The Ortomarine Propeller Trial

Dave Jesse

Who am I?

Engineer

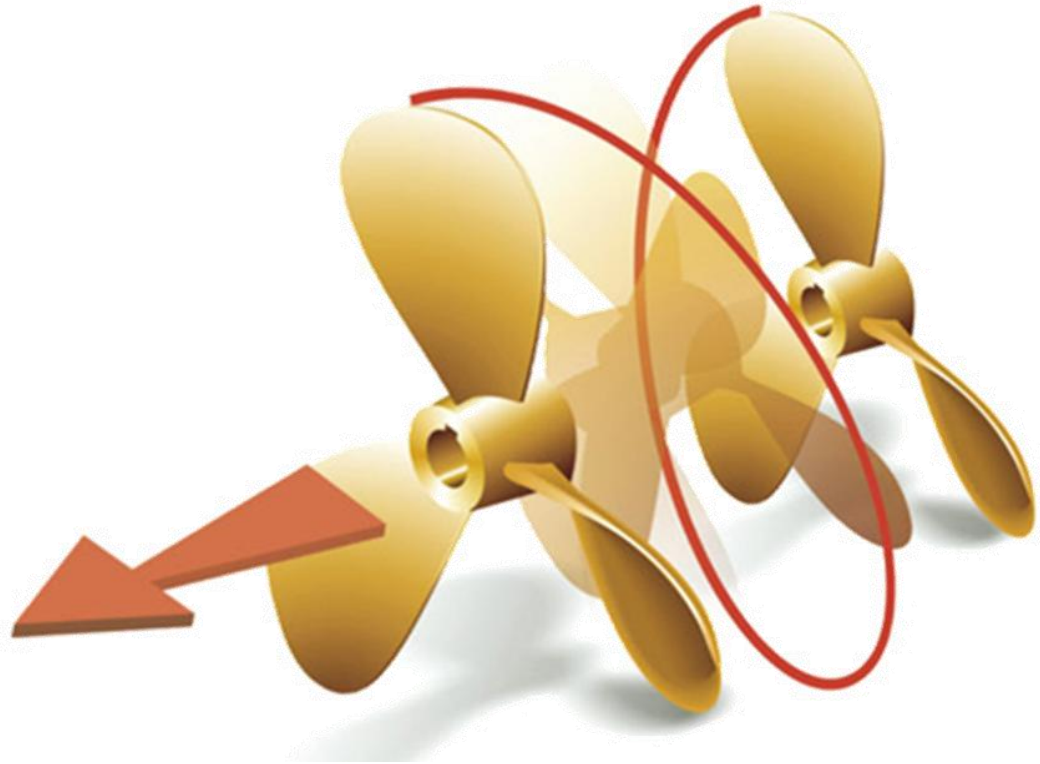
- Chartered Engineer
- Aviation Safety Specialist

Boater

- Father restored dredger “Perseverance” on the Basingstoke Canal
- Renting since 1976
- Ortomariner since 2021

Topics

- Getting Started
- The Propeller Trial
- Results and Analysis
- So What?



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Getting Started

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Engineering Stuff

- Torque is how hard it is to turn

- Propeller Power is:

  Torque x Propeller Speed

  or:

  Electrical Power x Motor Efficiency

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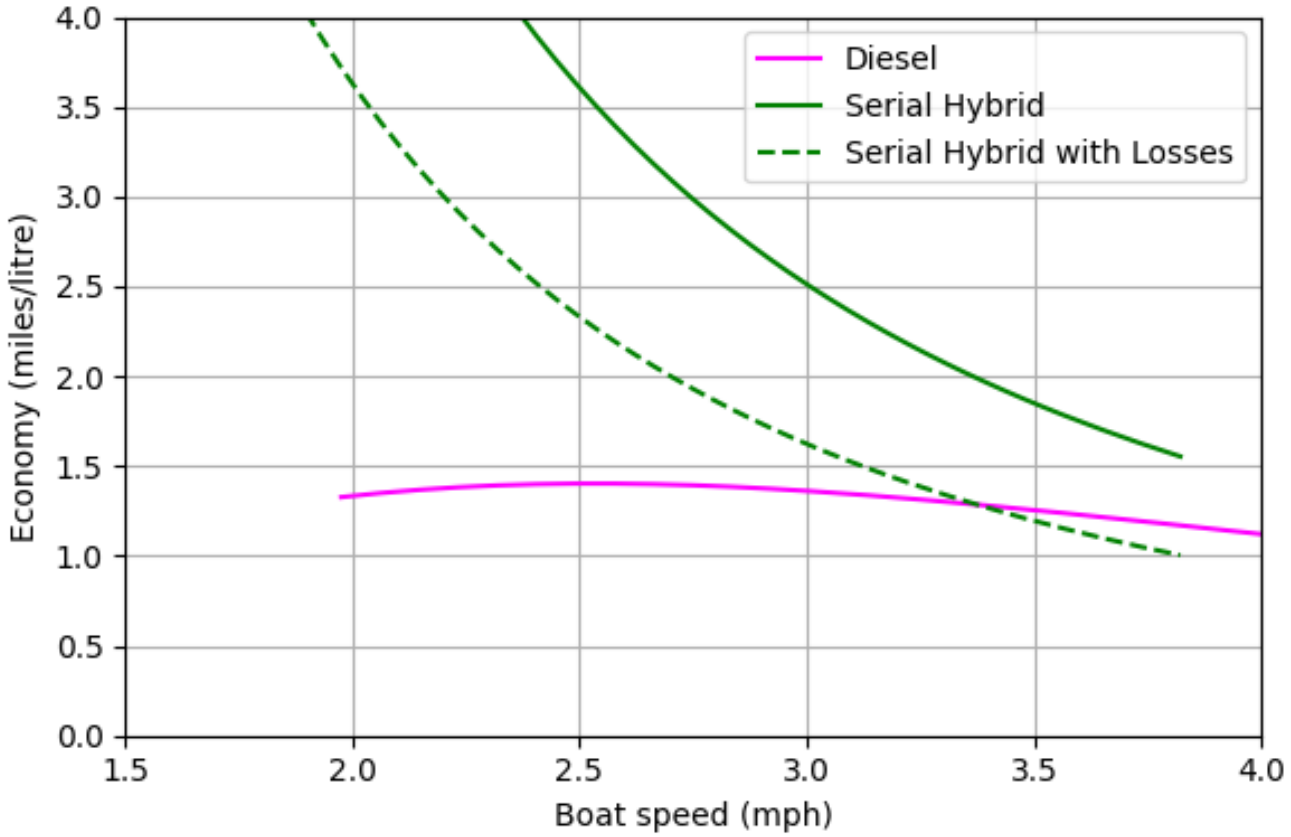
Recap of 2024 Efficiency Talk



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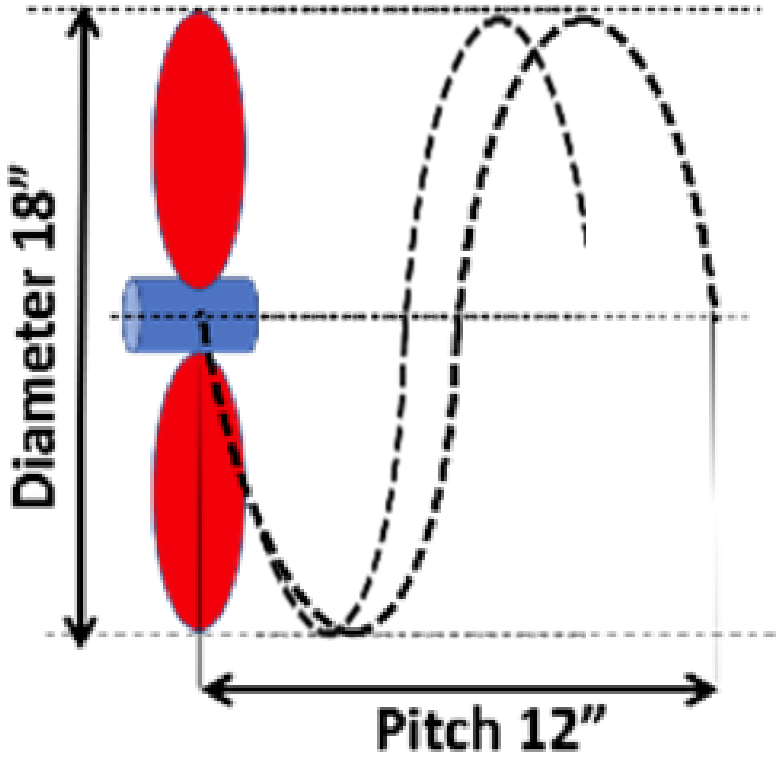
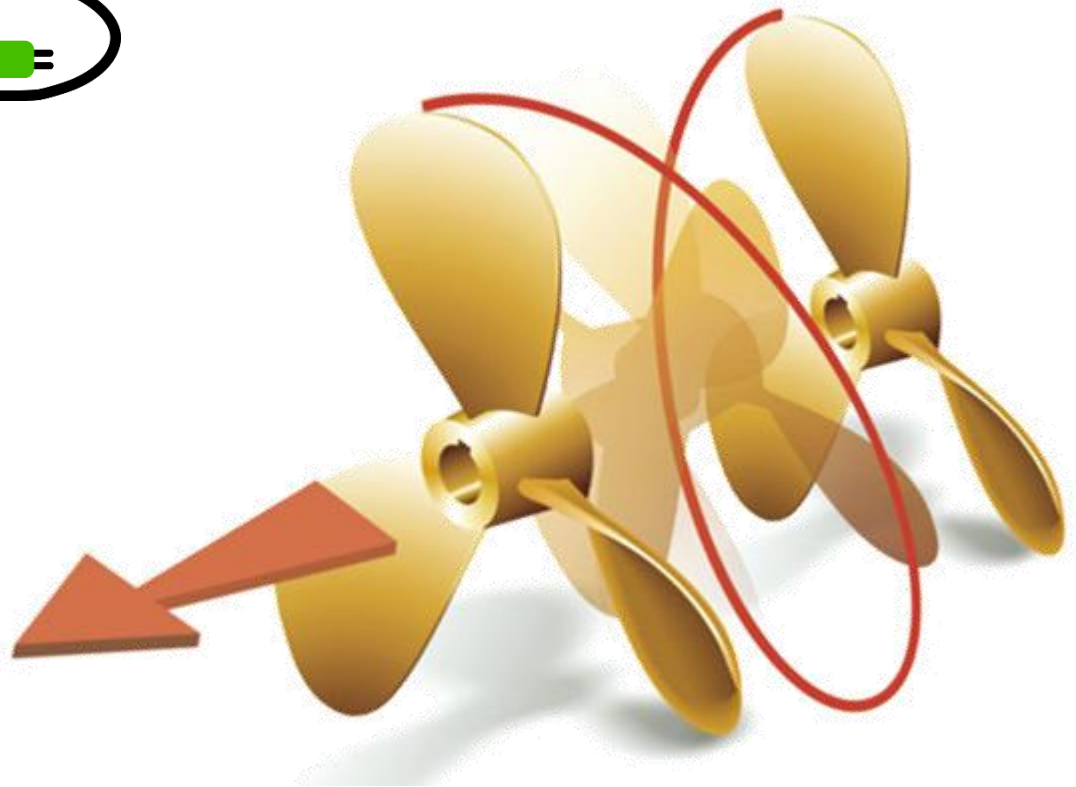
About Propellers



Selecting a Propeller

- Vicprop
  - 62 ft narrowboat
  - 10kW @ 1500 rpm
  - 12.6” x 7.1” 3 Blade
- Perseverance Props
  - 18” x 14” 4 Blade
  - 16” x 8” 4 Blade
  - 18” x 10” 3 Blade
  - 18” x 12” 4 Blade



The Propeller Trial

25th February 2025

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The Propeller Trial

- “Best” propeller for Electric Boating
- Set up by Ortomarine
  - Cafwin Cruisers
  - Droitwich Spa Marina
  - Ortomariners

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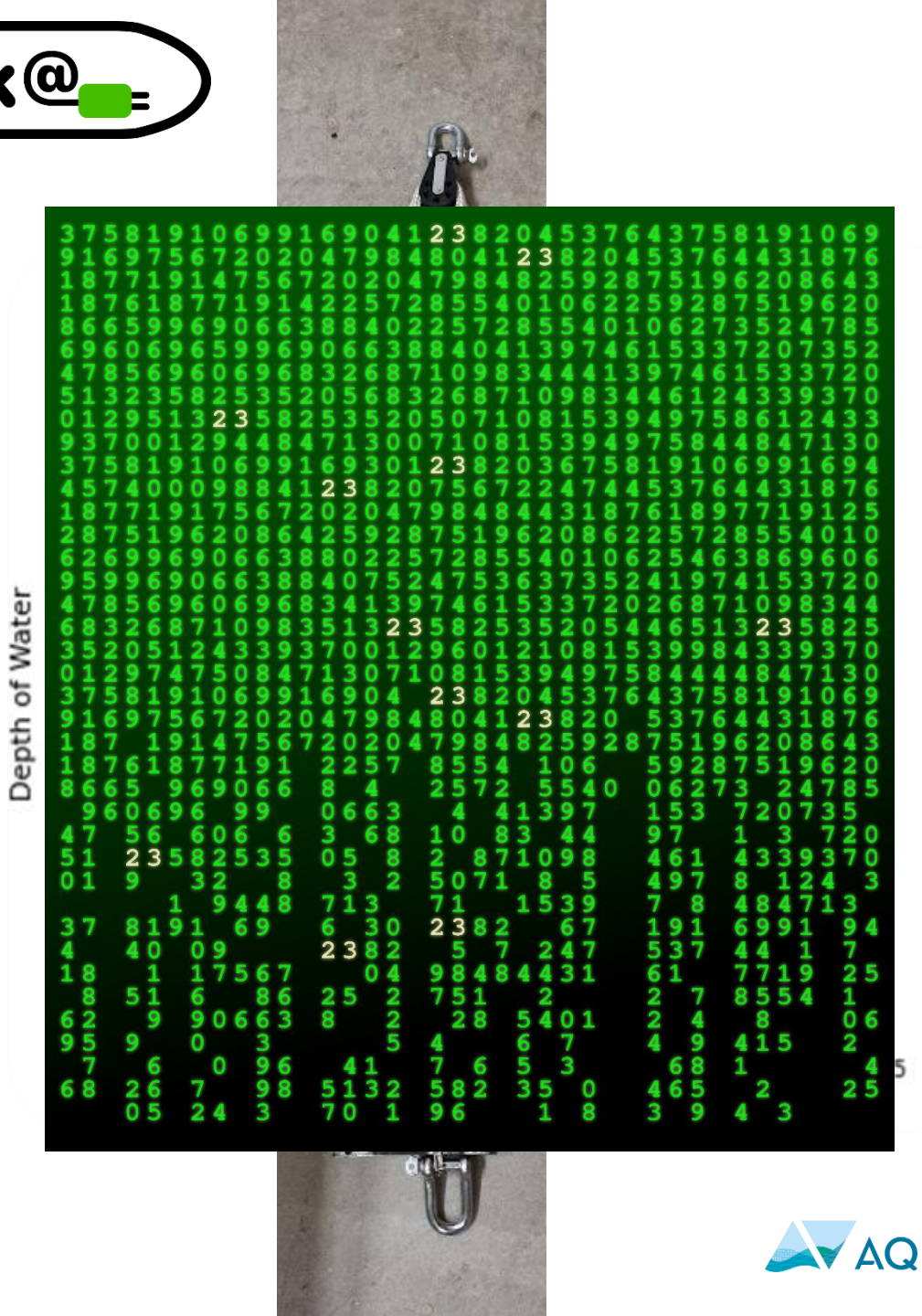
Tests

- Bollard Pull
  - Measure propeller thrust directly
- Cruising Speed
  - Typical operation – 1.5kW selected
- High Speed and Stop
  - Acceleration and Deceleration
- Qualitative Assessment

Instrumentation

- Paddle Wheel Speed Sensor
- Depth Sounder
- Tensiometer
- Digital Recording on board



Propellers

- 16 x 10 (on Ollie Owl already)
- 16 x 12 (Michigan Marine)
- 18 x 10 (Droitwich Marina)
- 18 x 12 (Ortomarine)
- 18 x 20_Ax (Ortomarine - Axiom Prop)
- 19 x 12 (Michigan Marine)
- 19 x 15_4B (Lightning Craft – 4 blades)

Marina Support

- Cruising the length of the marina
- Rapid boat turnround

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Results and Analysis

Bollard Pull

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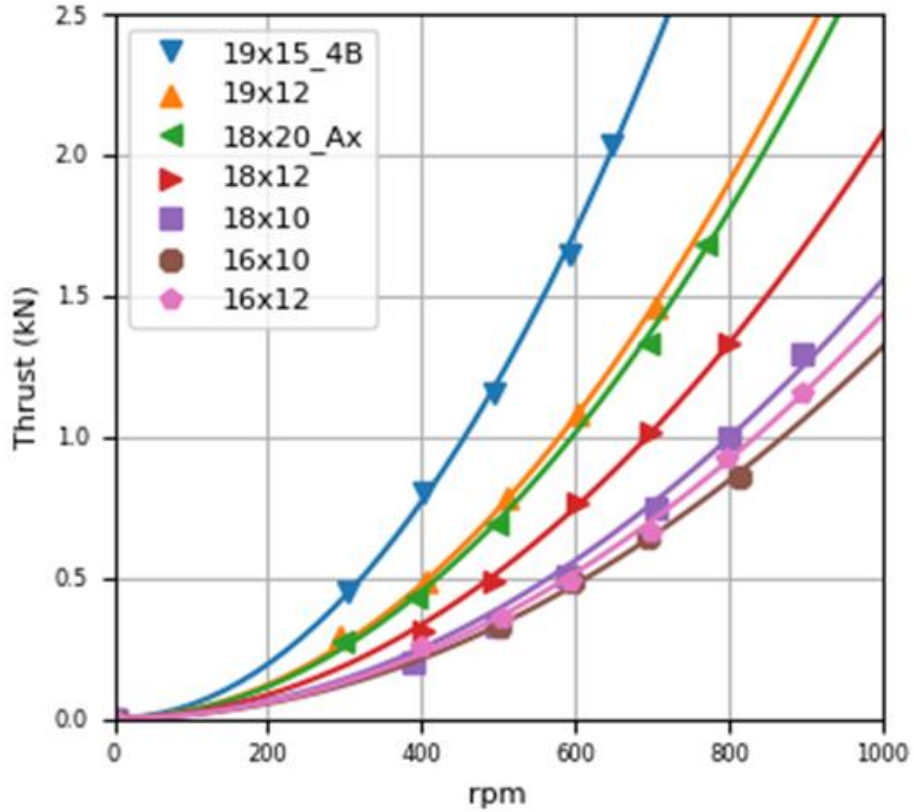
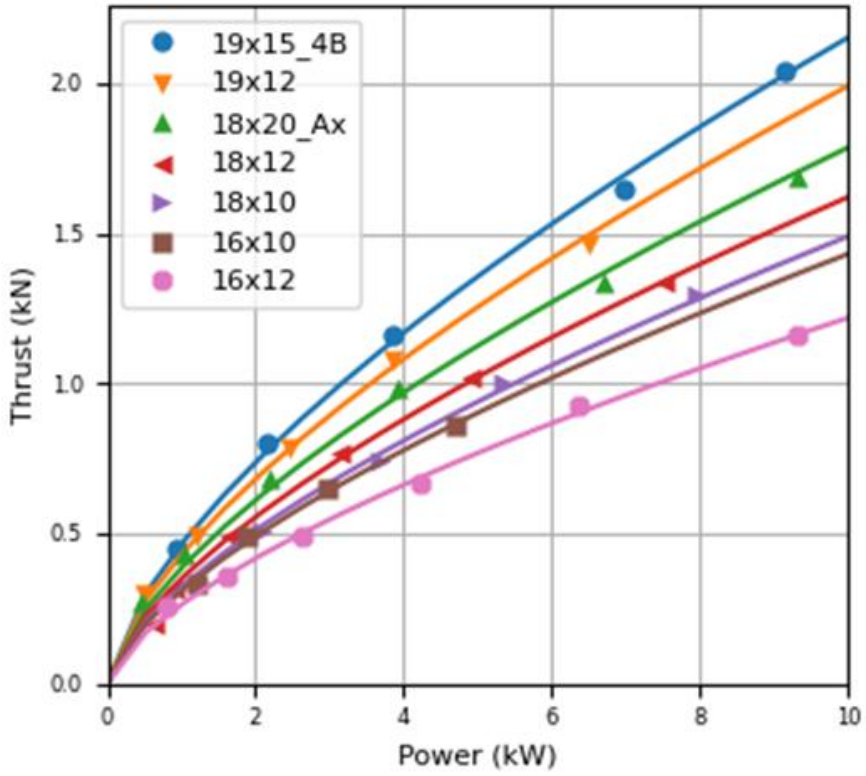
Thrust vs RPM

- Bigger Props give More Thrust
- 2 x RPM = 4 x Thrust



Thrust vs Power

- Bigger Props give More Thrust
- 2 x Power = 1.6 x Thrust
  - 16 x 10 prop is “too good” - perhaps too close to jetty?



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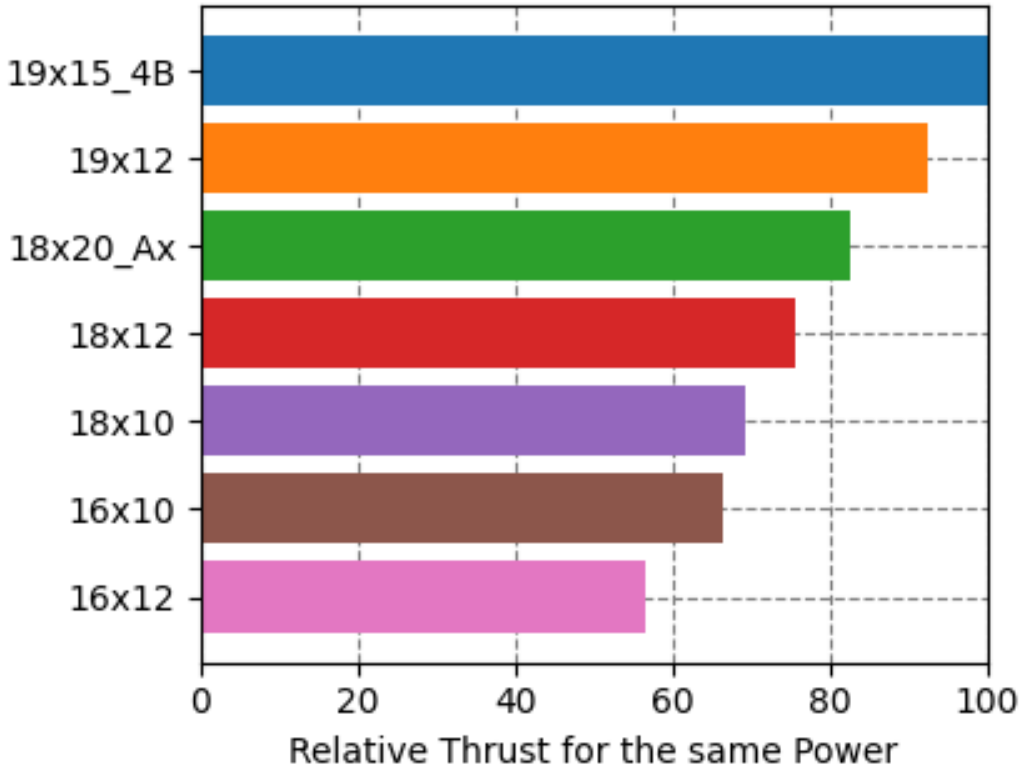
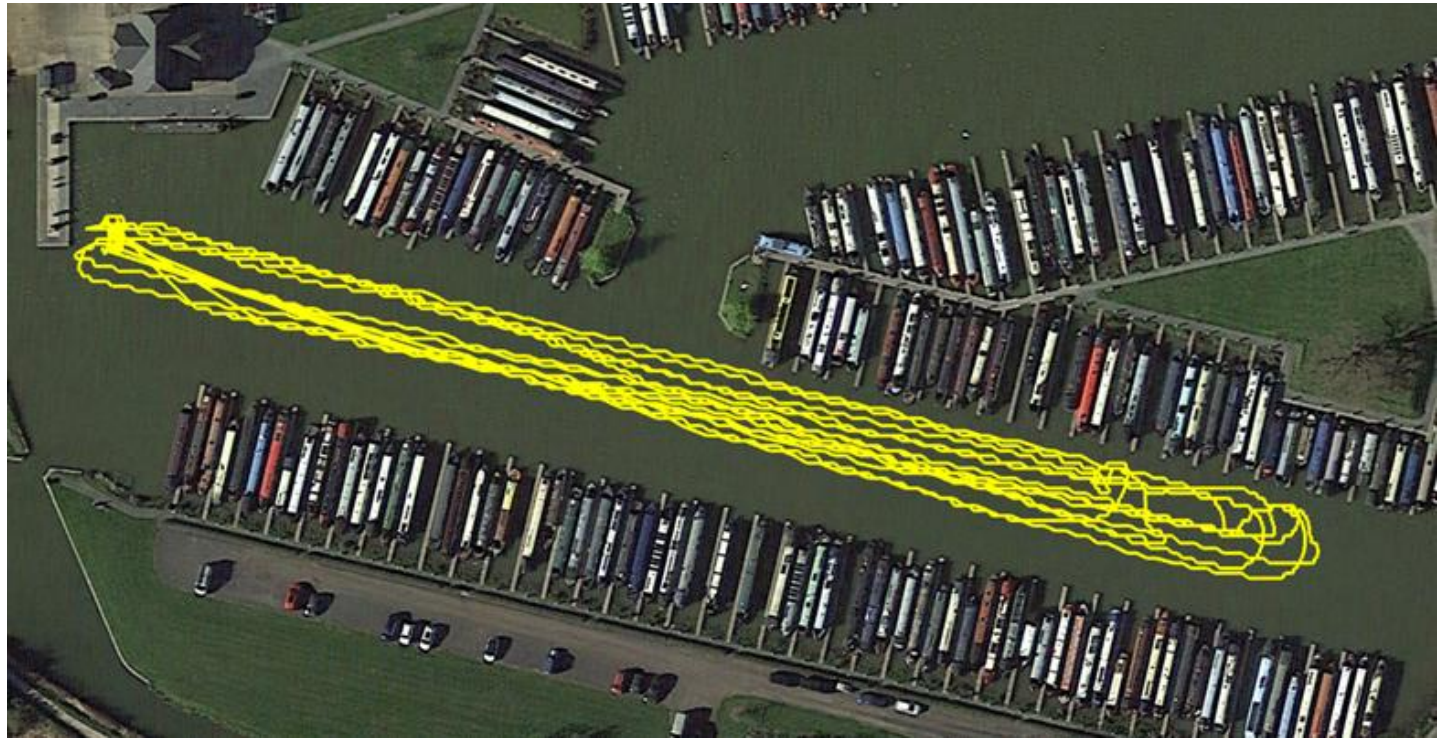
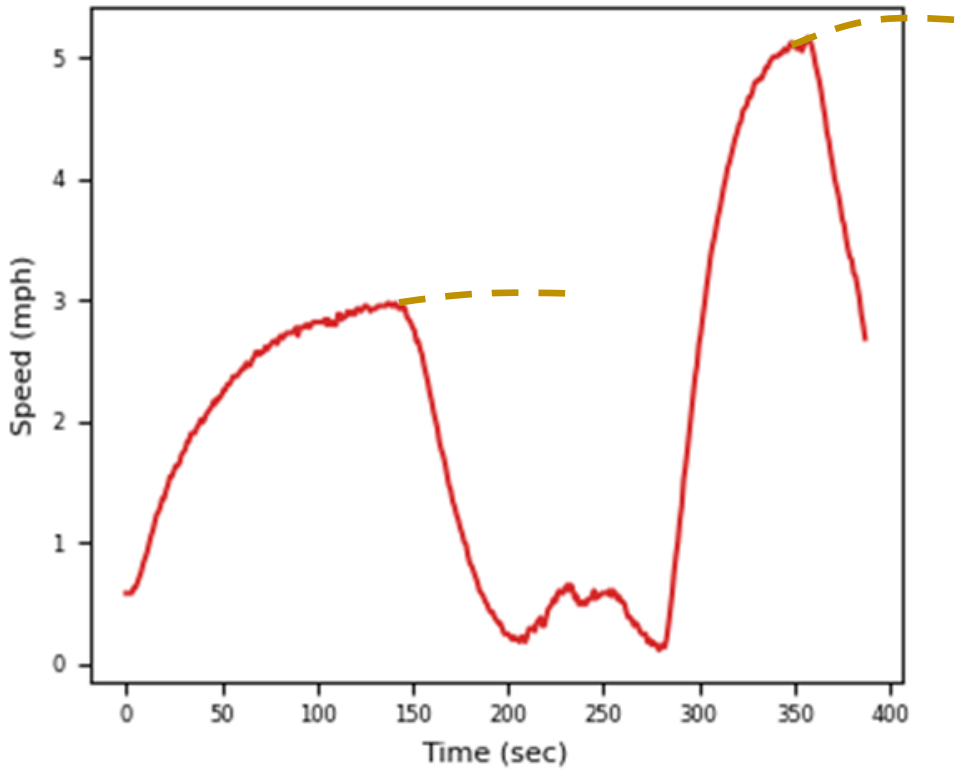
Relative Thrust for Same Power



Cruise & High Speed and Stop Tests





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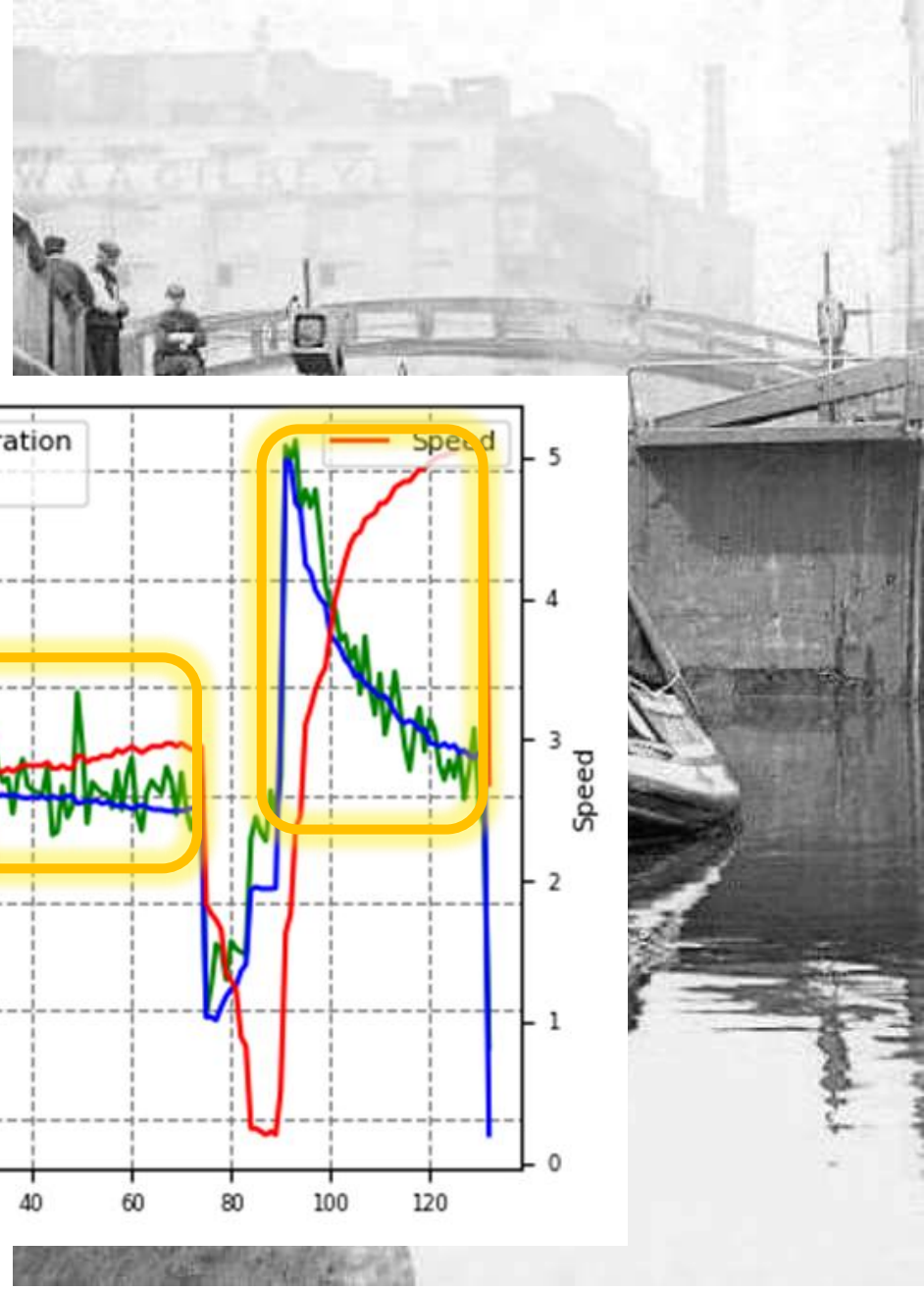
Mathematical Modelling

- Boat Acceleration
  - Thrust from Propeller
    - Propeller Speed & Slip
  - Drag from Hull
    - Boat Speed
- Propeller
  - Propeller Torque > Power
    - Propeller Speed & Slip
- Motor
  - Motor Efficiency > Power
    - Motor Torque
    - Motor Speed



Mathematical Modelling

Boat Speed

Acceleration

Propeller Speed

Propeller Power / Electrical Power

Propeller Torque

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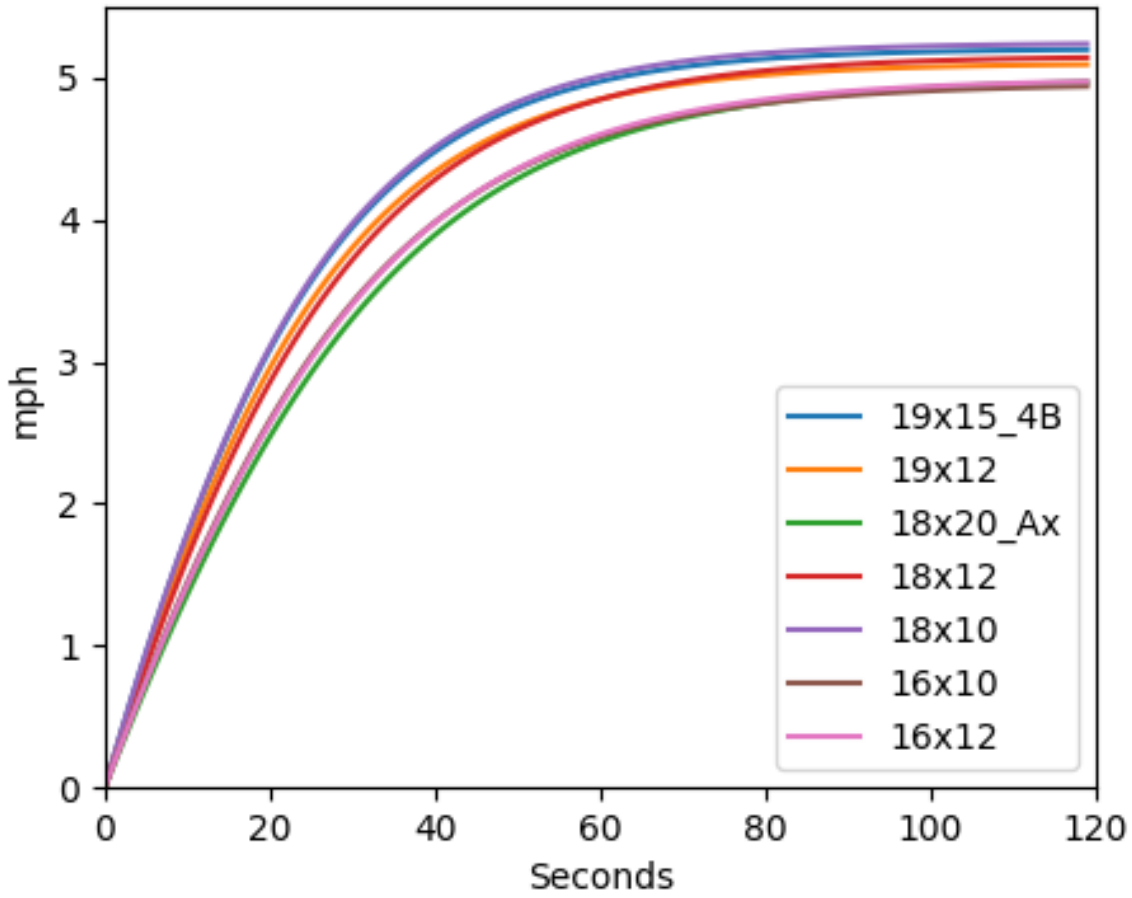
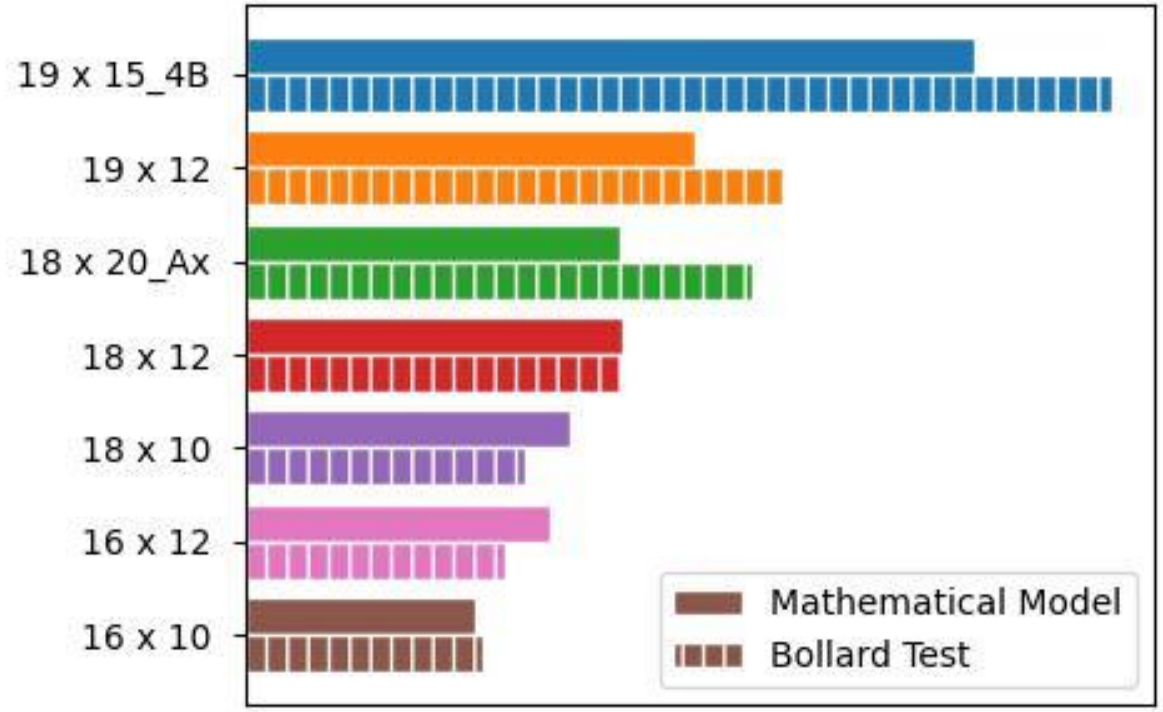
Modelled Acceleration – Any Power, Any Distance



Comparing Propeller Thrust - Model vs Bollard



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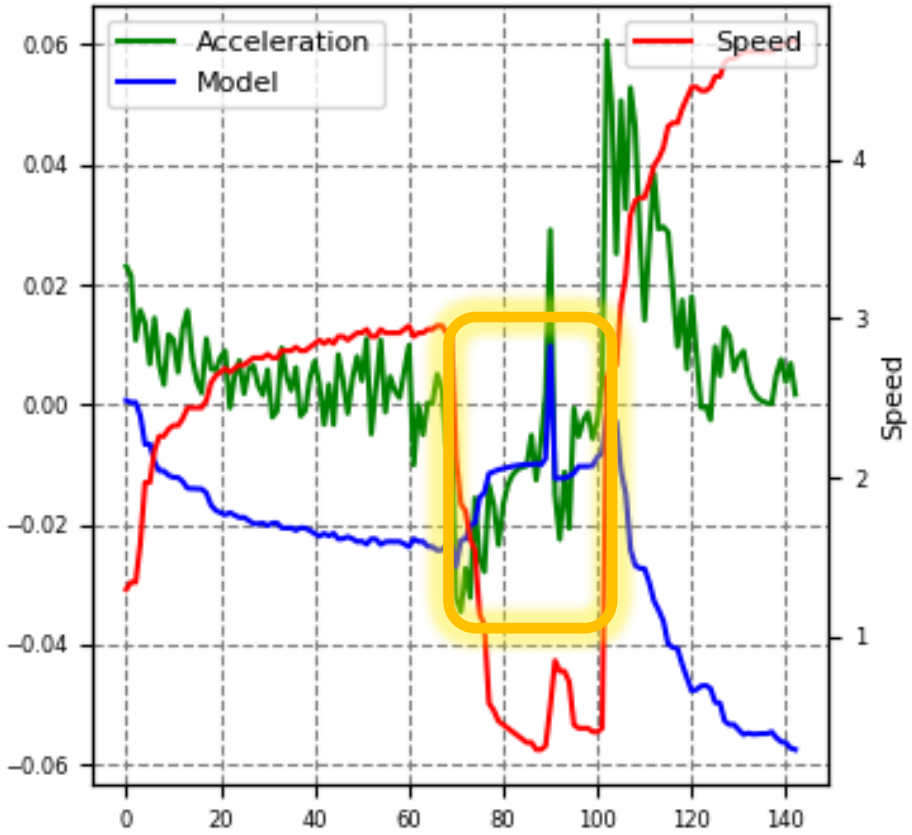
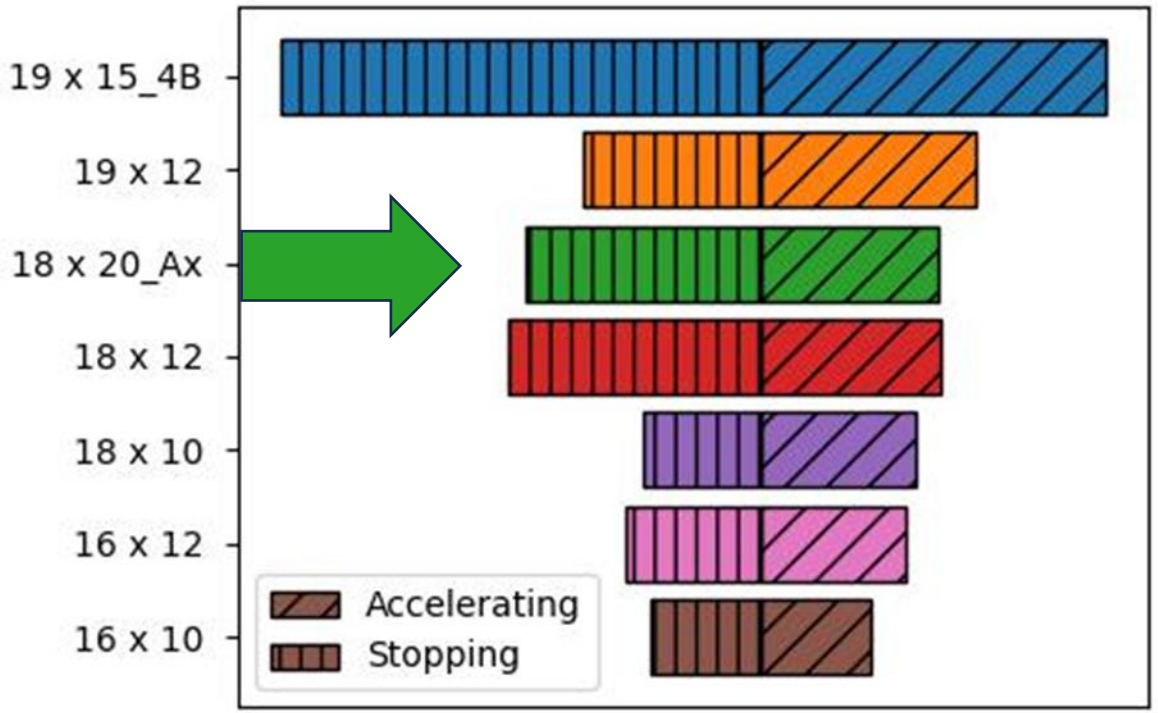
Stopping Performance





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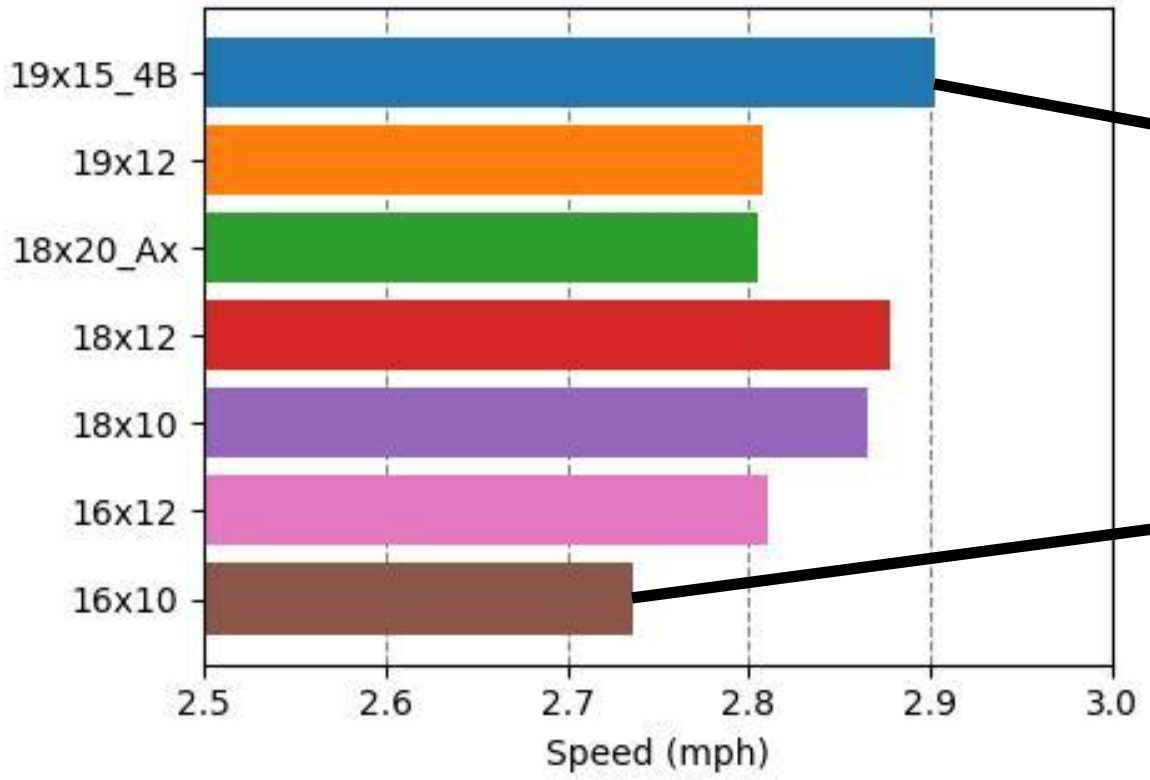
Ask the Model

- How fast will the boat go at 1.5kW?
- If I set 450 rpm, what speed will I get?
- How much power do I need to cruise at 2.5 mph?
- What is the best acceleration from standstill?
- What is the motor efficiency at 2 mph?

Speed for 1.5 kW Electrical Power



Diameter	Pitch 10	12	15	20
19		2.81	2.9	
18	2.87	2.88		2.8
16	2.74	2.81		

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The Dark Side…

		Pitch			
		10	12	15	20
Diameter	19		3.01	3.81	
	18	2.54	2.86		3.09
	16	2.28	2.67		

450 rpm

		Pitch			
		10	12	15	20
Diameter	19		2.81	2.9	
	18	2.87	2.88		2.8
	16	2.74	2.81		

1.5 kW

Larger props turn more slowly
…motor efficiency drops,
…less power to propeller

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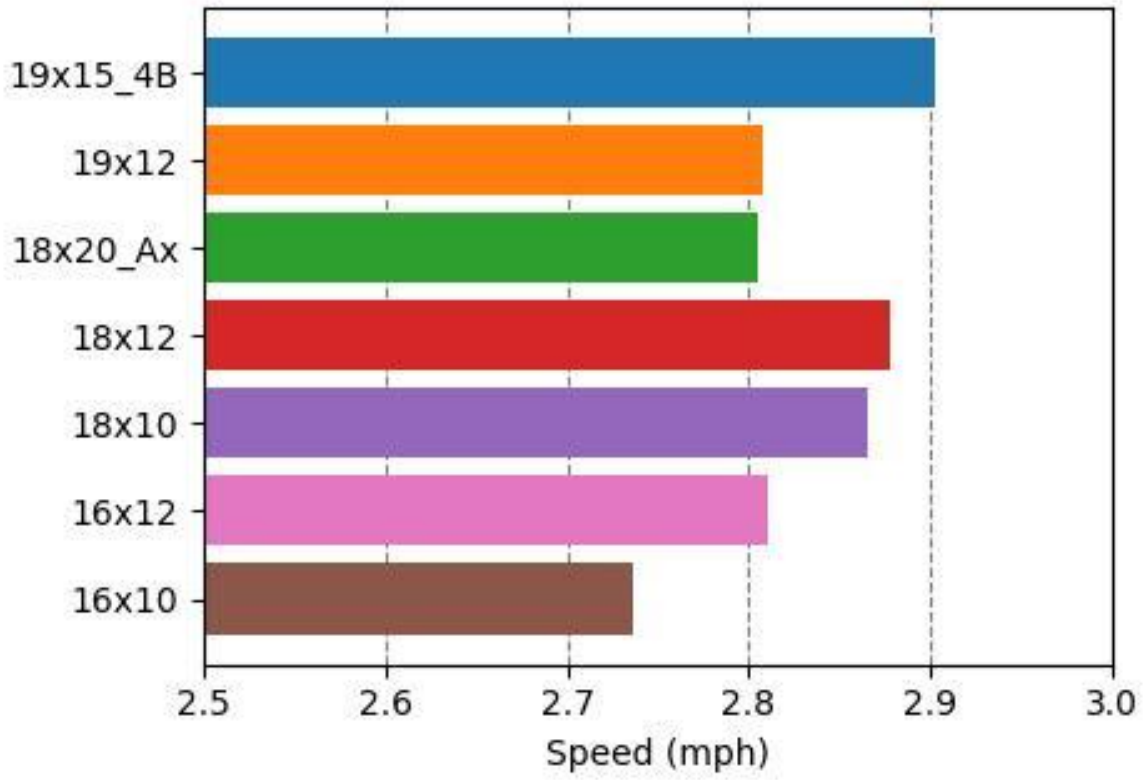
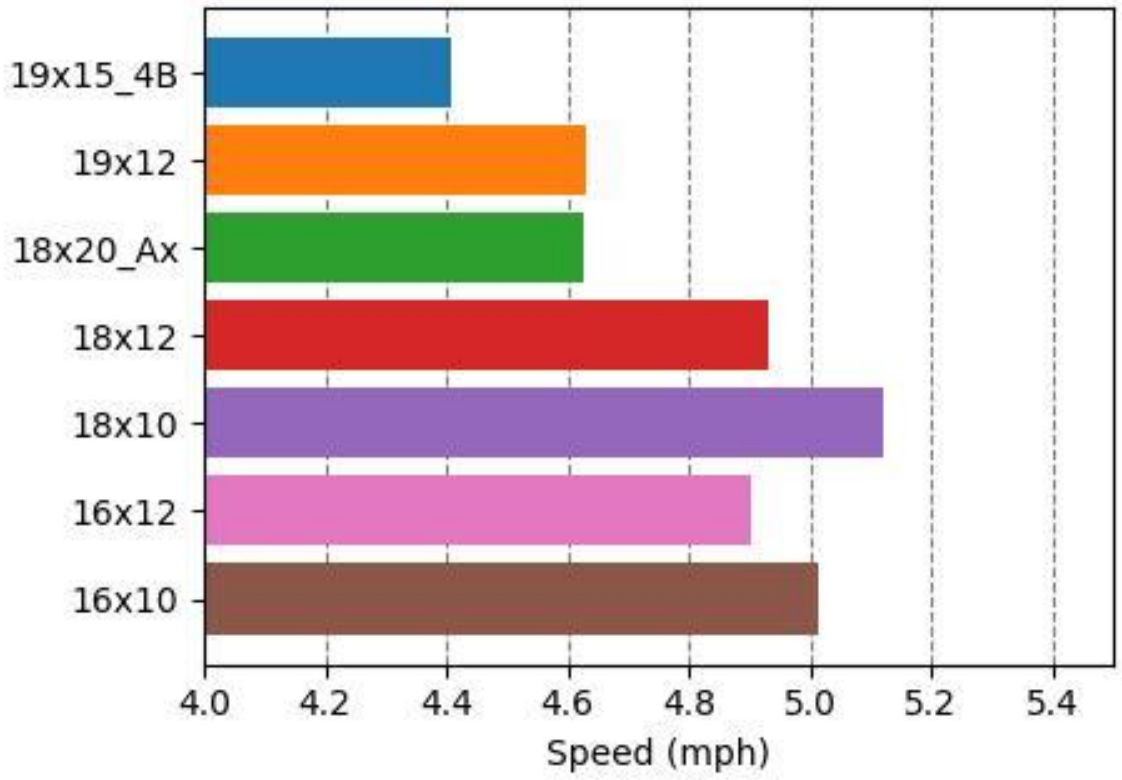
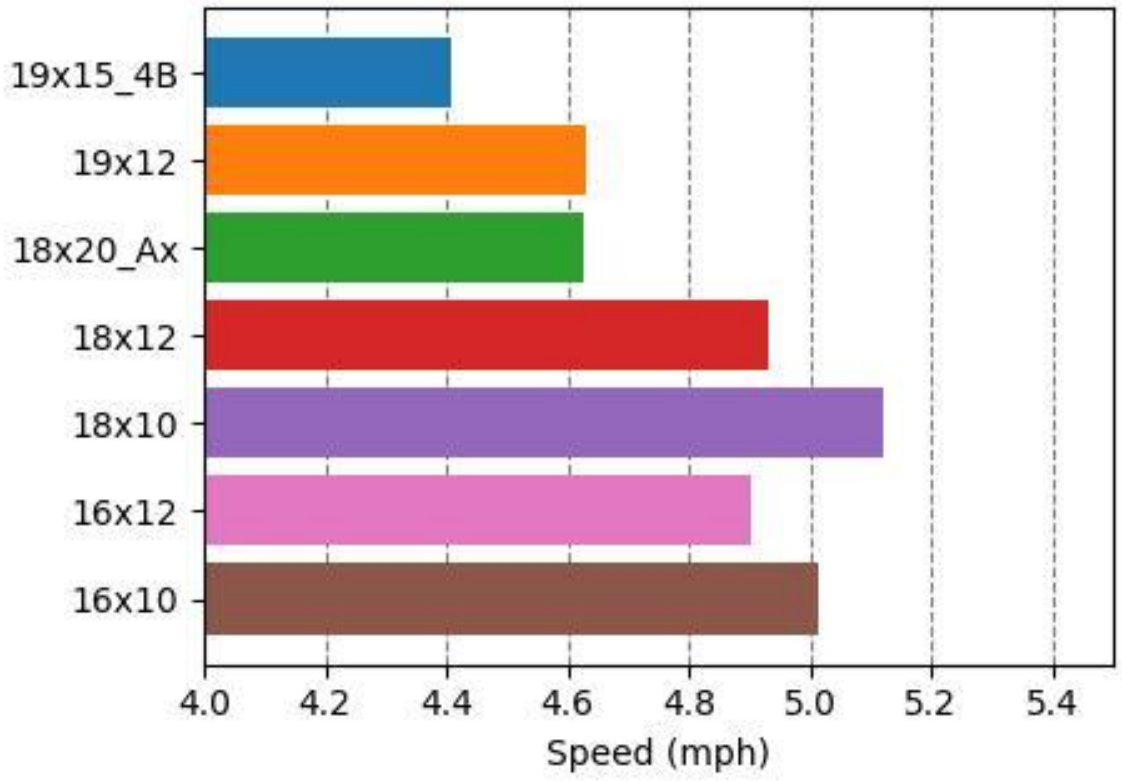
Speed for 1.5 kW Electrical Power



Speed for 10 kW



Speed for ~~10 kW~~ 70 Nm Torque



- No prop reaches 10kW at this torque limit
- 19x15 4-blade:
  - 5.6 kW
  - 521 rpm
  - Motor efficiency 69%
- 16 x 10:
  - 9.3 kW
  - 987 rpm
  - Motor efficiency 78%

Prop	Noise and Vibration	Acceleration, Deceleration & Handling
19 x 15 4-blade	Noisy at 650 rpm, throttled back at 750 rpm	Felt much more power
19 x 12	780 rpm throttled down because of vibration	Both good
18 x 20 (Axiom)	Large growl, vibration at 800 rpm	Handling poorer than others
18 x 12	Little noise at 1.5kw, Lot of noise on fast run.	Handled well.
18 x 10	Whine at 600 rpm, bad vibration at 800 rpm	Felt slow
16 x 12	800 rpm gravelly vibration	Steering not as responsive
16 x 10	Very quiet	Acceleration not great

So What?

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Trial Results

- “Smaller” props are
  - Slower for given power
  - Poorer handling
  - Can match motors better
- “Bigger” props are
  - Faster for given power
  - Better handling
  - More likely to reach motor torque limits

- “Excessive” props are harsh
- The Axiom prop did not perform well

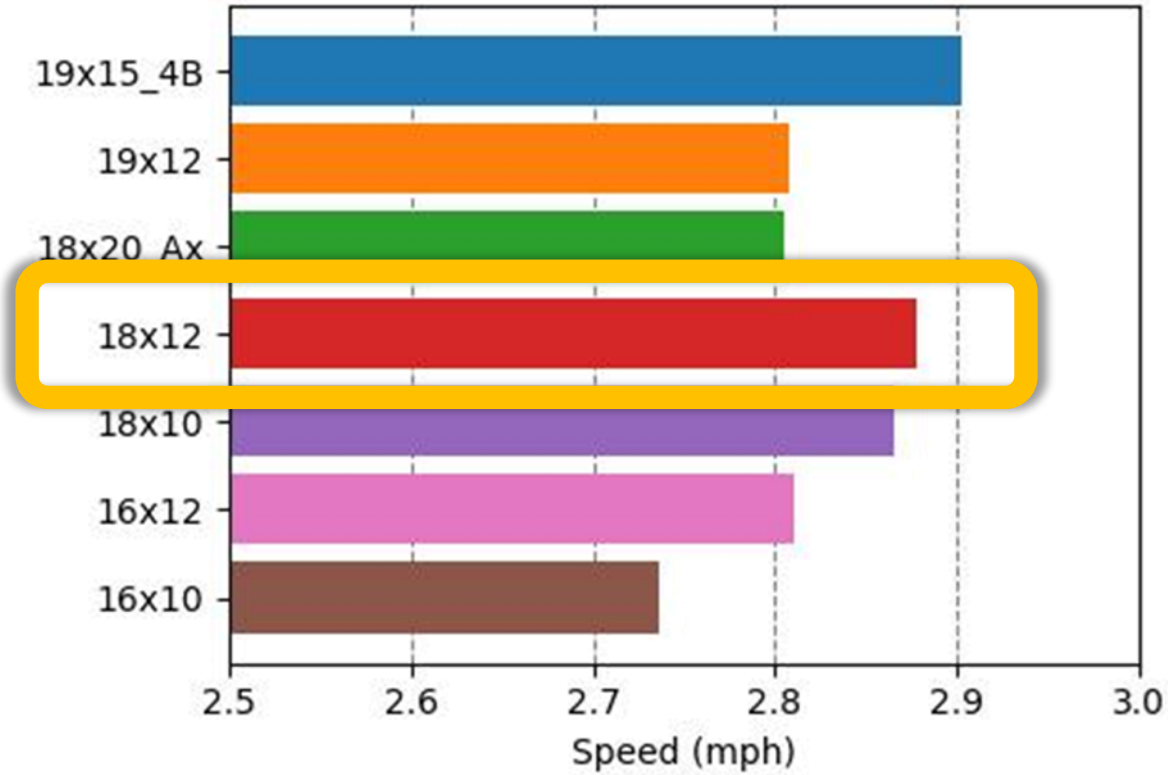
Conclusion

- Propeller selection for electric narrowboats must consider
  - ✓Hull clearance
  - ✓Thrust required for good handling
  - ✓Motor torque limits
  - ✓Motor efficiency at cruise conditions
  - ✓Required maximum speed and power

Finally…

- Olly Owl now has 18 x 12 prop
  - Cruise at 2.9 mph (1.5 kW)
  - “Very quiet”
  - “Handled well”

- *NOT* the fastest option




That's all Folks!

The Mathematical Model

Boat Speed
U

Propeller Speed
N

Propeller/Motor Torque
Q

Motor Mechanical Power
P_p

Motor Electrical Power
P_e

Bollard Pull Tension
$T = k_0 N^2$

"Advance Ratio"
$J = \frac{U}{N\theta}$

Acceleration
$A = k_2 N^2 (1 - J) + k_b U^2$

Power to the Propeller
$P_p = k_1 N^3 (1 - \alpha J) = 2\pi N Q$

Motor Efficiency
$\eta = m_0 + m_1 N + m_2 Q = \frac{P_p}{P_e}$

Propeller Constants
k_0, k_1, k_2

Propeller Pitch
θ

Torque Reduction with no slip
α

Boat Drag Term
k_b

Motor Coefficients
m_0, m_1, m_2

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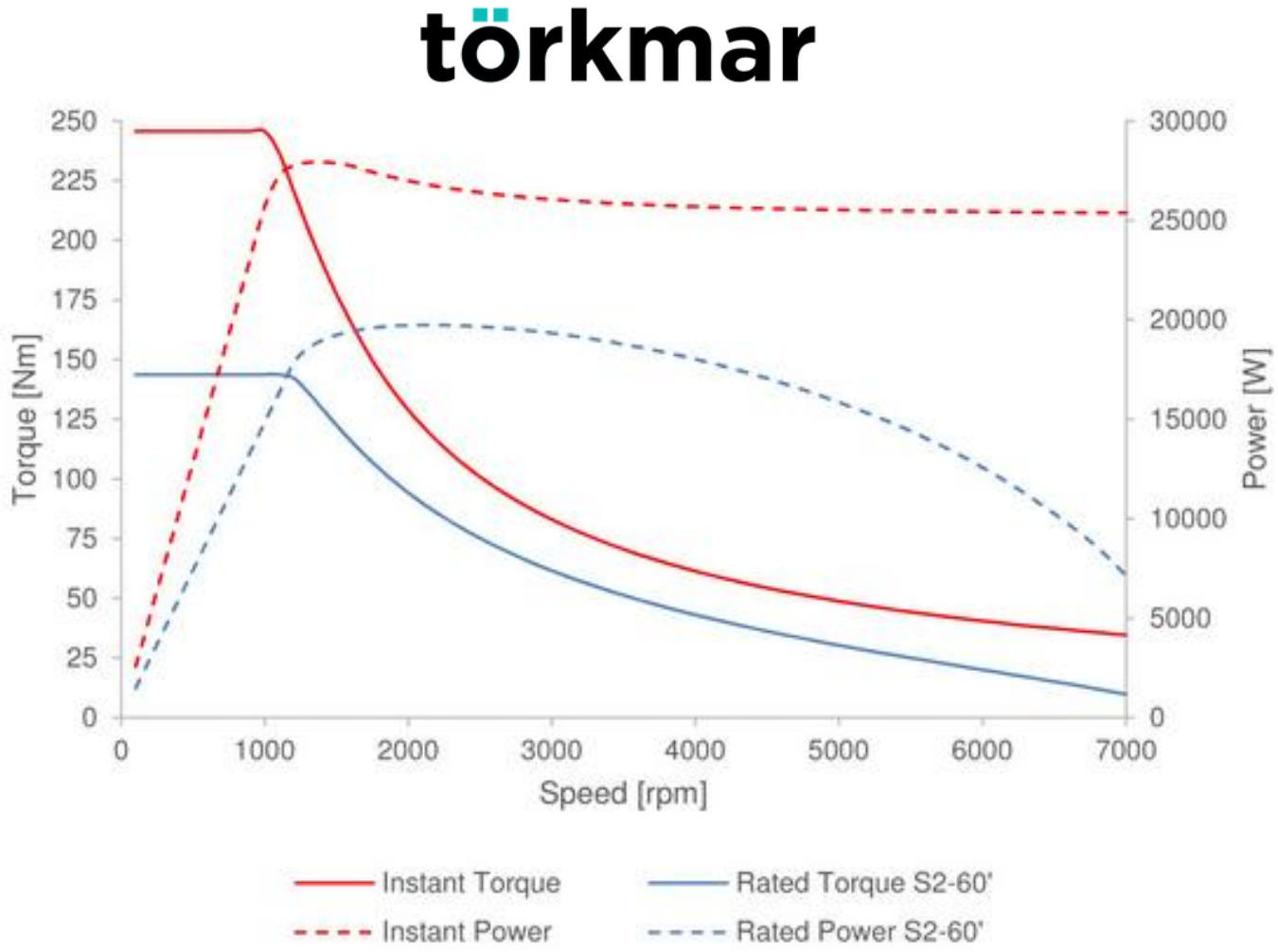
Motor Ratings

- Often quoted as power
- Normally torque limited at narrowboat speeds



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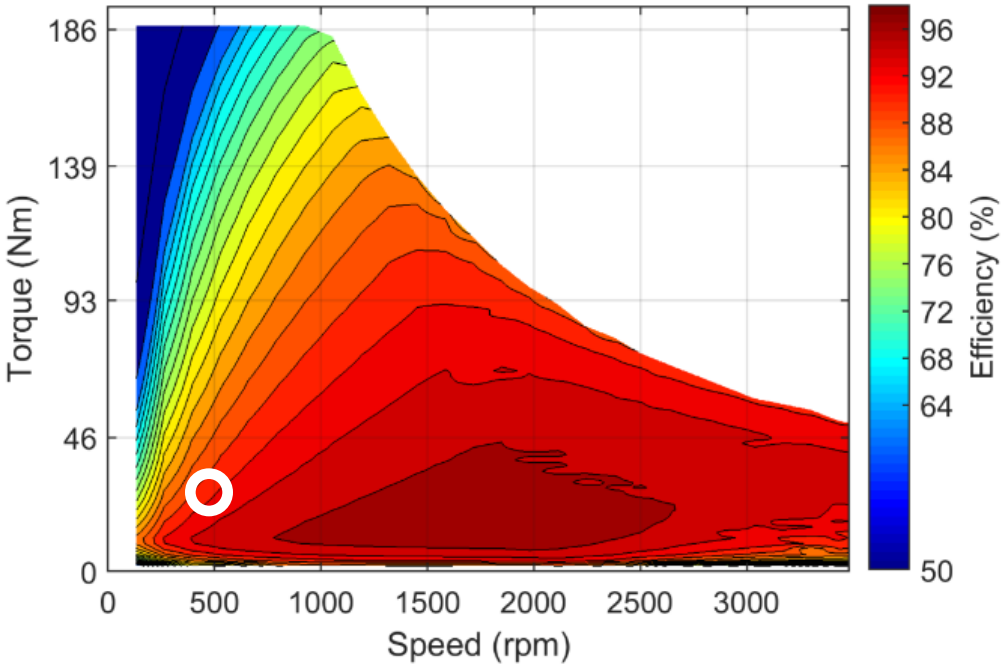
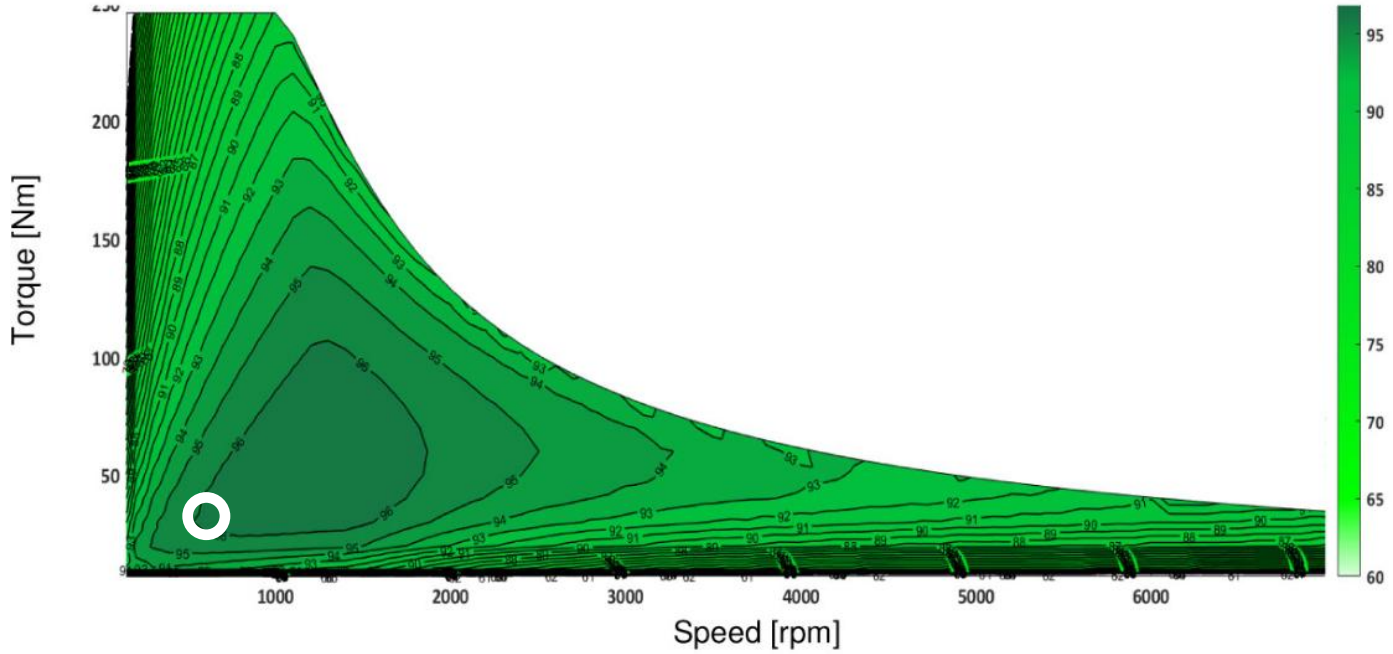
Motor Efficiency





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