High Perf - Low SWaP EO Payloads for SmallSats

A SAFRAN 'New Space' Initiative

Who we are – Assets & Capabilities

Safran Reosc

EU leader in space optics

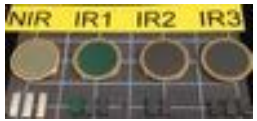
Serving Agencies & Primes worldwide

Telescopes & Lens assemblies

LW mirrors : *glass-metal-SiC*

Focal plane : *Filters & cryo assemblies*

OGSE : *Flats & Collimators*



Spot, Meteosat, Helios, Kompsat, Formosat, IRS, Oceansat, Ofeq, Astroterra, Pleiades Neo, Aeolus, Euclid, Merlin, µCarb

Safran Electronics & Defense

Leader in optronics, space electronics & critical software

EU #1 in Defence optronics

Submarine

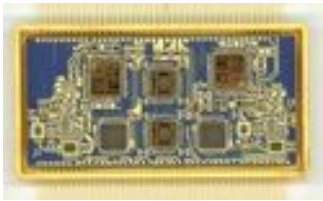
Marine

Land

Air

Space Electronics & Hybrids

Critical software



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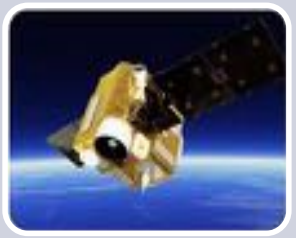
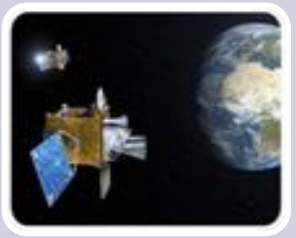
Changing our business model


Institutionnal	Supply the Prime	Meteo	Science
Very High Resolution Spot – Helios - CSO France - Europe	Airbus – Thales OHB - ISRO – KARI JAXA – ISA - CDTI	Meteosat - MSG - MTG	ISO - NIRSpec - GAIA IASI - COROT - µCarb EUCLID

Conventional Space Business

RFI – ITT – Nego – Contract

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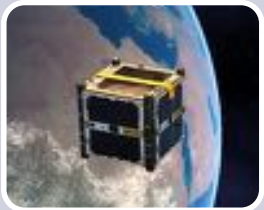
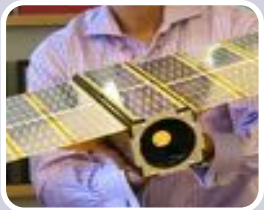
Our target niche for smallsat EO payloads



1U / 1-3 kg

Education



3U / 3-10 kg

Low perf

6U / 10-25 kg

Low perf

12U / 25-50 kg

27U / 50-100 kg

Hi perf missions @ low cost

> 100 kg

For the Primes

New Space expectations

- Highest resolution
- Pixels, FoV, MTF, SNR
- Low SWaP factor
- Thermal stability & Mech. strength
- On-board data processing, AI,

HAPS & other platforms

Risk ?

or

Opportunity !

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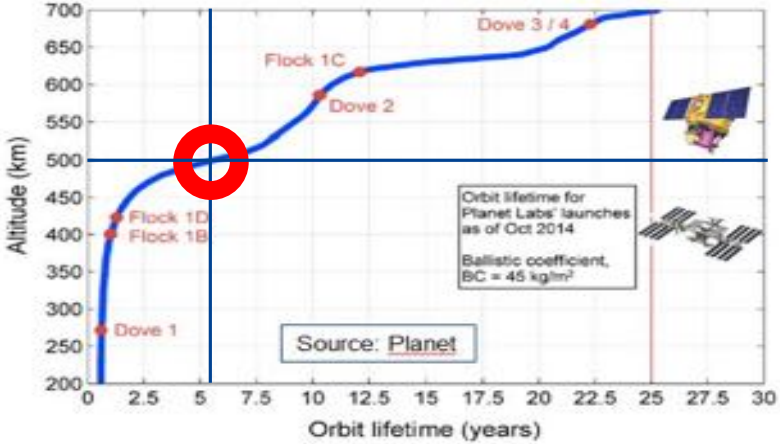
Orbit & target application

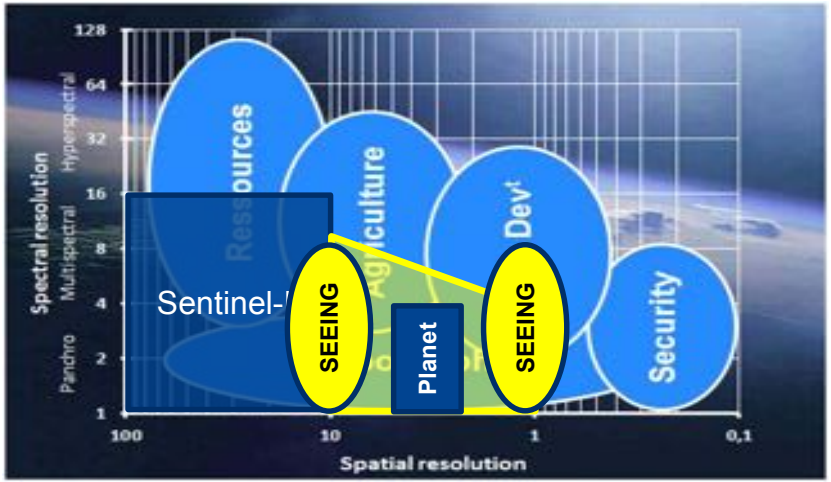
500 km orbit for lifetime



Low total EO service cost over 5 years

One 5-year satellite cheaper than five 1-year satellites !

Target Application



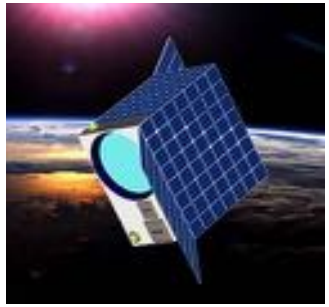
Opportunity for µsats with Hi-Tech COTS EO payloads:

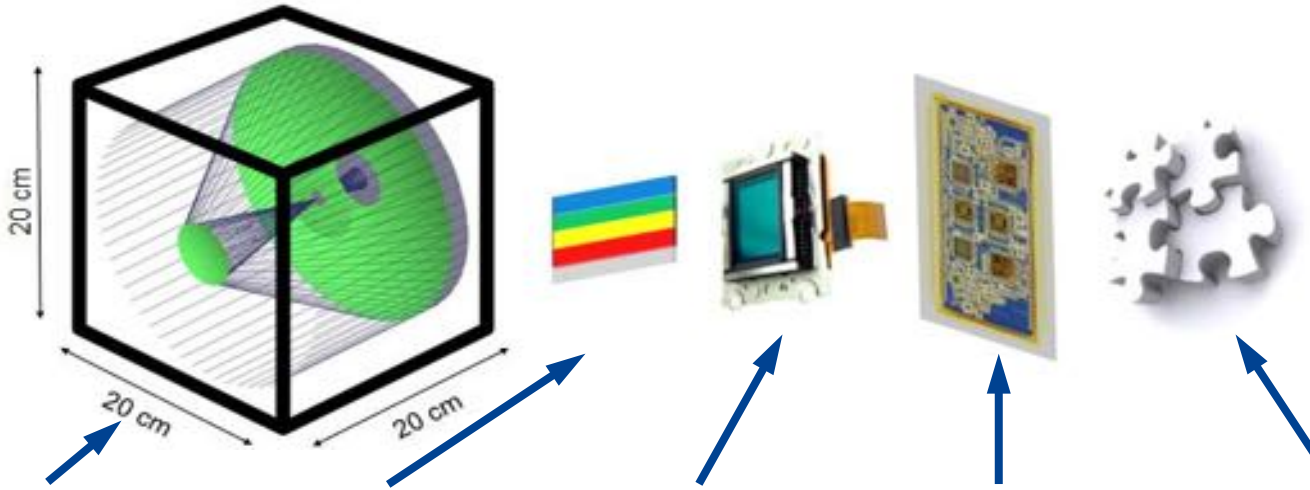
1 to 10-m GSD

Pan to 8 spectral bands

SEEING 1.5-m payload

Ultra low SWaP - High perf - Modular - Evolutive





Optics

Ultra compact in 8U
1,15° x 0,76° FoV
Diffraction limited
Pure mirror
Low distortion

Filter

Fully customable
Pan + RGB
4 to 8 bands

Sensor

24x36 mm
CCD or CMOS
29-50 Mpx
Pixels of 5.5 to 4 µm

Electronics

Power management
Memory
Signal processing

Software

Compression
Data pre-processing
On demand
Per Safran catalog

SEEING 1.5-m: High resolution – Wide FoV

Optics	**∅ 190 mm F/9**
Image quality	**Diffraction limited**
Sensor	**35 mm full frame**
	6600x4400 pixels (5,5 µm)
FoV	**10 x 6.7 km²**
GSD	**1.52-m from 500 km**

Ikonos 1-m GSD image

Under good conditions 0,76-m GSD is reachable from 500 km orbit with super-resolution processing

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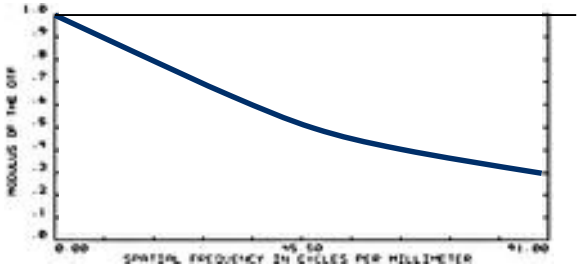
SEEING 1.5-m: State of the art MTF & SNR

MTF



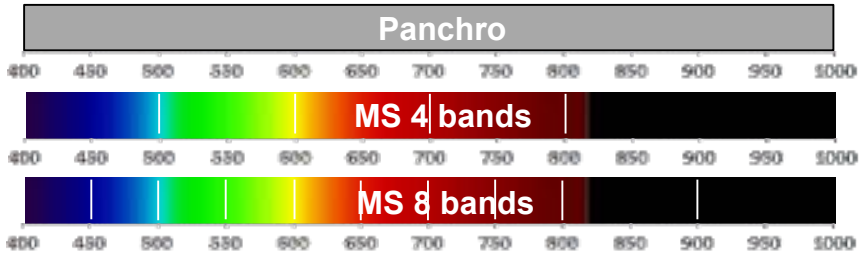
MTF budget

Design	0,29
As built	0,22
In use in orbit	0,20
1 pixel image smear	0,18
Sensor & electronics	0,10

Comparable to Pleiades specs !

MTF > 0,08 SNR > 90

Solid SNR



SNR computations with MODTRAN

For same GSD of 1.5-m

Panchro	SNR = 136 to 141
MS 5 bands	SNR = 91 to 141
MS 10 bands	SNR = 60 to 106

Nota: Doubling GSD will double SNR

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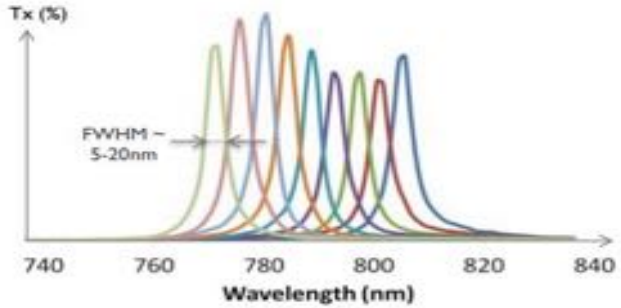
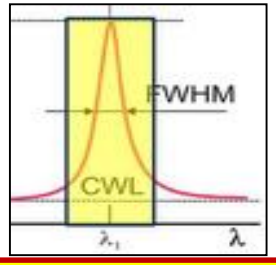
Superior filter technology

Conventional Bayer filter technology

Variable Fabry Perot filters
Deposited on detector
2D patterning

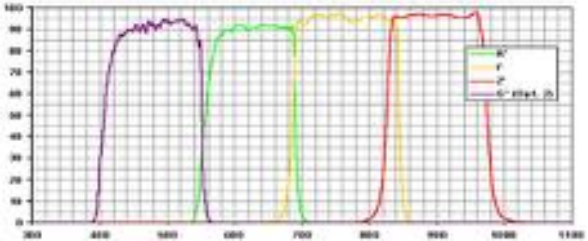


Gaussian like profile



REOSC 2D structured filters

Bandpass MLD filters
Deposited in various steps
On various 2D patterns



Rectangular spectral function

Reosc filters offer 2 x higher total throughput

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Thermal Management & Robustness

Smaller satellite ⇨ Higher thermal loads & gradients

Top choice 1 : Mono-material pure mirror design
- Perfect homothetic scaling with temperature
- Stable focus & image quality

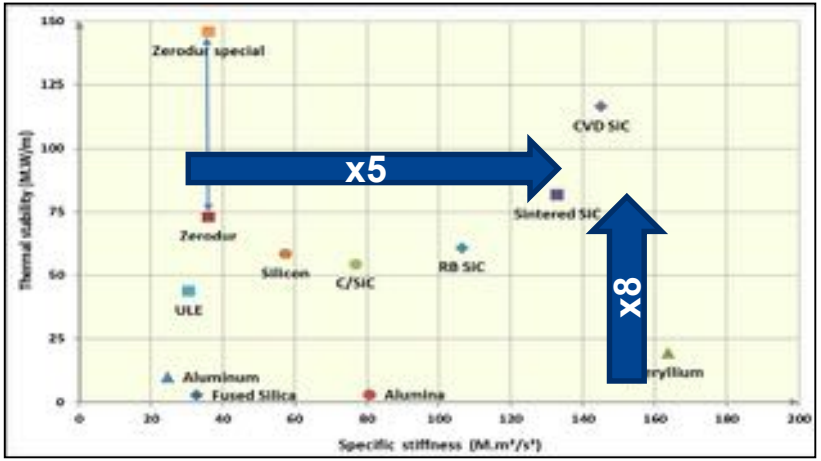
Top choice 2 : Ceramics better than metal
- High mech. stability & strength
- High thermal stability

⇨ **All ceramic – All mirror design**

Then : Easy thermal management
- No or low power active thermal control

And : Compatible with Deep Space
- Opening to science applications
  - e.g. Rosetta NAC

JWST NIRSpec CAM



Disruptive features for disruptive value creation

Ultra-Low Size Weight and Power (SWaP) factor

Mass	**6 kg**	***others are 18 kg***
Volume	**20x20x20 cm^3 = 8U**	***others are 80 liters***
Power	**15-30 W**	

New manufacturing technologies

Disruptive optical manufacturing & AIT technologies
Designed for Additive Manufacturing

Shorter production schedule

Highly contributive to the global value model

5 year lifetime @ 500 km orbit	**=> Lower long term service cost**
10X lower volume	**=> Lower system cost**
3X lower mass	**=> Lower system cost**

Smallsat platform + SAFRAN's Disruptive payload = Highest value

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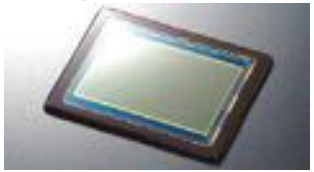
Modular & Evolutive

New sensors technology

35 mm Full Frame sensor

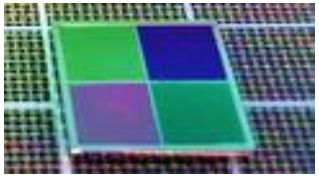
Evolution to 50 Mpixels & new technologies

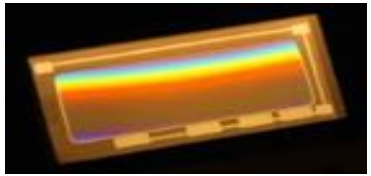


More complex filter

More bands or 2D structuration

Linear variable filter ?



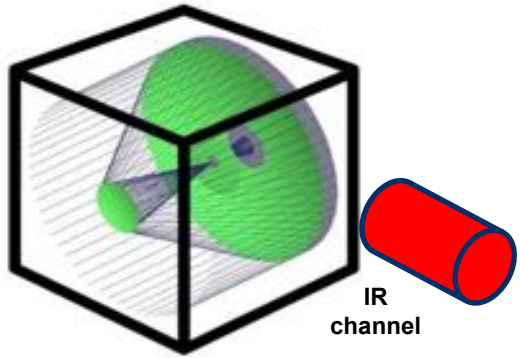


UV or IR channel addition

All-mirror design allows adding a 2nd channel

Replace a folding mirror by a dichroic and add a final eyepiece module for :

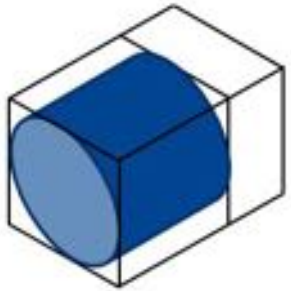
- Pupil relay to cryostat (IR)
- EFL adaptation



Implementation possible into smallest cubesats

12 U

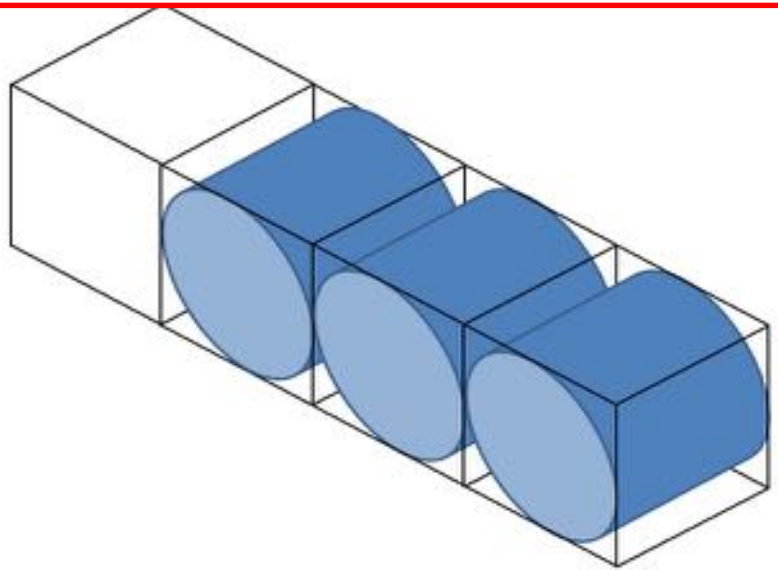
The min configuration



Confirmed by
NEXEYA

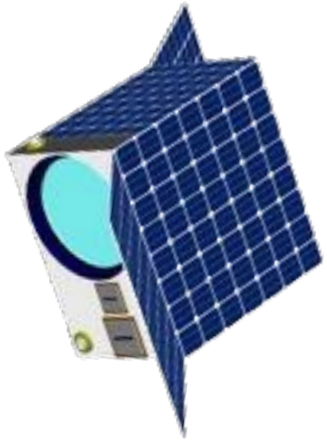
16 U

Payload stacking
Shorter revisit time - lower constellation cost



18 U & more

Max flexibility



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Data processing

SAFRAN assets

Broad catalog of real-time video processing algorithms with related ASIC and electronics.
Fast, compact, efficient, optimised for 2D images « battle proven »

Onboard

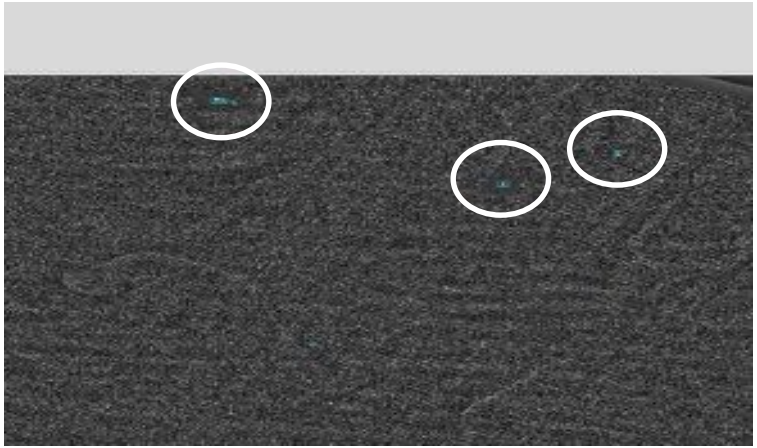
Data volume reduction & pre-processing

- Image compression
- Cloud, sea or land removal
- Target detection (ship, iceberg, oil spill,)

On-ground

Basic processing

- MTF enhancement by deconvolution – denoising
- Motion or jitter compensation
- Super-resolution
- Local contrast enhancement
- Etc



Sentinel-II image: Ships auto detection
(re-use of tank & aircraft detection algorithms)

Another advanced payload: SEEING 10-m

Ultra low SWAP – Wide FoV – High sensitivity - Modular - Evolutive

Optics

High NA & Very compact
6.3° x 4.3°
Diffraction limited
475 – 900 nm
Very low distortion

Same modular & compact spirit but

Wide FoV	**60 x 40 km from 600 km orbit**
Small volume	**180x180x200 mm³ (+ baffle)**
GSD	**10-m**
MTF budget	**> 0,15**
SNR	**> 400 (PAN) > 256 (MS)**

The plus : High sensitivity in twilight conditions

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SEEING: SAFRAN's multipurpose disruptive EO payloads

SAFRAN top optics & optronics skills

Self funded – Exchanges with Cnes & Nexeya - Demonstrator in 2019

Hi-perf & robust to any mission profiles

Diffraction limited – Efficient filters – Ceramic structure

Modular & evolutive

Additional channel possible

High value generation

Long life @ 500 km orbit

Low mass – Lowest volume – Fits in 12U cubesats

Stacking options

SAFRAN's Electronics & Software

Ex: sub-meter GSD with super-resolution processing

Multipurpose : EO, science, debris tracking, tactical, HAPS,

SAFRAN

Need a compact hi-perf space imager ?

roland.geyl@safrangroup.com