Computational Fluid Dynamics Analysis for TNI AD Amphibious Vehicles

By
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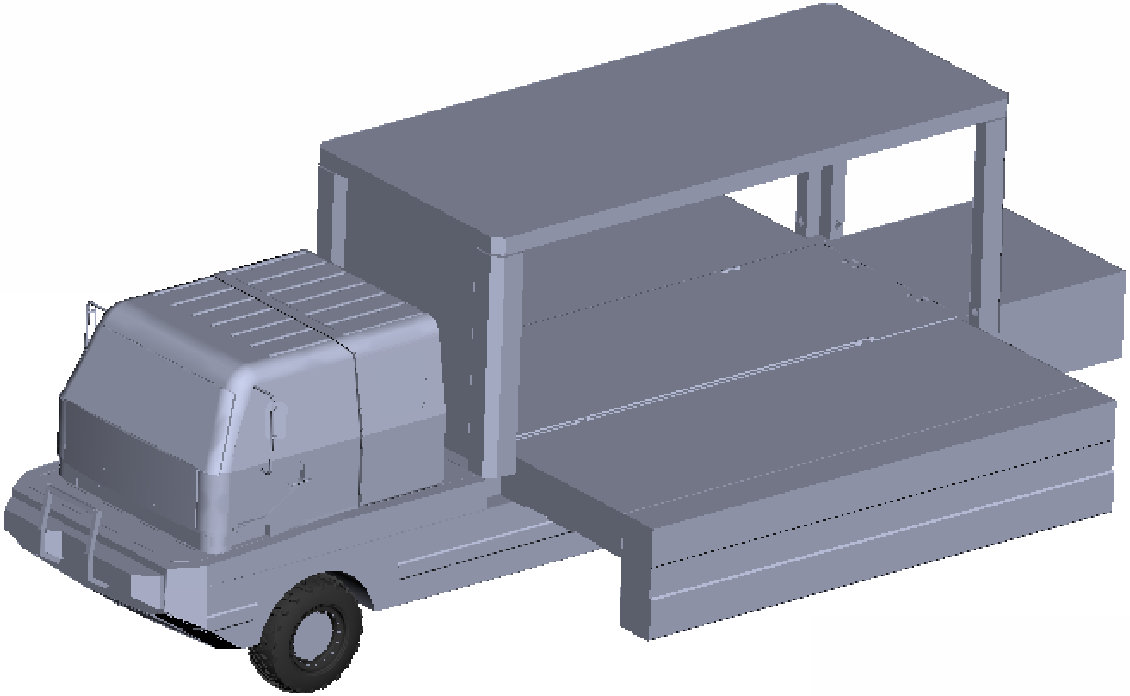
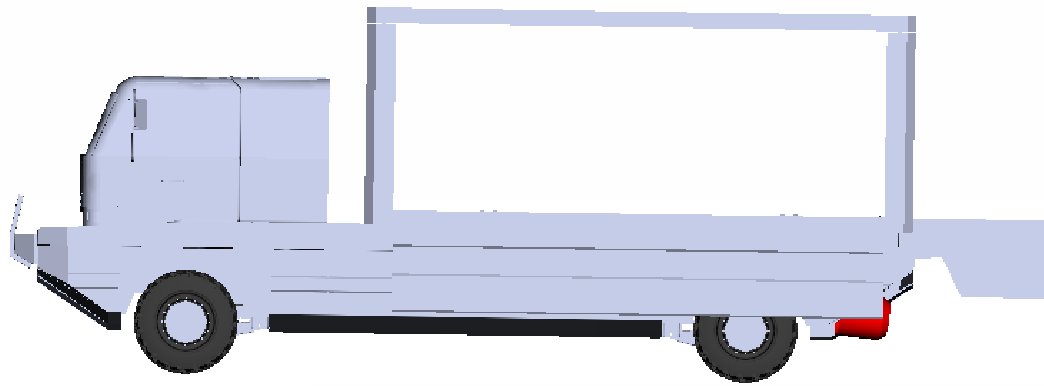
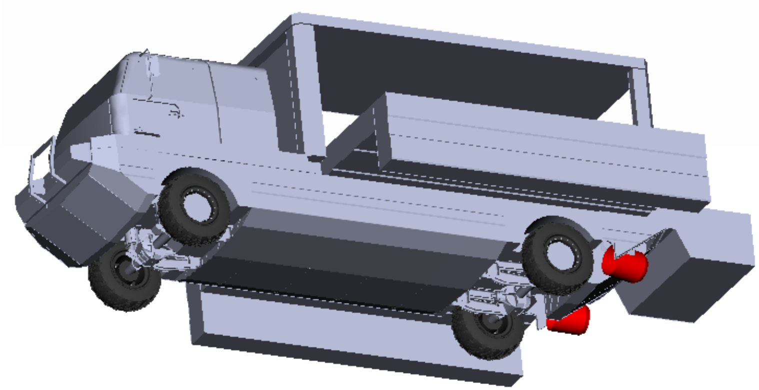
Water Test for Amphibious Vehicle



Model vs. Prototype

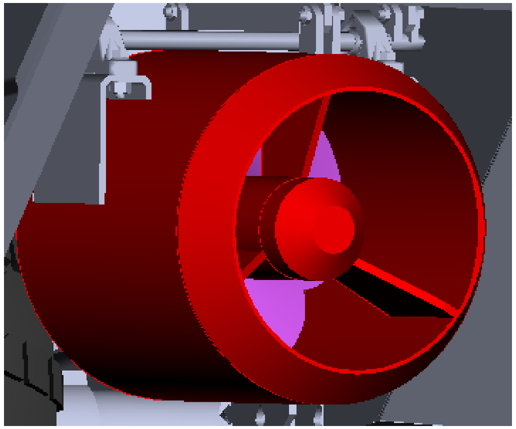


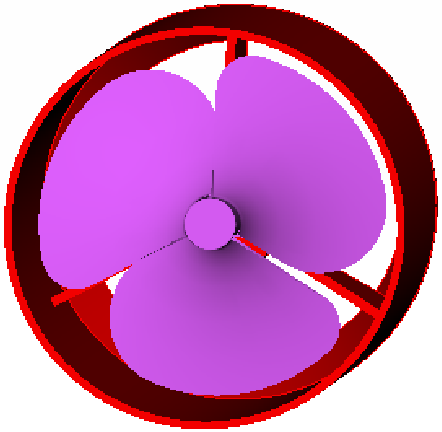


TURBINE MOTOR ANALYSIS

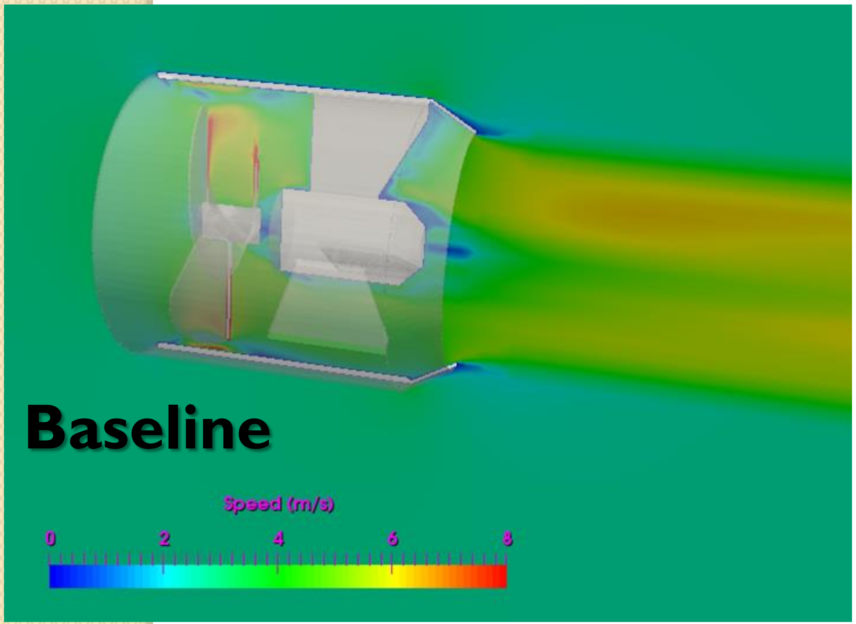
Studies:

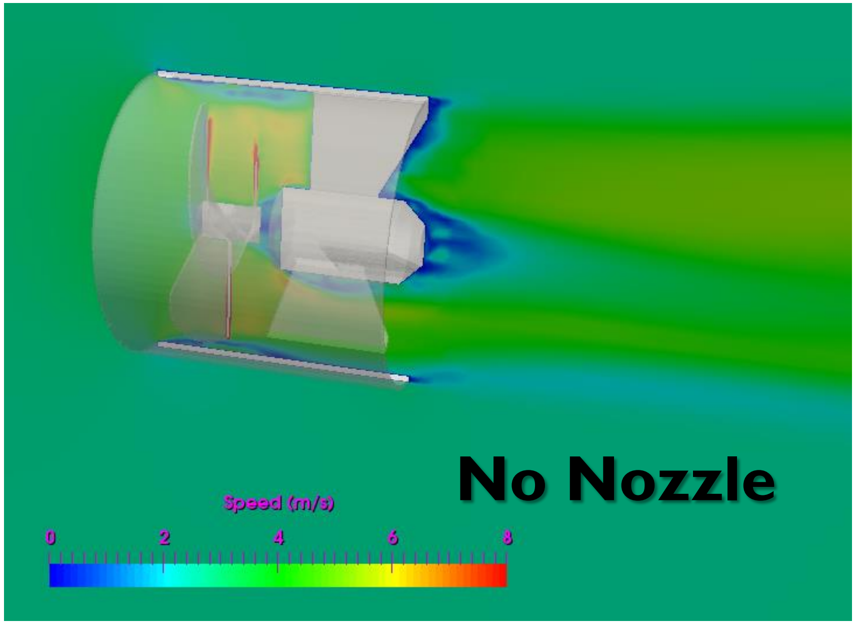
- ❑ **Effect of Nozzle**
- ❑ **Effect of Blade Position**
- ❑ **Effect of Blade-Tunnel Gap**

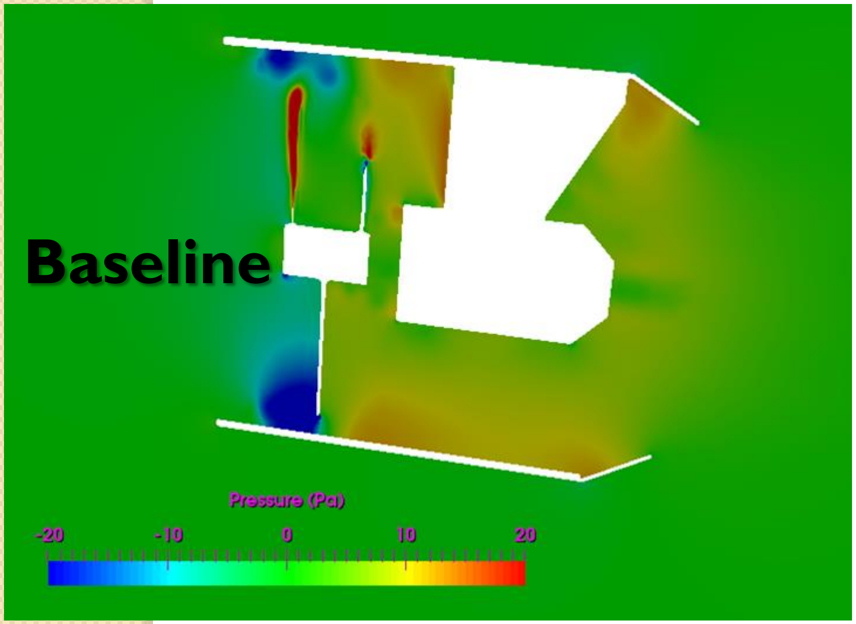


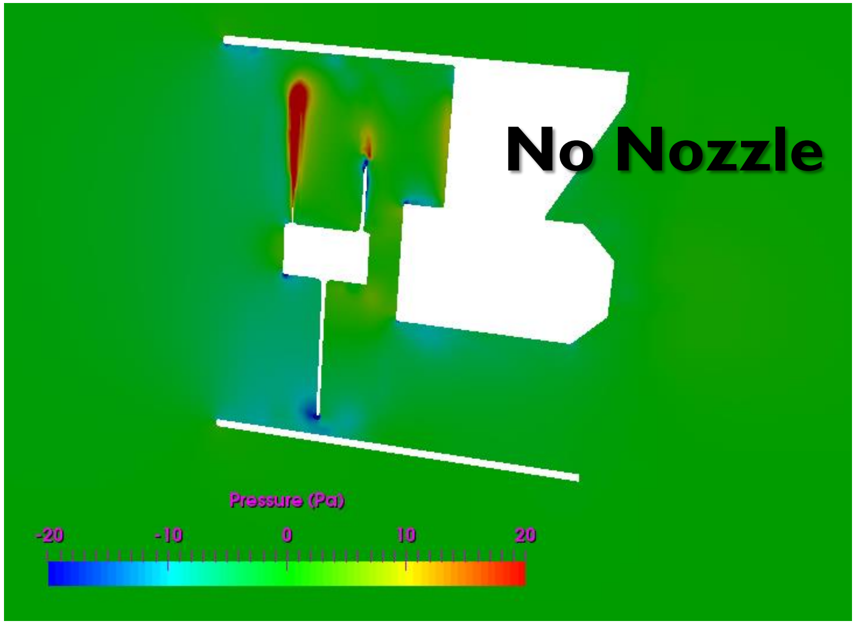


Effect of Nozzle



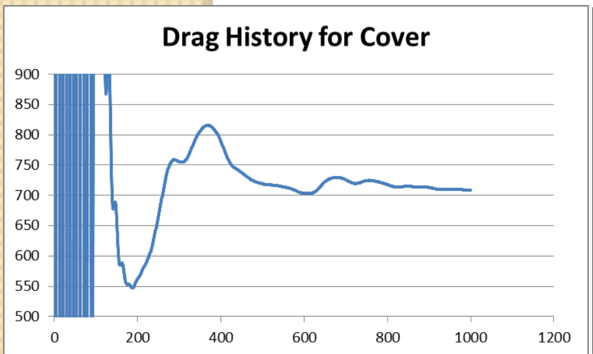


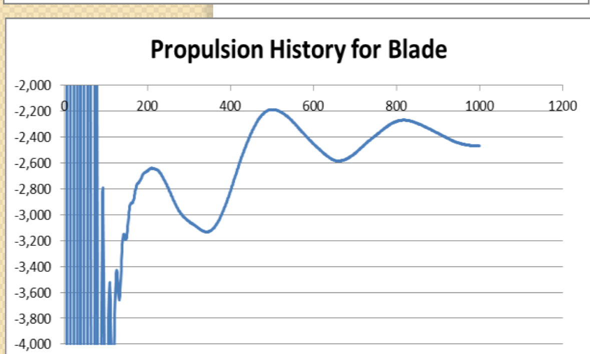


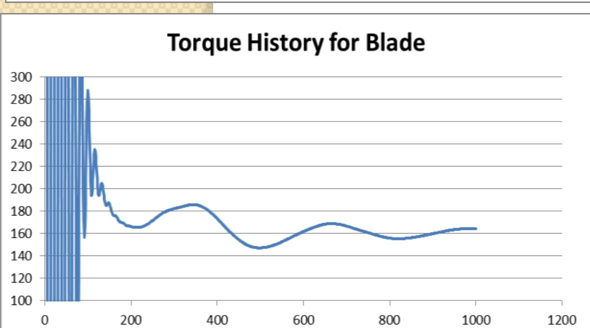


Effect of Nozzle

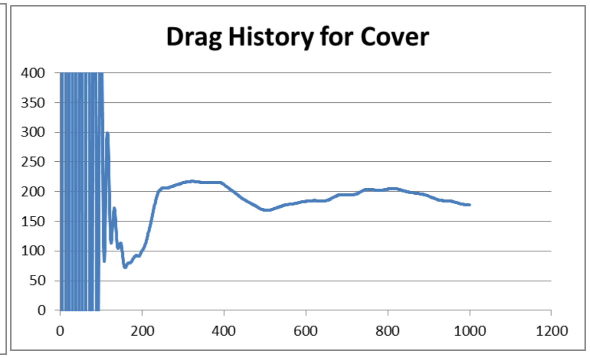
Baseline

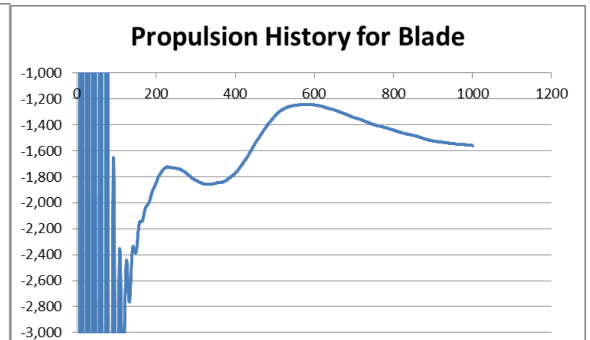


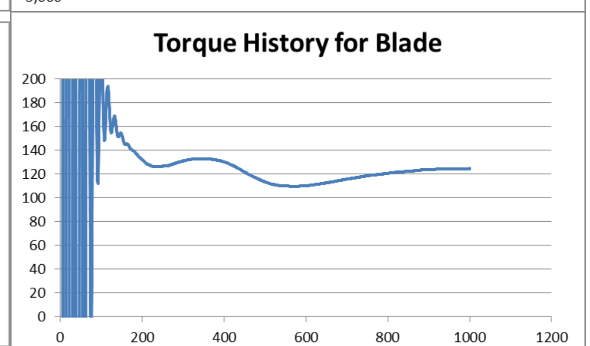




No Nozzle







Baseline:

Cover drag = 710 N
Blade propulsion = -2370N
Blade torque = 160 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 2370 – 710 = 1660 N
Blade Power = 160 x 125.7 = 20 112 Watt

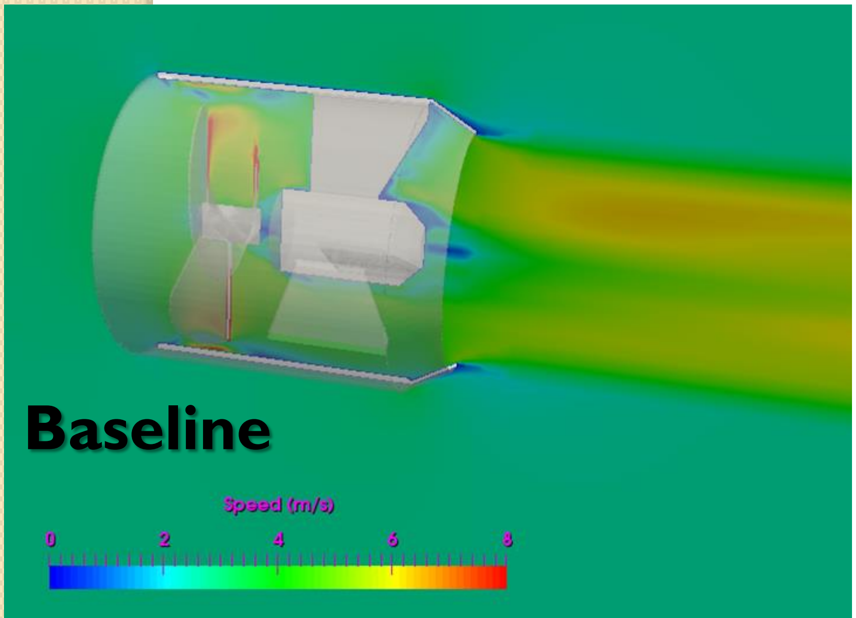
No Nozzle:

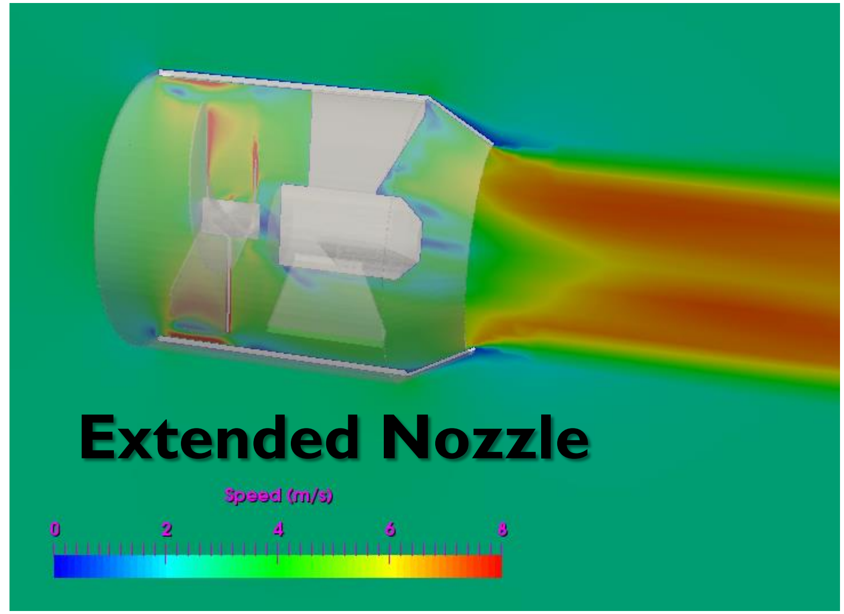
Cover drag = 190 N
Blade propulsion = -1400N
Blade torque = 125 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 1400 – 190 = 1210 N
Blade Power = 125 x 125.7 = 15 712 Watt

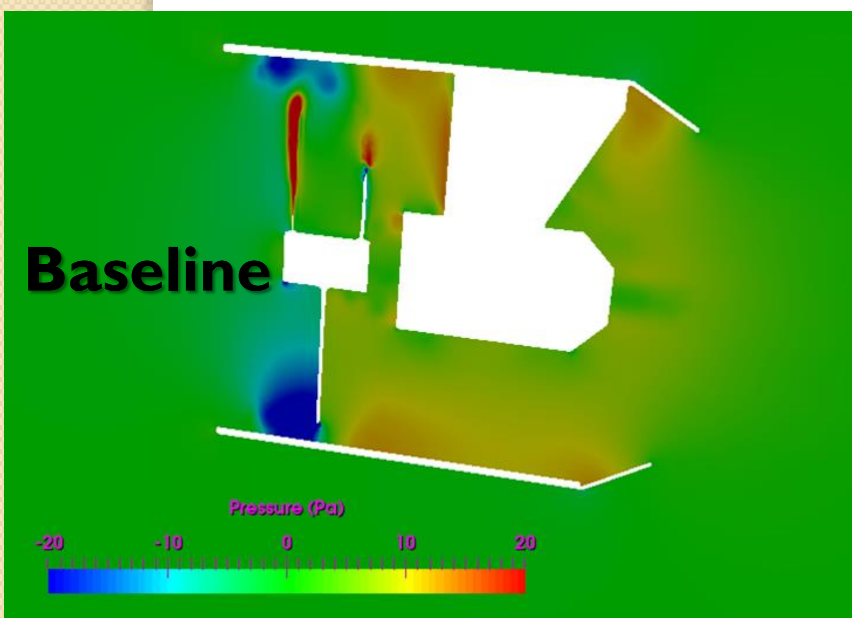
Notes, removing nozzle gives:

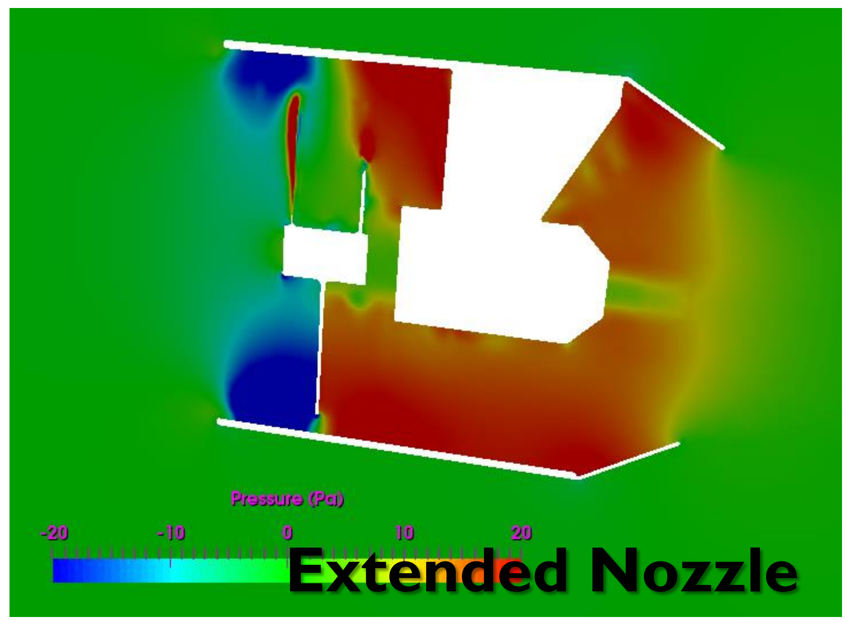
- less propulsion
- less input power
- lower water presssure behind blades
- less water velocity behind tunnel

Effect of Nozzle



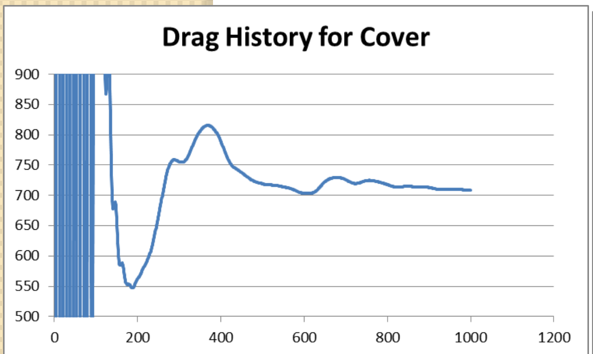


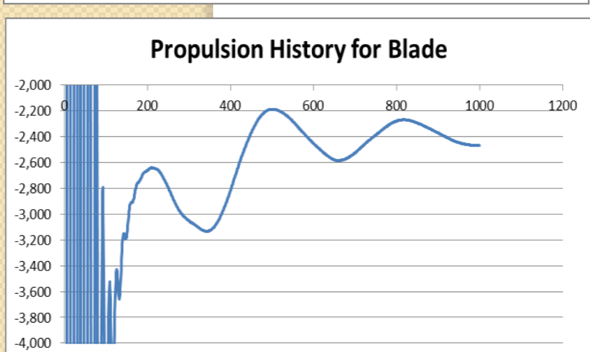


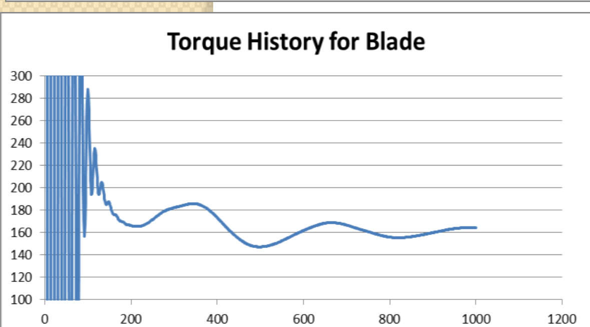


Effect of Nozzle

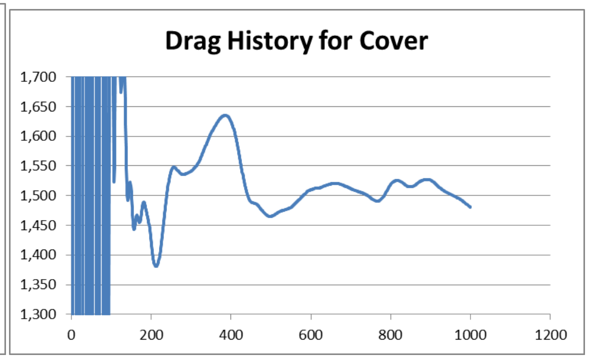
Baseline

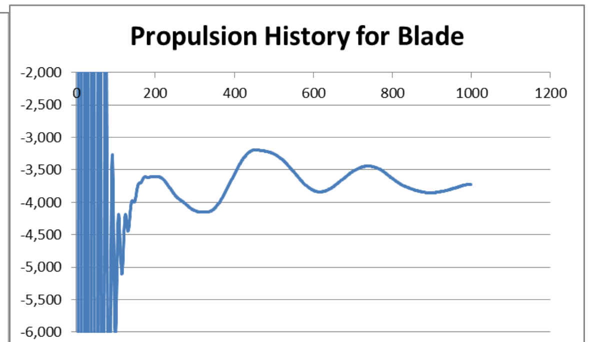


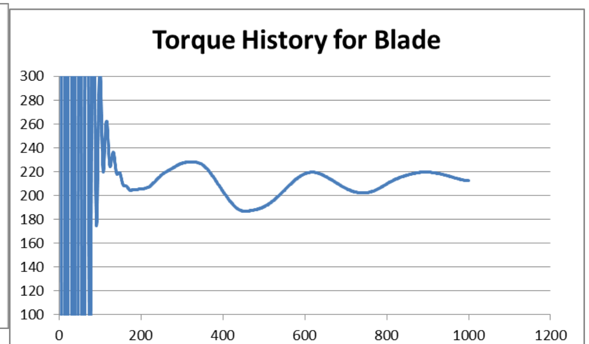




Extended Nozzle







Baseline:

Cover drag = 710 N
Blade propulsion = -2370N
Blade torque = 160 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 2370 – 710 = 1660 N
Blade Power = 160 x 125.7 = 20 112 Watt

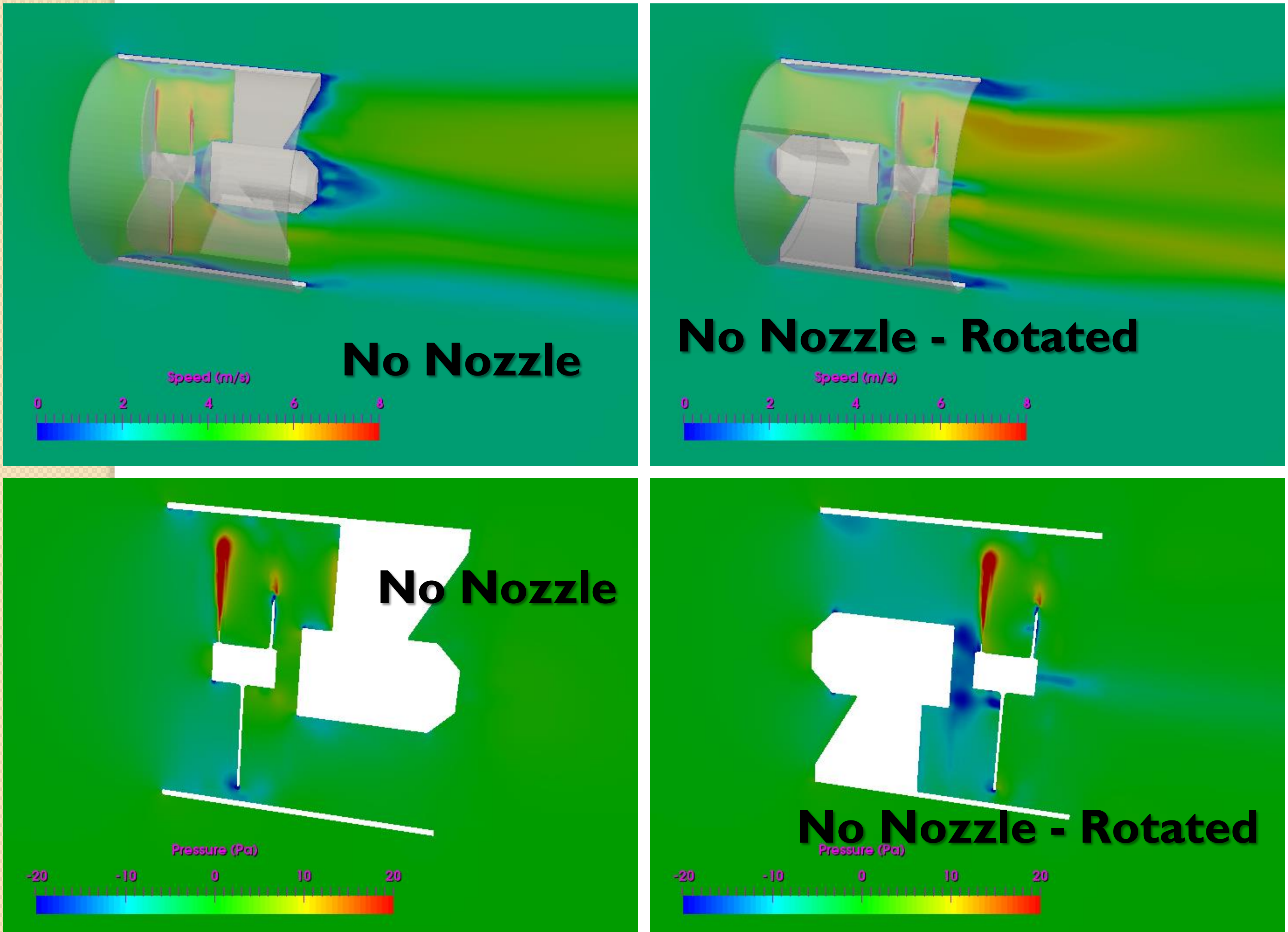
Extended Nozzle:

Cover drag = 1500 N
Blade propulsion = -3720 N
Blade torque = 212 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 3720 – 1500 = 2220 N
Blade Power = 212 x 125.7 = 26 648 Watt

Notes, extending nozzle gives:

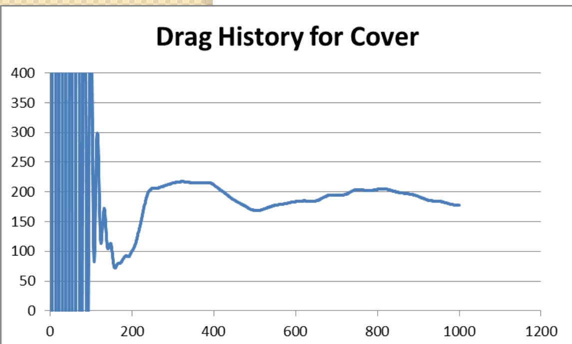
- More propulsion
- More input power
- Higher water presssure behind blade
- More water velocity behind tunnel

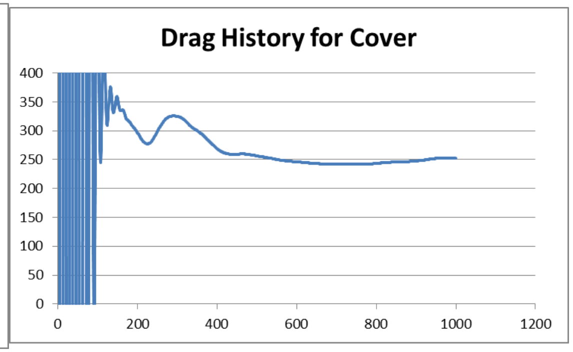
Effect of Blade Position

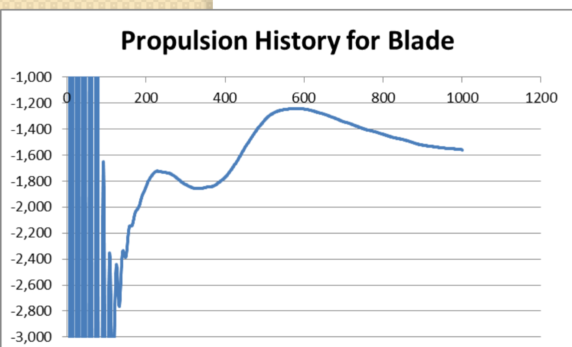


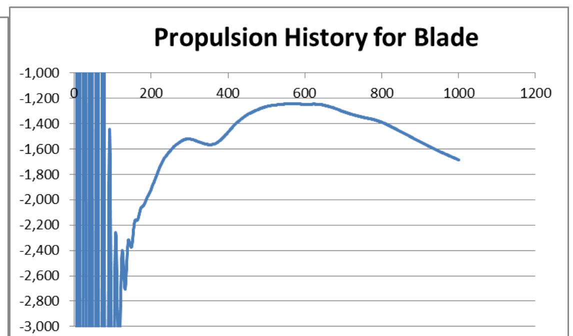
Effect of Blade Position

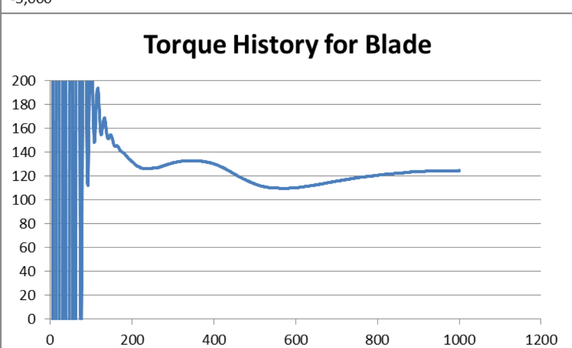
No Nozzle   No Nozzle - Rotated

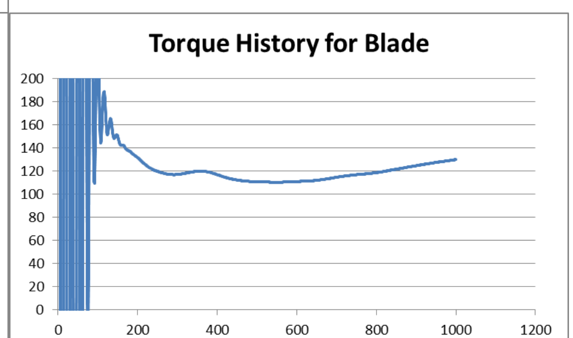












No Nozzle:

Cover drag = 190 N
Blade propulsion = -1400N
Blade torque = 125 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 1400 – 190 = 1210 N
Blade Power = 125 x 125.7 = 15 712 Watt

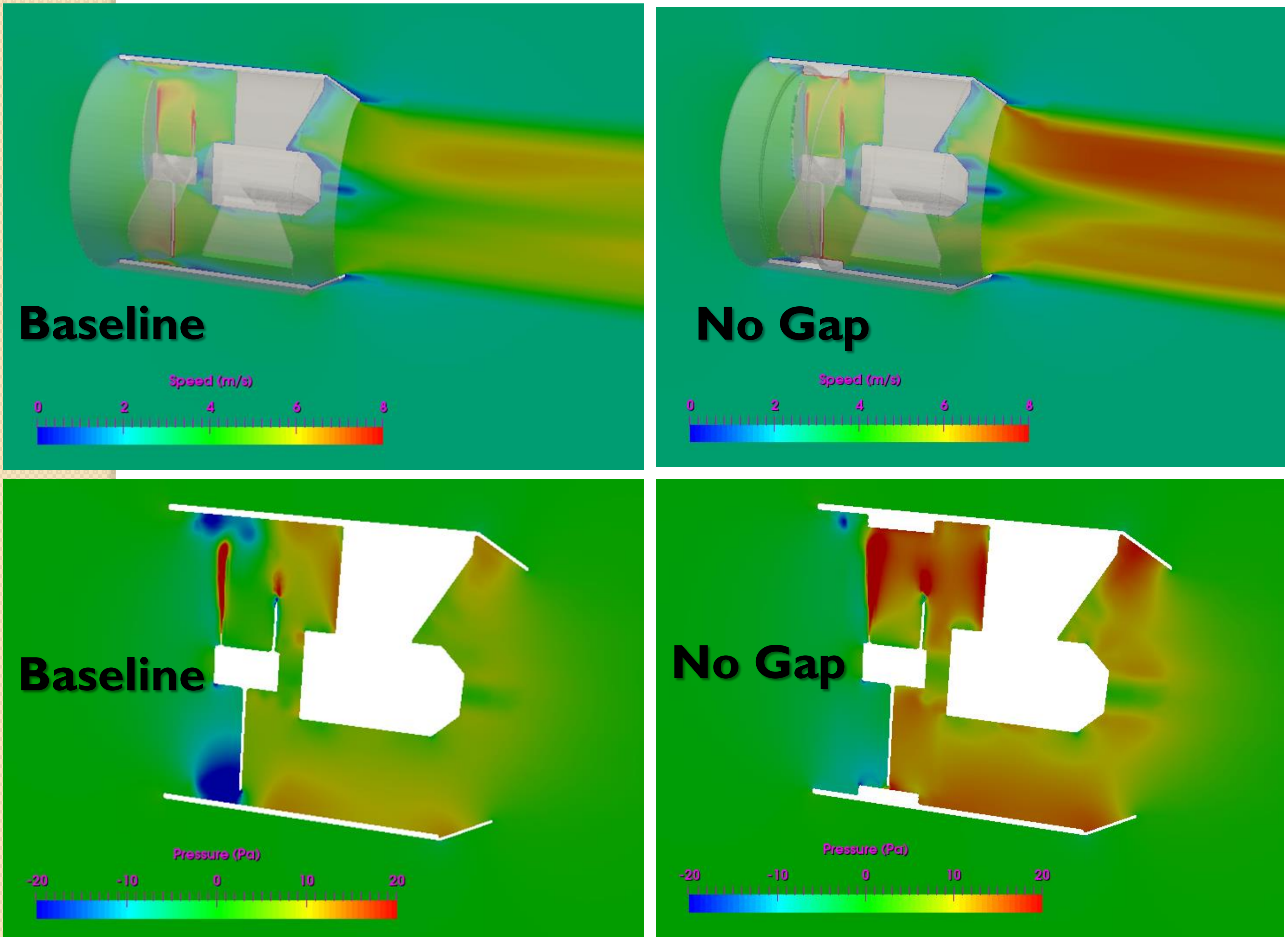
No Nozzle - Rotated

Cover drag = 250 N
Blade propulsion = -1500N
Blade torque = 135 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 1500 – 250 = 1250 N
Blade Power = 135 x 125.7 = 16 969 Watt

Notes, changing blade position gives:

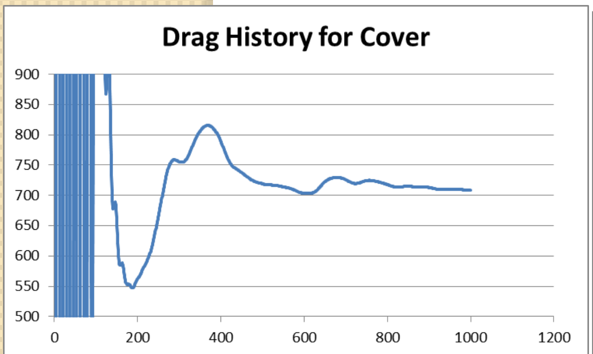
- Almost the same propulsion
- More input power
- lower water presssure in front of blade (more prompt to cavitation problem)
- More water velocity behind tunnel

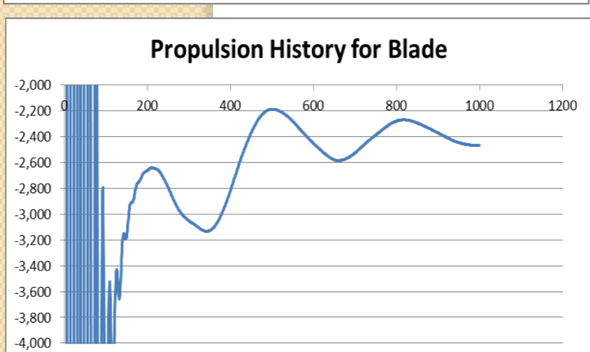
Effect of Blade-Tunnel Gap

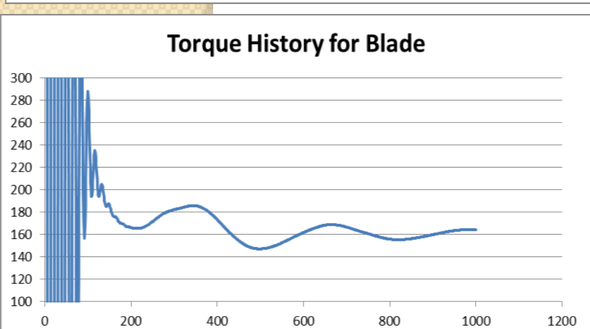


Effect of Blade-Tunnel Gap

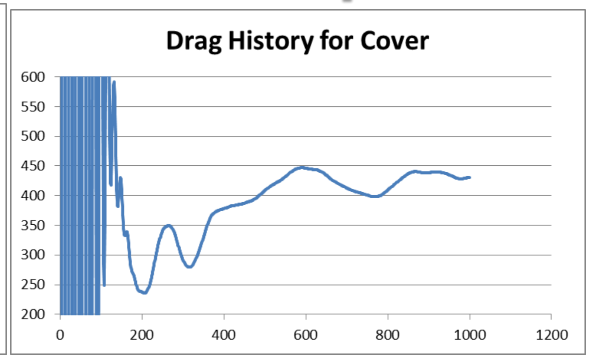
Baseline

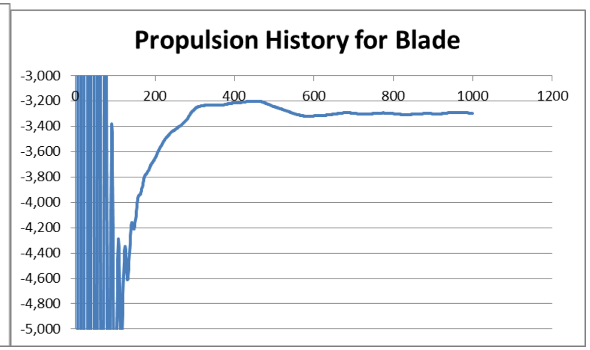


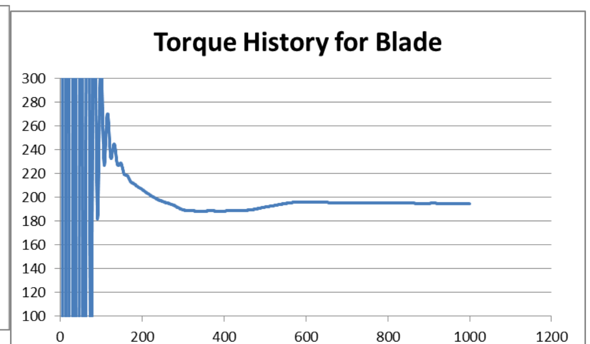




No Gap







Baseline:

Cover drag = 710 N
Blade propulsion = -2370N
Blade torque = 160 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 2370 – 710 = 1660 N
Blade Power = 160 x 125.7 = 20 112 Watt

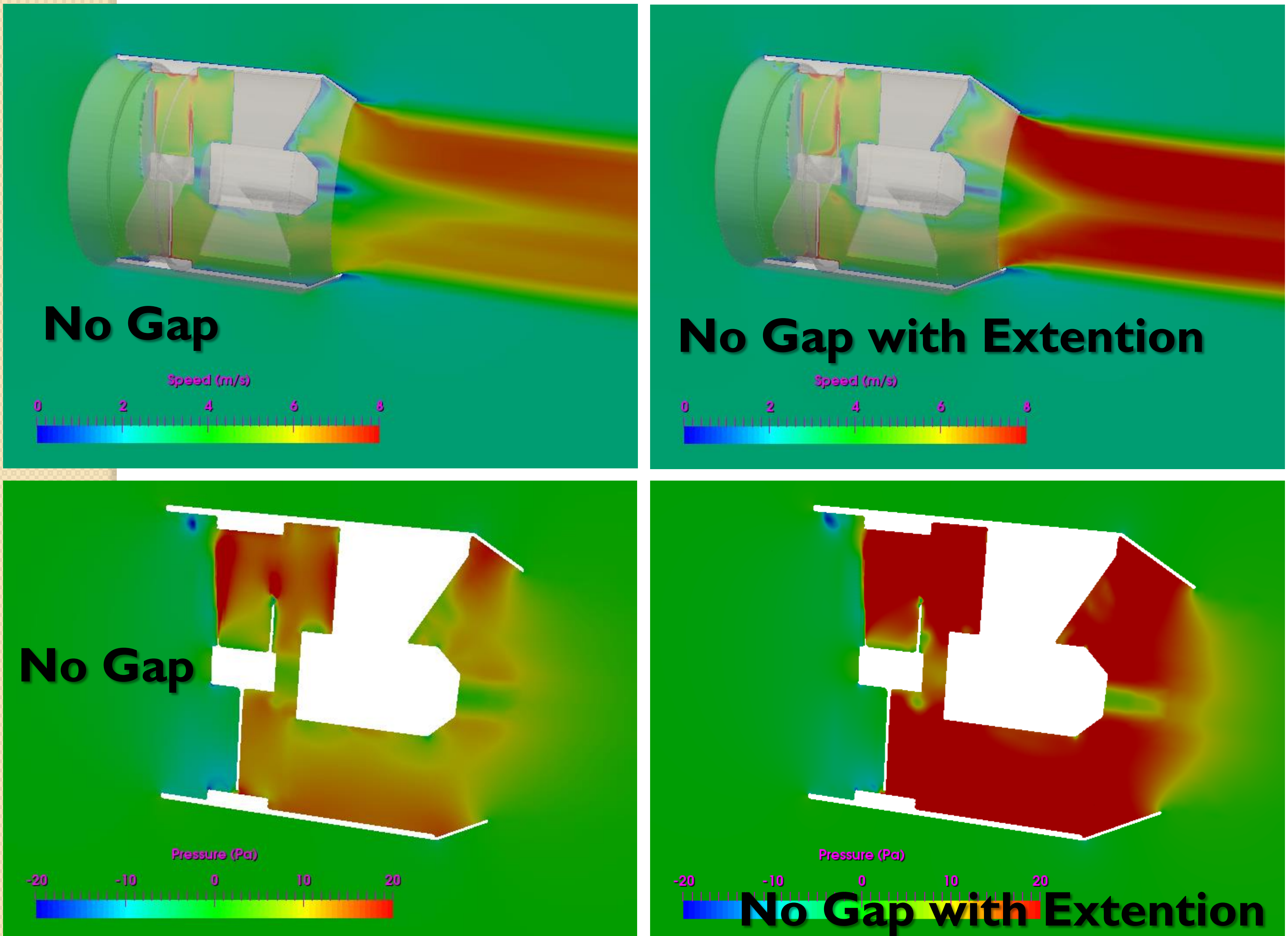
No Gap:

Cover drag = 432 N
Blade propulsion = -3300 N
Blade torque = 194 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 3300 – 432 = 2868 N
Blade Power = 194 x 125.7 = 24 386 Watt

Notes, removing the gap gives:

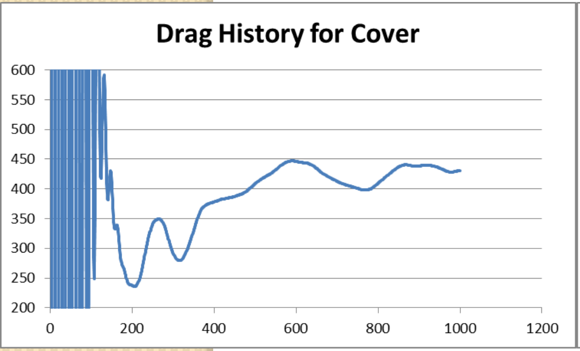
- Much more propulsion
- More input power
- Higher water presssure behind blade
- More water velocity behind tunnel

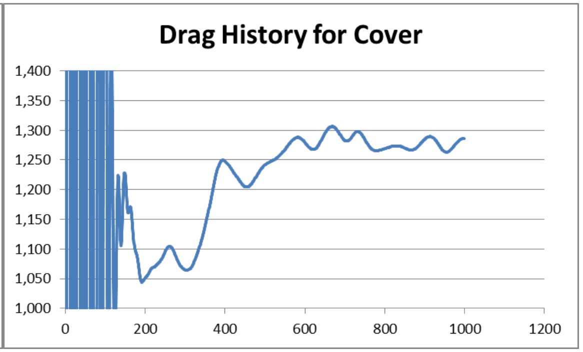
Effect of Blade-Tunnel Gap + Ext. Nozzle

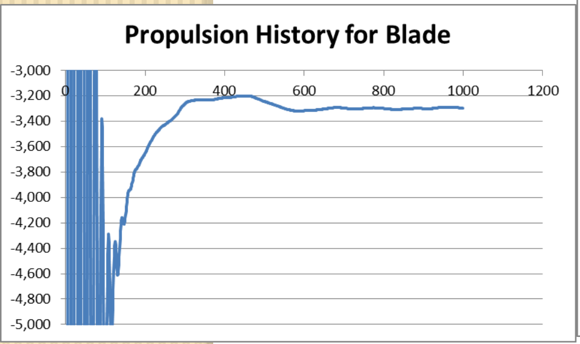


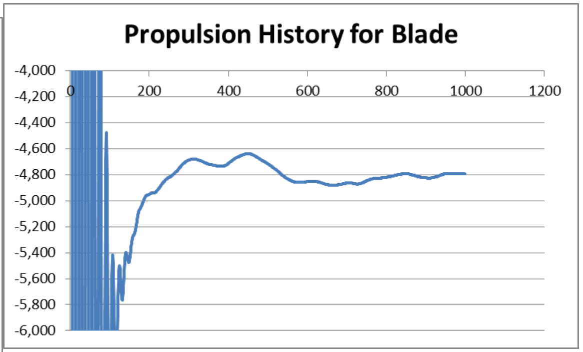
Effect of Blade-Tunnel Gap + Ext. Nozzle

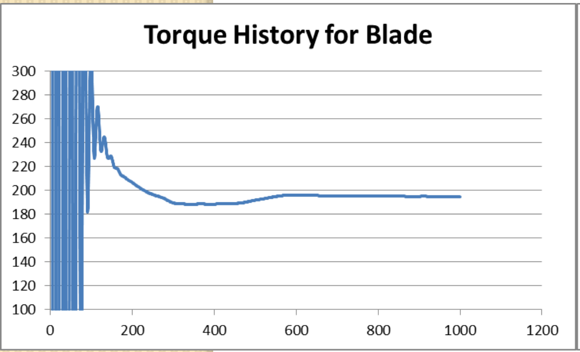
No Gap   No Gap with Extention

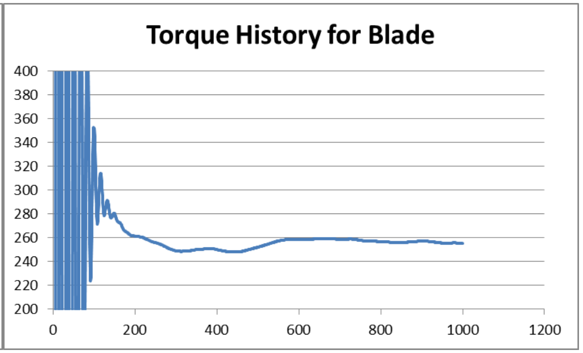












No Gap:

Cover drag = 432 N
Blade propulsion = -3300 N
Blade torque = 194 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 3300 – 432 = 2868 N
Blade Power = 194 x 125.7 = 24 386 Watt

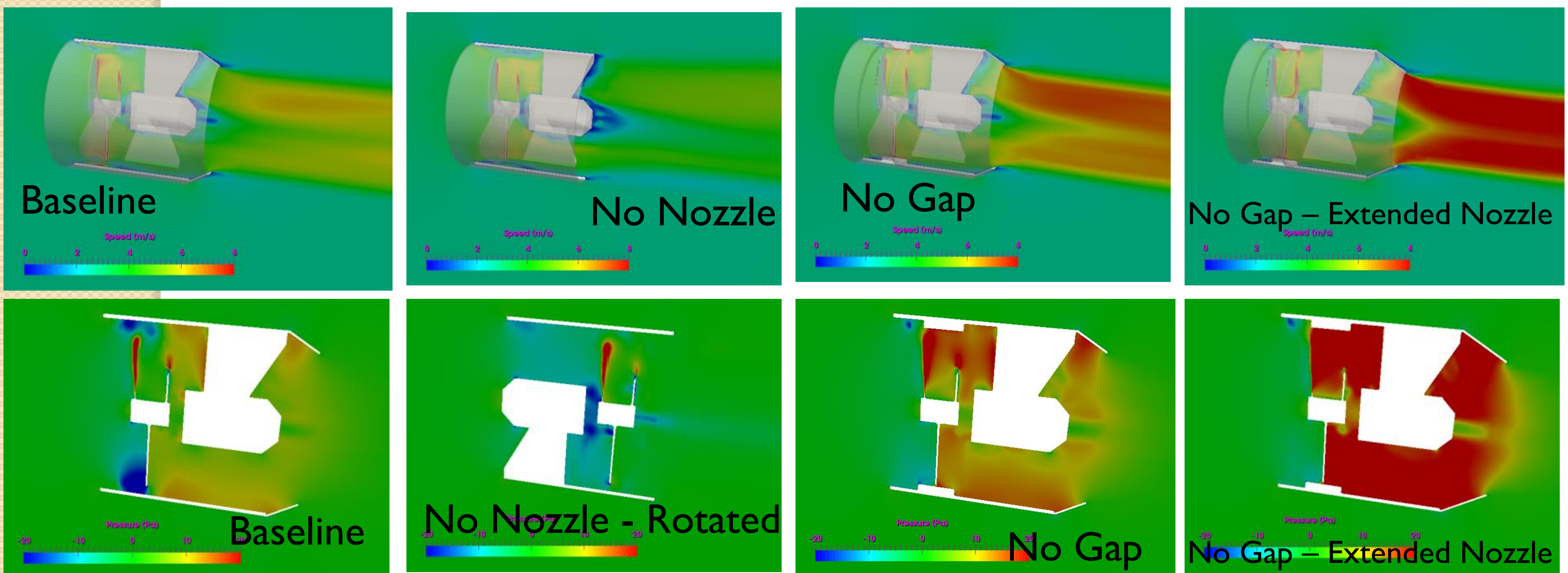
No Gap with Extention:

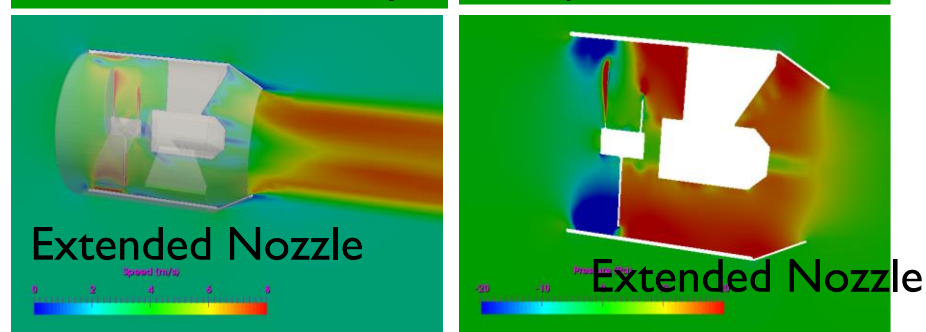
Cover drag = 1280 N
Blade propulsion = -4800 N
Blade torque = 256 N.m
Blade rotation = -125.7 rad/s
Total Propulsion = 4800 – 1280 = 2520 N
Blade Power = 256 x 125.7 = 32 180 Watt

Notes, no gap + nozzle extention gives:

- Less propulsion
- More input power
- Higher water presssure behind blade
- More water velocity behind tunnel

No	Configuration	Total Propulsion (Newton)	Power Required (Kwatts)	Notes
1	Baseline	1660	20,1	
2	Remove nozzle	1210	15,7	Nozzle add propulsion force
3	No Nozzle + blade in the back	1250	17,0	Large area with low pressure, potential cavitation
4	No gap between blade and cover	2868	24,4	Removing gap reduce the propulsion but reduce the power also
5	No gap + with nozzle extension	2520	32,2	This configuration gives the highest propultion with lower power
6	Baseline with nozzle extension	2220	26,6	Nozzle extension only does not give higher propulsion





Summary

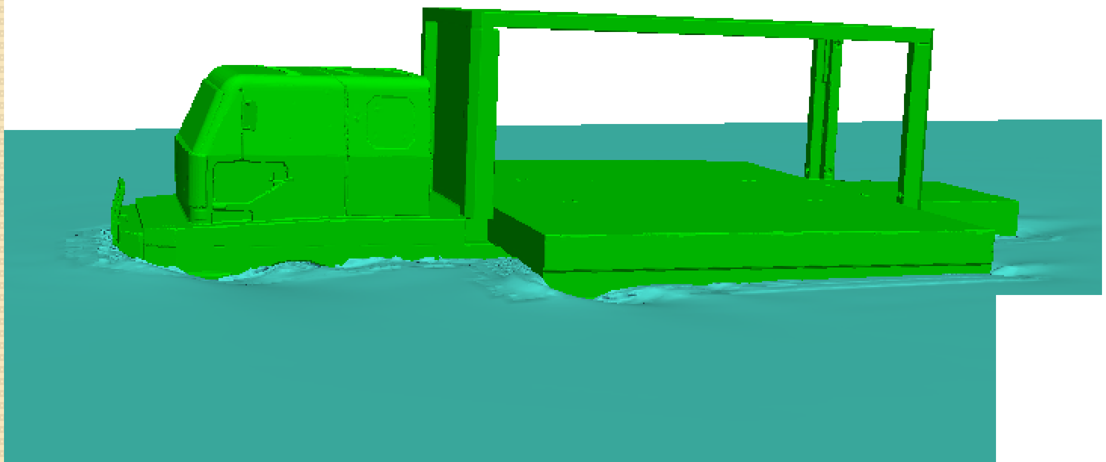
- Remove the gap
- Optimize the nozzle length

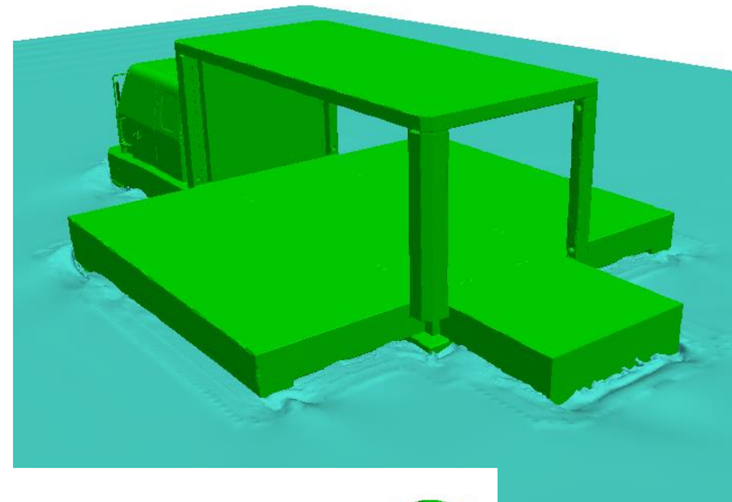
AMPHIBIOUS VEHICLE DRAG ANALYSIS

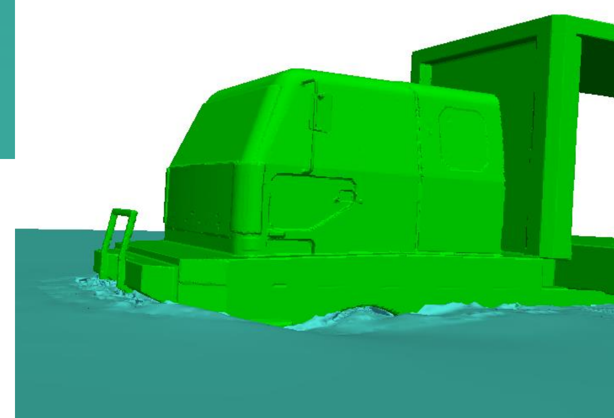
Studies:

- ❑ Drag as a function of knot
- ❑ Geometry changes to reduce drag
- ❑ Estimate speed
- ❑ How to increase speed

Model vs. Prototype



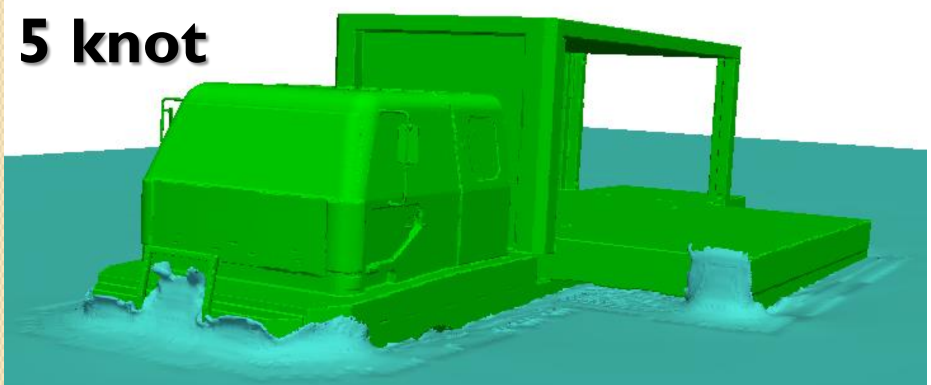




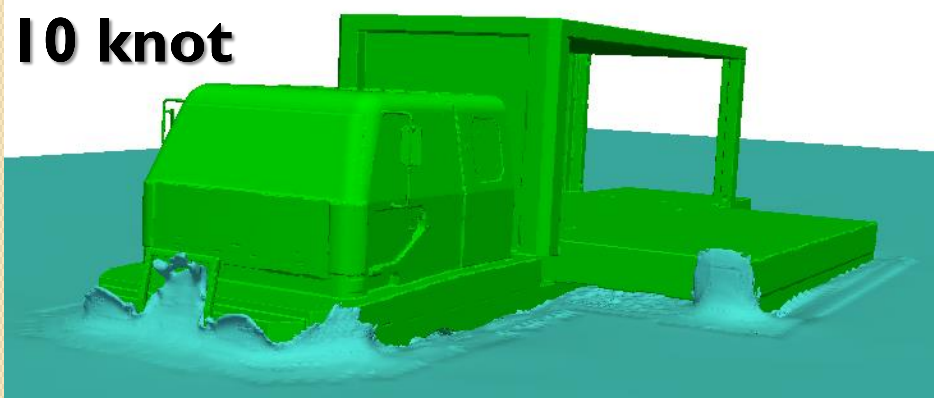
Amphibious Vehicle Drag as a function of knot

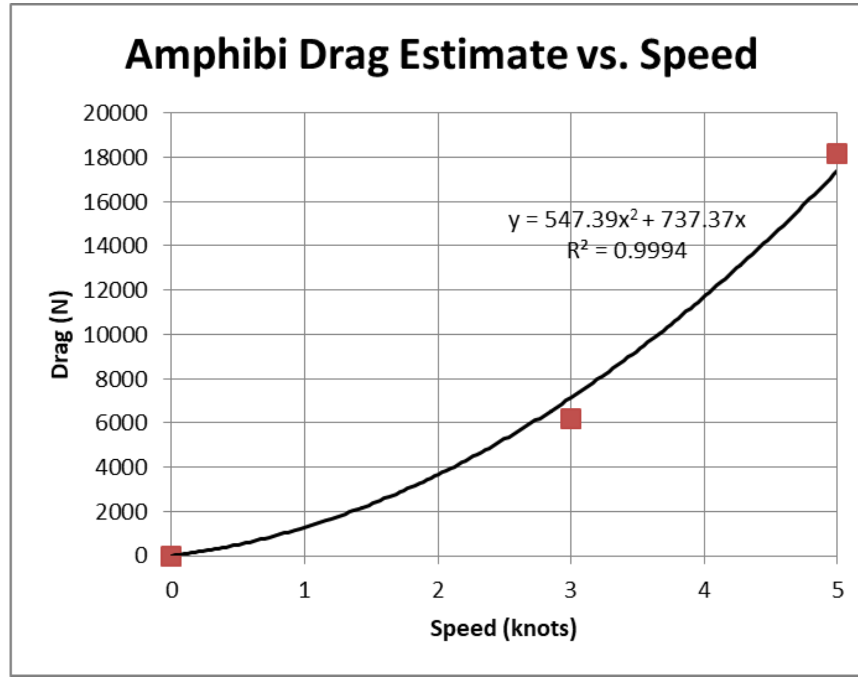
3 knot

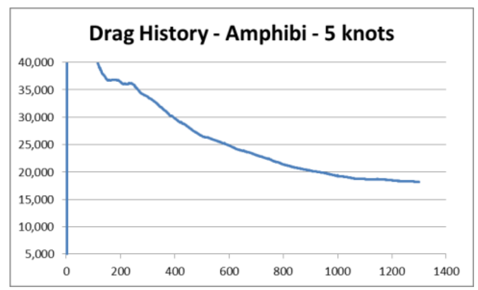
5 knot

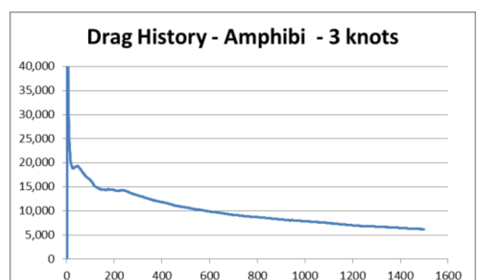


10 knot







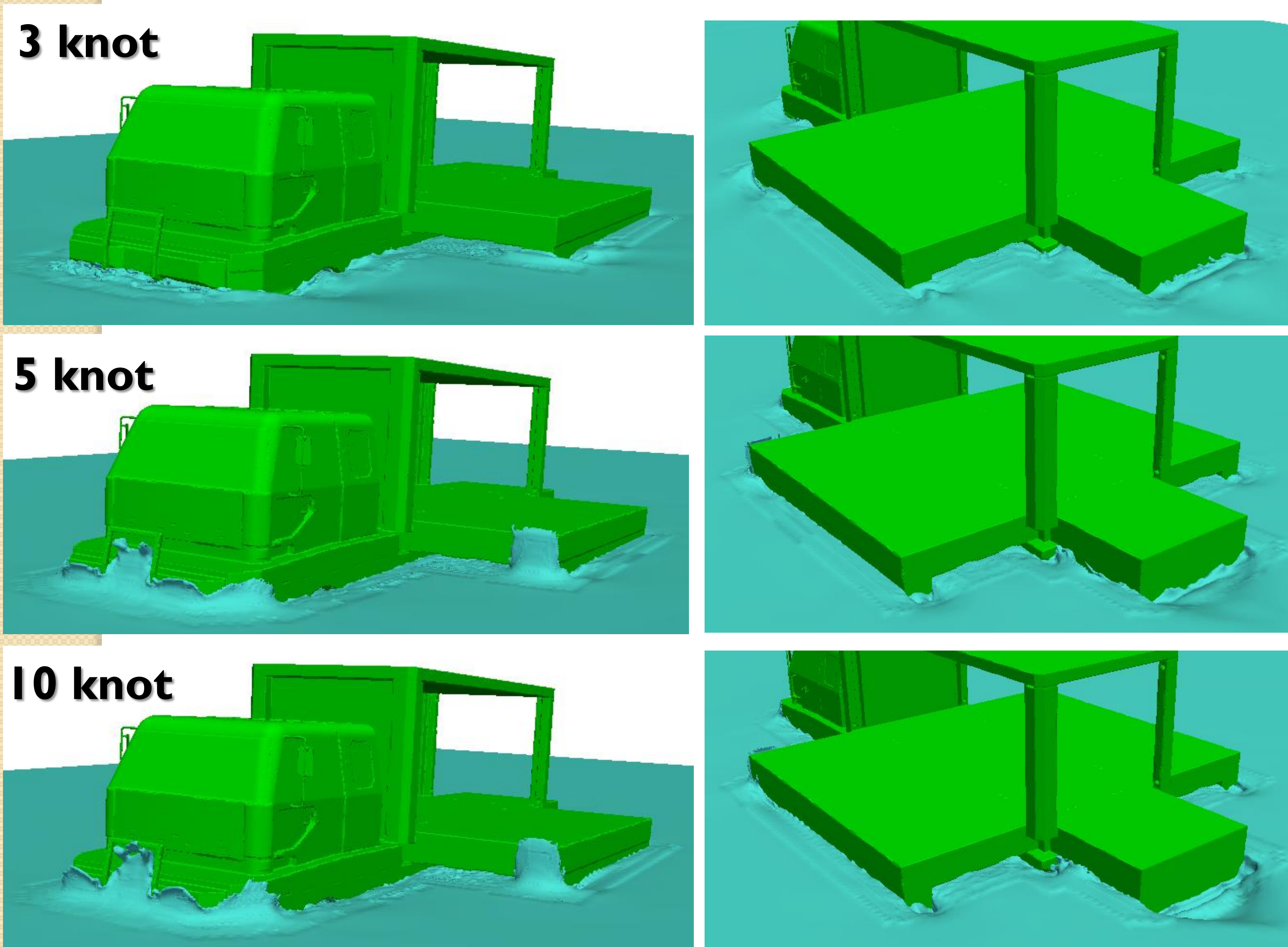


1 knot = 0.5144 m/s

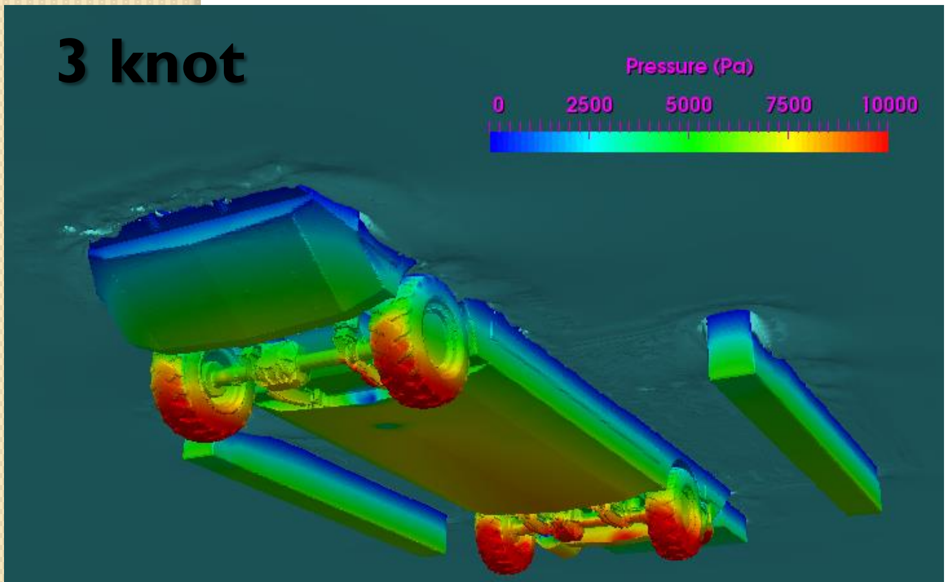
Theoretical

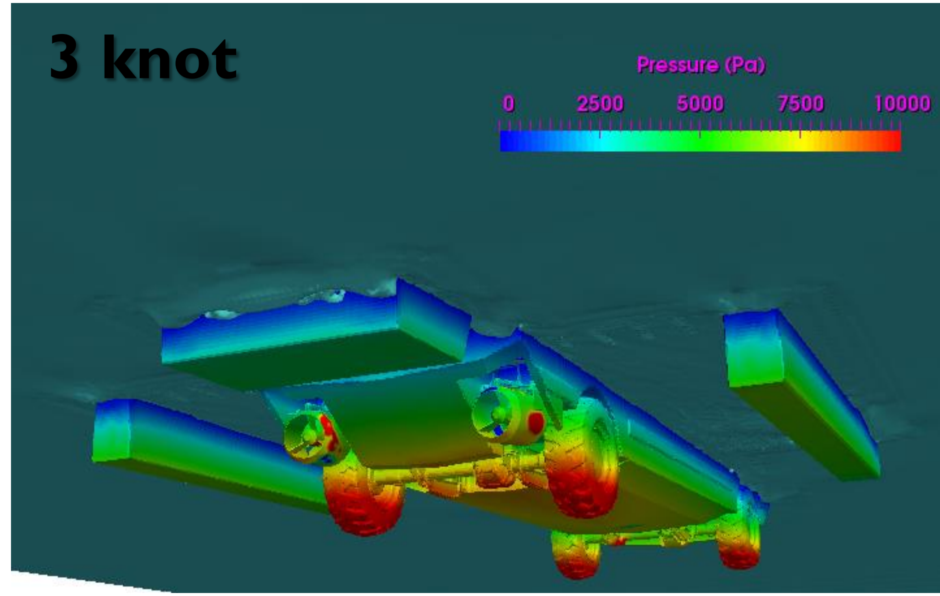
$$Drag \sim V^2$$

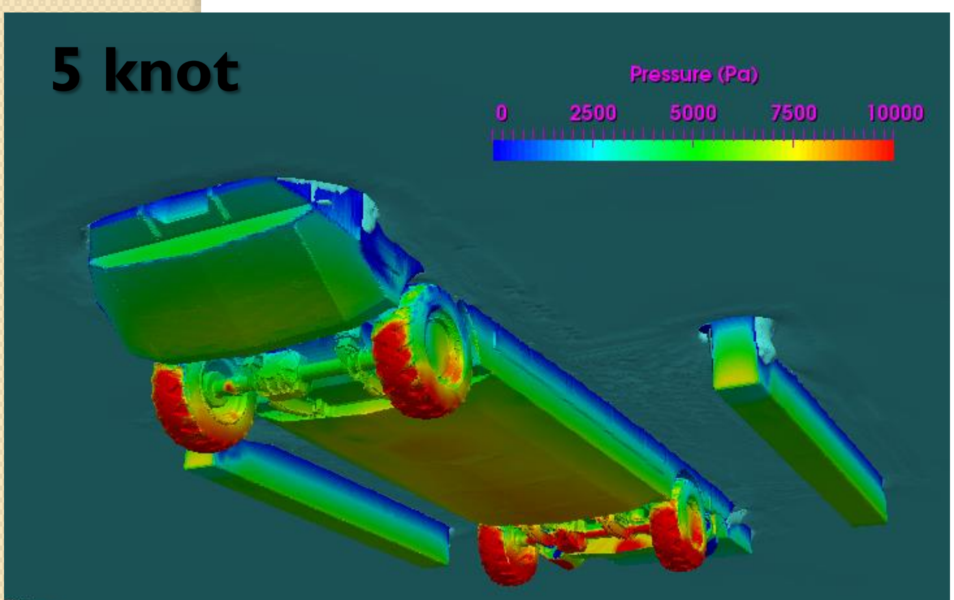
Amphibious Vehicle Drag as a function of knot

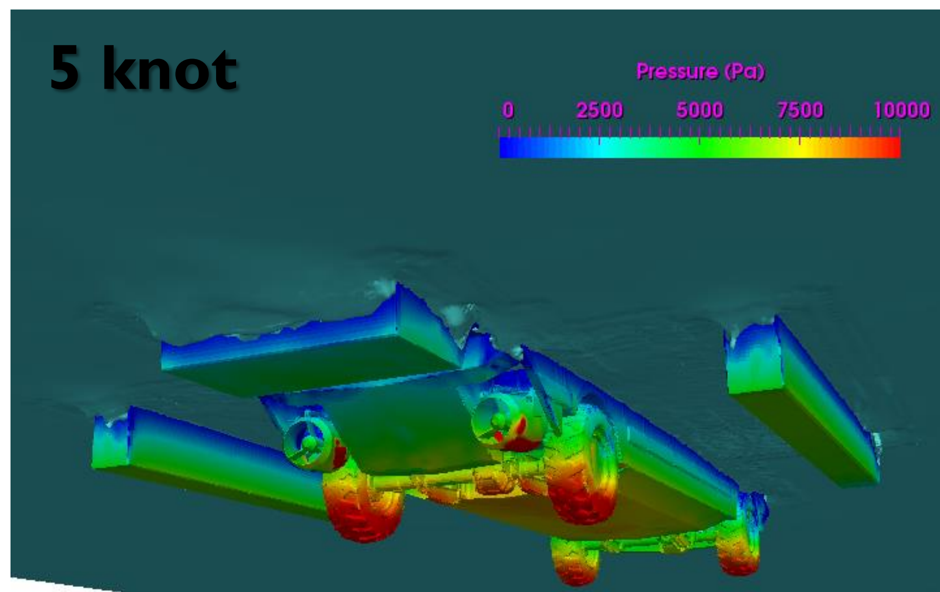


Amphibious Vehicle Drag as a function of knot



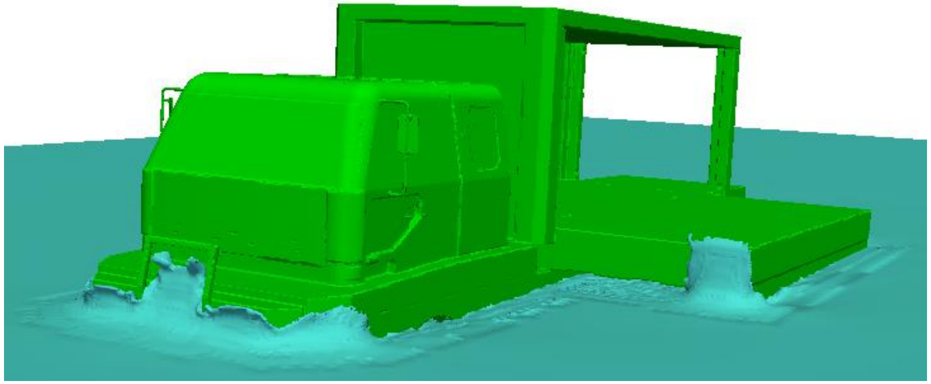


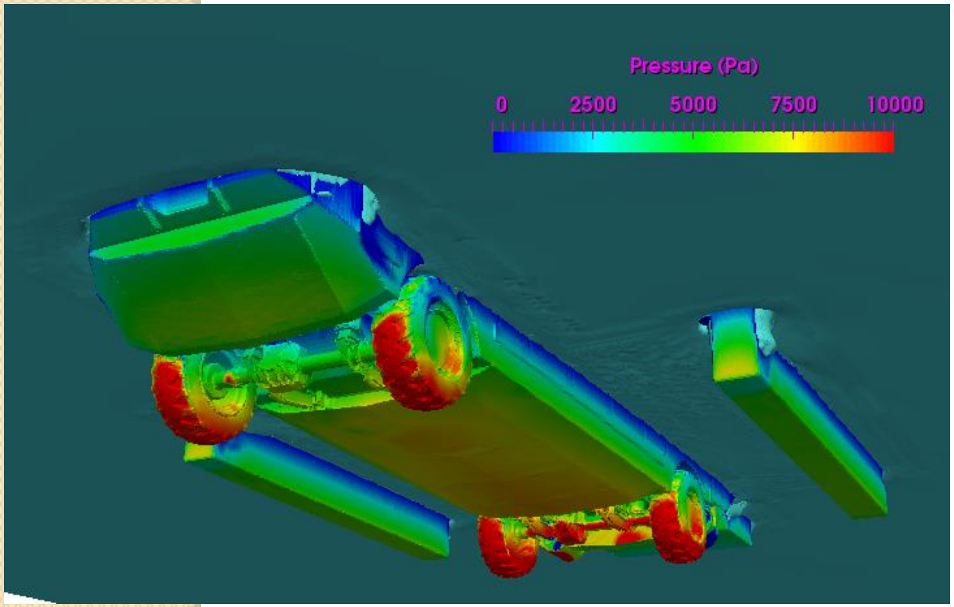


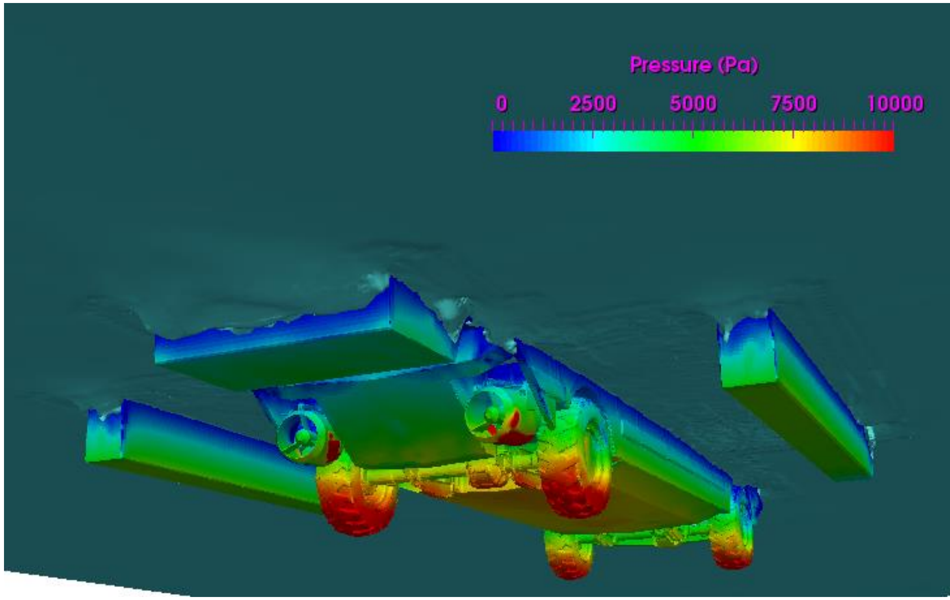


Summary:

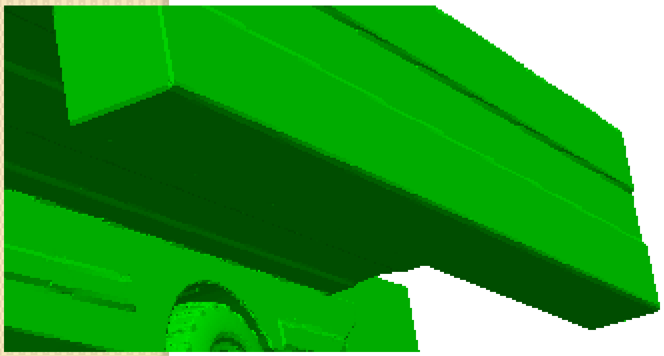
- ❑ Pitch angle in the model is not the same as in the testing of prototype
- ❑ Vehicle drag from simulation is following theoretical graph of drag
- ❑ Drag contribution from vehicle design can be predicted:
    - ❑ Nose area
    - ❑ Rear box
    - ❑ Side box
    - ❑ Wheels
    - ❑ Suspension

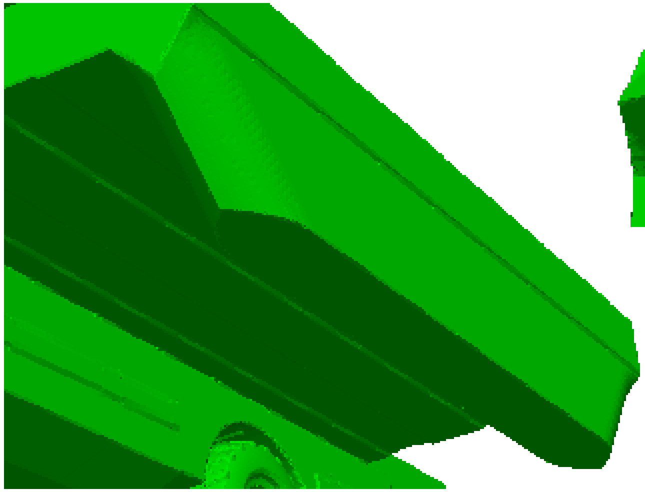






Geometry Changes Study to Reduce Drag

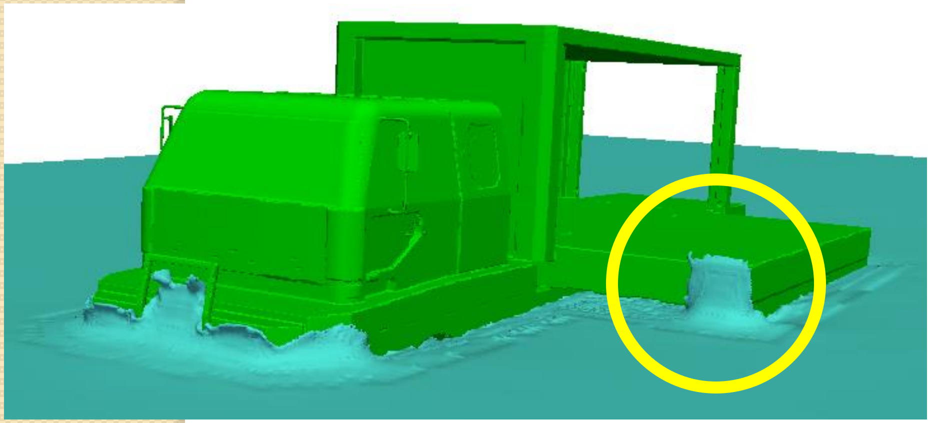


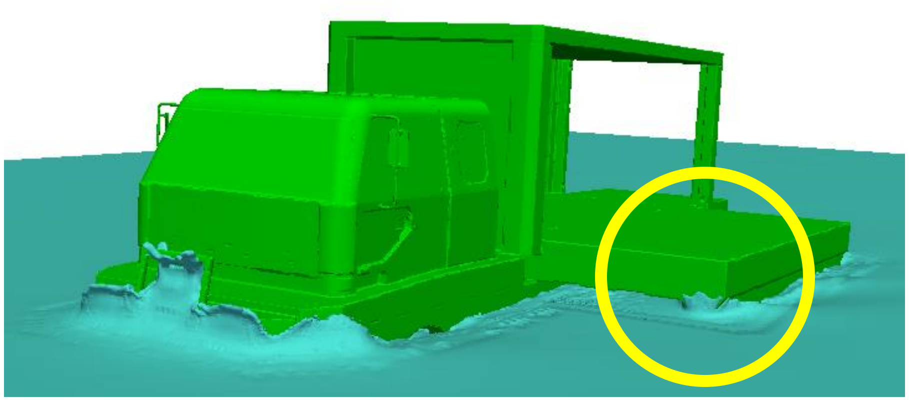


Side Box Change

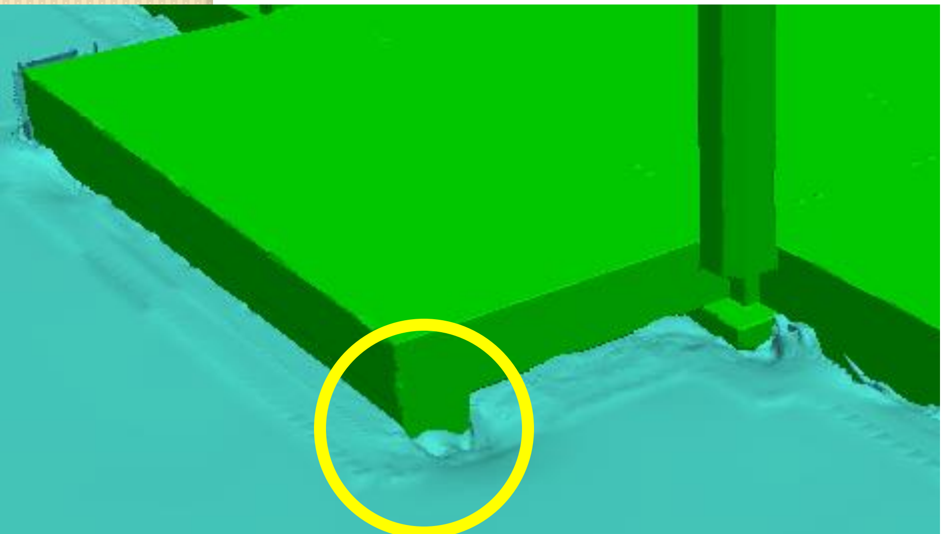
Geometry change descriptions:

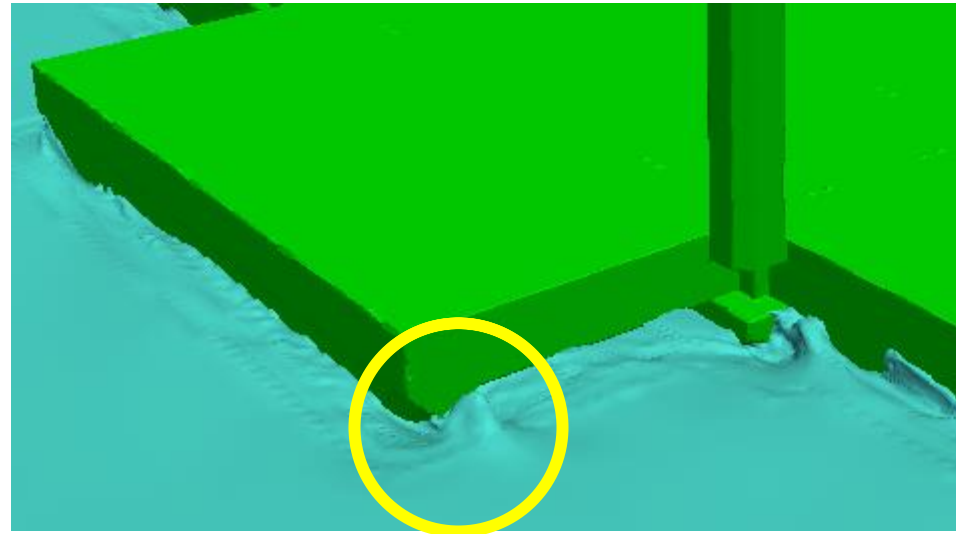
- Round at front and rear with split of around 60 degree
- Profile is slided 45 degree upward as in the image

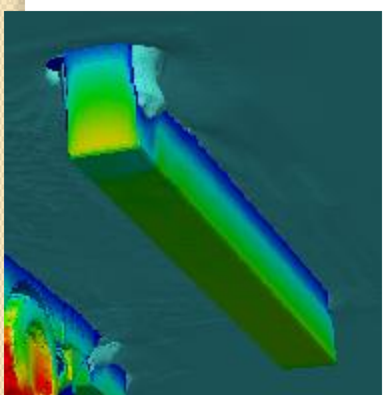


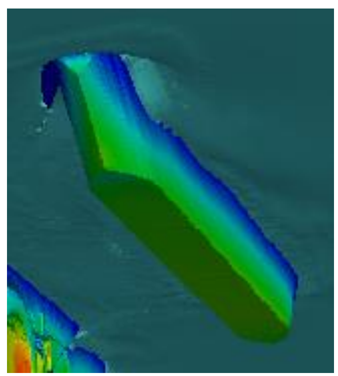


Geometry Changes Study to Reduce Drag

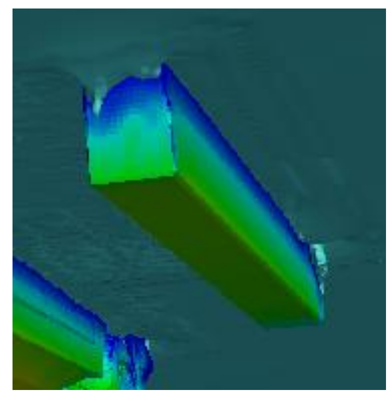


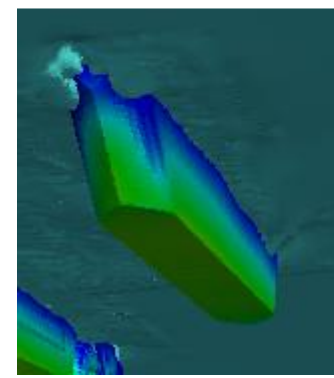






Front Face



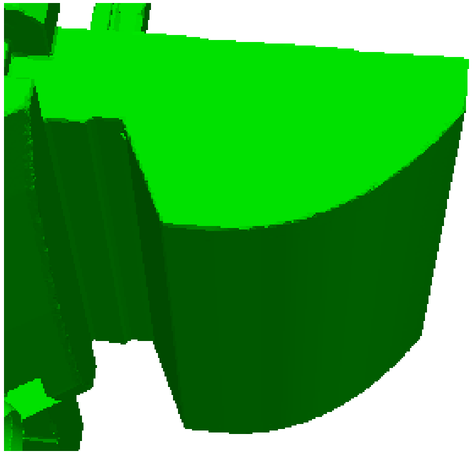


Rear Face

Baseline total vehicle drag = 18 160 N
New Shape total vehicle drag = 16 100 N

>> Drag change = 2060 N
Drag reduction of 11%

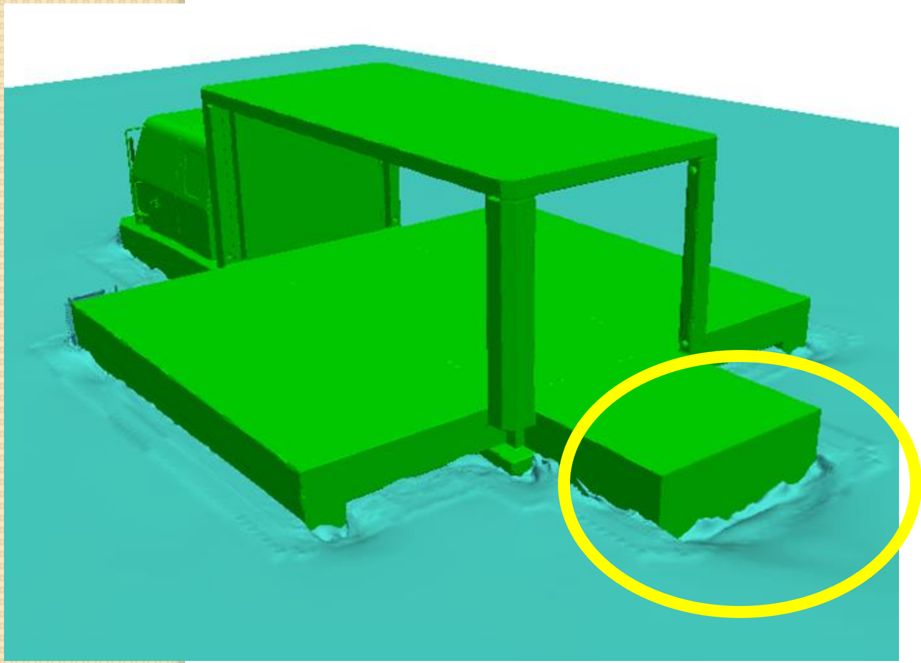
Geometry Changes Study to Reduce Drag

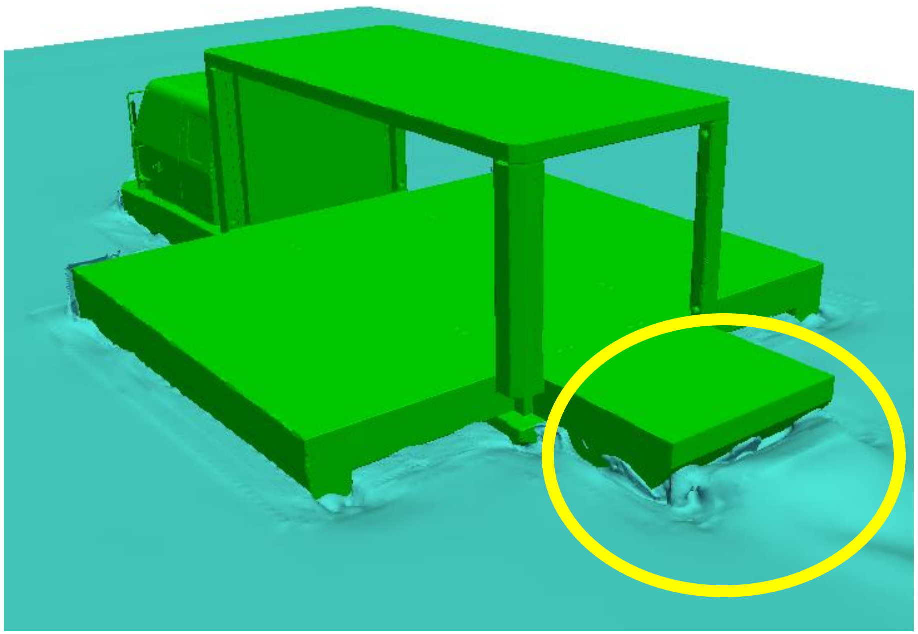


Rear Box Change

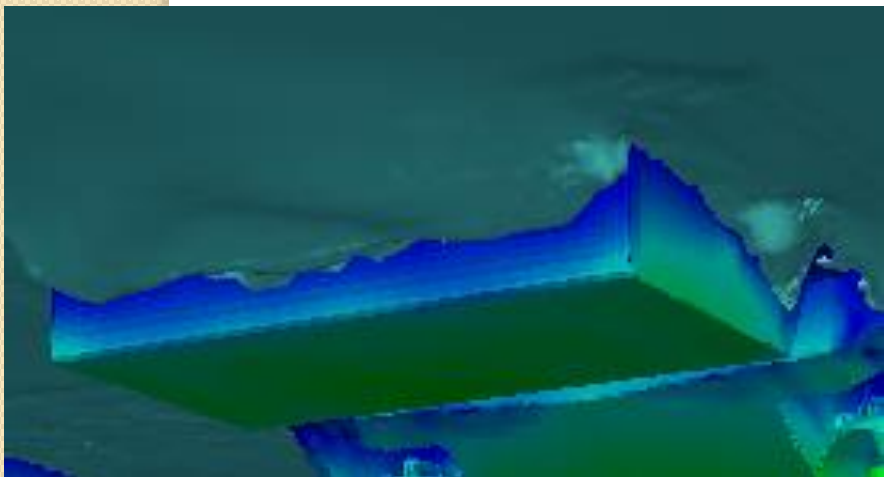
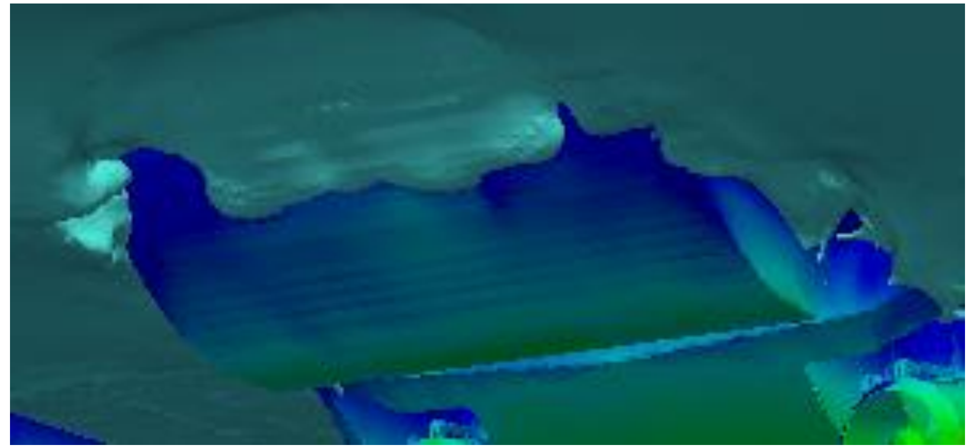
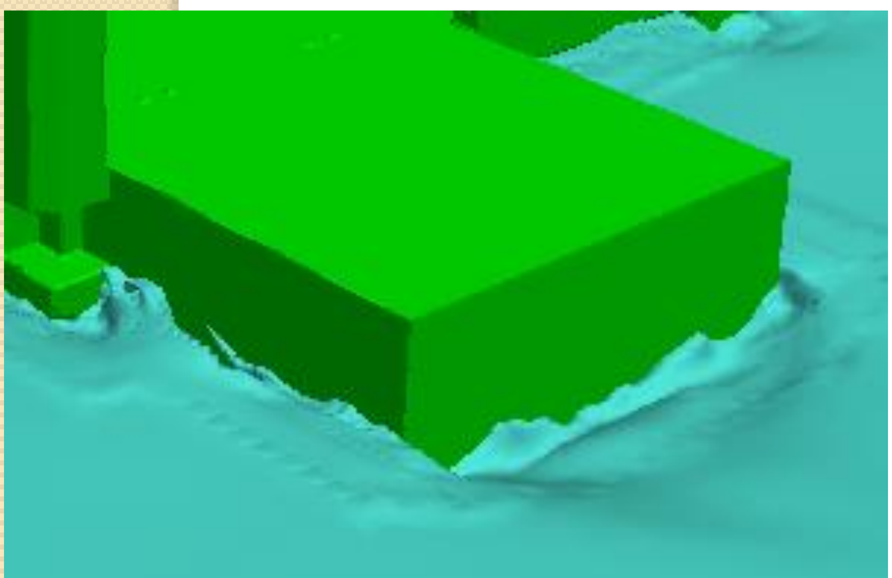
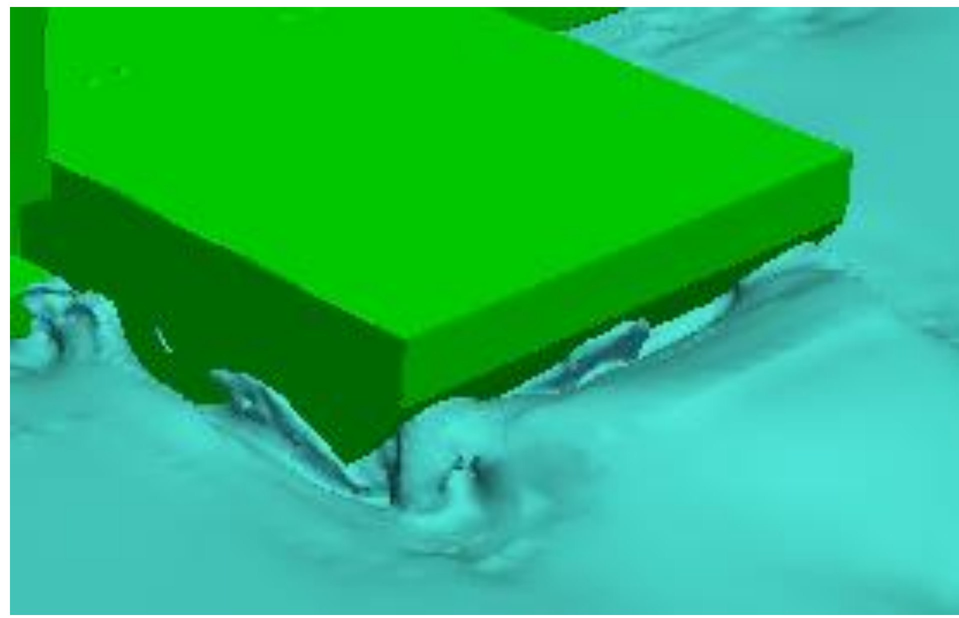
Geometry change descriptions:

- Round smooth from lower part
- Side surfaces stay unchanged





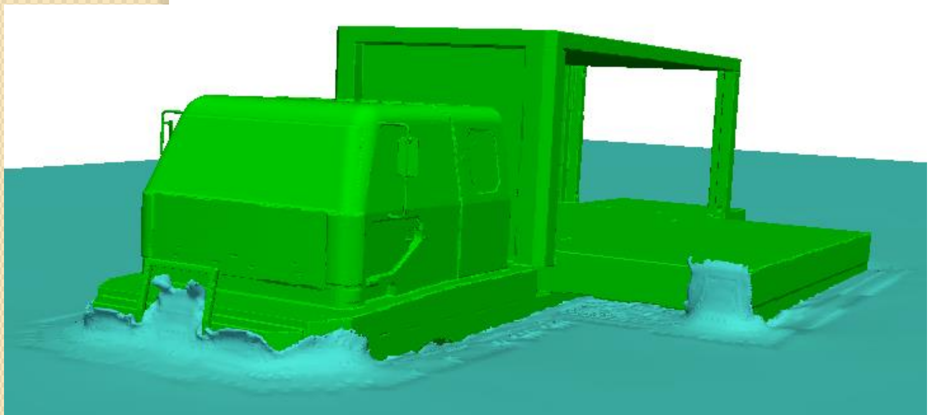
Geometry Changes Study to Reduce Drag

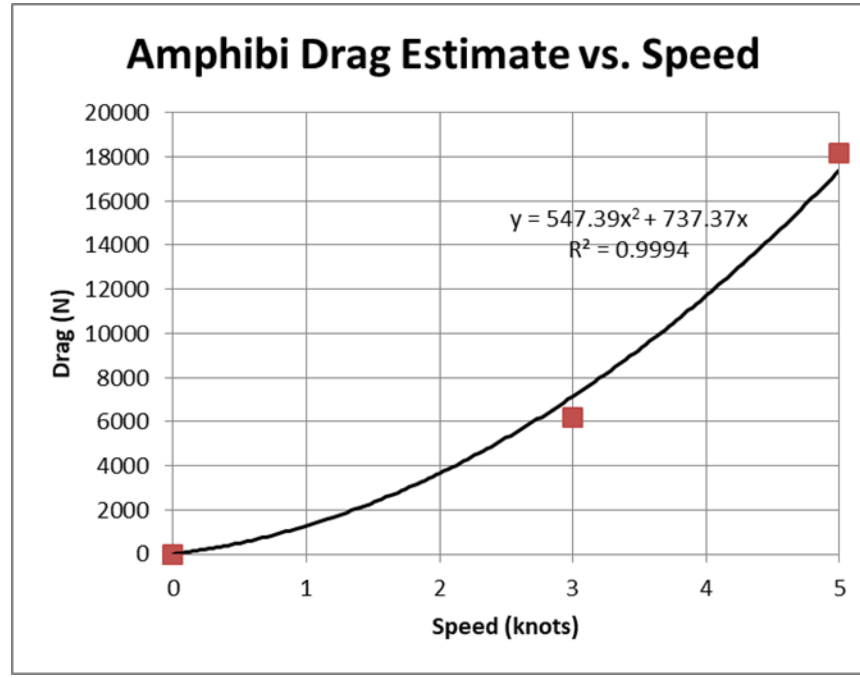





Baseline total vehicle drag = 18 160 N
New Shape total vehicle drag = 17 300 N

>> Drag change = 860 N
Drag reduction of 5%

Amphibious Vehicle Estimated Speed

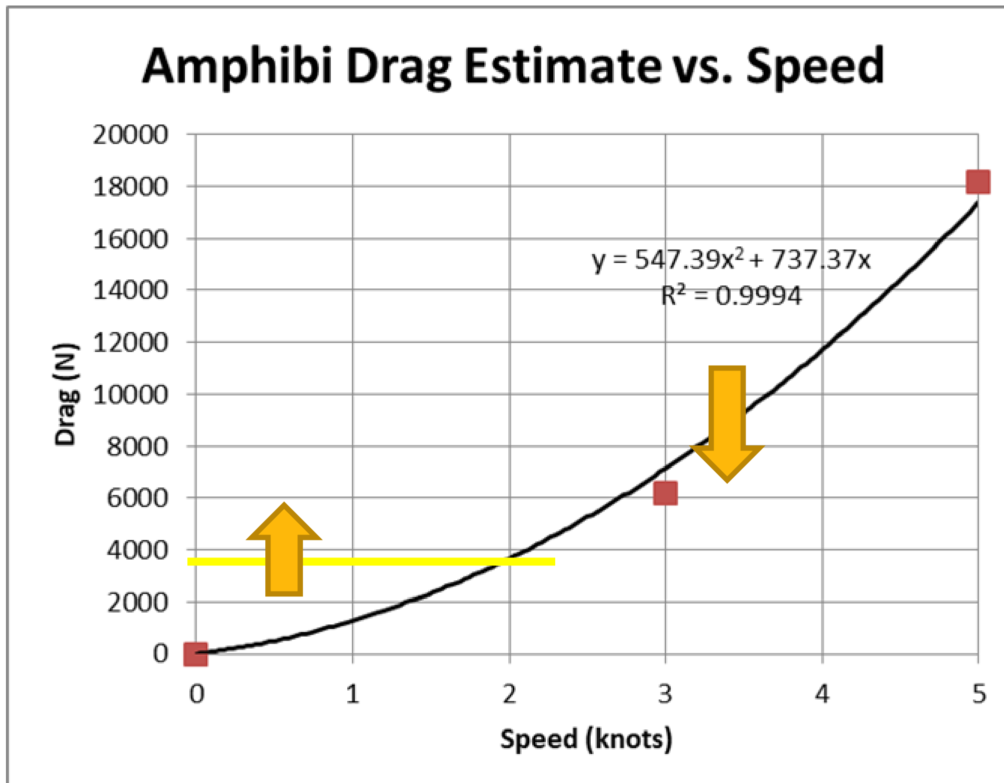




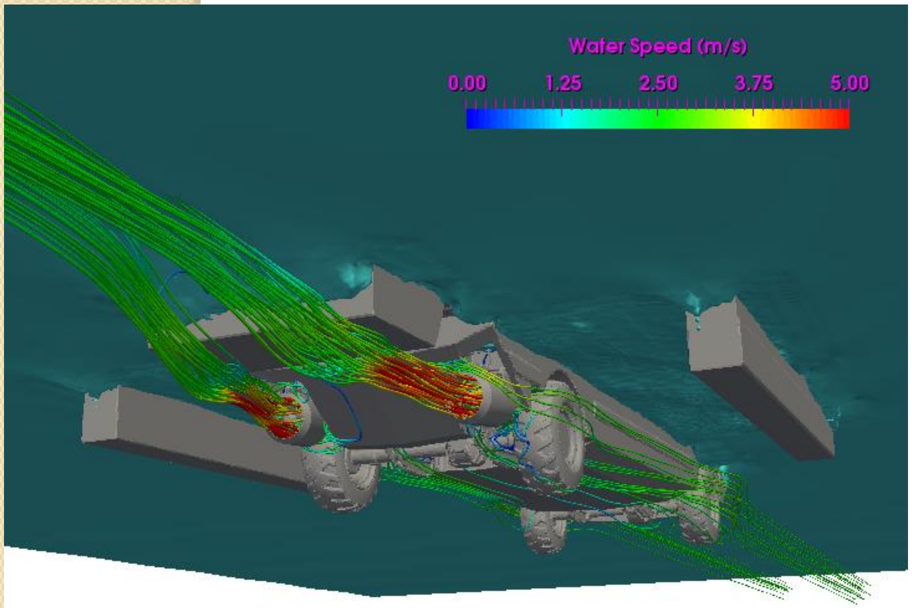
Propulsion of 2 motors = 1660 x 2 = 3320 N
Based on Drag curve, Speed = 1.8 knot
Real test estimation: ~1.5 knot

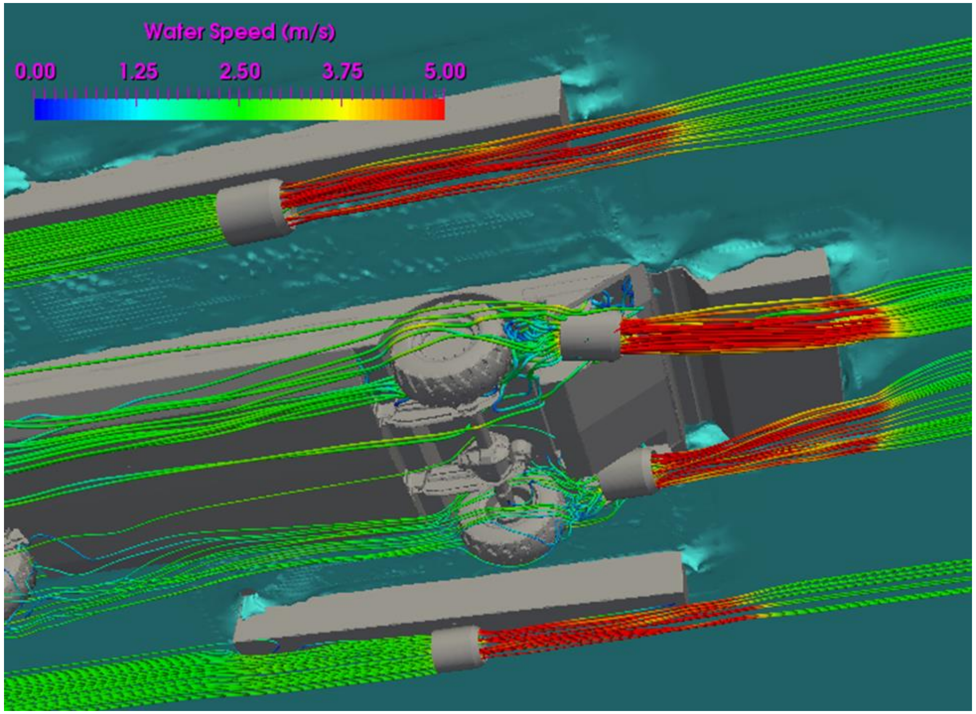
How to Increase Vehicle Speed

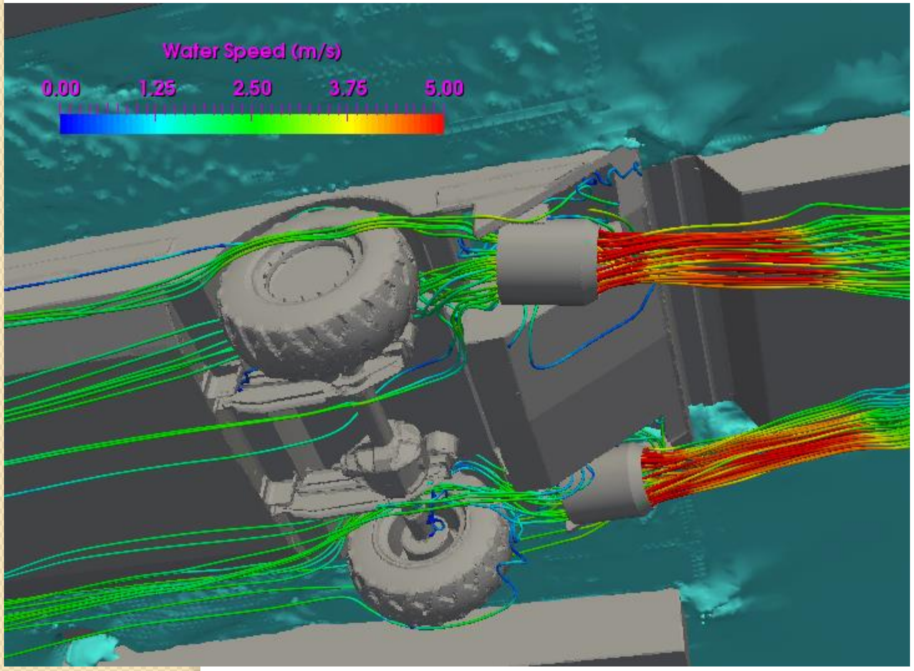
1. Improve motor performance
    - Close gap of blades to tunnel
    - Optimize nozzle length
2. Add more motors
    - Add 2 more motors at side box
3. Reduce drag curve
    - Change side box
    - Change rear box
    - Cover suspensions
    - Cover wheels
    - Improve nose area



Forces in Motors







Velocity = 5 knots = 2.5722 m/s
Blade ON
Propulsion RR = 4 920 N
Propulsion Frt = 4 280 N

Drag = 12 540 N

Baseline total vehicle drag = 18 160 N

SWISS GERMAN UNIVERSITY

Assignment Letter/Surat Tugas

No. AL/MME/784A/XII/17
Date 30 December 2017
Page 1 of 1
Doc. Type Main Document / *Dokumen Utama*

Dena Hendriana, B.Sc., S.M., Sc.D.

Activity Assignment — ***Penugasan Kegiatan***

Dean of the Faculty of Engineering and Information Technology

Dekan Fakultas Teknik dan Teknologi Informasi

In consideration of:

His appointment as the Dean of the Faculty of Engineering and Information Technology under agreement no. SK/014/Y-SGU/X/17.

Mengingat:

Pengangkatannya sebagai Dekan Fakultas Teknik dan Teknologi Informasi di bawah perjanjian no. SK/014/Y-SGU/X/17.

Herewith permits to

Dengan ini menugaskan kepada

Name/*Nama:* Dena Hendriana, B.Sc., S.M., Sc.D.

Position/*Jabatan:* Head of Master of Information Technology/ Ketua Jurusan Magister Teknik Mesin

Faculty/*Fakultas:* Engineering and Information Technology/ Teknik dan Teknologi Informasi

To participate on the following activity:

Untuk berpartisipasi pada kegiatan berikut ini:

No	Event / Acara	Organizer / Penyelenggara	Date / Tanggal	Venue / Tempat
1.	Melakukan penelitian untuk mengubah kendaraan truk menjadi amphibius untuk DislitbangAD	SGU dan DislitbangAD	1 January 2018 – 31 December 2018	SGU, dan DislitbangAD di Batu Jajar, Jawabarat

Immediate Supervisor / *Pemberi Ijin:*

Dr. Irvan S. Kartawiria, S.T., M.Sc
Dean of Faculty Engineering and Information Technology
Dekan Fakultas Teknik dan Teknologi Informatika

Swiss German University
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UJI COBA
TNI AD
7795-54

SWISS GERMAN UNIVERSITY

LAPORAN

PENELITIAN MODIFIKASI TRUK MENJADI AMPHIBIUS

BEKERJA SAMA DENGAN LITBANG AD

Dena Hendriana, B.Sc., S.M., Sc.D – Team Leader
Kol. Simon P. Kamlasi (LitBang AD) – Team Member

MASTER OF MECHANICAL ENGINEERING

2018

Swiss German University
The Prominence Tower Alam Sutera
Jalan Jalur Sutera Barat No 15, Tangerang 15143
INDONESIA

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Judul Penelitian	: Penelitian modifikasi Truk menjadi Amphibious Bekerja sama dengan Litbang AD
Nama Team Leader	: Dena Hendriana, B.Sc., S.M., Sc.D
Research Center/Dept.	: Master of Mechanical Engineering
E-mail	: dena.hendriana@sgu.ac.id
Mobile phone	: 081213715844
Masa program	: Januari – Desember 2018 (12 bulan)
Keterangan Aktifitas	: TNI Angkatan Darat memerlukan transportasi Truk yang dapat melewati perairan, seperti sungai atau danau. Untuk itu, bagian dari Litbang AD melakukan modifikasi Truk menjadi Amphibious. Untuk itu, mereka memerlukan analisa hydrostatics dan hydrodynamics untuk Truk desain baru yang dapat mengambang dengan stabil dan dapat bergerak di permukaan air. Analisa ini juga diperlukan untuk mengetahui aliran air disekitar propeler untuk optimalisasi aliran. Kegiatan ini merupakan kegiatan pengabdian masyarakat dari Swiss German University yang memanfaatkan keilmuan akademik dari hydrostatics dan hydrodynamics untuk kebutuhan masyarakat yang disini adalah dari pihak TNI angkatan darat, yaitu Litbang AD. Hasil dari penelitian ini tidak dipublikasikan dikarenakan kerahasiaan dari Litbang AD.

Alam Sutera, Tangerang

Date: Juni 2018

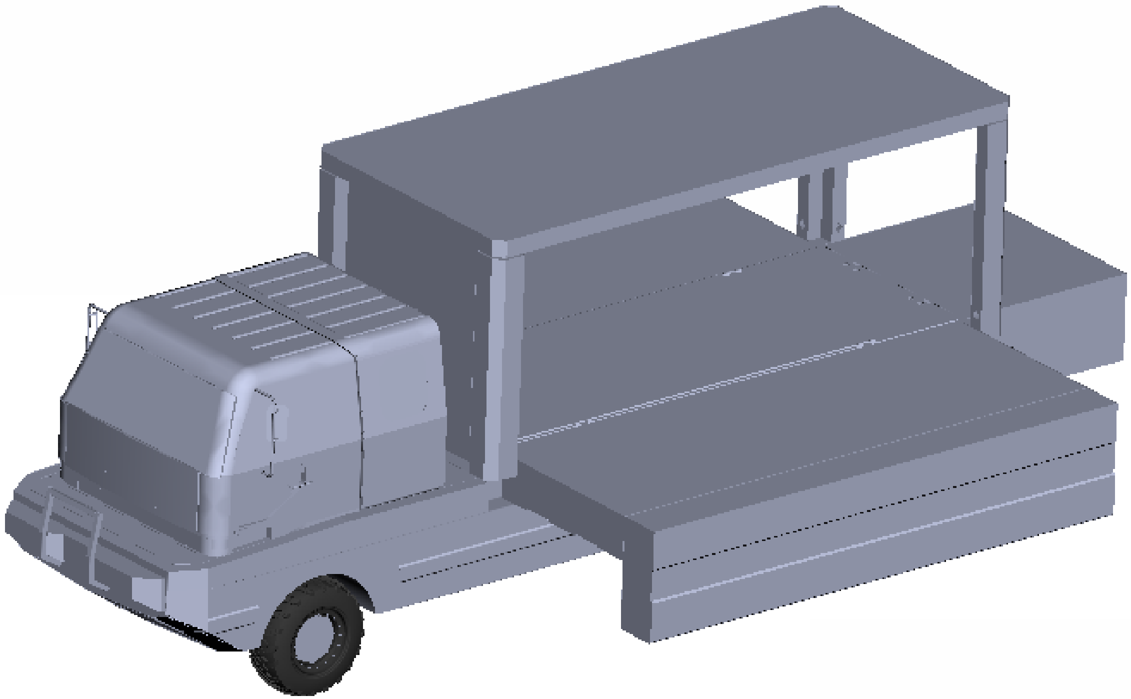
Dena Hendriana, B.Sc., S.M., Sc.D

NIK: 11211528

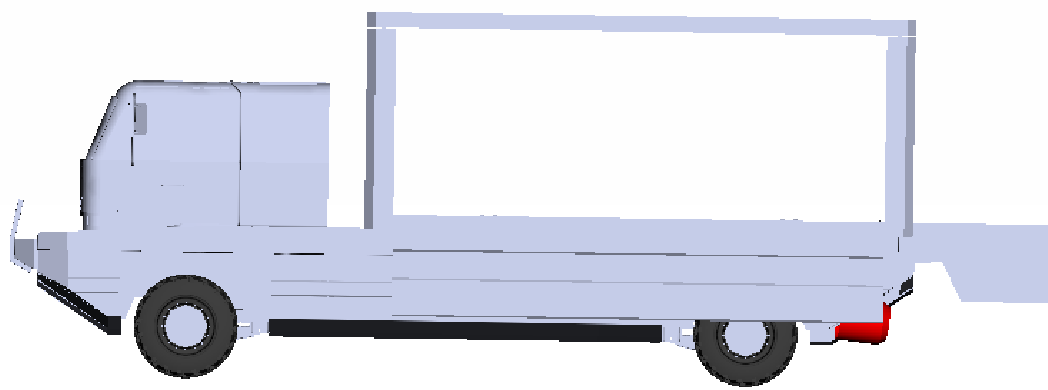
Computational Fluid Dynamics Analysis for TNI AD Amphibious Vehicles

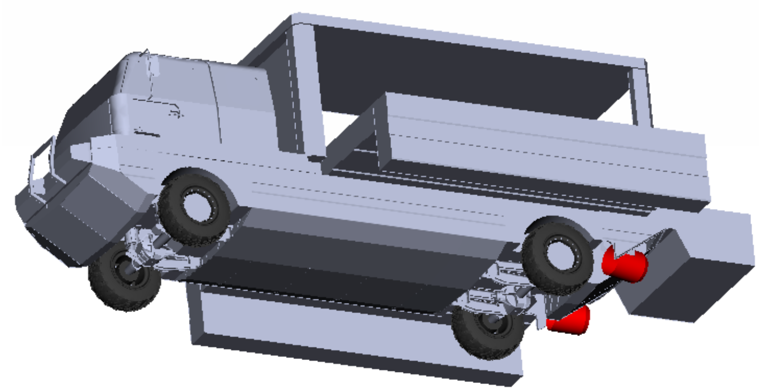
By
Dr. Dena Hendriana
Swiss German University
2 March 2018

Water Test for Amphibious Vehicle



Model vs. Prototype

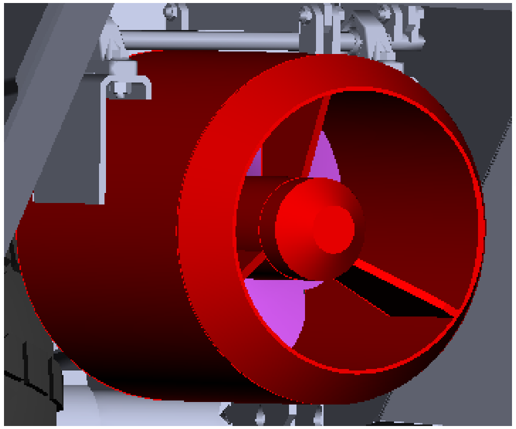


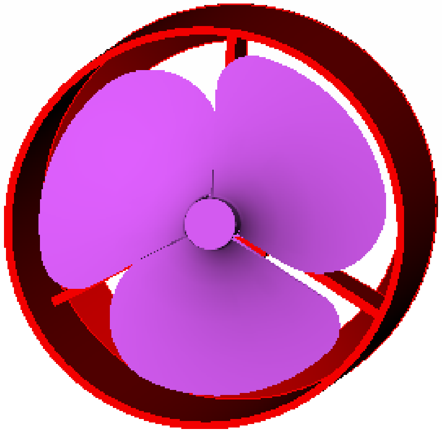


TURBINE MOTOR ANALYSIS

Studies:

- ❑ **Effect of Nozzle**
- ❑ **Effect of Blade Position**
- ❑ **Effect of Blade-Tunnel Gap**





Effect of Nozzle