

NAVDAT Planning: Power, Coverage, Infrastructure & Investment

Wednesday, Oct 7
9:00 am EST, 15:00 CET



Kenta

NAVDAT Planning: Power, Coverage, Infrastructure & Investment

- NAVDAT Review
- Power-Range-Data
- Transmitter & ATU
- Antenna & Towers & Space
- Investment Economics
- Leveraging NAVTEX Infrastructure
- Observations
- Questions/Resources



John Brennan
MF Team Lead, Nautel



Bobby Cox
Senior Engineer, Kintronic Labs



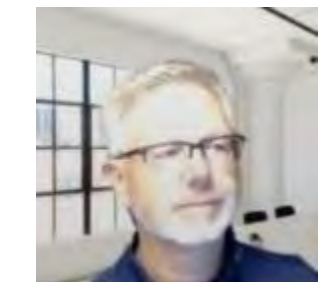
Christophe Huriaux
Head of R&D, Kenta



Joshua Mardling
Engineer, Nautel



Philipp Schmid
CTO, Nautel

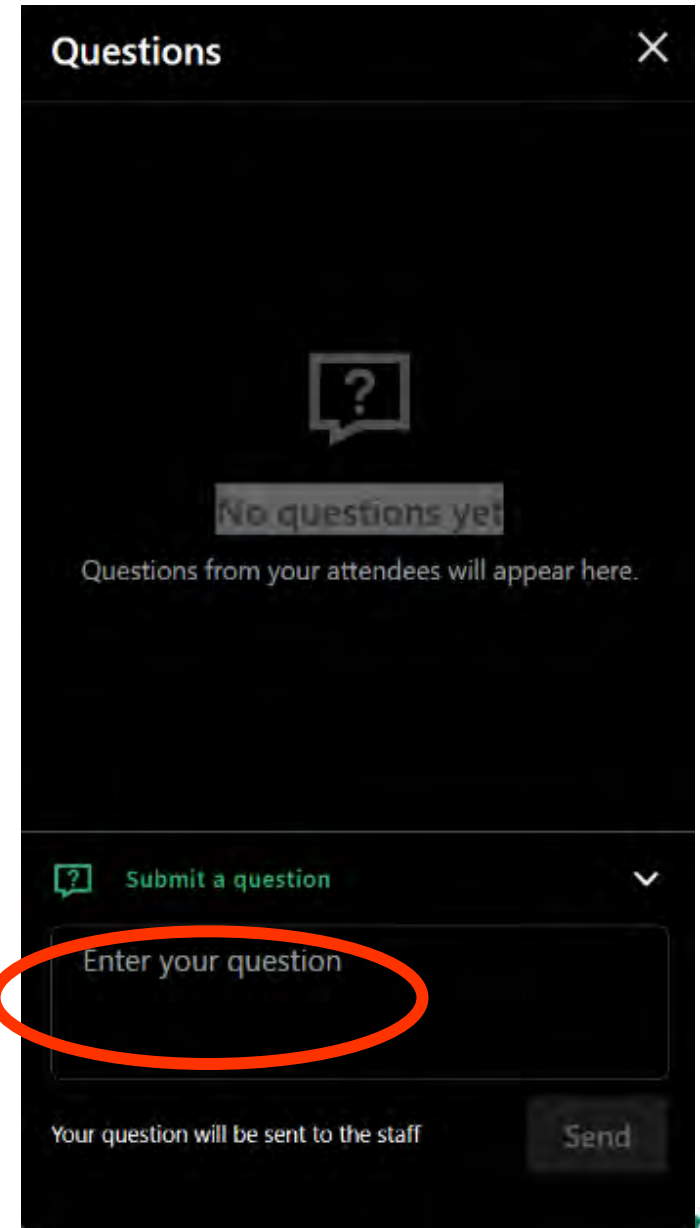


John Whyte
Product Strategy, Nautel

Your questions please?

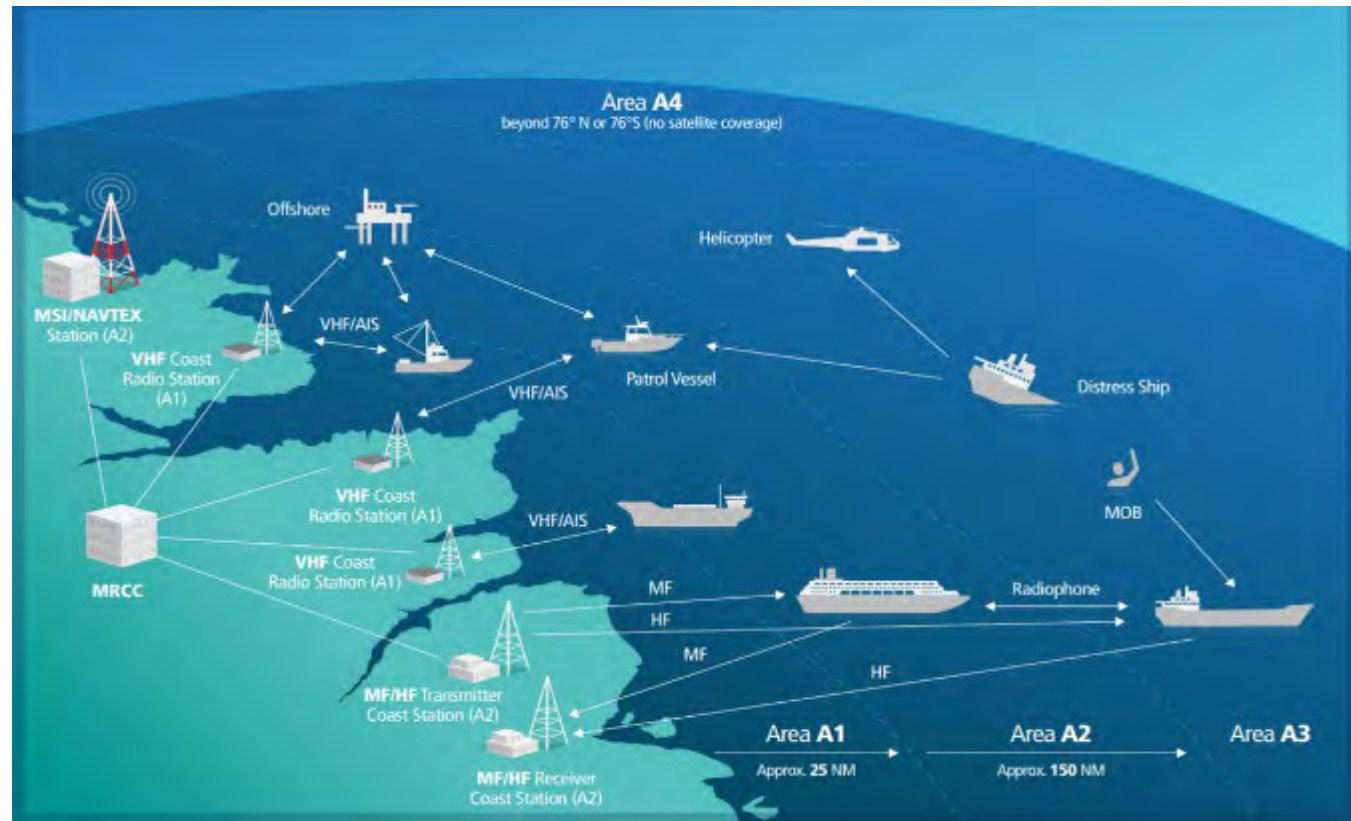


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KENTA & NAUTEL:

Shared passion for maritime communications



Nautel HQ, Halifax, Canada

Nautel Maine, Bangor, US

Kenta Technologies, France

20,000 Deployments

Five Decades

CIRM

IALA

RTCM

Kenta

Nautel + Kenta Expertise



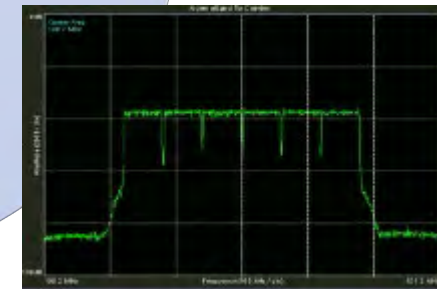
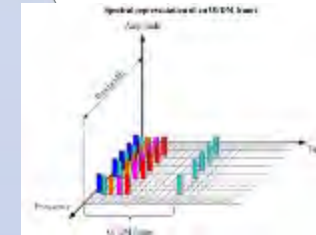
World's Largest
NAVTEX Supplier

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NAVDAT

High Power
Transmitters

Digital
Transmission



Kenta

Today: Design Considerations vs Service Design

“Each implementation of a NAVDAT coast station should be the subject of a specific study.” ITU

There isn't a standard "NAVDAT station" or antenna to pick from a catalog

Start with the coverage requirement and existing infrastructure, then engineer the appropriate solution.



Modernizing Coastal Navigation

NAVDAT

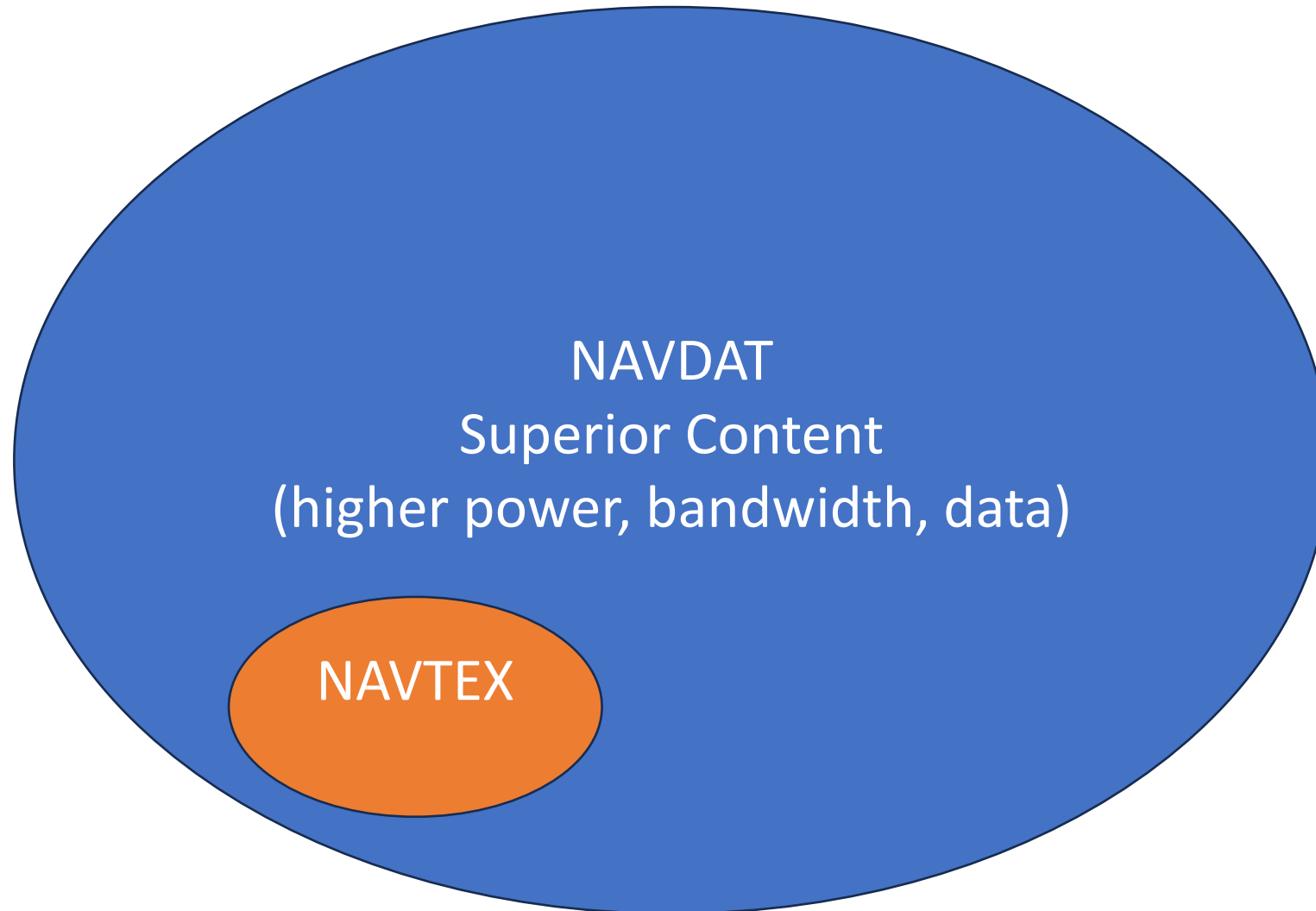
1 Minute Overview

The promise of NAVDAT: Better data and content



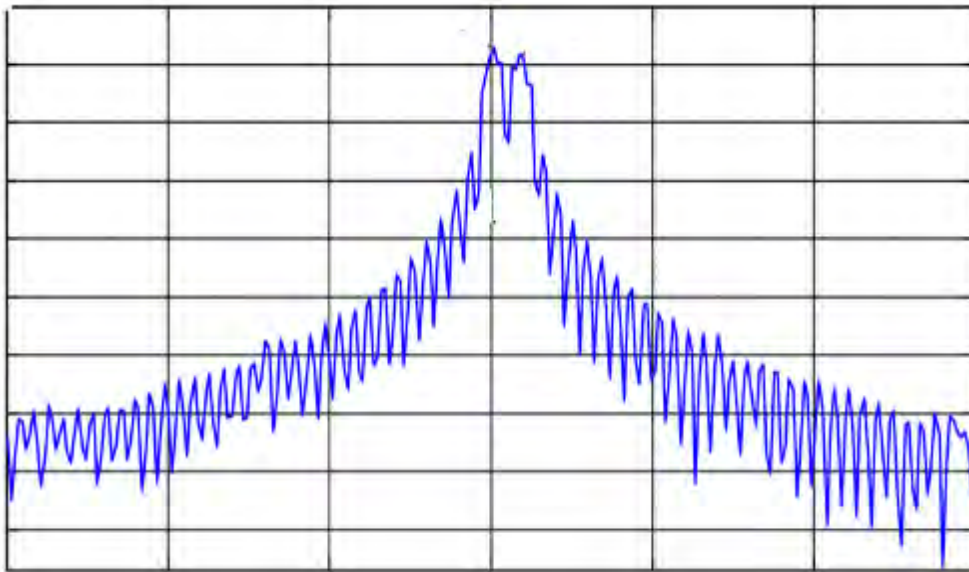
The NAVDAT SIGNAL

NAVTEX - NAVDAT relationship

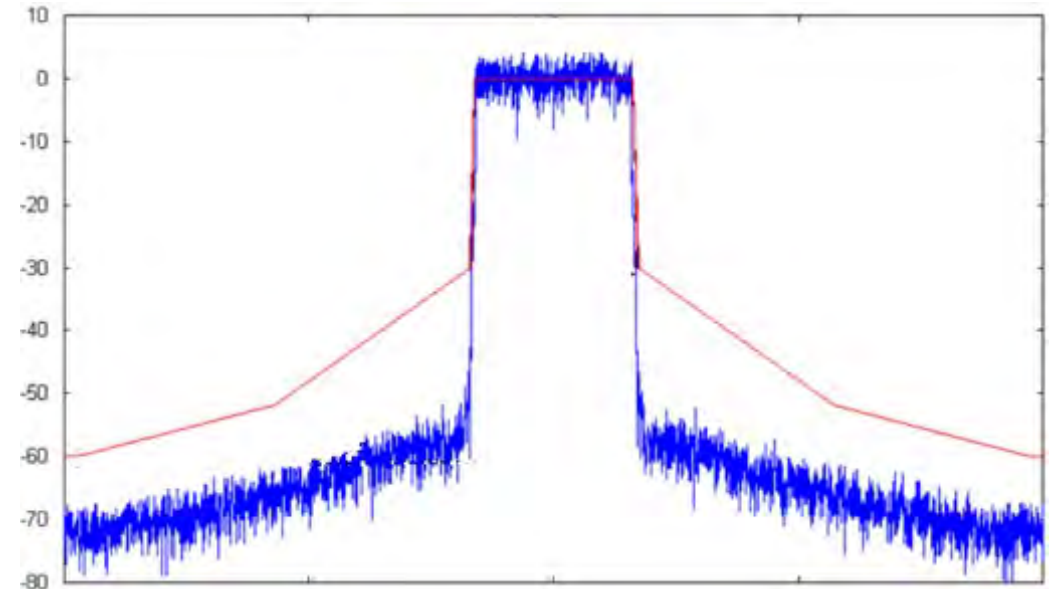


Typical Spectra: NAVTEX and NAVDAT

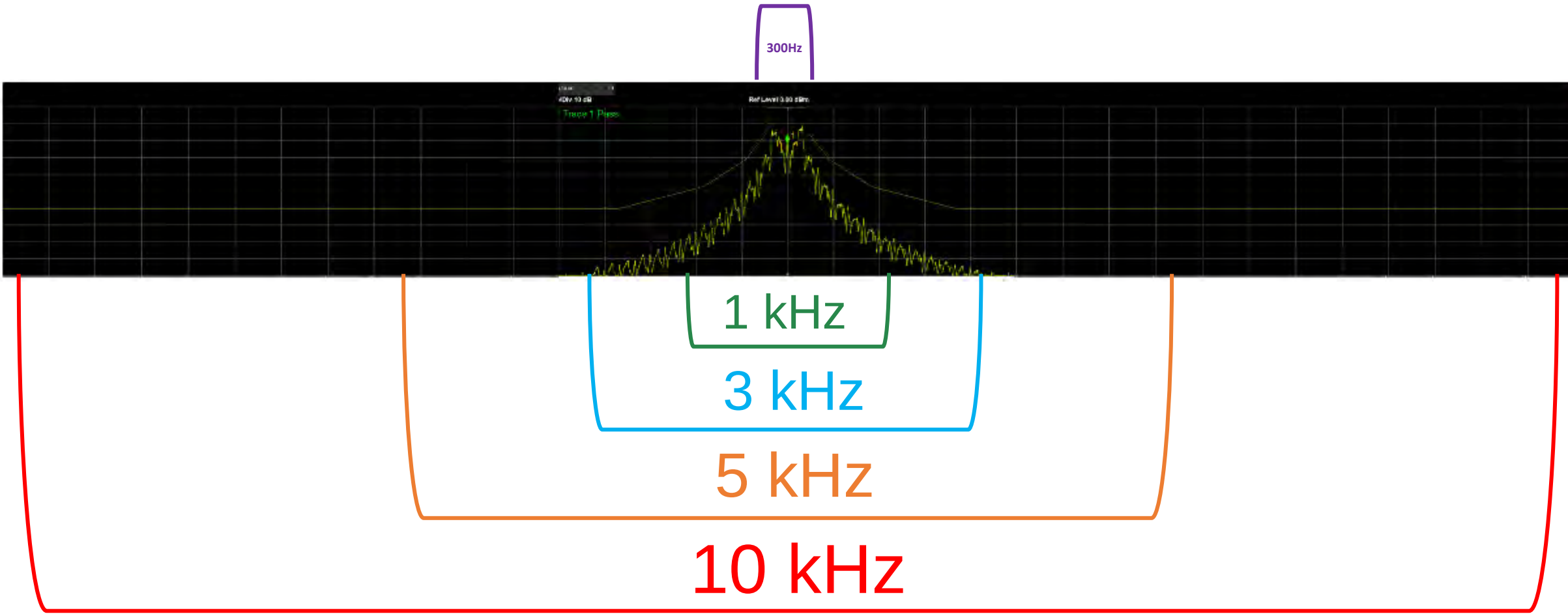
300 Hz NAVTEX



10 kHz NAVDAT



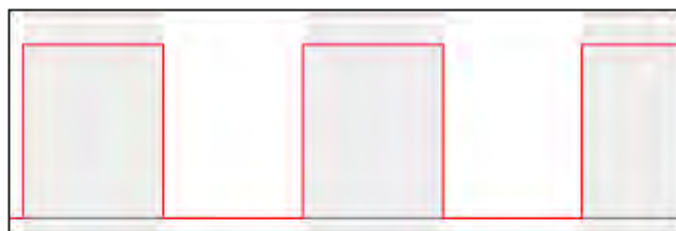
NAVTEX vs NAVDAT Bandwidth Requirements



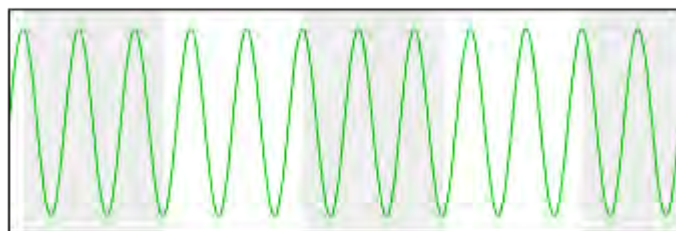
Significant implications for transmission chain:

- Transmitter, Antenna Tuning Unit, Antenna

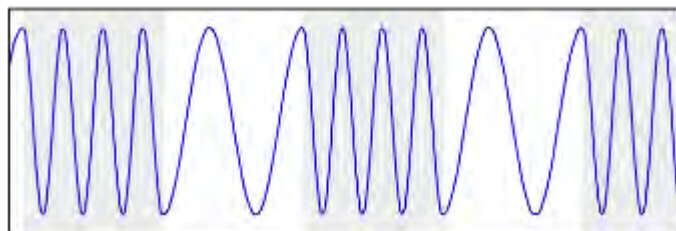
NAVTEX Simple Signal vs NAVDAT Complex Digital



Data



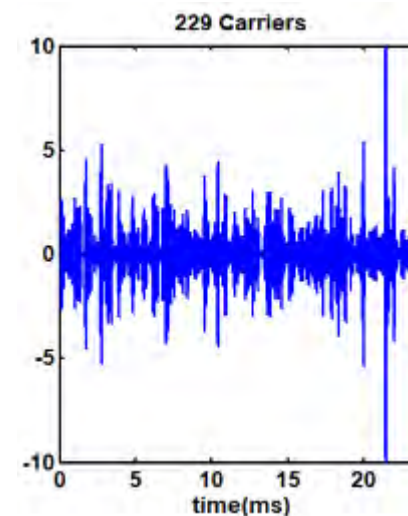
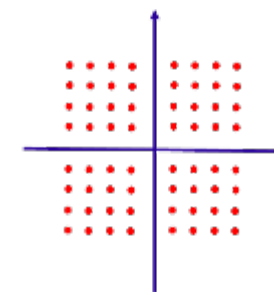
Carrier



Modulated Signal

Constant power envelope

RMS Power == TX Size == PEP Power



Complex Signal High Signal Peaks

RMS Power << TX Size == PEP Power

Digital Modulation

MF NAVDAT Modulation

ITU: Bit rates

Flexible Configurations

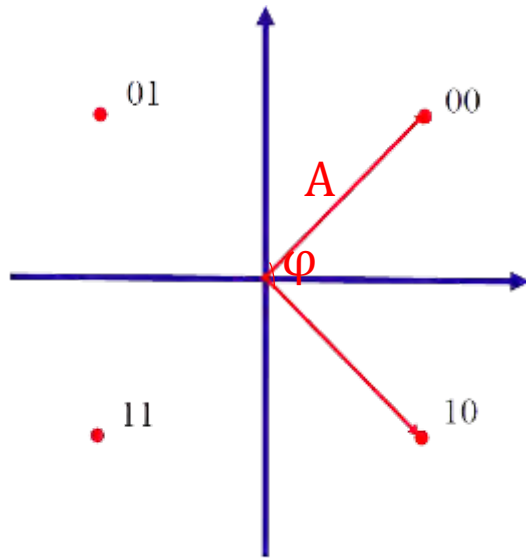
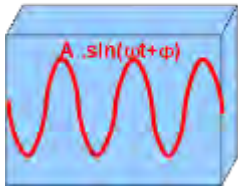


TABLE 24
LDPC parameters of data stream for mode A

Bandwidth (kHz)	Number of subcarriers	Number of pilots	Number of data subcarriers	Modulation	TIS and MIS	Information bits	Channel coding	Information rate (kbits)
10	228*14	38*14	190*14	4-QAM	100	2560*2	(2560,5120)	6.36
10	228*14	38*14	190*14	4-QAM	100	2560*2	(3840,5120)	9.56
10	228*14	38*14	190*14	16-QAM	100	2560*4	(2560,5120)	12.72
10	228*14	38*14	190*14	16-QAM	100	2560*4	(3840,5120)	19.12
10	228*14	38*14	190*14	64-QAM	100	2560*6	(2560,5120)	19.08
10	228*14	38*14	190*14	64-QAM	100	2560*6	(3840,5120)	28.68
5	114*14	271	1325	4-QAM	100	1224*2	(1224,2448)	3.02
5	114*14	271	1325	4-QAM	100	1224*2	(1836,2448)	4.55
5	114*14	271	1325	16-QAM	100	1224*4	(1224,2448)	6.04
5	114*14	271	1325	16-QAM	100	1224*4	(1836,2448)	9.10
5	114*14	271	1325	64-QAM	100	1224*6	(1224,2448)	9.06
5	114*14	271	1325	64-QAM	100	1224*6	(1836,2448)	13.65
3	68*14	159	793	4-QAM	100	692*2	(692,1384)	1.69
3	68*14	159	793	4-QAM	100	692*2	(1038,1384)	2.555
3	68*14	159	793	16-QAM	100	692*4	(692,1384)	3.38
3	68*14	159	793	16-QAM	100	692*4	(1038,1384)	5.11
3	68*14	159	793	64-QAM	100	692*6	(692,1384)	5.07
3	68*14	159	793	64-QAM	100	692*6	(1038,1384)	7.665
1	22*14	4*14	252	4-QAM	100	152*2	(152,304)	0.34
1	22*14	4*14	252	4-QAM	100	152*2	(228,304)	0.53
1	22*14	4*14	252	16-QAM	100	152*4	(152,304)	0.68
1	22*14	4*14	252	16-QAM	100	152*4	(228,304)	1.06
1	22*14	4*14	252	64-QAM	100	152*6	(152,304)	1.095
1	22*14	4*14	252	64-QAM	100	152*6	(228,304)	1.59

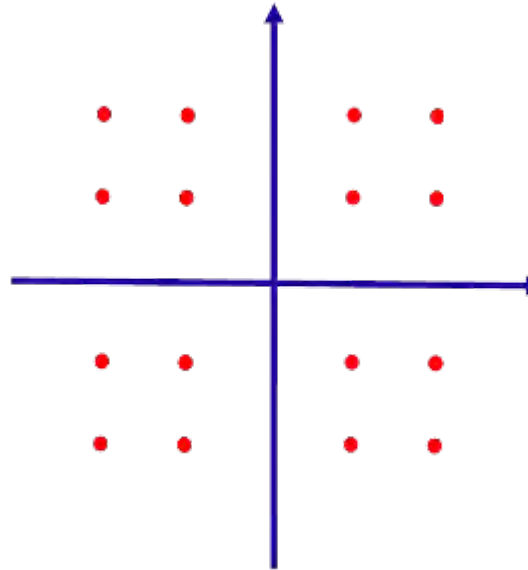
Low, Medium, High Data Rate Modes

Up to 229 carriers (sine waves)



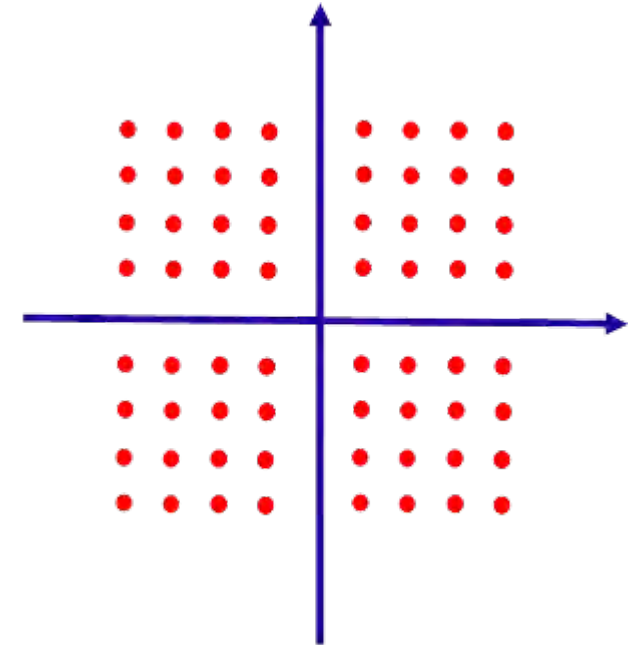
4 QAM

2 bits per carrier/symbol
Robust waveform
~14 dB SNR
6.4-9.6 kbps



16 QAM

4 bits per carrier/symbol
~18 dB SNR
12.7-19.1 kbps

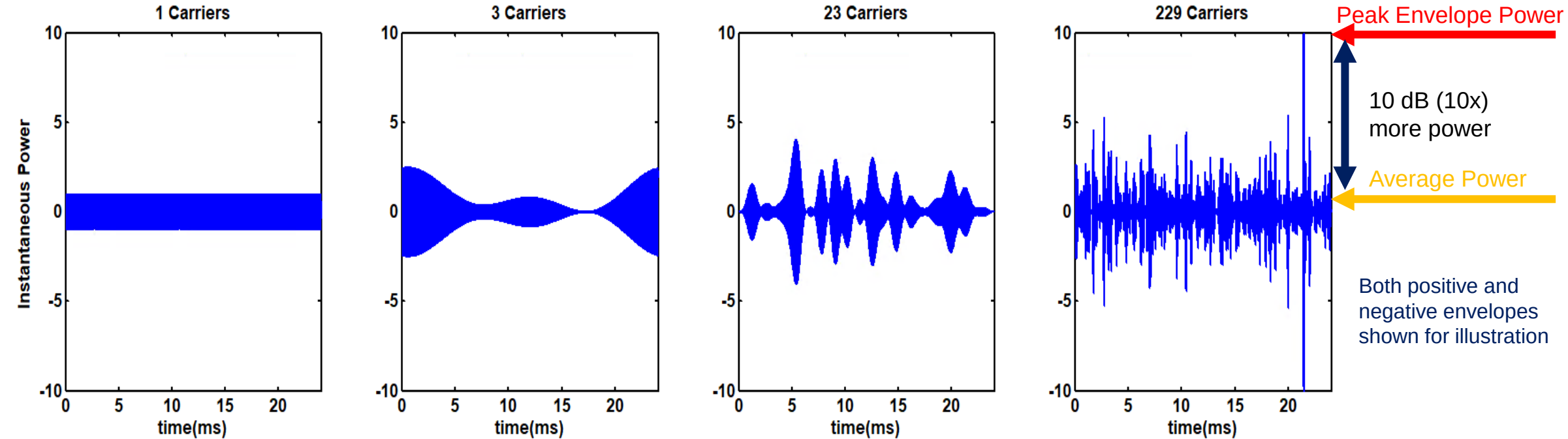


64 QAM

6 bits per carrier/symbol
Highest data rate
~22 dB SNR
19-29 kbps



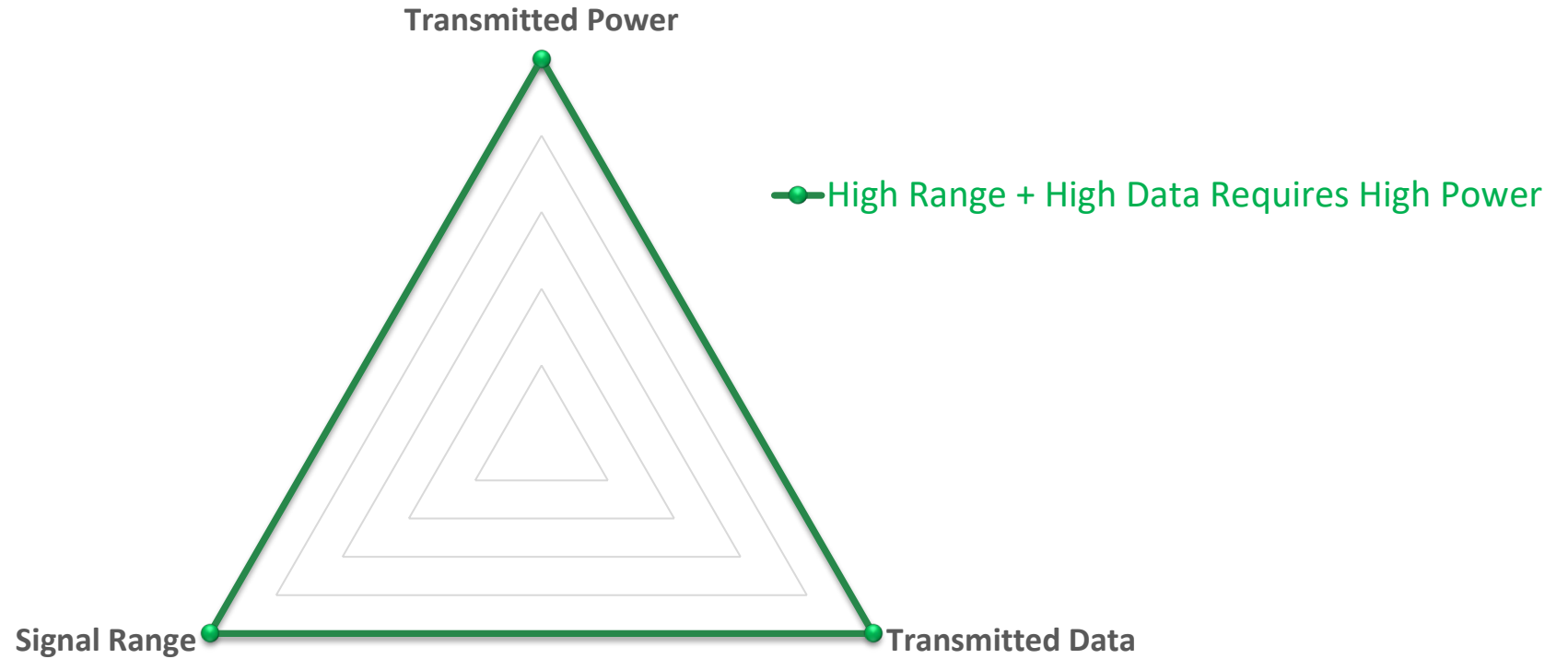
NAVDAT Transmitters Must be Sized for Peak Power



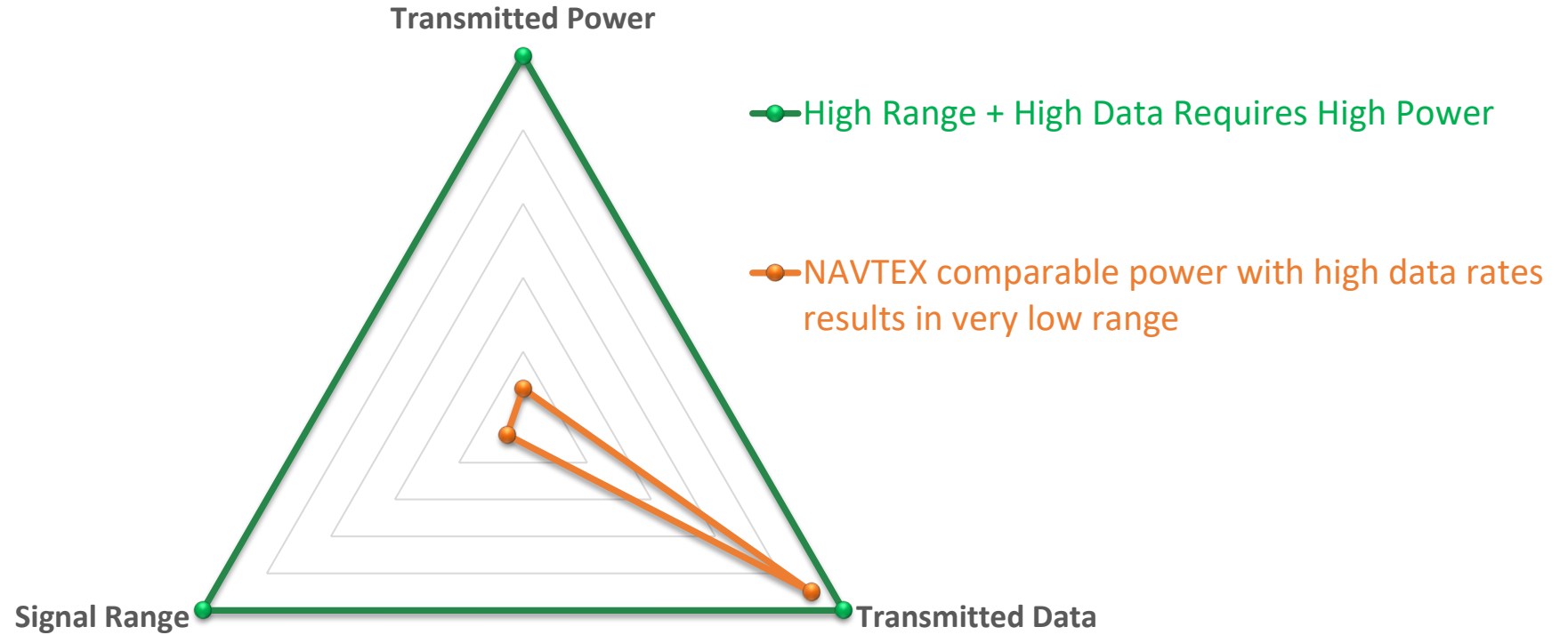
- Size transmitter for varying power envelope up to 10 dB (10x) - conservative
 - Carriers with random phase and amplitude add constructively and destructively
 - Peak to average power reduction algorithms will be optimized in the future
- NAVTEX is a single carrier system: Average Envelope Power == Peak Envelope Power

Power-Range-Data

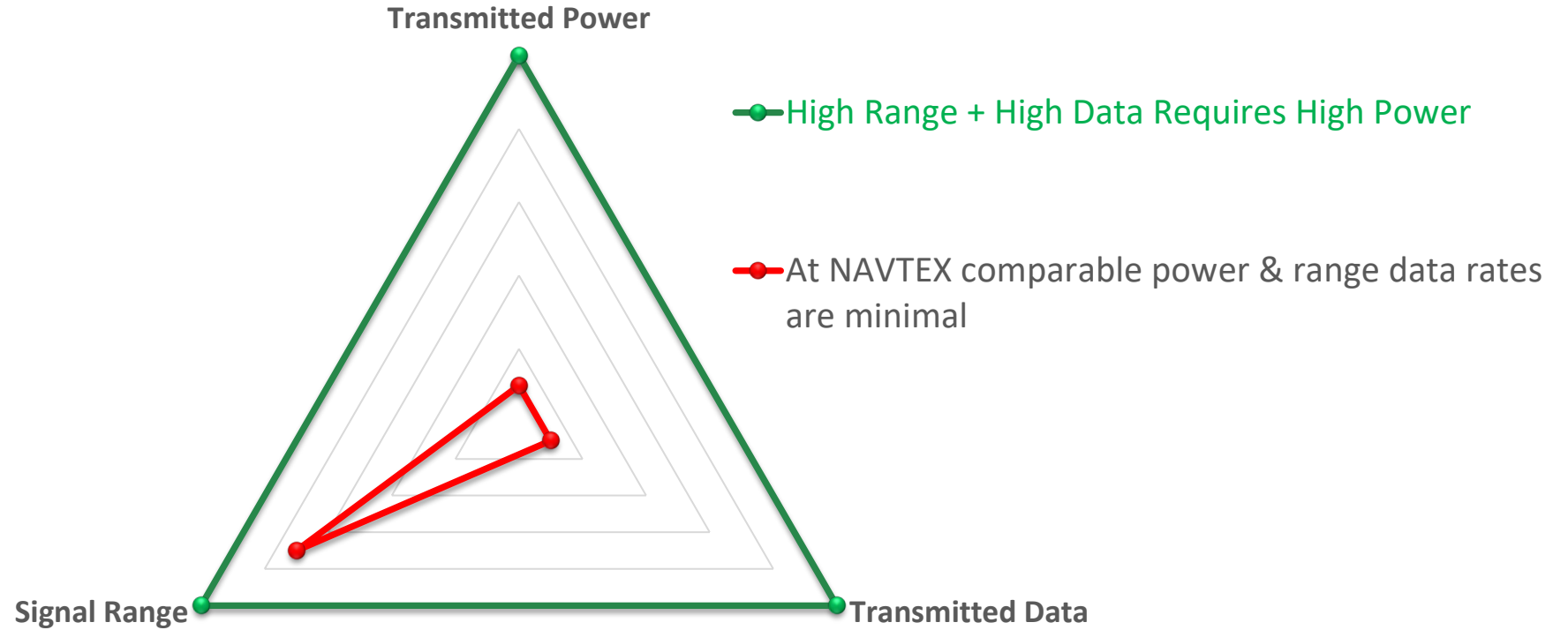
Power-Range-Data Trade-offs



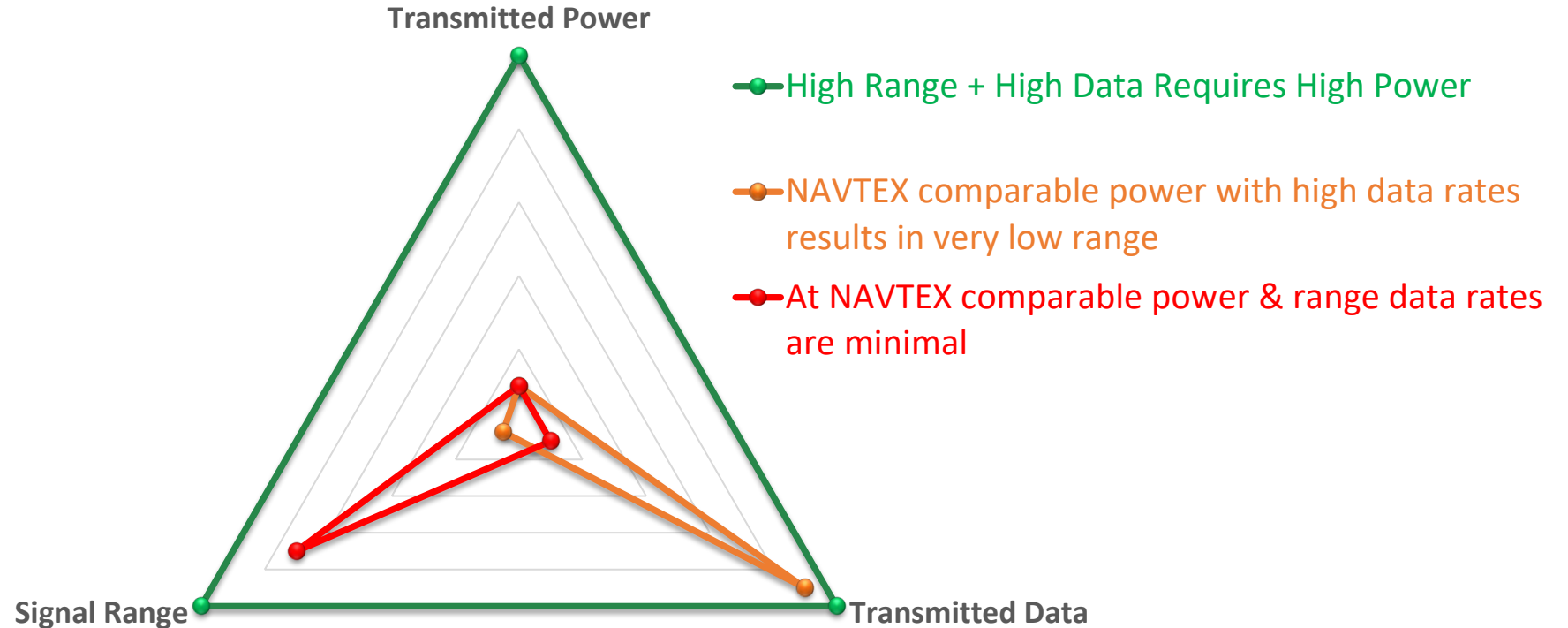
Power-Range-Data Trade-offs



Power-Range-Data Trade-offs



Power-Range-Data Trade-offs

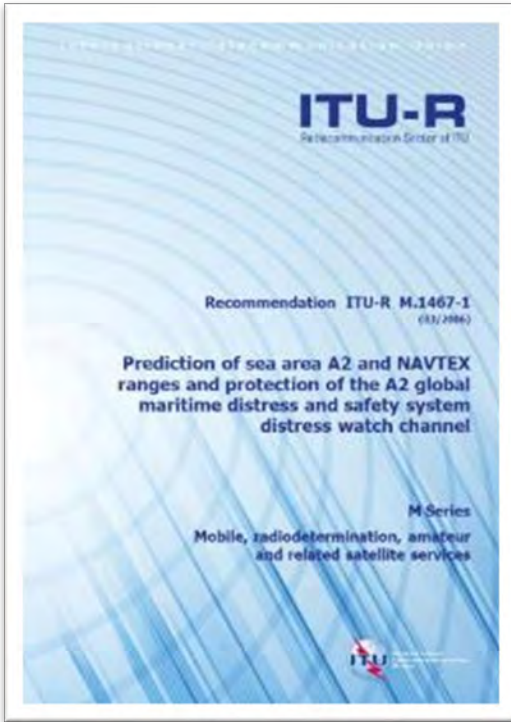


Power • Range • Data Rate
System design involves trade-offs among all three.

NAVTEX Coverage Planning

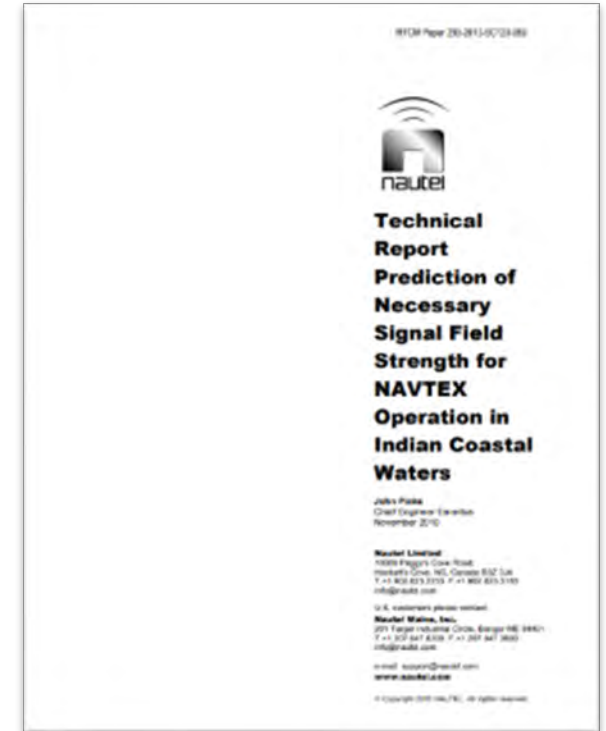
Reception is limited by:

- Shipboard / manmade noise
 - Vessel RX dependent
- Atmospheric Noise, varies by
 - Geography
 - Time of day
 - Season



Recommendation ITU-R M.1467 provides guidance to administrations for predicting sea area A2 and NAVTEX coverage areas by taking into account variations in the propagation conditions.

- Nautel India Example:
 - 100 $\mu\text{V/m}$ – 40 dBu Signal Strength
 - **3 kW** TX => **389 nm** range



<http://rtcm.info/sc123/293-2010-SC123-08.pdf>

Frequency:	490 kHz and 518 kHz
Bandwidth:	300 Hz
RF full bandwidth signal/noise ratio:	8 dB
Mean Tx power below peak:	0 dB
Fading margin:	3 dB
IMO Reference:	Resolution A.801(19)
Availability required:	90%

NAVDAT ranges

(Radiated RF power: 550 W, bandwidth: 10 kHz)

Area	Fa (dB)	Range (NM)	Modulation(code rate)
Huaniao island (Shanghai)	89.6 ~ 107.4	142.3 ~ 365.6	4-QAM(0.5)
		93.3 ~ 295.3	16-QAM(0.5)
		60.5 ~ 235.8	64-QAM(0.5)
Copenhagen	87.8 ~ 99.1	240.6 ~ 391.0	4-QAM(0.5)
		177.5 ~ 319.8	16-QAM(0.5)
		128.0 ~ 259.1	64-QAM(0.5)
Singapore	91.0 ~ 113.4	87.5 ~ 347.5	4-QAM(0.5)
		53.0 ~ 277.9	16-QAM(0.5)
		32.6 ~ 219.3	64-QAM(0.5)

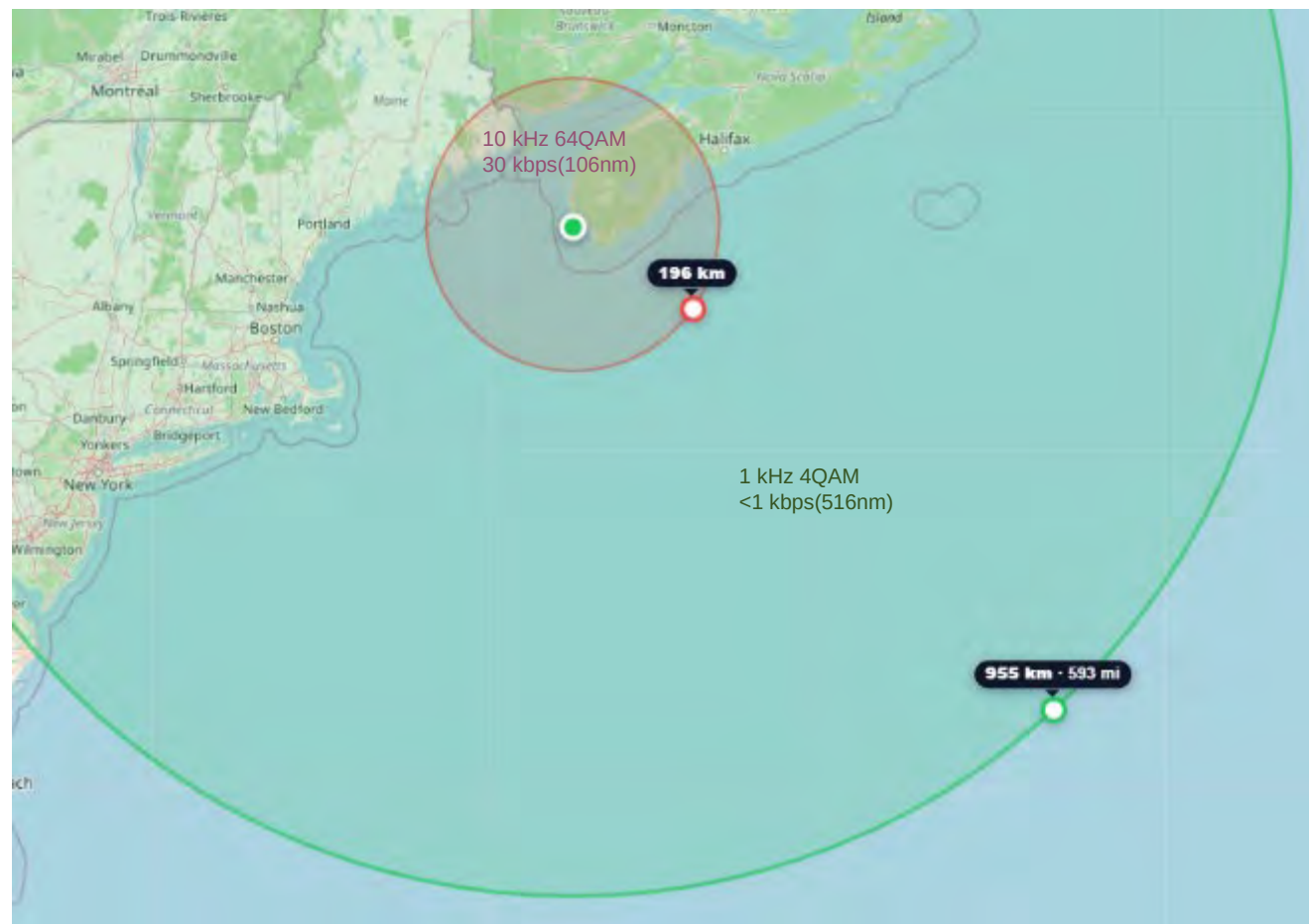
Source: ITU

Range Prediction Analysis

- Sea-path range estimate for two flavours of NAVDAT
 - o 1 kHz BW 4-QAM (slow, long-range) <1 kbps
 - o 10kHz BW 64 QAM (fast, short-range) 30 kbps
- Based on NAV25 (25kW PEP) into 5-Wire Tee

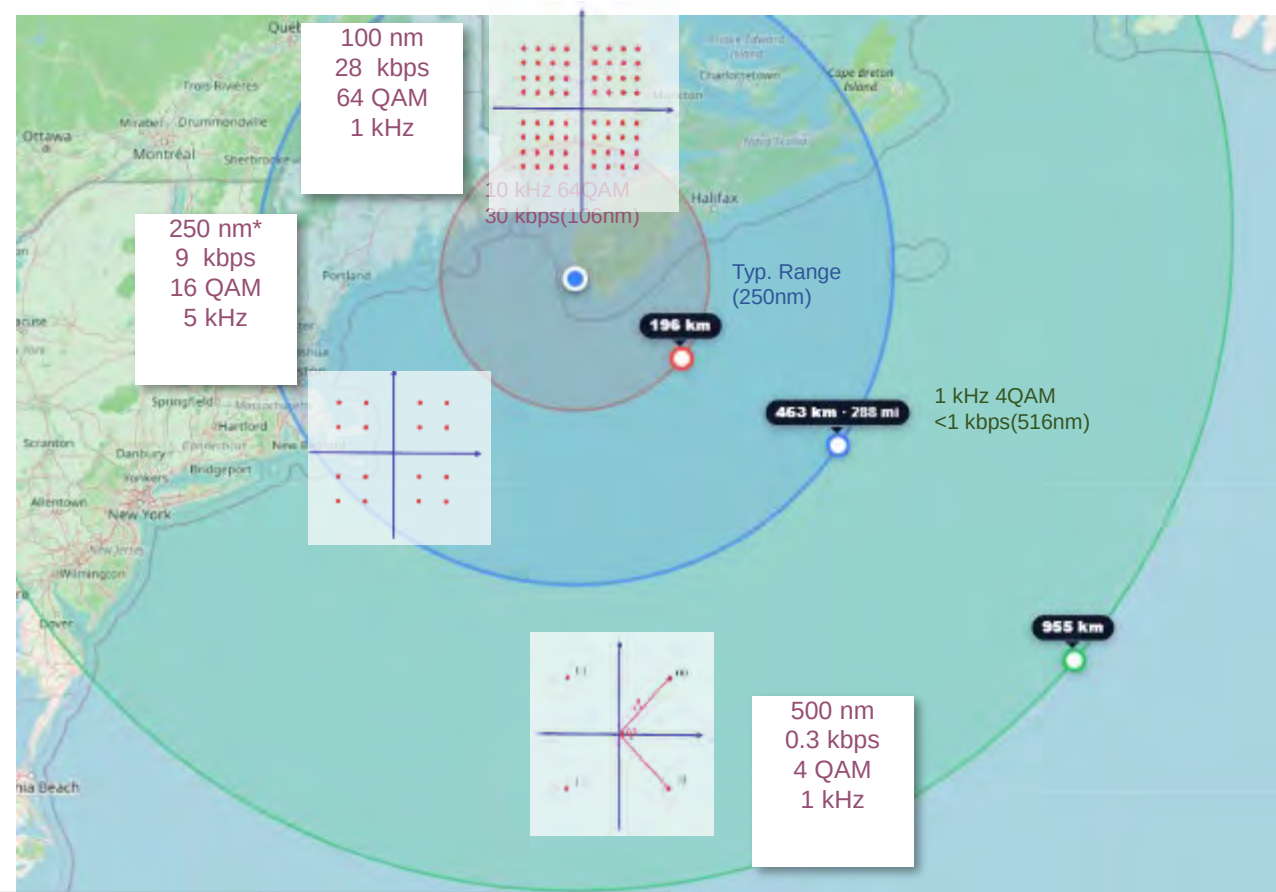
Table: Predicted NAVDAT Ranges, NAV25 into 5-Wire Tee, Yarmouth, N.S.

Modulation	NAV25 + 5-Wire Tee ERP (W)	Min. RX Threshold (uV/m)	Predicted Range (NM)
1 kHz 4-QAM	4632	115	516
10 kHz 64-QAM	2924	2034	106



Range Prediction Analysis

- Well designed 5 wire T antenna and site
 - 50% antenna efficiency
 - 10 kHz bandwidth
 - NAV25 25kW PEP
- Insufficient sites can possibly be used with lower data rate
- Match NAVDAT to service area with best data rate
- SOS messages can be sent beyond service contour
 - Switch to 4 QAM 1 kHz



Modulation	NAV25 + 5-Wire Tee ERP (W)	Min. RX Threshold (uV/m)	Predicted Range (NM)
1 kHz 4-QAM	4632	115	516
10 kHz 64-QAM	2924	2034	106

Table: Predicted NAVDAT Ranges, NAV25 into 5-Wire Tee, Yarmouth, N.S.

* estimate

Planning for NAVDAT: Things to consider

“Can a 1 kW or 5 kW NAVTEX transmitter can be replaced by similar power NAVDAT transmitter?”

Technically yes:

- But you'll probably need more power.
- The promise of NAVDAT challenging at NAVTEX power levels
- NAVDAT requires more peak power to take advantage of its higher data capacity.
- If NAVDAT Tx power = NAVTEX Tx power:
 - Maintain similar range as NAVTEX but at data rates not much better than NAVTEX
or
 - Transmit at higher data rates but at a much-compromised range

Antenna Tuning

ATU Considerations

The ATU must be sized for:

- Peak voltages
- Bandwidth
- Current regulation
- Multimode:
(If NAVTEX now & then NAVDAT later)

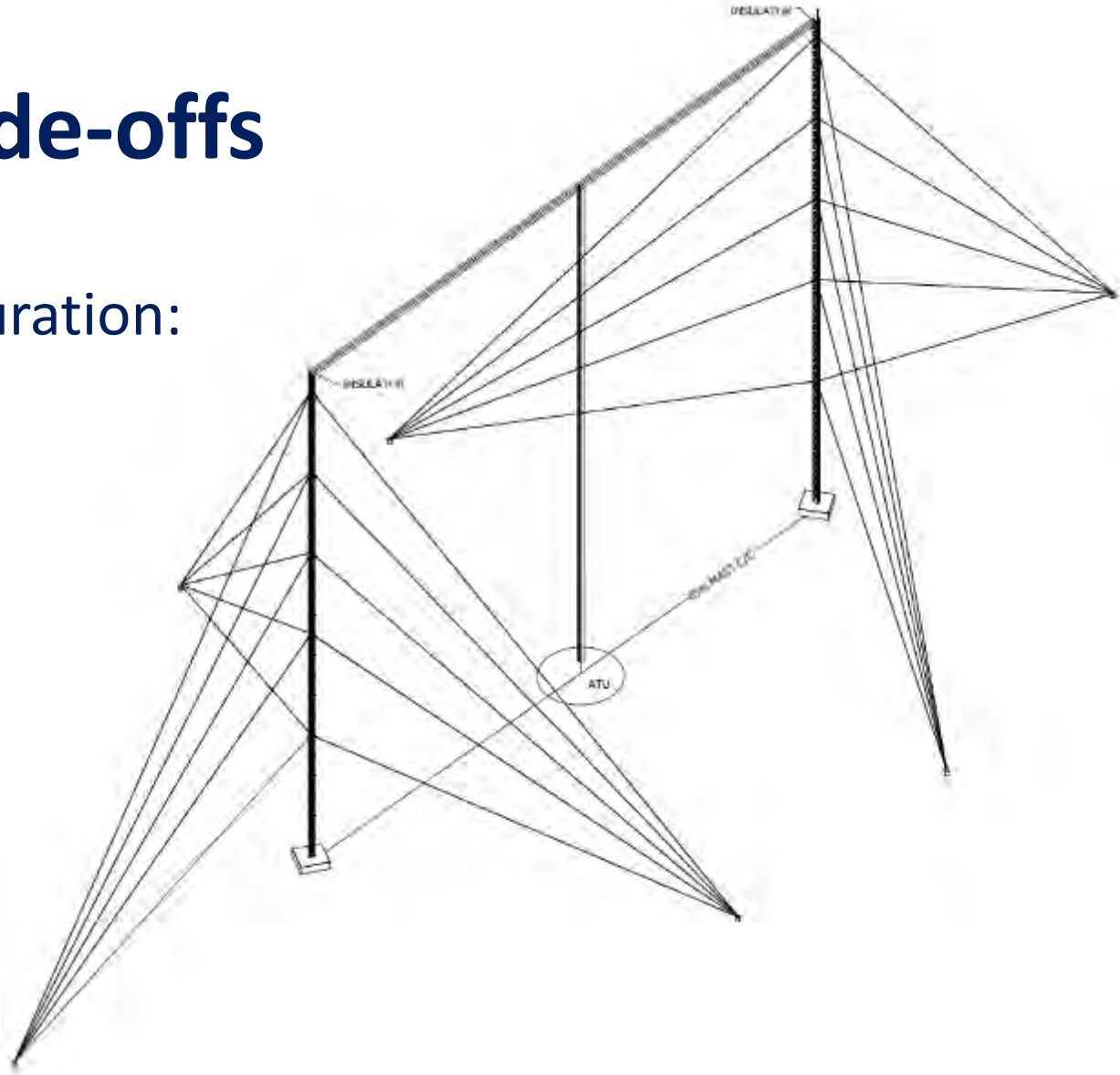


Antenna + Towers & Site

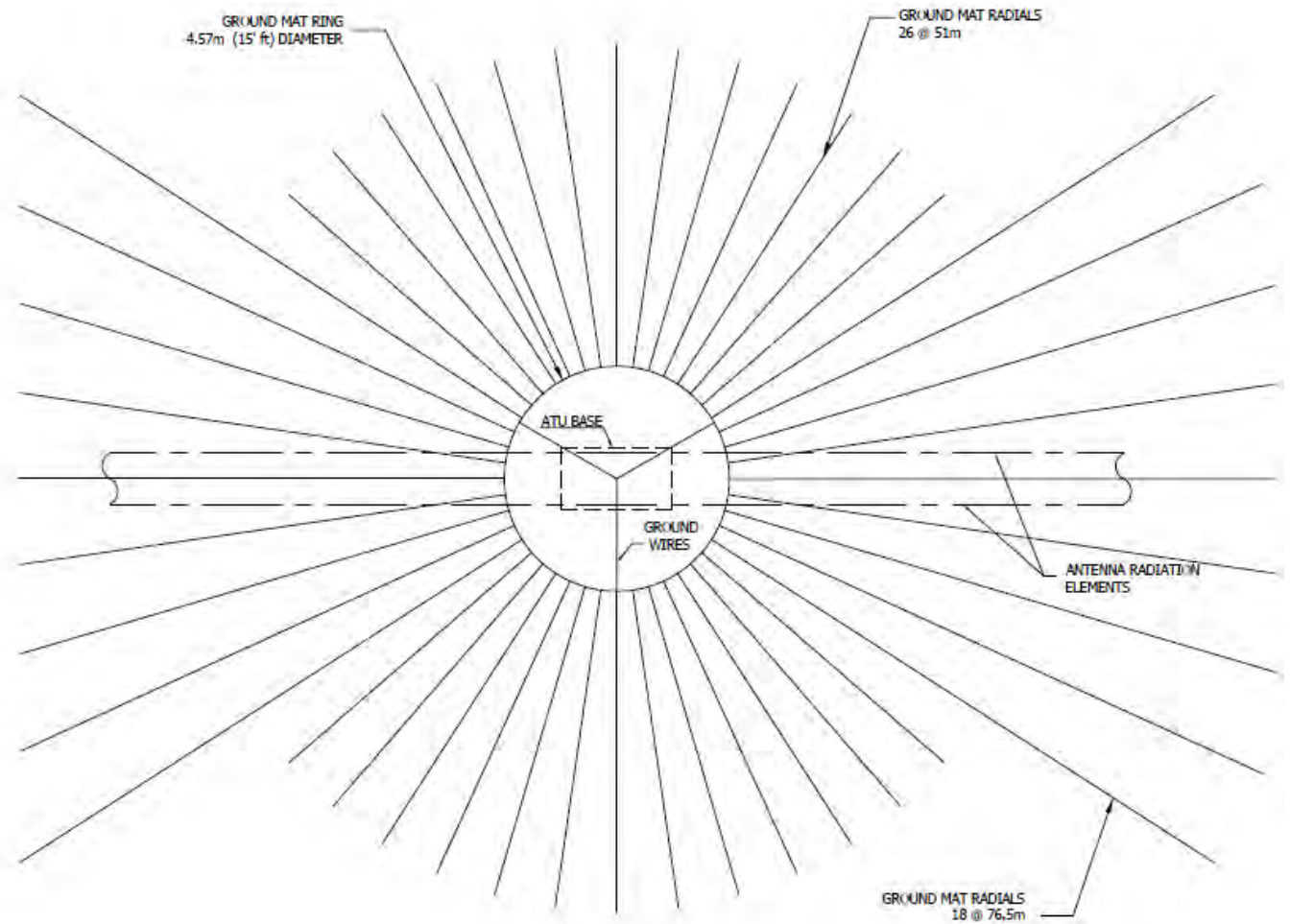
Antenna options/trade-offs

Example NAVDAT antenna configuration:

- T-Antenna
- 2 x 72m towers
- 85m separation
- 250 m x 180 m level site
- Good bandwidth & efficiency

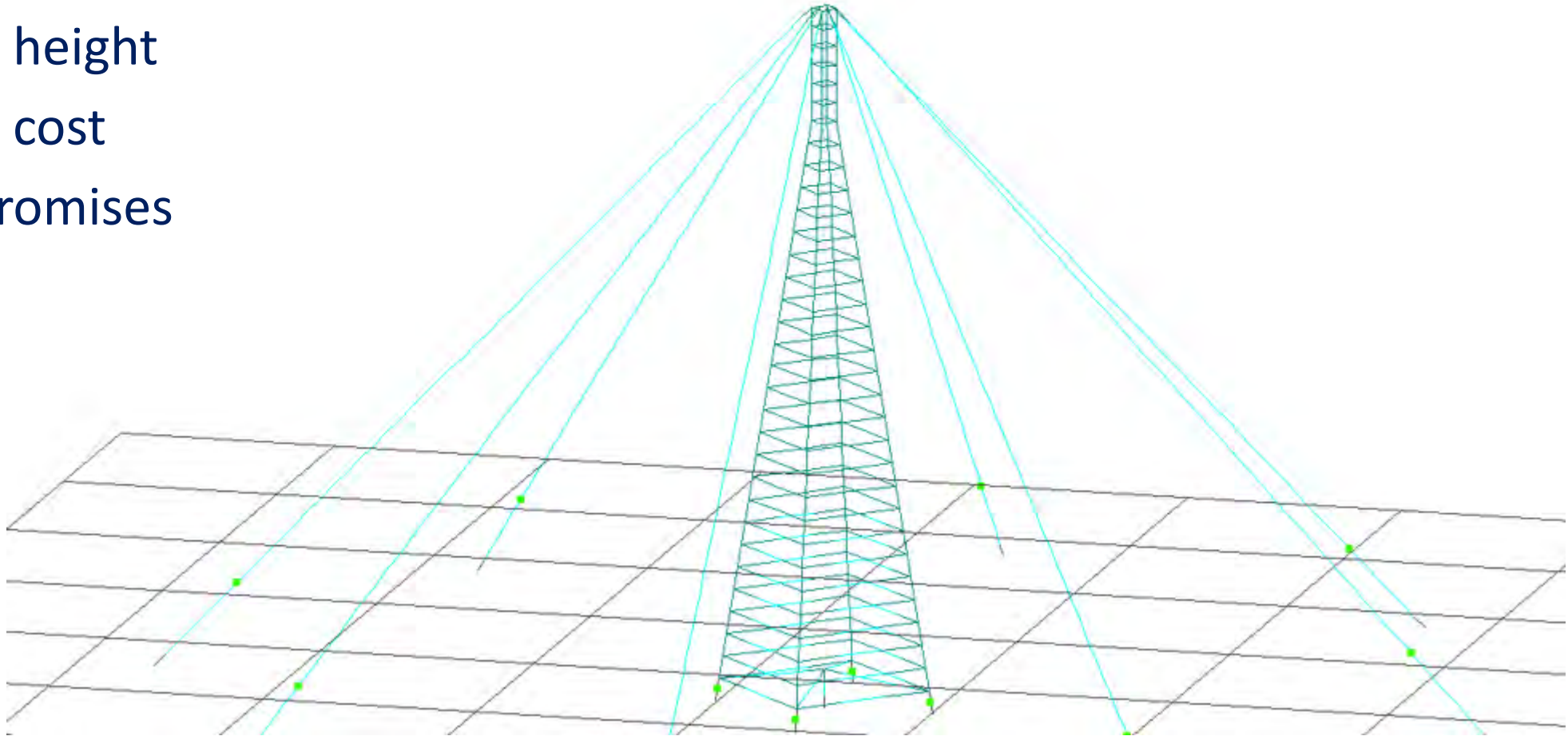


Ground system



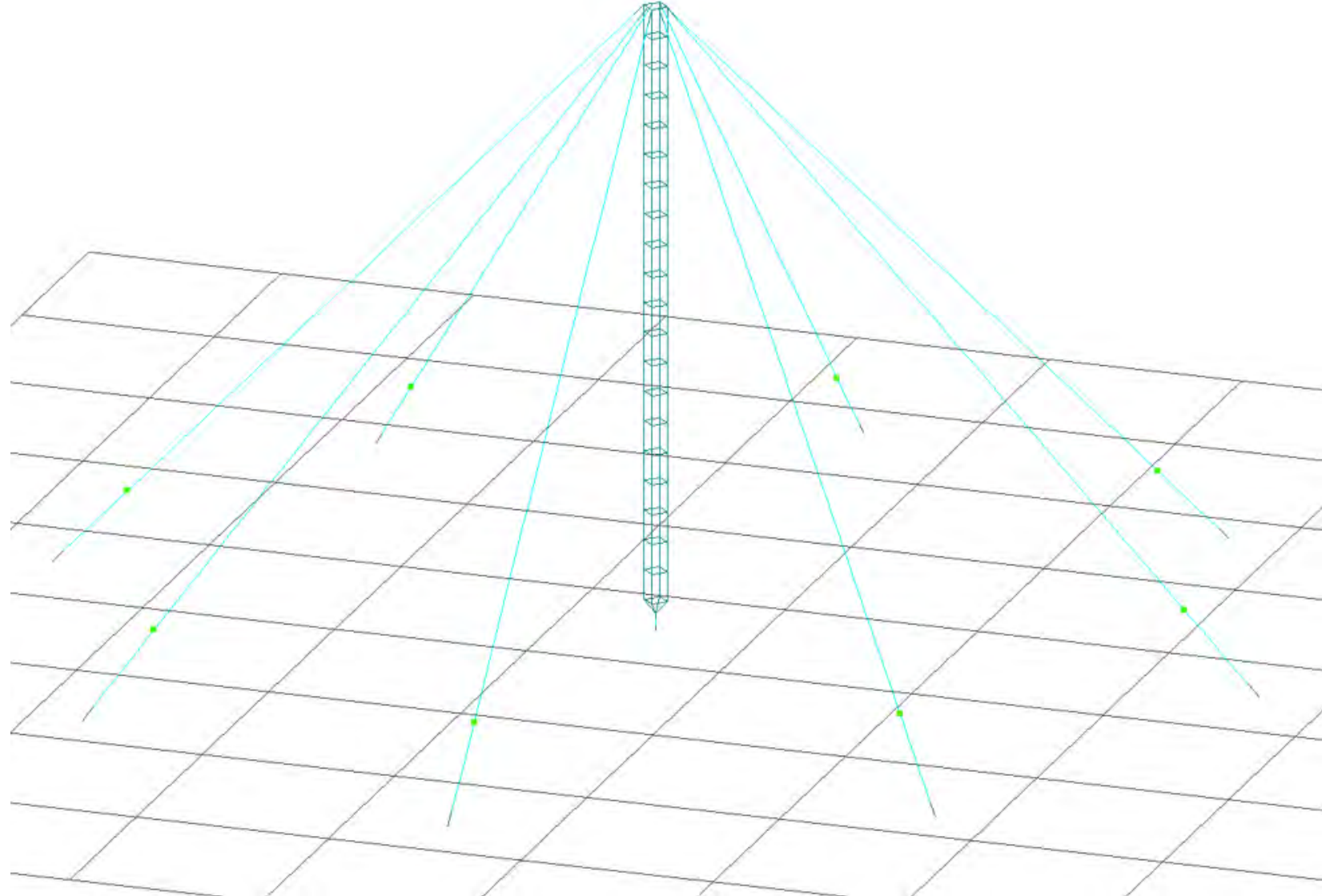
36m with 8 top-loading guys

- Lower height
- Lower cost
- Compromises



36m guyed tower, 8-way top-loading

- Lower height
- Lower cost
- Compromises



Investment

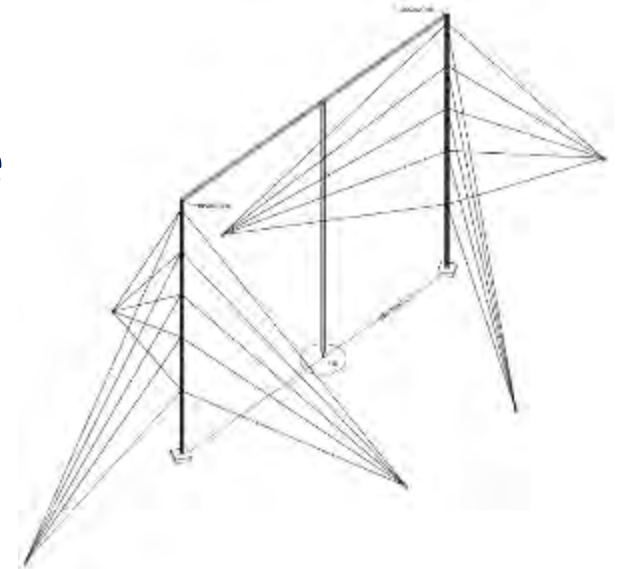
Towers: The biggest cost component

Potentially significant infrastructure costs

- Tower/antenna infrastructure & installation
- Ground system
- Building, feeder and shore-station works
- RF measurement, tuning and proof of performance
- Fencing/security
- Land
- Utility/grid connection

- \$500K to >\$1M

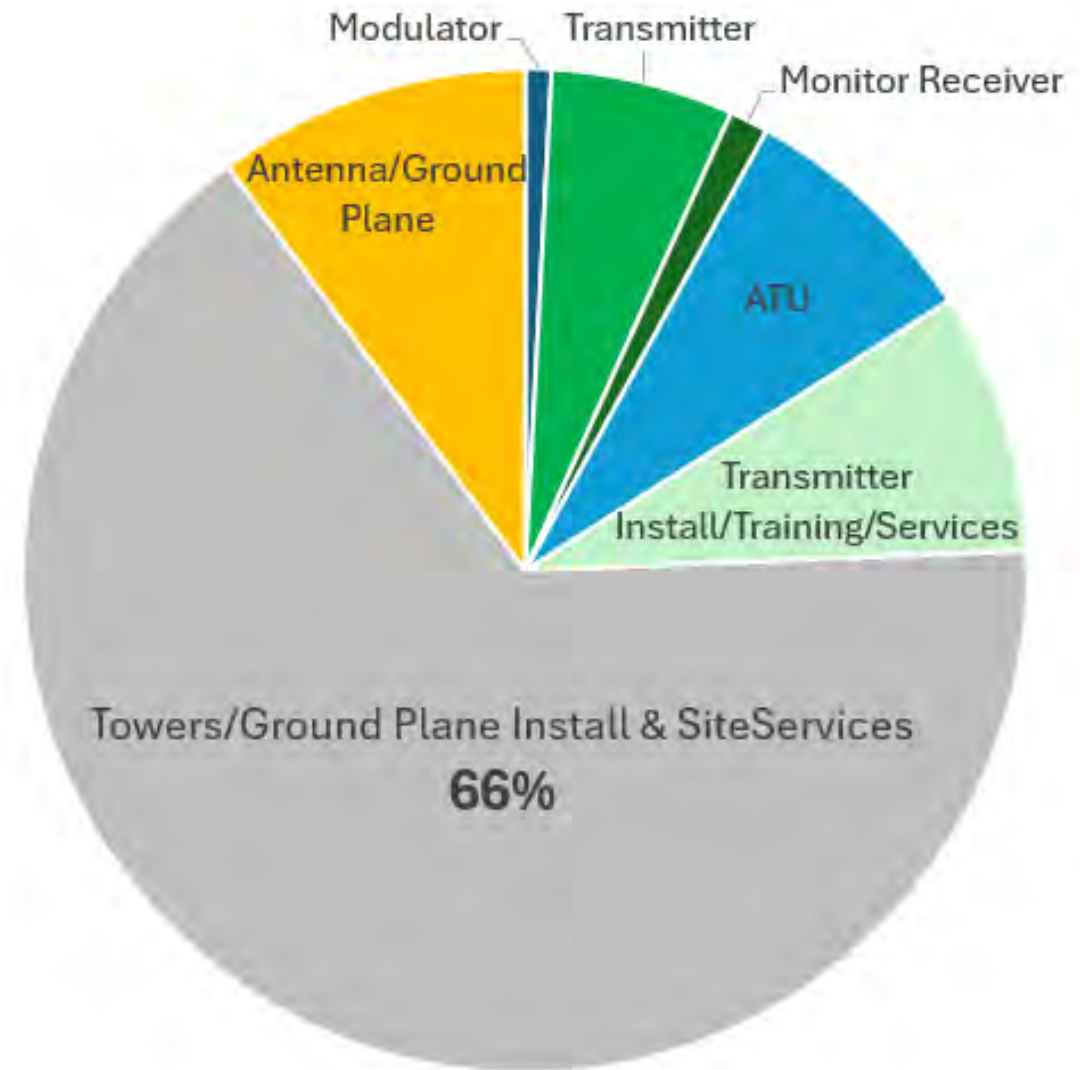
“Your mileage will vary”



Sizing up the Investment

- Majority of investment is tower related
- Transmitter power: Increase or Decrease
 - Only modest cost sensitivity
 - But high impact on data rates & range

Q. Are there options to reduce the tower, ground plane, & installation costs?

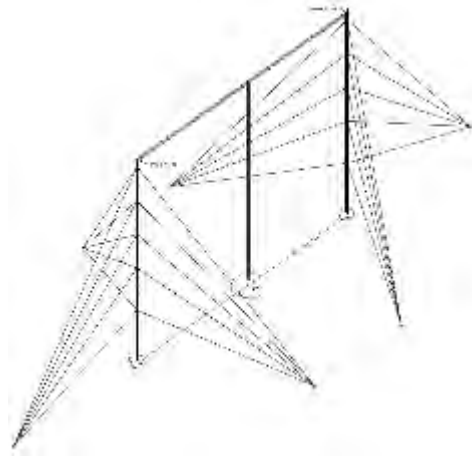


Leveraging NAVTEX Infrastructure

Can a NAVTEX site be repurposed?

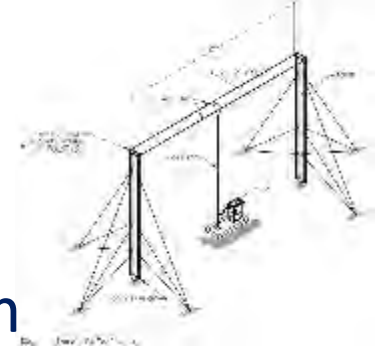
Excellent NAVDAT:

- T-Antenna
- 2 x 72m towers
- 85m separation
- Radiator
- Ground Plane
 - 26 x 51m & 18 x 76.5m radials



Excellent NAVTEX:

- T-Antenna
- 2 x 36.5m to 45.5m
- 73m separation minimum
- Radiator: 70m
- Optional Ground Plane
 - 18 x 152m radials



Can a NAVTEX site be repurposed?

The question breaks into:

Can the land be reused?



Can the towers be reused?



Can the antenna be reuse or modified?



Can the ground system be reused?



Can the matching system provide the required NAVDAT bandwidth?



What antenna-system efficiency results?



What transmitter power then achieves the required coverage?



Buenos Aires Station



Mar del Plata Station

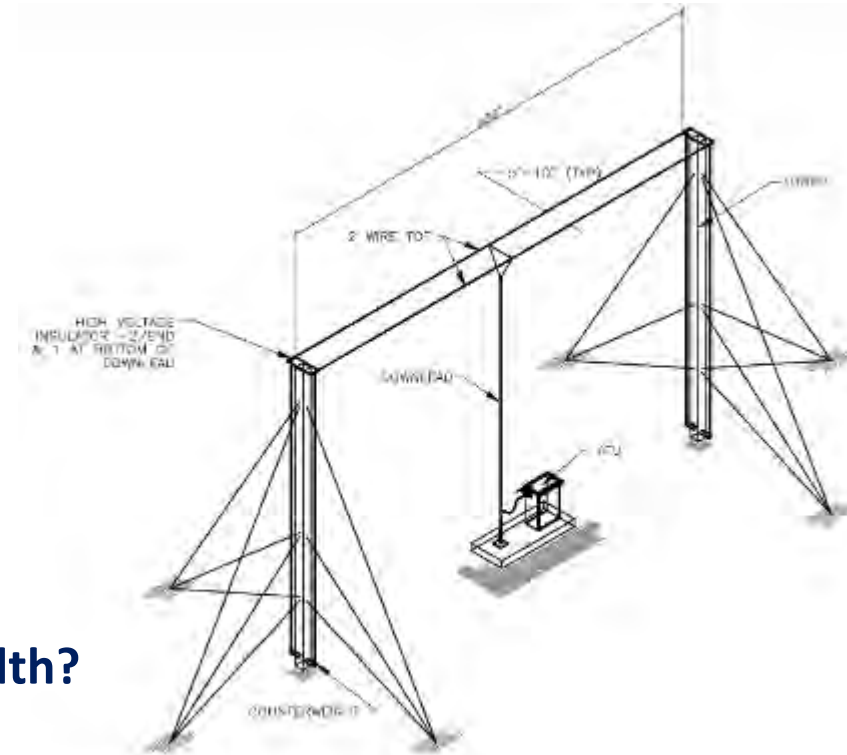


Diagram 1 - Two Wire Flat Top Antenna

Planning for NAVDAT: Things to consider

“Can existing NAVTEX infrastructure can be reused for NAVDAT?”

MAYBE

- Maybe, but implies possible NAVDAT compromises
- NAVDAT requires much more peak power to transmit its digital signal.
- Existing antenna, ATU, and power supply need to be evaluated
 - can it handle the required peaks?
 - can it handle the broader bandwidth?
 - may need to be upgraded?
 - some may choose to use a separate transmission infrastructure for NAVDAT

Observations

“Each implementation of a NAVDAT coast station should be the subject of a specific study.” ITU

There isn't a standard "NAVDAT station“ or antenna to pick from a catalog

Start with the coverage requirement and existing infrastructure, then engineer the appropriate solution.

Planning for NAVDAT: Things to consider

- NAVDAT deployment design will be more involved than NAVTEX
- Define the service:
 - Content, capacity, coverage
- Assess what you already have
 - Existing NAVTEX sites, towers, infrastructure
- Engineer the complete transmission path
 - Coverage, data rate, bandwidth are interrelated
 - Reuse or modify existing infrastructure? New purpose designed site?

Nautel and Kenta can help you begin the assessment

NAV Series

- Advanced digital
- Linear amplification
- High peak power, ideal for NAVDAT
- NAVTEX and NAVDAT capable

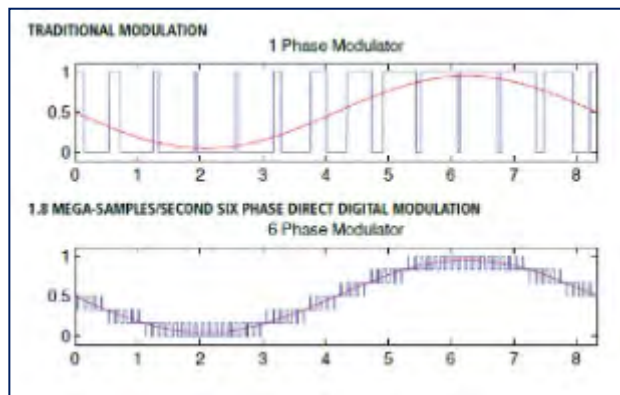
NAV Series
NAVDAT/NAVTEX MW



Proven

Digital

40
Mega
Watts
Deployed



NAV25 | NAV12.5 | NAV5



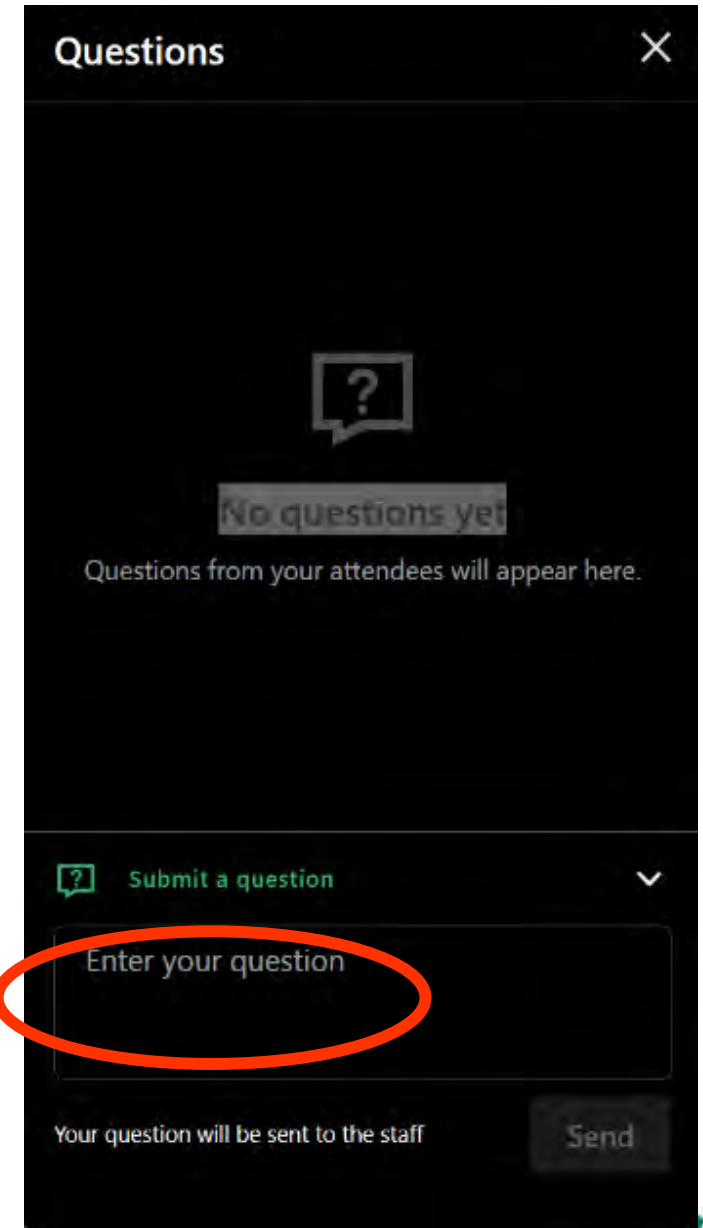
Kenta Modulator

Kenta

Your questions please?

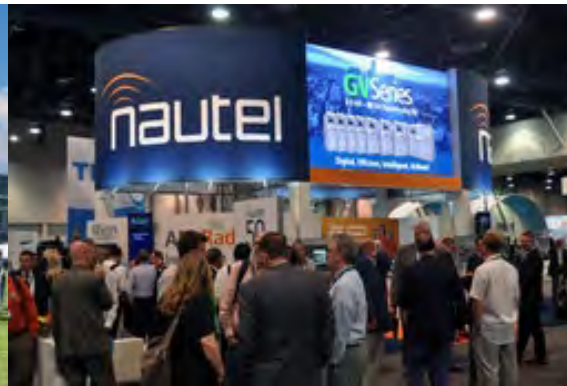


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Thank You!

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NAVDAT ranges

(Radiated RF power: 550 W, bandwidth: 10 kHz)

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Source: ITU

Agenda

NAVDAT Planning: Power, Coverage, Infrastructure & Economics

- NAVDAT Review (John W)
- Power Range Data (Philipp/John)
 - Understanding the tradeoffs/complex signal
- Transmitter & ATU
 - NAVDAT dedicated, vs NAVDAT & NAVTEX
- Antenna & Towers & Space
 - Bobby Cox? What you need?
 - Options to reuse existing structures? Can reuse towers from NAVTEX T antenna site?
 - Should we be concerned that customers might choose HF
- Economics (pie graph, John Whyte)
- Leveraging NAVTEX Infrastructure
- Observations
- Questions/Resources



John Whyte
Head of Marketing &
Product Strategy
Nautel

practical discussion on the key factors that influence system design and data transmission effectiveness, including coverage objectives, power requirements, infrastructure and the scale of

Not to be shown...just for discussion

- Our goal today isn't to design your NAVDAT station. It's to help you understand the major choices that drive configuration, infrastructure requirements and cost, so you know what questions to ask as you begin planning.

This is not “Webinar taught me how to design a 500 kHz antenna.”

It is:

“webinar helped me understand how to approach my NAVDAT project, what questions I need answered, what the important cost drivers are, what assets I may already have, and where specialist engineering begins

“NAVDAT Planning and Economics: The Questions Coastal Authorities Should Be Asking”

- Every coastline, coverage requirement and existing infrastructure base is different. Rather than prescribe a universal NAVDAT architecture, we'll look at the major technical and economic decisions authorities should evaluate when considering a deployment.

Not to be shown...**three graceful answers for difficult Q&A**

When you know the principle but not the number

"There isn't a single number we would want to give you without knowing more about the site. The important planning point is that [X] has a material influence on the system design."

When ITU goes deeper than your webinar

"That's covered in considerably more engineering detail in the ITU guidance. Rather than oversimplify it here, we'd recommend treating that as an input to the site-specific engineering study."

When someone essentially asks you to design their site

"That's exactly the sort of question that moves from general NAVDAT planning into site-specific engineering. We'd need to understand your existing infrastructure, coverage requirement and site conditions before giving you a responsible answer."