DEVELOPMENT OF MHTS AUTOMATIC IDENTIFICATION SYSTEM (AIS) RECEIVER AND UPGRADE TO VDES & BLUE FORCE TRACKING AIS.

- Introduction of Motseni-HI-TechSpace (MHTS)
- **Kgabo Mathapo**
  - Technical Director -Satellite Engineer
  - CO-Founder Motseni HI-TechSpace
- MHTS Company specializes in Design & Development of:
  - GNSS Radio Occultation Receivers (& GNSS-R) For Weather Prediction and Space Weather Monitoring (TEC)
  - RF & Microwave Subsystems , Satellite TT&C Transceivers, Radar Subsystems,
  - Inter-Satellite Links Transceivers ,TERRESTRIAL-AIS, SAT-AIS, VDES for Maritime monitoring & BFT AIS

AIS- TERRESTRIAL MONITORING SYSTEM & SAT-AIS

- AIS mandated by IMO to be carried by Vessels, Maritime

- AIS Exchange information between ship-ship & ship-shore

- Address Safety of life at sea (Collision Avoidance), efficiency of navigation & Protection of marine environment

- Messages, Static- MMSI, IMO, Name. Dynamic- Position, GNSS-Time stamp(UTC), COG, SOG e.t.c

- Navigational voyage related Messages-Destination, ETA, Cargo

- Limitations- coverage limitations-& Overloading
  - Bandwidth & No Duplex Comms between SAT & SHIPS

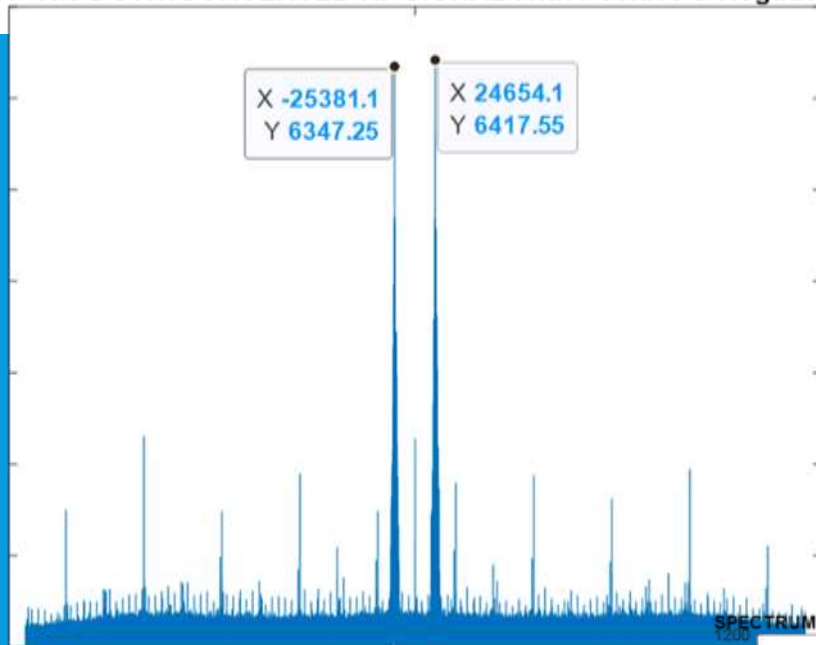# AIS-TERRESTRIAL MONITORING SYSTEM-TDMA-FRAME = 2250 SLOTS
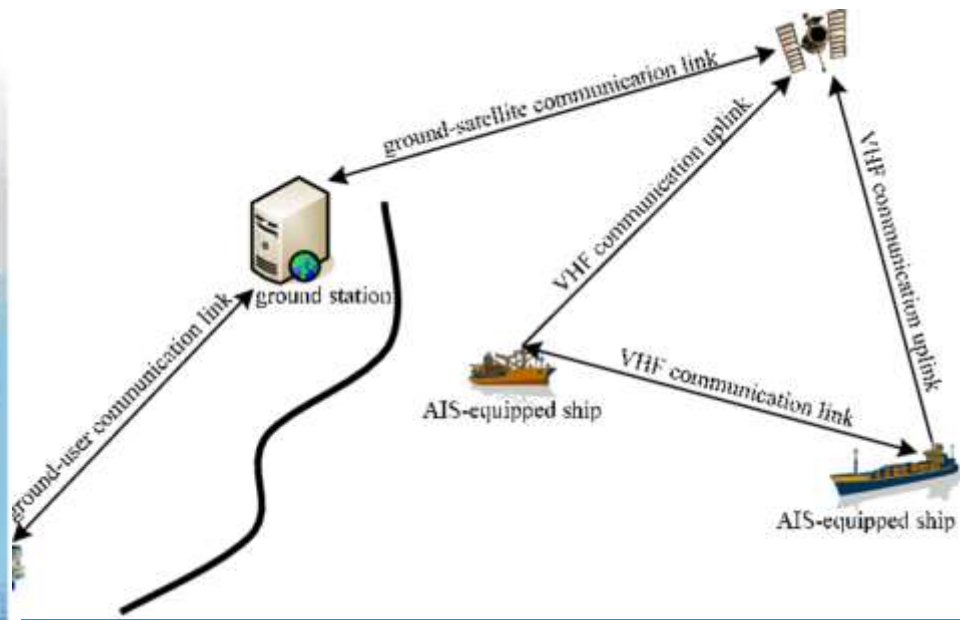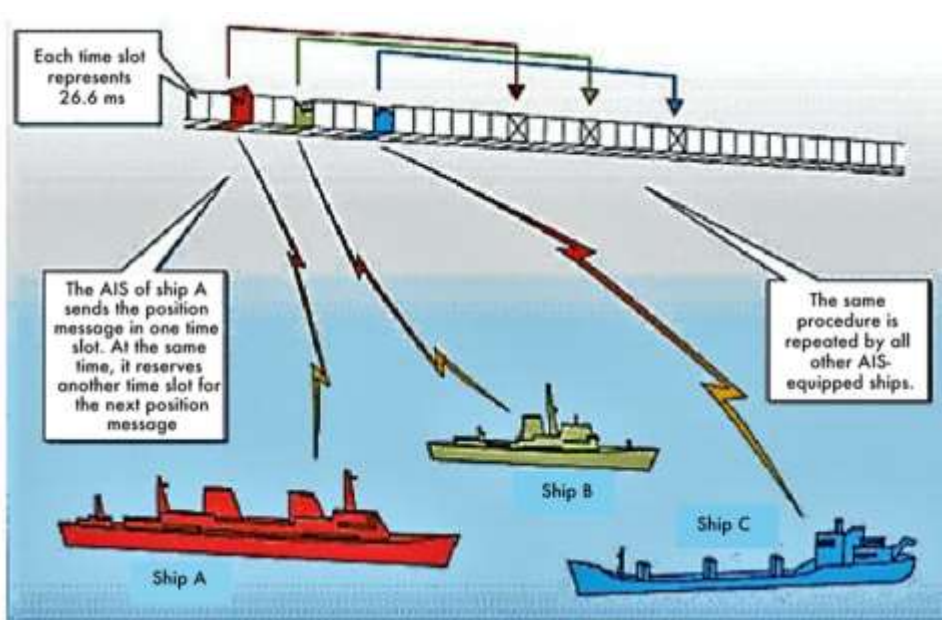
AIS Frequencies: 161.975 MHz & 162.025 MHz,
GMSK Modulation & Demodulation

OF The DOWNCONVERTED RF SIGNAL With Positive & Negative Frequency

X -25381.1
Y 6347.25

X 24654.1
Y 6417.55

Product to Sum Identities

$$sin(x)cos(y) = \tfrac{1}{2}\left[sin(x+y) + sin(x-y)\right]$$

$$cos(x)sin(y) = \tfrac{1}{2}\left[sin(x+y) - sin(x-y)\right]$$

$$cos(x)cos(y) = \tfrac{1}{2}\left[cos(x-y) + cos(x+y)\right]$$

$$sin(x)sin(y) = \tfrac{1}{2}\left[cos(x-y) - cos(x+y)\right]$$

$$e^{j\theta} = \cos\theta + j\sin\theta$$

$$e^{-j\theta} = \cos\theta - j\sin\theta$$

SPECTRUM OF DOWNCONVERTED BASEBAND SIGNAL before filtering

SPECTRUM OF COMPLEX CARIER SIGNAL

01/09/2023
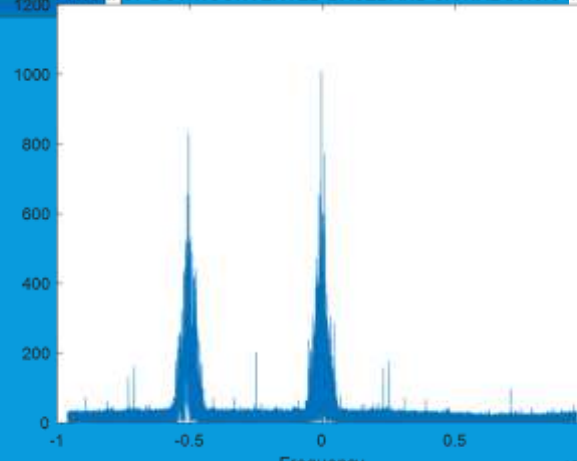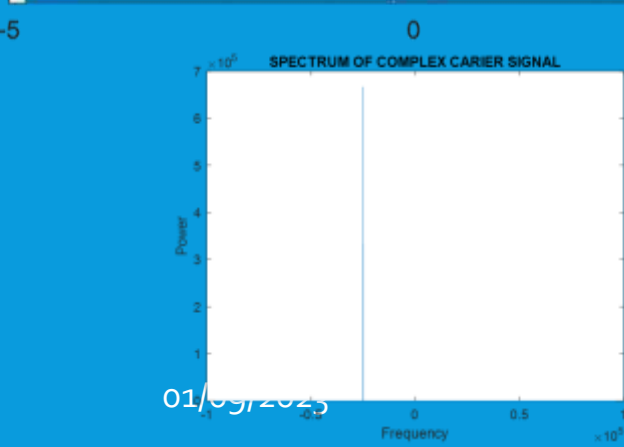
# MHTS AIS RECEIVER-SDR: FREQUENCY TRANSPOSITION & NEGATIVE FREQUENCY, MULTIPLE RECEIVERS
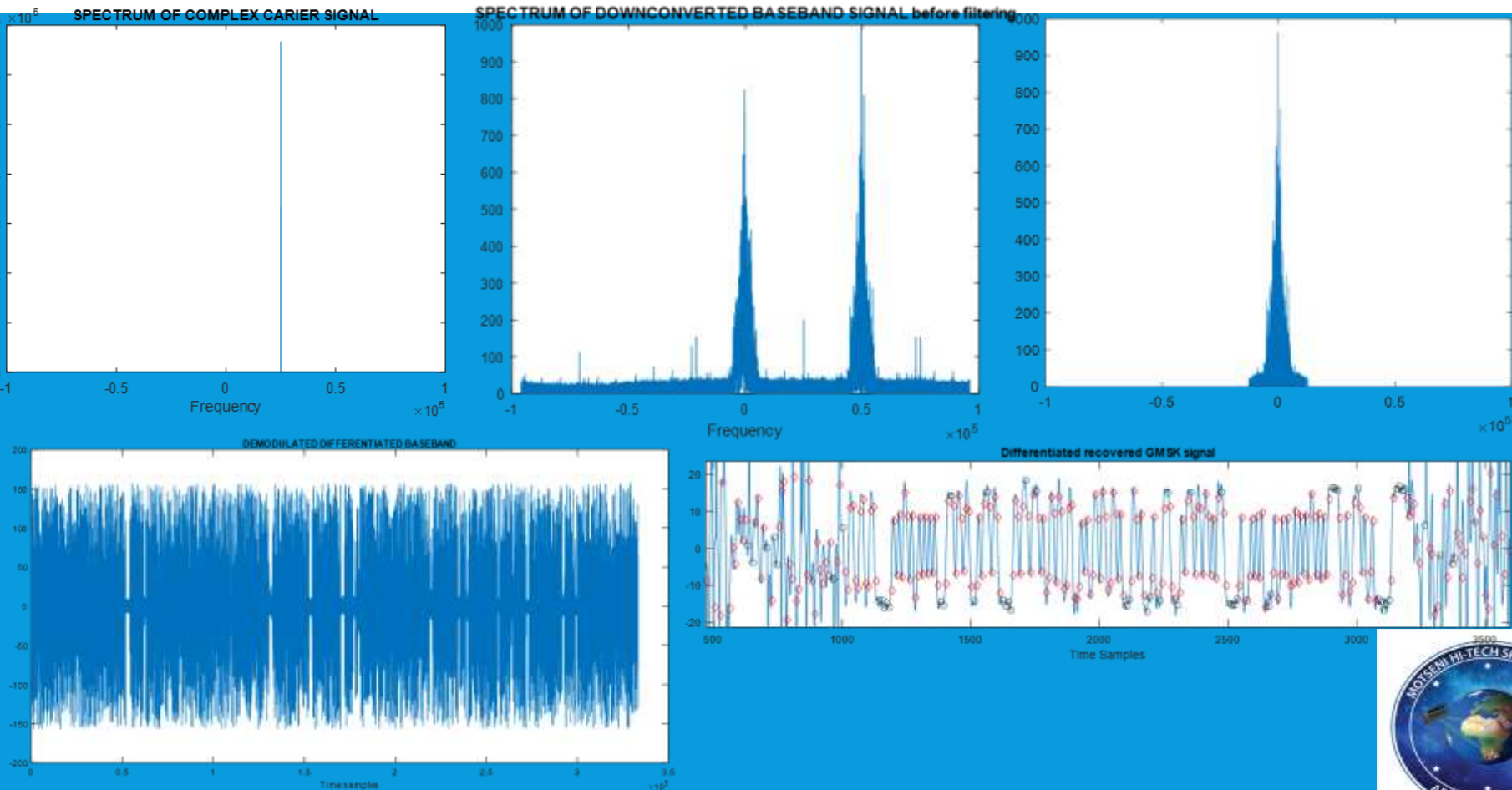
MHTS AIS DEMONSTRATOR-DUAL CHANNEL RX IN SDR: RESULTS

AIS_VDM ='18v3ta:000QDE`gdVD2f41Od25`P'

AIS_VDM = '18u`>27P00QDFeodVFI>4?wl2@R='

AIS_VDM = '18u:Mg0P00QDFPidVEG>4?v22<19'

AIS_VDM = '13F=qV0P001DK:udUugg<?wp2PRd'

AIS_VDM ='53F=qV02>n<<D<`J221A8tpTv22222222222220N3`J384J80>4m0CS1FH888888888888'

AIS_VDM = '18uPOq?P00QDDUudVAbn=Owp0W3h'

AIS_VDM = '18uPSk70001DKk9dUs9`01D@05`T'

AIS_VDM = '18JQ=L40001DJl1dV4f9ET6:0<1e'

AIS_VDM = '405flaQvIO=991DGIkdVHL?02<0u'

AIS_VDM = '18uE8t0P00QDFrAdVGqf4?vL200j'

AIS_VDM = '18uQ=w00001DDNQdVB;n`JJN0<1e'

AIS_VDM = '58Hro382=qv?UKG;CJ0l4E9<f1<PDE8pE=>22217NQKL?5O80T4iljCggVP@l588888888'

AIS_VDM ='18u:Mg0P00QDFPidVEG>4?vb25`T'

AIS_VDM = '13F=qV0P001DK;1dUuga<wwp2PSH'

AIS_VDM ='33ku9W50001DG7udV6cd<9hd0Dfb'

AIS_VDM = '18uPOq?P00QDDV7dVAaV=Owp0W3h'

AIS_VDM =_'18uQ3m7P00QDFdGdVFNf4?w42HDT'

MHTS AIS RECEIVER DEMONSTRATOR RESULTS
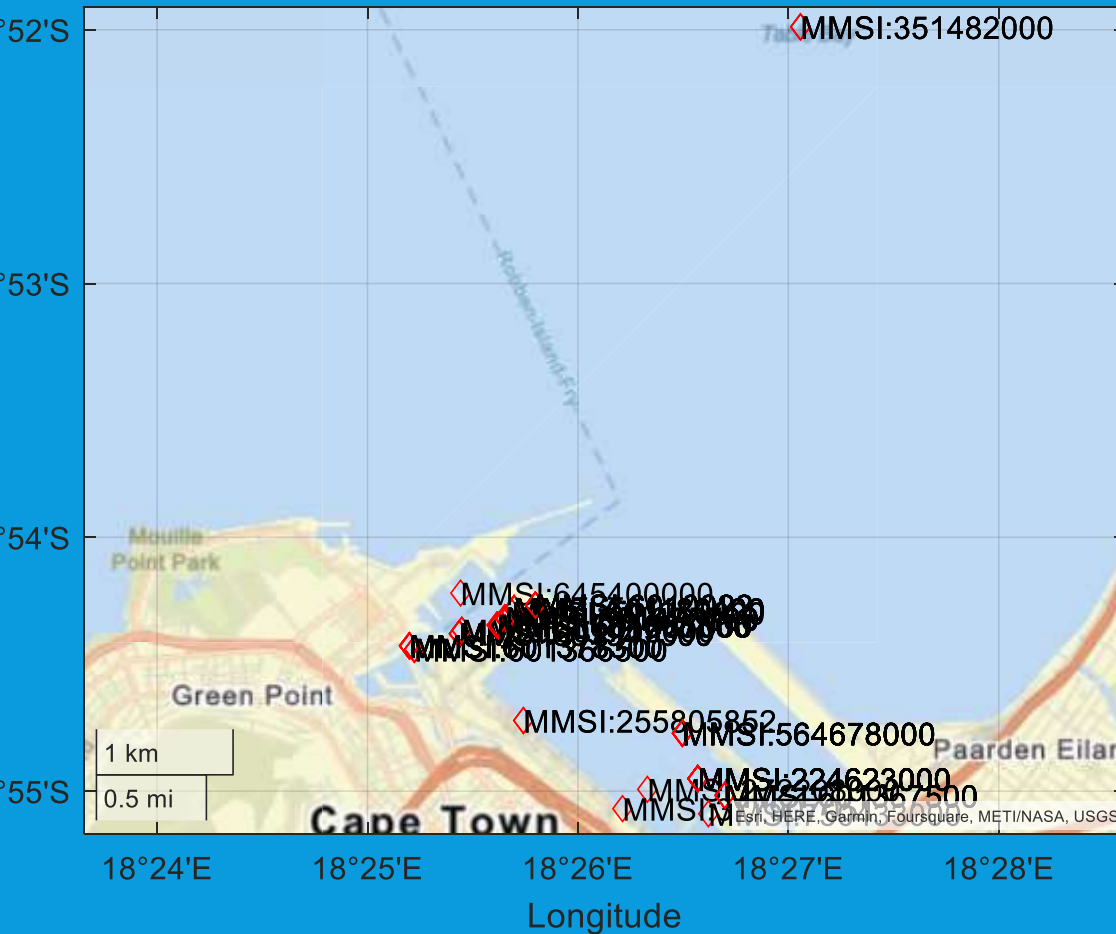
VHF DATA EXCHANGE SYSTEM – VDES EVOLUTION OF AIS: AIS.2MODES - AUTONOMOUS, ASSIGNED & POLLED

- Next-generation VHF maritime communications service designed to Deliver two-way communication across planet. M2M

- The system will complement to both terrestrial and satellite based AIS. VDE-TER (Duplex or Simplex mode). Band - 156.025-162.025 MHz

- IMO and IALA develop and prove its feasibility of the satellite based VDES, -Testing Phase. Industry partners testing the downlink segment of VDES, using Satellites," and Terrestrial Links.

- VDES means exchanging data between Maritime Stations (M-M)

- Ship-to-ship, ship-to-shore, shore-to-ship, ship-to-satellite

- and Satellite-to-ship. –Incorporate GNSS Rx & Antennas

- Multi-component system-AIS, ASM & VDE (VDE-TER &VDE-SAT)

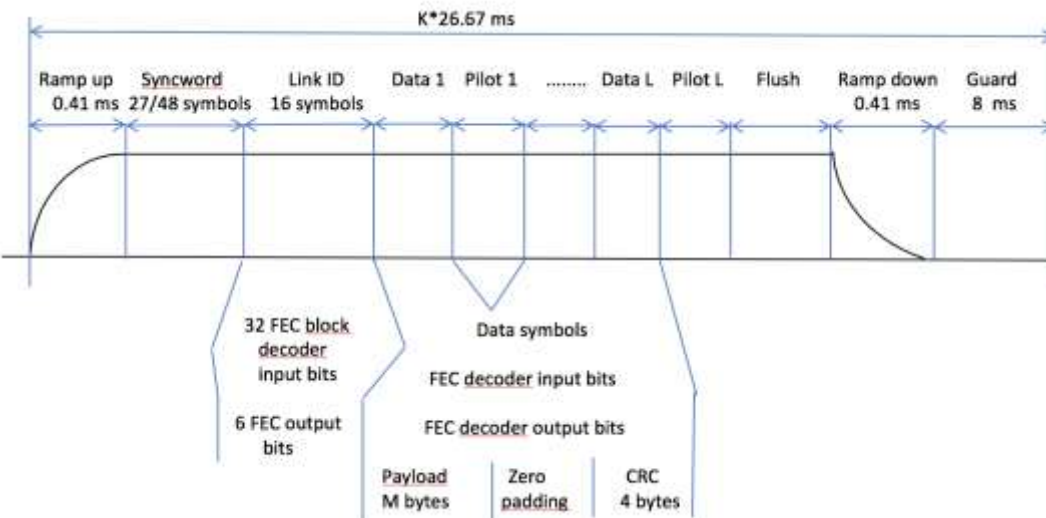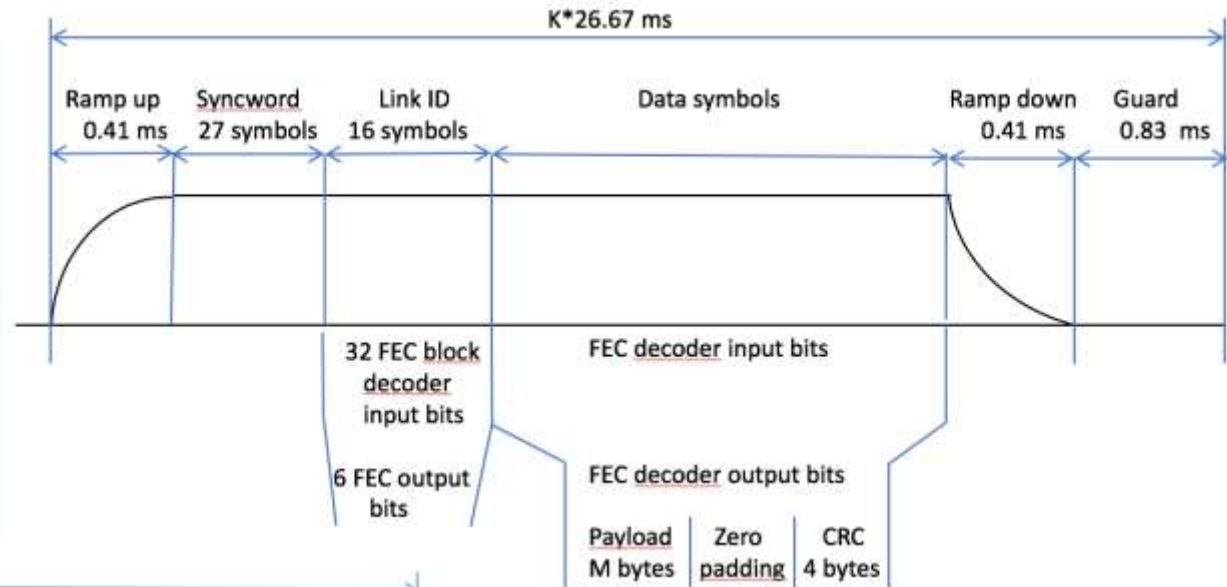# AIS.2(VDES)-EVOLUTION OF AIS EXPECTED 500K TERMINALS BY 2030
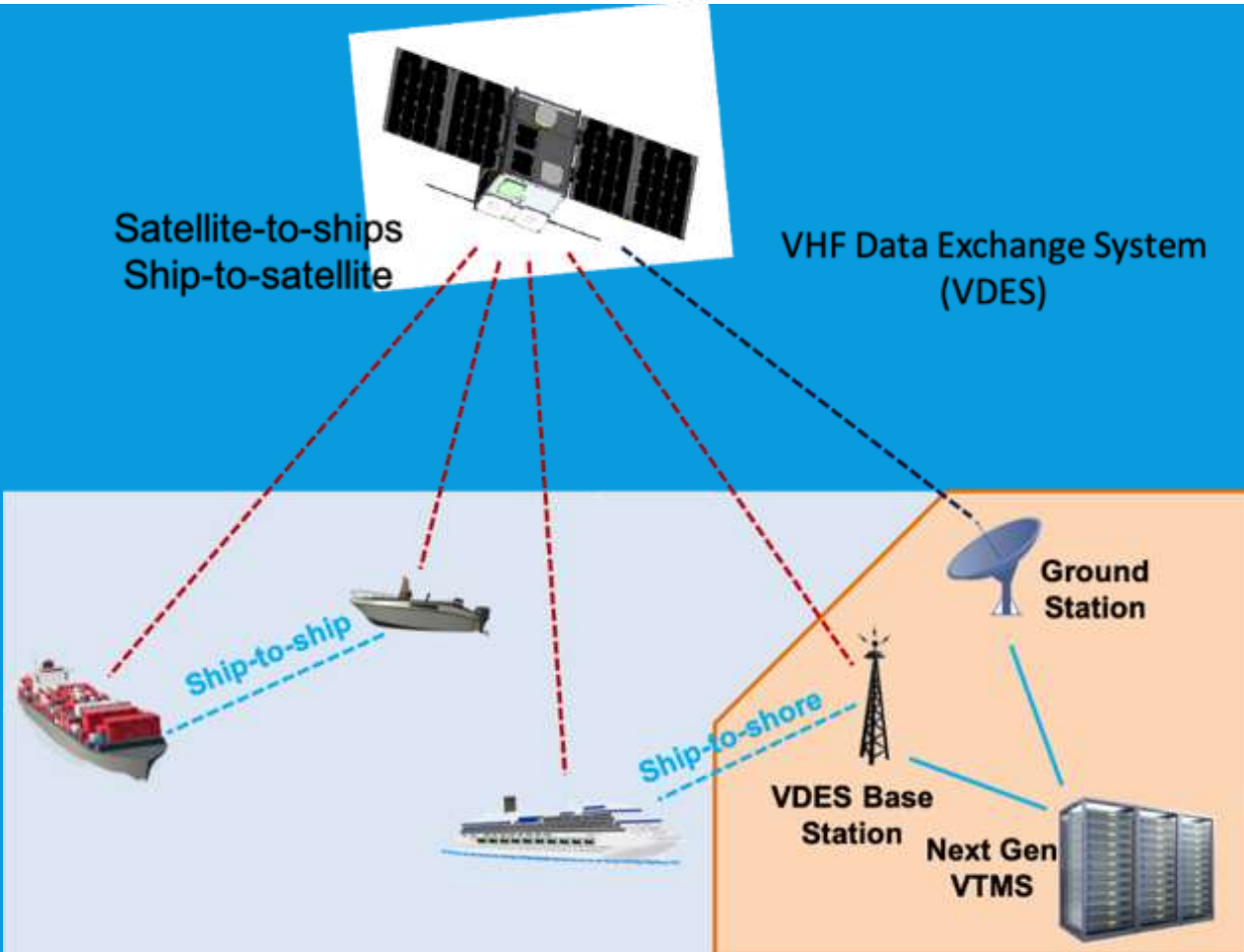
VDES - FREQUENCY USAGE
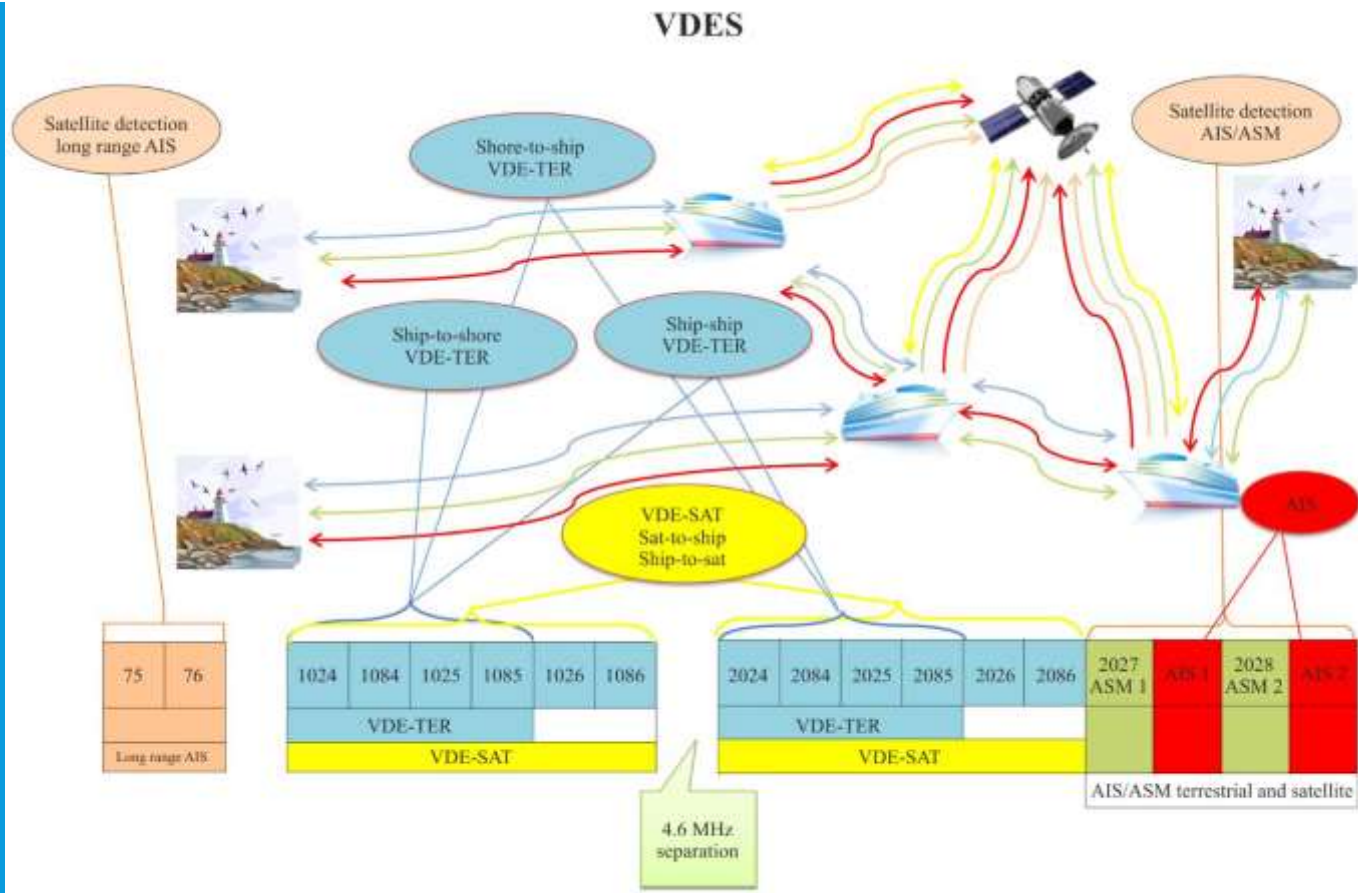
VDES-ASM-TER AND VDE-TER
AND
ASM-SAT & VDE-SAT PACKET FORMAT ITU

VDES-SYSTEM – ITU-R

System- Various Sync words based on usage – VDER-TER, ASM-SAT, SAT. Identification & Location of Active Stations is still by AIS

MCS & Link ID defines - channel configuration

Data with CRC is interleaved, FEC encoded, scrambled, and bit mapped
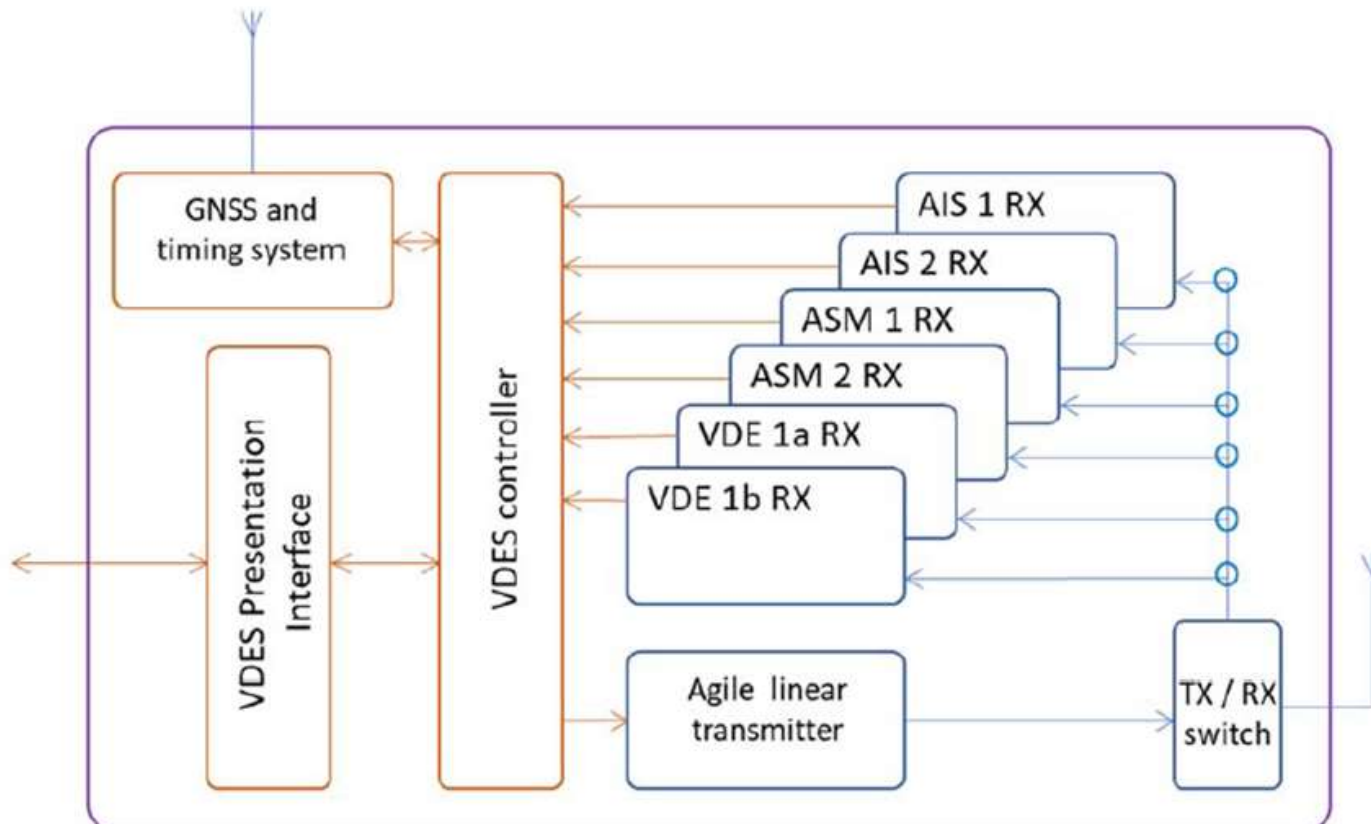
VDE-ASM – Link Identification Parameters – Pi/4 QPSK

VDE-TER – Link ID Parameters - Pi/4-QPSK, 8-PSK, 16-QAM

VDE-SAT – Link ID Parameters-Pi/4-QPSK,BPSK & QPSK/CDMA

VDES-SYSTEM – APPROACH
CAN BE IMPLEMENTED IN SDR

Figure 7 VDES ship station logical description

MHTS VDE – ASM
ASM 1-161.95 MHZ & ASM 2-162.0 MHZ

Implement

Transport Layer
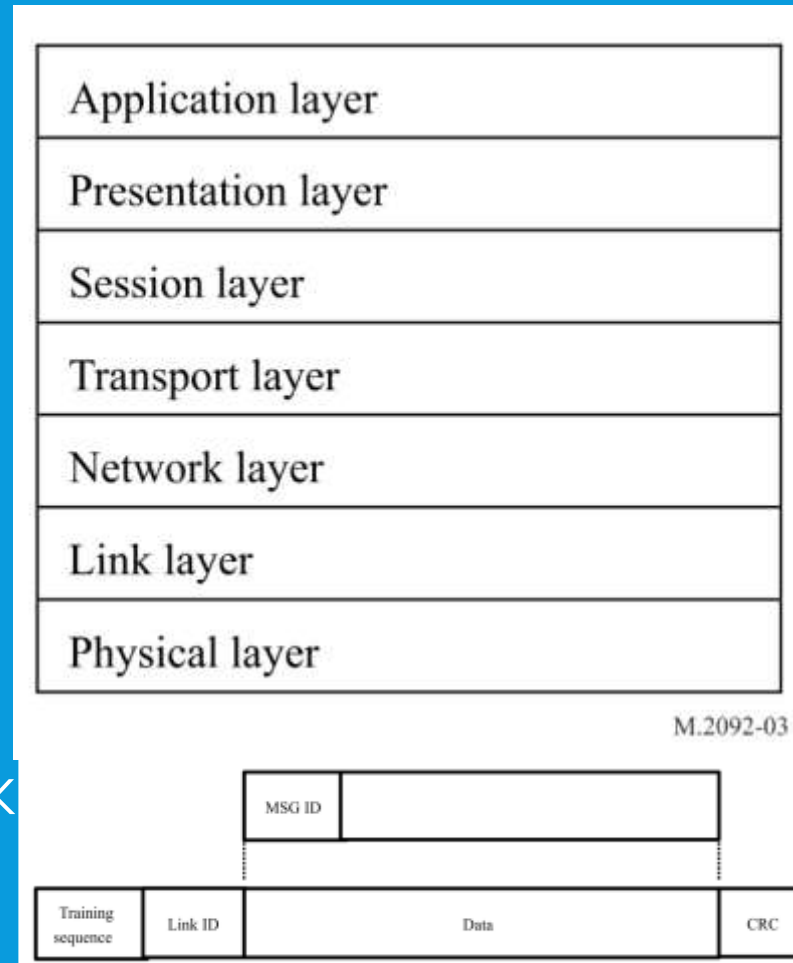
Network Layer

Link Layer

Link Management Entity
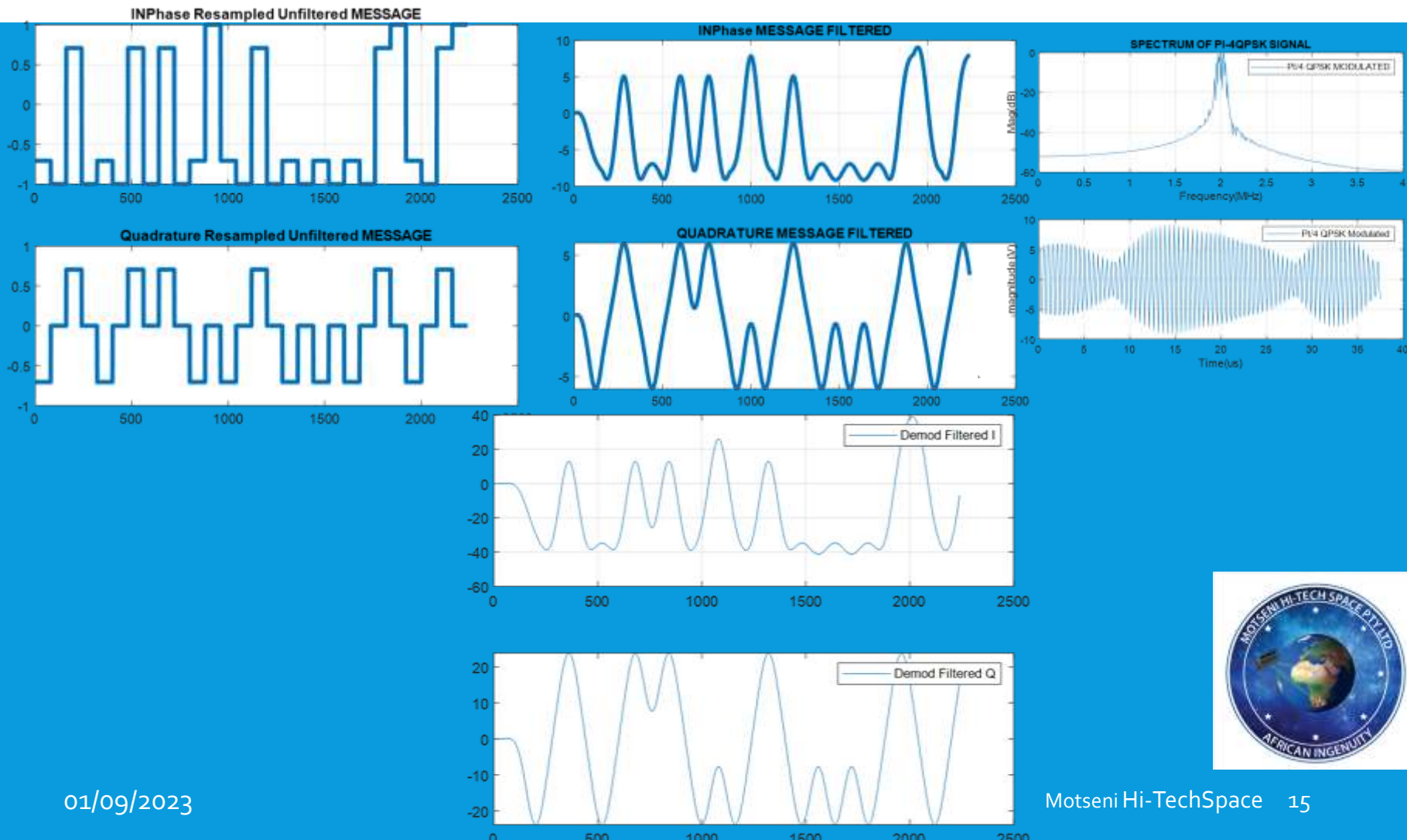
Data Link Services

Media Access Control?

Physical Layer

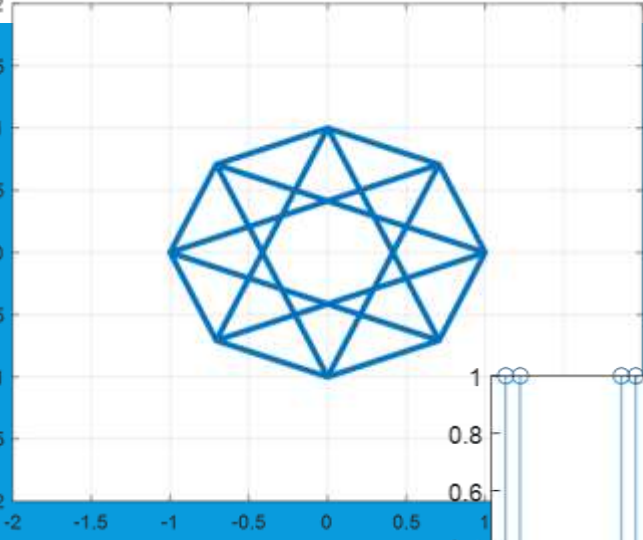- Bit Rate -19.2 kbps Pi/4-QPSK

- Tx Power = 1W & 12.5W

| Application layer |
| Presentation layer |
| Session layer |
| Transport layer |
| Network layer |
| Link layer |
| Physical layer |

M.2092-03

| MSG ID | |

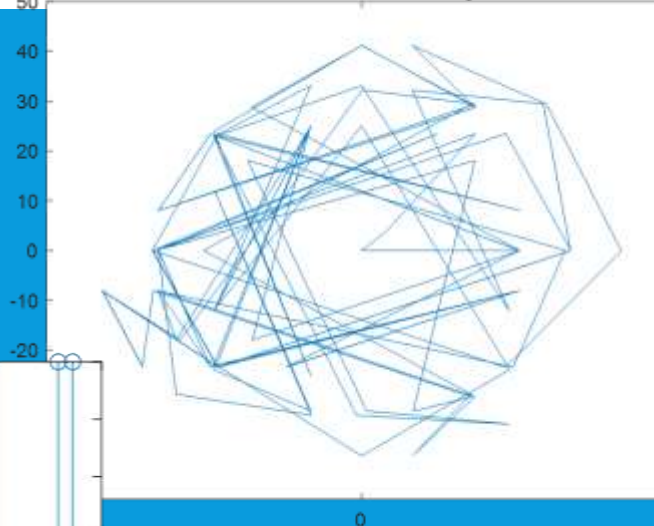| Training sequence | Link ID | Data | CRC |

MHTS VDE- ASM-SIMULATIONS-RESULTS-PI/4-QPSK
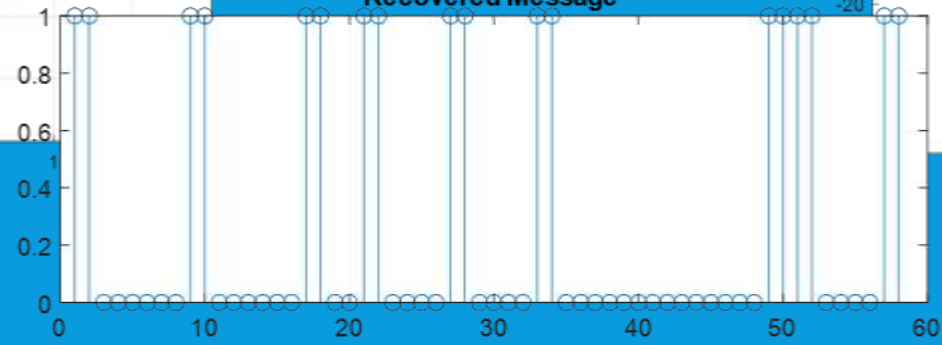
MHTS VDE- ASM-SIMULATIONS-RESULTS-PI/4-QPSK

PI/4-QPSK TX CONSTELLATION

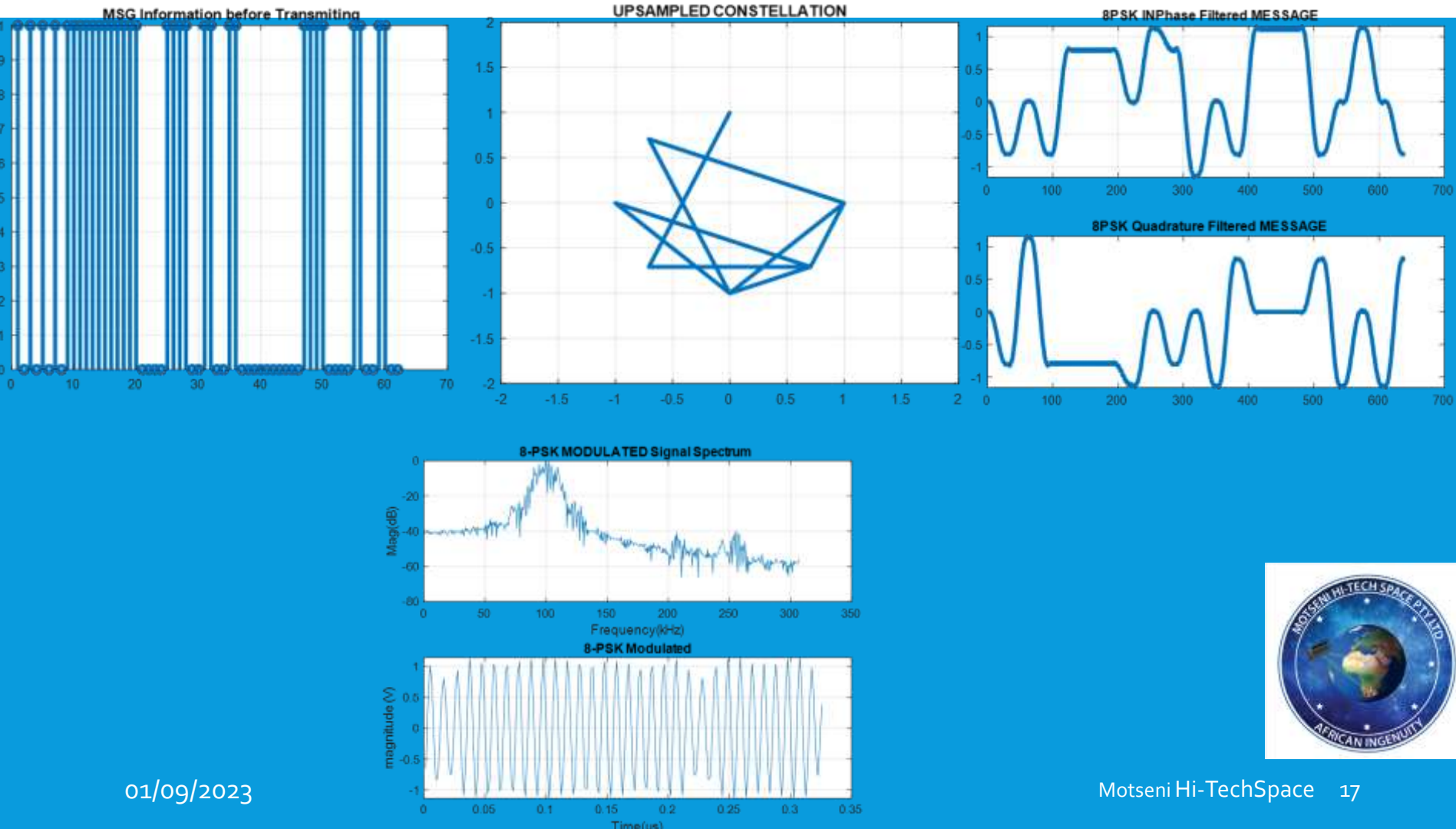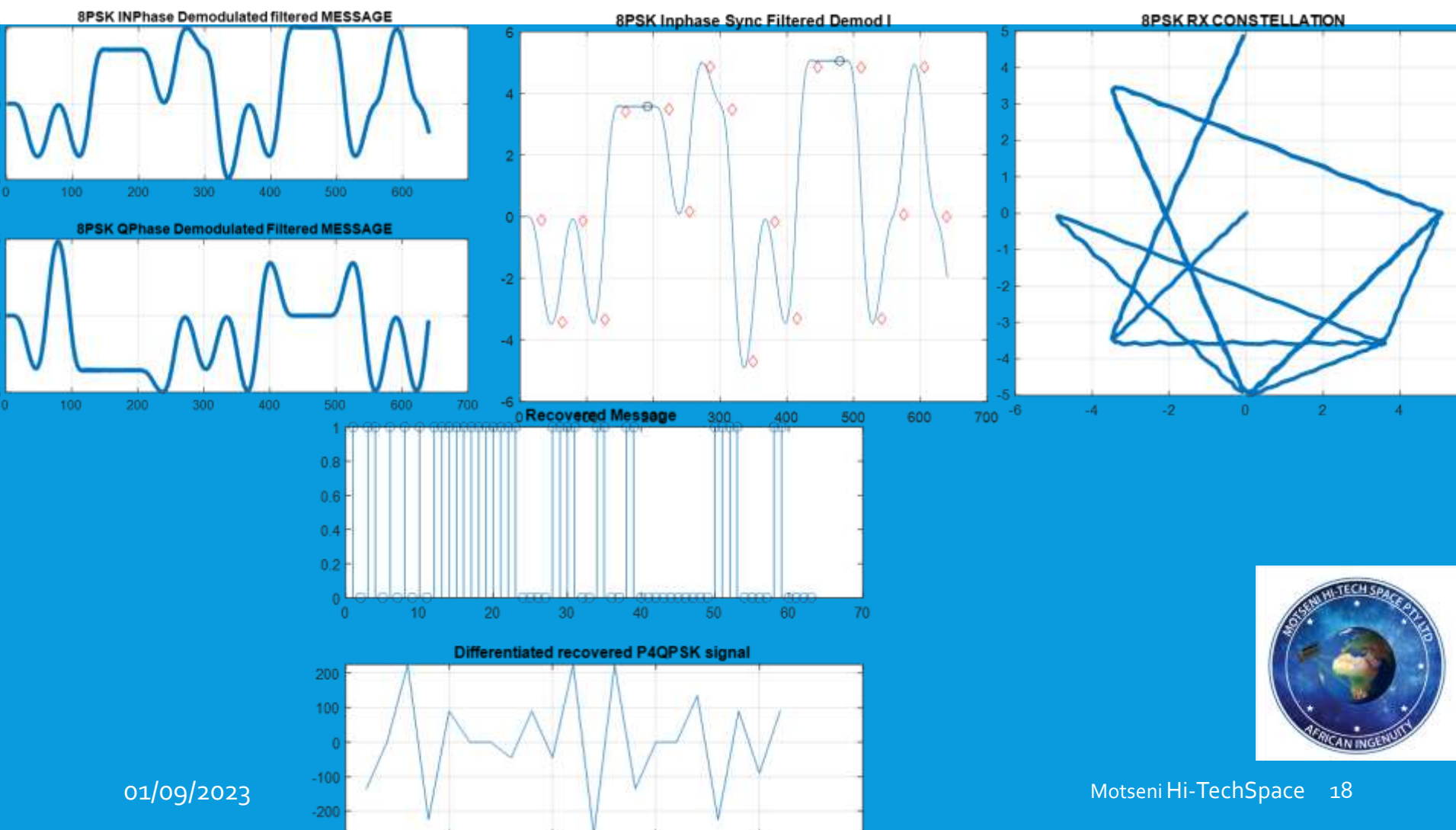Received PI/4-QPSK Constellation of Sync received I & Q
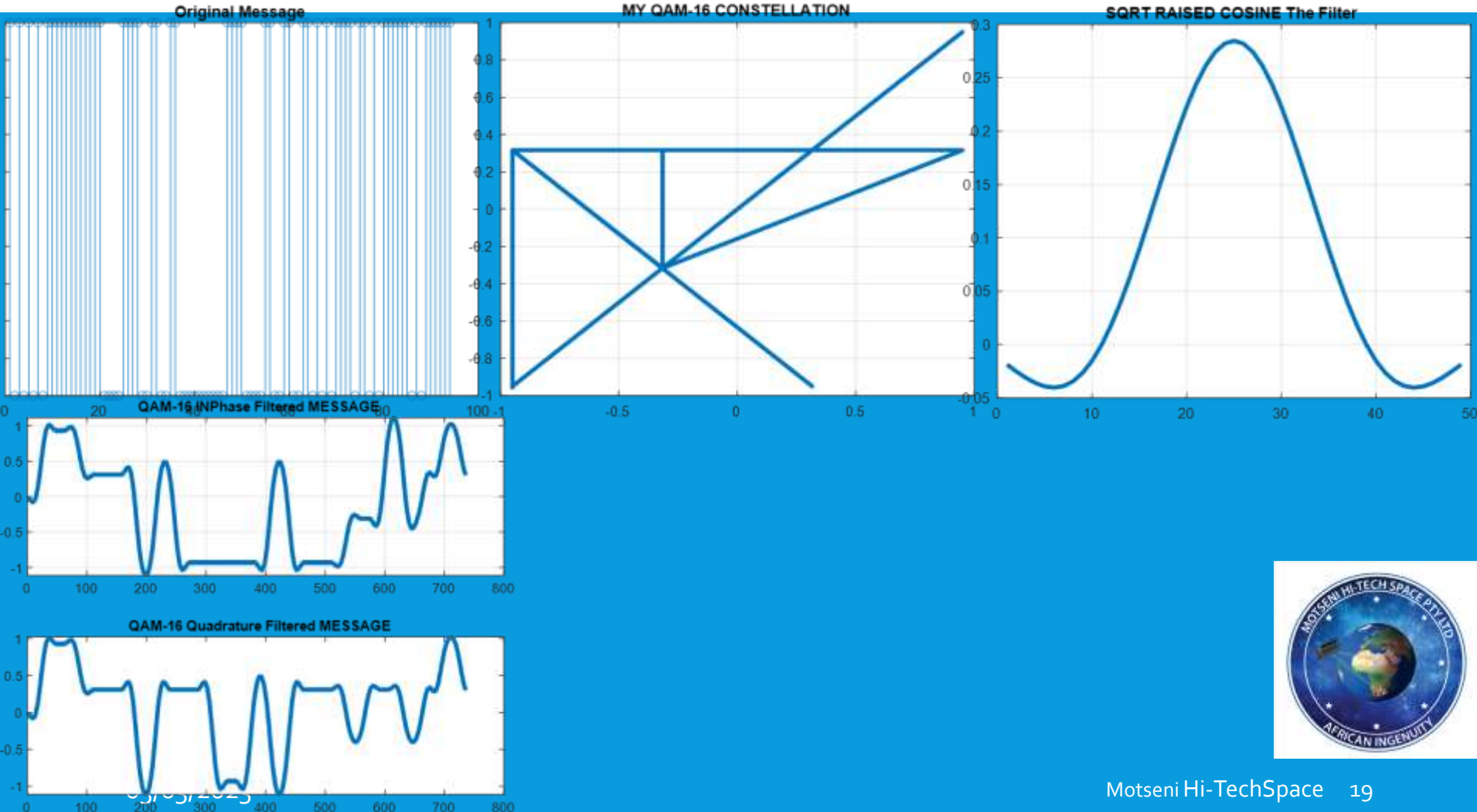
Recovered Message

Original Message

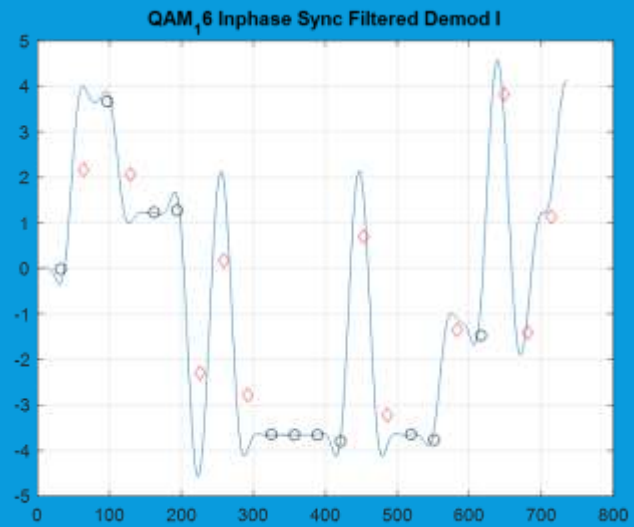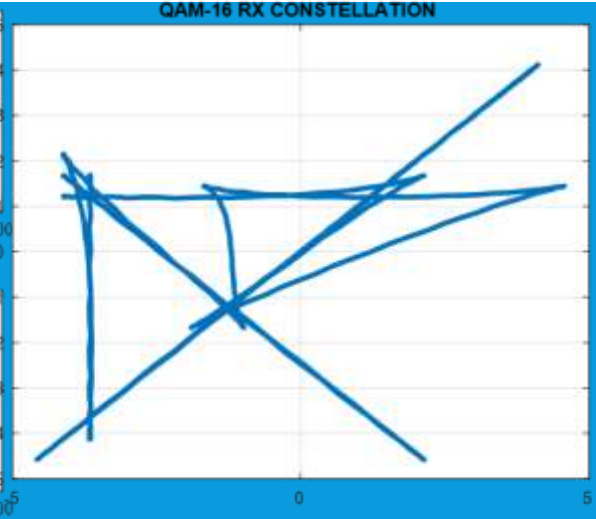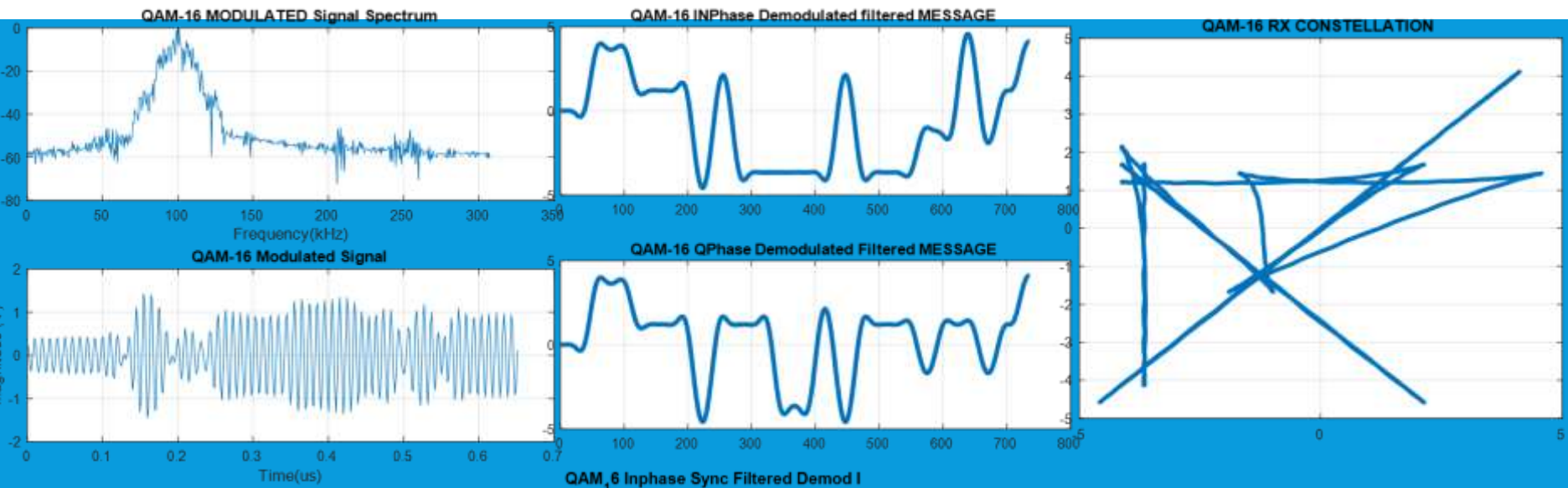# MHTS VDE- ASM-SIMULATIONS-RESULTS-8-PSK

MHTS VDE- ASM-SIMULATIONS-RESULTS-8-PSK

MHTS VDE- ASM-SIMULATIONS-RESULTS-16-QAM

# MHTS VDE- ASM-SIMULATIONS-RESULTS-16-QAM

BLUE FORCE TRACKING (BFT) AIS
I SEE U, BUT YOU CAN'T SEE ME.

Requirements for SBU Tactical Information Exchange. Navy, Coast Guard and Police: Perform AIS communication outside the public AIS network.

Feature allows boats in a group to operate stealthily(hidden) to boats that are not in the Same group, but still able to receive from all normal AIS Vessels.

Boats in their groups (A, B, and C) can only be "seen" within their own groups.
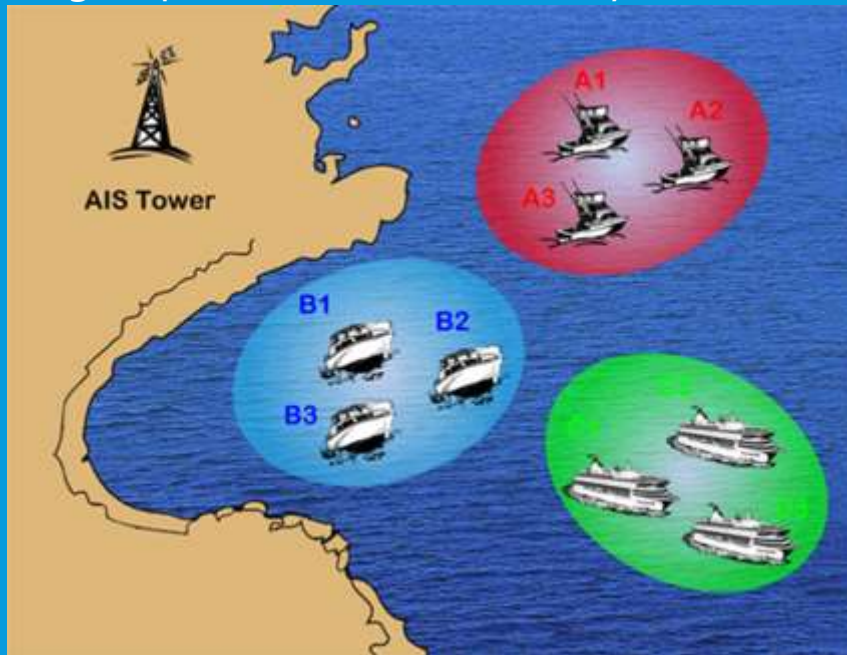
BLUE FORCE TRACKING (BFT) AIS: STEALTH AIS

Modes of Operation:

Visibility: Vessels can be seen within their group including shore based receivers, but, Invisible to all others.

Can see everybody, but not visible to everyone: Capability of Tx open AIS

Capability to receive both open AIS and non-open AIS information

How?

Can include extra channel, encryption, Frequency hopping and/or spread spectrum

Built-in crypto functions and external encryption software be supported

Benefits - Encrypting Vessel ID Data can thwart Maritime Piracy

BLUE FORCE TRACKING (BFT) EAIS MODES OF OPERATION

BFT EAIS TRANSPONDER CAN OPERATE IN:

1. NORMAL MODE –

2. SENDS & RECEIVES OPEN AIS & EAIS

3. RECEIVE ONLY MODE –

4. RECEIVE AIS & EAIS MESSAGES

5. RESTRICTED MODE-

6. TRANSPONDER TRANSMIT ONLY EAIS BUT

7. RECEIVES AIS & EAIS MSGS

- THANK YOU

- MHTS: THE FUTURE IS HERE

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