advanced defense thermal imaging applications. Ophir offers over 40 years of experience in the most advanced Electro-Optics programs, developed by the leading global defense OEMs. These partnerships have resulted in unmatched capabilities, reliability, knowledge, and solutions that serve major defense platforms worldwide.

With decades of knowledge and experience, having designed and delivered thousands of thermal imaging optics for multiple defense applications, Ophir has earned its reputation as a world-leading, one-stop-shop designer and manufacturer of Infrared thermal imaging components for defense OEMs.

Our R&D engineering team works in collaboration with defense customers to develop, design and deliver high-performance optics, delivering solutions for high precision and environmentally challenging applications, answering the strict demands of defense customers worldwide, enabling today's most advanced aerospace and defense solution deployments.

Applications served

- **Ground-based:** 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.



Build-To-Spec (BTS) & Build-to-print (BTP) expertise

With decades of knowledge and experience, having designed and delivered thousands of infrared components in the LWIR, MWIR or SWIR wavebands for multiple defense applications, Ophir has earned its reputation as a world-leading, one-stop-shop designer and manufacturer of Infrared thermal imaging components for defense OEMs.

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 (BTP) component and assemblies, including aspheric, diffractive and spherical lenses, mirrors, domes, windows and prisms.

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

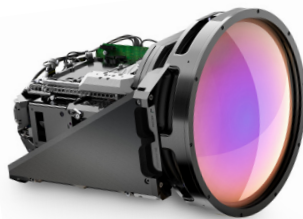
From LWIR, MWIR to SWIR we excel in the production of the following product configurations:

- 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.



SupIR 80-1200mm f/5.5
> 26km detection range
* For 15µm pixel pitch



SupIR 50-1350mm f/5.5
> 26.5km detection range
* For 15µm pixel pitch



SupIR 60-1200mm f/4
> 28km detection range
* For 10µm pixel pitch

Meeting defense market strict demands

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

- Lightweight, compact designs answering the strict SWaP restraints
- Ruggedized design for durability in harshest environmental conditions
- Outstanding detection, recognition, and identification (DRI) ranges >28km
- Accurate Line on Sight (LOS)
- High precision optics with MTF close to the diffraction limit
- Focal length ranges from 1.8mm to 1350mm

STRICT QUALITY ASSURANCE (QA) PROCESSES

With rigorous QA testing throughout the production process, we ensure that any finished product is optimized for the defense market requirements with the highest performance requested.

From design to delivery, our material control, in-process testing, operator inspections and final inspections all ensure that Ophir products meet the highest specifications and quality standards.

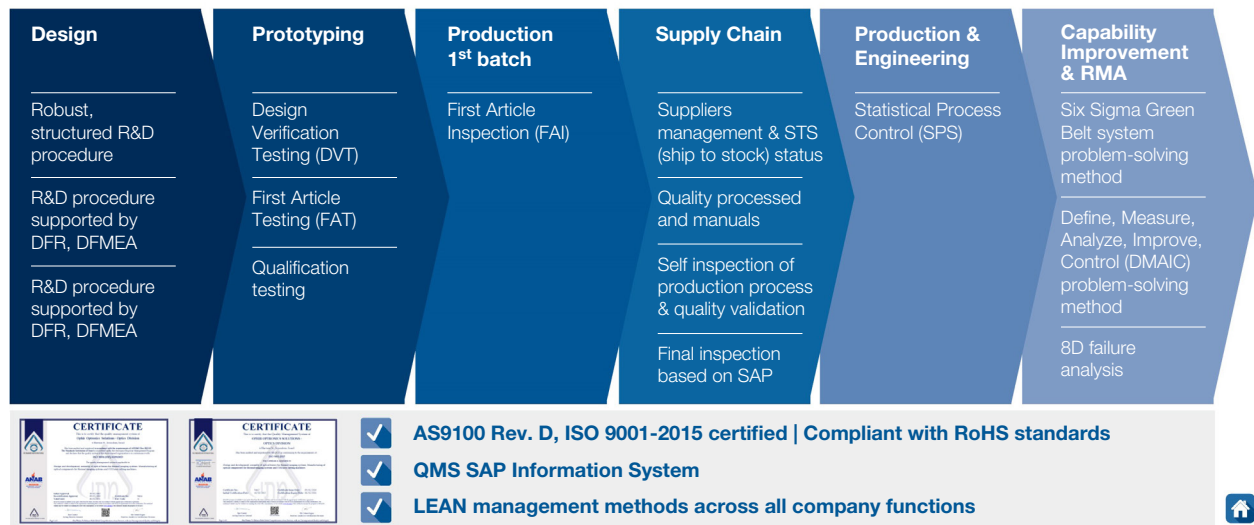


Figure 1: QA process throughout product manufacturing cycle

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

Radius	IRR	Roughness	Angle	Spectrum	Environmental
Test glass IRS Computerized SAG Device	Interferometers 0.633, 3.39 and 10.6µ CGH Twyman Green and Fizeau Aspheric Interferometer VFA Lupho Scan Profilometers technology	Optical Profiler New View Profilometers Talysurf	Goniometer Prism Master	FTIR Perkin Elmer Cary UV, VIS and NIR	Humidity Salt spray Salt Solubility Adhesion Abrasion Wiper Temperature cycles Chemical Attack

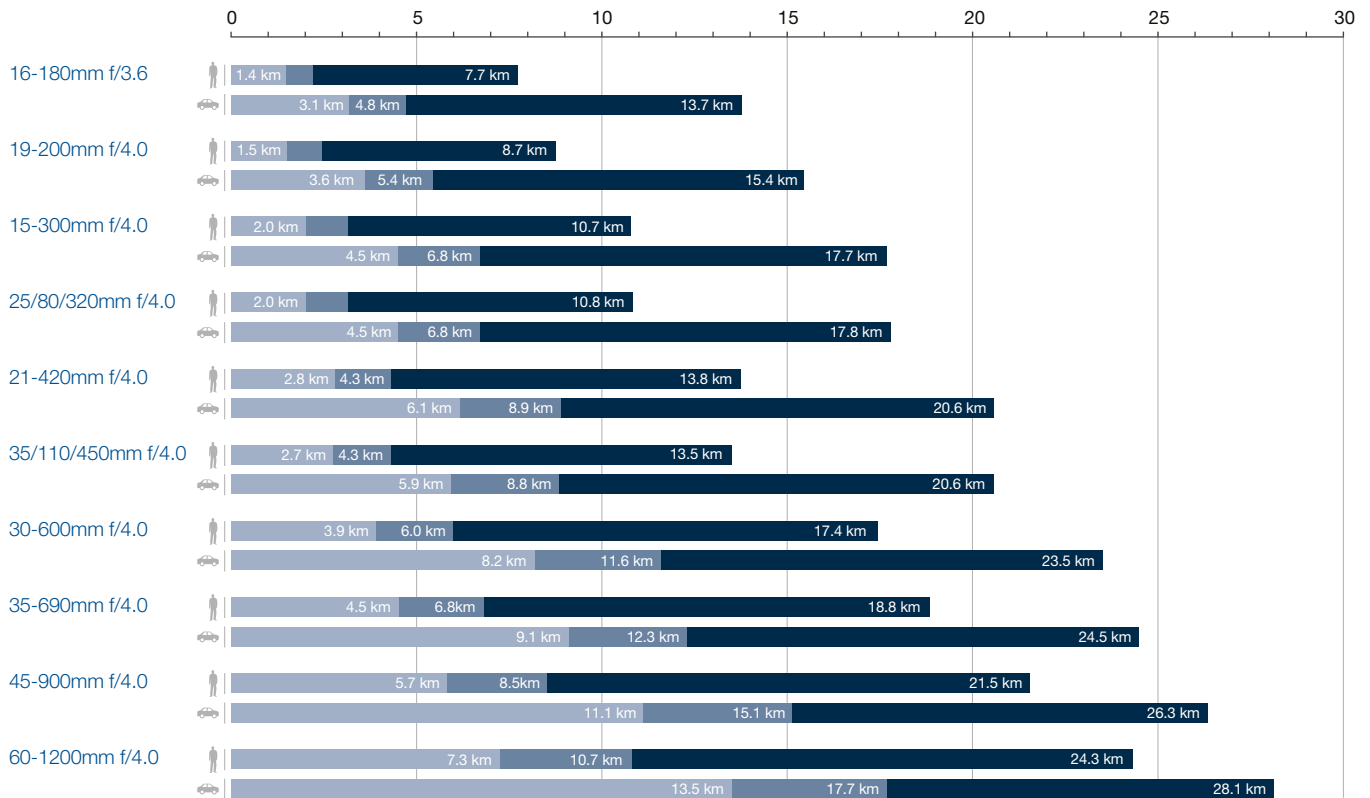
Figure 2: QA testing tools per specification requirements

Standard Compliance

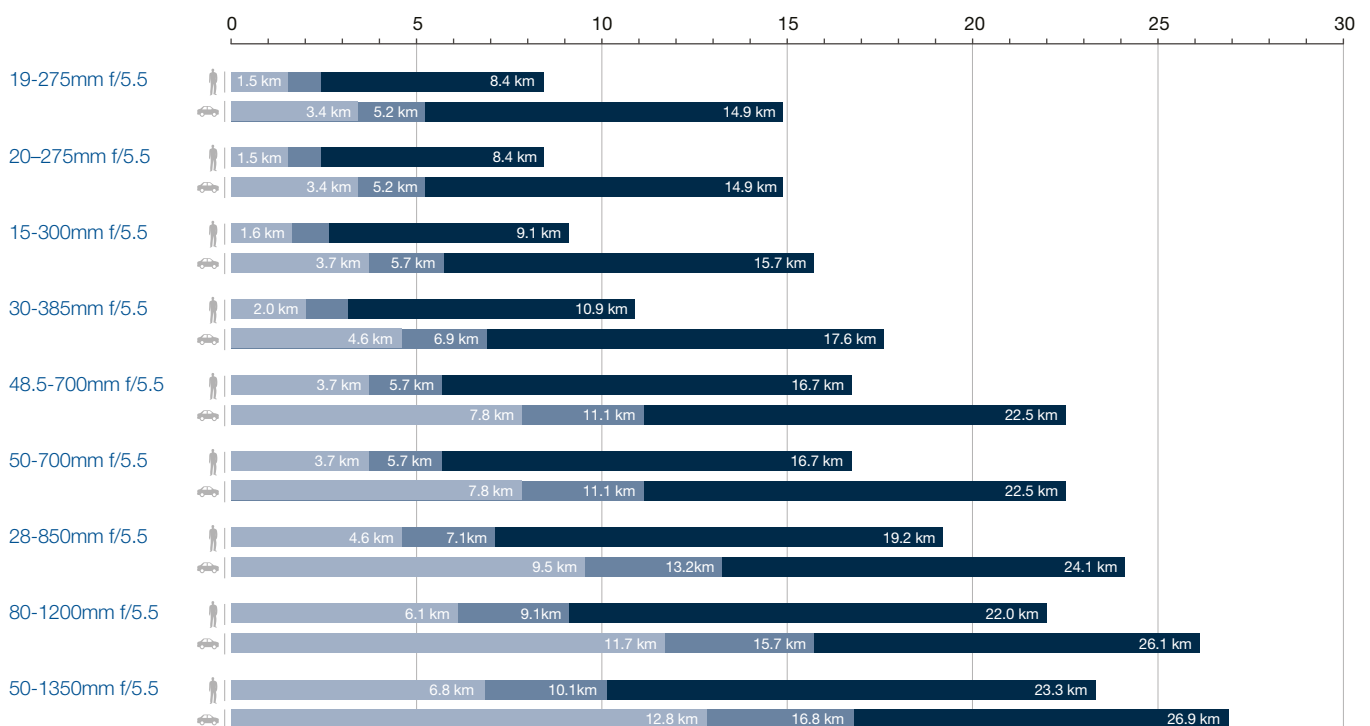
- AS9100 Rev. D and ISO 9001:2015 certified
- US and European military standards compliant with:
 - DIN 3140
 - IPC 620
 - MIL-PRF 13830
 - MIL-PRF 85285
 - MIL STD 810
 - MIL-C-48497
 - MIL-C-48616
 - ISO 10110 sections 1-19, ANSIVASQ Z1.4

Detection, Recognition & Identification (DRI) performance

Cooled MWIR, 10µm pixel size detector*

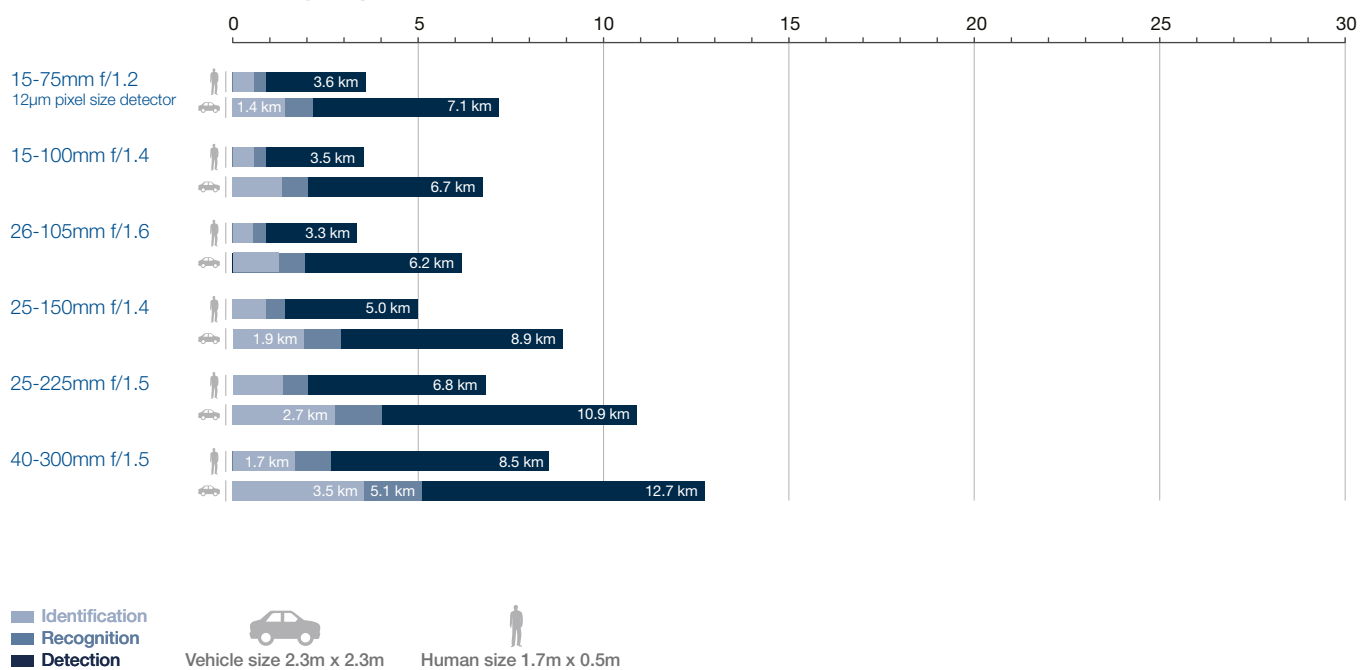


Cooled MWIR, 15µm pixel size detector*



* Assumptions: 23mK NETD (f/4 & f/5.5) | 30Hz frame rate | 50% detection probability

Uncooled LWIR, 17 μm pixel size detector



Note: Calculation used are based on "Johnson Criteria" | Real world performance may vary depending on the weather conditions
 * Assumption: 50mK NETD (f/1.2 – f/1.6) | 30 Hz frame rate | 50% detection probability

COMPONENTS MANUFACTURING EXPERTISE MEETING ANY SPECIFICATION

- 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 or triplets
- Substrates: BK7, Fused-Silica, Zerudor, Chalcogenides, Germanium, Silicon, Calcium Fluoride, Zinc selenide, Zinc sulfide cleartran, Copper, Aluminum and more
- 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 for the coating, inspection and packing processes.

Core capabilities

- In-house, cutting-edge manufacturing technologies:
 - MRF technology
 - Lupho Scan Profilometers technology
 - Diamond turning
 - CNC polishing
 - Coating
 - Metrology

Superior components manufacturing

- 5-400mm diameter components fabrication and coating
- Free form optics manufacturing and metrology
- Variety of Chalcogenide glasses
- Large Silicon lenses > Ø300mm
- Large Aluminum mirrors for Cassegrainian telescopes
- 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 2Fr 1Fr	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



Figure 3: Ophir's selected components: mirrors, domes, truncated shapes, prisms

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 for 1.064μ and 10.6μ
- 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 4: Ophir's 1,000 clean room coating chambers



About Ophir IR Optics

With decades worth of knowledge and experience, Ophir Optronics Solutions LTD., Infrared Optics, an MKS Company (NASDAQ: MKSI), is a world-leading designer and manufacturer of high performance IR thermal lenses and optical elements for SWIR, MWIR & LWIR imaging. Using advanced technologies, innovative engineering, and design configurations, Ophir provides a global solution for homeland security, surveillance, commercial and defense applications: IR Components and complex lens assemblies with fixed or motorized focus and zoom lenses.

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