

27th Meeting of the Advisory Committee on Commercial Remote Sensing Commercial Synthetic Aperture Radar (COMSAR) Working Group Report

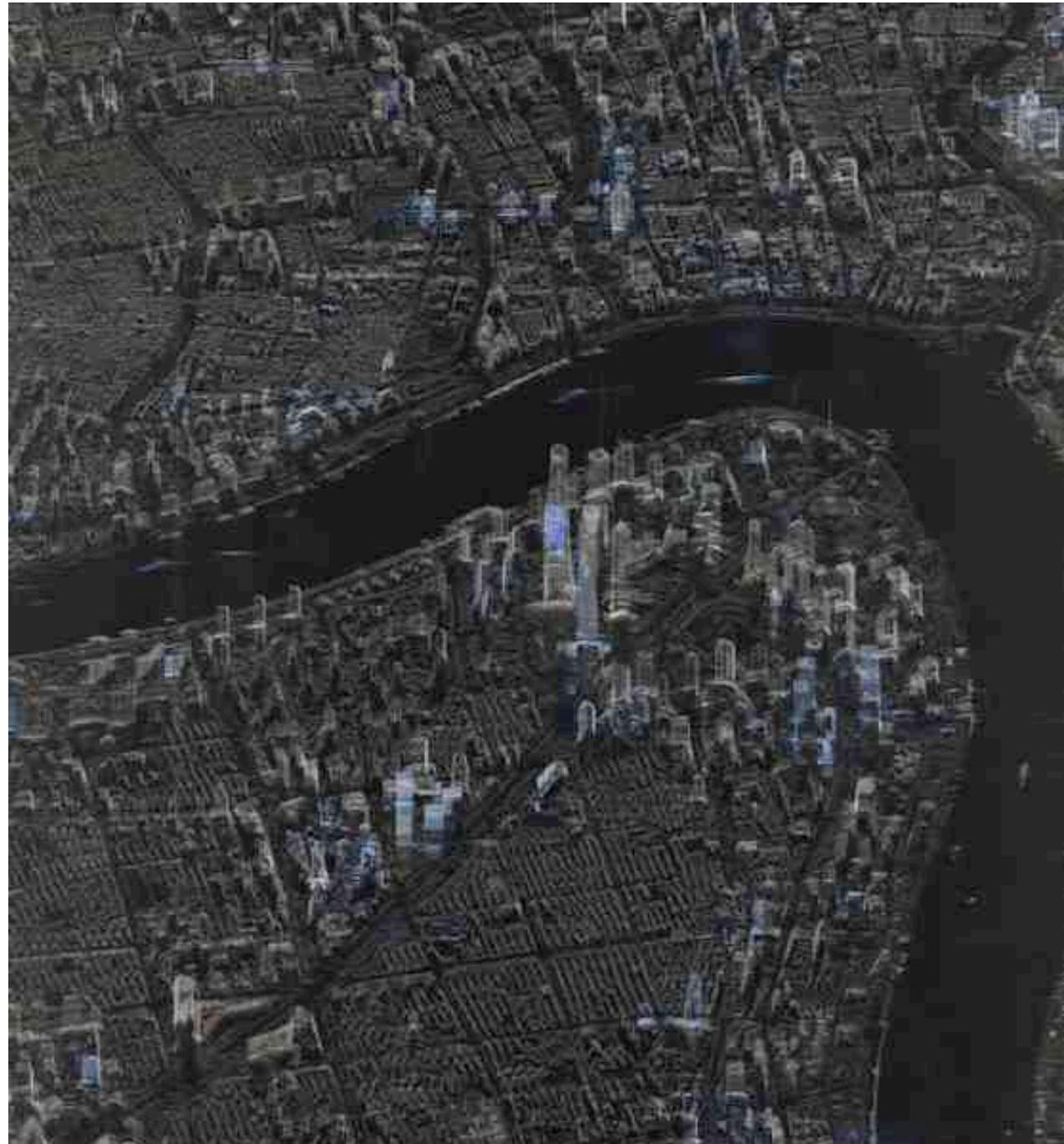
June 23-25, 2020



Diego Garcia .25m -19db

Briefing Outline

- Working Group Participants
- Working Group Mandate
- SAR Committee Findings
- What is Synthetic Aperture Radar?
- Key Parameters for SAR
- How Does SAR Work?
- COMSAR Competitive Landscape
- Non US Commercial SAR Providers
- US Commercial SAR Providers
- COMSAR Applications
- VHR SAR-A Precise Measuring Tool
- Committee's Recommendations
- New Regulation Impact
- Back-Up Files



SAR Working Group

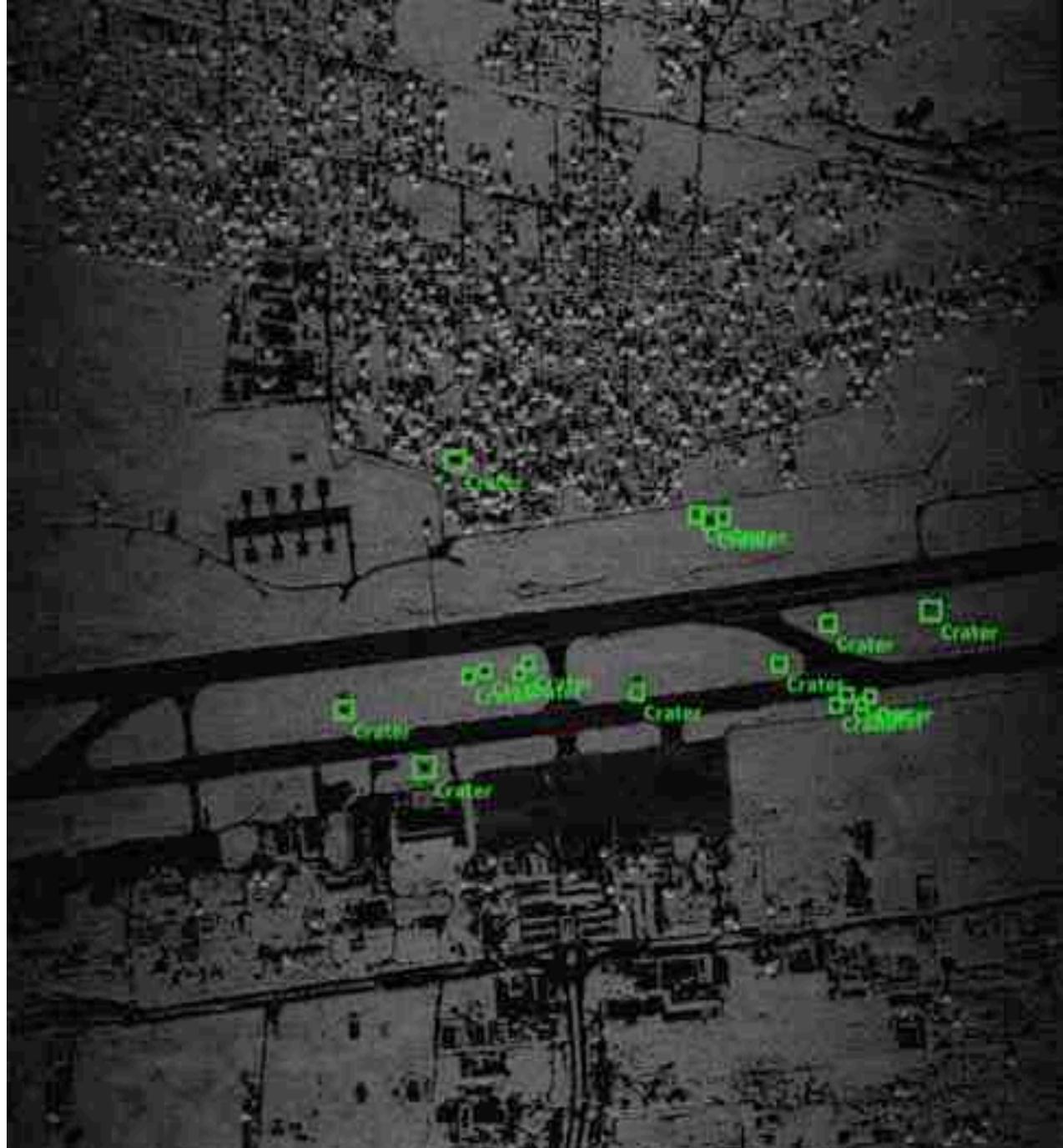
Committee Members and Non Member Participants

Working Group Members

David S. Germroth	Chair, SAR Working Group
Gregg Black	NGA
Michelle Kley	MAXAR
Dr. Josef Koller	The Aerospace Corporation
David Langan	Umbra Lab
Jamie Morin	The Aerospace Corporation
Alan Robinson	NOAA Staff Member
Gil Klinger	ACCRES Chair, ex officio
Tahara Dawkins	Director, CRSRA, ex officio

Non ACCRES Participants

Payam Banazadeh	Capella Space
Dan Brophy	Capella Space
Jörg Herrmann	Capella Space
Paul Midzak	XpressSAR



Russian Base in Syria .25m Spotlight

Working Group Brief Out

Working Group Mandate

- Established by the ACCRES Chairman to focus on current COMSAR market and identify “barriers to entry” into the market for US industry.
- The goal of the working Group is to the develop a better understanding and recommendation on how a US COMSAR industry could be nurtured to effectively compete in the global COMSAR market.



Missile Test Stand, Sinpo, North Korea, .25 Spotlight

SAR Committee Findings

Global COMSAR Competition

- The COMSAR Market is **inherently Governmental**.
- To Date, all operational COMSAR systems:
 - ✓ are non-US owned and operated
 - ✓ enjoy significantly subsidies in the form of funding for construction and and data contracts from their respective defense ministries and national governments.
 - ✓ deliver very high-resolution, high-quality SAR data products and services on a worldwide basis.

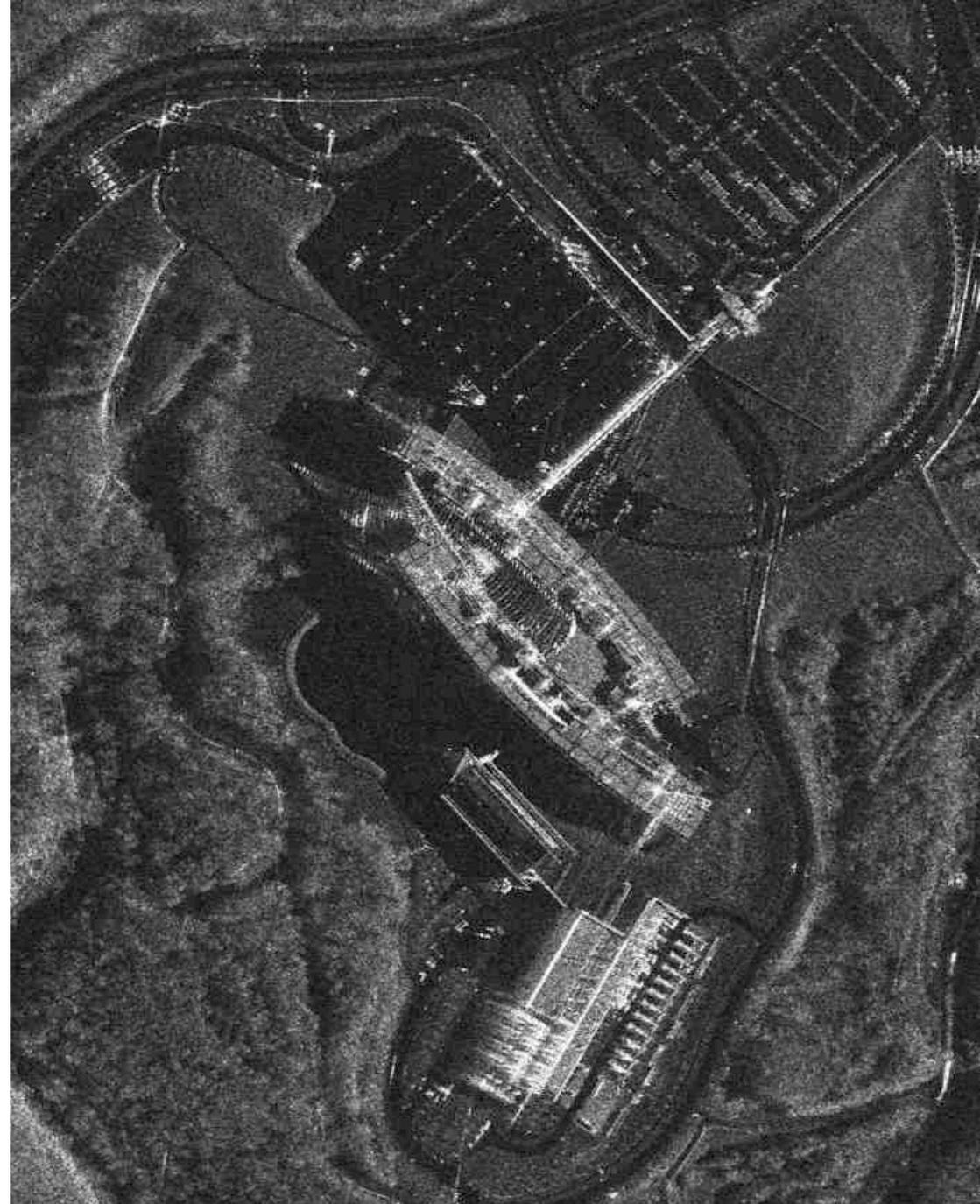


Northern Virginia, .25m Spotlight

SAR Committee Findings

US COMSAR Industry

- US licensing policy applied more stringent controls on SAR systems and data dissemination than on optical.
- Years of Restrictive phase data and spatial resolution policies deterred US firms from entering the Global COMSAR market.
- Emerging US COMSAR entities offer an opportunity to work toward regaining US leadership of the Global COMSAR market.
- A vibrant US COMSAR industry provides an accountable commercial alternative to foreign competitors and a complementary addition to the nation's fleet of satellites.

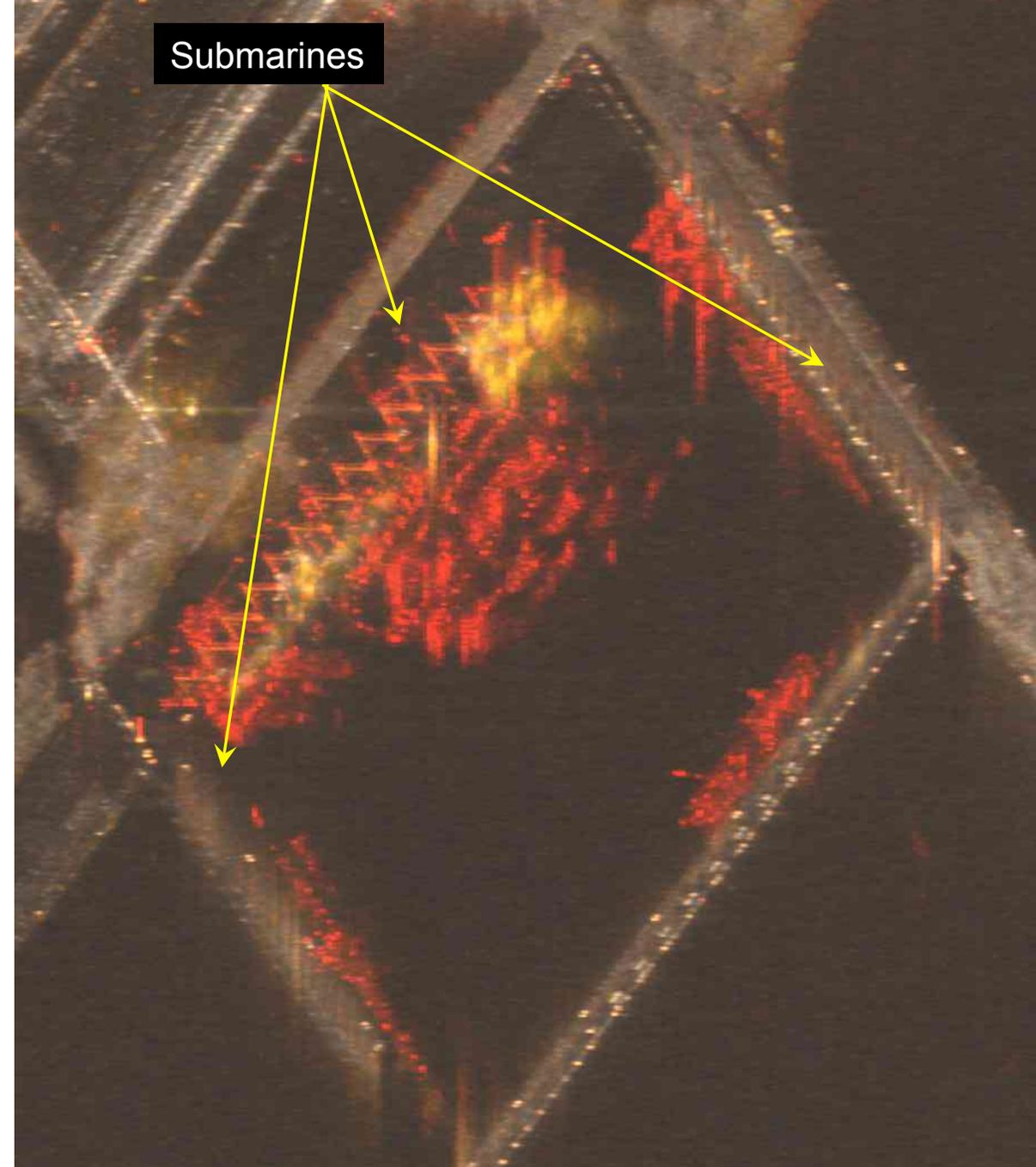


Springfield, Virginia, .25m spotlight

SAR Committee Findings

Viability of US COMSAR

- Industry needs to be able to compete with the next generation systems being deployed by global COMSAR providers.
- Requires a technical leapfrog over the competition which were subsidized during the decades US industry was hampered by policy.
- New Space is making strides toward viable SAR systems though these attempts are still in their early stages and technical infancy.
- The capability gap between New Space SAR and the global COMSAR providers will sufficiently handicap US industry from developing



What is Synthetic Aperture Radar (SAR)?

An phenomenology which takes advantage of the long-range propagation characteristics of radar signals and the complex information processing capability of digital electronics to provide phase data of which imagery is one of many bi-products. It is not limited by the time of day or atmospheric conditions.

It's more a MASINT tool than a **GEOINT** system:

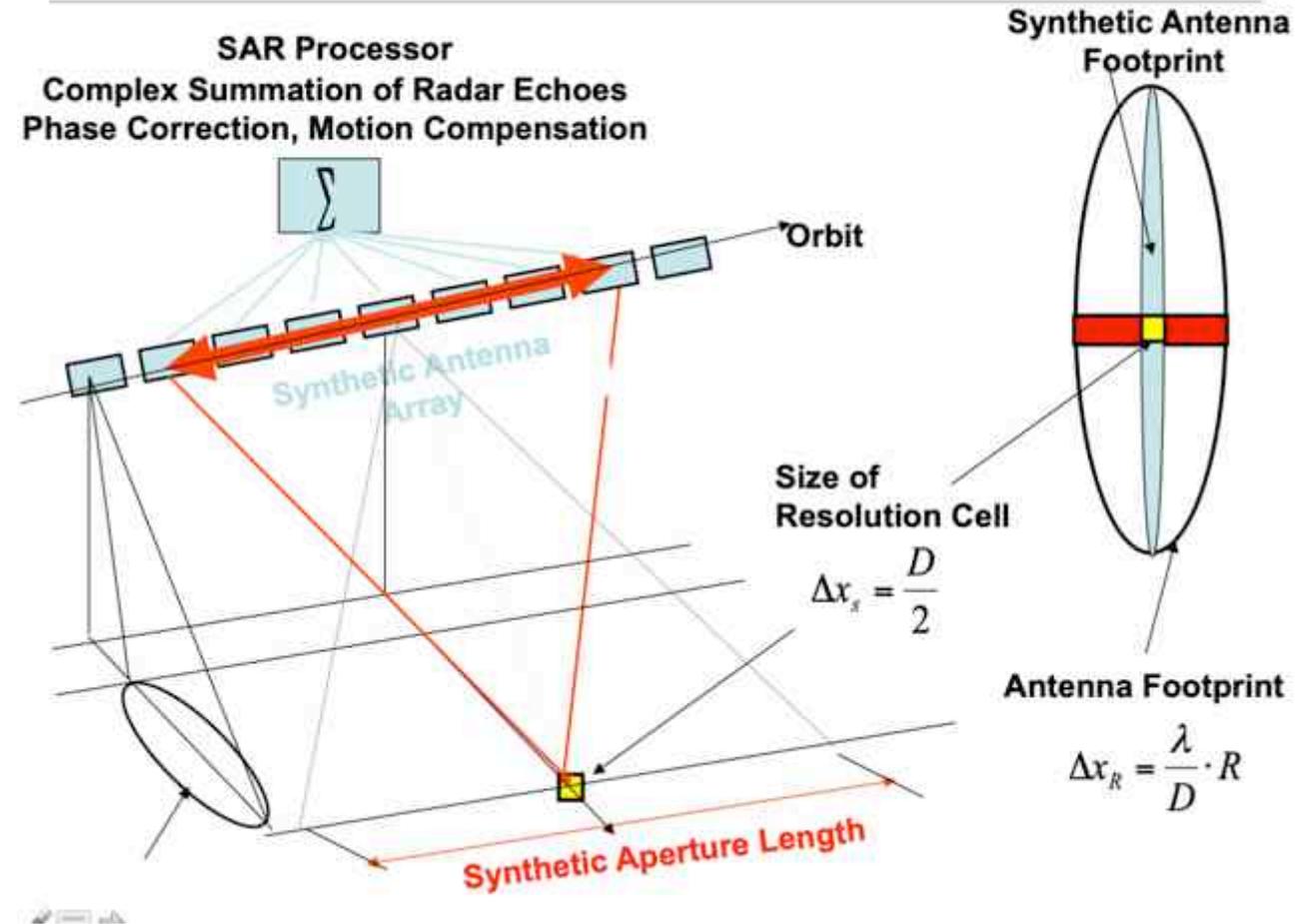
- **MASINT**: information which when collected, processed, and analyzed, results in intelligence that detects, tracks, identifies, or describes the signatures of fixed or dynamic target sources.
- **GEOINT**: the exploitation and analysis of imagery to describe, assess, and visually depict physical features and geographically referenced activities on the earth.



How Does SAR Work?

- SAR is an **active sensor** which transmits its own energy. **key acquisition dimensions** in the process are **Range** and **Azimuth**
- **Range** is a measure of the "line-of-sight" distance from the radar to the target. **Range Resolution** is determined by measuring the time from transmission of a pulse to receiving the echo from a target
- **Azimuth** is perpendicular to the range. An antenna is needed to focus the transmitted and received energy into a sharp beam. The sharpness of the beam defines the **azimuth resolution**.
- Even moderate SAR resolutions require an antenna too large to be practically carried by a Space Craft. So the **distance the Space Craft flies** in synthesizing the antenna and is the **synthetic aperture**.

SAR Imaging Geometry



Note: Range and Azimuth Resolution are often different values

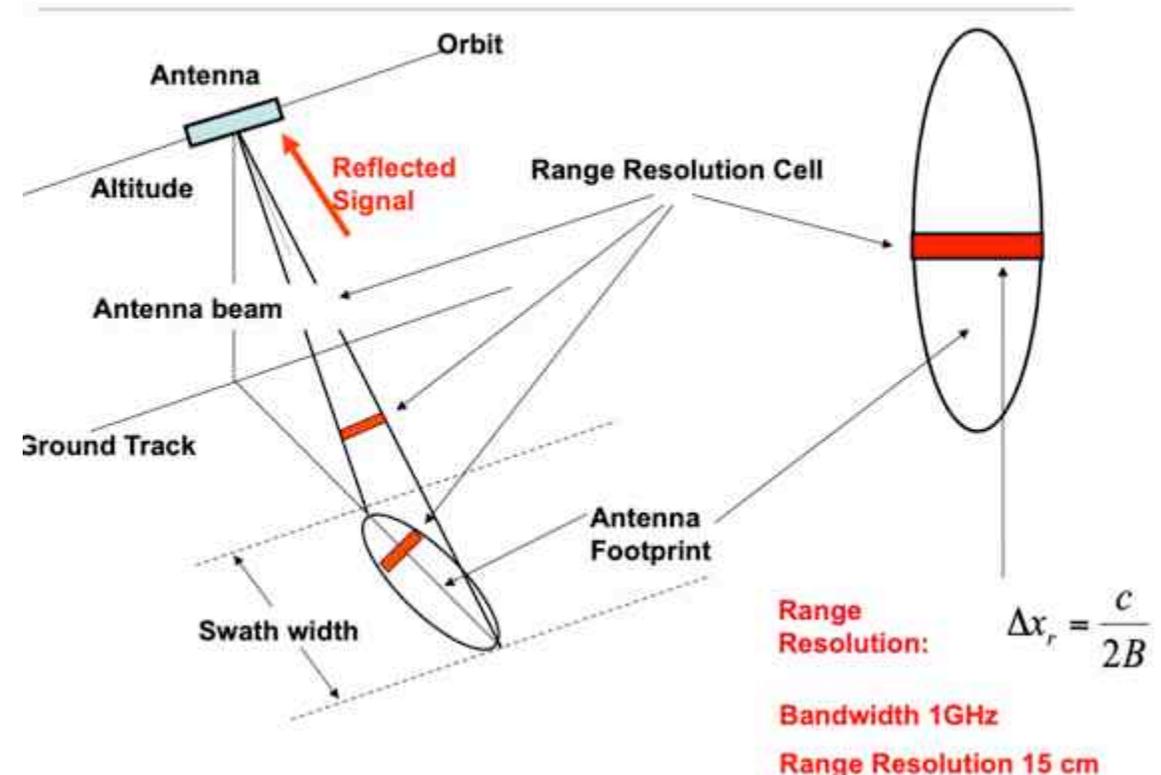
Key Parameters for SAR

- ✓ **Energy:** Necessary for the active sensor to transmits microwave signals to the target. The Level of energy determines the nature of the return and the value of the noise

The Resolutions

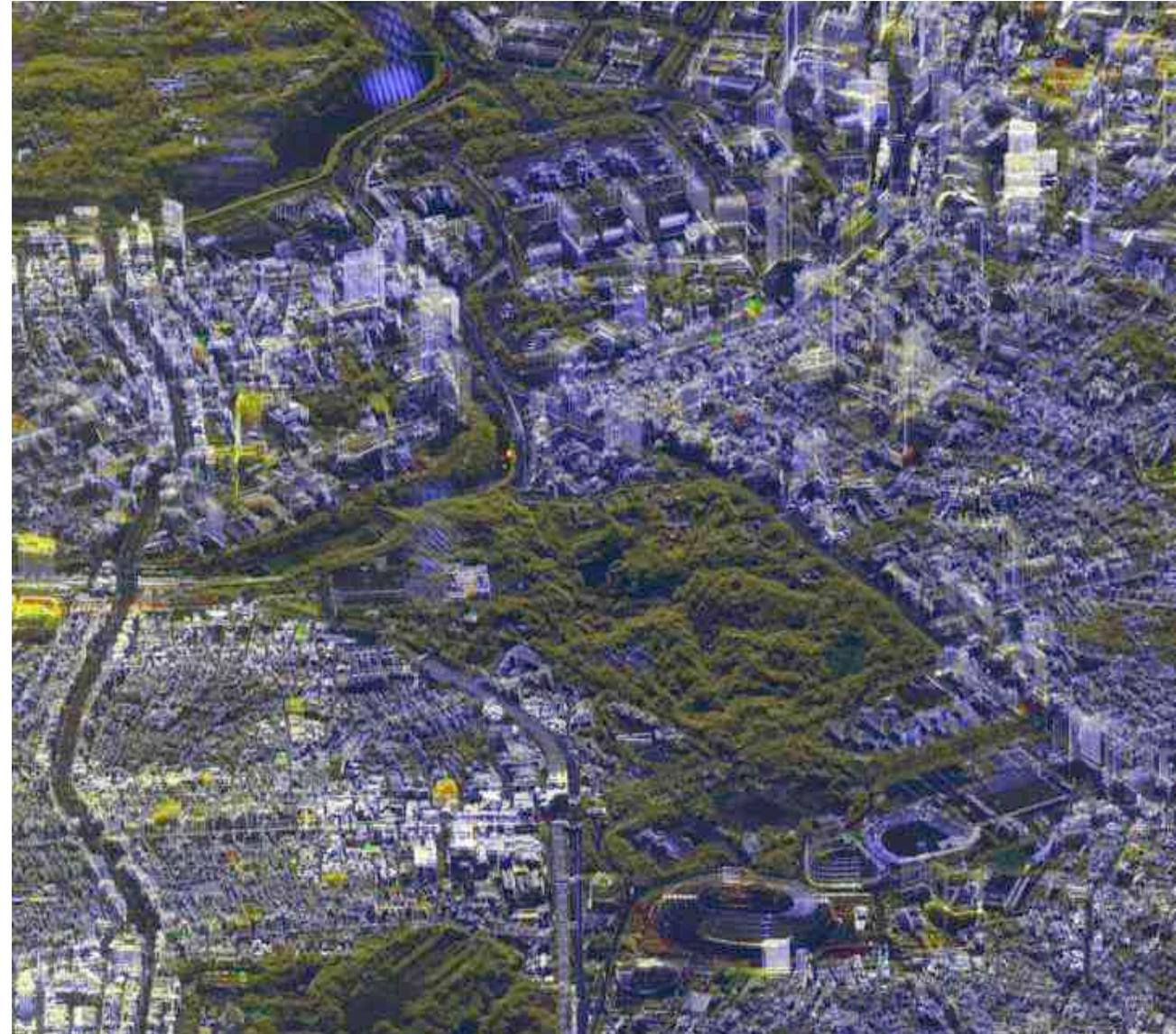
- **Azimuth Resolution:** Spatial resolution along a vector that is parallel to the synthetic aperture
- **Radiometric Resolution:** Describes the ability of an imaging system to discriminate between varying levels of energy
- **Range Resolution:** Spatial resolution along the imaging vector. Parameter is inversely proportional to waveform bandwidth when using pulse compression
- ✓ **Spatial Resolution:** The higher the resolution the more objects on the ground that can be discriminated. **Often confused with the pixel size,**

Sidelooking Radar Imaging Geometry



Key Parameters for SAR

- **Incidence Angle**: Angle between vertical and incident plane wave. Typically reported for the scene reference center.
- **Polarization**: the direction of travel of electromagnetic wave vector's vertical (up and down), horizontal (left to right), or circular (rotating in a constant plane left or right)
- **Repeat Cycle**: Could be interpreted in several ways but, most likely, the count of repeat ground track cycles or the period of a repeat ground track cycle.
- ✓ **Wavelength**: Determines the penetration depth of the transmitted signal The longer the wavelength, the deeper the penetration
- ✓ **Noise-Equivalent Sigma Zero (NESZ) or signal-to-noise** is the sensitivity of the system to areas of low radar return.



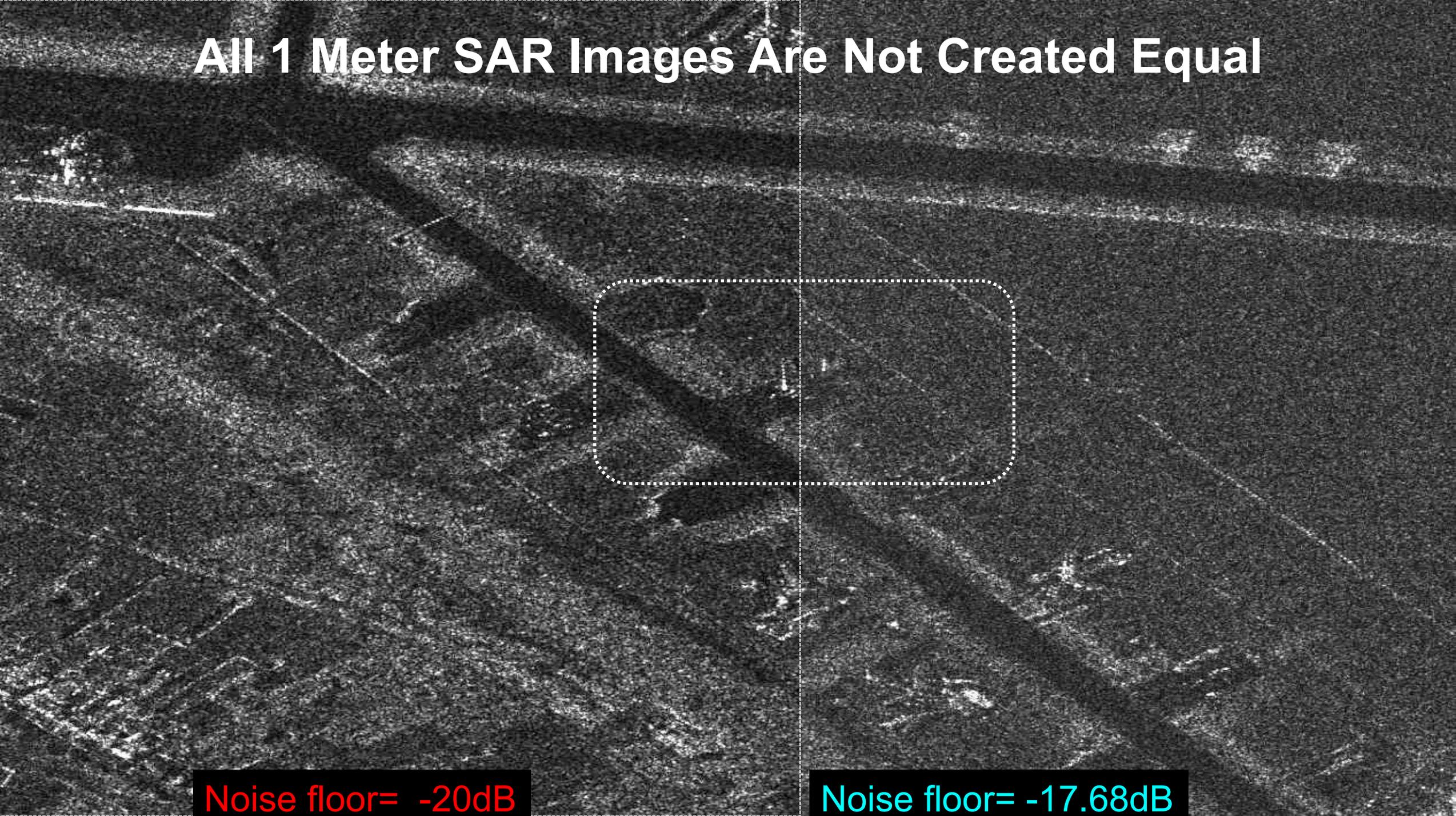
Olympic Stadiums Tokyo, Japan .25m Spotlight

All 1 Meter SAR Images Are Not Created Equal



Noise floor= -20dB

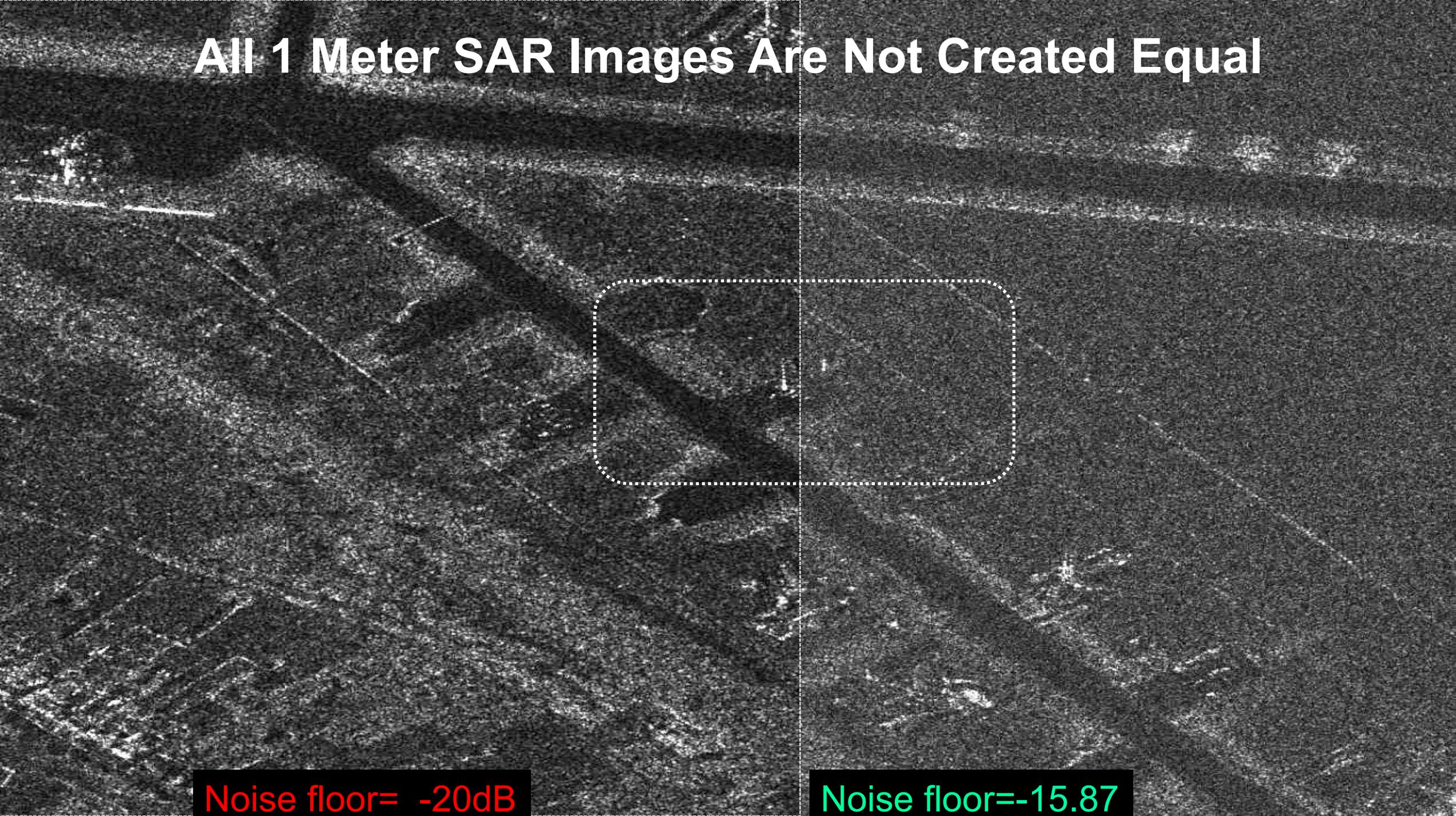
All 1 Meter SAR Images Are Not Created Equal



Noise floor= -20dB

Noise floor= -17.68dB

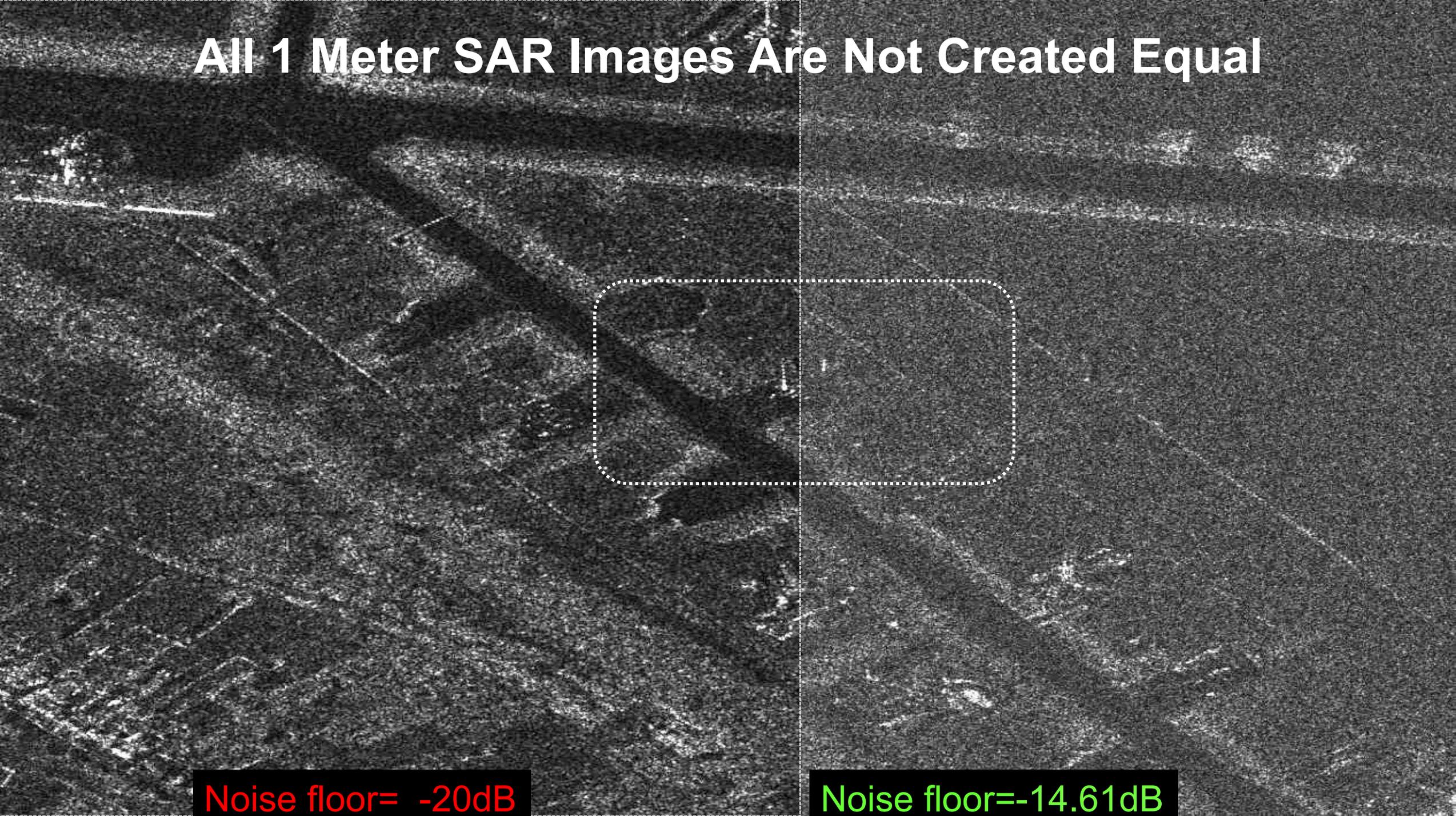
All 1 Meter SAR Images Are Not Created Equal



Noise floor= -20dB

Noise floor=-15.87

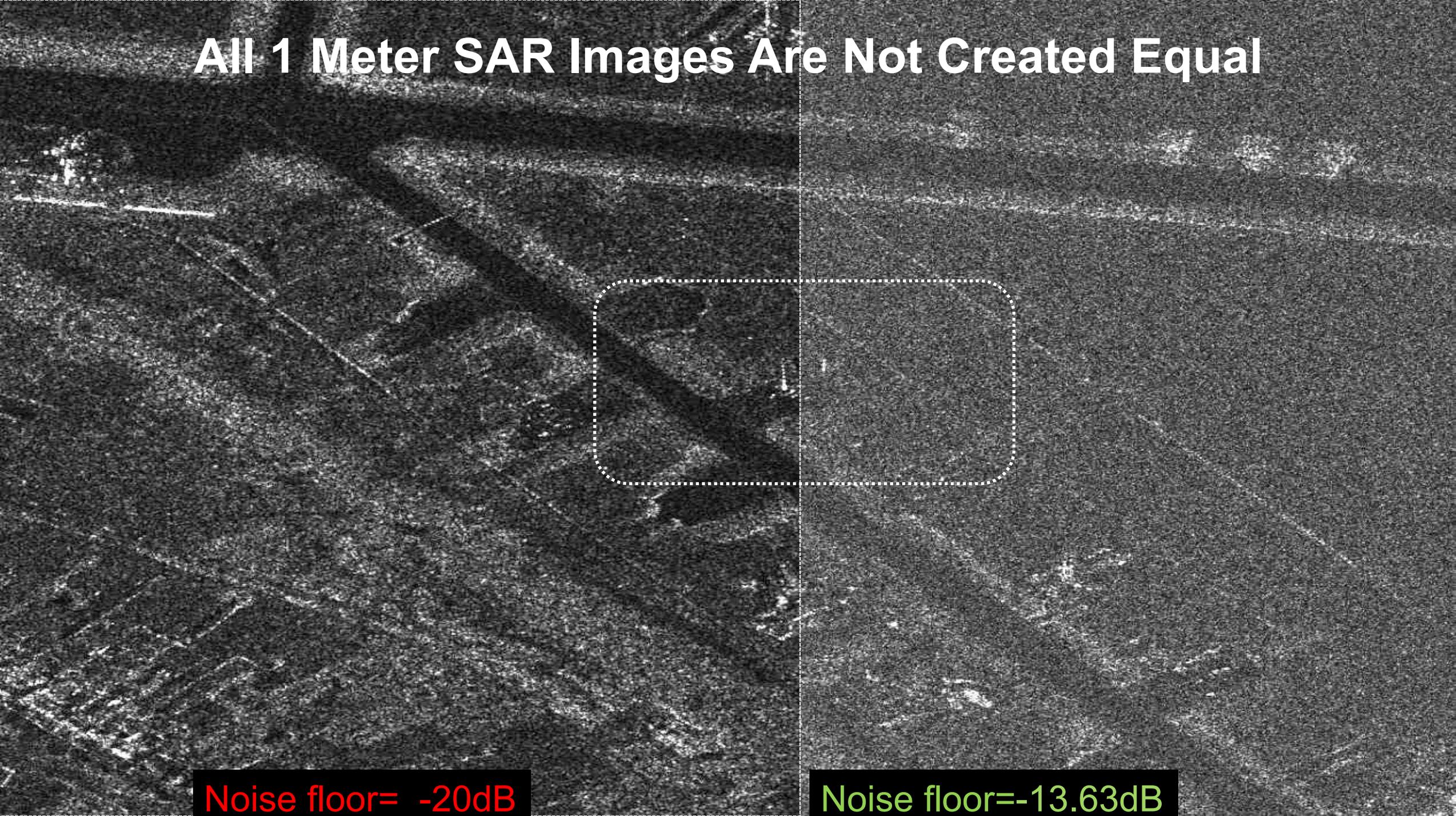
All 1 Meter SAR Images Are Not Created Equal



Noise floor= -20dB

Noise floor=-14.61dB

All 1 Meter SAR Images Are Not Created Equal



Noise floor= -20dB

Noise floor=-13.63dB

All SAR Images Are Not Created Equal



SAR 0.50m
-23dB NESZ
Multilooked 3x3



SAR 0.25m
-23dB NESZ



SAR 0.50m
-25dB NESZ
Multilooked 3x3

All SAR Images Are Not Created Equal



SAR 0.37m
-43dB NESZ



SAR 0.50m
-23dB NESZ



All SAR Images Are Not Created Equal



SAR 0.37m
-43dB NESZ



SAR 0.25m
-23dB NESZ

All SAR Images Are Not Created Equal



SAR 0.37m
-43dB NESZ



SAR 0.50m
-25dB NESZ
Multilooked 3x3



COMSAR Competitive Landscape

- **US COMSAR industry is starting from ground zero**
 - ✓ US has significant SAR capabilities not available to the US COMSAR Industry`
 - ✓ New Space innovations are welcomed but needs to be combined with “Now Space” capabilities if the US ever intends to catch up--let alone take COMSAR leadership
- **Non-US COMSAR providers have made significant and impressive advances with government subsidies**
- **SAR will remain an inherently governmental product for the near future**
 - ✓ VHR Space borne COMSAR industry has its beginning in 2007 (13 years old) prior to 2007 SAR was primary a defense and intelligence Phenomenology
 - ✓ As with all infant industry's it requires time and education to build a market
 - ✓ All current operational COMSAR providers depend significantly on Government customers. (But the non governmental side is growing)

Non US Commercial X Band SAR Providers

Satellite name	TerraSAR-X	Tandem-X	PAZ	HRWS	Aznaro 2	COSMO-SkyMed	COSMO-SkyMed NG	ICEYE	KompSAT 5
Country	Germany	Germany	Spain	Germany	Japan	Italy	Italy	Finland	Korea
Launch	2007	2010	2018-	2025	2018	2007.-2010	2019	2018--	2013-20
Altitude	514km	514km	514km	514km	504km	620km	620km	570 km	550 km
Orbit Inclination	97.44 deg. Polar	97.44 deg. Polar	97.44 deg. Polar	97.44 deg Polar	97.44 deg Polar	97.86 deg. Polar	97.86 deg. Polar	97.68 deg Polar	97.6 deg Polar
Ground Track Revisit	4 & 7 days	4 & 7 days	4 & 7 days	N/A	14 days	16 days	16 days	18ndays	28 days
Frequency (band)	9.95GHz (X)	9.95GHz (X)	9.95GHz (X)	9.95GHz (X)	9.65GHz (X)	9.65GHz (X)	9.65GHz (X)	9.65GHz (X)	9.66GHz (X)
Polarization	Single, Dual, Quad	Single, Dual, Quad	Single, Dual, Quad	Single, Dual, Quad	Dual	Single, Dual	Single, Dual, Quad	Single	Dual
Government Mode	Yes.	Yes	Yes	Yes	No	Yes	Yes	No	N0
Government Subsidies	Yes 2/3	Yes 2/3	Yes 2/3	Yes 2/3	Yes 1/2	Yes %100	Yes %100	Yes	Yes 100%
Best Azimuth Resolution	.25m	.25m	.25m	.14m	1m	1m	.35m	.30m	.50m
Best NESZ	-22db	-22db	-22db	-26db	-18db	-19db	-23db	-19db	-17db
Notes	Operates as the WorldSAR Constellation			Bi-Static on Demand	Dual Use System	Constellation of 4	Constellation Of 2	18 Ball Constellation	KompSAT 6 is planned for a 2020 Launch

COMASR Competitive Landscape

C-Band

Very High Resolution and NESZ (Sub-meter)

None

X-Band

Very High Resolution and NESZ (Sub-meter)



Low Resolution and/or NESZ



Designed to fulfill European, Canadian needs first

Good potential to use in synergy with commercial missions. No tasking possible to serve adhoc customer needs

Good Spatial Resolution



limited image quality and acquisition capacity limit market penetration, only advantage in high revisit applications that tolerate limited resolution and performance

No NOAA License

US Commercial X-Band SAR Providers

Satellite name	Capella Space	Umbra Lab	PredaSAR	York	Tyvak	XpressSAR	HybredSAR	R2 Space
Launch	2020	2020	2021	TBD	2020	2023	2024	2021
Altitude	500 km	515 km	N/A	500	500 km	540km	579 KM	570 km
Orbit Inclination	Mix of 90 deg polar 42 deg inclined	N/A Polar?	N/A Polar?	40 deg Inclined	97.7 deg Polar	45deg Inclined	45 deg inclined	97.68 deg Polar
Ground Track Revisit	N/A	N/A	N/A	N/A	N/A	4 days	3.9 days	18ndays
Frequency (band)	9.6 GHz (X)	9.6- 9.8 GHz (X)	N/A (X)	9.95GHz (X)	9.65GHz (X)	9.65GHz (X)	9.65GHz (X)	9.65GHz (X)
Polarization	Single	Dual	N/A	Single,	Single	Single, Dual, Quad	Single, Dual, Quad	Single
Government Mode	Yes	N/A	N/A	N/A	N/A	Yes	Yes	N/A
Best Azimuth Resolution	0.50m	.25m	1m	.03m	1.25m	.25	.12m .25 Commercial	.03m
Best NESZ	-11 db	-13db	N/A	-19db	N/A	-26db	-25dm	-19db
Notes	44 ball Constellation	12 Ball constellation	Constellation of 48	S Platform	2 ball constellation	Constellation of 4	Constellation of 4	18 Ball Constellation

COMSAR Market Considerations

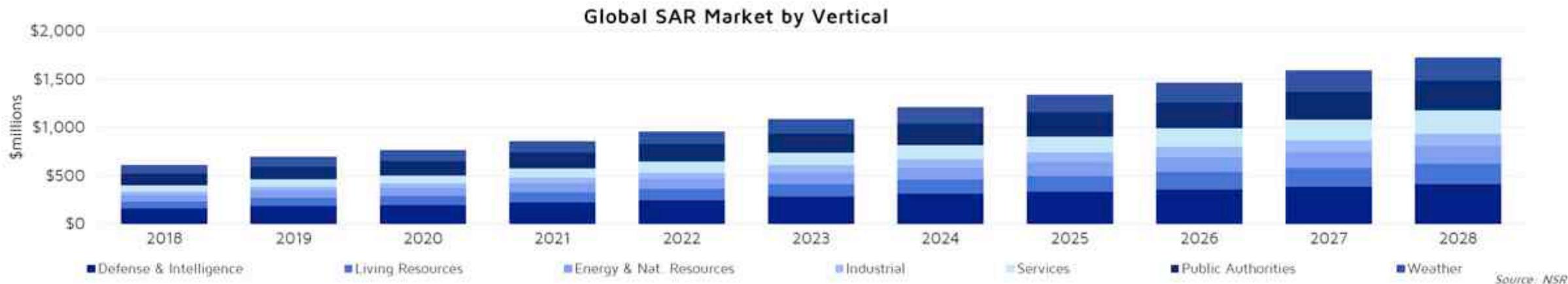
- Military and Defense segment is accounted for \$477.93 million in 2017 and is expected to reach \$1,245.32 million by 2027 according to NSR
- Military agencies utilization of the data for surveillance and reconnaissance operations are expected to drive the segment growth.
- SAR is used to detect surface features, like building complexes and missile sites, and topographical features of the surrounding terrain. it is used in battlefield reconnaissance, ship detection, Orders of Battle determinations, weapon guidance, mission planning for future operations, etc.



Barking Sands Missile Range, Kauai Hawaii .25m Spotlight

COMSAR Market Considerations

- An adolescent but rapidly maturing market
- Unlike optical, the satellite SAR supply base is highly immature
- The satellite based SAR data market today is relatively small, totaling ~\$715 million in 2018 (including downstream) according to NSR.
- Government, defense & intelligence customers are and will be the dominant users for the foreseeable future.

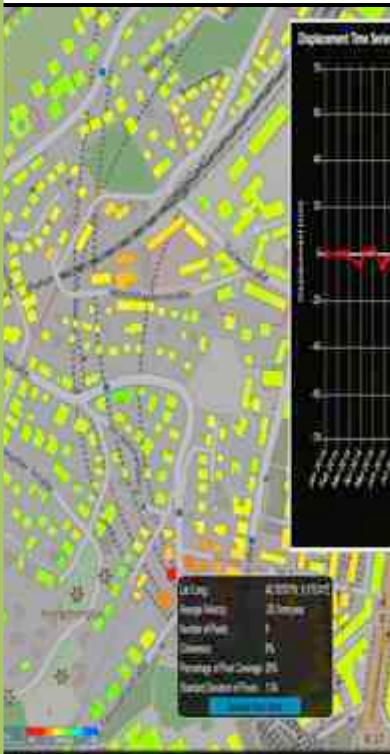


VHR COMSAR Applications

Imagery / Data



Surface Movement Monitoring



Change Detection



Vessel Detection



GCPs



Elevation



COMSAR Applications

VHR SAR-A Precise Measuring Tool



→ 2D MEASUREMENTS

- Location
- Identification of Changes

Application:

- Image Analysis



→ 3D MEASUREMENTS

- Location
- Height

Application:

- DSMs-DTMs
- Ground Control Points



→ 4D MEASUREMENTS

- Location
- Height
- Displacements over Time

Application:

- Surface Movement Monitoring

Committee's Recommendations

New Regulation Impact

If applied as articulated in the text, the rules will improve U.S. COMSAR competitiveness in the global marketplace. The rule:

- Eliminates blanket, capability-based restriction on SAR in favor of maintaining status quo with global competition
- Shifts the burden to the national security community and away from industry, forcing DoD, State and the IC to accept international market realities.
- Overturns the approach of permanent restrictions in favor of time-limited technology controls.
- Strikes a balance between U.S. technological innovation, competition from foreign actors and national security



Committee's Remaining Recommendation

Initially the Committee had six key recommendation. However, the **new rules made five of the six key recommendation Moot, leaving only one**

Explore Financial Support of US COMSAR Industry

- Years of restrictive policies deterred US firms from entering the Global COMSAR market
- The non-US providers of COMSAR all commercialized data from government subsidized satellites under quasi public private partnership (PPP) models and have made significant and impressive advances in SAR under these subsidies.
- A technical leapfrog over the competition who were subsidized during the decades in which US industry was hampered by US policy is required to level the playing field

Committee's Remaining Recommendation

Explore Financial Support of US COMSAR Industry

- The US government should take proactive steps in support of the emergent US COMSAR industry.
- First and foremost, SAR data is still inherently governmental in its use. In that sense early data and product purchases would provide the Industry needed support while the industry develops .
- Other methods of support to be considered include:
 - ✓ Industry specific grants, financing and loans
 - ✓ Funding to support small and medium-sized businesses and startups in the industry
 - ✓ SAR focused Investment Schemes
 - ✓ Tax relief to reduce tax liabilities through annual investment allowance, capital allowance, employment allowance, etc.
 - ✓ SAR specific R&D tax credits,
 - ✓ SAR focused seed enterprise investment schemes



Thank You

Pearl Harbor Naval Base, Honolulu, Hawaii 1m StripMap

Imagery Courtesy of:

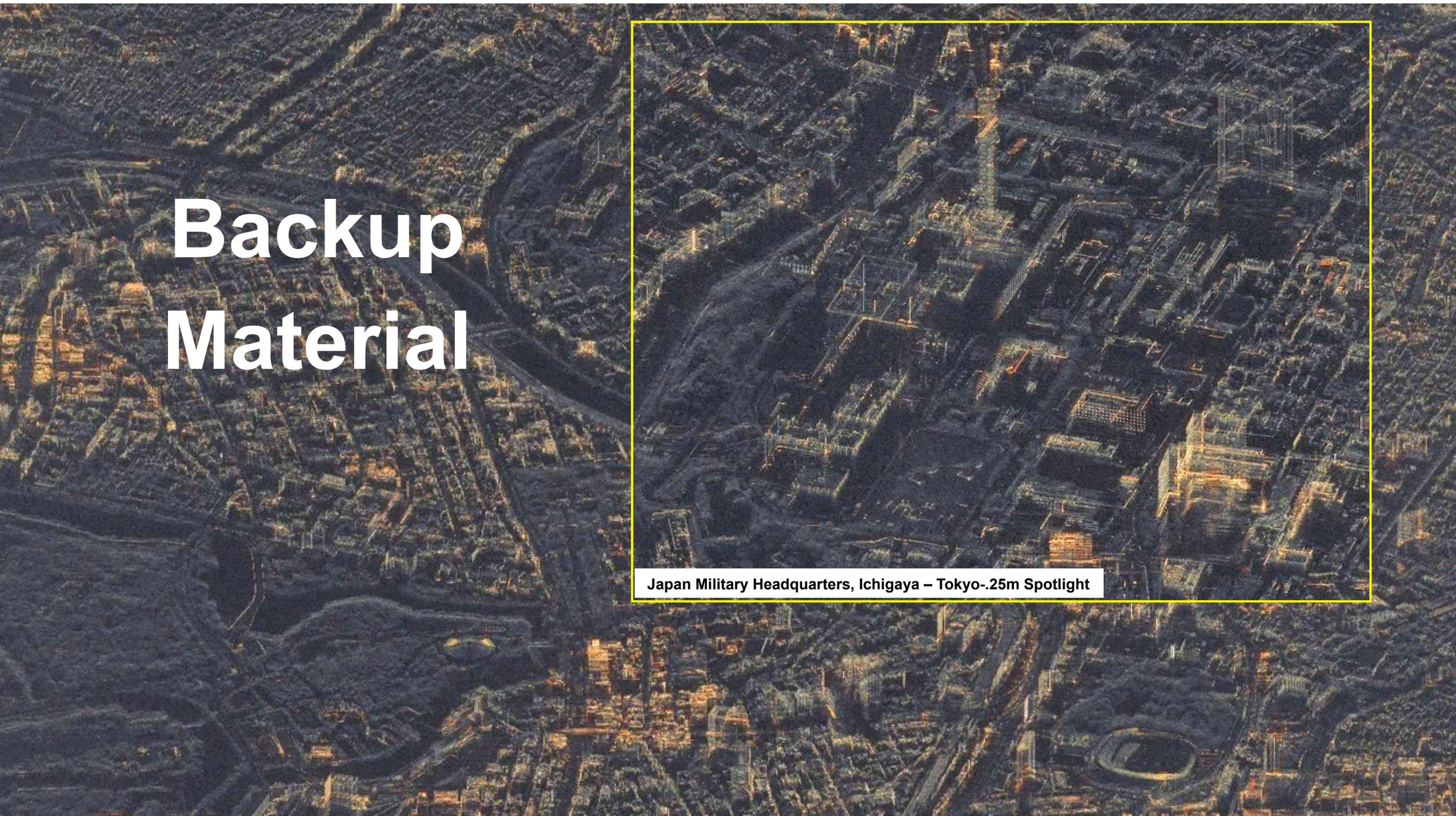
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Backup Material

An aerial night-time photograph of Tokyo, Japan, showing a dense urban landscape illuminated by city lights. A prominent yellow rectangular box highlights a specific area in the center-right of the image, which is identified as the Japan Military Headquarters in Ichigaya. The surrounding city lights create a complex pattern of bright spots and lines against the dark background of the night.

Japan Military Headquarters, Ichigaya – Tokyo-.25m Spotlight

Why COMSAR? The Arc of Instability

The Zone of Energy, Terrorist, Commerce, Drugs and Thugs

