

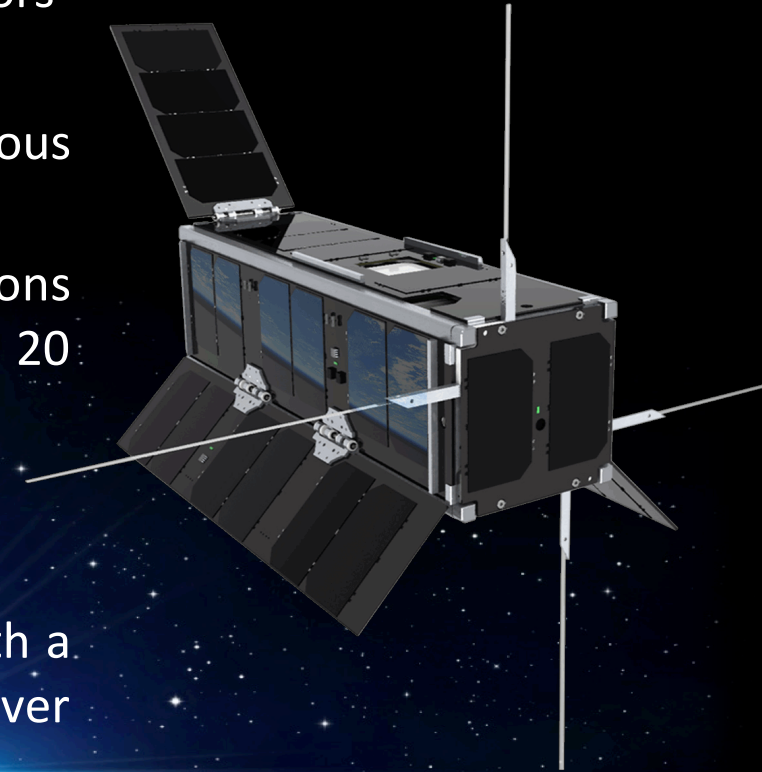


SeaHawk: A Nanosatellite Mission for Sustained Ocean Observation

About Clyde Space



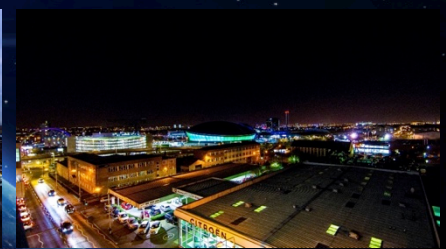
- Leading UK space company:
 - One of only 2 UK spacecraft prime contractors
 - Member of Space Leadership Council
 - Currently has over 10 spacecraft at various stages of design and production
 - Supporting leading NewSpace applications company, SPIRE, to integrate a further 20 spacecraft in our facility.
- Global leader in CubeSats
 - Hardware on c40% of CubeSat missions
 - Hardware flying on over 100 spacecraft with a combined on orbit operation duration of over 200 years
- Broad Space capability from subsystems to platforms to end-to-end mission



Headquarters Glasgow, UK



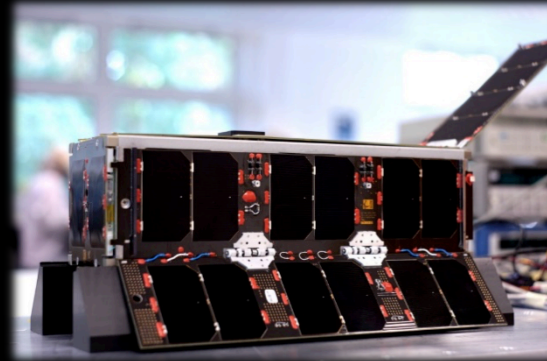
- Fully integrated space mission design, manufacture and operations capability.
- ESA level manufacturing.
- In-house environmental test capability including vibration, thermal, and thermal vacuum.



Current CubeSat Missions

UKube-1

- Complex 6-payload 3U CubeSat for UK Space Agency
- Successfully launched 8th July 2014, currently operational



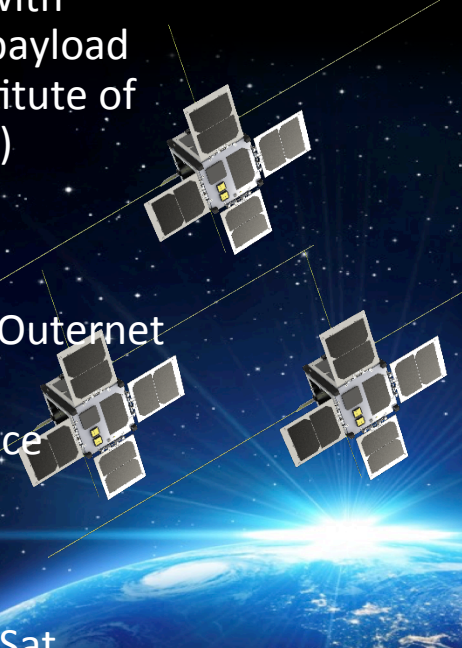
PICASSO

- Advanced 3U CubeSat with hyperspectral imaging payload for ESA and Belgian Institute of Spatial Aeronomy (BISA)
- Launch Q1 2016



Outernet

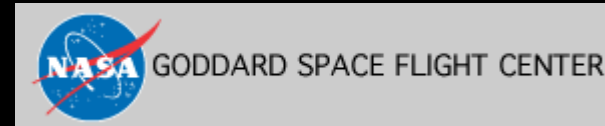
- 3x 1U CubeSats for the Outernet project
- Funded through UK Space Agency's International Partnerships in Space Programme (IPSP)
- Precursor to 200+ CubeSat constellation



Current CubeSat Missions: SeaHawk



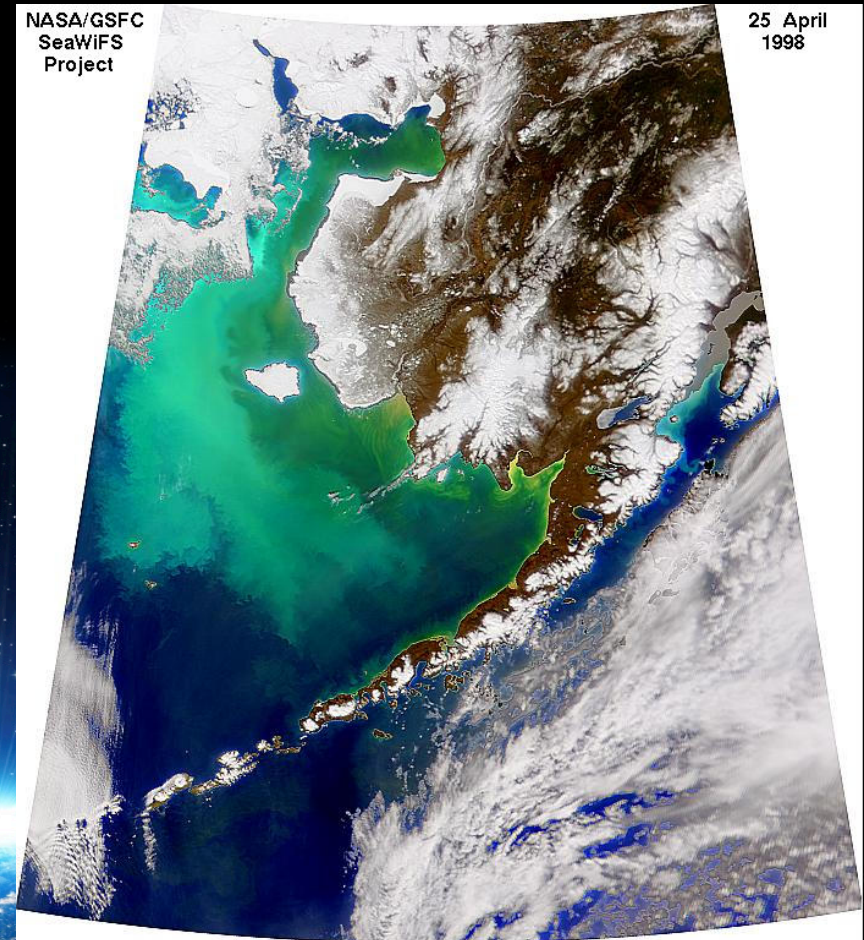
- Delivering 2x 3U CubeSats with HawkEye payload as a technology demonstrator
- Part of SOCON project: Sustained Ocean Colour Observation from Nanosatellites
- Project Partners:
 - University of North Carolina Wilmington
 - Cloudland Instruments
 - Clyde Space
 - NASA Goddard Space Flight Center
 - Hawk Institute for Space Science
 - UK Astronomy Technology Centre
- Funded by Gordon and Betty Moore Foundation



Ocean Colour Monitoring



- Optical & near-IR measurements of ocean surface
- Indicates presence of phytoplankton, and other factors such as sediment
- Used to study:
 - Ocean surface biology
 - Marine Ecosystem
 - Climate System

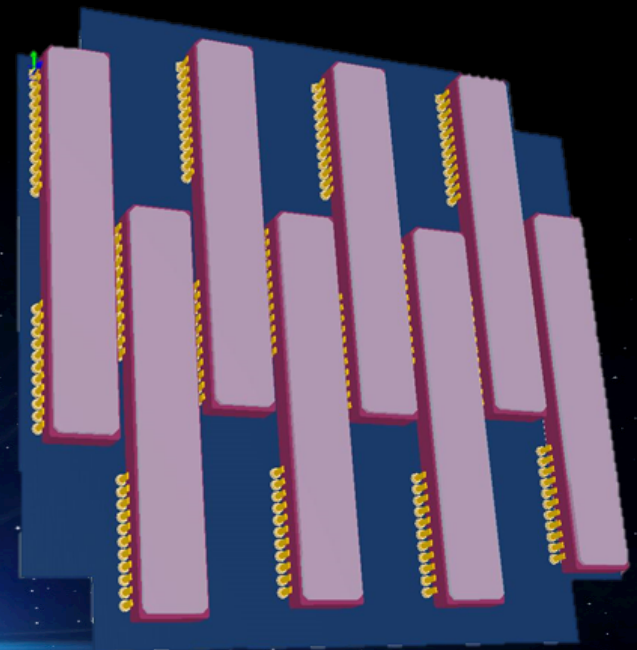


HawkEye Payload: Challenges



- Extremely high data handling requirements
 - HawkEye collects data at 3.28 million pixels a second
 - 53 times faster than SeaWiFs
- Very dense electronic packaging
- Reducing imaging artifacts to less than system noise
- Control of stray light in such a small package
 - Challenging to design simple-yet-efficient baffle with tight envelope

Cloudland
Instruments

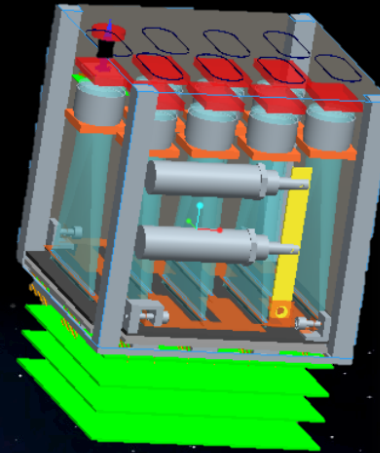


**HawkEye Optical Detector
Array Board**

Platform Challenges



- Immense data downlink requirement
 - 40 Mbps full resolution data generation
 - On Board data processing capability
 - Over 600 MB data downlink per observation
- High Speed payload to platform data interface development
- Severe mechanical accommodation limitations
 - 8 CCD array & associated lenses within regulated 100mm width
- Challenging Power & Thermal Stability requirements



Addressing the Issues



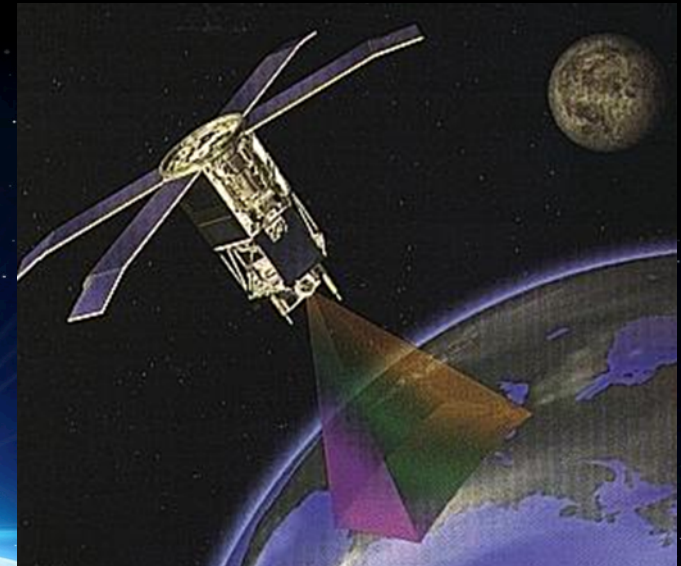
- Apply state of the art, but COTS, components to handle tough requirements.
- Careful operations planning.
- Close co-operation with project partners.



Predecessor: SeaWiFs Summary



- 8 observation bands (range: 402-885nm)
- Orbit Type Sun Synchronous at 705 km
- Equator Crossing Noon +20 min, descending
- Orbital Period 99 minutes
- Swath Width 2,801 km LAC/HRPT (58.3 degrees)
- Swath Width 1,502 km GAC (45 degrees)
- Sensor resolution: 1km/pixel
- Real-Time Data Rate 665 kbps
- Revisit Time 1 day
- Digitization 10 bits
- Mass: 390kg
- Development time: >10 years
- Cost: 14.1M USD



SeaHawk Take-Over Aims



- To observe in the same eight spectral bands as SeaWiFs
- To achieve equivalent or better SNR performance
- To improve sensor resolution

Comparison



	NASA SeaWiFs	SeaHawk	Comparison
Development Time	> 10 years	2 years	20%
Cost	\$14.1M	\$1.675M	12%
Mass	390kg	4kg	1%
Sensor Resolution	1km / pixel	150m – 75m / pixel	7 – 15 times better

Constellation Scalability



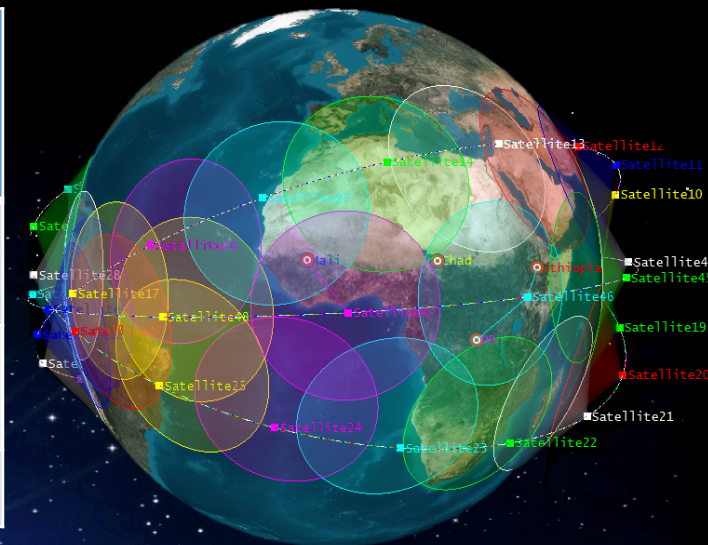
- 2x 3U spacecraft under development are precursors for future platforms
- Goal is to create constellation of dozens of SeaHawk CubeSats
- Priority must be placed on spatial coverage versus revisit time



Example Constellation Performance Comparison



Typical Performance	Single CubeSat	Three-Plane CubeSat Constellation
# of CubeSats	1	48
Maximum Revisit Time	~ 12 Hours	~ 5 Minutes
Target Visibility	~ 1 Hour	>50 Hours



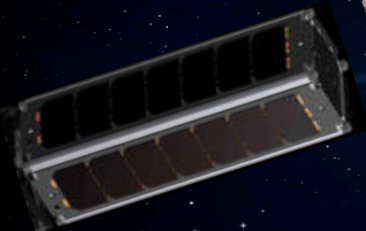
Moore's Law in Space



- CubeSat technology continues to advance
 - More power
 - Better pointing
 - Faster downlink
- Capability & value advance alongside



~2W

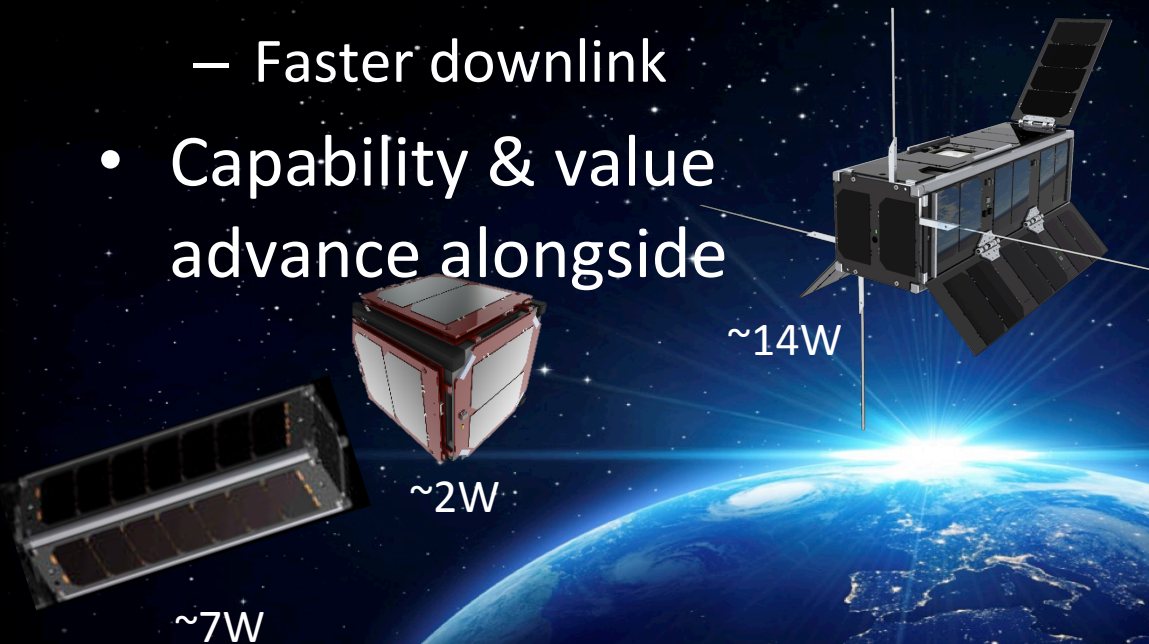


~7W

Moore's Law in Space



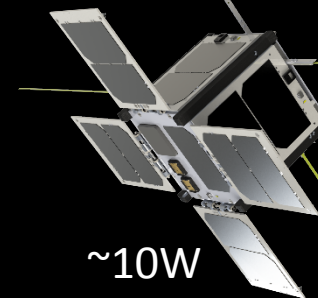
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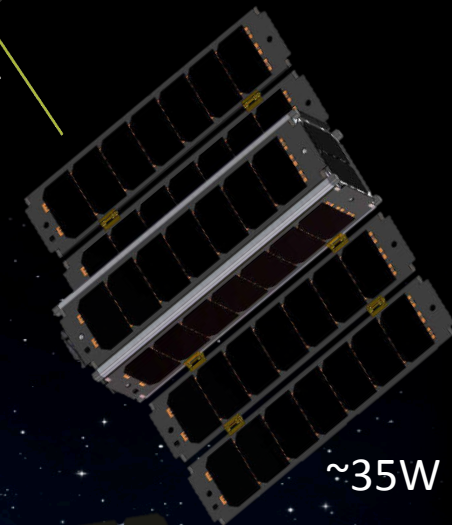
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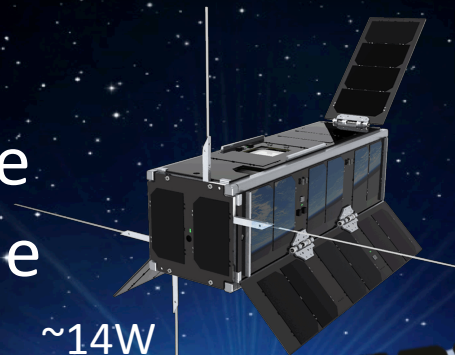
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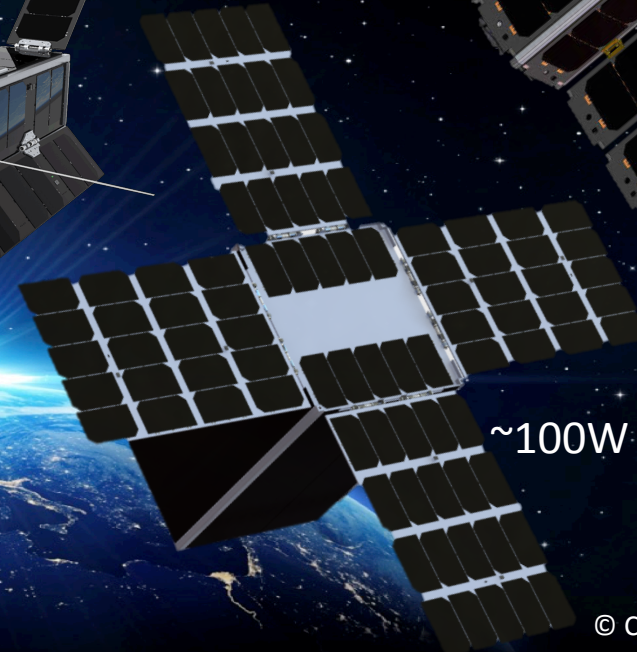
~10W



~35W



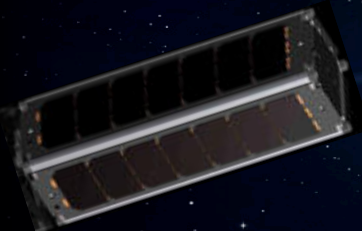
~14W



~100W



~2W



~7W

Summary



- SeaHawk is a pair of 3U CubeSats with an Ocean Colour Monitoring mission
- Thanks to Moore's Law CubeSat-sized payloads are now delivering valuable scientific data



Summary



- SeaHawk is a pair of 3U CubeSats with an Ocean Colour Monitoring mission
- Thanks to Moore's Law CubeSat-sized payloads are now delivering valuable scientific data
- SeaHawk and PICASSO offer a standardised, high-performance CubeSat bus for Earth Observation missions
- We're looking forward to doing more!



Thanks for your time,
Come visit us at Booth 18-19!

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