

Tech Brief:

Rise of Commercial Intelligence Satellite Networks

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The SmallSat Revolution Ushered in Low Cost Imaging The War in Ukraine Forged Them Into an Intelligence Network

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- On February 20th 2022 Russia invaded Ukraine
 - The U.S. and our allies provided Ukraine not only Military Assistance, they also provided Intelligence Assistance
 - However, Security concerns limited Ukrainian access to the U.S.'s most Secret Satellite Intelligence Assets
 - Alternate Sources of real-time intelligence were required ASAP
- Enter DARPA, the NRO, Ukrainian ingenuity, and others to cobble together a commercial version of military C4I system:
 - Synthetic Aperture Radar (SAR) Satellites (All Weather) - strategic surveillance
 - Imaging Satellites including infrared imaging- strategic surveillance
 - SpaceX StarLink satellite network - real-time communications
 - Local UAV imaging drones for tactical surveillance (w/ "Delta" battlefield intel)
 - Home grown Ukrainian "GIS Art for Artillery" command and control APP
 - Ukrainian rebuild of NATO battlefield-awareness platform
 - US and NATO Alliance precision weapons (& Air Defense Systems, e.g. Patriot)



Starlink SatCom Terminal



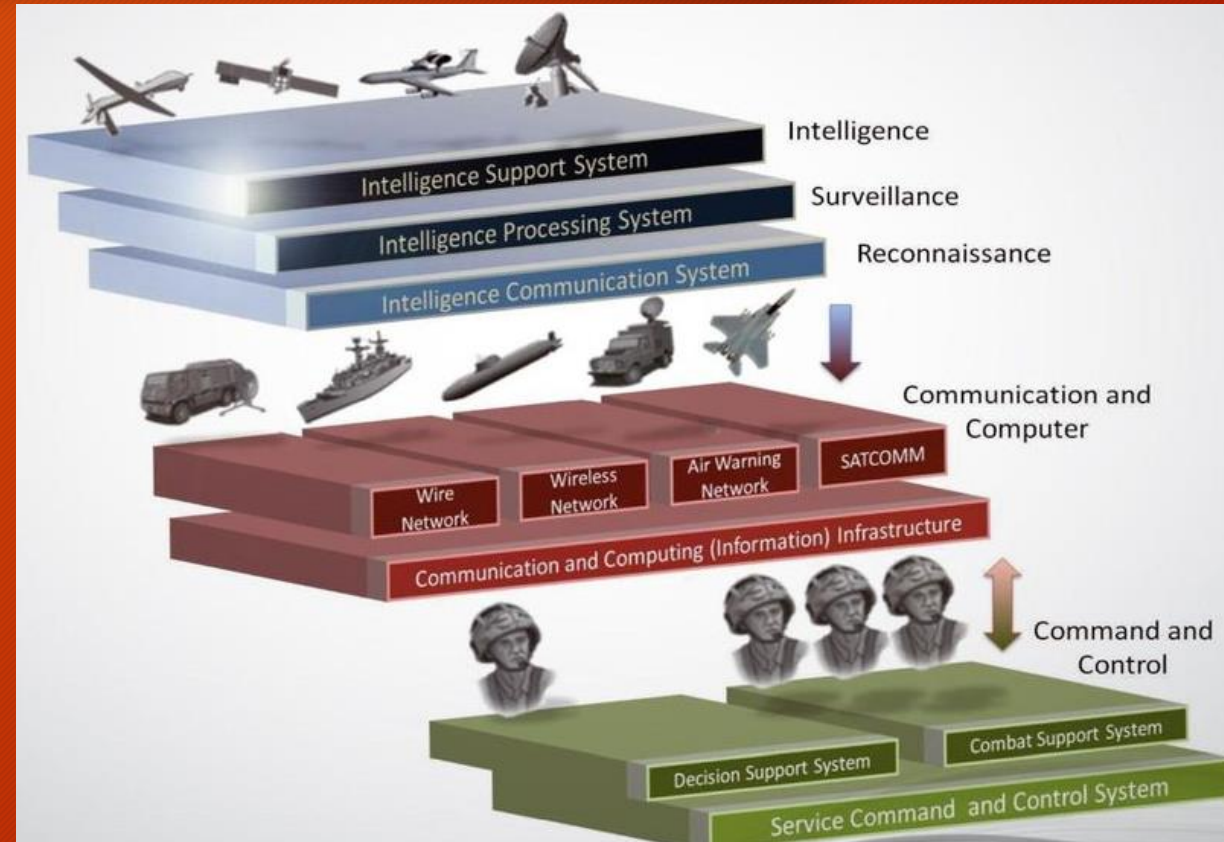
Turkish Bayraktar TB2 UAV

C4I:

Command, Control, Communications, Computers and Intelligence

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- Modern wars are won with precision guided weapons targeted in real-time from both strategic (satellite) and tactical (drone) imaging tied into a command and control structure for weapons release
- Today, Ukraine is capable detecting, targeting, authorizing, and firing upon targets in as little as 1 minute
- NATO takes much longer to execute the same cycle. Why?
 - It's not technology or systems ...
 - legal decision making including the assessment of collateral damage cause nearly all of the delay



Communications: A war made for Starlink

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- Starlink commercial services had just launched when Russia invaded Ukraine
- Destruction of cellular and telecommunications infrastructure created the perfect opportunity for SpaceX/Starlink
- While some level of jamming/interference has occurred, Starlink has been surprisingly robust in the Ukraine theatre
- Starlink Today
 - As of December 2022, Starlink consists of over 3,300
 - Residential throughput 100 Mbps to 200 Mbps
 - Commercial throughput up to 500Mbps
 - Terminal cost ~\$1,500 (customers pay ~\$500 up front)
- On Dec 1, 2022 the FCC granted 7500 of the 30,000 requested satellites for SpaceX “Gen2” system

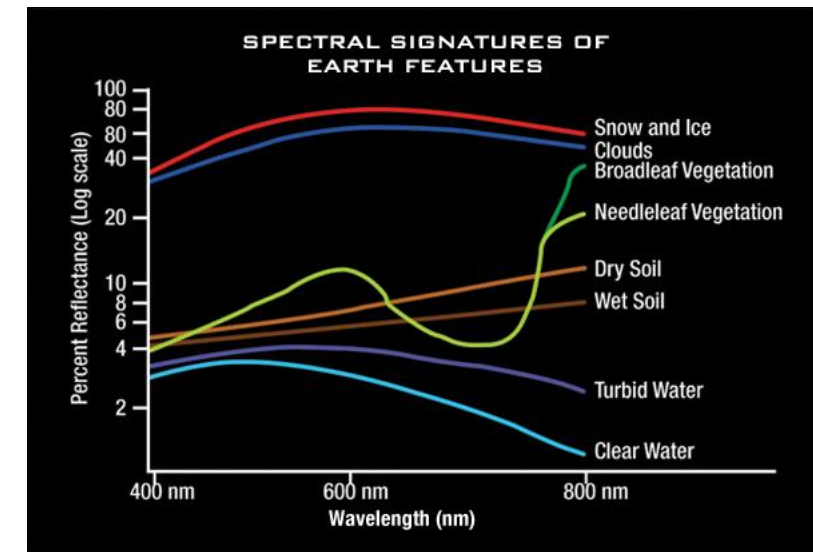
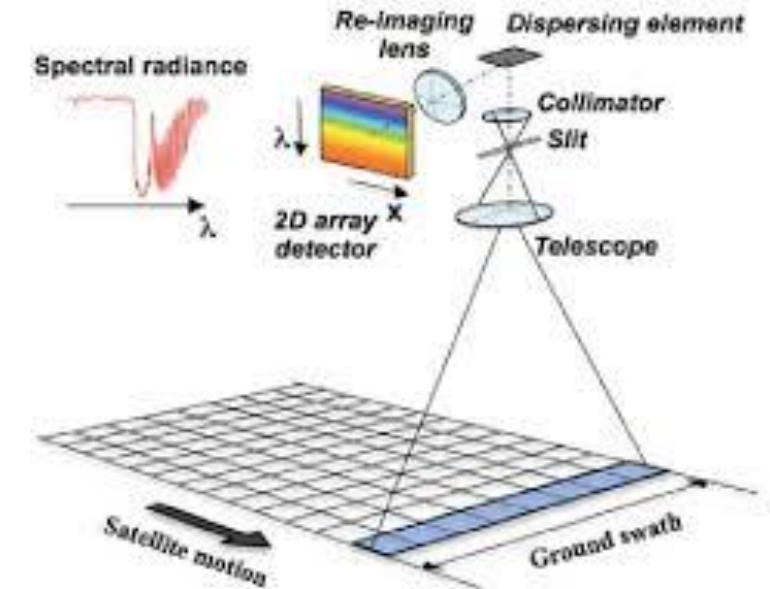


EYEs In the SKY: Imagery and Synthetic Aperture Radar

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Hyperspectral Imagery:

- Imaging Sensors
 - **Imaging Radiometer:** two-dimensional array of sensors scanned electrically or mechanically
 - **Spectrometer:** uses a prism or grating for spectral discrimination
- Earth Features and materials reflect specific spectral components
 - “Spectral Signatures”
- Current state of art is Hyperspectral Imaging
 - Evolution through a multiple decades of technology advances
 - Hyperspectral captures hundreds of narrow bands from infrared thru ultraviolet
 - Advantages of Hyperspectral:
 - Capture all data at one time
 - More accurate segmentation and classification of the image

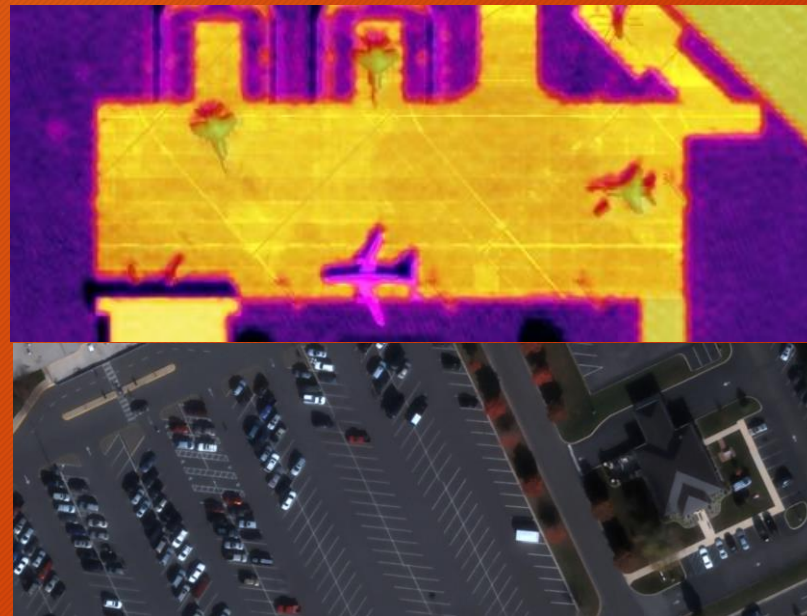


Commercial LEO Imagery satellite constellations

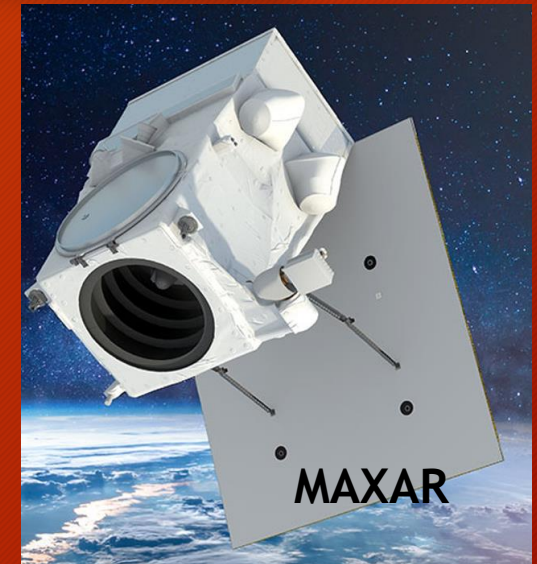
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Constellation: 21 sats (Pelican)
Optical Res: 30 cm (Pelican)
2-5 m (Dove)
Infrared Res ~2 m



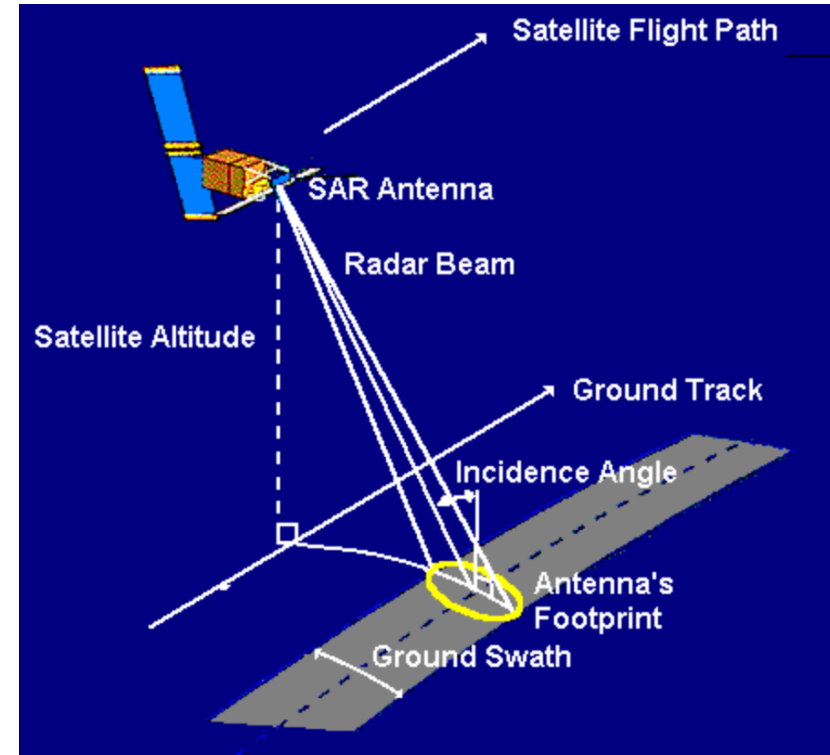
10 cm RGB & Infrared Imaging
(Albedo)



Constellation: 6+ Sats
Optical Res: 15 - 30 cm
Multispectral 0.15 - 2 m

What is SAR?

- Synthetic-aperture radar (SAR) is a form of radar that is used to create two-dimensional images or three-dimensional reconstructions of objects, such as landscapes
- The distance the SAR device travels over a target in the time taken for the radar pulses to return to the antenna creates the large synthetic antenna aperture
 - A 450 Km orbit LEO SAR Sat has synthetic aperture ~0.9 km
- SAR can create high-resolution images with relatively small physical antennas - PERFECT for LEO CubeSats
- LEO X-Band SAR can achieve resolutions < 50 cm
- Interferometric (InSAR) and differential Interferometric (D-InSAR) processing can approach GPS in accuracy



Commercial LEO SAR satellite constellations

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Constellation: 21 Sats
Frequency Band: X-Band
Bandwidth: 30 to 300 Mz
Resolution: 0.25 m



Capella Space 0.3M Multilook Resolution



Constellation: 30 Sats planed
Frequency Band: X-Band
Bandwidth: 0 to 500 MHz
Resolution: 0.3, 0.5, 0.75 M

NRO, DARPA, & the War in Ukraine: Drivers of LEO commercial satellite intelligence

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- NRO granted study contracts to five commercial SAR satellite companies:
 - Airbus's US arm
 - Capella Space (California startup)
 - Finnish firm ICEYE's US branch
 - Florida startup PredaSAR
 - California-based Umbra
- Equivalent DARPA program is enabling Imagery Sat companies
- Ukraine provided real time imagery by MAXAR and others



Planet launched 36
SuperDove
Hyperspectral Satellites
January 3, 2023

Thank You

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