Photonics Technologies for SWaP-driven Airborne Sensors

DIEHL
Defence

EPIC Technology Meeting on Photonics in Defense

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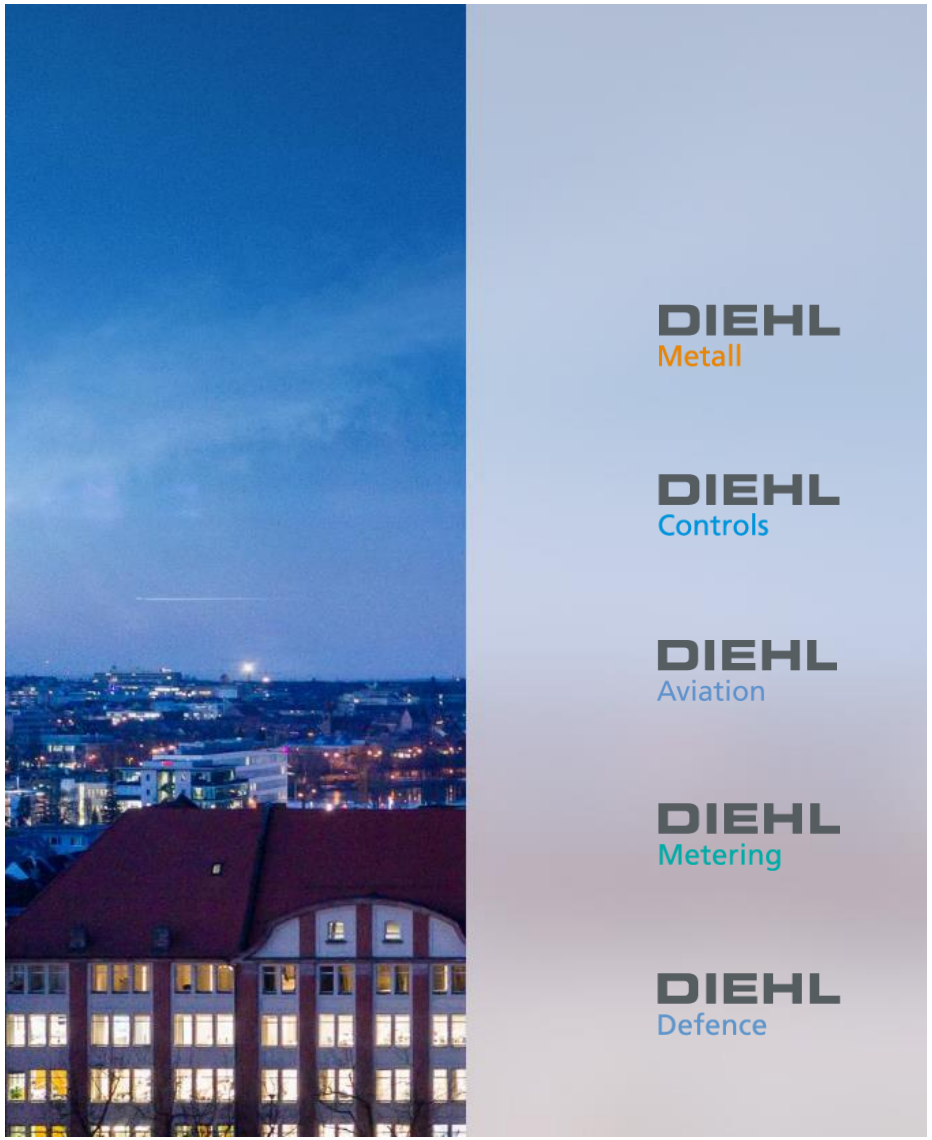
Photonics technologies for airborne sensors driven by size, weight, and power (SWaP) requirements

THE DIEHL GROUP



Sales : **3.5 billion € (fiscal year 2022)**
Employees : **16,550 (year 2022)**
Family-owned company since 1902

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Rods, Tubes, Profiles, Die-Forgings, Synchronizer Rings, Strip and Wire, Formed Parts, Cell Contact Systems for alternative Drive Systems

Electronic Display and Control Systems, Controls, Networking Solutions, Compressors, Pumps and Fan Drives

Avionics and Cabin Outfitting, Galleys, Lavatories and Monuments, Sanitary Solutions for aircraft, Fire Prevention, Water Supply, Air-Conditioning, Retrofit Service

Radio Modules, Remote Reading Systems, Meters for Water, Thermal Energy, Gas and Electricity

Guided Missiles, Air Defence Systems, Ammunition, Surveillance and Protection Systems, Training Systems, Infrared Modules and Fuzes, Special Batteries, Packaging

COMPANY PROFILE DIEHL DEFENCE

Sales: **810 million € (fiscal year 2022)**
Employees : **3,190 (year 2022)**
Headquarters: **Ueberlingen, Germany**

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- Guided Missiles
- Air Defence Systems
- Ammunition
- Sensor and Security Systems
- Components/Packaging
- Customer Support
- Training
- Infrared Modules and Fuzes

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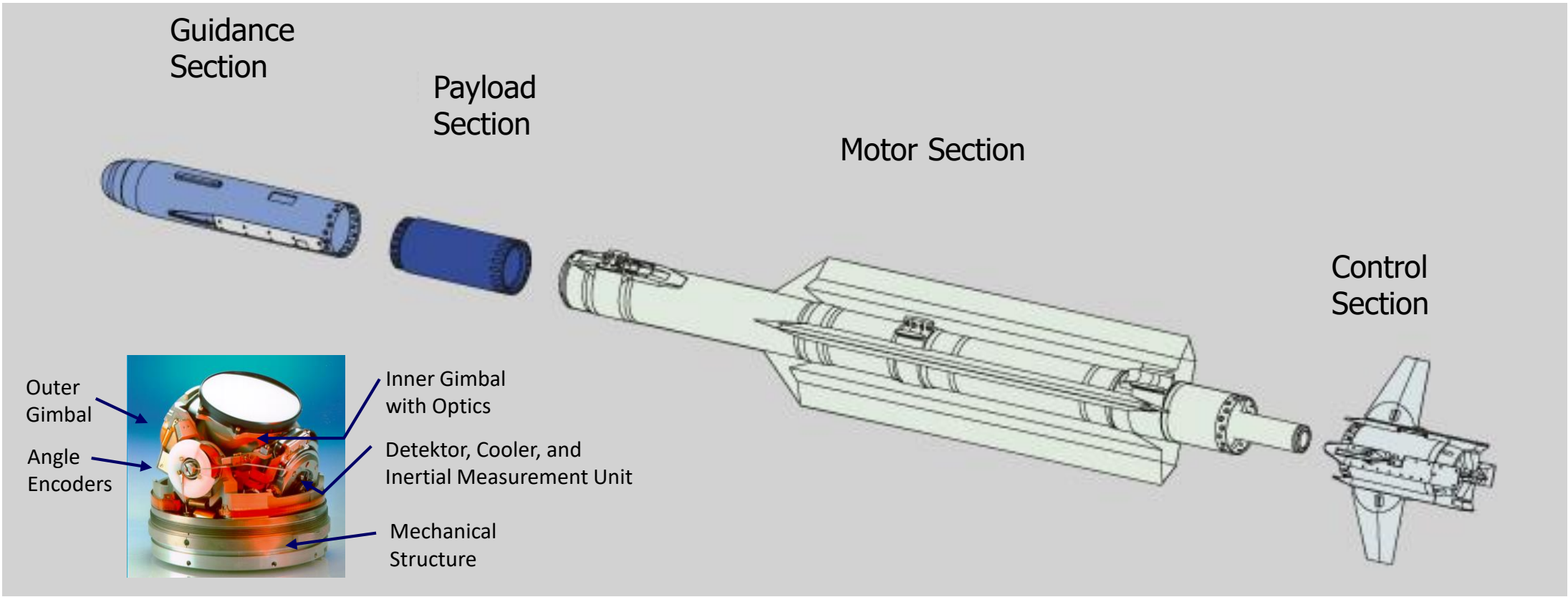
COMPANY PROFILE DIEHL DEFENCE

Selection of products incorporating SWaP-driven airborne sensors

PHOTONICS IN SWAP-DRIVEN AIRBORNE SENSORS

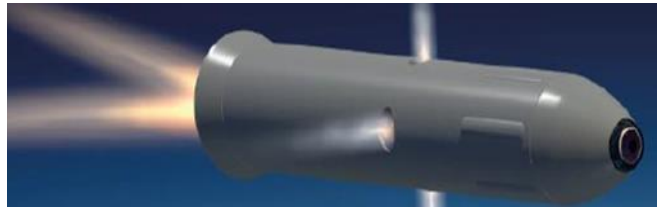
Subassemblies of a missile as an example of a SWaP-driven airborne platform



PHOTONICS IN SWAP-DRIVEN AIRBORNE SENSORS

Challenges in missile/remote carrier/small UAS applications

- **High speed (towards hypersonics) airborne platforms**
  => dome/window materials to resist high heat flux and atmospheric erosion

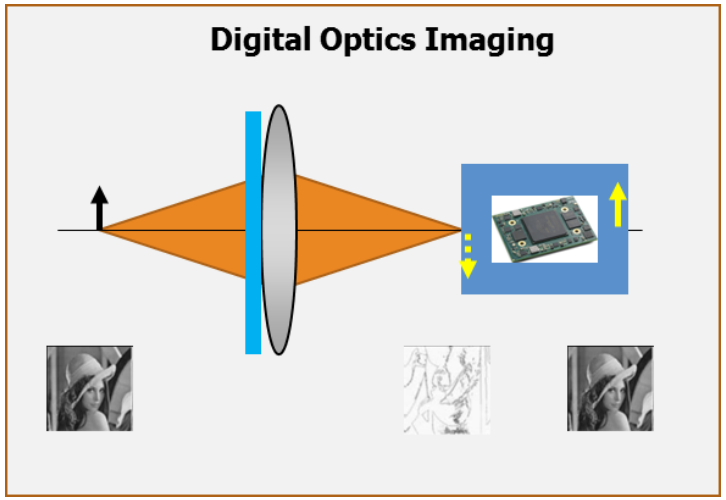


- **SWaP-C improved sensors**
  => multispectral, high frame rate, low noise, digital imaging sensors
  => polarization sensitive imaging sensors
  => free-form optics
  => meta-materials
  => phase-coded aperture optics
  => precision miniature inertial measurement units
  => optical slip rings

- **Integration/manufacturing**
  => optical cabling and communicaton inside the platform
  => optical fibres
  => optics integration & testing technologies
  => laser additive manufacturing

PHASE CODED DIGITAL IMAGING

- **Principle of phase coded digital imaging**
  - Combination of spatial phase modulation in the pupil plane with digital electronics demodulation in the image plane

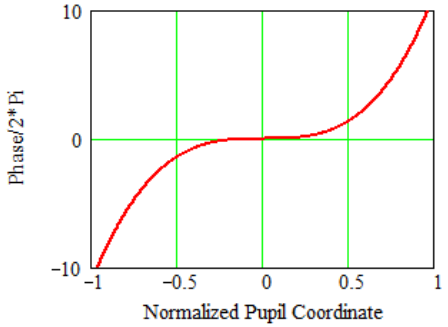


- **Advantages**
  - replace HW aberration compensators (lenses) by SW compensators (algorithms)
  - increase tolerances for manufacturing inaccuracies
  - increase tolerances for mounting inaccuracies
  - reduce size, weight, and cost

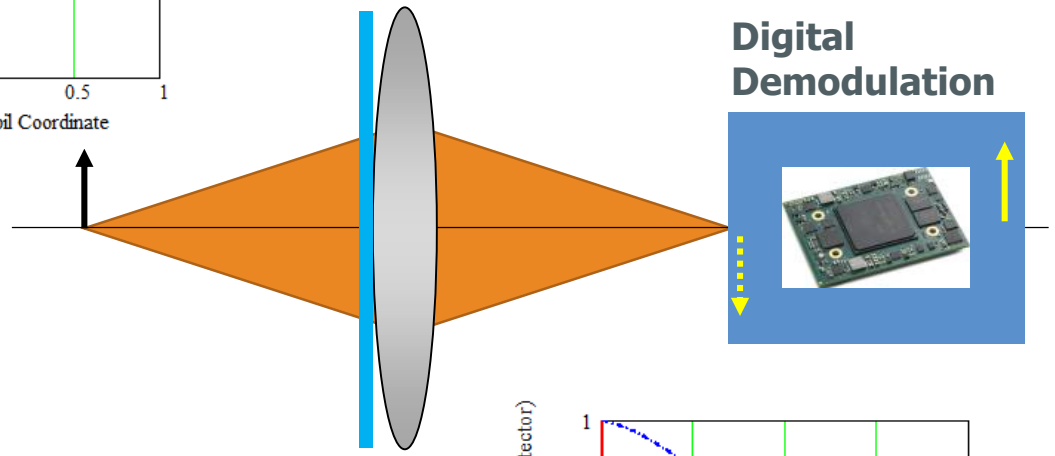
- **Challenges**
  - reduction of SNR in final reconstructed image
  - introduction of image artefacts in final image
  - manufacturing and mounting issues caused by the wavefront coding phase plate
  - increased computational load in image processing electronics

PHASE CODED DIGITAL IMAGING

System Design Illustration

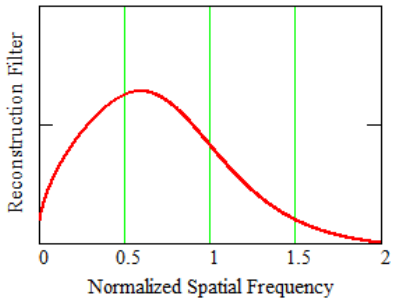


Phase Modulation



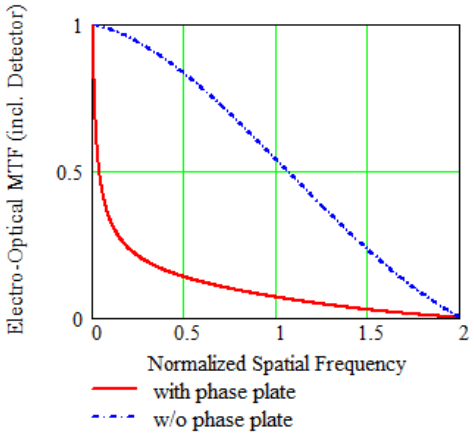
Optical System

Digital Demodulation



Digital processing

- reconstructs image information
- controls noise amplification at high spatial frequencies

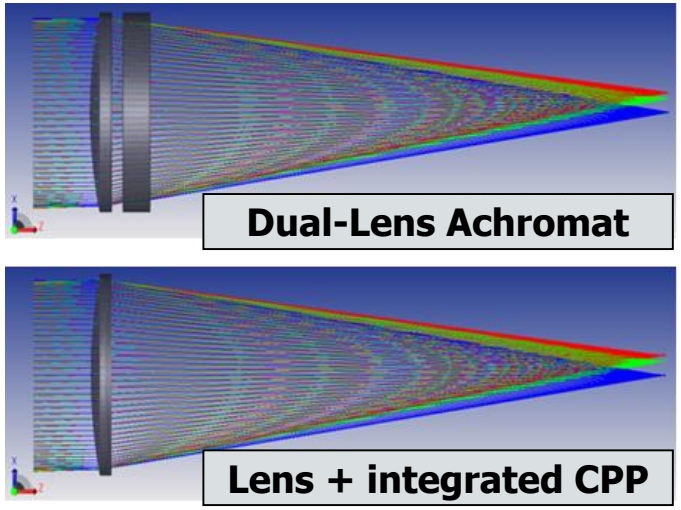


Phase plate

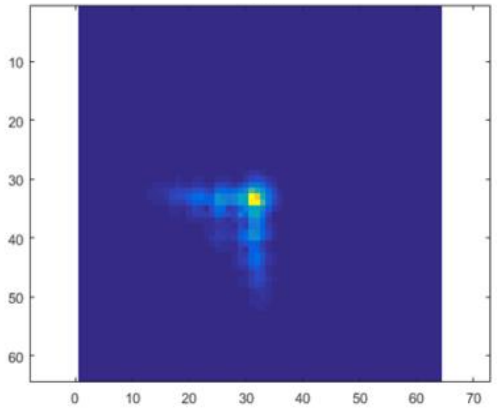
- dominates System MTF
- eliminates contrast reversal (zero MTF points)

PHASE CODED DIGITAL IMAGING

(Chromatic) defocus aberration compensation with a cubic phase plate (CPP)



Point Spread Function



Edge Transfer Function

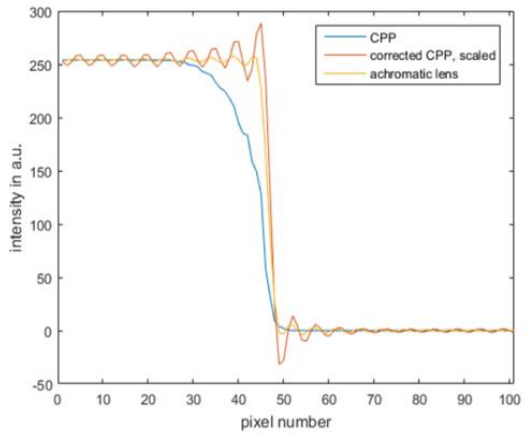
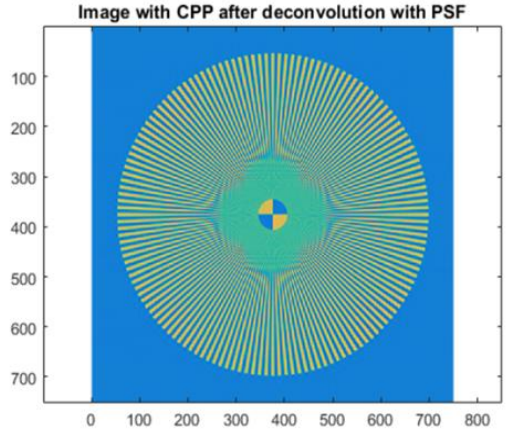


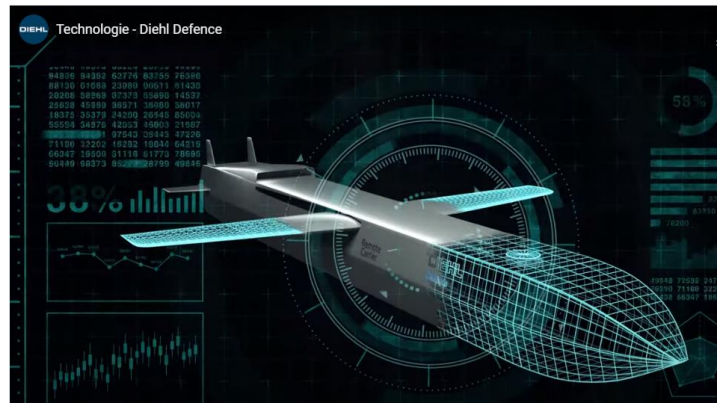
Image with CPP after deconvolution with PSF



CONCLUSIONS

Photonics technologies for SWaP-driven airborne sensors

- Future combat air systems will be based on networks of small and agile airborne platforms.
- Guidance and control relies on photonics remote sensing of targets and backgrounds.
- Phase coding, meta-optics, and quantum technologies are candidates to reduce SWaP-C and to increase sensitivity and accuracy of airborne sensors.
- Defence product development cycles and service lifetime are rather long compared with civilian applications. Suppliers need to secure a stable long term business to successfully participate in the defence value chain.



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