
# *Viability of Bulk Cargo Merchant Sailing Ships*

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# Summary

- 1975 Report to MARAD: bulk cargo merchant sailing ships not commercially viable compared to steam vessels
- We update the 1975 Report and find the opposite is now true.

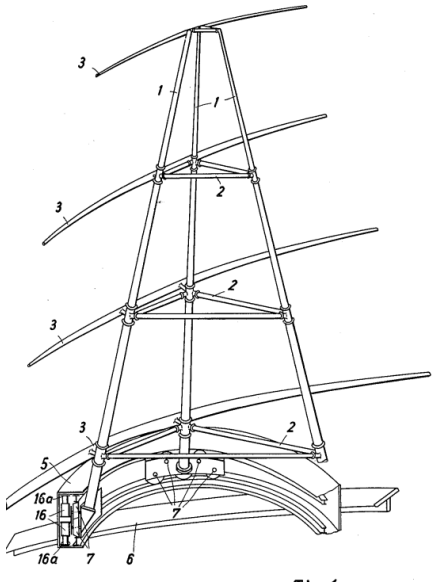
## Prior work:

1

Engineer Wilhelm Prolss, inventor of the Dynarig sailing ship.

Photo from Sueddeutsche Zeitung, circa 1970.
https://www.sueddeutsche.de/auto/grosssegler-zurueck-in-die-zukunft-1.584119-2

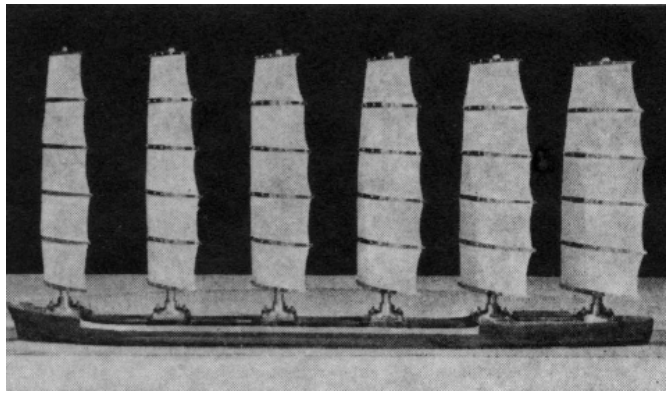
2




From 1963 Prolss U.S. Patent

## Prior work continued:

3 Engineer Von B. Wagner, Technical University of Hamburg



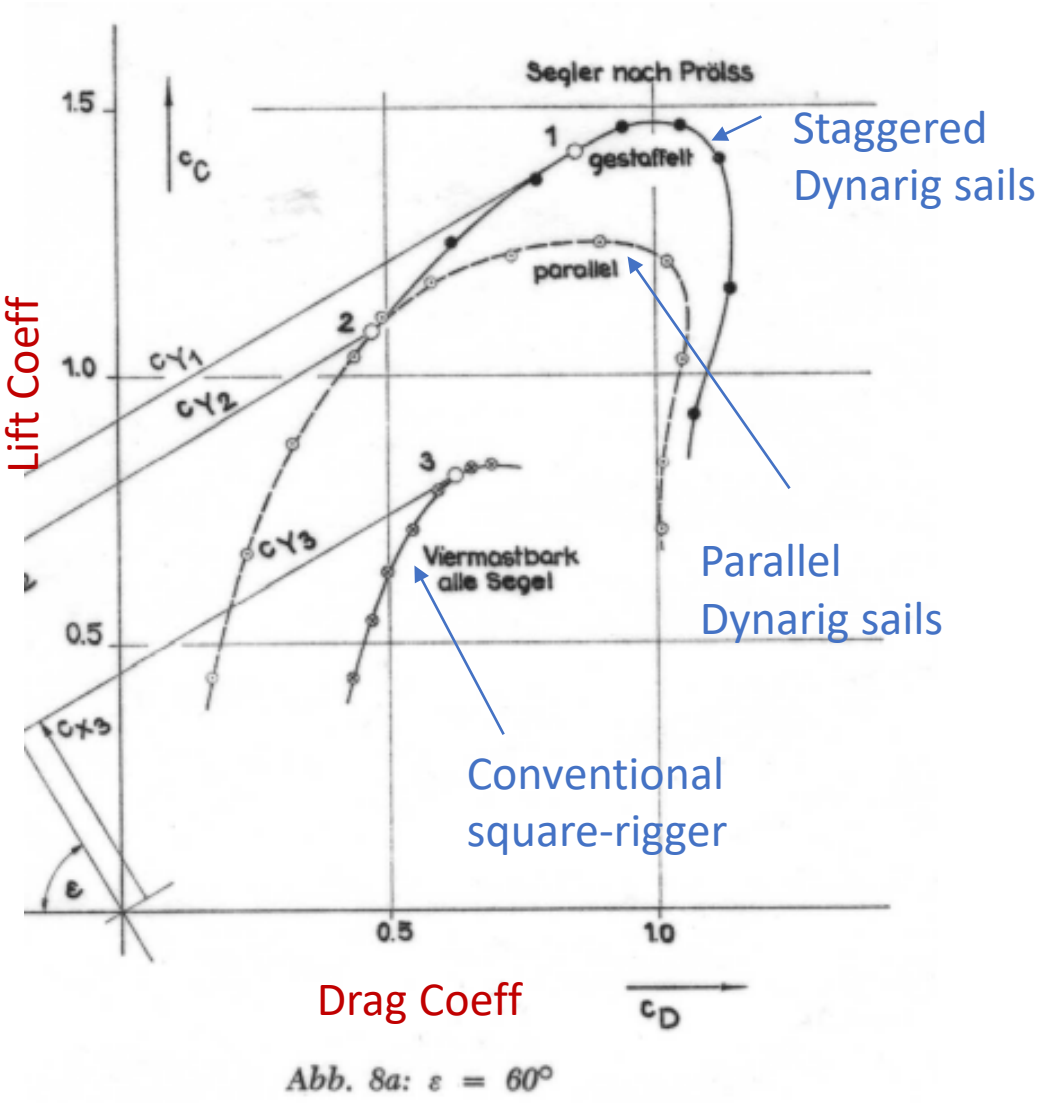



*Abb. 8a: ε = 60°*

# 1975 MARAD Report

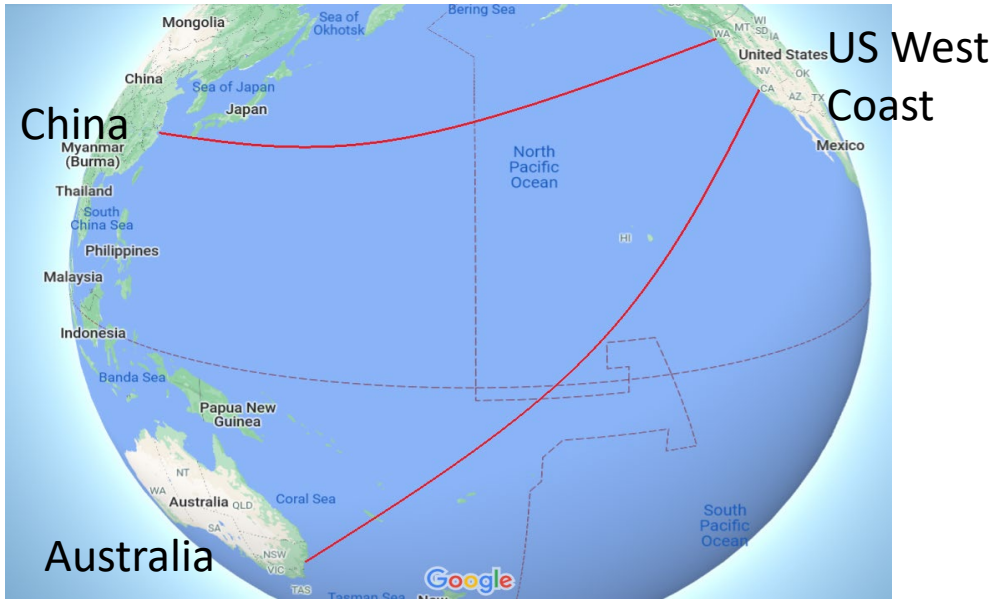
4 Prof. John Woodward, University of Michigan

- Applied Wagner's data to Dynarig sailing vessels
- 15,000 , 30,000 and 45,000 tons cargo deadweight ships
- Computer Program predicted sailing speeds
- Monte-Carlo routine predicted average crossing times and variance in crossing times
- Compared Required Freight Rates of steamships vs. Dynarig sailing vessels

Photo from University of Michigan web site

# Woodward's 1975 Report:

- Simulated 4 routes:


- Auxiliary engines of 600, 1000 and 1200 HP
- Fuel use strategy: turn engines on if sailing speed < 6 knots
- NY-Liverpool: 29 days R/T (sailing ship 15,000 DWT),

  26 days R/T (sailing ship 30,000 DWT)  25 days R/T (45,000 DWT sailing ship)

  Steamship: 21 days

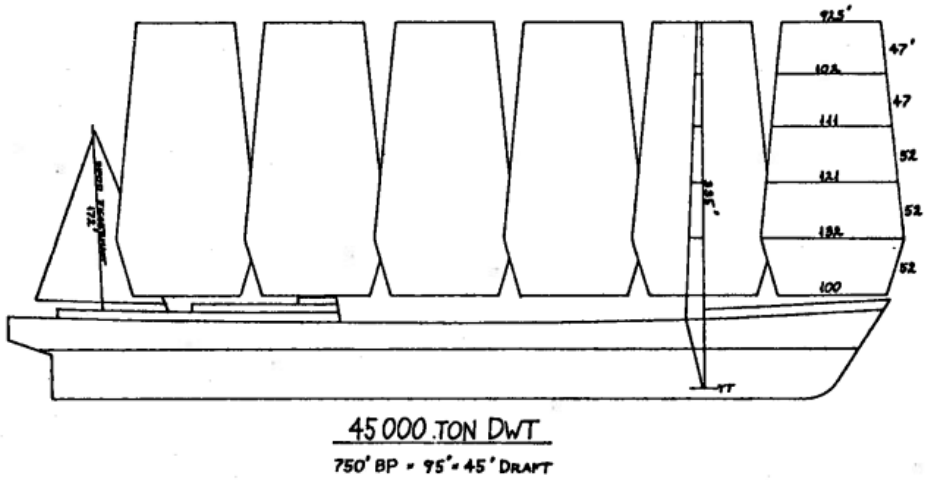
# THE VESSELS

Image from 1975 MARAD Report

250 m LOA

Sail area: 16,638 sq. m

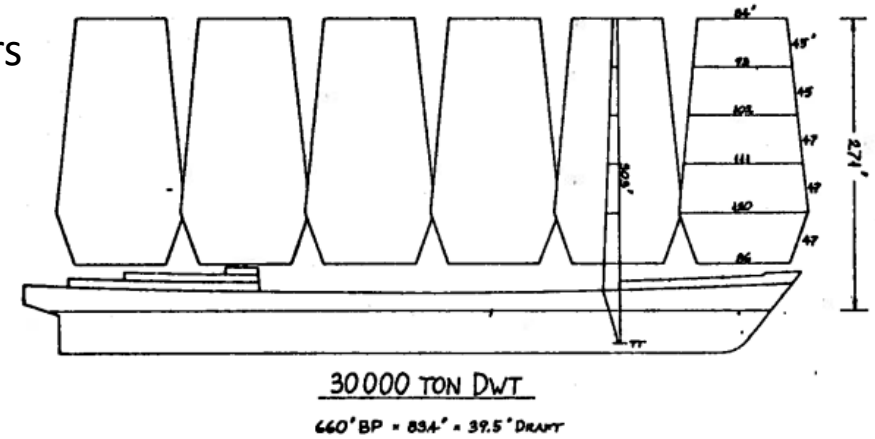
30 crew members (30 steam)




92 m

Sail area: 12,920 sq. m

28 crew members (27 steam)

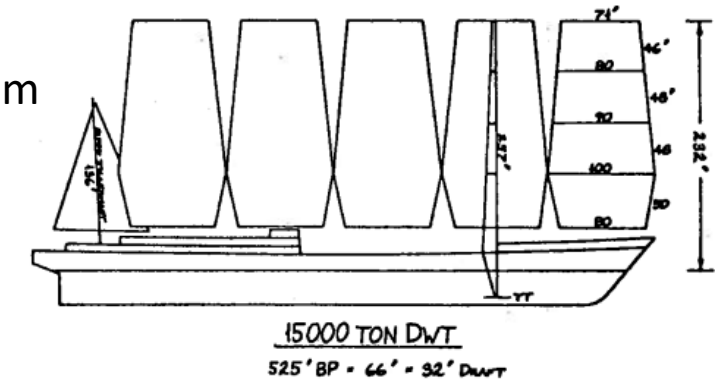



83 m

220 m

Sail area: 8,180 sq. m

28 crew members (24 steam)




71 m

175 m

**Result of 1975 MARAD Study**: bulk cargo ships sailing vessels had a higher required freight rate (RFR) than engine-driven vessels.

**Updating the 1975 MARAD Report**:

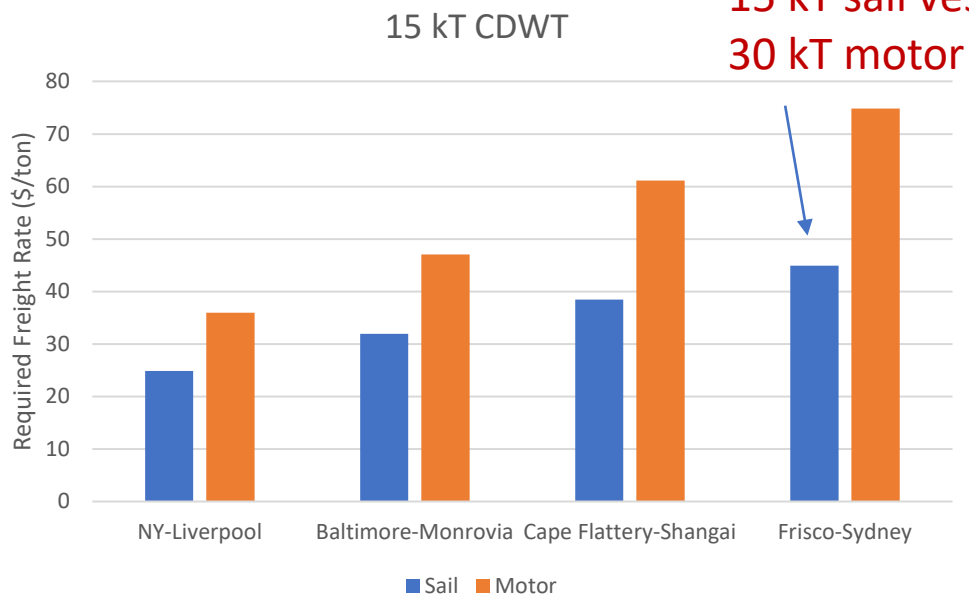
- Use IFO 380 fuel
- Improved fuel efficiency
- Same sailing ship design as 1975 report (Dynarig)
- Chinese manufacture of the vessels, assuming 20% higher construction cost for sailing vessels, as compared to engine-driven vessels. U.S. manufacture also studied.
- Use the 10-year average IFO 380 price ($72/barrel, Rotterdam) to calculate required freight rate (RFR) for sailing and engine-driven vessels.

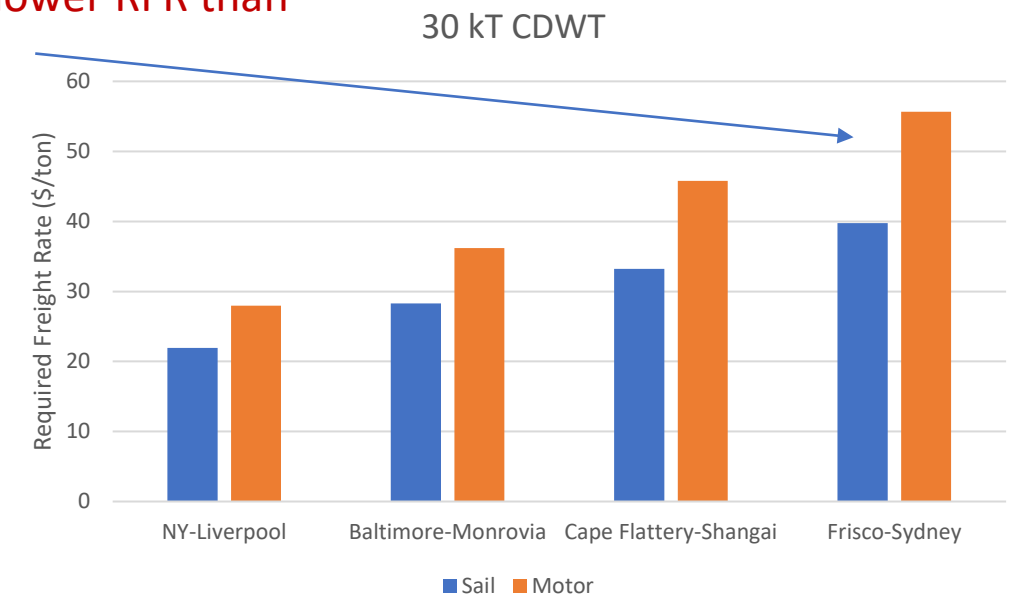
# Updated MARAD 1975 Report, continued

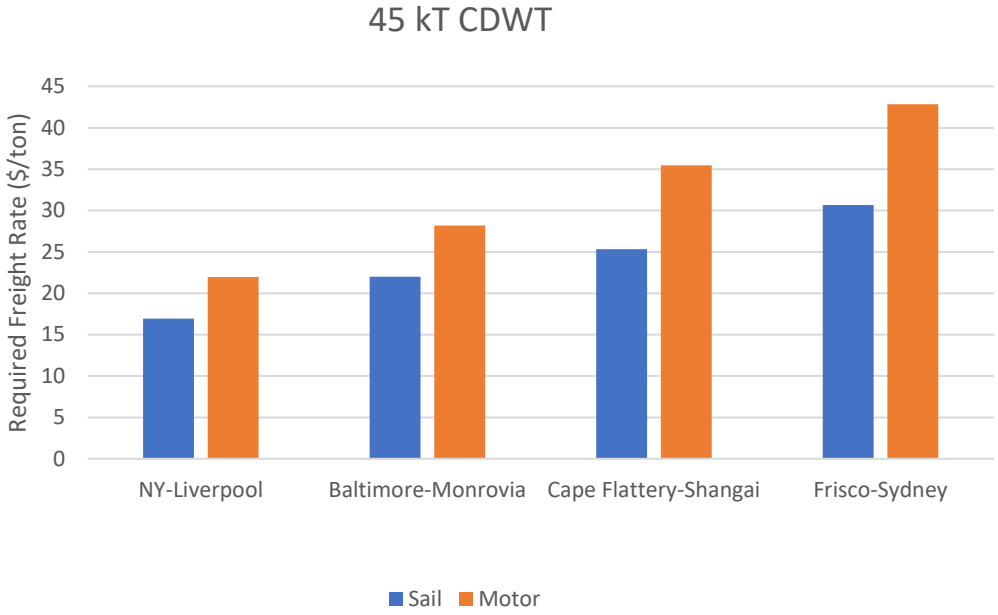
- Updated costs due to crews, sails, stores & lubes, insurance, maintenance and repair, port fees, overhead
- Sails have a 2-year life, with Asian manufacturing cost of $240K  $379K, $489K for the 15, 30 and 45 kDWT vessels.
- Engine-driven ship costs: $11.1 million, $24.45 million and $27.8 million for 15, 30 and 45 kDWT vessels, including scrubbers, based on Chinese manufacture.
- US manufacture was assumed 4 times greater cost.

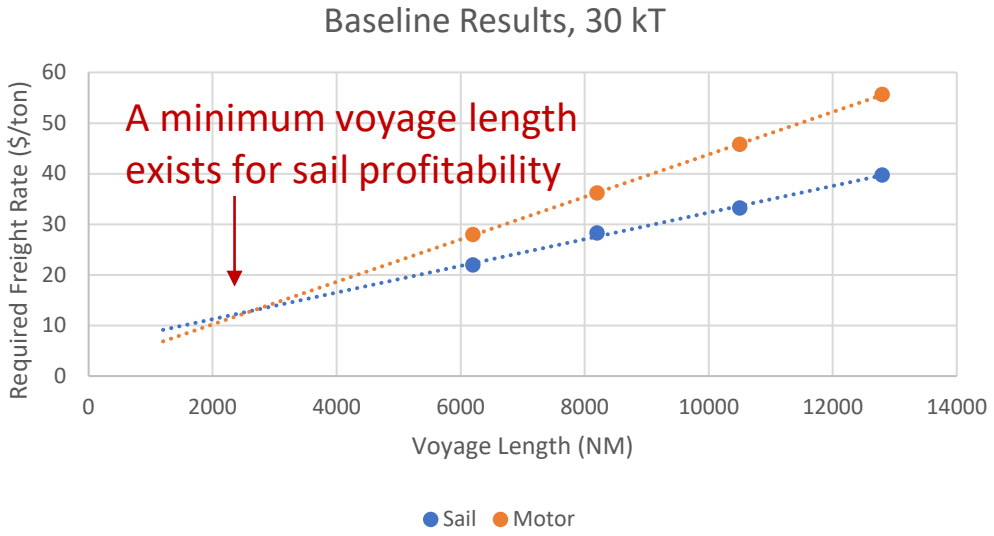
# Analysis using IFO 380 10-year av. price, Asian manufacture

15 kT sail vessel has lower RFR than 30 kT motor vessel !

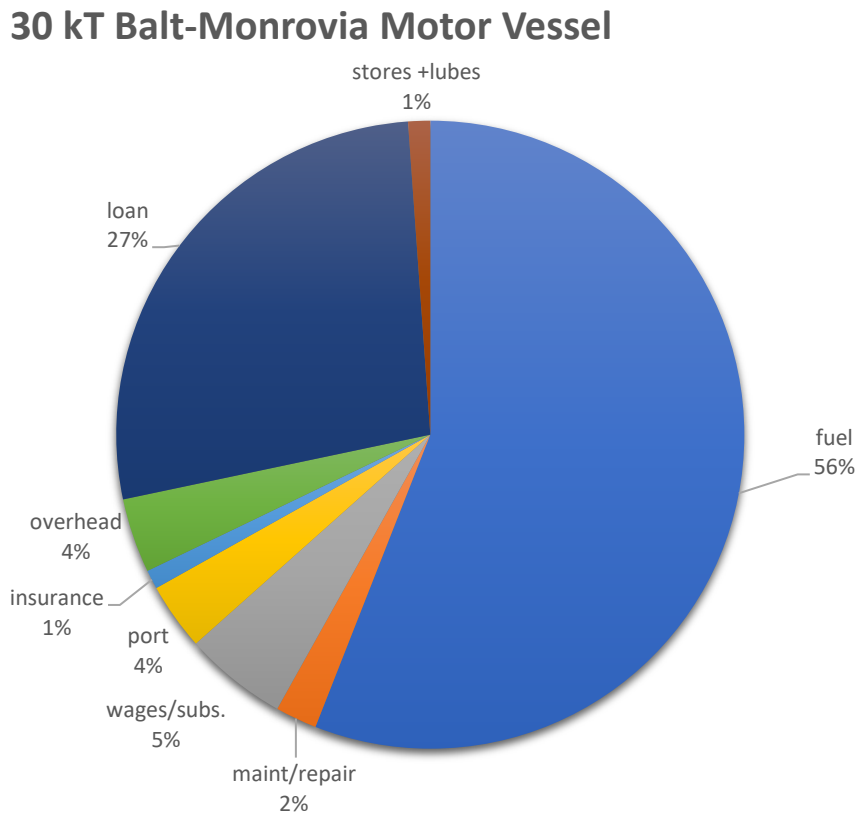


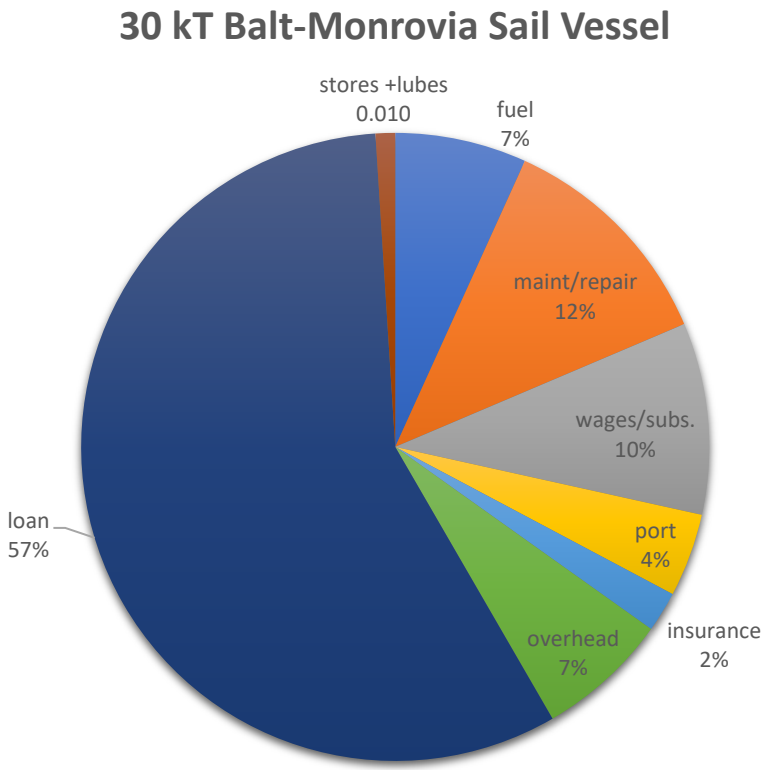



# What affects totals? (plots based on Asian construction, $72/barrel fuel (recent 10 year-av) and 20% higher build cost for sailing vessel)

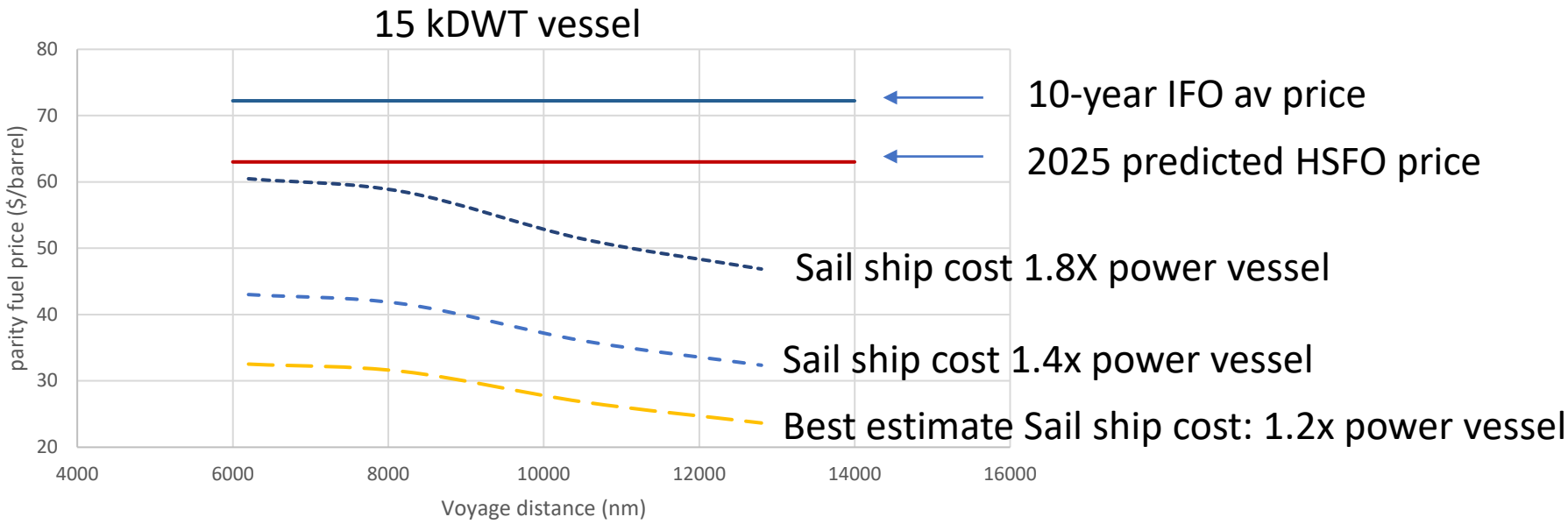


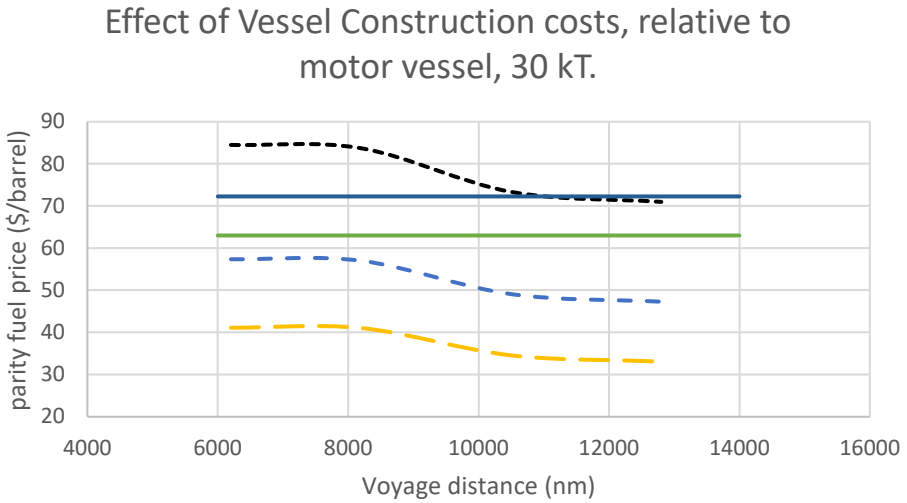



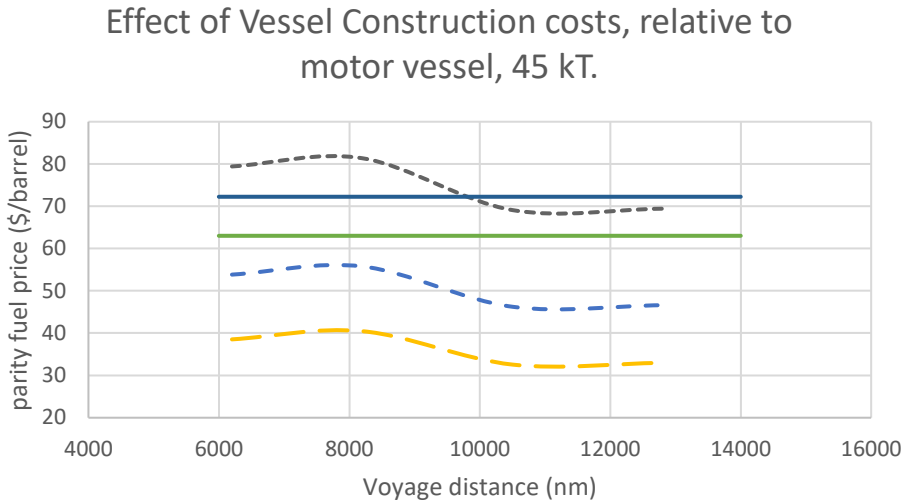
# A better way to analyze: the fuel parity price

- Very high fuel prices tend to favor sailing vessels over power vessels
- Very low fuel prices favor power vessels
- At some fuel price between high and low is a price resulting in equal required freight rates (RFR) for both types of vessels. We call this the fuel parity price.
- We calculated fuel parity prices for each voyage and vessel size, and use it to determine at what fuel price the sailing vessel has the economic advantage.
- Fuel prices greater than parity price favor sailing vessels, while those below favor power vessels.

# Effect of Vessel Construction Costs : what if estimated sailing ship cost is too low? (estimate is 1.2 times power vessel cost)

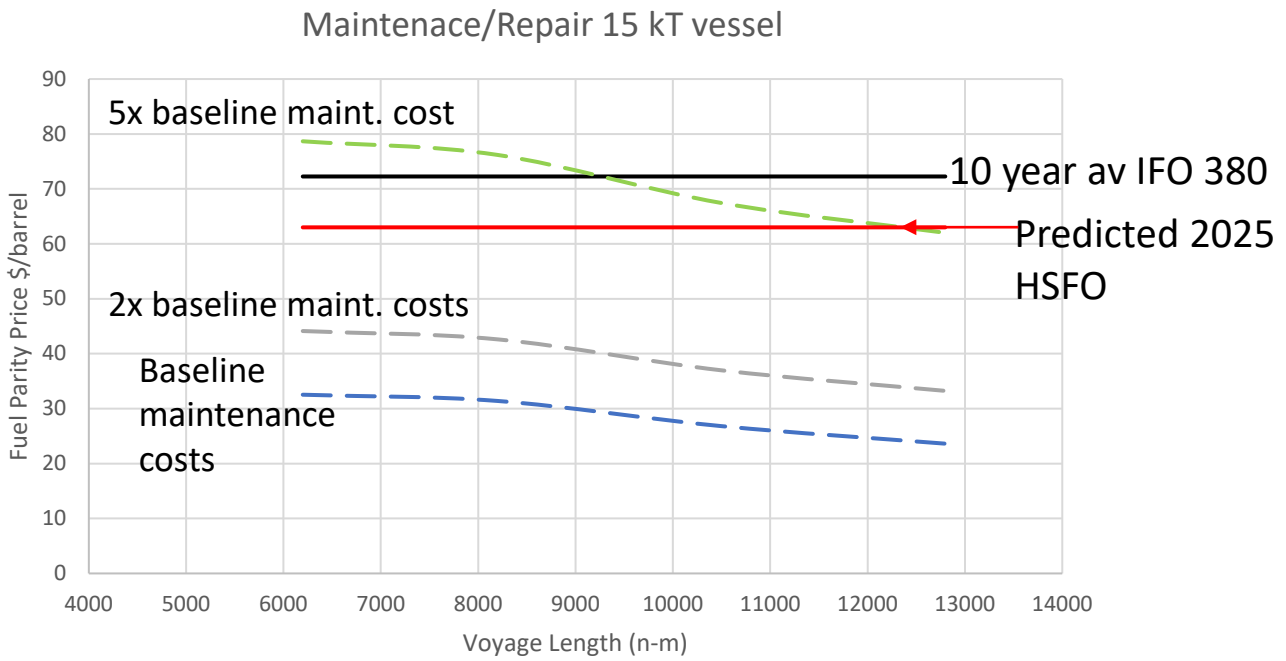


# Effect of Maintenance and Repair costs

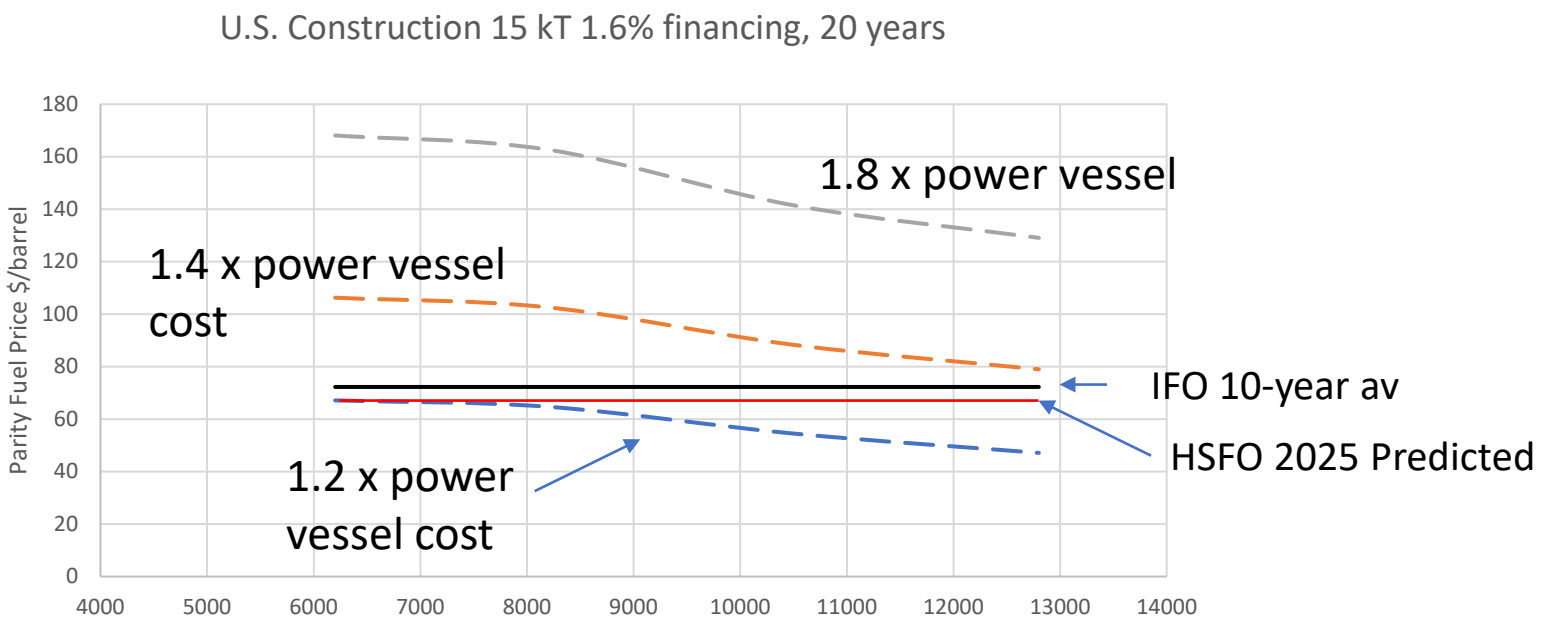
**Fuel prices over dashed lines represent sailing vessel advantage**




- Maintenance includes sail replacement every two years.

# US Construction: 15 kT vessel

Fuel prices over dashed lines represent sailing vessel advantage




With US build, less shield against cost over-runs in sailing vessel build, but still profitable using predicted HSFO prices

## Conclusions

- Based on recent-past HSFO fuel costs as well as on predicted prices, it appears that bulk cargo merchant sailing ships between 15,000 and 45,000 CDWT display a significantly lower required freight rate (RFR) than engine-driven vessels.
- The longer the voyage, the greater the advantage for the sailing vessel.
- There is a voyage length below which sailing vessel is no longer profitable.
- Particularly attractive may be the 15,000 CDWT vessel, which has a lower RFR than the 30,000 CDWT engine-driven vessel.
- More complete economic analysis required: round-trip cargo and delay costs considered, as well as port accessibility.
- Folding/collapsing masts or some other alternatives need to be developed to permit access of more ports (due to air draft).