A Port for Offshore Wind

enabling

New Technology and Industrial Development

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Presented at

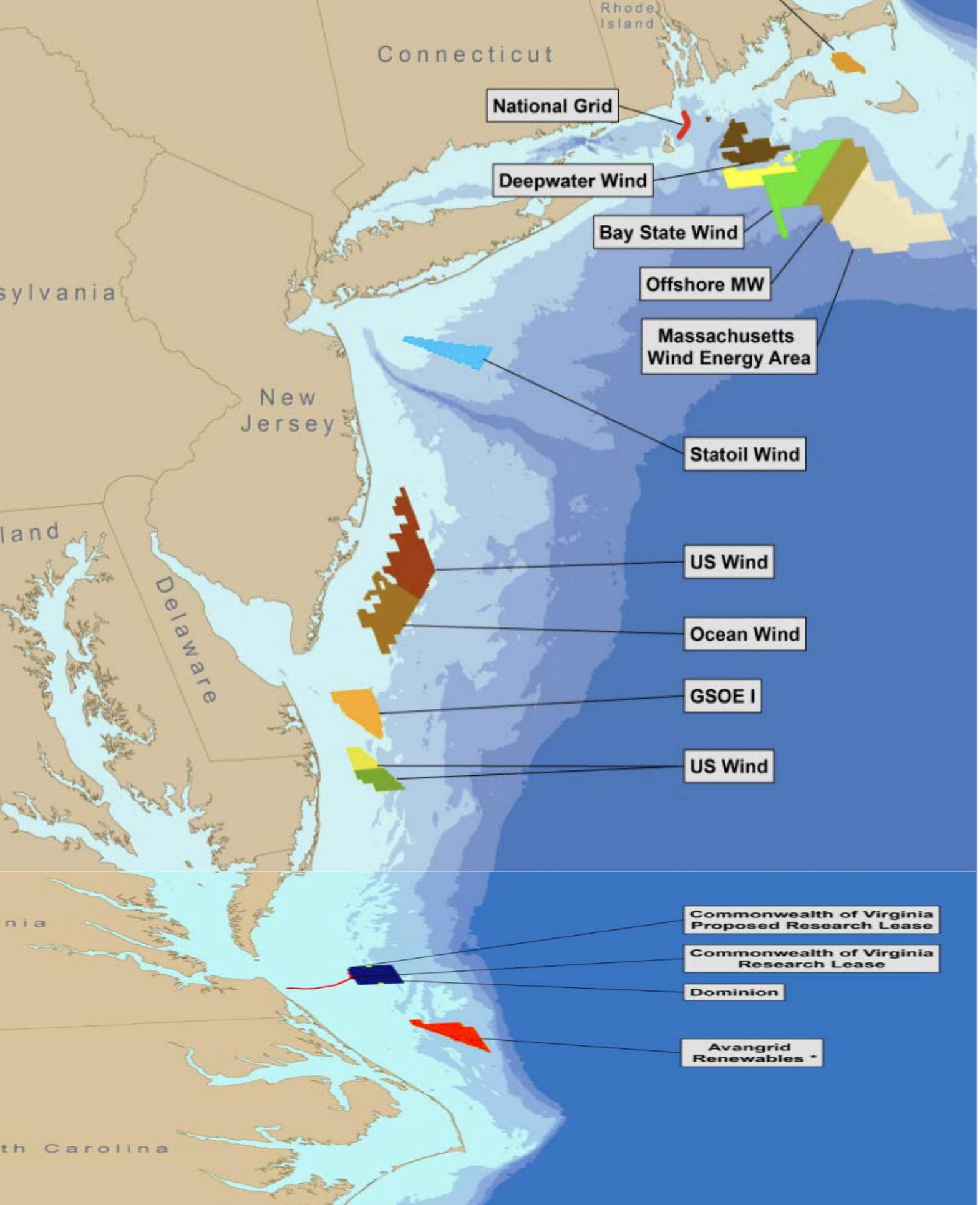
Offshore Wind Working Group
Dover, DE
1 November 2017

Context

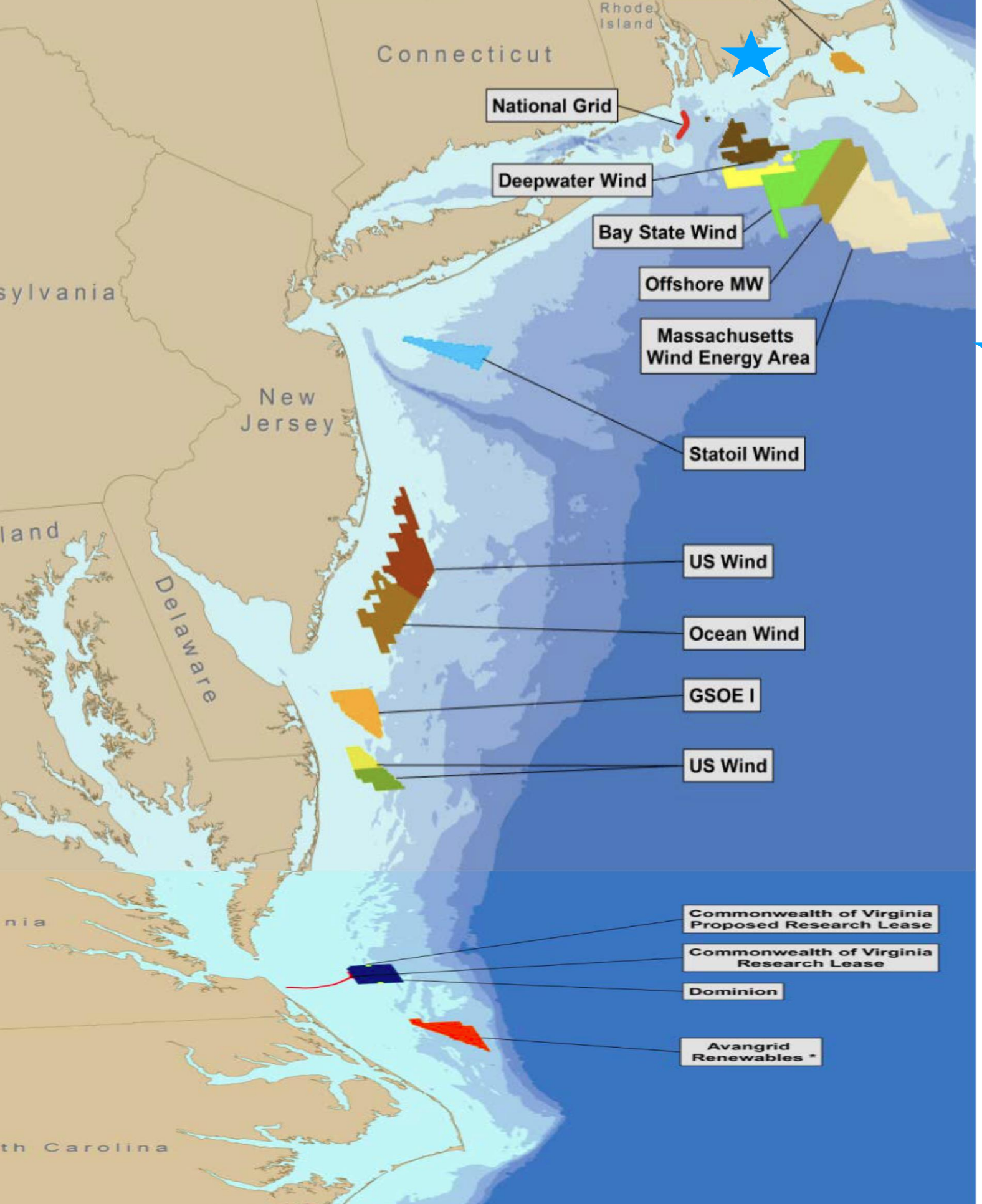
- Very large industry coming to the Atlantic continental shelf
- Existing state law, contract or committment to build >4,400 MW by 2030, about 12 builds and a $13 Billion investment
- All builds will require a nearby port; over time manufacutring will move from primarily Europe to US
- States attracting industry & jobs via conditions for PPA versus creating attractive infrastructure

Port Requirments

- Heavy lift quay (>15-25 tonne/m^2)
- Large laydown area (>86ha or 200 acres)
- Water, rail and highway connections
- No overhead obstruction from port to the sea



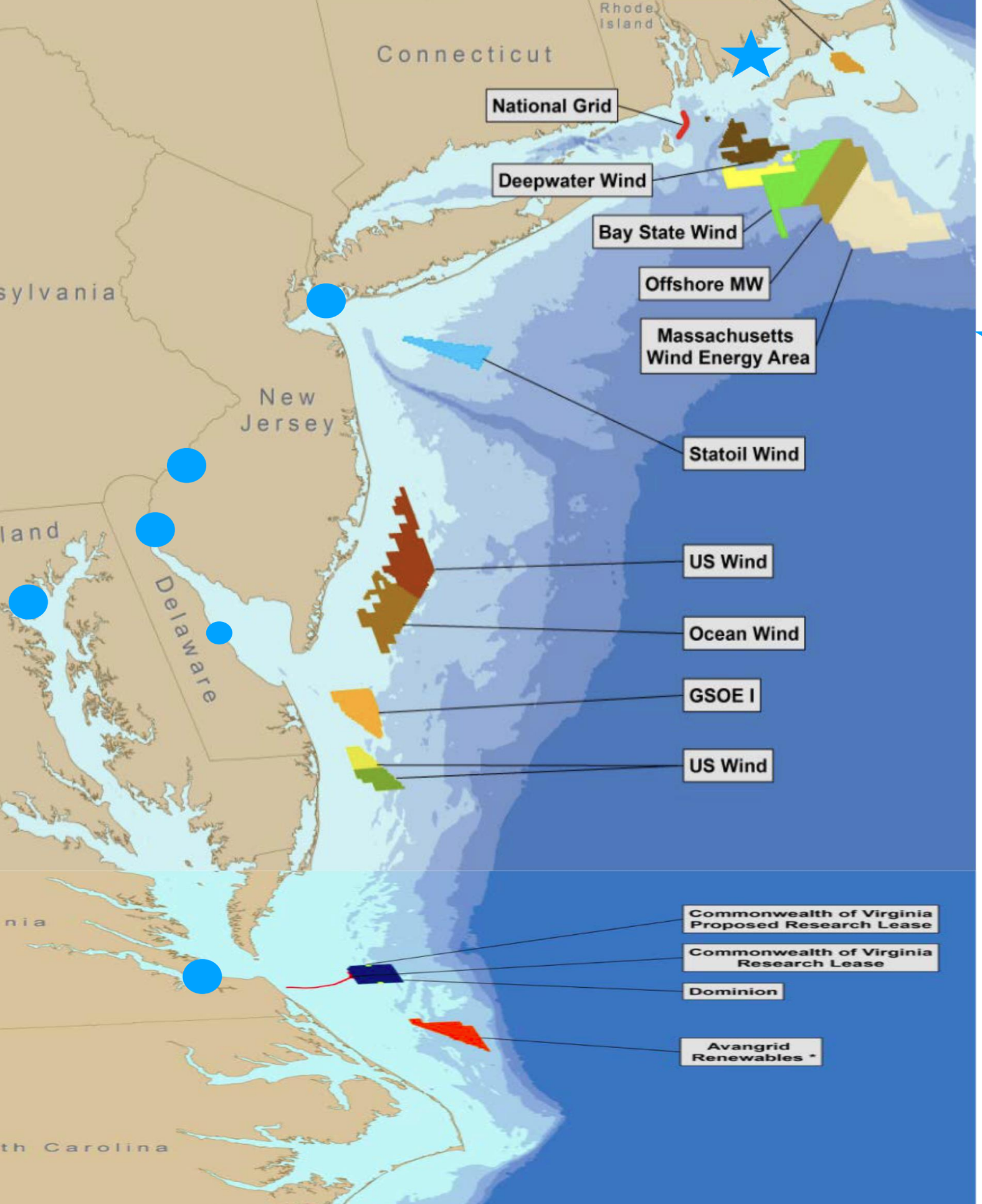
Many leased sites; where to deploy from?



Now, one OSW Deployment port

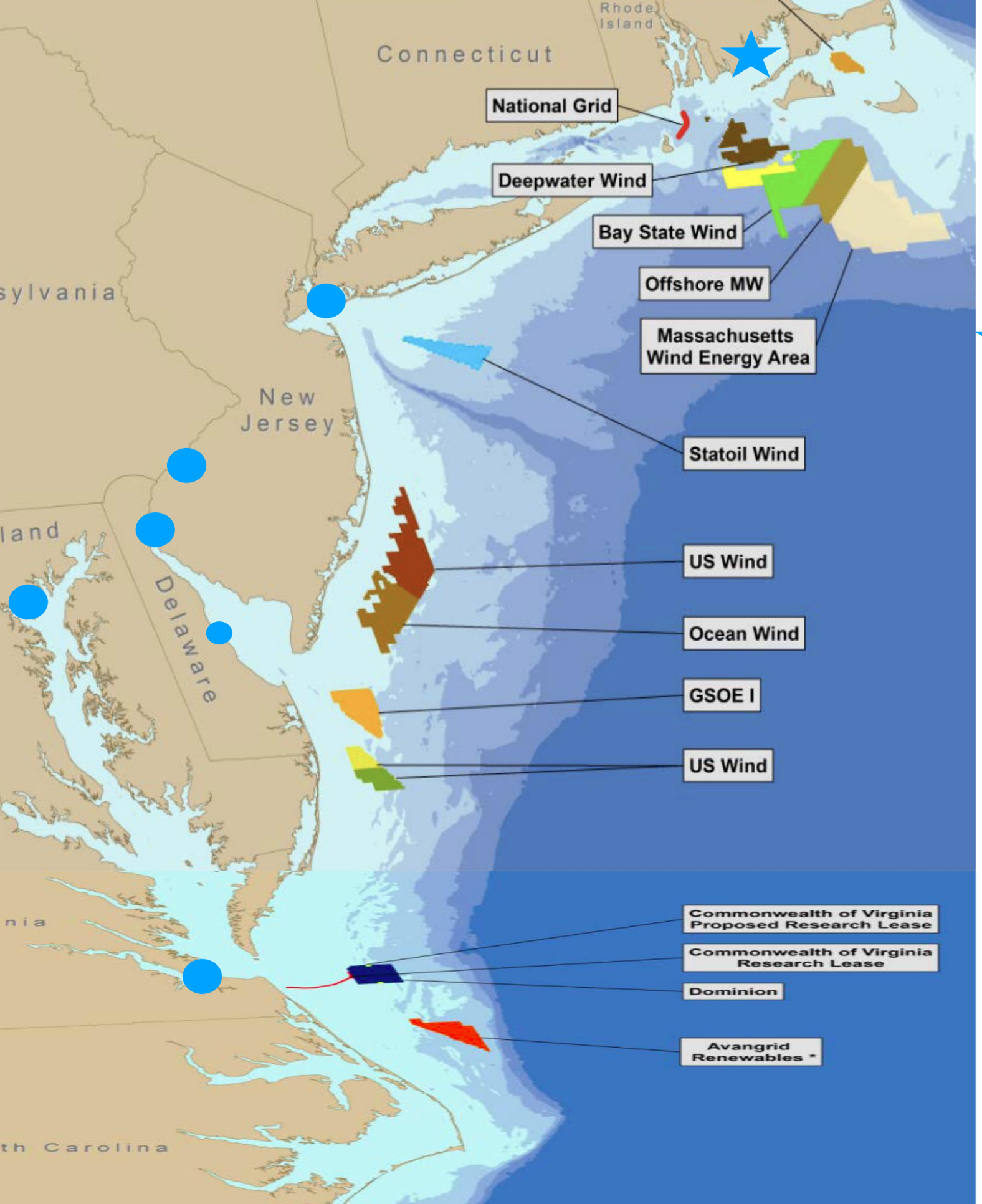
★New Bedford

Much too far away for mid-Atlantic installation



Possible new ports to develop

- ★ New Bedford
- New York
- Paulsboro
- Sparrows Point
- Delaware City
- Norfolk
- Dover



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But, only DE port sites have: proximity to development, large laydown areas.

Today’s OSW deployment

- Components are brought to a deployment port, or laydown area, staged for installation
- Installation ships are “jack up vessels” that can put down “spuds” to become stable w.r.t. the ocean floor
- Monopile is driven into the sea floor, to ~40 m depth,
- Transition piece is placed over monopile, grouted
- Tower, nacelle and blades all lifted

DOE Study

- UD and contractors were awarded “Integrated Design to Industrialize Offshore Wind Power, with Example of Wilmington Canyon” DE-FOA-0000415

- Study was to show how new technologies can be combined to greatly improve installation of offshore wind and reduce the cost of energy

- Three methods compared using detailed engineering from experienced industrial firms

- Lowest cost method is described here

Collaborators and Contractors

Project Lead:

UNIVERSITY OF DELAWARE

Sponsor: US DoE, award DE-EE0005484

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

WIND ENERGY TECHNOLOGIES OFFICE

PARTICIPATING COMPANIES AND CONTRACTORS:

MAMMOET

WEEKS MARINE, INC.

SPT Offshore

Atlantic Grid Development

EEW

moffatt & nichol

Clipper

Eni GROUP Saipem

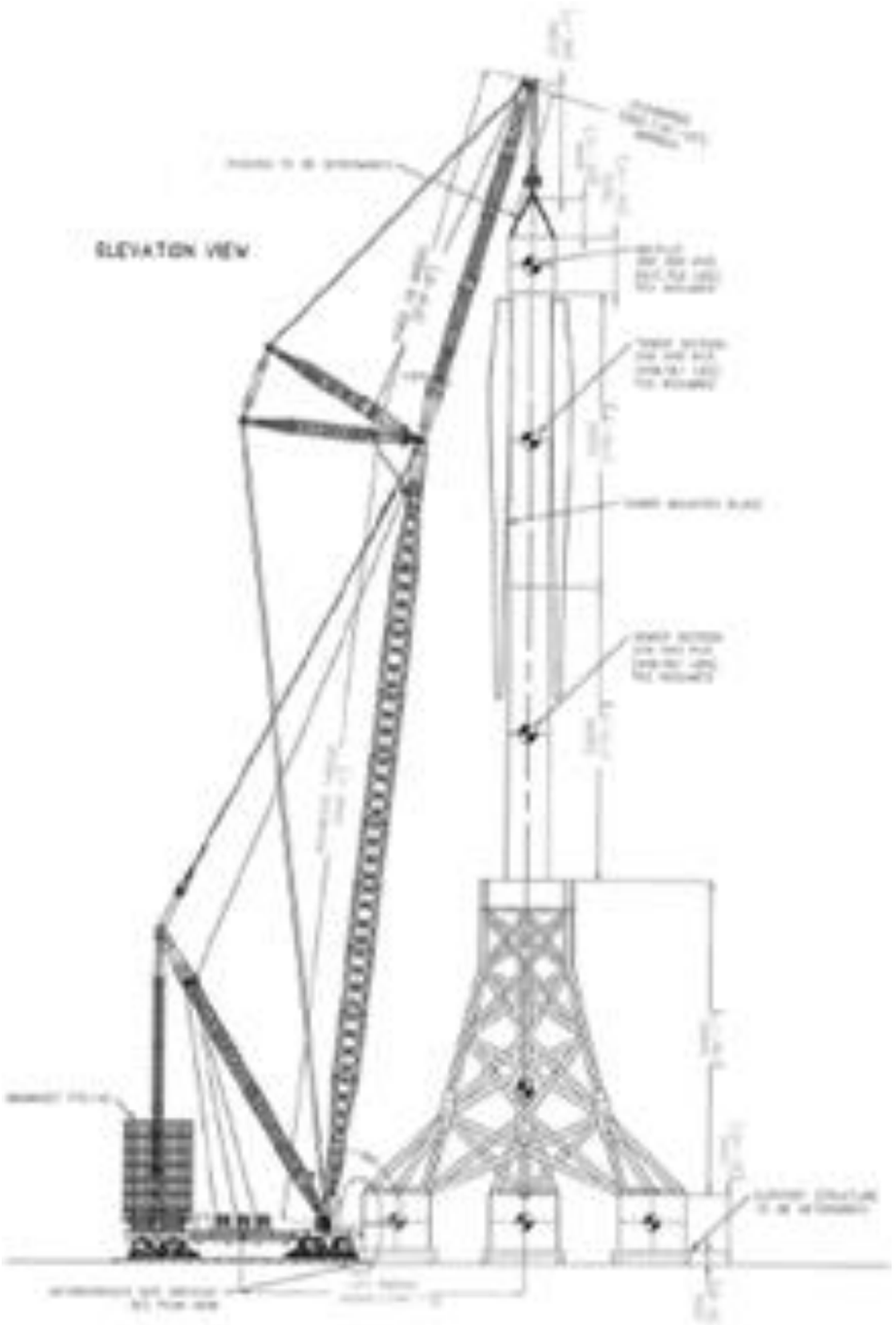
SIGNAL INTERNATIONAL
A Marine & Fabrication Company

STEEL SUPPLIERS ERECTORS INC.

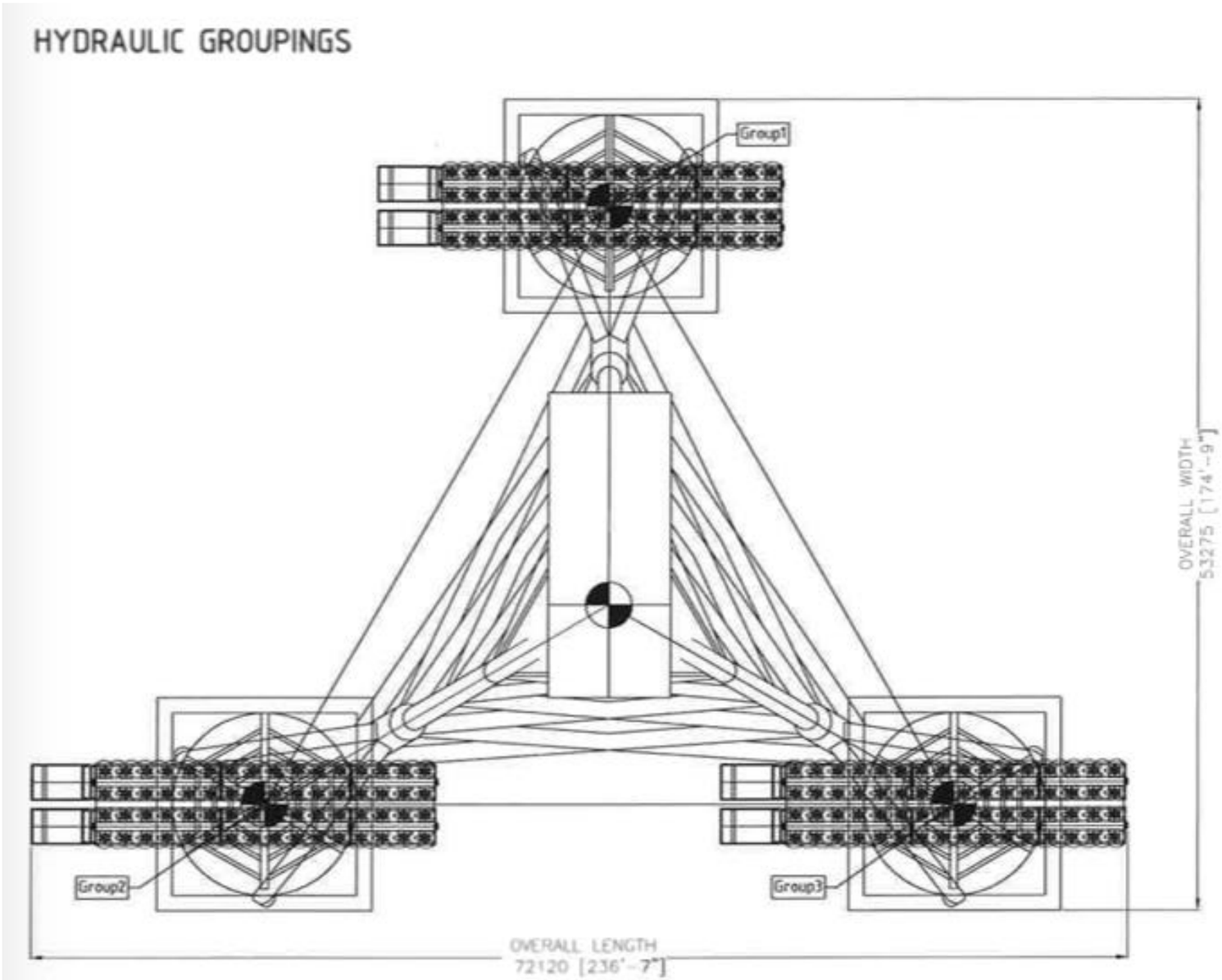
AALBORG UNIVERSITY

XKP VISUAL ENGINEERS

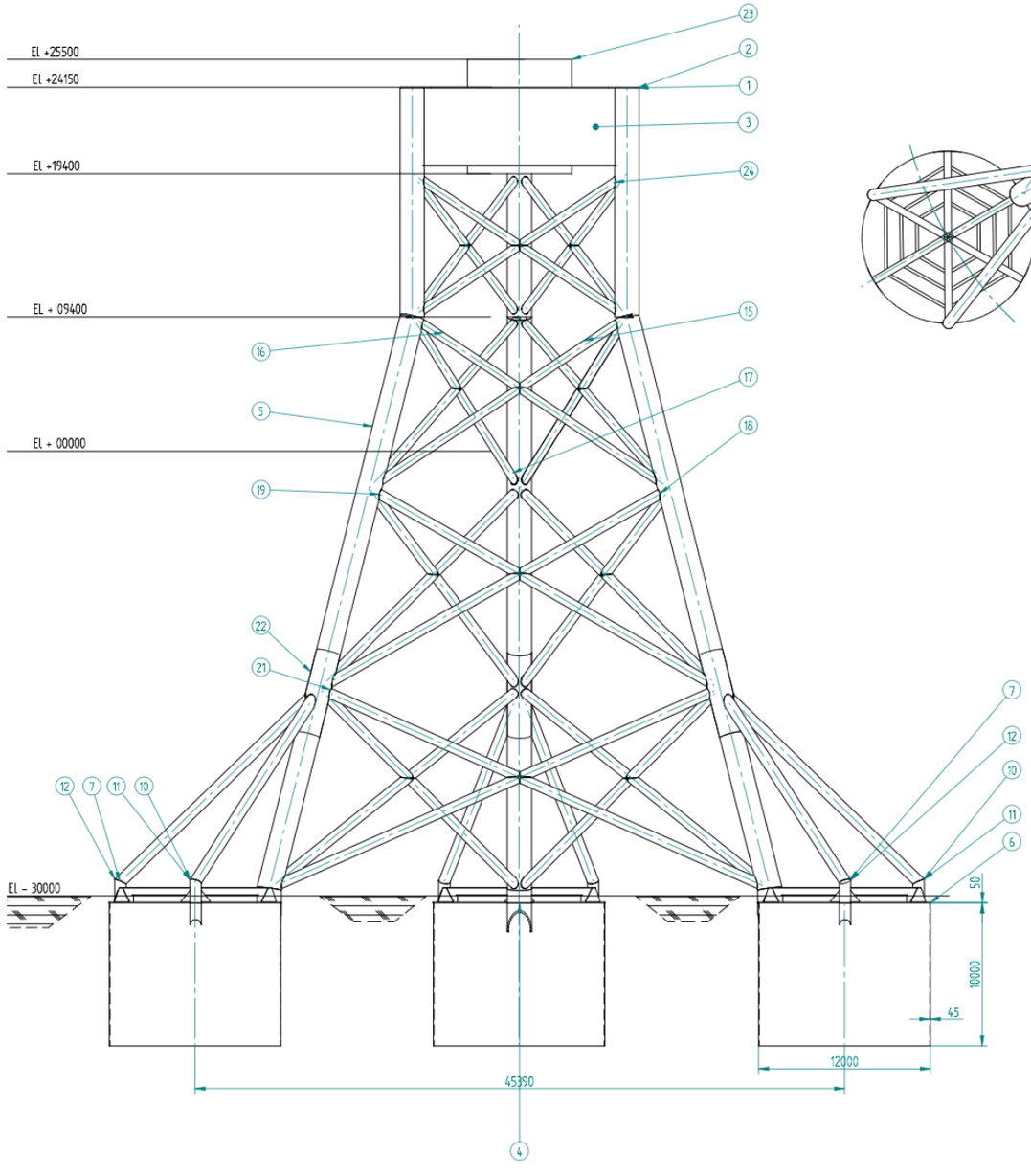
Full Engineering Design

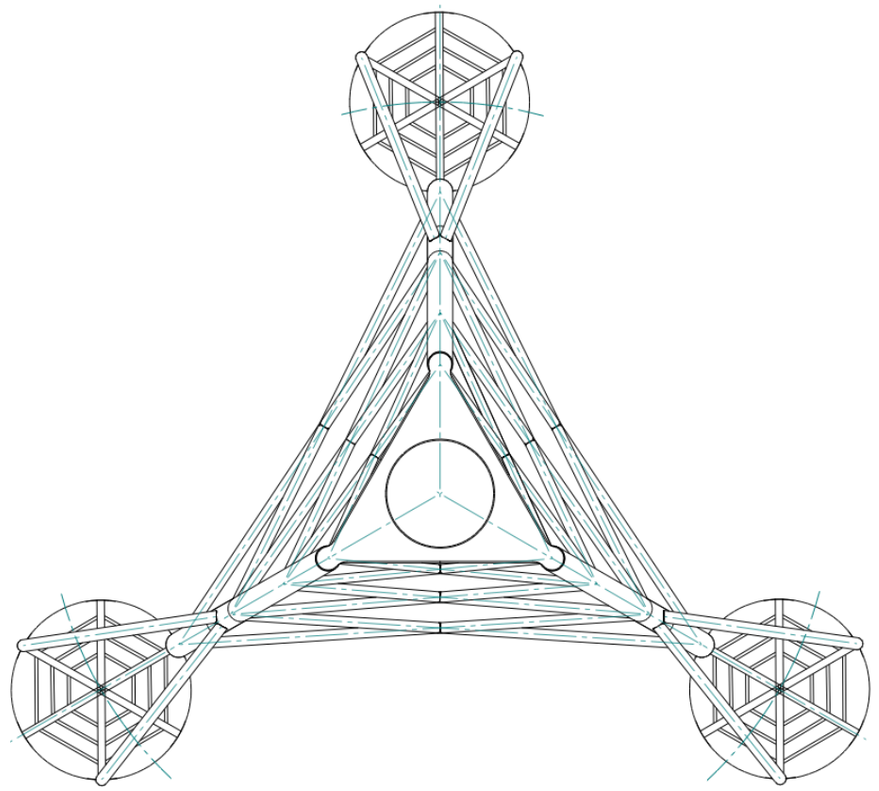


Highest cane lift: Nacelle top, 182 meters
= 47 story office building



SPMTs to carry full structure of 2500 Tonne
= 183 semi tractor-trailers





Item Number	Title	Quantity	Mass (Quantity)
1	1700,0X25,0	3	49462 kg
2	Plate 50	2	53740 kg
3	Plate 20	3	34262 kg
4	1700,0X25,0	3	3091 kg
5	1700,0X25,0	3	128705 kg
6	Pile Dia 12 m, H 10 m	3	626521 kg
7	0800,0x25,0	3	25672 kg
10	0800,0x25,0	3	25655 kg
11	0800,0x25,0	3	2146 kg
12	0800,0x25,0	3	2146 kg
15	0600,0x15,0	3	13263 kg
16	0600,0x15,0	4	18740 kg
17	0600,0x15,0	3	771 kg
18	0700,0x15,0	3	20504 kg
19	0700,0x15,0	3	20597 kg
20	0700,0x15,0	3	25189 kg
21	0700,0x15,0	3	25565 kg
22	1700,0x50,0	3	36543 kg
23	7300,0X70,0	1	99633 kg
24	0600,0x15,0	6	22074 kg

General Information

Description	
Substructure	607 Ton
Piles	627 Ton
Total	1234 Ton

Rev.	Date	Description	Drawn	Check	Appr.
A1	23-04-2013	Initial Issue	LSC		

SPT Offshore

Client: University of Delaware

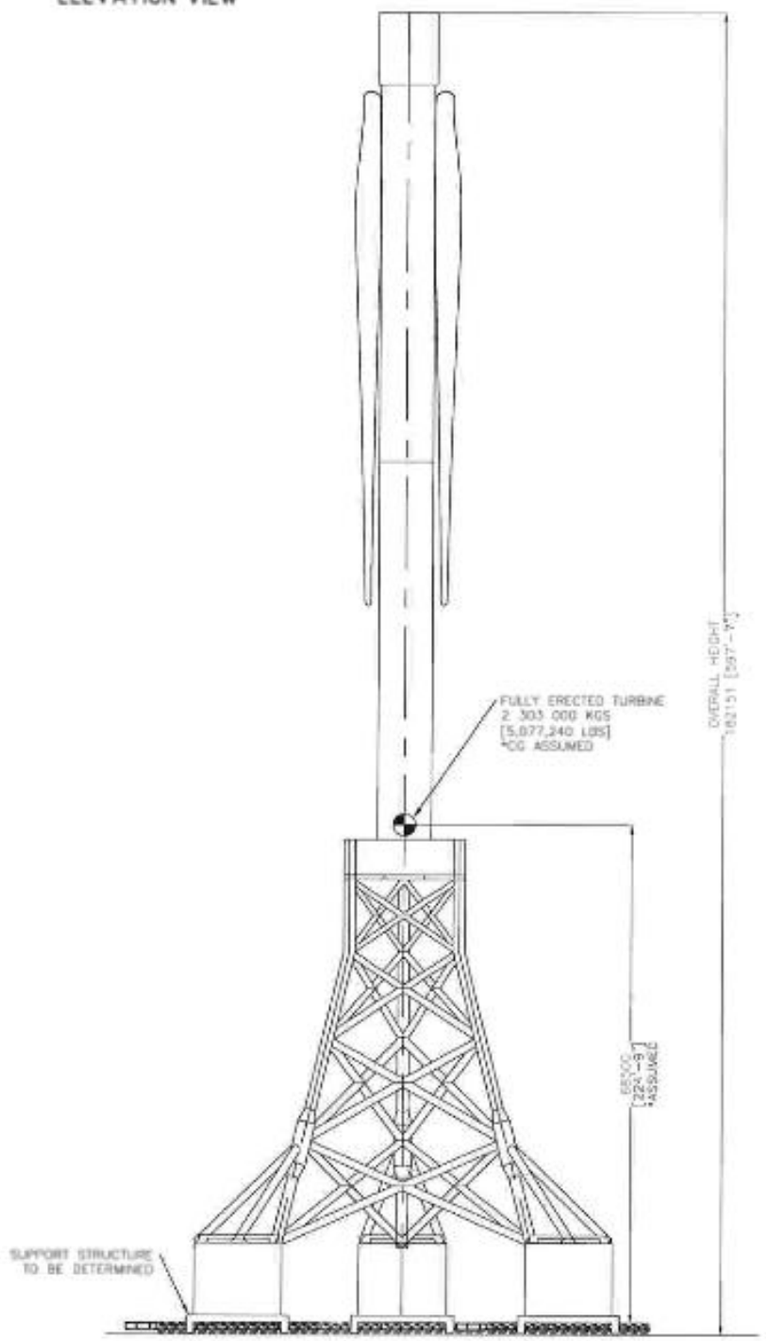
Project: Wilmington Canyon Offshore Wind Farm

Title: Substructure
General Arrangement

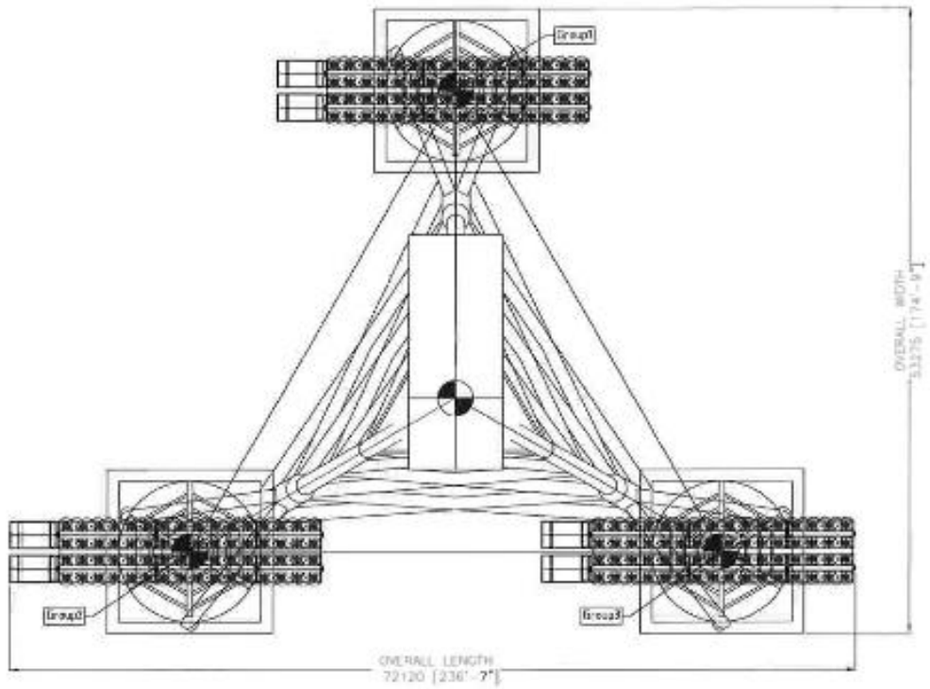
Scale 1: | Size A1 | Drawing nr. 20123001.001 | Revision A1

Computer Aided Drawing Drawing/archive nr.

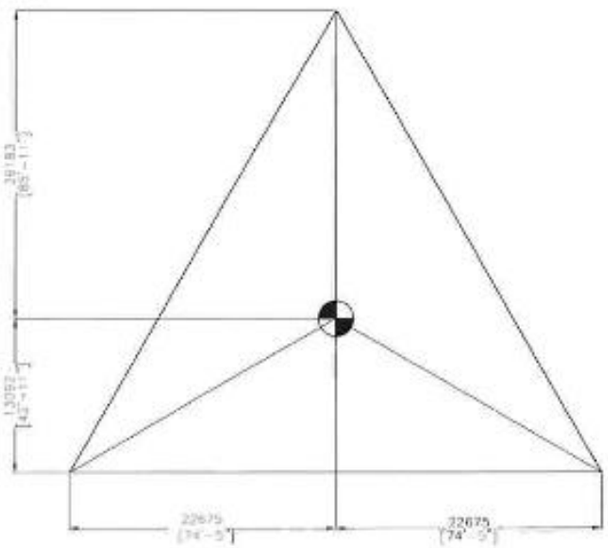
ELEVATION VIEW



HYDRAULIC GROUPINGS



STABILITY TRIANGLE



Scheuerle SPMT2004 96 Lines	Group1	Group2	Group3	Total	
Amount AxleLines	32	32	32	96	nos.
Mass Item	834.3	834.3	834.3	2503.0	ton
Mass Trailer	141.4	153.2	129.6	424.2	ton
TOTAL	975.7	987.5	963.9	2927.2	ton
Load per Axle	15.2	15.4	15.1	15.2	ton
Load per Wheel	7.6	7.7	7.5	7.6	ton
Ground bearing pressure	8.0	8.1	8.9	8.0	ton/m²

Weight Breakdown Items	Weight [t]	X [m]	Y [m]	Z [m]
Fully Erected Turbine	2303.0	33.875	14.542	68.500
Equipment	200.0	33.875	14.542	68.500
Total	2503.0	33.875	14.542	68.500

NOTES:

1. EQUIPMENT SHOWN IS FOR REFERENCE ONLY.
2. EQUIPMENT IS SUBJECT TO DETAILED ENGINEERING ANALYSIS AND AVAILABILITY.
3. FULLY ERECTED TURBINE WEIGHT (2 303 000 KGS) CALCULATED FROM; 3xSUCTION BUCKETS WEIGHT (270 000 KGS), FOUNDATION LATTICE STRUCTURE WEIGHT (607 000 KGS), 2xTOWER SECTIONS WEIGHT (208 000 KGS), NACELLE WEIGHT (380 000 KGS) AND 3xBLADES WEIGHT (30 000 KGS) PROVIDED BY CLIENT. C.G. FOR ALL PIECES ARE ASSUMED.

Conceptual

REV.	DESCRIPTION	DATE	DRAWN	CHECKED
00	FIRST ISSUE	15Dec16	RC/MV	JJ/SD

Without authorized signatures this document is uncontrolled, not binding and for indicative purposes only.

CLIENT: DELAWARE UNIVERSITY

PROJECT: OFFSHORE WIND TURBINE INSTALLATION

TITLE: TRANSPORT ARRANGEMENT FOR FULLY ERECTED TURBINE USING 3x DOUBLE WIDE 16L SPMT

MAMMOET

SCALE: NTS | SIZE: D

DRAWING NUMBER

SAP No: 7000163969

PROJECT No: 15029150 | SUB: 000 | PART: P153 | SHT: D | REV: B03 - 1/1 - 00

Design Decisions: Port Assembly and Installation

- Port Assembly:
  - Assemble foundation, tower, and nacelle on quay
  - Attach blades to tower not on hub, more stable at sea, less stress on bearings
  - Pre-assembly of turbines is nearly continuous; install during weather windows

- Installation
  - Shearleg crane vessel to transport completed structure to installation site
  - All work done from floating vessel
  - Assembly and installation can be done in parallel

Design Decisions: At sea

- No jack up vessels; No pile driving
- Shallower bucket depth (10m) allows acoustic sub-floor scanner & CPT for jacket buckets
- Crane vessel installs entire structure in one operation
- Blades hoisted by workers with winch in nacelle, not by lift vessel

New method install video

https://youtu.be/Lo5iNH-wb9I

Or, near top of the following page:

http://www.ceoe.udel.edu/research/affiliated-programs/wind-power-program/resear
projects/industrializing-offshore-wind

Capital Costs

Table 10. Capital cost of all components, all figures in $/kW capacity

Design	Foundation	Work at sea	Port Work	Turbine and Tower	Electrical Infrastructure	Total Capital Cost [1]	Percentage capital cost
Piled Jacket, 5 MW turbine	808.08	882.50	25.20	1952.00	937.50	4605.28	100%
Piled Jacket, 10 MW turbine	462.46	465.60	23.50	1615.00	600.00	3166.56	69%
Suction Bucket jacket, 10 MW turbine (existing equipment & processes)	514.65	333.40	32.55	1615.00	600.00	3095.60	67%
Suction Bucket jacket, 10 MW turbine (mature market)	425.10	251.92[2]	26.89	1615.00	600.00	2918.91	63%

How DE Could Utilize

- Port study of Oxychem/Valero versus Dover or more South
- Pick a location for small laydown and single-loadout
- Demonstrate with 2-6 turbines from small port
    - Make agreement with developer for test
    - Develop confidence in industry
- Expand port for larger builds
- Then port has natural competitive advantage for future builds

END

More information at: http://bit.ly/2hJF27v

and Twitter @WillettKempton