Underkeel Clearance Analyses

Coastal Navigation Portfolio Management

Brandan Scully, PE, PhD
CIRP CNPM Co-PI, Study Lead
David Young, PhD
Research Civil Engineer

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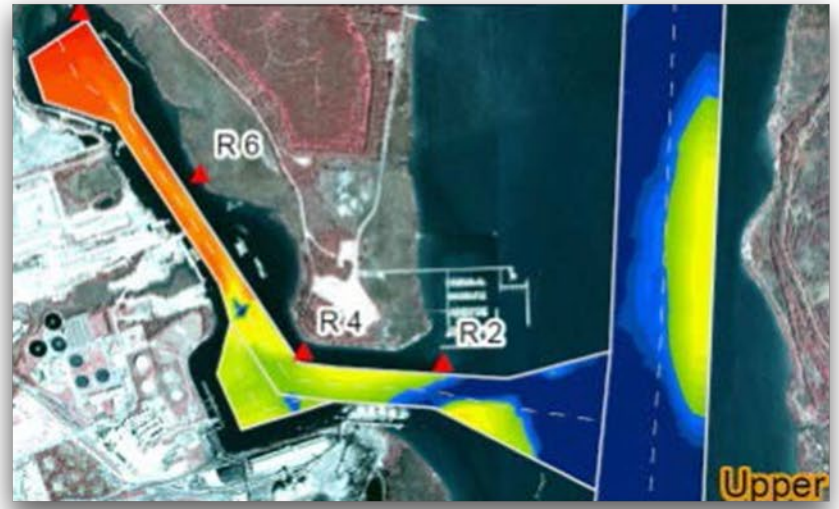
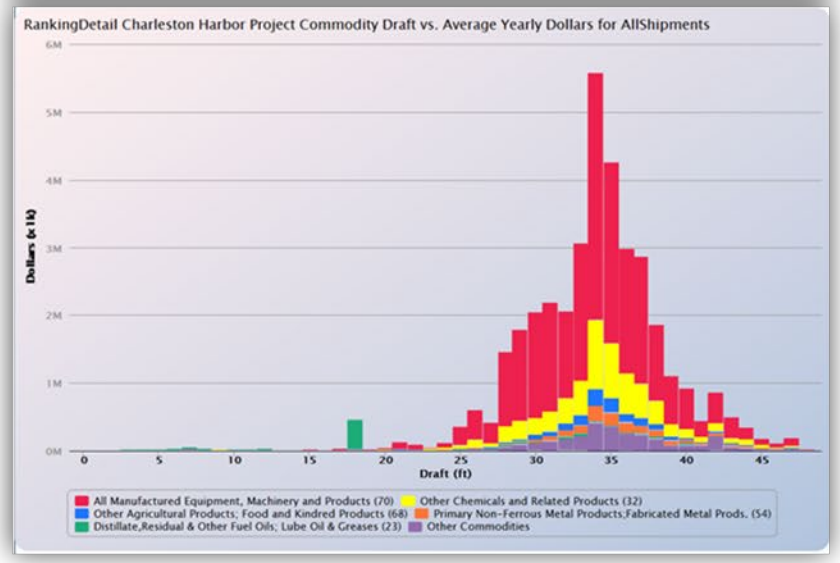
US Army Corps of Engineers
COASTAL & HYDRAULICS LABORATORY
CIRP Mission Support Technology Transfer Research & Development
ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

Why this matters…

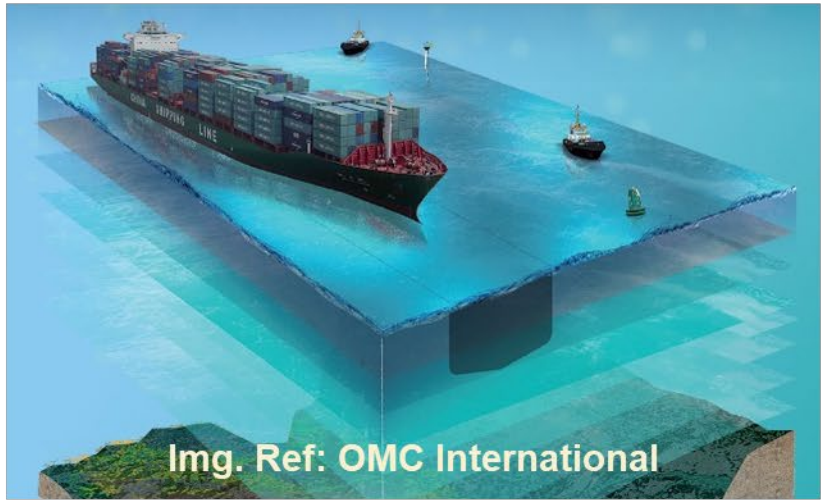
- USACE spends approximately $1B annually on dredging [6,7]
- USACE routinely reports low channel availability due to constrained maintenance funding [1,2,3]
- Increasing vessel size trends increases C, O&M dredging [4, 5, 7]
- Inadequate channel depth impacts the safety and efficiency of waterborne goods movement [7]
- Cargo tonnage and value used to prioritize maintenance dredging funds in ad hoc framework [3, 6, 7]
- Dredge reassignment has costly network implications in NAV and FRM BLs.
- Gains in vessel navigability from dredge activity is not measured.

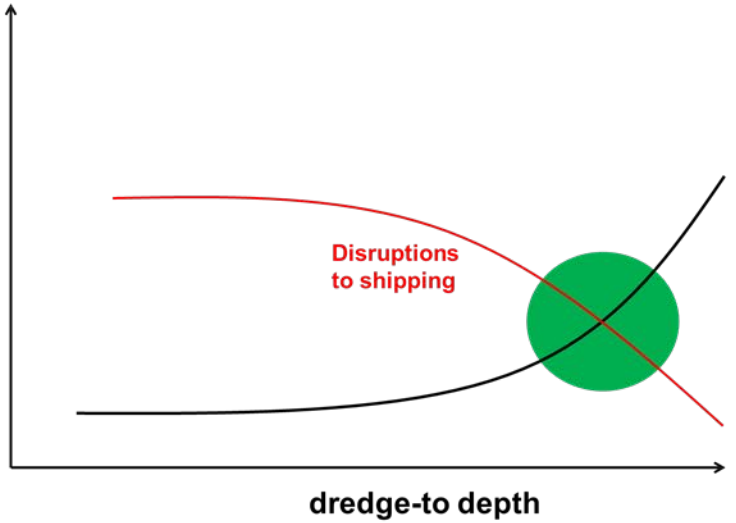




Research Topics

- Leverage emerging technology to improve ~~underkeel~~ “around hull” clearance estimates for transiting vessels.
- Develop improved management framework that enables maintenance dredging prioritization based on acceptable clearance “around hull”.





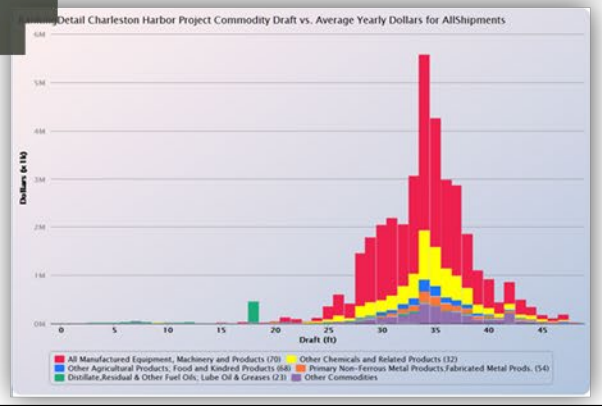
Research Goals

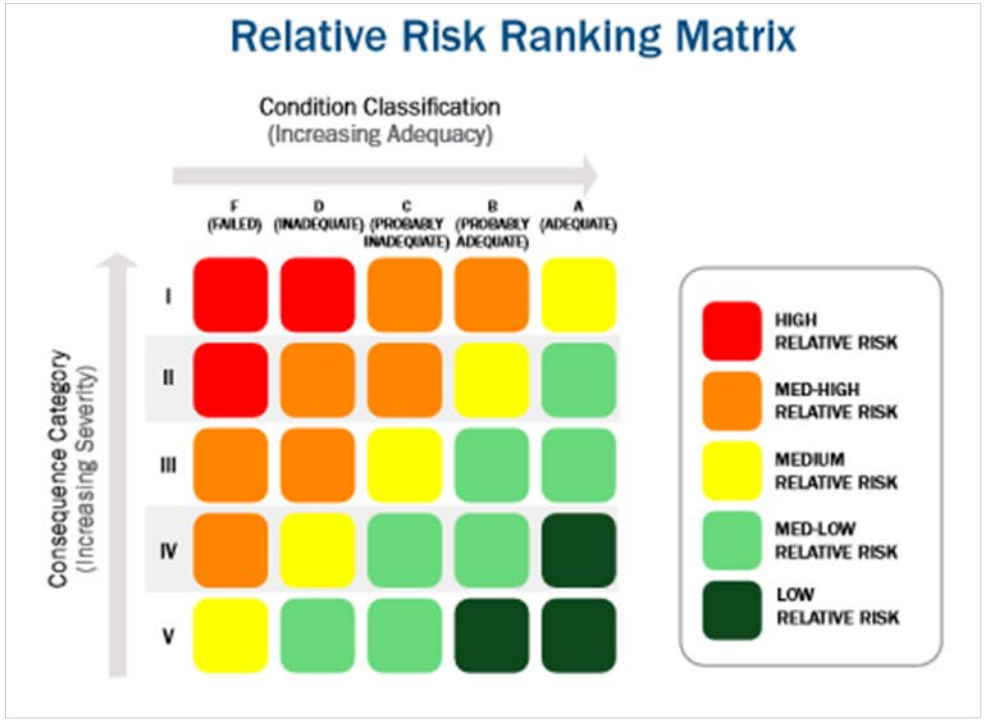
- Augment navigation channel performance metric (available depth), and proxy project maintenance prioritization metrics (tonnage, value).
- Cast channel performance in terms of vessel clearance.
- Formulate management metrics at “portfolio scale”.

BALTIMORE HARBOR CHANNEL DEPTHS

TABULATED FROM SURVEYS BY THE CORPS OF ENGINEERS - SURVEYS TO AUG 1998

CONTROLLING DEPTHS FROM SEAWARD IN FEET AT MEAN LOWER LOW WATER (MLLW)						PROJECT DIMENSIONS		
NAME OF CHANNEL	LEFT OUTSIDE QUARTER	LEFT INSIDE QUARTER	RIGHT INSIDE QUARTER	RIGHT OUTSIDE QUARTER	DATE OF SURVEY	WIDTH (FEET)	LENGTH (NAUT. MILES)	DEPTH MLLW (FEET)
BREWERTON CHANNEL	A47.5	50.9	50.5	A46.6	6-98	700	3.06	50
BREWERTON ANGLE	46.3	49.2	48.6	46.2	6-98	700-1450	0.79	50
FORT MCHENRY CHANNEL	A46.5	50.2	49.6	48.4	6-98	700	3.77	50





Controlling Depth in Reach

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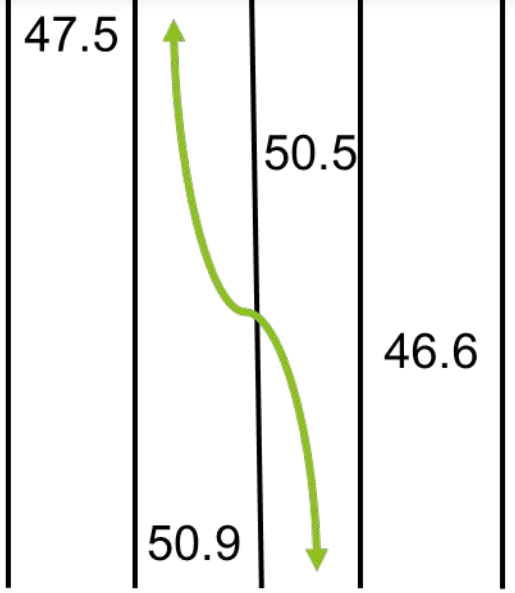
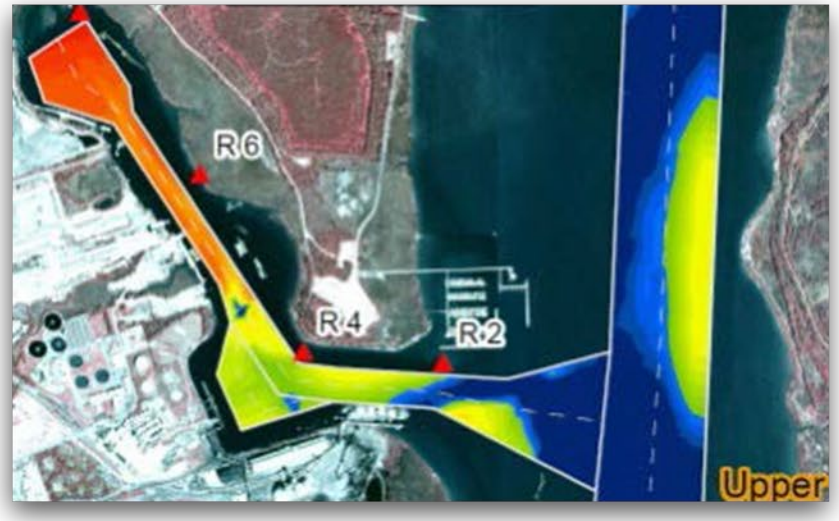
FORT MCHENRY CHANNEL	A46.5	50.2	49.6	48.4	6-98	700	3.77	50

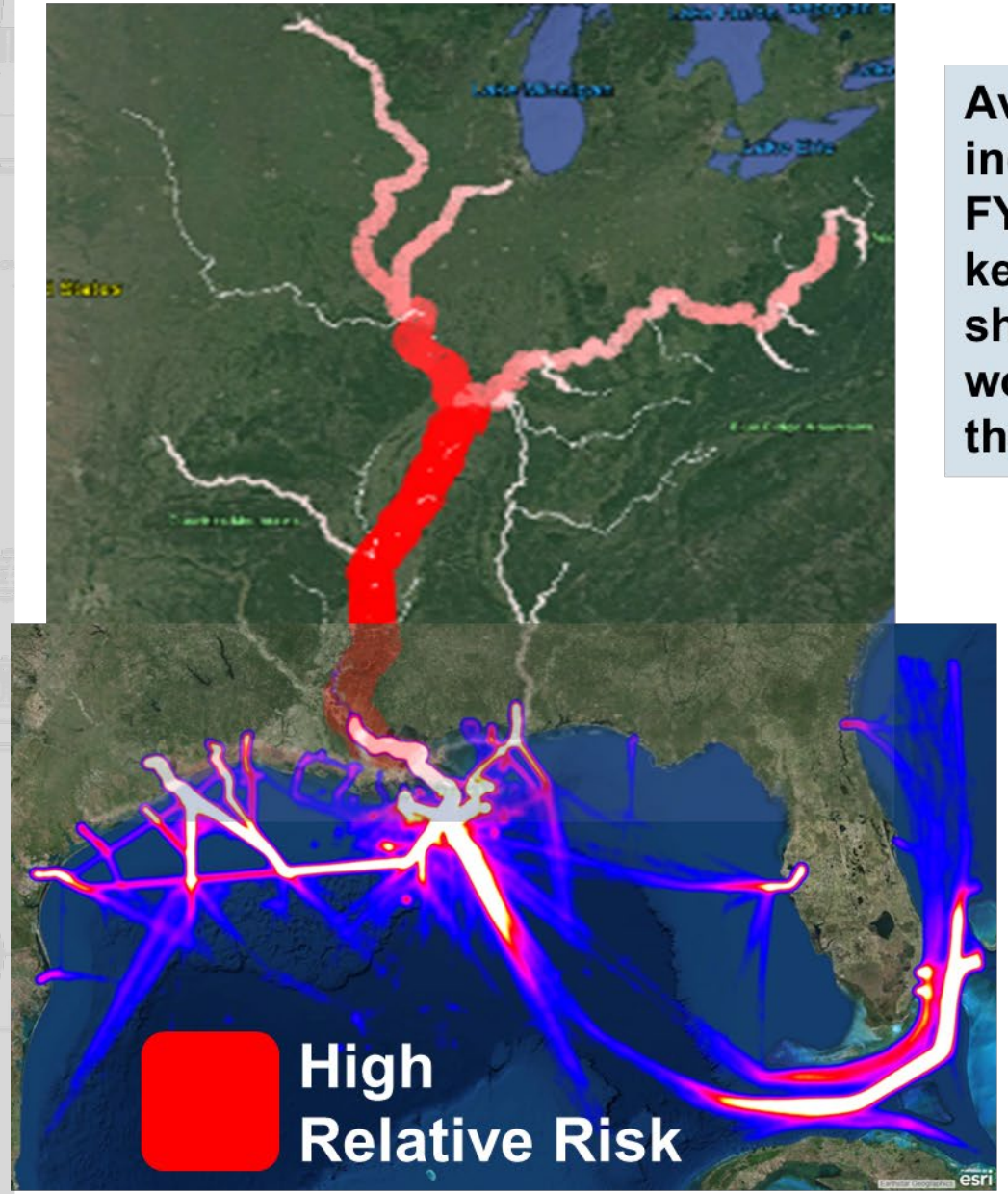
- Controlling depth location within reach not specified
- Possible to pass through a reach without encountering the controlling depth.
- May result in “unavailability” without significant risk of keel strike.





Southwest Pass Draft Restrictions

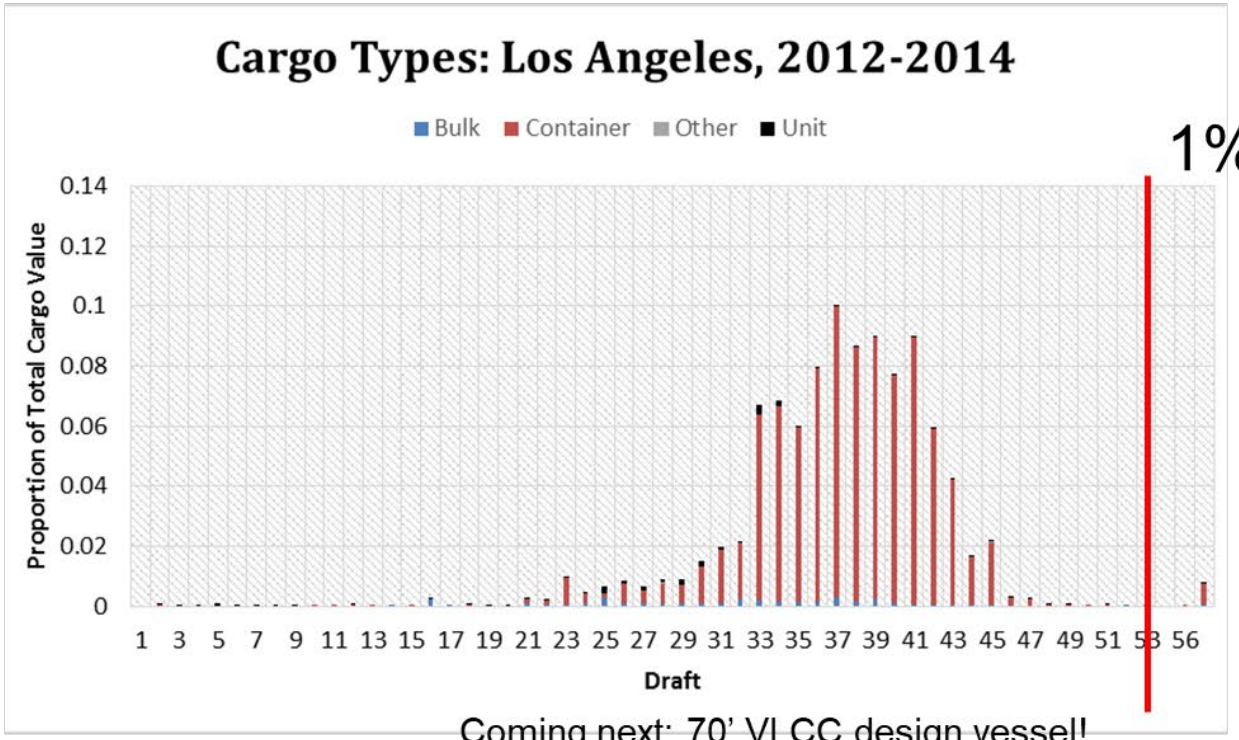
Average channel condition of 42-ft since 18 NOV 2018 has incurred $73.2M in additional shipping costs as of 15 JUL 2019. FY19 dredging expenditures at Southwest Pass of $236M have kept channel conditions stable and prevented even higher shipping cost impacts. For example, a 38-ft draft restriction would have incurred $410M in additional shipping costs over the same time period.



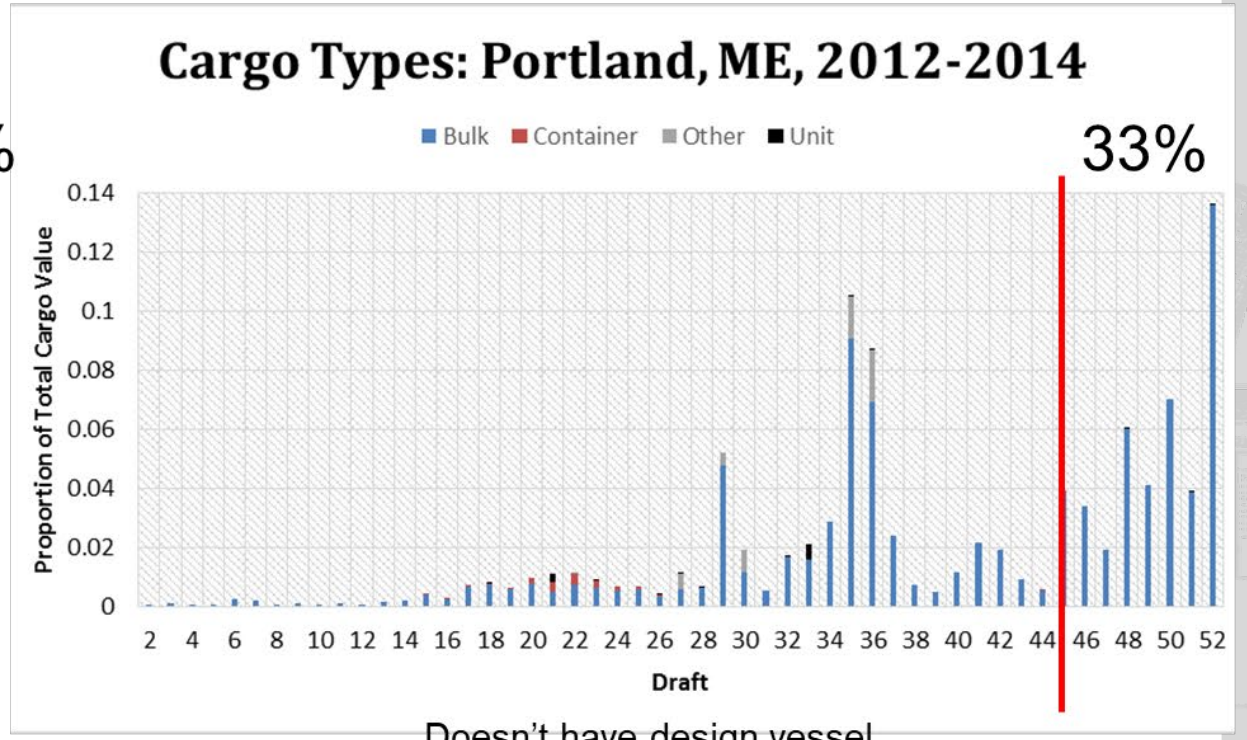
Avg. annual # of trips per year by vessel sailing draft

Draft (ft)	Corpus Christi	Freeport	Houston-Galveston	Beaumont/Port Arthur	Lake Charles	Lower Miss. River	Pascagoula	Mobile	Tampa	Miami	Port Everglages	Jacksonville	Savannah	Charleston	Norfolk	Baltimore	Delaware River	New York-New Jersey
40	106	40	616	442	98	1291	15	95	54	45	57	55	214	138	216	72	80	386
41	44	27	115	3	1	157	0	7	0	28	11	1	143	79	153	60	11	363
42	38	55	85	3	0	180	0	9	1	12	3	0	129	99	104	38	5	247
43	24	1	66	5	2	126	0	8	0	13	1	0	19	43	76	23	3	276
44	25	0	17	0	0	124	0	7	0	6	0	0	1	17	53	12	3	147
45	31	0	28	0	0	175	0	154	0	0	0	0	0	12	39	12	5	112
46	0	0	0	0	0	48	0	0	0	13	1	0	0	6	45	22	53	51
47	0	0	0	0	0	130	0	0	0	1	0	0	1	4	78	82	1	28
48	2	0	1	0	0	3	0	0	0	0	0	0	0	1	86	16	3	11
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	2	3	3
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	25	1

Distribution of Value wrt Vessel Draft

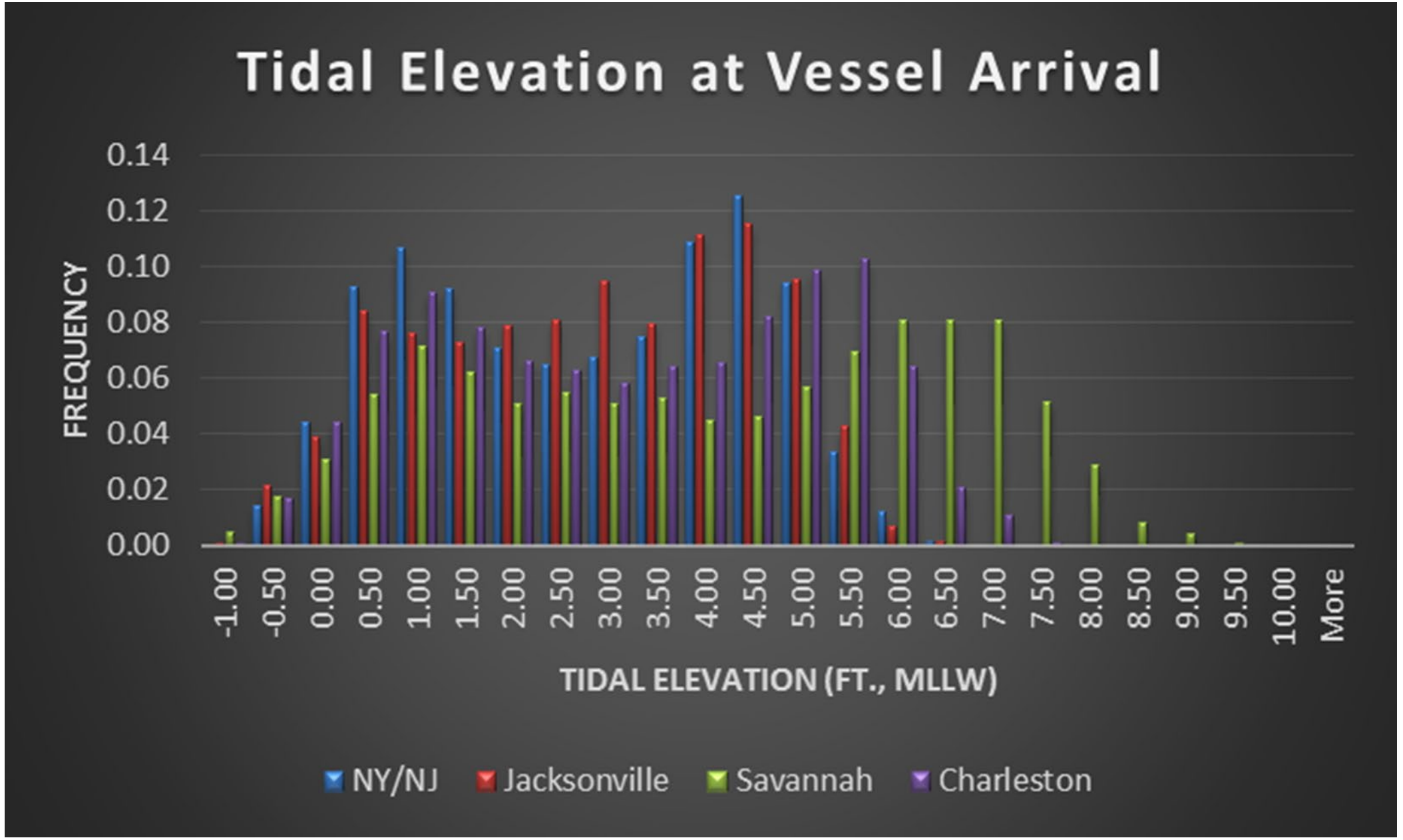


Coming next: 70' VLCC design vessel!

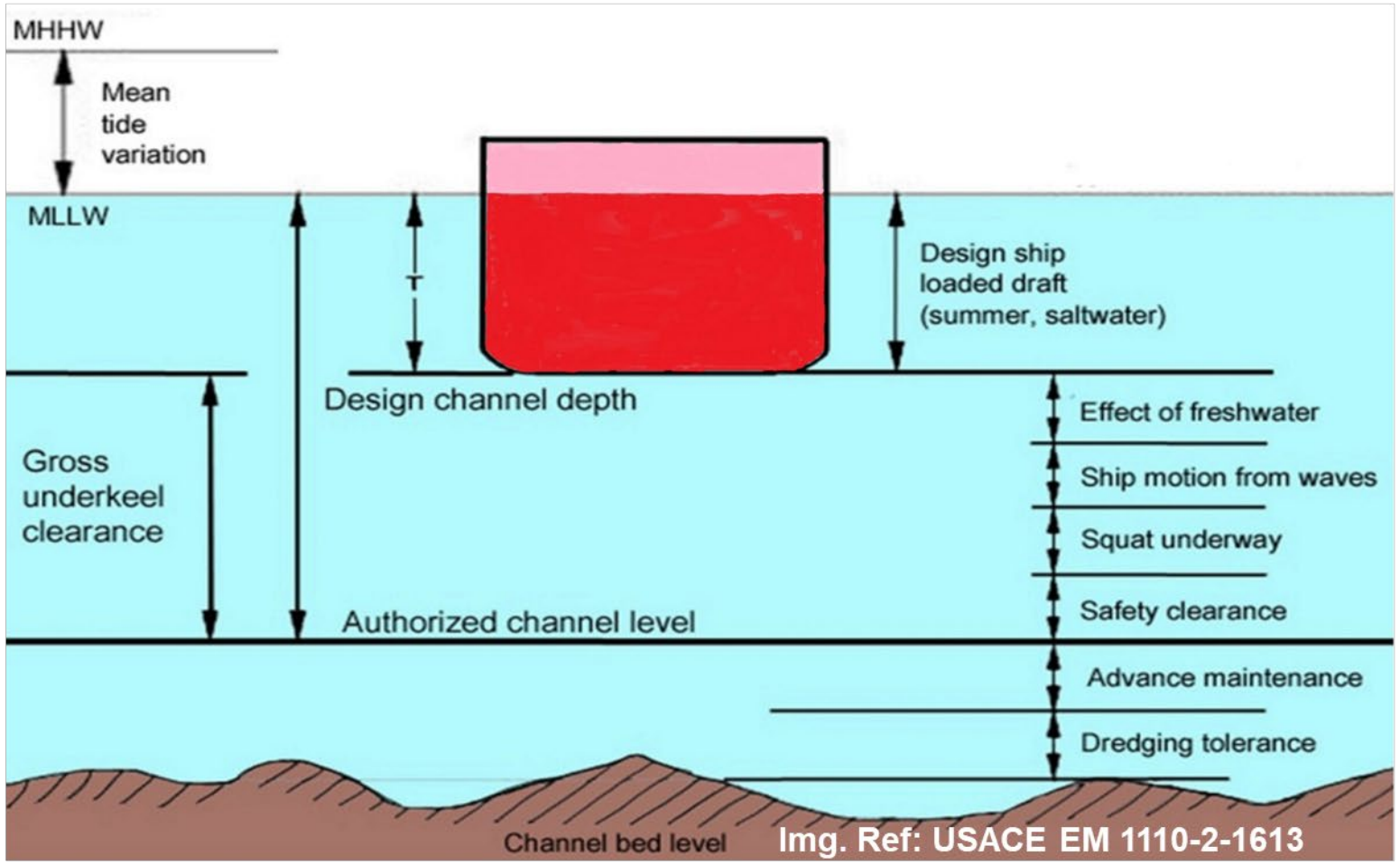


Doesn't have design vessel.

- Amount of cargo moved on vessels with draft exceeding design depth varies by port. Many ports have long tails at deeper drafts.


Tidal Elevation at Vessel Arrival
FREQUENCY
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-1.00
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00
9.50
10.00
More
TIDAL ELEVATION (FT., MLLW)
NY/NJ
Jacksonville
Savannah
Charleston

Channel Depth and Underkeel Clearance



Existing Underkeel Clearance Use Cases

Ship Operation[12] e.g. EMOGS

Likelihood of safe passage right now

- **Uses:**
  - 1 ship (well defined)
  - 1 transit
  - Real time, Ambient conditions
  - Determine probability keel will exceed a depth
- **Parameters:**
  - Tidal water surface
  - Atmospheric setup
  - Authorized depth (or controlling depth if available)
  - Probabilistic wave response motions
  - Water density
  - Squat (model verified empirical relationship)
- **Consequence:**
  - Keel strike

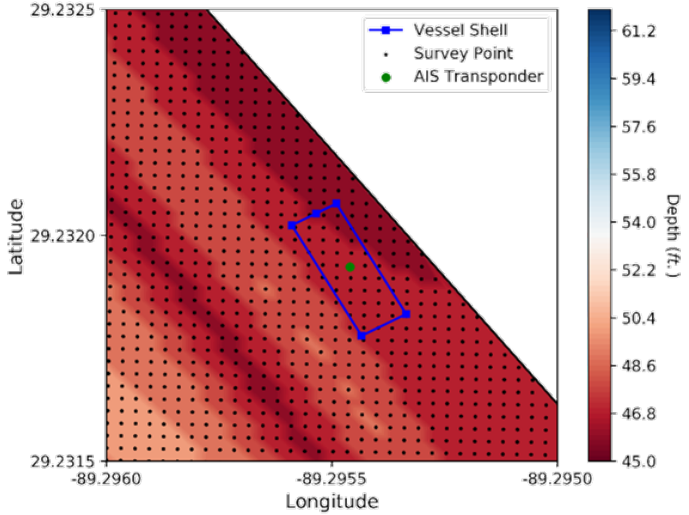
Channel Design[9,10,11] e.g. CADET

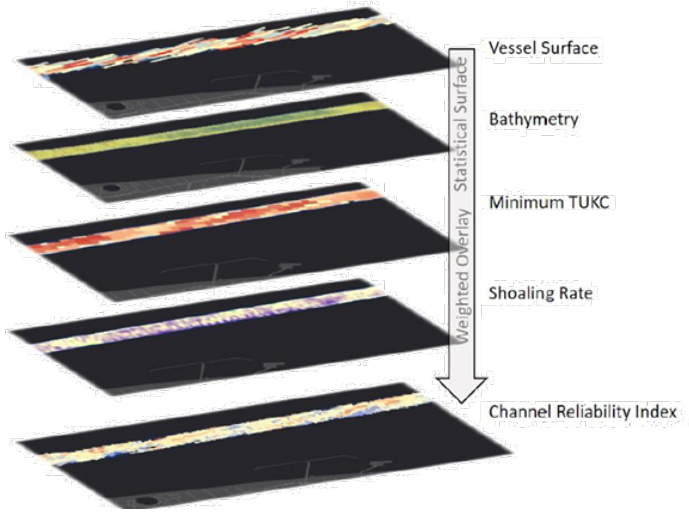
Likelihood of safe passage in the future or % depth available to design vessel

- **Uses:**
  - 1 ship (largest, well defined)
  - Many simulated transits
  - Model time, Simulated conditions
  - Determine new-work depth
- **Parameters:**
  - Reference low water datum
  - Probabilistic wave response motions
  - Water density
  - Squat
  - Excludes tidal variation
  - Excludes atmospheric effects
- **Consequence:**
  - Cost inefficiency in construction / maintenance / transport

Vessel Clearance Analysis

- Nationwide AIS - vessel footprint & draft
  - Coupling IWR Entrance & Clearance or 3rd party data improves draft accuracy
- eHydro – bathymetric elevation
- CSAT – historical shoaling rate
- NOAA – water level & tide harmonic data
- Channel Framework links input & provides boundaries
- Channels can be characterized by 3D vessel clearance

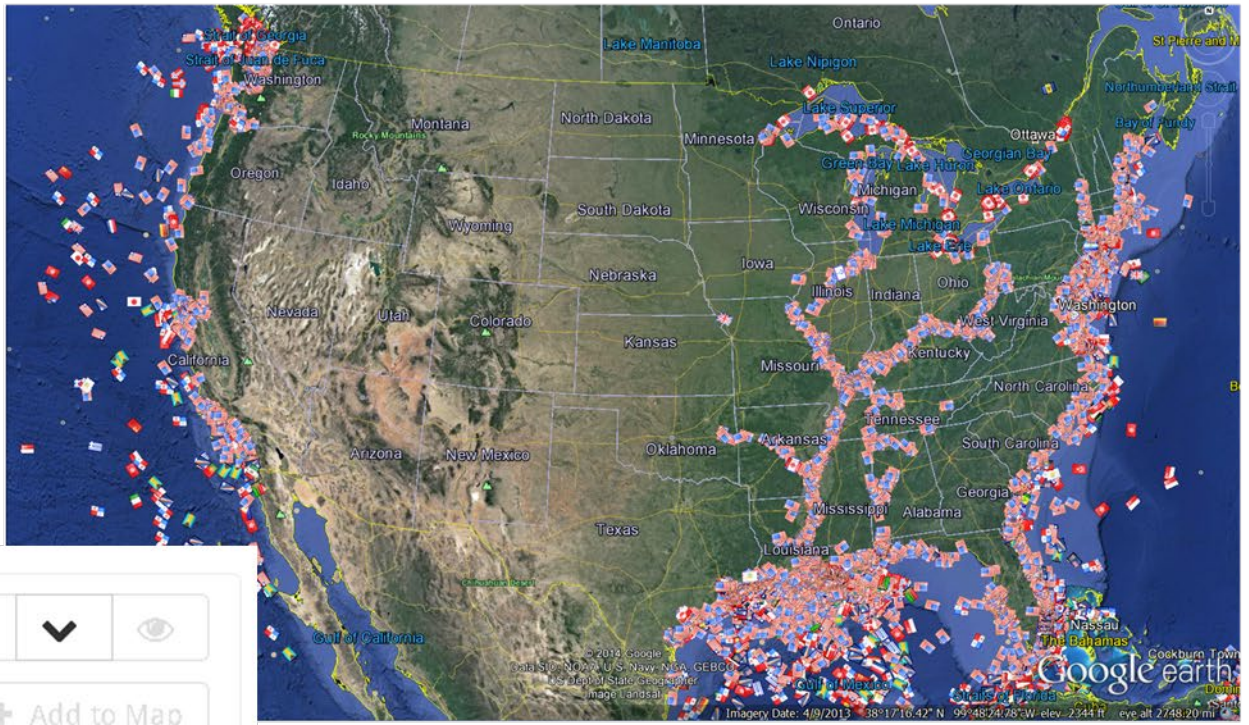




Billions of vessel positions Thousands of channel surveys

Marine Cadastre

- Nationwide AIS 1-minute sampling
- Available 2009-2017
- Marinecadastre.gov



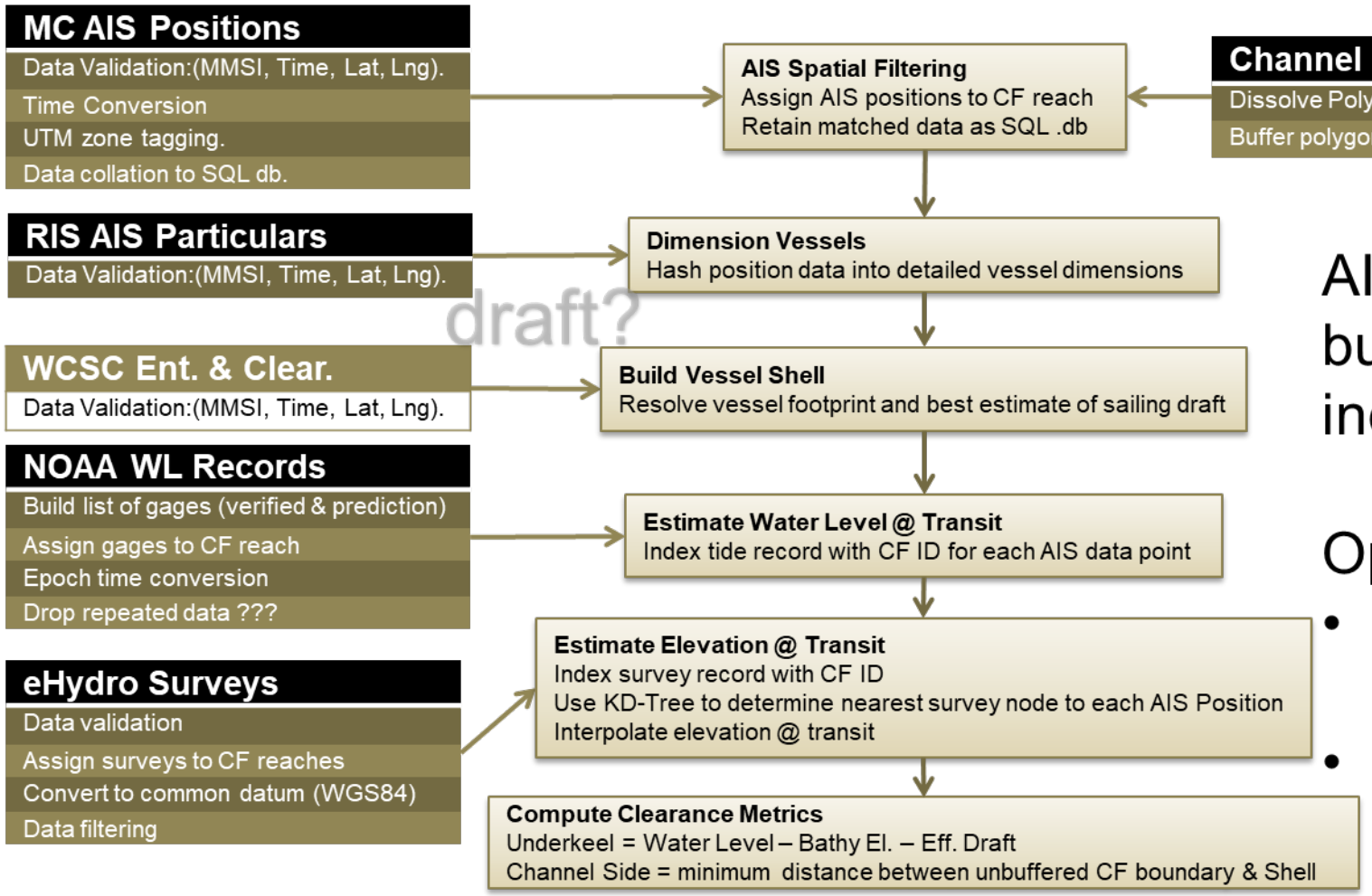
2009 - 2017 National AIS at 1 Minute Intervals

MarineCadastre.gov

Add to Map

Automatic Identification System (AIS) data are information collected by the U.S. Coast Guard to monitor real-time vessel information to improve navigation safety. Data such as ship name, purpose, course, and speed are acquired 24 hours per day primarily in coastal U.S. waters. However, the data sets featured on this website are the 2009 to 2017 archived AIS data sets intended to be used by the ocean planning community to better understand vessel traffic patterns. These data are provided for analysis in desktop GIS software. For more information, visit the Nationwide Automatic Identification System website.

Vessel Clearance Analysis



AIS Draft is available, but unreliable on individual transits.

Options to pursue:

- WCSC E&C: data covers some ships.
- Large-Draft isolation: better than ex. metrics?

Management Metrics

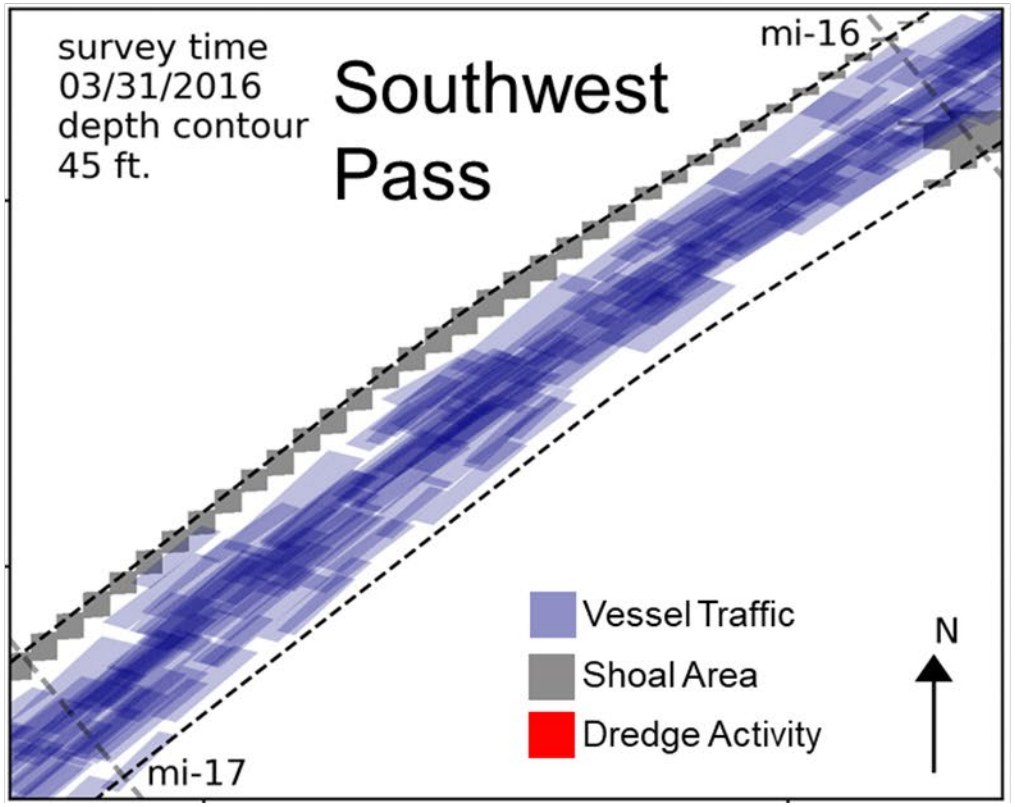
Convey to decision makers the volume of traffic in dredged reaches with "insufficient clearance".

- **Requires someone to decide what that means.**

Opportunity to combine all relevant data and contextualize dredging operations.

- **Possibly more functional than underkeel.**
- **Potentially significant questions about business as usual**

Need to socialize this concept and derive a metric that conveys the right information.



Conclusions

- In general, USACE pays a premium to support a small number of vessels at drafts approaching or exceeding authorized depth, with or without authorization to do so.
- AIS-derived traffic metrics quantitatively relate vessel clearance at time of vessel transit
  - Still working out some uncertainties
- AIS-derived traffic metrics can relate operational tactics to user experience
  - Bypasses some uncertainties
  - Needs hard questions answered about channel dimensions.
- AIS-derived metrics facilitate rational allocation of scarce operating funds
- Development of parallel computing capability in this space strategically positions CIRP within the vessel computational analysis space

Benefits

- **Working at scale strategically positions CNPM to explore other AIS-derived portfolio-wide metrics**
  - **4-D around-ship clearance – FY 20 goal**
  - **Vessel-based infrastructure classification**
  - **Large scale quantification of navigation risk**
- **Nationwide answers – navigation projects don't exist in a vacuum.**