2023 전자파학회 하계학술대회 워크샵

Intellian

저궤도 위성통신용 Ku/Ka 대역 위상배열안테나 개발

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인텔리안테크놀로지스

Aug. 23, 2023

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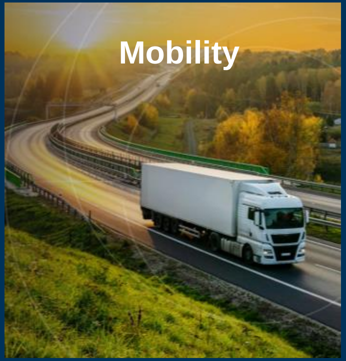
A Global Leading Manufacturer of Satellite Communications Equipment

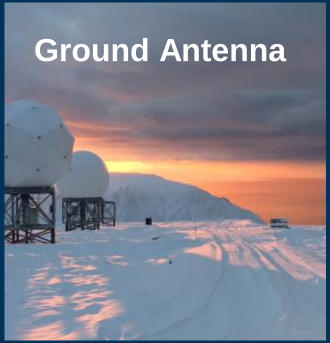
Empowering the Global Connectivity in maritime, on land and in air

- Critical & Resilient Communications
- Maritime Internet
- Satellite TV Entertainment
- Multi-Orbit Connectivity
- Merchant, Energy, Cruise, Leisure, Fishing, Mi/Gov

- Enterprise Internet
- Mobile Backhaul
- Telco & MNO Backhaul
- Community Broadband
- Disaster Recovery
- Multi-Orbit Connectivity



- ESA Antenna
- Automotive
- Transportation
- UAV/Drone
- UAM
- IFC



- LEO/MEO Gateway Antenna
- Satellite Data Link Antenna
- 5G/6G Satellite Terminals

- Multiband/Wideband Terminal
- Seamless Commercial & Military Ka-band
- Multi-Orbit Connectivity
- Unmanned Vehicles
- Flyaway/Transportable

INTELLIAN TECHNOLOGIES

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SATELLITE TVROs	GX MARITIME VSATs	INMARSAT FLEETBRODBAND	IRIDIUM CERTUS	XEO/NX SERIES VSATs	FLYAWAY

● **10 THINGS NSR Learned at SATELLITE 2023**

"Flat Panel Antennas Were Everywhere"

Walking around the show floor this year, **flat panel antennas (FPAs) 'smelled real' – literally.** As more and more arrived fresh … run into tradeshow booths, they moved beyond engineering mockups and into another stage of refinement

……

With a limited number of planes/trains/gov. in the world, **is the market big enough to support a large and diverse vendor base?**

…..

The next 12 to 24 months will be key to see how this market moves from **limited production runs** to **mainstream**

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● ESA MARKET GROWTH PERSPECTIVE

- **NSR projection**

  - **The most challenging and crucial piece of the ground technology** for future LEO constell.

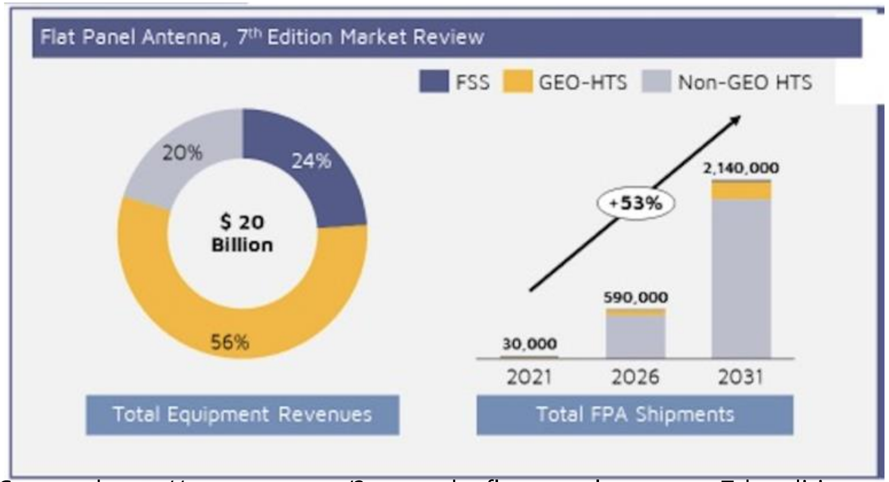
  - To rise to about **1.5M units** shipped annually by 2028 with equipment revenues exceeding **$1.1B** annually by 2028

  - **Aeronautical equipment** will drive revenue growth, while **fixed broadband LEO/MEO** will be the main volume market

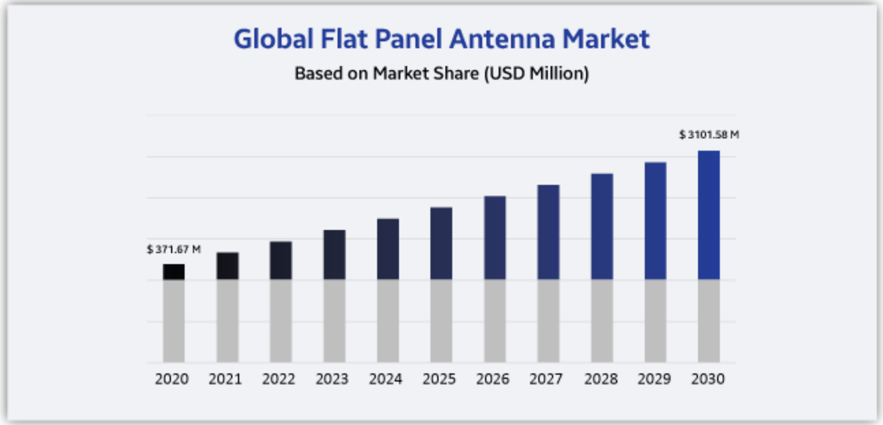
- **"Satcom Future Hinges on ESA"**

  - To reach **$3.1B** by 2030 **@CAGR 29%**

  - Demand for COTM, Autonomous systems, UAV/UAM, IFC, Automotive

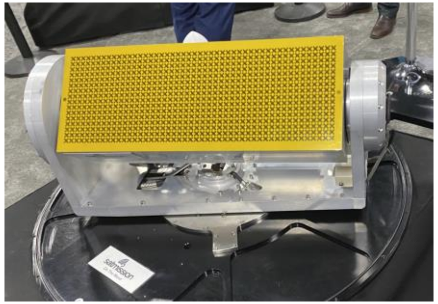


Source: https://www.nsr.com/?research=flat-panel-antenna-7th-edition

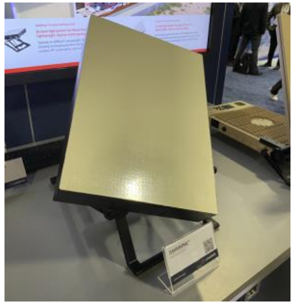


Source: https://www.strategicmarketresearch.com

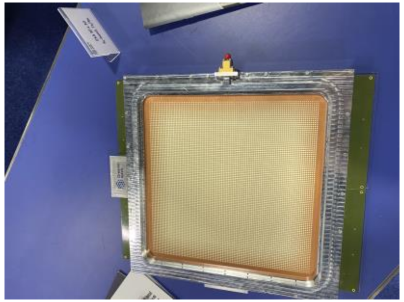
● ESA PRODUCT/TECHNOLOGY @ SATELLITE 2023



Satmission



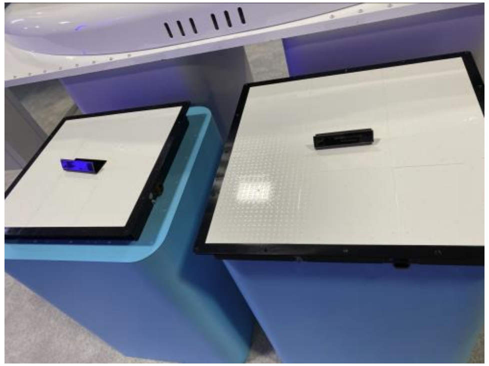
L3Harris



Greener Waver

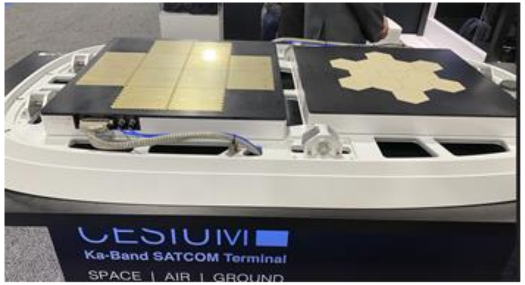
Intellian Technologies

SatixFy

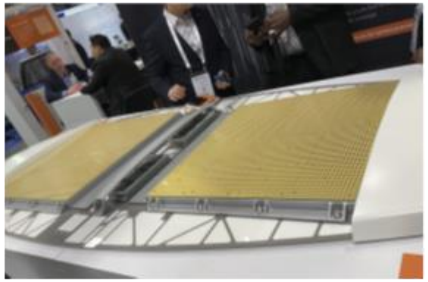


Ball Aerospace

Getsat

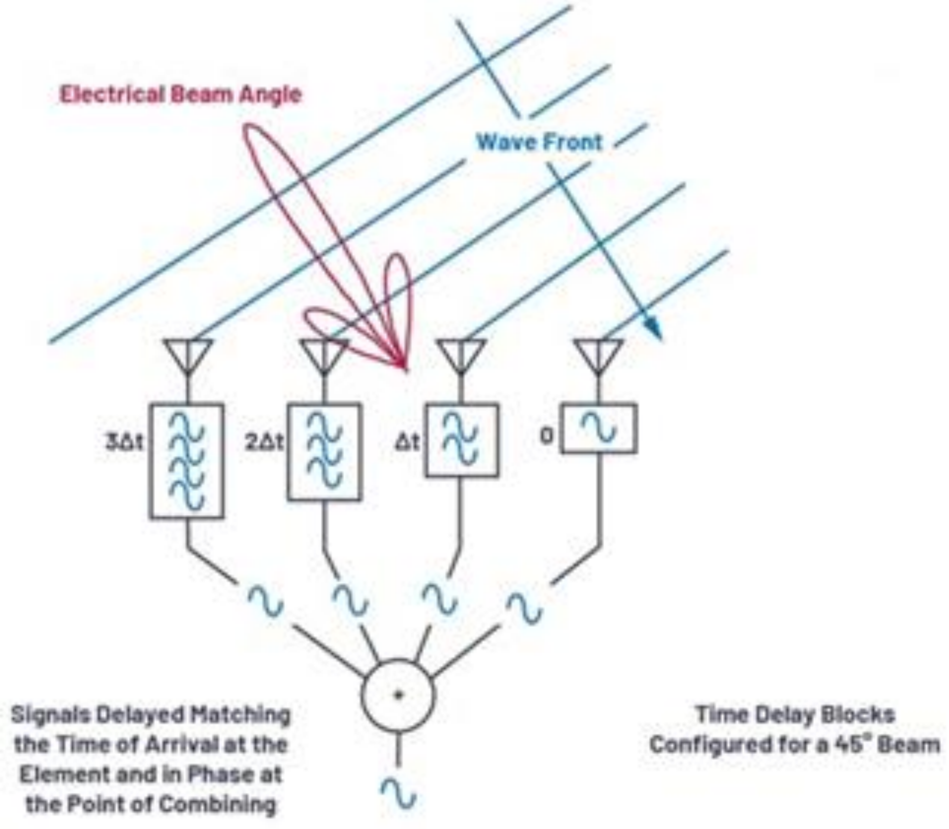


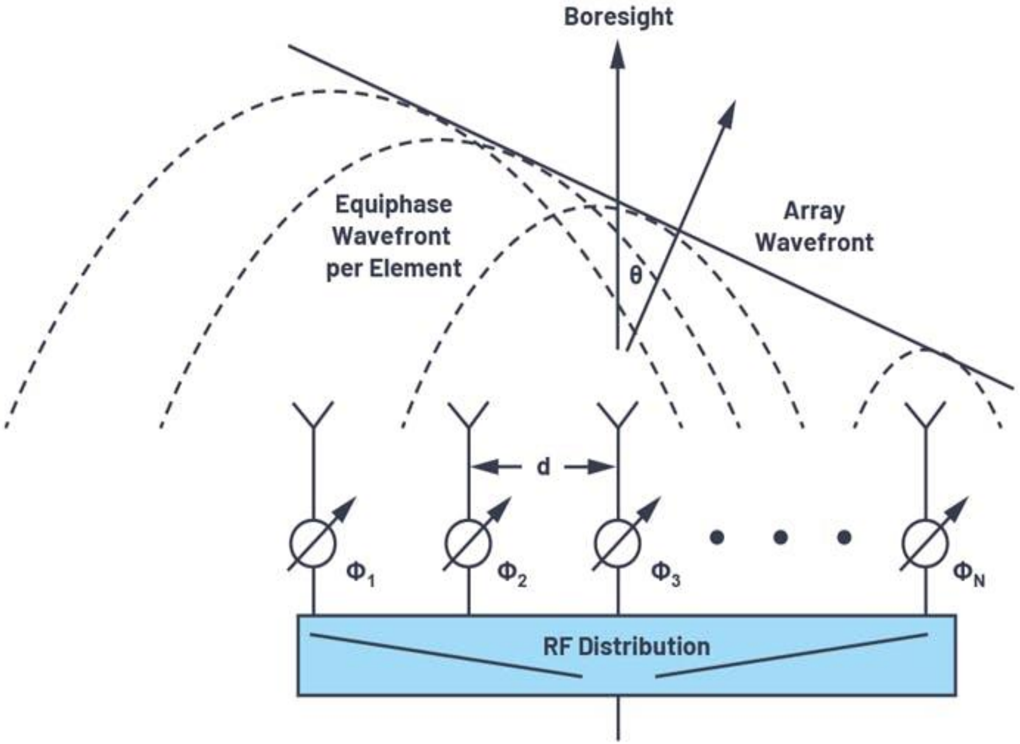
Cesium IFC ESA Antenna



Phasor IFC ESA Antenna

LINEAR ARRAY BEAM STEERING (1/2)





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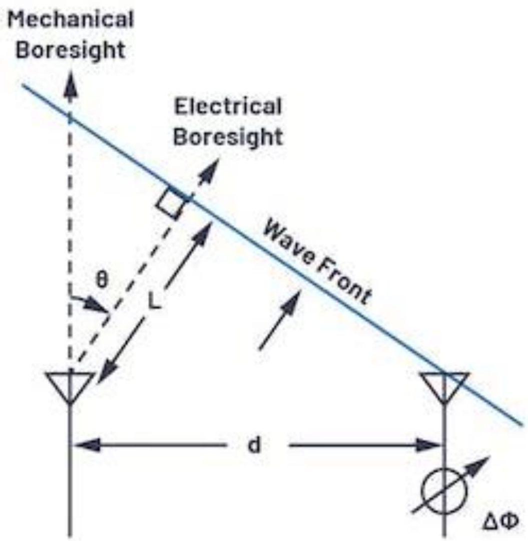
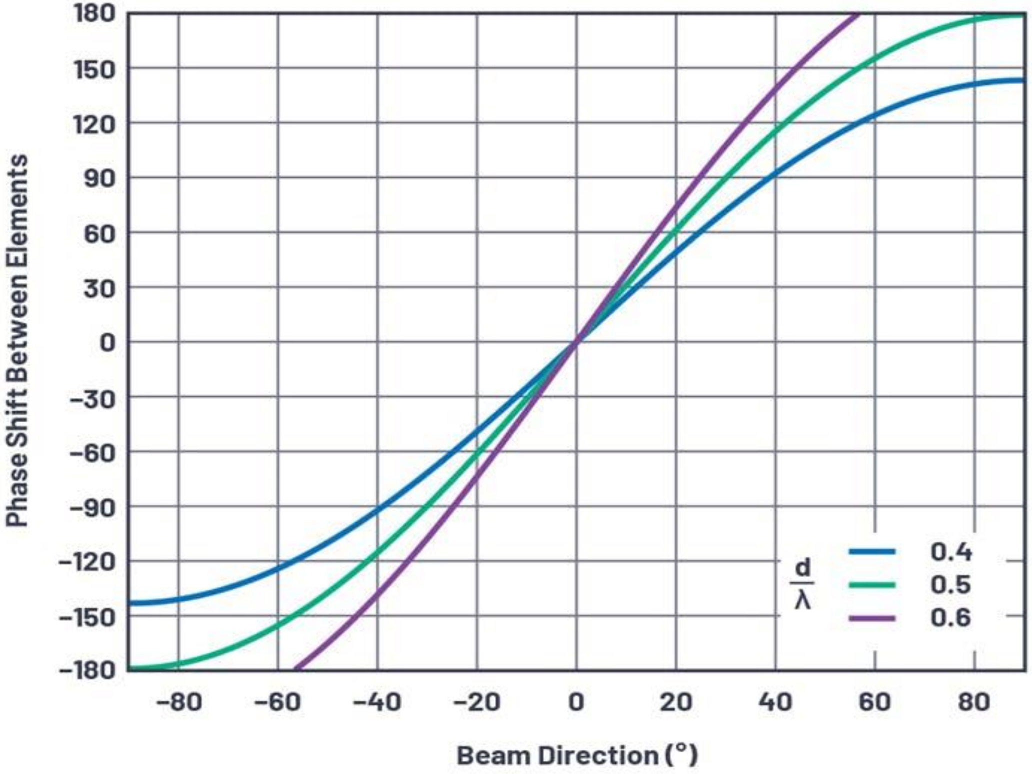
LINEAR ARRAY BEAM STEERING (2/2)



What Phase Shift, ΔΦ, Is Required to Steer the Beam to an Angle θ?

$$\Delta\Phi = \frac{2\pi d sin\theta}{\lambda}$$

$$\Delta\Phi = \pi\ sin\theta,\ \text{for } d = \frac{\lambda}{2}$$



● PHASED ARRAY ANTENNA GAIN PATTERN

$$G(\theta) = G_E(\theta) + G_A(\theta), \text{ in dB} \qquad (7)$$

where G_E is element factor gain, G_A is array factor gain

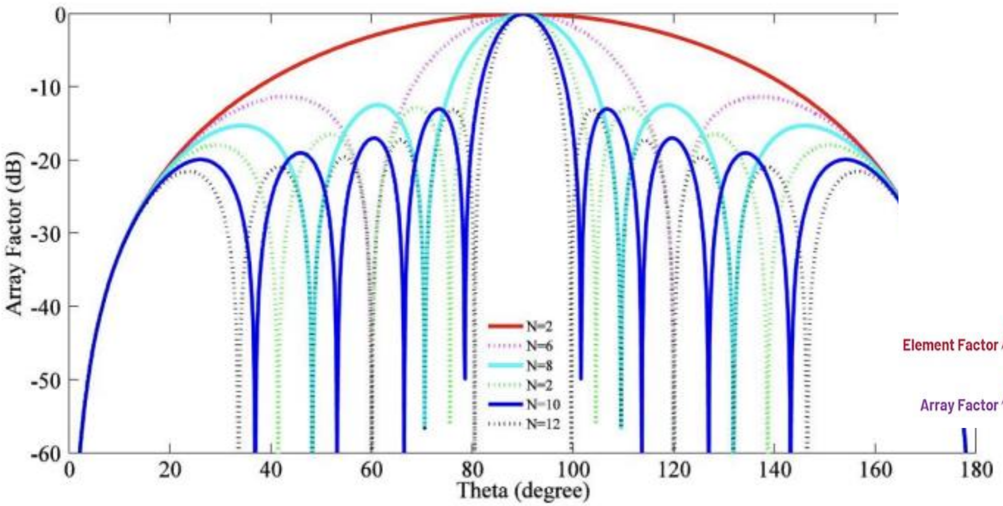
$$\boxed{\text{Antenna Gain } (Gt) = \frac{\text{Radiation Intensity in Desired Direction}}{\text{Radiation Intensity of Isotropic Antenna (All Angles)}} = 10 \text{ Log } N + Ge}$$

$$EIRP = Pt \times Gt$$

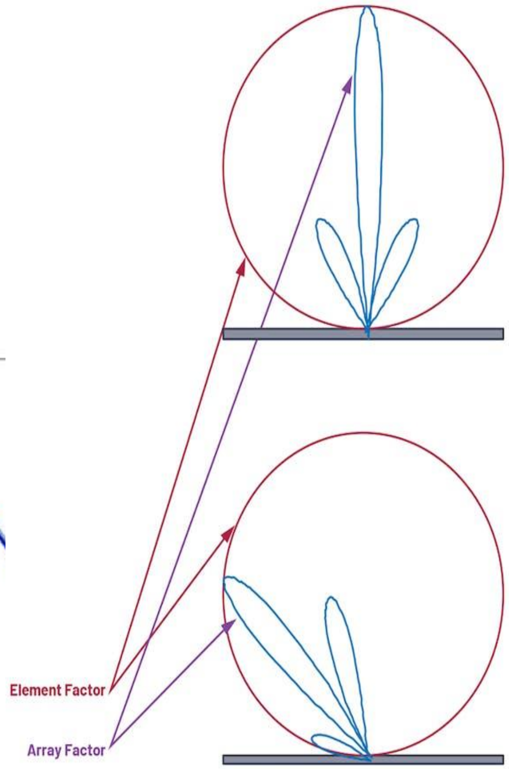
$$\frac{Gt}{Tn} = \frac{\text{Antenna Gain}}{\text{Noise Temperature}}$$

$$Tn = [\text{Noise Factor} - 1] \times \text{Temp}$$

$$\boxed{Pt = 10LogN + Pe}$$

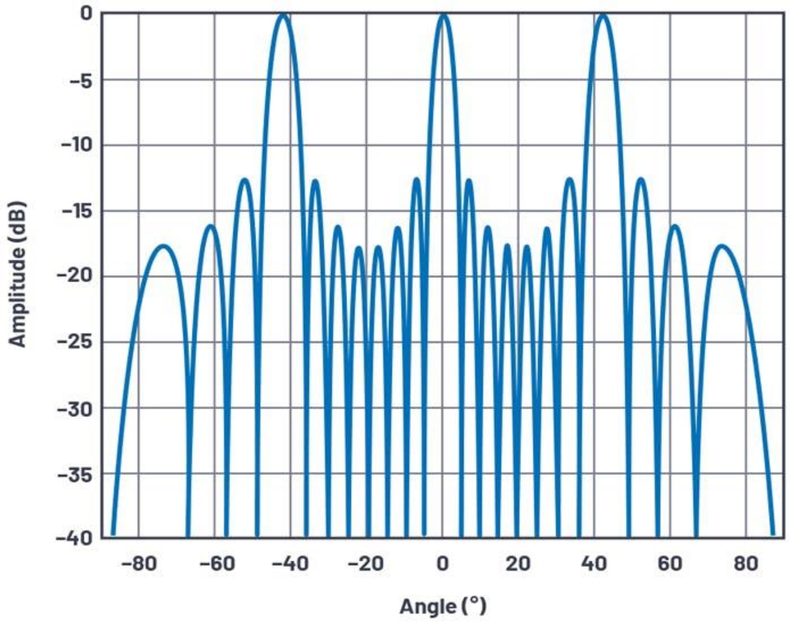


Array Factor (AF) varied with number of antenna elements (N from 2 to 12)

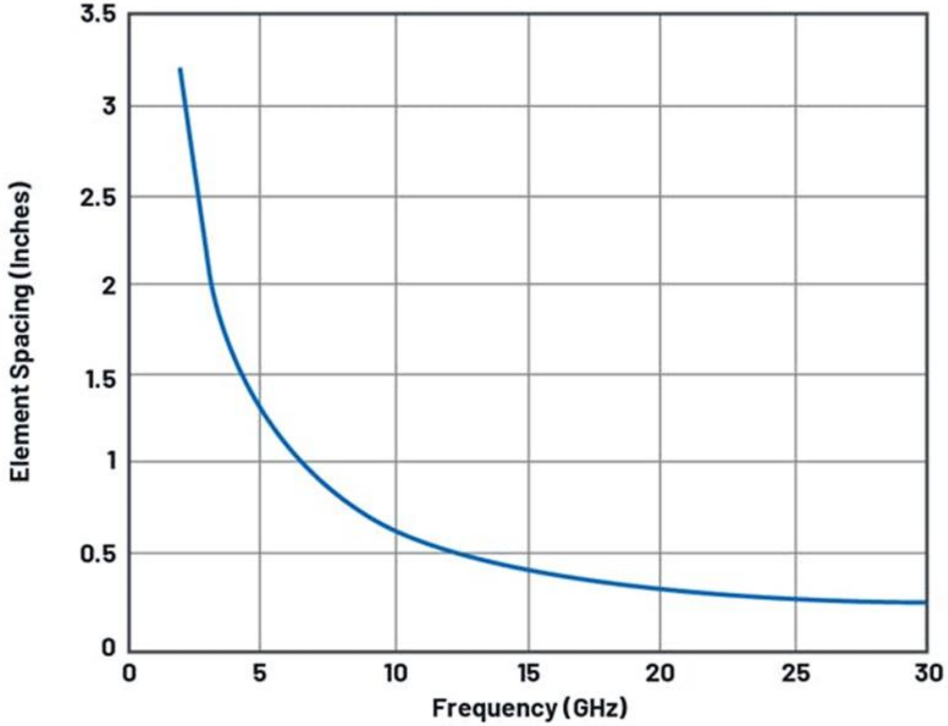


● **GRATING LOBES**

Grating Lobes for d > λ



An array factor plot at boresight for d/λ = 1.5, N = 8 shows three main lobes at angles of 0° and ±41.3°.



Maximum antenna-element spacing to prevent grating lobes for up to a 60-degree scan angle is 0.54 λ.

● FLAT PANEL PHASED ARRAY (1/3)

• MSA(Mechanically Steerable Antenna)

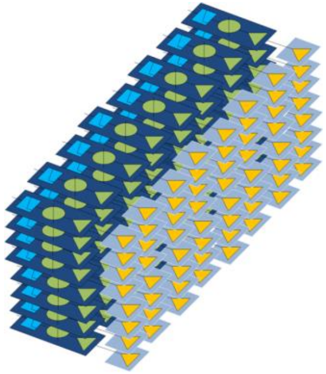
- Parabolic dish antennas
- Lower cost, physically large, slow to steer, worse long-term reliability, single beam

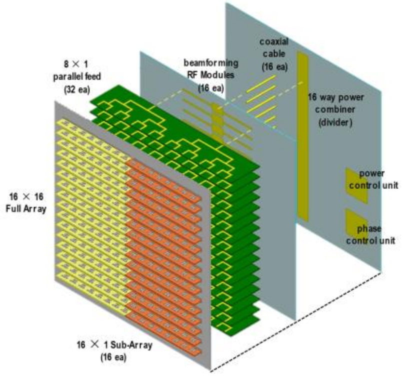
• ESA(Electrically Steerable Antenna)

- Phased array antennas
- Lower profile, less volume, better long-term reliability, faster steering, multiple beams

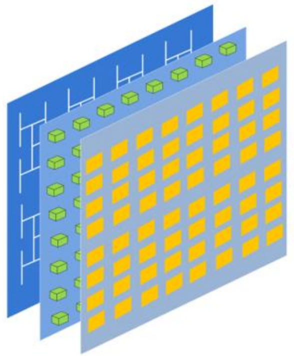
• Phased Array Antenna Design

- Antenna element panel and ICs on the back side
- **Flat panel layout approach** (planar and line array)
- Wider panel, Reduced depth, Easier to fit into Portable or Airborne applications

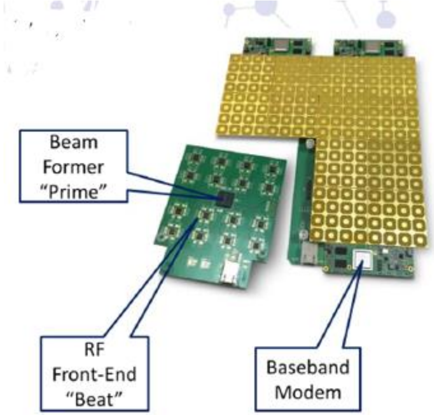




(a) 브릭형 배열 안테나 구조
(a) Brick type array antenna



(b) 타일형 배열 안테나 구조
(b) Tile type array antenna



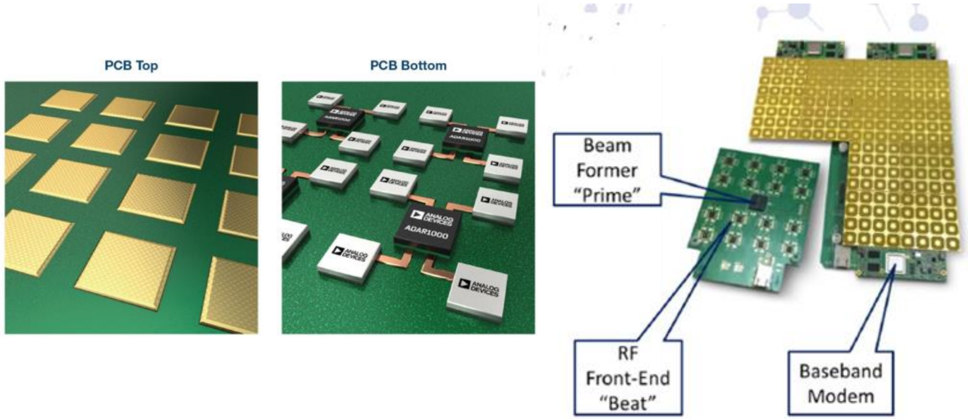
Design of Tile-Type Rx Phased-Array Antenna for Ku-Band Satellite Communications

FLAT PANEL PHASED ARRAY (2/3)

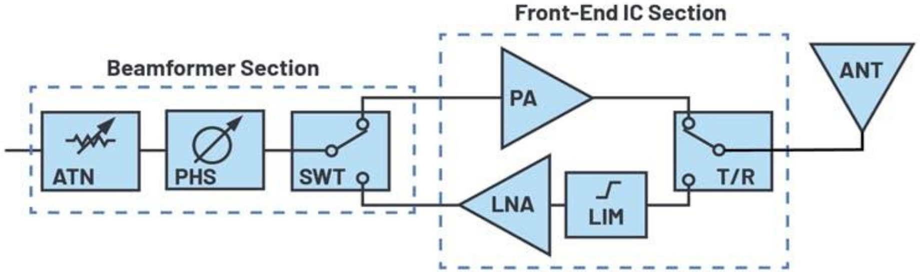
ADVANTAGES	DISADVANTAGES
High antenna gain with large side-lobe attenuation	Limited scanning range (up to max. 120° in azimuth and elevation)
Very fast change of beam direction (in msec. range)	Deformation of the antenna pattern during beam steering
High beam agility	Low frequency agility
Arbitrary space scanning	Very complex structure (computer, phase shifter, data bus to each radiator)
Freely selectable dwell time	High costs (still)
Multi-function operation by simultaneous generation of multiple beams	
Failure of some components does not result in a complete system failure	

FLAT PANEL PHASED ARRAY (3/3)

- **Typical Phased Array Antenna**
  - Patch antenna elements on the top side of the PCB
  - Analog RF FE on the bottom side of the PCB
  - Multiple Layers of PCB



- **IC Packaging**
  - Beamforming IC and FE ICs were separately packed
  - FE IC Evolution : Single Tx/Rx Amplifier + Switch -> Multiple channel Integrated IC
  - SiGe BiCMOS, silicon-on-insulator (SOI), and bulk CMOS have a combined digital and RF circuitry
  - Multichannel beamforming IC : **4 - 32 channels**
  - Multichip modules(MCMs) : IC+ passive components



RF and RF ICs comprising a typical RF front end

● BEAMFORMING TECHNOLOGIES

① Active Beamforming

- **RF amplifiers** are built into the Antenna Array
- **Beam shape and direction are** controlled by **adjusting the phase shifters** along the RF paths
- **Analog Beamforming, Digital Beamforming, Hybrid Beamforming**

② Passive Beamforming

- Beamforming architectures with **external amplifiers or RF**

TABLE 1

FLAT PANEL ANTENNA TECHNOLOGIES FOR BROADBAND LEO CONSTELLATIONS (ASSUMES GIVEN EIRP AND G/T)

	Active Analog	Active Digital	Active Hybrid	Passive Analog	VICTS [15,16]	Lens [17]
Size	Medium	Medium	Medium	Large	Small	Medium
Weight	Light	Light	Light	Medium	Heavy	Medium
Power Consumption	High	High	Medium	Low	Low	Low
Cost	Medium	High	High	High	Medium	Medium
Manufacturer	Ball	SatixFy	SpaceX	Alcan Systems	ThinKom	Isotropic Systems

Source : www.microwavejournal.com/articles/36729-modern-flat-panel-antenna-technology-for-ku-ka-band-user-terminals-in-leo-satellite-communications-systems

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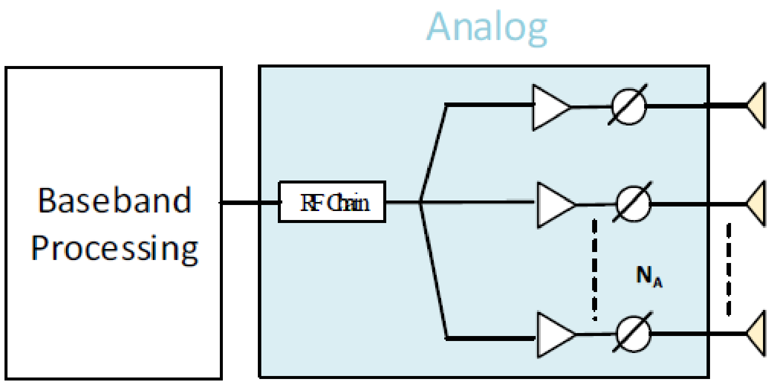
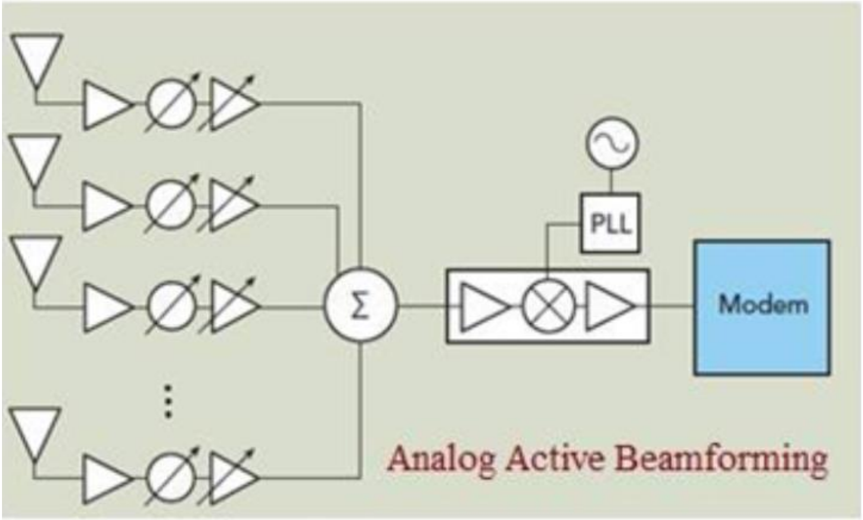
● ANALOG BF ARCHITECTURE

- It consists of **single RF chain** which connects antenna element with **amplifiers, phase shifters, splitters/combiners**
- The simplest to implement, **using one signal** to steer the beam **by shifting its phase at RF or IF** for each antenna element
- Due to its **single RF chain**, it can usually only steer **one beam(**No Freq. selective**)**
- **More cost-effective** and **less complex** than digital beamforming
- Beam benefits from **the full array gain**
- It offers **lowest system DC power**





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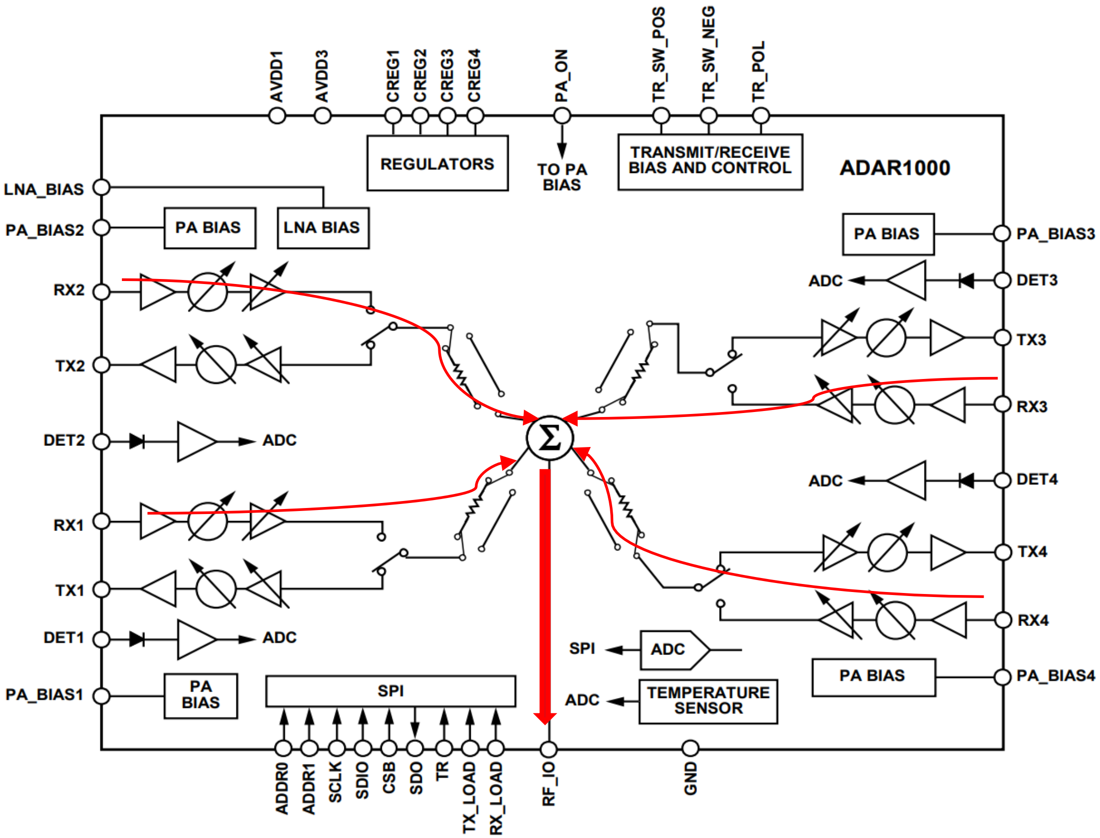
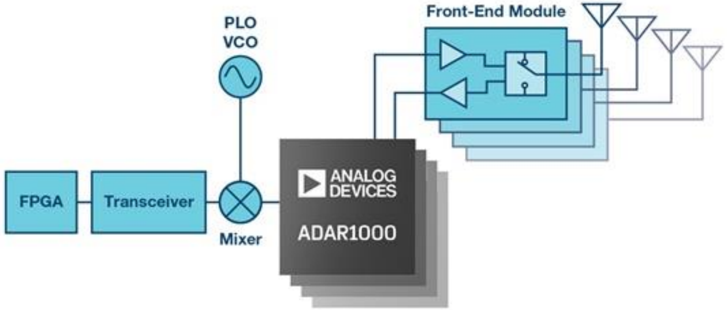
● ANALOG BFR EXAMPLE (1/2)

- **ADAR1000**
  - X-/Ku-band 4-Ch IC in TDD mode
  - Housed in a 7 × 7 mm QFN surface-mount package
  - Power dissipation
    * 240 mW/channel in Tx mode
    * 160 mW/channel in Rx mode





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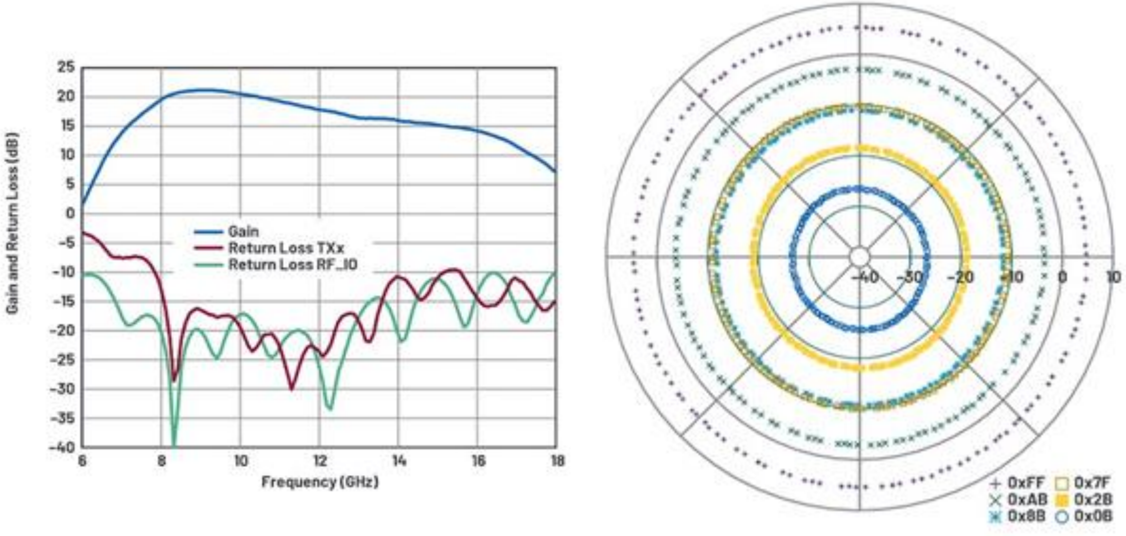
● ANALOG BFR EXAMPLE (2/2)

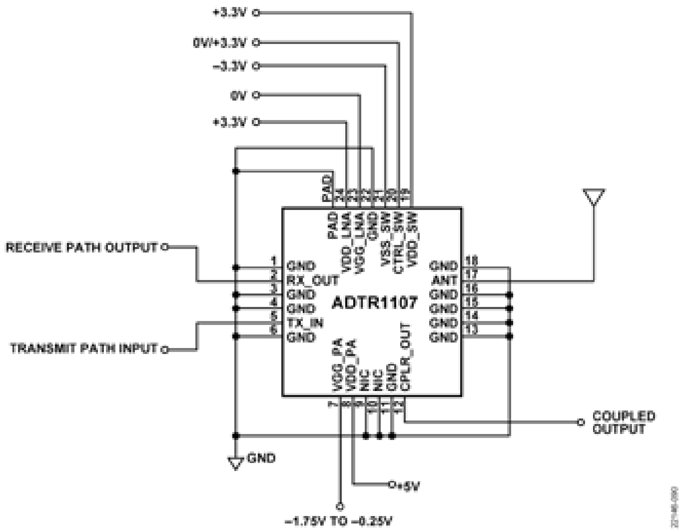
- **ADAR1000 (cont'd)**
  - **SPI controls** the on-chip registers
    * Two address pins - control of 4 devices
  - Full 360-degree phase coverage
    * Phase steps less than 2.8 degrees
    * Gain adjustment over 30 dB
  - **On-chip memory**
    * Storing up to **121 beam states**
    * Contains all phase and gain settings for the entire IC

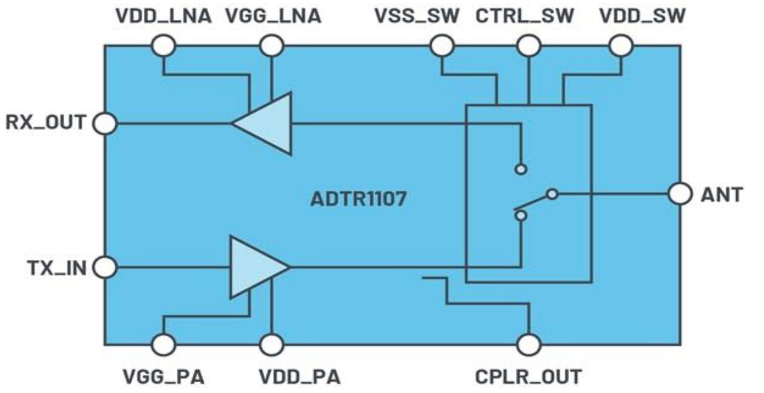


Tx gain/return loss (left) and phase/gain control (right) for the ADAR1000 beamforming IC, @11.5 GHz

● RF FRONT-END IC EXAMPLE

- **ADTR1107**
  - 6- to 18-GHz, front-end IC with an integrated PA, LNA, and a reflective single-pole, double-throw (SPDT) switch
    - * 5×5 mm, 24-lead, land-grid-array (LGA) package
  - Tx Gain : 22 dB, **PSAT : 25 dBm**
  - Rx Gain : 18 dB, **NF 2.5(including T/R switch)**
  - **-** 4 ADTR1107 ICs are driven by a single ADAR1000 beamformer chip





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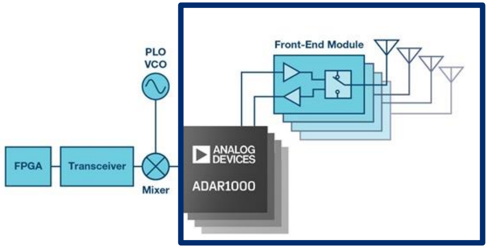
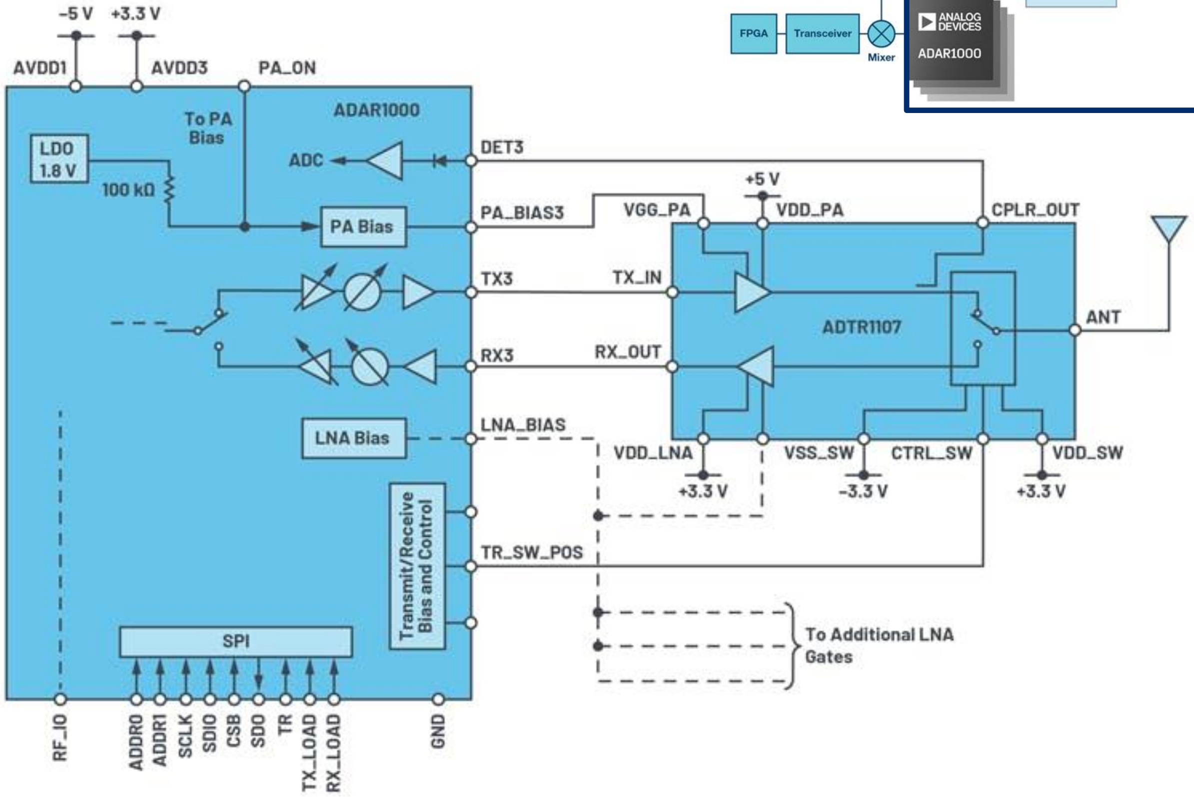
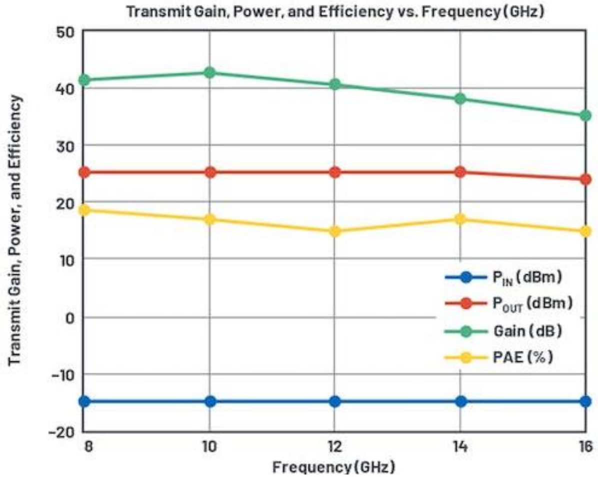
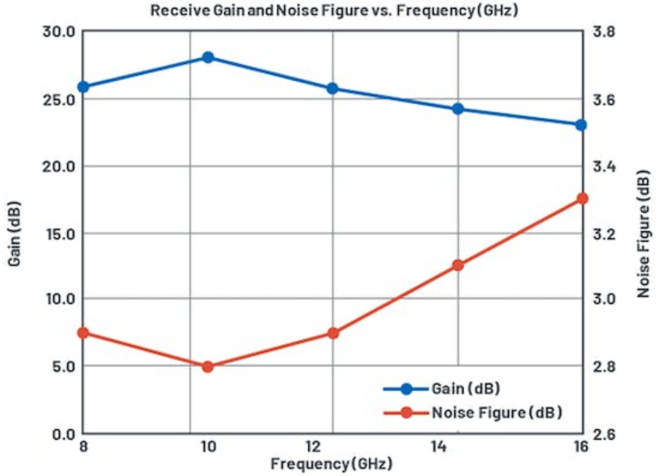
- **ANALOG BFR + RF FE IC**

  (ADAR1100 + ADTR1107)



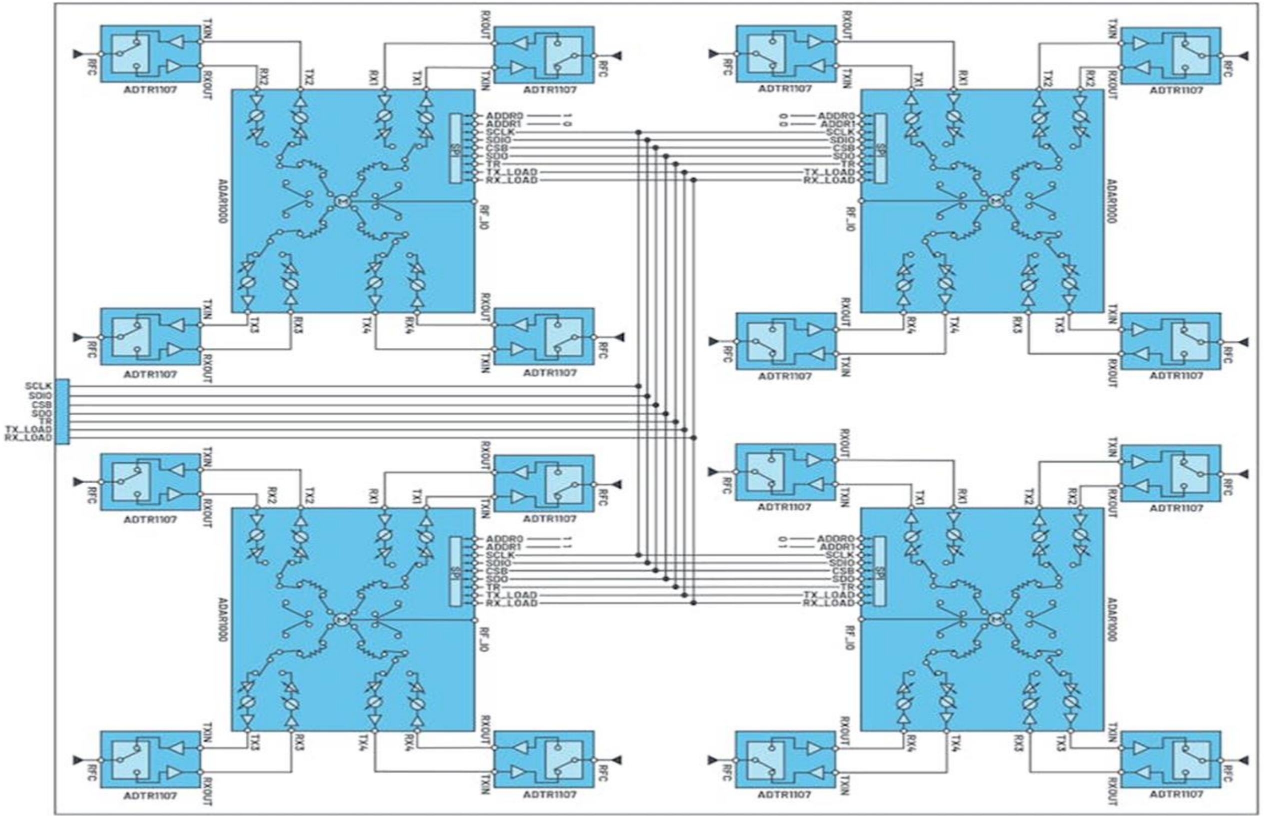






● ANALOG BEAMFORMING NETWORK EXAMPLE

- **4 ADAR1000 chips driving 16 ADTR1107 chips**



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● RF TRANSCEIVER EXAMPLE

- **ADRV9009**

  - A 12×12 mm, 196-ball chip scale ball-grid array

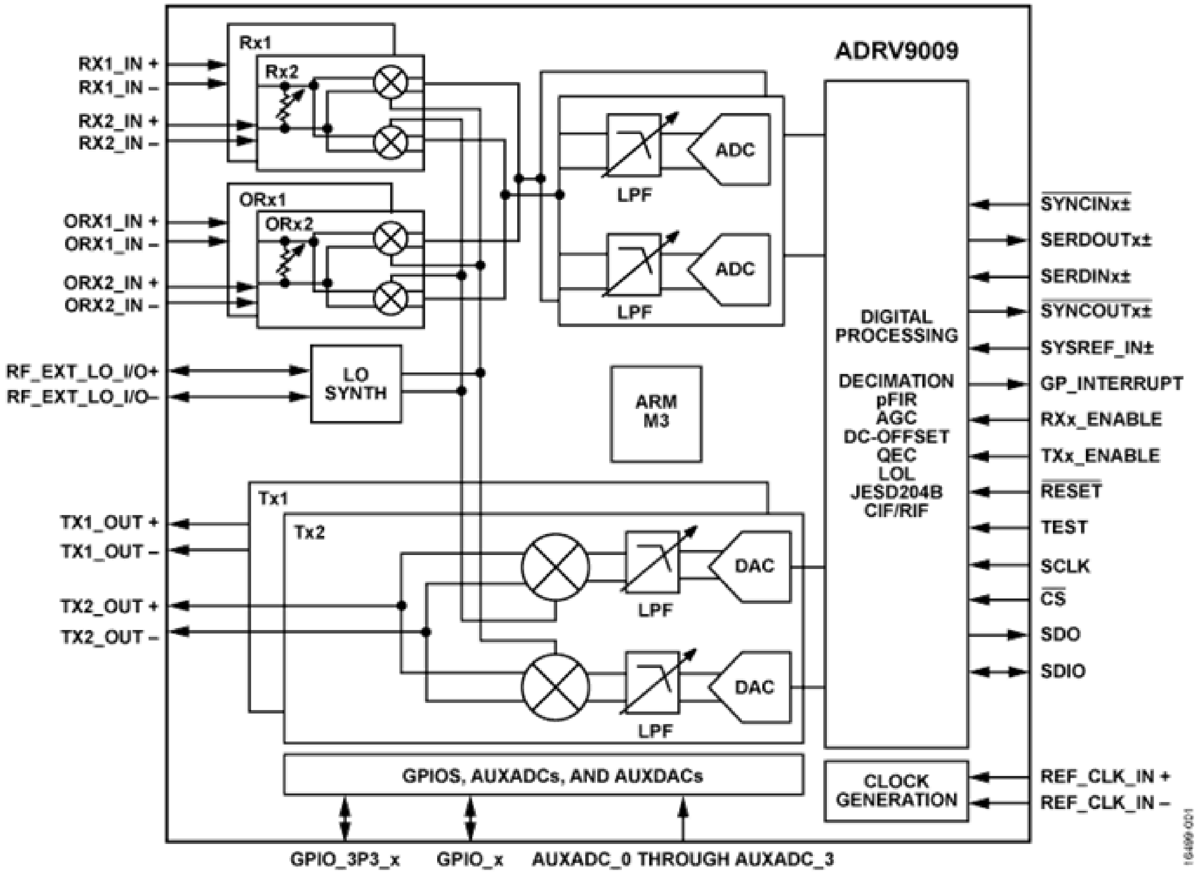
  - A dual transmitter and receiver, integrated synthesizer, and DSP functions

  - A direct-conversion receiver with error correction, and digital filtering built -in

  - ADC and DAC

  - GPIO for the PA and RF front-end controls

  - PLL provides fractional-N RF frequency synthesis for Tx and Rx



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● INTELLIAN ESA TERMINAL DESIGN

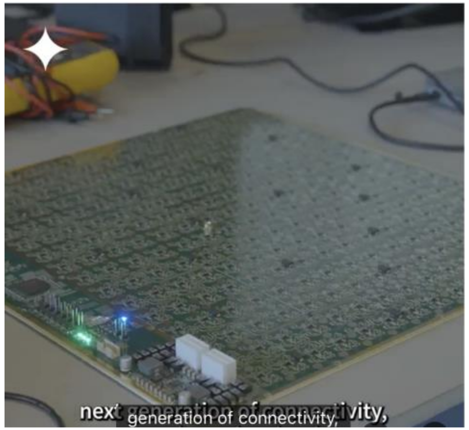
- LEO Ku-band broadband residential terminal
- Analog beamforming technology to reduce the cost and power consumption
- Low cost LEO terminal design

  - A planar PCB to integrate PA antenna aperture, RF FE chips, and control electronics in one module

  - Minimizing aperture area with high efficiency RF FE design

  - Minimizing number of antenna elements – 1,024 elements

  - RF PCB stackup designed for highest performance vs. cost



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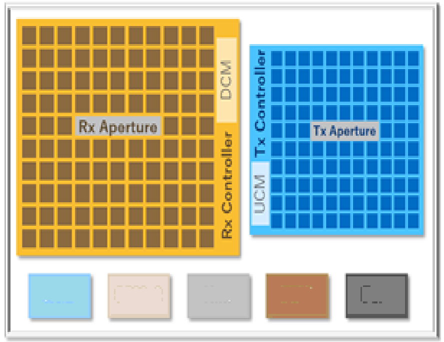
● INTELLIAN ESA TERMINAL - OW11FL

- EIRP : 36.6dBW, G/T : 11dB/°K
- Frequency Tx: 14.0-14.5 GHz, Rx: 10.7-12.7 GHz
- Data Rate(Max) : 195Mbps(down)/32Mbps(Up)
- Field of View : +/- 55° scan
- Size : 96cm x 49cm x 16cm, Weight : 18kg
- Fully integrated ACU, Modem, Power supply, Dual GNSS receivers
- Automated True North Calibration & Tilt Error Compensation
- User friendly Intellian Mobile App.
- BDU : CNX-WiFi, CNX-E, CNX-T
- Applications : Enterprise, Retail, Community Wi-Fi and Civil Government/Military

High Performance Terminal



OW11FL

11dB/K Full Duplex Land Fixed Terminal

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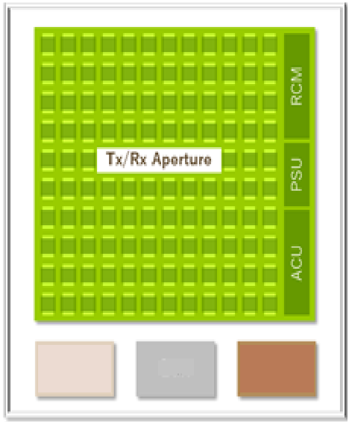
INTELLIAN ESA TERMINAL - OW10HL

- EIRP : 36.6dBW, G/T : 10dB/°K
- Frequency Tx: 14.0-14.5 GHz, Rx: 10.7-12.7 GHz
- Field of View +/- 55° scan
- Size : 54cm x 42cm x 16cm, Weight : 8kg
- Fully integrated ACU, Modem, Power supply, Dual GNSS receivers
- Dual TX carrier support (2*20 MHz)
- Automated True North Calibration & Tilt Error Compensation
- User friendly Intellian Mobile App.
- BDU : CNX-WiFi, CNX-E, CNX-T
- Applications : Retail, Community Wi-Fi and Civil Government/Military

Compact Terminal



OW10HL
10dB/K Half Duplex Land Fixed Terminal

● INTELLIAN ESA TERMINAL – MOBILE/PORTABLE

OW6HP
6 dB/K Half
Duplex
Portable

Connectivity on the Go

OW9HM
9 dB/K Half
Duplex
COTM/Maritime

OW11FM
11 dB/K Full
Duplex
COTM/Maritime

Maritime

Defense Man-pack

Land Mobility

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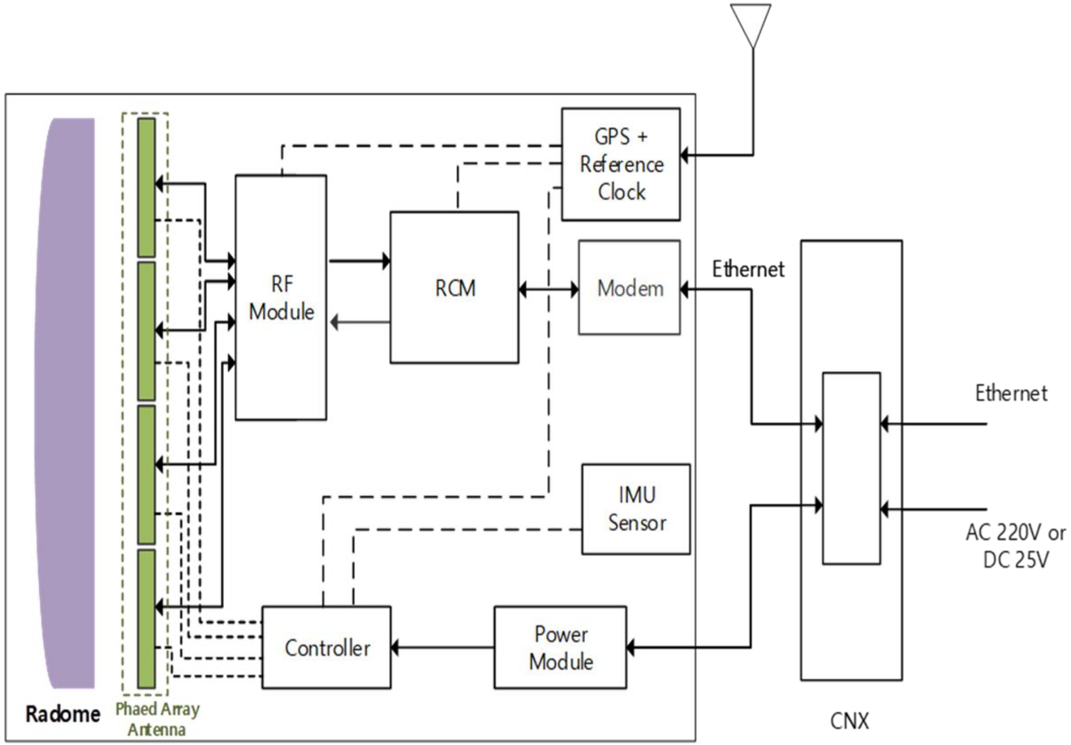
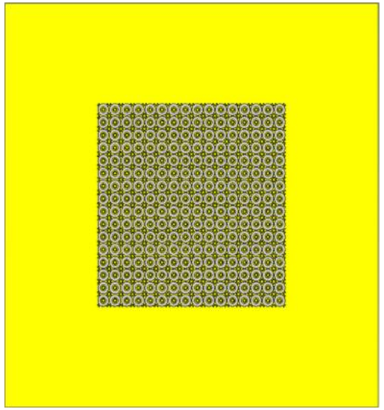
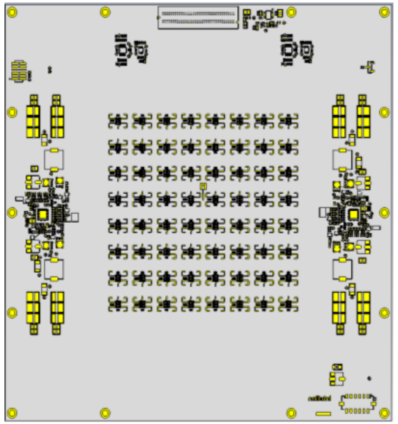
INTELLIAN KA-BAND ESA (Developing)

- **16x16 Interlaced Phased Array Antenna**

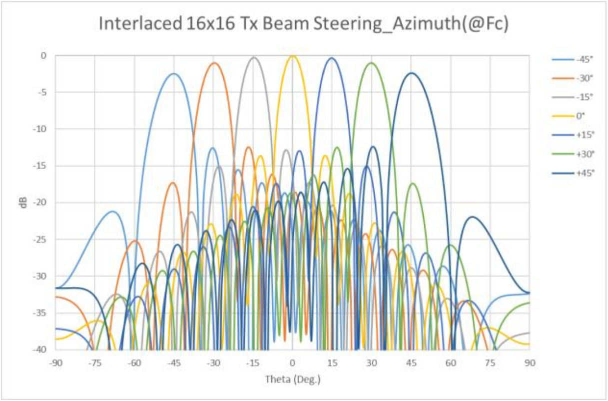




Top view



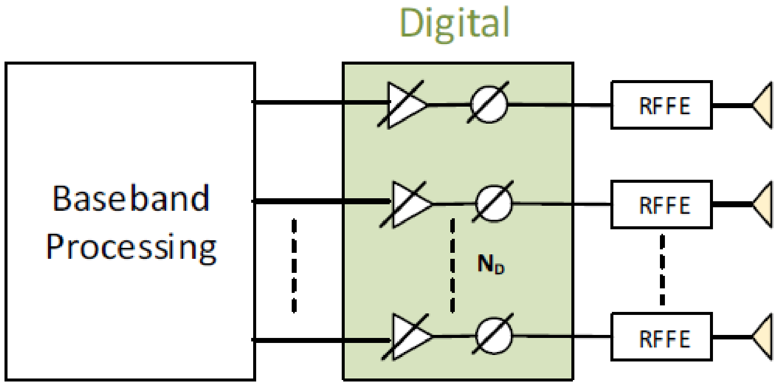
Bottom view

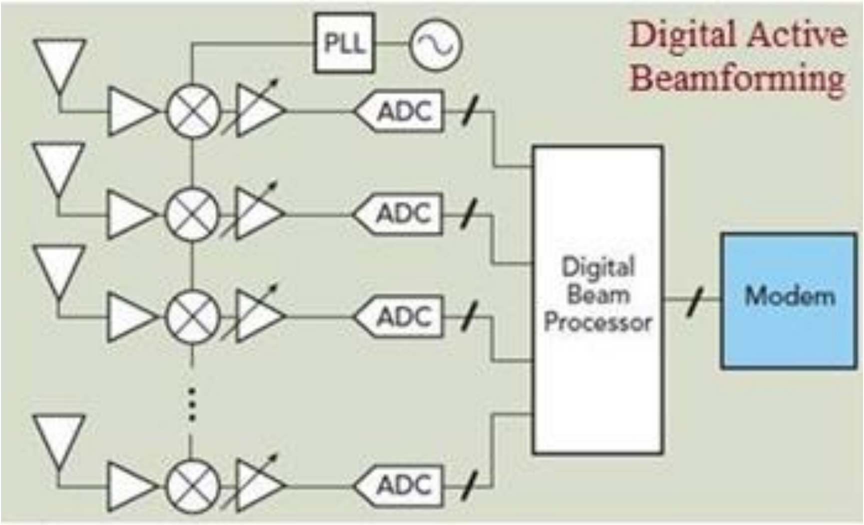


Intellian

● DIGITAL BEAMFORMING ARCHITECTURE

- Beamforming is done completely **in the digital baseband** and requires **a dedicated RF circuit to digital path** to the antenna element
- A dedicated signal for each antenna element controls **multiple RF beams independently**
- **ADC/DAC as well as RF FE for each digital beamforming chain** increases complexity and power consumption
- The **most flexible solution** with **high degree of control,** better in **multi-beam applications**

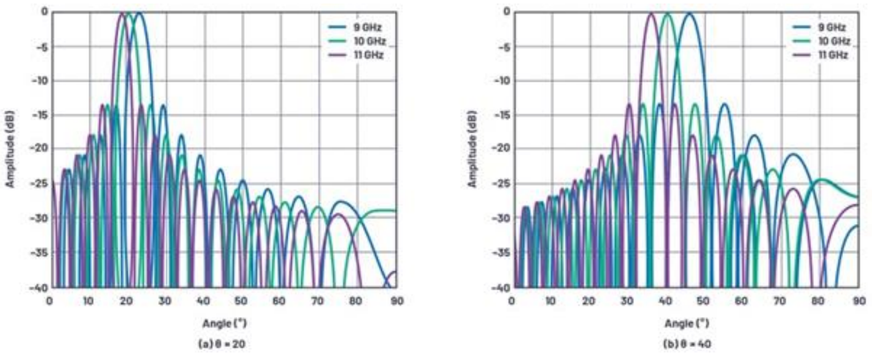




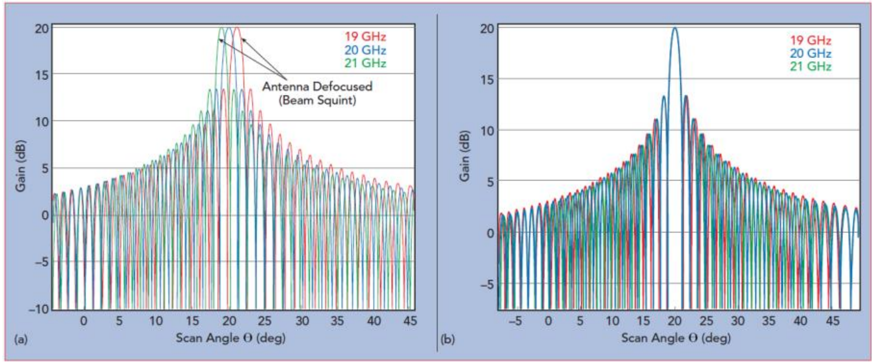
Intellian

TTD AND BEAM SQUINT

- For **wideband waveforms**, **the beam can shift direction as frequency changes**
- The **beam squint**, or **deviation in steering angle vs. frequency**
- Caused by approximating a time delay with a phase shift
- **true time-delay(TTD)**
- In DBF, **TTD** can be implemented in the **DSP logic** and **digital beamforming algorithms**



Example of beam squint at X-band for a 32-element linear array with a λ/2 element spacing



Phased array radiation patterns showing beam squint vs. frequency (a) and no beam squint with true time delay (b).

SOURCE : Multi-Beam Phased Array with Full Digital Beamforming for SATCOM and 5G, MICROWAVE JOURNAL® from the March 2019

DIGITAL BEAMFORMING FEATURE

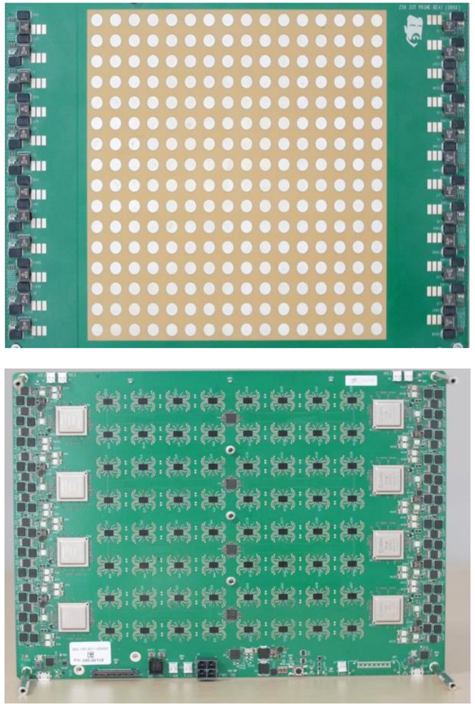
- **DBF Advantages**
- Wideband Signal Reception and Transmission
  - High precision **phase shifts & TTD**
- Ability to scale to build large antennas
  - Suited for **a modular design** easily **scaled**
- Support large number of beams
- **Fast Beam Steering**
- **Precise Beamforming and Nulling**
- Antennas based on Conformal Structures
  - Decoupling the antenna's geometry

- **DBF Disadvantages**
- Increase of **cost, design complexity and power consumption** because of individual RFFE ICs for each antenna element
- Beamforming module is **a custom ASIC**. Supply is limited or a custom ASIC production is required
- **Much more computationally intensive**, needs additional processing beyond the ASICs, **FPGA or GPP**
- High Data Rate ADCs and DACs required
- **Timing is extremely critical** between the components and in digital signal processing

● SATIXFY DBF ESA - ESMA

- **Electronically steered multi-beam antenna array(ESMA)**

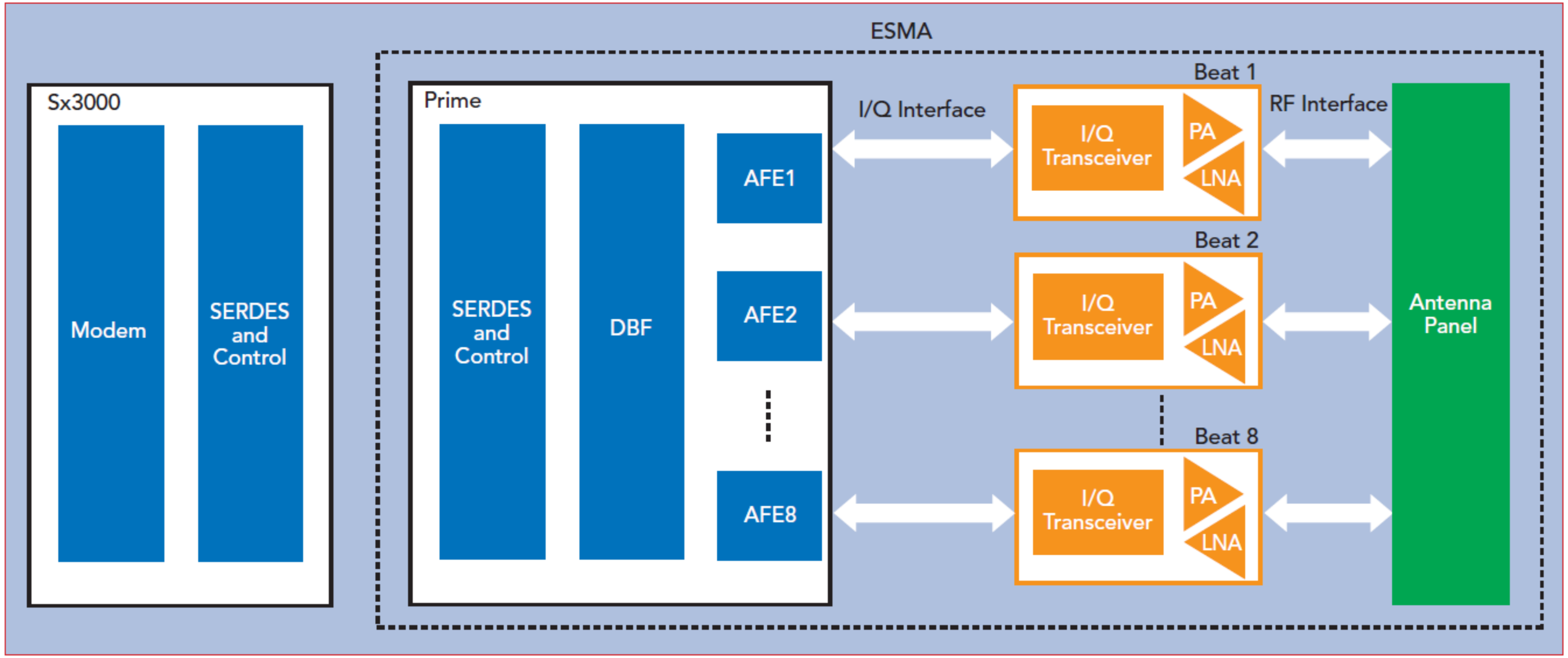
- 256 Tx/Rx patch antennas
- The first fully digital multi-beam ESA
- Self installation, Multiple satellite tracking
- **Payloads can be more flexible**, enabling multi-beam, beam hopping and flexible beam shaping
- **Fast-tracking functions, TTD feature**
- **Supporting many beams simultaneously**



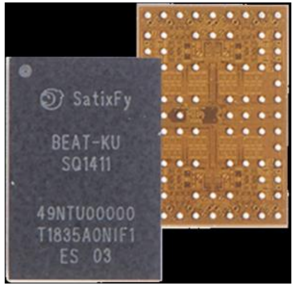
Front and rear-view of 16x16 ESMA digital beam-forming array

SOURCE : Multi-Beam Phased Array with Full Digital Beamforming for SATCOM and 5G, MICROWAVE JOURNAL® from the March 2019

● SATIXFY ESMA ARCHITECTURE



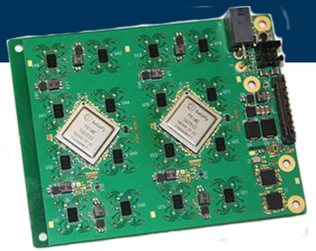
PRIME DBF ASIC



BEAT RF front-end

SOURCE : Multi-Beam Phased Array with Full Digital Beamforming for SATCOM and 5G, MICROWAVE JOURNAL® from the March 2019

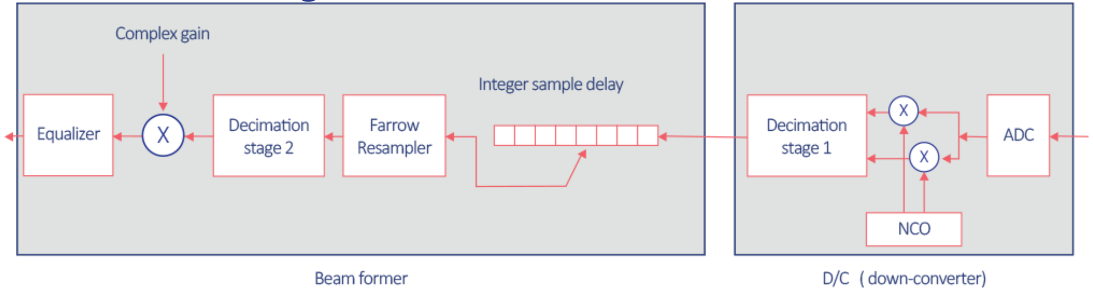
Intellian



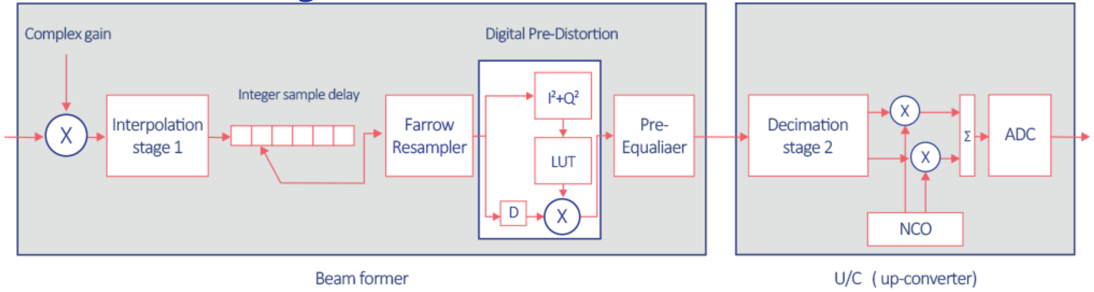
● PRIME ASIC ARCHITECTURE

- **Support up to 32 antenna elements**
- Connected to other PRIME chip using a cascading SERDES port
- High speed ADC and DAC
- Digital phase shifters and TTD circuit
- Connects to RF FE RF transceivers
- Over 1 GHz instantaneous signal BW
- **Multi-beam capability: up to 32 Beams**
- Linear and circular polarization control
- Self-calibration with internal synchronization

Rx DBF block-diagram:



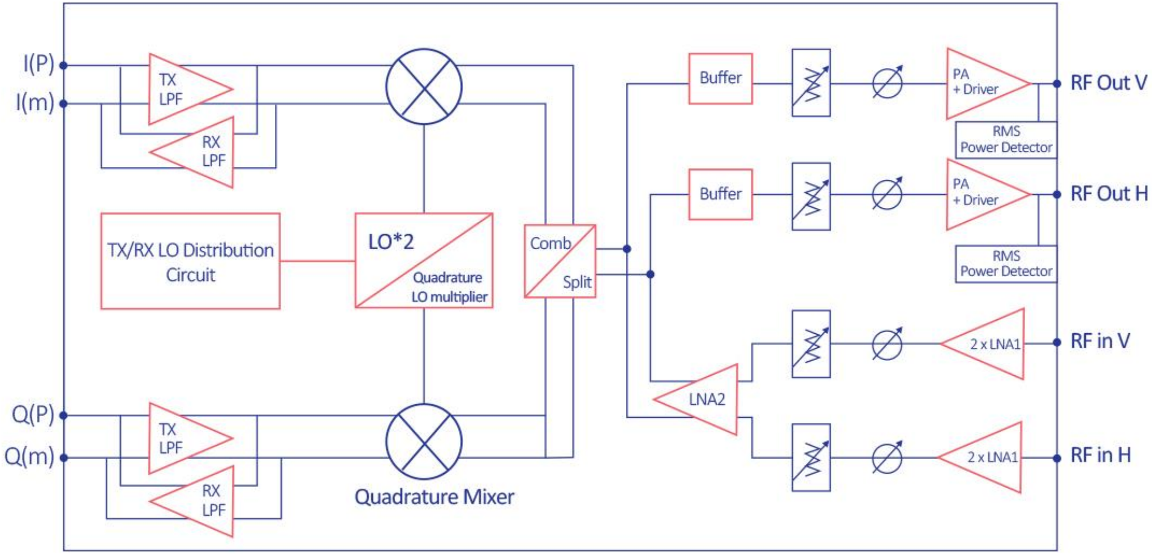
Tx DBF block-diagram:



SOURCE : Multi-Beam Phased Array with Full Digital Beamforming for SATCOM and 5G, MICROWAVE JOURNAL® from the March 2019

BEAT ASIC ARCHITECTURE

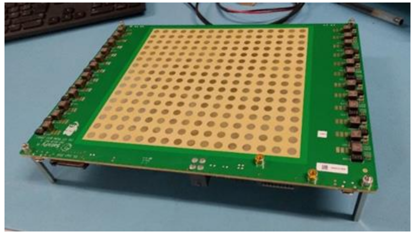
- A Ku-Band RFIC linking the PRIME's I/Q signals with antenna elements
- Integrates the transmit driver and PA, up-converter, LNA, down-converter and antenna polarization control
- **A single Beat supports 4 Ku-Band antenna elements** operating in half-duplex mode



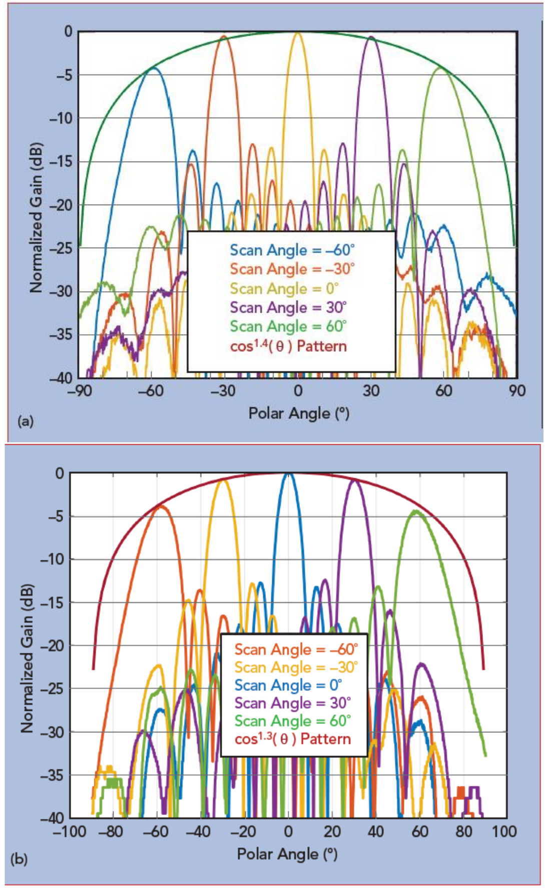
High Level Block diagram of single transceiver:

SOURCE : Multi-Beam Phased Array with Full Digital Beamforming for SATCOM and 5G, MICROWAVE JOURNAL® from the March 2019

● ESMA PERFORMANCE



Number of elements	256 (16x16) Scalable to 512 (2 panels) or more
Beam width (at bore-sight)	~6° for 256(16x16)
Side-lobes	13 dBc (without tapering) <30 dBc (with Taylor window tapering)
Operation frequencies (Analog RFIC)	Ku: 10.75-12.7 GHz (Rx), 14-14.5 GHz (Tx) Ka: 22.55-23.15 GHz (Tx), 25.5-27 GHz (Rx)
Number of beams	Up-to 32
Typical EIRP (dBW), Tx	26 dBW(256 elements)
Typical G/T, dB, Rx	1-2 dB/K (256 elements)
Signal Bandwidth	Up-to 880 MHz (≤ 2 beams) Up-to 440 MHz (≤ 4 beams) Up-to 220 MHz (≤ 8 beams) Up-to 110 MHz (≤ 16 beams) Up-to 55 MHz (≤ 32 beams)



H-plane radiation patterns vs. scan angle:
Tx at 13.75 GHz (a) and Rx at 11.7 GHz (b).

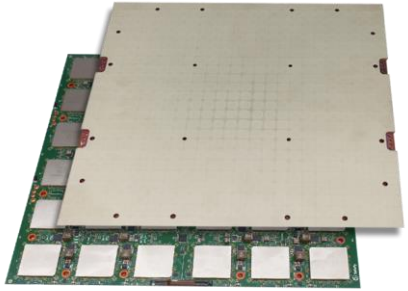
SOURCE: ELECTRONICALLY STEERED MULTI-BEAM ANTENNA ARRAY PERFORMANCE AND BEAM TRACKING IN MOBILITY, Ka-conference 2019

SOURCE : Multi-Beam Phased Array with Full Digital Beamforming for SATCOM and 5G, MICROWAVE JOURNAL® March 2019

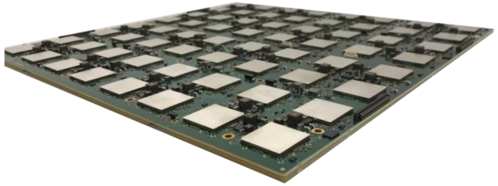
● DIGITAL BEAMFORMING – AERO ESA

- **Multibeam(OneWeb Ku + GEO Ku) ESA**
- SatixFy's ESMA technology applied and developed together with JetTalk
- Tx tile of 576 elements and Rx tile of 1024 elements
- Multibeam capability and Simultaneous operation on multiple LEO and GEO satellites
- JetTalk (SatixFy UK and ST Engineering JV)

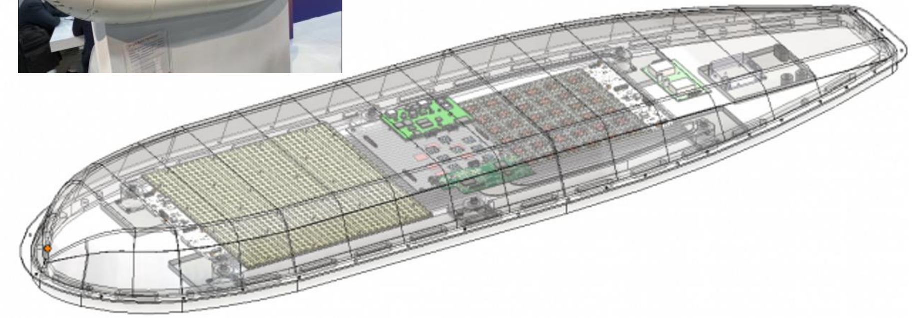
"The new aviation terminal will make use of the Prime, Beat and Sx3099 ASIC chips developed with UK Space Agency backing, showing how supporting our most innovative companies leads to results that make a real difference for people all over the world."



SatixFy's Aero Tx Tile



SatixFy's Aero Rx Tile

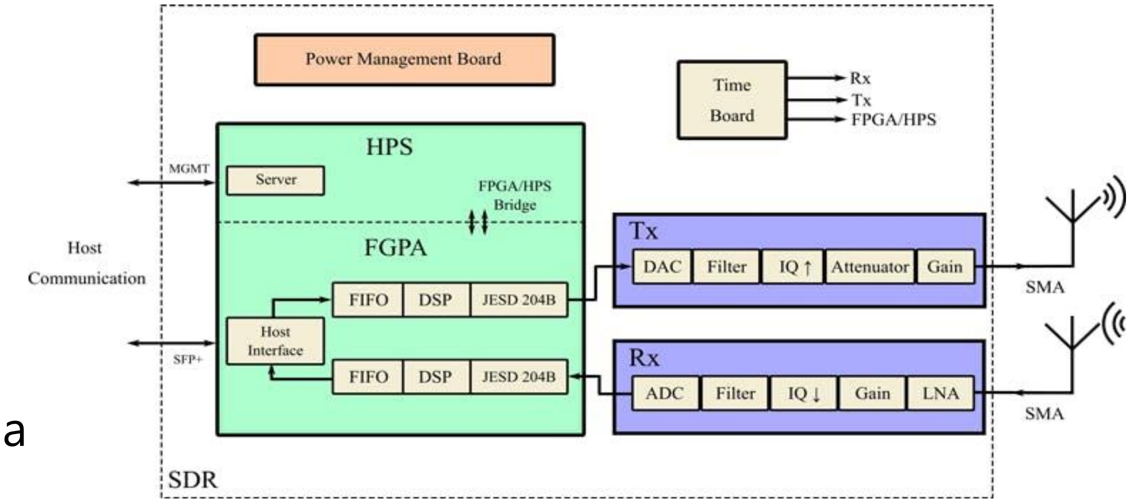


https://www.satixfy.com/news/oneweb-and-satixfy-sign-agreement-for-in-flight-connectivity-ifc-compact-terminal/

Intellian

● SDR-Enhanced ESA

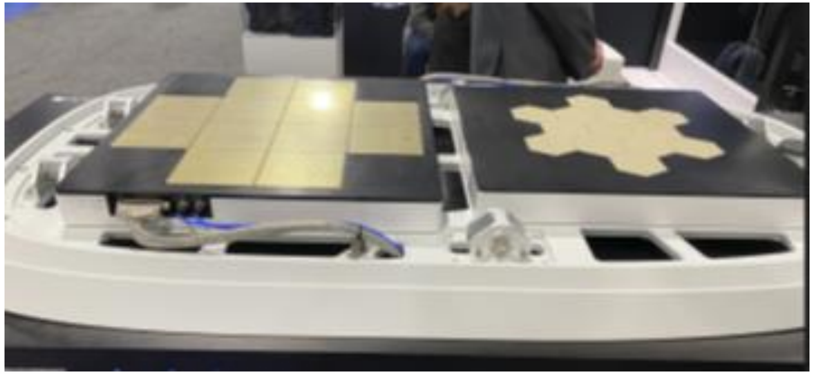
- SDR provides a flexible and modular solution usually don't require any hardware modification
- SDRs can be completely reconfigured **on-the-fly**
- Digital back end of SDRs applied in phased-array antennas must implement a **FPGA with high-performance DSP capabilities** for parallel beamsteering
- **FPGA spec. is one of the most important SDR selection criteria for phased-array systems**



SDR block diagram shows power, time, Rx, Tx, and management boards

CesiumAstro's Ka-Band SATCOM Terminal

- Multiple beams provide seamless H/O between multiple constellations and multiple orbits
- Multiple beam tracking - Simultaneously communicates with multiple GEO/MEO/LEO satellites
- Reconfiguration of parameters during operation
- **All-in-one integrated solution** including two antenna apertures (receive and transmit), ACU, RF and Modem



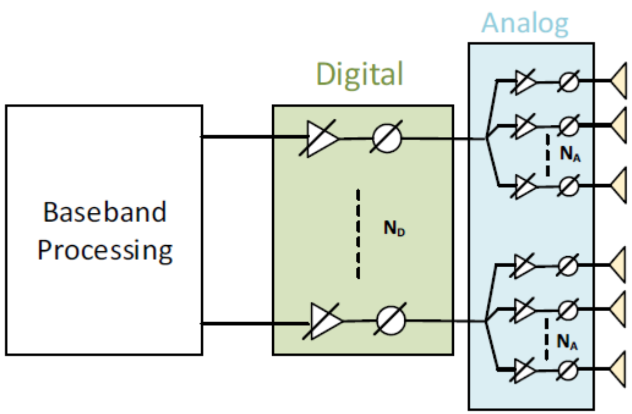
SDR-1001 includes four receive channels, four transmit channels, and a state-of-the-art FPGA in a credit-card-sized footprint.

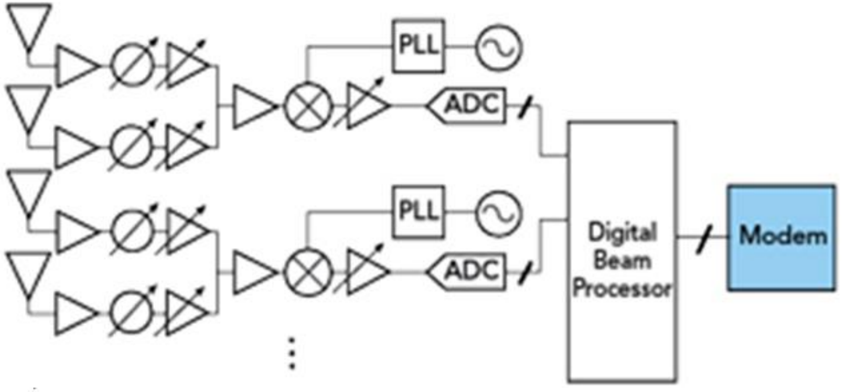
Vireo
Multi-Beam Communications System

Source : https://www.cesiumastro.com/

● HYBRID BEAMFORMING ARCHITECTURE

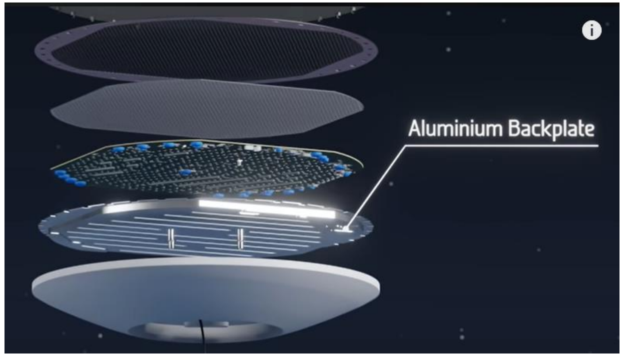
- **Two stage beamforming** by concatenation of **analog and digital beamforming**
- **Compromise** of performance and complexity
- **Advantages of both** analog and digital beamforming
- **Reduced number of RF chains** combined with analog phase shifters
- **Some limited multibeam capability** but performance is **sub-optimal**
- **Signals of subarray of elements** are combined coherently to form the required beams **within the digital domain**

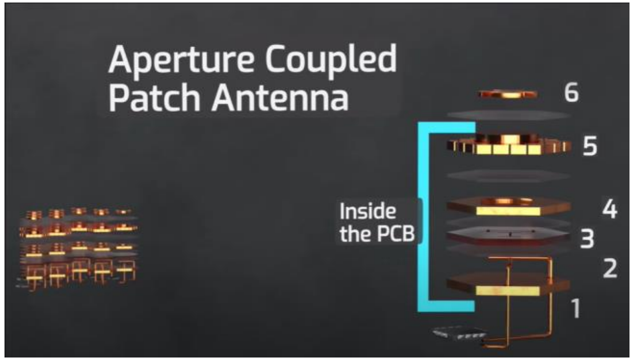


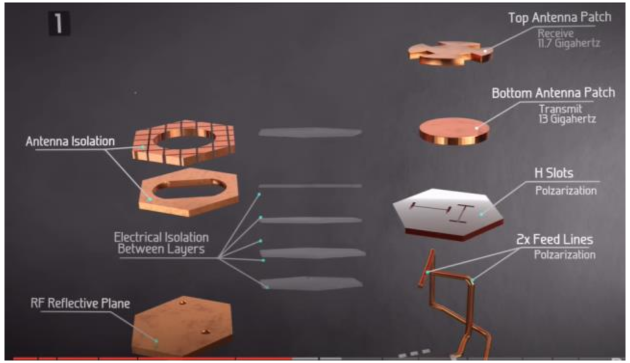


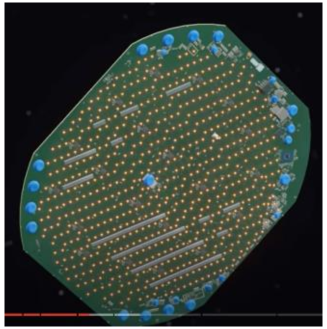
https://www.youtube.com/watch?v=qs2QcycggWU

- **STARLINK ESA TERMINAL – 1280 Elements**

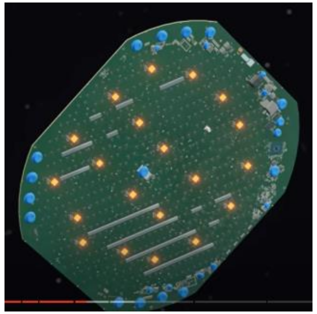




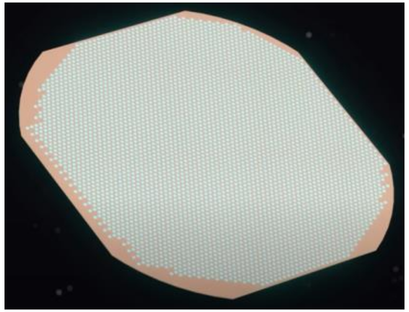




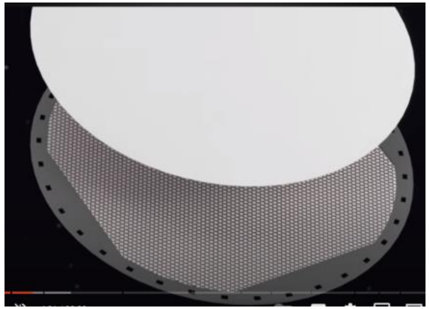
640 RF FE Chips

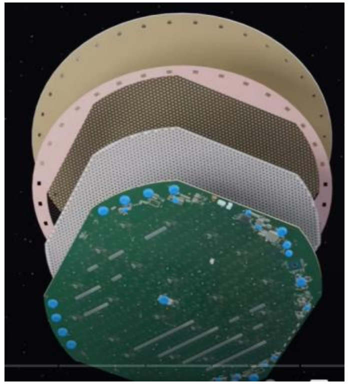


20 Beamformer Chips



1400 Copper Circles

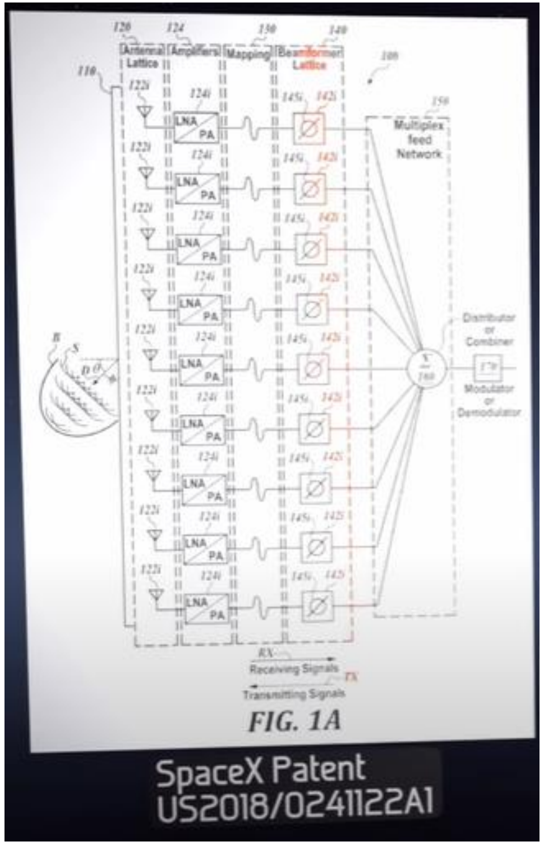


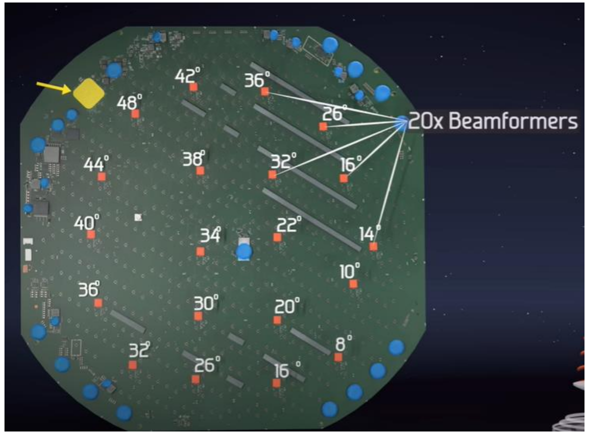


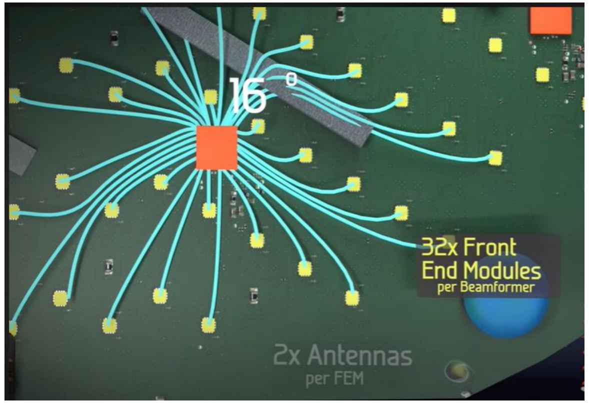
Intellian

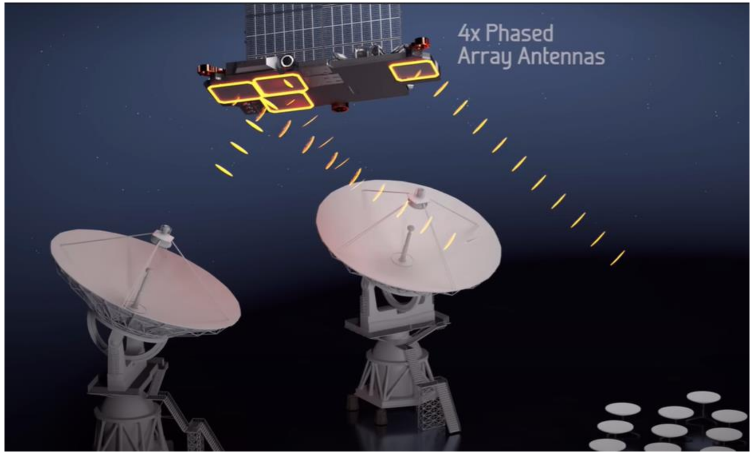
https://www.youtube.com/watch?v=qs2QcycggWU

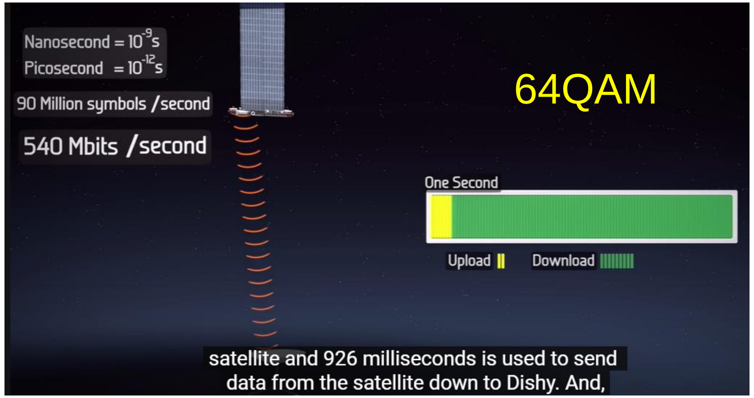
- **STARLINK ESA TERMINAL – 1280 Elements**







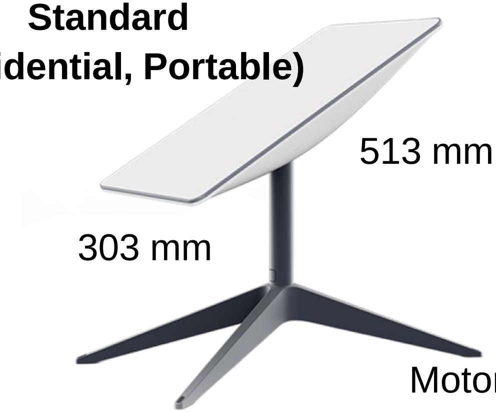




Intellian

● STARLINK ESA TERMINAL

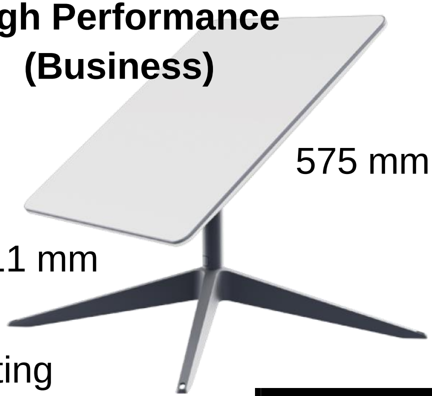
Standard (Residential, Portable)



513 mm

303 mm

High Performance (Business)



575 mm

511 mm

Motorized Self Orienting

Flat High Performance (In-motion)

575 mm

511 mm

41 mm (8°)

Mounting Wedge Mount kit

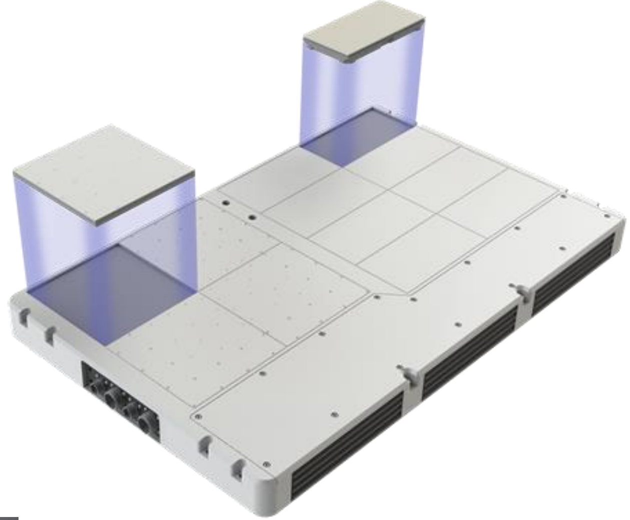
SERVICE PLAN	STANDARD (FIXED)	PRIORITY (FIXED)	MOBILE (MOBILITY)	MOBILE PRIORITY (MOBILITY)
AVAILABILITY	≥99%	≥99%	≥99%	≥99%
DOWNLOAD	90-240 Mbps	120-270 Mbps	75-240 Mbps	85-275 Mbps
UPLOAD	10-25 Mbps	12-35 Mbps	8-30 Mbps	10-30 Mbps
LATENCY*	25-60 ms	25-60 ms	<99 ms	<99 ms

*Customers in certain remote locations will experience higher latency (e.g. Oceans, Islands, Antarctica, Alaska, Northern Canada, etc)

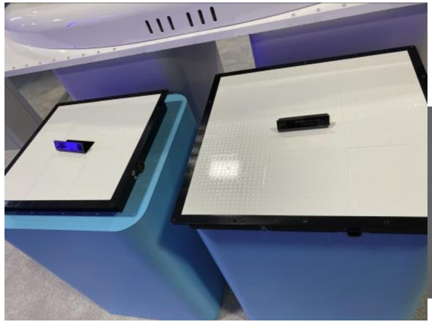
HYBRID BEAMFORMING TECHNOLOGY

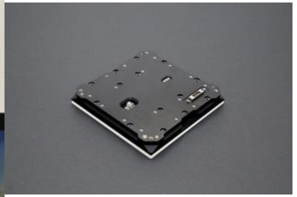
● BALL AEROSPACE ESA

- Ku-band SATCOM
- A subarray antenna architecture for Tx, Rx



a Ku-Band land mobile terminal with 4 Tx and 8 Rx subarray.





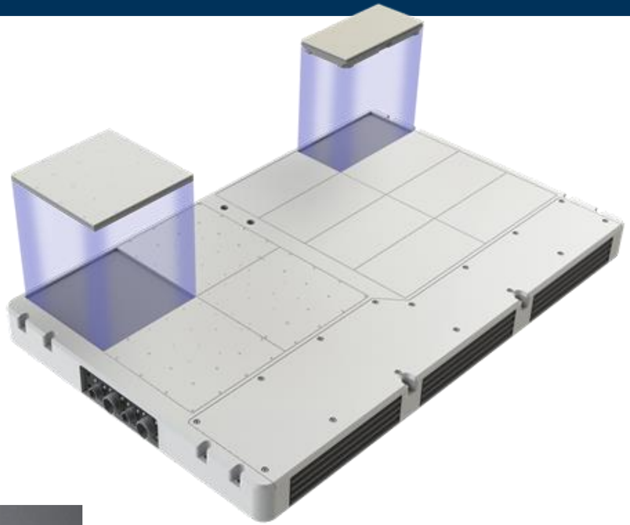
ANTENNA CONFIGURATION (SUBARRAYS)		ESTIMATE ANTENNA PERFORMANCE		APERTURE SIZE		WEIGHT (SUBARRAYS ONLY)
Tx	Rx	EIRP (dBW)	G/T (dB/K)	Tx (in)	Rx (in)	(lbs)
2	4	40.5	9	13×7	15×15	18
4	6	46.5	10.8	13×13	15×23	30
9	9	53.6	12.5	19×19	23×23	50

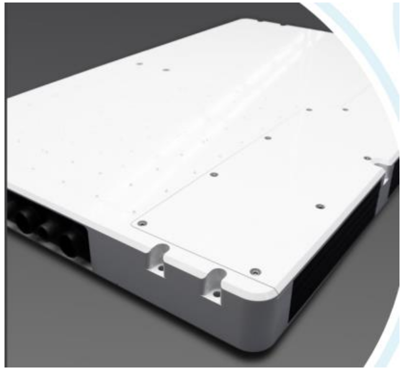
ESA CAPABILITIES

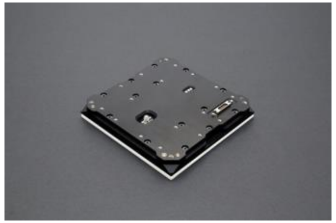
- Frequency Tx: 13.75* – 14.50 GHz
  Rx: 10.70 – 12.75 GHz
- Polarization : V/H/RHCP/LHCP (software switchable)
- Axial Ratio < 2.0 dB (software controlled)
- Coverage : Azimuth: 360°
  Elevation: 10° to 90°
- Beam Update Rate < 1ms (any position, any polarization)
- Interfaces : Open AMIP / Custom
- Dual Beam : Receive capable

● BALL AEROSPACE ESA

- Ka-band SATCOM
- A subarray antenna architecture







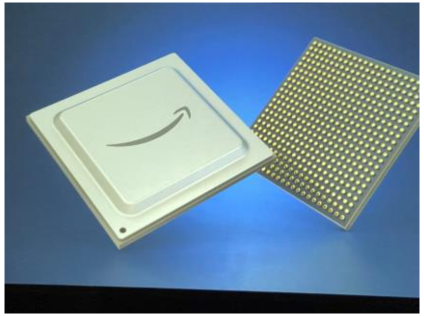
a Ka-Band land mobile terminal with 4 Tx and 8 Rx subarray.

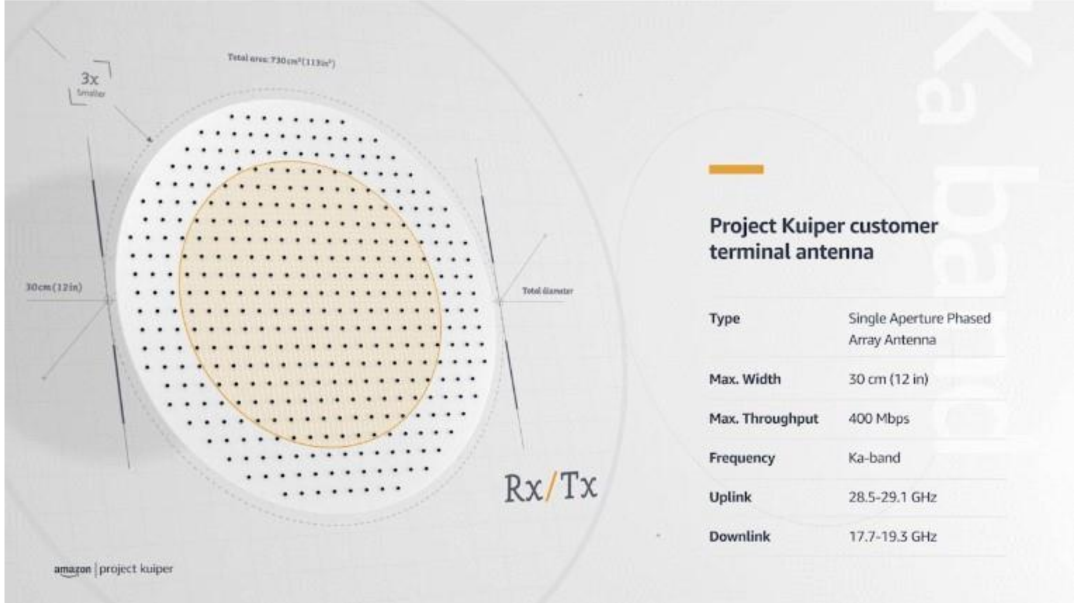
ANTENNA CONFIGURATION (SUBARRAYS)		ESTIMATE ANTENNA PERFORMANCE		APERTURE SIZE		WEIGHT (SUBARRAYS ONLY)
Tx	Rx	EIRP (dBW)	G/T (dB/K)	Tx (in)	Rx (in)	(lbs)
1	2	41	8	8×8	9×9	8
2	4	47	11	16×8	18×9	15
4	8	53	14	16×16	18×18	30
4	12	53	15.8	16×16	18×27	40

ESA CAPABILITIES

- Frequency Tx: 27.5 – 31.0 GHz
  Rx: 17.7 – 21.2 GHz
- Polarization : RHCP/LHCP (software switchable)
- Axial Ratio < 2.0 dB (software controlled)
- Coverage : Azimuth: 360°
  Elevation: 10° to 90°
- Beam Update Rate < 1ms (any position, any polarization)
- Interfaces : Open AMIP / Custom
- Dual Beam : Receive capable

● AMAZON KUIPER ESA TERMINAL



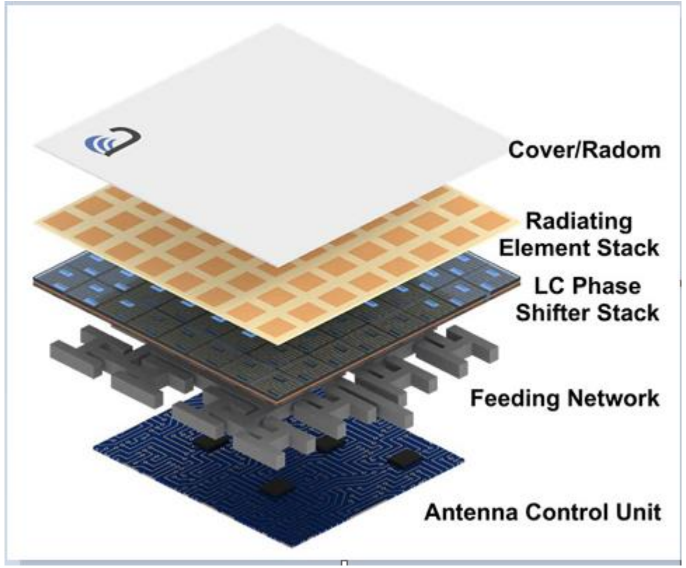


Transmit Antenna Gain 34.5 dBi at 28.8 GHz
Receive Antenna Gain 34.5 dBi at 18.0 GHz

Source : https://www.aboutamazon.com/news/innovation-at-amazon/amazon-marks-breakthrough-in-project-kuiper-development https://www.rfwireless-world.com/Terminology/Active-Beamforming-vs-Passive-Beamforming.html

● ALCAN SYSTEMS (1/2)

- **Beamforming by Liquid Crystal Phase Shifter Stack** by applying and controlling a DC voltage bias across the LC layer
- **Advantages**
  - **Lower DC power consumption** (No electronic amplifier)
  - Antenna array architecture is **simple and straightforward**
  - **Low cost**
- **Drawbacks**
  - **Antenna panel is larger in size** due to intrinsic losses of LC elements and PCB materials used
  - **Slower beam switching** (slow response of LC molecules - temporary link interruption during H/O)
  - **Molecular response time** depends on operating temperature(extra heater required in cold area)



● ALCAN SYSTEMS (2/2)

Enterprise NGSO Terminal

systems alcan

- Ka-Band LEO/MEO Satellite Terminal
- Technical University of Darmstadt
- LC based phased array antenna
- Full duplex operation
- Full terminal price estimated at EUR 2,500
- Throughputs in excess of 400 Mbps

Electrical	
Receive Frequency	17.7 - 20.2 GHz
Transmit Frequency	27.5 - 30.0 GHz
Instantaneous Bandwidth	Rx: 400 MHz, Tx: 400 MHz
Polarization	Fixed circular
Scan Range	55° conical 2D scan about boresight
G/T	10.8 dB/Kat boresight across band
	7.3 dB/K at 55° scan across band
EIRP	44.9 dBW min at boresight (6W BUC)
	41.4 dBW at 55° scan
Sidelobe Envelope	ITU Article 22, ETSI EN 303 699
XPD	20 dB min.
Power Consumption	35W typical (exc. LNB and BUC)
	98W (inc. LNB and BUC)
Slew Time	< 20ms at 20°C

Mechanical	
Dimensions	550 x 995 x 90 mm
Weight	18 kg

Environmental	
Operating Temperature	-20 °C to +55 °C
Humidity	Up to 100%

Source : Advanced Antenna Design Using Radio Frequency Liquid Crystals And LCD Manufacturing

● KYMETA ESA TERMINAL TECHNOLOGY

- **Metasurface and Holographic Beam forming**

  - A metasurface antenna is an aperture antenna of resonant and scattering metamaterial elements

  - Holographic Beam Forming

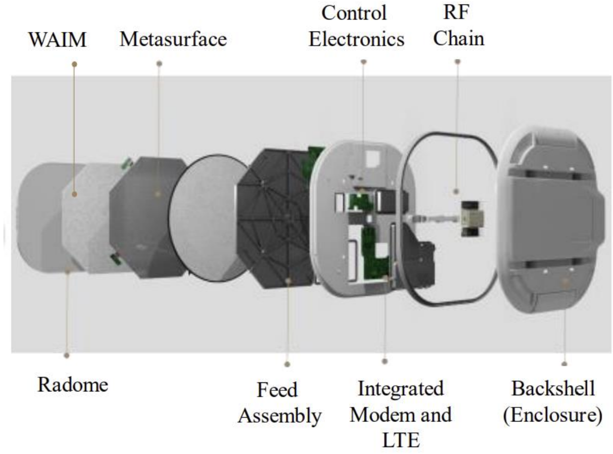
- **Tripleband Metasurface Aperture**

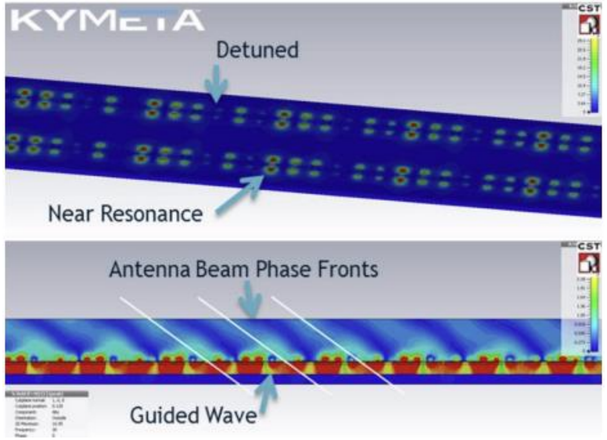
  - Metasurface is designed to operate in full duplex mode for simultaneous Ku Rx and Tx

  - Rx sub-array and Tx sub-array must be interleaved across the metasurface

- **Flat Panel Display Technology**

  - Metasurface design manufactured using flat panel display technology with liquid crystal as a tunable dielectric





Top view and cross section showing the antenna elements, feed structure, and the antenna beam

KYMETA LEO TERMINALS

- **Hawk u8 - LEO**
- **Aperture** - RX and TX combined, 82 cm active diameter
- **Polarization** - Linear, circular by SW upgrade
- **G/T** - Up to 11.25 dB/K,
  9.0 dB/K(@ 45° EL, TYPICAL LAND MOBILE)
- **Gain** - Up to 34.0 dBi,
  32.0 dBi(@ 45° EL, TYPICAL LAND MOBILE)
- **Scan Angles** - Az 360°, El +15° ~ +90°
- **Dimension** - L 90cm× W 90cm x H 12.1cm
- **Weight** ~23.5 kg

HAWK™ u8

PEREGRINE™ u8

Thank you for your attention !

Disclaimer

All information regarding management performance and financial results contained herein has been prepared on a consolidated basis in accordance with International Financial Reporting Standards (“IFRS”). The information contained herein includes forward-looking statements in respect to future plans, prospects, and performances of the Company The aforementioned forward-looking statements are influenced by changes in the management environment and relative events, and by their nature, these statements refer to uncertain circumstances. Consequently, due to these uncertainties, the Company’s actual future results may differ materially from those expressed or implied by such statements.

Please note that as the forward-looking statements contained herein are based on the current market situation and the Company’s management direction, they are subject to change according to the changes in future market environment and business strategy. The information contained herein should not be utilized for any legal purposes in regards to investors’ investment results. The Company hereby expressly disclaims any and all liability for any loss or damage resulting from the investors’ reliance on the information contained herein.