



# IR Optics for Long Range Security & Surveillance Applications

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Ophir Optics Group

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# Outline

- Introduction
  - Company Overview
  - IR Thermal Imaging trends and application drivers
- **Advanced IR Long-Range Continuous Zoom Lens Solutions**
  - Lightweight zoom lenses
  - Folded-optic, long focal-length zoom lenses
- Summary



# MKS helps the most innovative companies in the world

## **SOLVE COMPLEX PROBLEMS**

### MARKET LEADER

MKS is a leading global provider of process control solutions for

- Semiconductor
- Industrial Technologies
- Life & Health Sciences
- Research & Defense

### STRATEGIC GROWTH

- Q1 2019 – acquired Electro Scientific Industries (ESI)
  - Leader in laser-based manufacturing for the micro-machining industry
- Q2 2016 – acquired Newport Corporation
  - Leader in sophisticated laser, light and motion products

### INNOVATIVE SOLUTIONS

- Vacuum Processing
  - Pressure measurement & control, flow, power, reactive gas analysis, automation
- Laser Solutions
  - Precision laser applications
- Motion, Photonics & Optics
  - Vibration & performance motion control, gratings & optics, laser measurement
- Laser-Based Process Equipment
  - Advanced PCB, Semi & component manufacturing

### KEY FACTS

- Founded: 1961
- HQ: Andover MA
- IPO: 1999 (NASDAQ MKSI)
- Selling in 60+ countries
- In 2018\*
  - Sales: \$2.45B
  - Employees: 5,600+
  - R&D: 900+
  - R&D Spend: \$170M
  - Worldwide Patents: 2,500+

# Ophir Optics – World Class Infrared Optics

## COMMERCIAL



- Ophir's IR optical components and assemblies for thermal imaging are integrated in a variety of commercial applications.
- Offering innovative cost-effective solutions for high-volume, lightweight, infrared optics

AUTOMOTIVE | SECURITY & SURVEILLANCE  
AERIAL | MARITIME

## DEFENSE



- Leading provider of high quality IR optical components and assemblies for sophisticated military applications.
- Decades of experience in meeting manufacturing defense standards

SECURITY & SURVEILLANCE | WEAPON SIGHTS  
MISSILES

## INDUSTRIAL



- Industrial laser customers include laser processing machine manufacturers and end users.
- Providing optical components and assemblies with high damage threshold capabilities for high-power 1 $\mu$ m and CO<sub>2</sub> laser processing

LASER MATERIAL PROCESSING

## IR THERMAL IMAGING OPTICS



### IR Optical Components:

Lenses, mirrors, prisms, windows

### IR Optical Assemblies:

- Manual and Motorized zoom IR lenses
- Lenses for SWIR, MWIR and LWIR cameras

## LASER OPTICS



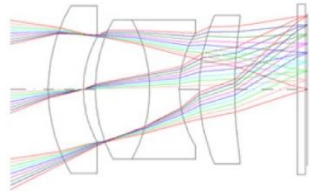
- Optics for CO<sub>2</sub> lasers: focusing lenses, mirrors

- Optics for 1 $\mu$ m lasers: protective windows, spherical and aspheric lenses, collimating and focusing assemblies

# Competitive Capabilities and Differentiation

## Technology Leader

- Recognized leader in delivering innovative, high quality and reliable optomechanical solutions
- With over 40 years of experience
- Cutting-edge design and manufacturing capabilities
- Military credibility highly valued in commercial markets



## Comprehensive Portfolio

- Diversity of optical components and assemblies for the commercial, defense, and industrial markets
- Multiple FOV & continuous zoom lenses for SWIR, MWIR & LWIR
- Spherical, aspheric, flat, diffractive, and free-form
- UV to LWIR wavelengths



## Vertical Integration

- A one-stop-shop from design, diamond turning, polishing, coating, assembly, and testing
- Capacity to deliver at high volumes



## Quality & Testing

- Recognized for the highest quality products
- Testing and inspection at every phase of the process to ensure full customer satisfaction
- AS 9100 Rev. D and ISO 9001-2015 certified



# IR Commercial Applications



Homeland Security • Border Control • Perimeter Security



Drones  
(20-275mm f/5.5)



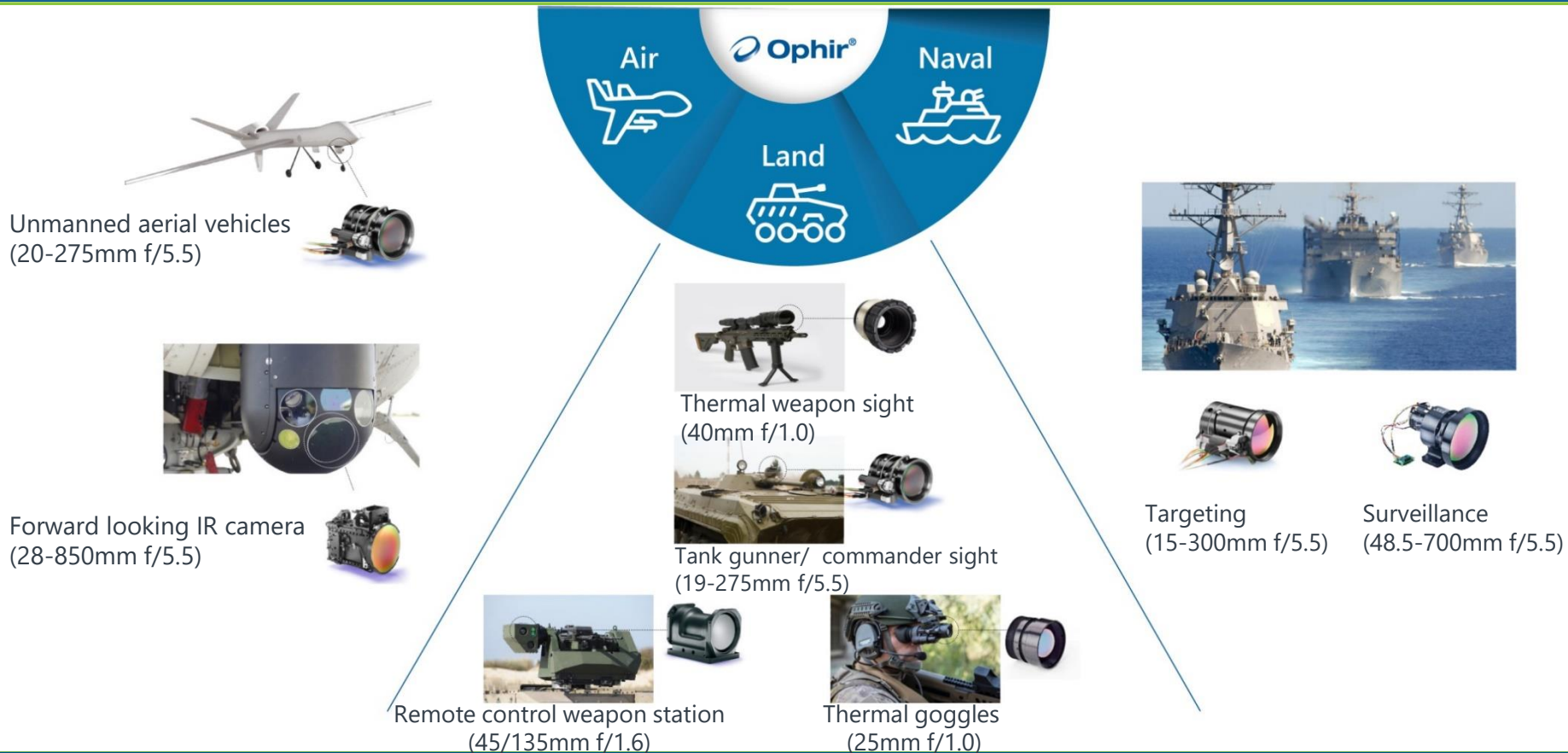
# Thermal Sensing for Driver Assistance and Autonomous Vehicles



- Ophir is a leading provider of high volume optical assemblies for automotive thermal sensing cameras
- Such cameras excel in driving situations where other sensor technologies are challenged, including low-visibility, high-contrast conditions, and challenging weather conditions including fog
- Excellent for detecting pedestrian and wild life



# IR Defense Applications



# IR Thermal Imaging Trends and Application Drivers (1/2)

- Growing use of small UAVs and Drones

- Security & Surveillance, HLS, Border Control,...
- Requirements for reduced Size, Weight, and Power (SWaP)
- Increased operational ranges



- Growing use of hand-held lightweight thermal imaging systems



- Growing demand for long-range all-weather security & surveillance



- Need for increased camera resolution and format

- Sensors have gone to HD
- Pixels are shrinking to 10 $\mu$ m and the systems become optics-limited
- Lower SWaP FPAs



- Increased need for multi-spectral capabilities

- SWIR+MWIR
- MWIR+LWIR
- VIS+ IR bands



# IR Thermal Imaging Trends and Application Drivers (2/2)

- Self driving cars and ADAS are potentially killer applications for Commercial IR
  - High volume, high performance IR optics
  - Demanding requirements



- Autonomous drones will be the next driver ...
  - Environmental monitoring
  - Infrastructure inspection
  - Emergency services
  - Security
  - ...



# How do we address the challenges for IR Optics?

## ● Continuous zoom lens design

- Can keep high performance with reduced size and weight
- Smaller and lighter compared to multiple single field-of-view (FOV) lenses
- Better mission flexibility, by allowing changes in magnification during operation

## ● Innovative optical design

- Advanced IR materials with reduced number of elements (athermalization, achromatization, size, and weight)
- Folded-optic configuration (size and weight)
- Diffraction-limited design
- Multi-spectral design

## ● Innovative mechanical design

- Advanced materials (athermalization, size, and weight)
- High accuracy
- Durability to harsh environmental conditions

## ● Cutting-edge optical components production

- Spherical, aspheric, flat, diffractive, and free-form
- Large optics manufacturing capabilities
- High durability (HD) or low reflection hard carbon (LRHC) AR coatings
- Multis-spectral coating capabilities



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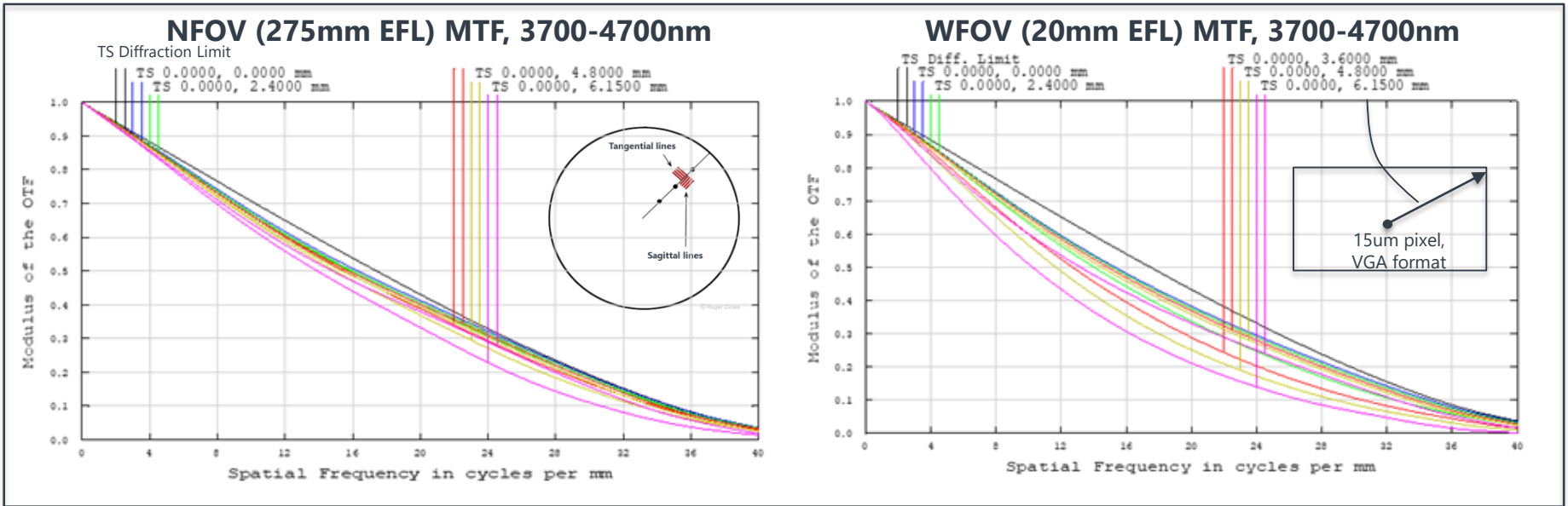
# Lightweight Zoom Lenses

- The LightIR continuous zoom lenses incorporate unique, low SWaP design, with reduced number of opto-mechanical elements
- Unique athermalization and achromatization concepts
- Wide operating temperature range  $-35^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$
- The  $F\#$ , focus and MTF characteristics are maintained through the entire zoom and temperature ranges with tight thru-zoom boresight
- Our 20-275mm f/5.5 (264 gr) and 15-75mm f/1.2 (320 gr) zoom lenses enable long operational ranges on constrained platforms with high performance detection, ranging, and identification (DRI) capabilities.
- For example, the detection range of a 2.3m vehicle using the 20-275mm lens would be around 15km(!) when integrated with a 15 $\mu\text{m}$  pixel detector

Light IR  
By Ophir



# 20-275mm f/5.5 Optical Performance

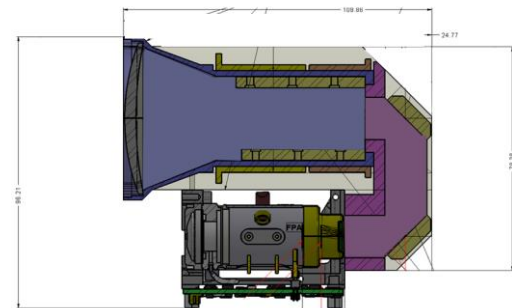


- Optical performance close to the diffraction limit in the NFOV along the entire image frame. For the WFOV, the image slightly degrades in the peripherals
- High level MTF performance is maintained over the entire zoom range and over the entire operating temperature range

# Folded-Optic, Long Focal-Length Zoom Lens

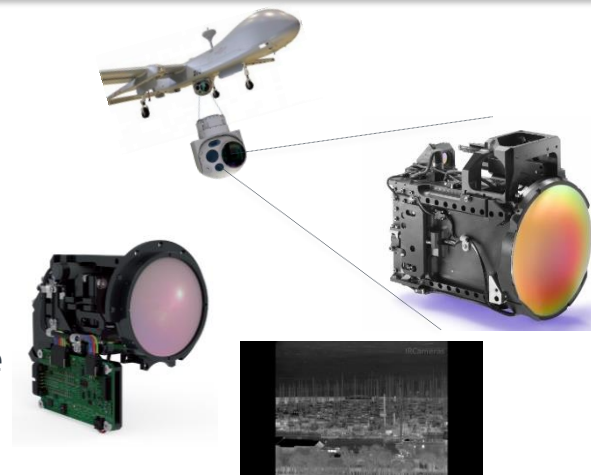
## Motivation:

- Shorten system overall length while maintaining a long EFL
- Long optical length for reduced sensitivity to tolerances
- Efficient volume utilization
- Compact design
- Ideal for airborne gimbals / constrained platforms



## Key Products:

- 16-180mm f/3.6 for MWIR with 640 x 512, **10 $\mu$  pixel pitch**
- 28-850mm f/5.5 (x30 zoom ration) for MWIR 1280x1024 (HD), 15 $\mu$  pixel pitch. Optimized for stabilized payloads with accurate LOS capabilities of less than 2 pixels and **>20km detection range**
- 50-1350mm for MWIR 1280x1024 (HD), 15 $\mu$  pixel pitch. Performance **close to the diffraction limit over a detection range of >25km**





# 50-1350mm f/5.5 Folded-Optic Continuous Zoom Lens

- MWIR spectral range 3 to 5 $\mu$
- HD format 1280 x 1024, 15 $\mu$  pixel pitch
- The longest focal-length and zoom ratio capabilities for high resolution imaging in harsh environmental conditions and constrained platforms
- Performance close to the diffraction limit with a detection range of >25km over the entire temperature range
- **Addresses the need for persistent IR surveillance over long distances, constrained platforms, and harsh environmental conditions**



# Summary

- Advanced low-SWaP IR zoom lenses based on innovative lightweight and folded optomechanical concepts suitable for small pixel FPAs and long-range detection
- Lightweight continuous zoom lenses with the highest level of performance over a wide zoom range
- Longest focal-length and zoom ratio capabilities for high resolution imaging in harsh environmental conditions and constrained platforms
- Such lenses open-up new opportunities in next generation UAVs and small gimbals thermal imaging applications





Thank you !

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