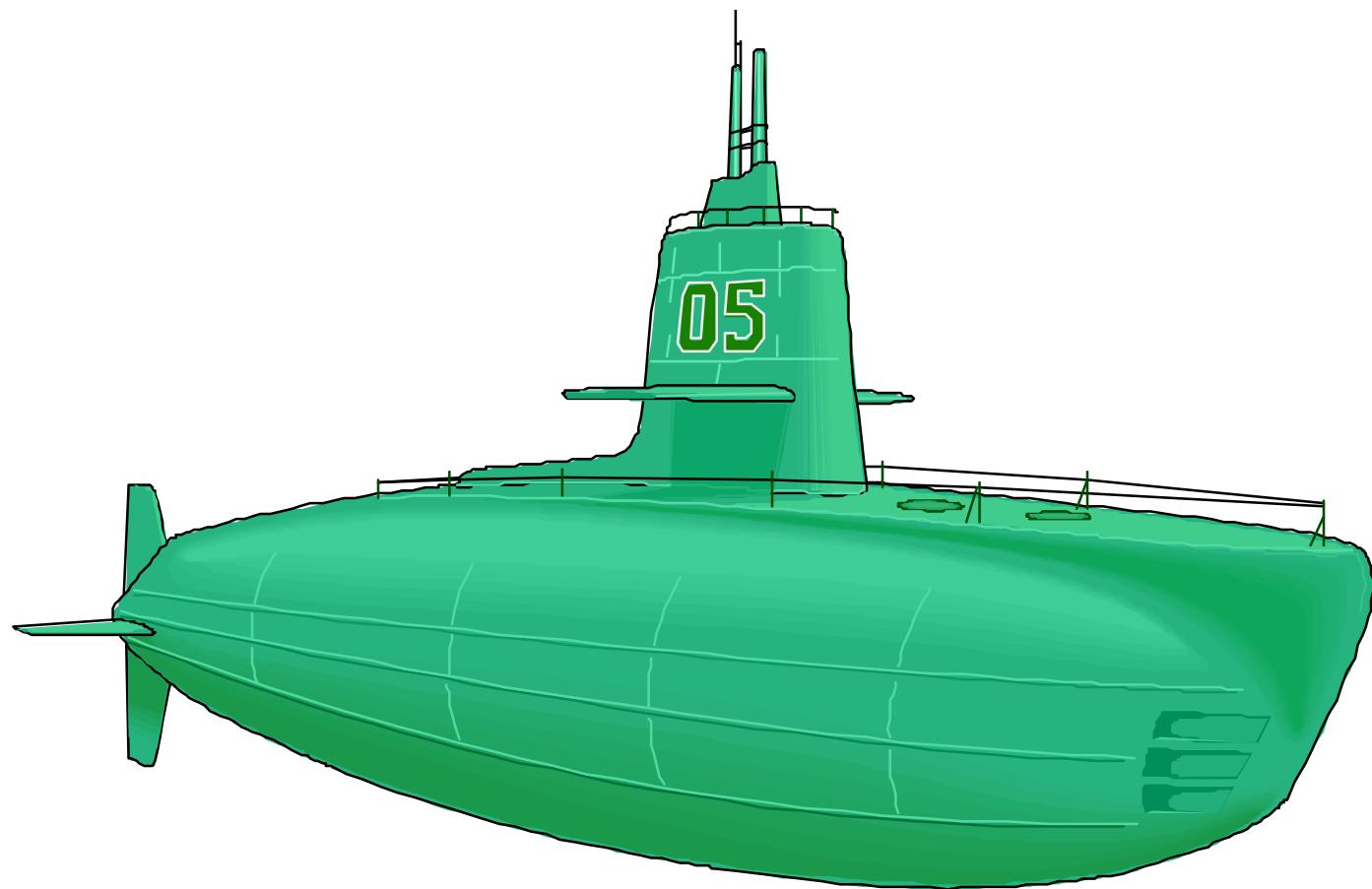


# U.S. SUBMARINE FORCE

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# **Thesis Presentation**

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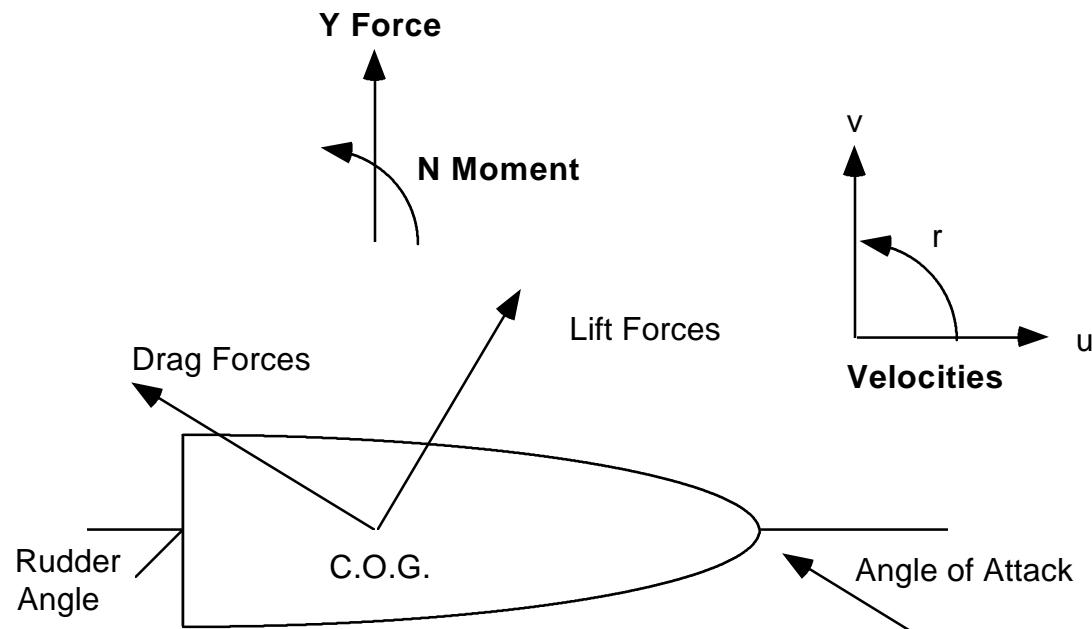
## **Prediction of Hydrodynamic Coefficients Utilizing Geometric Considerations**

**LCDR Eric P. Holmes**

**Advisor: Fotis A. Papoulias**

# Forces and Moments

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# Hydrodynamic Coefficients

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$Y_v'$

$N_v'$

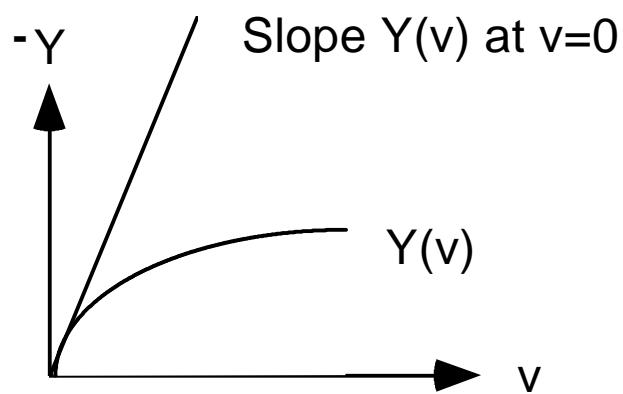
$Y_r'$

$N_r'$

$Y_v'$

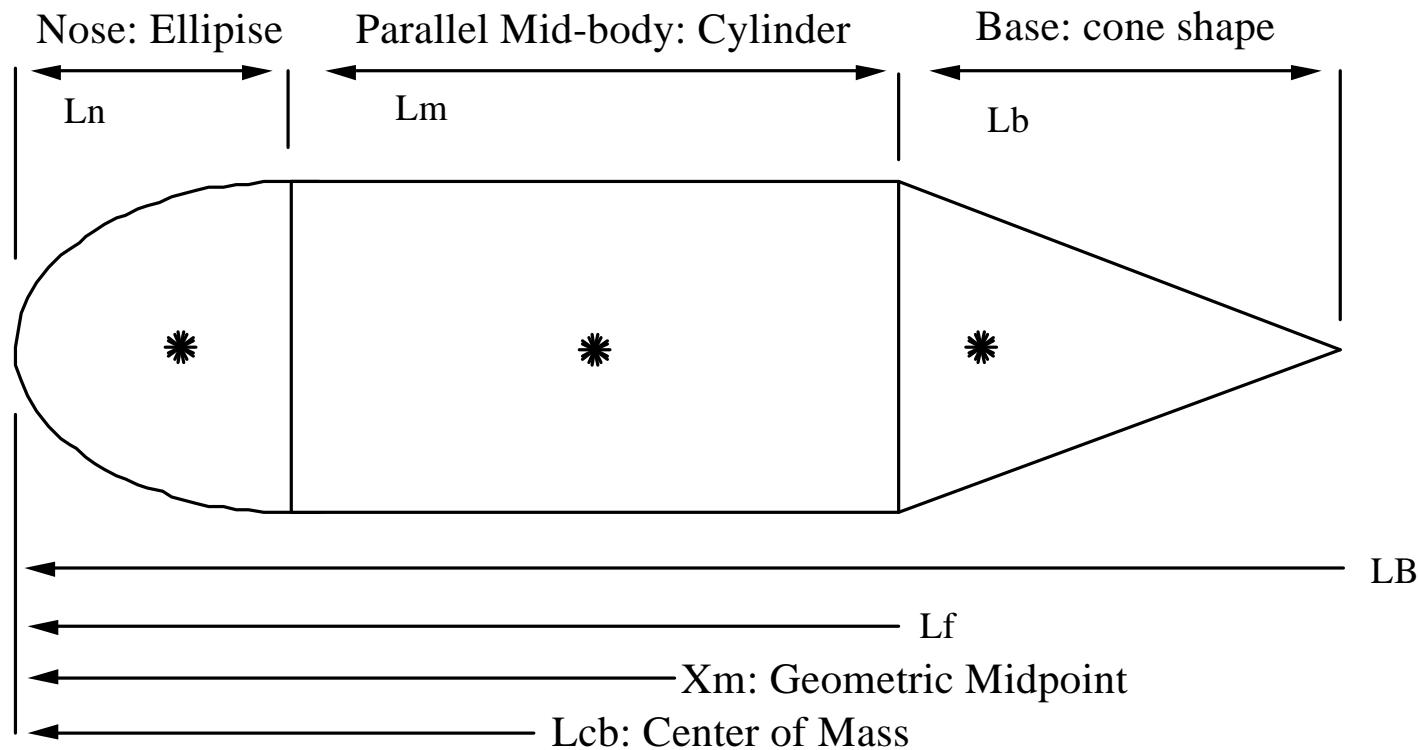
$N_v'$

$N_r'$



# Geometric Parameter Description

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\*: Individual section geometric center

# Equation Functional Form

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$$HC = F\left(F_n, F_m, \frac{V}{L^3}\right)$$

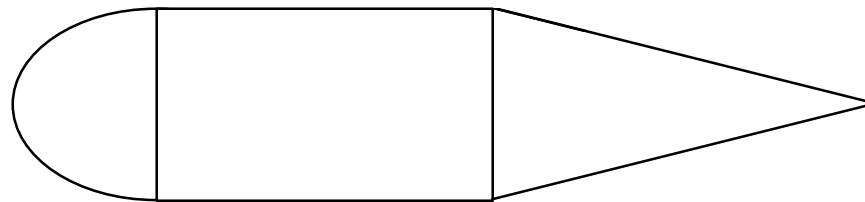
# Assumptions

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- ¾ Proven semi-empirical methods using small angles of attack
- ¾ Constant body volume
- ¾ Nominal body configuration
- ¾ Fractional sections
  - Elliptical Nose: 5-25%
  - Parallel Mid-body: 40-60%
  - Conical Base: 15-55%
- ¾ Volume/Length<sup>3</sup>: 0.006-0.01

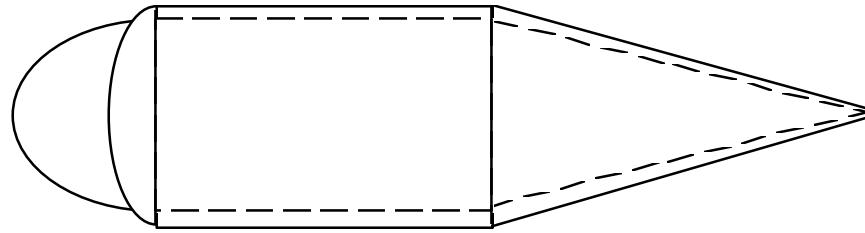
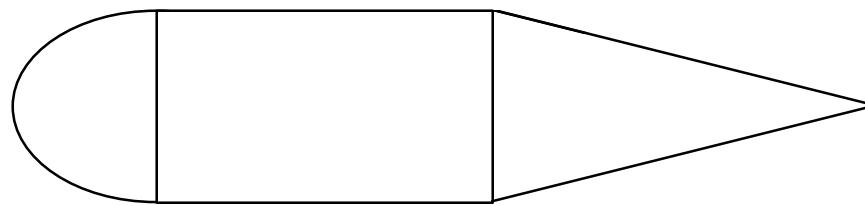
# The Basic Shape

---



# Lower Nose Fraction

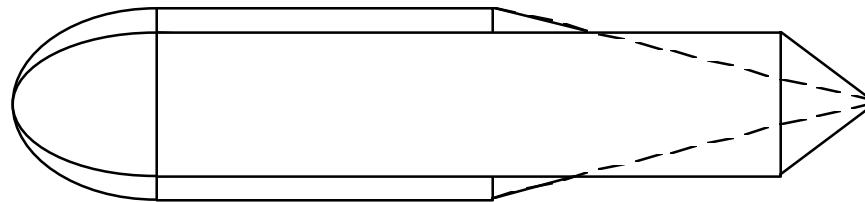
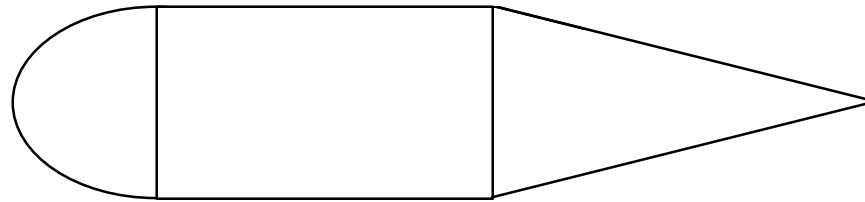
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**Lower Slenderness Ratio**

# Higher Mid-body Fraction

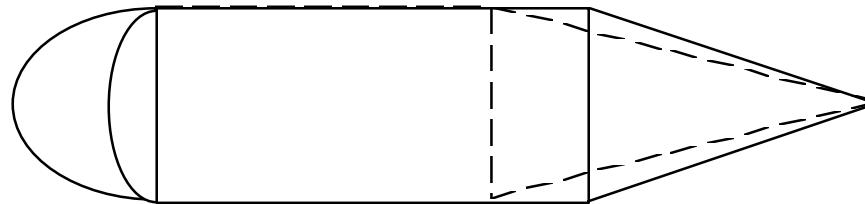
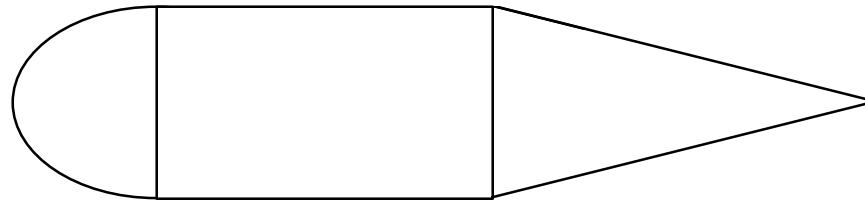
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**Higher Slenderness Ratio**

# **Lower Nose, Higher Mid-body**

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**Lower Slenderness Ratio**

# Data Matrix

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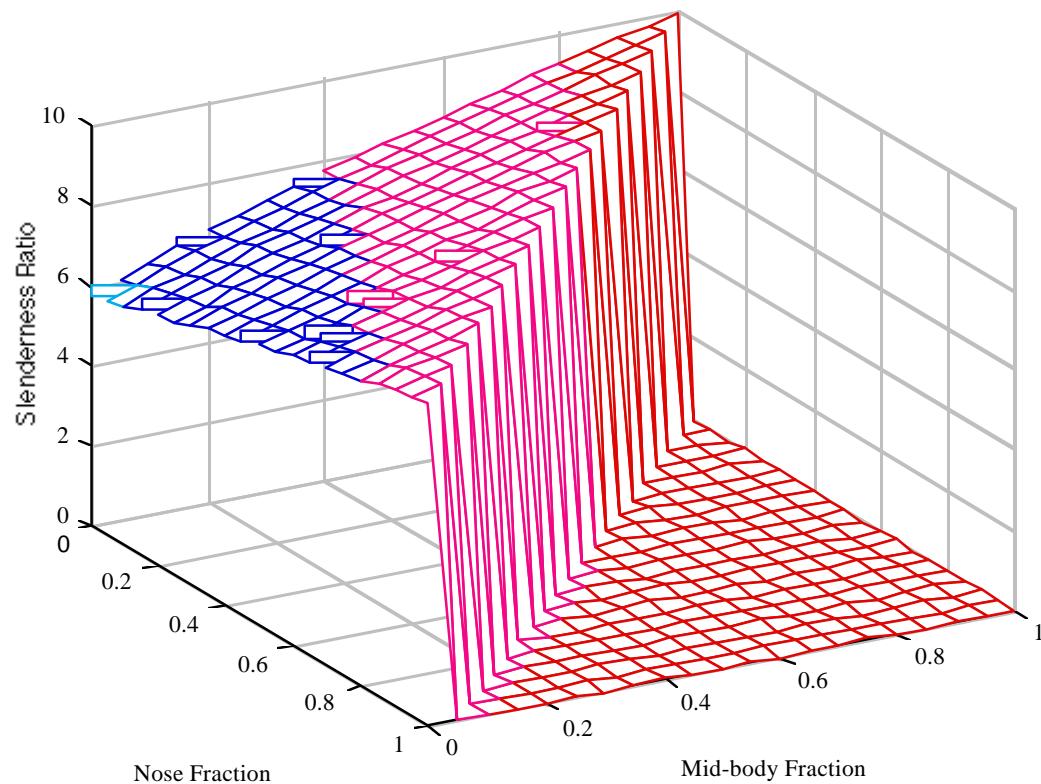
Mid-Body Fraction

		Nose Fraction										
		0	10	20	30	40	50	60	70	80	90	100
0	100	90	80	70	60	50	40	30	20	10	0	0
10	90	80	70	60	50	40	30	20	10	0	0	0
20	80	70	60	50	40	30	20	10	0	0	0	0
30	70	60	50	40	30	20	10	0	0	0	0	0
40	60	50	40	30	20	10	0	0	0	0	0	0
50	50	40	30	20	10	0	0	0	0	0	0	0
60	40	30	20	10	0	0	0	0	0	0	0	0
70	30	20	10	0	0	0	0	0	0	0	0	0
80	20	10	0	0	0	0	0	0	0	0	0	0
90	10	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0

Matrix Body: Base Fraction

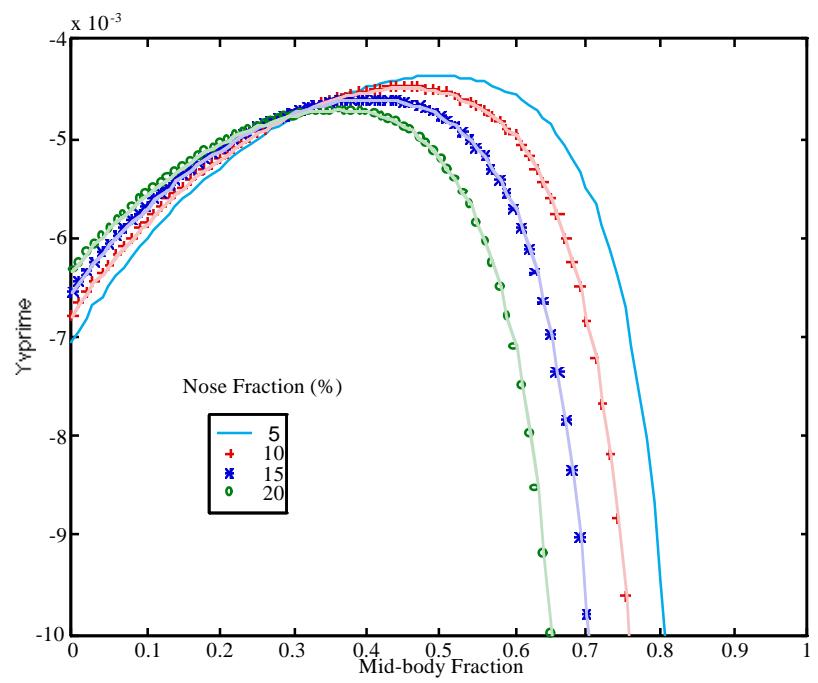
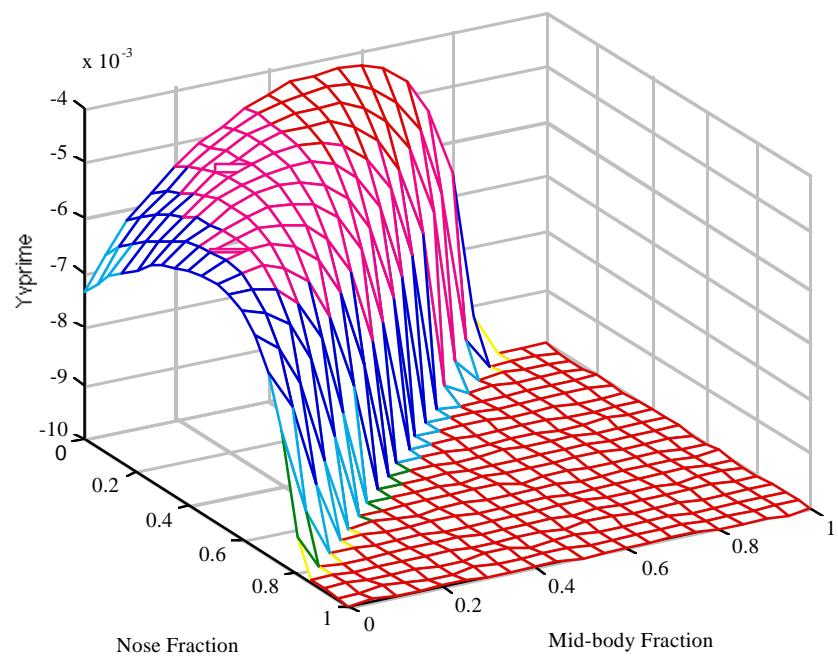
# Slenderness Ratio ( $L/d$ )

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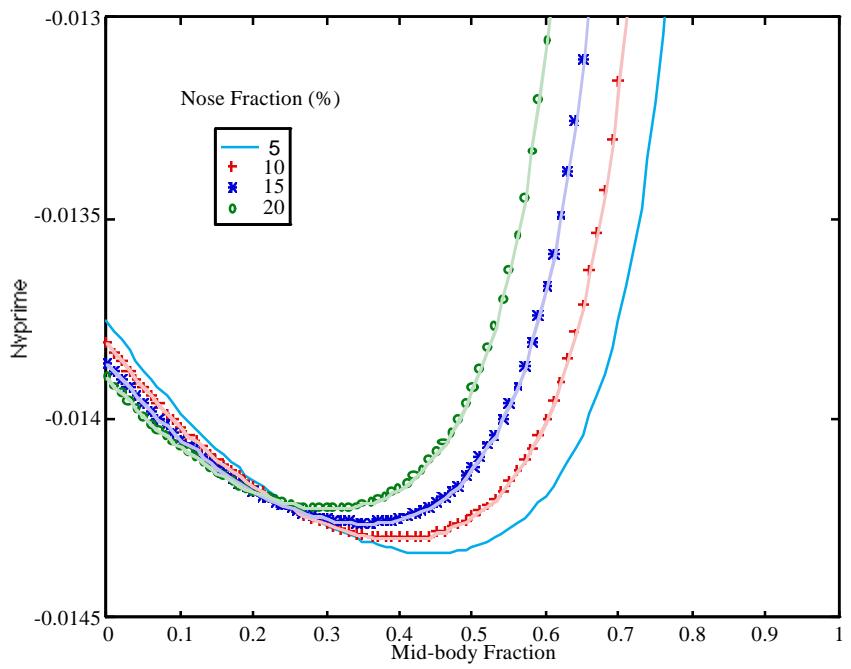
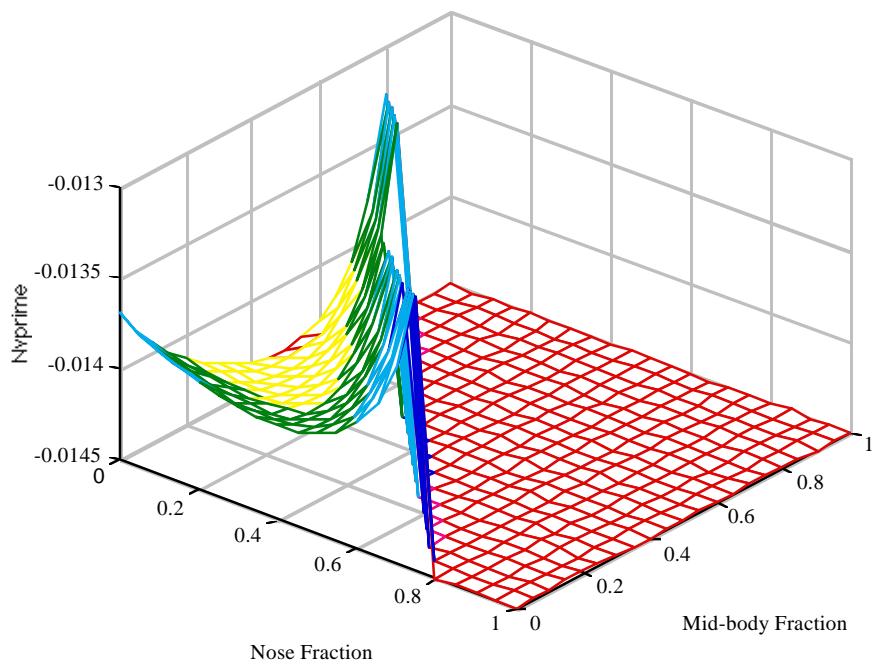
# $\mathbf{Yvprime}$

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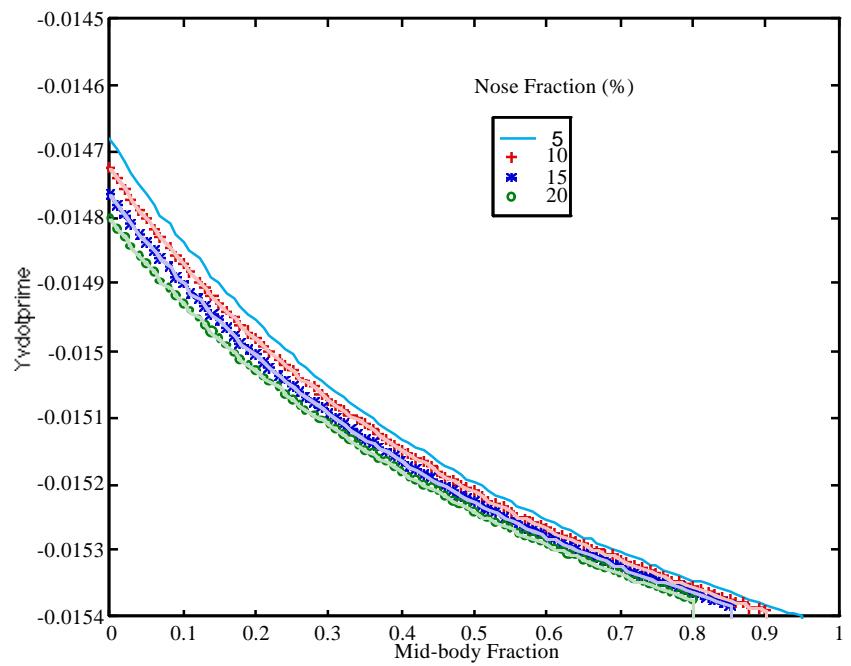
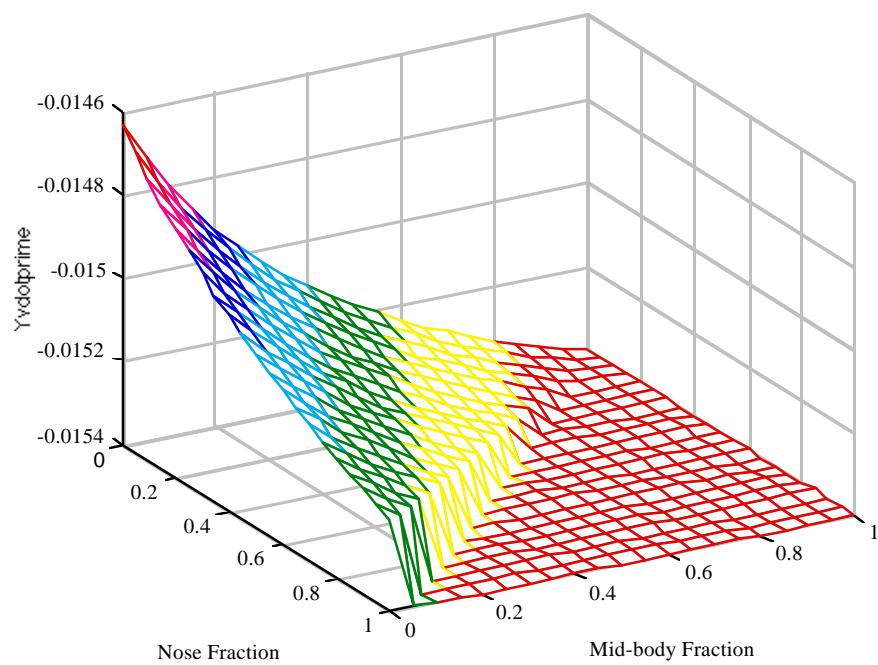
# N<sub>vprime</sub>

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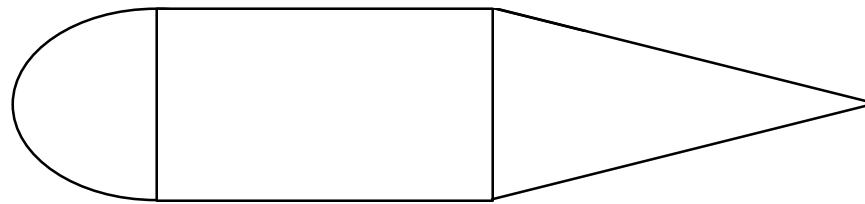
# $Y_{vdotprime}$

---



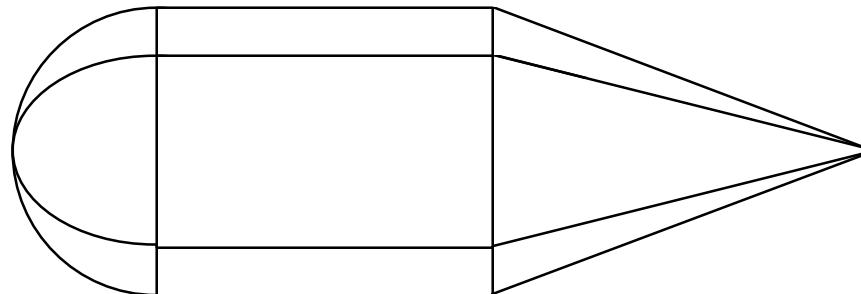
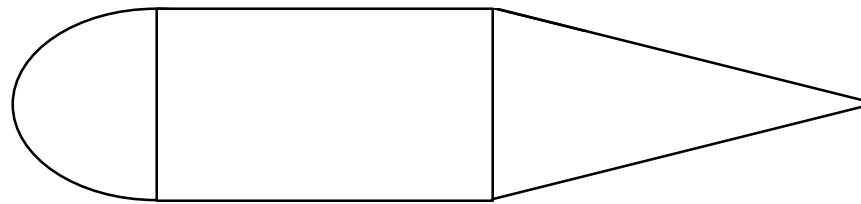
# The Basic Shape

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# Higher Volume/Length Ratio

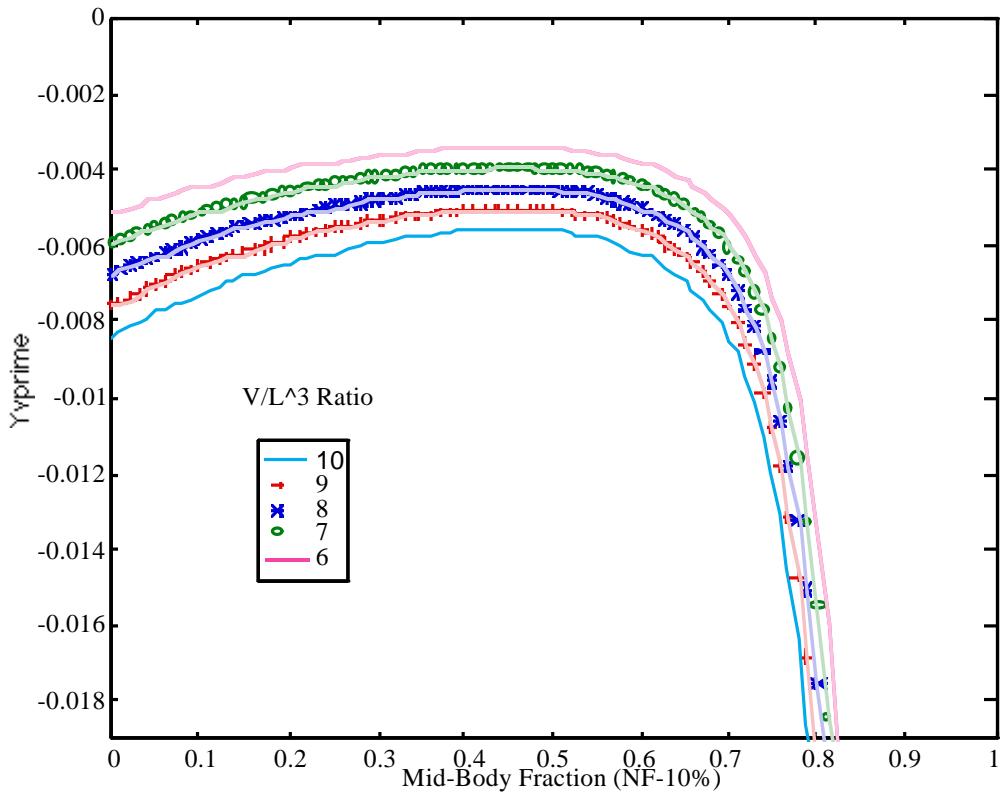
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**Higher Volume with a given Length**

# **Yvprime**

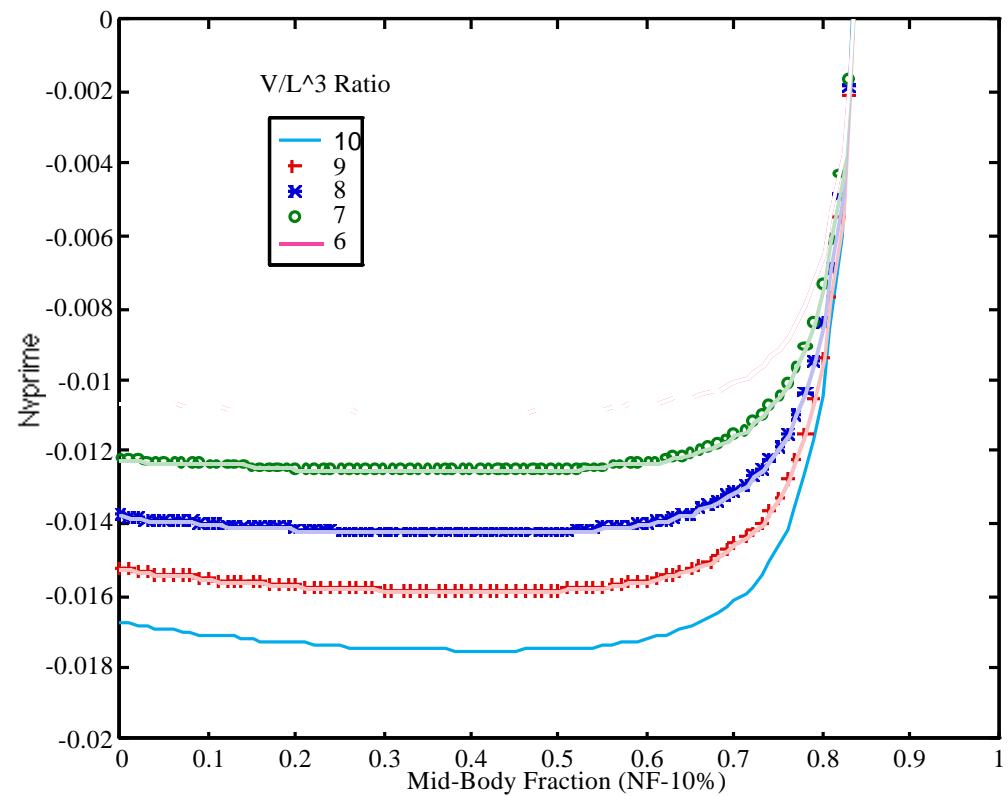
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**Variations with volume and length**

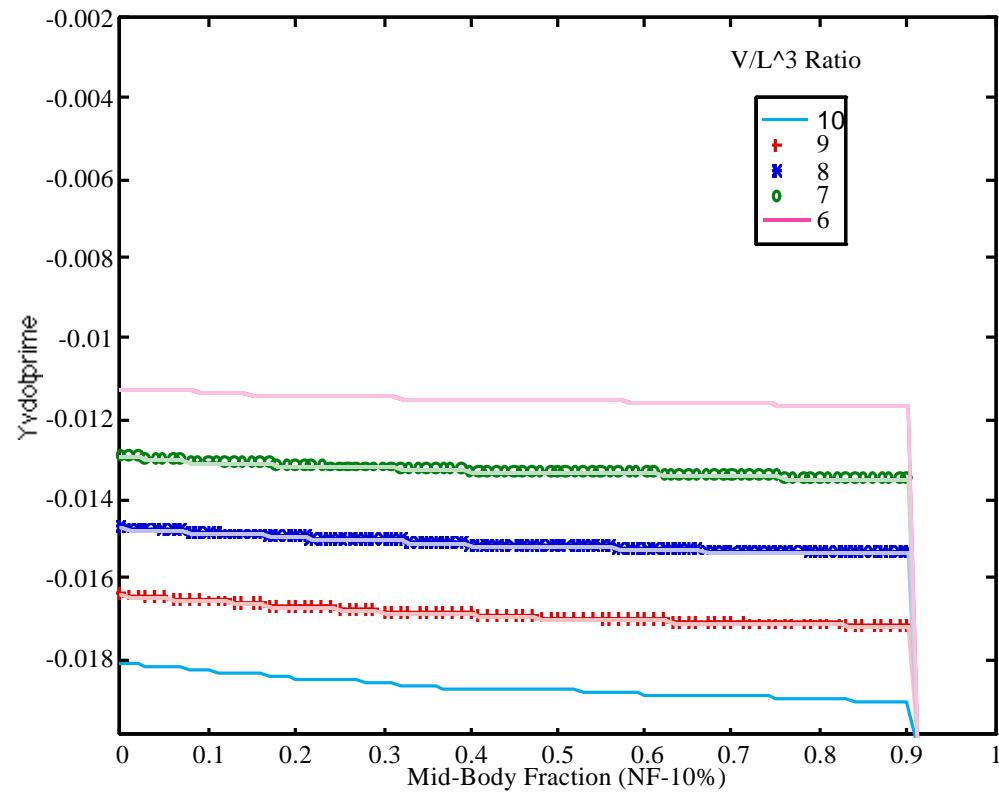
# Nvprime

---



**Variations with volume and length**

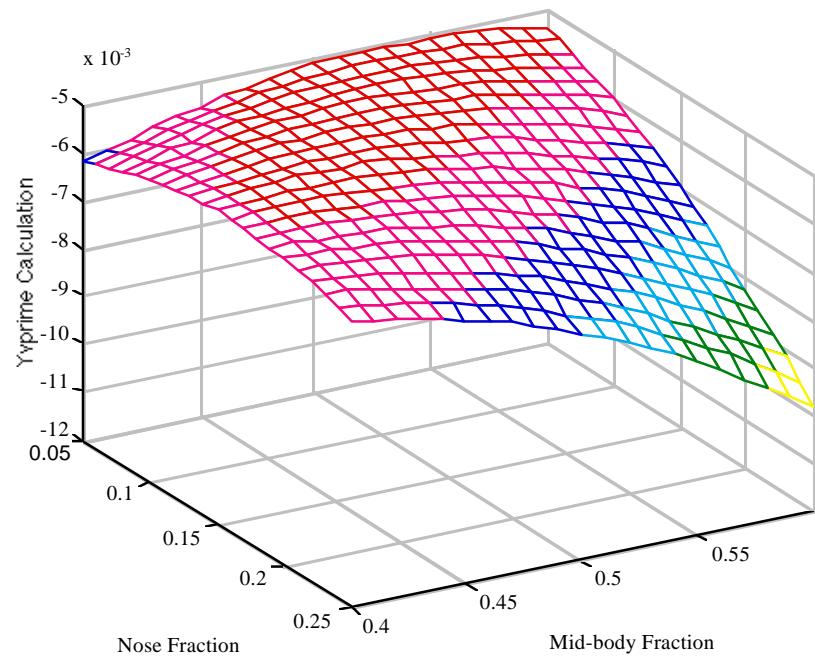
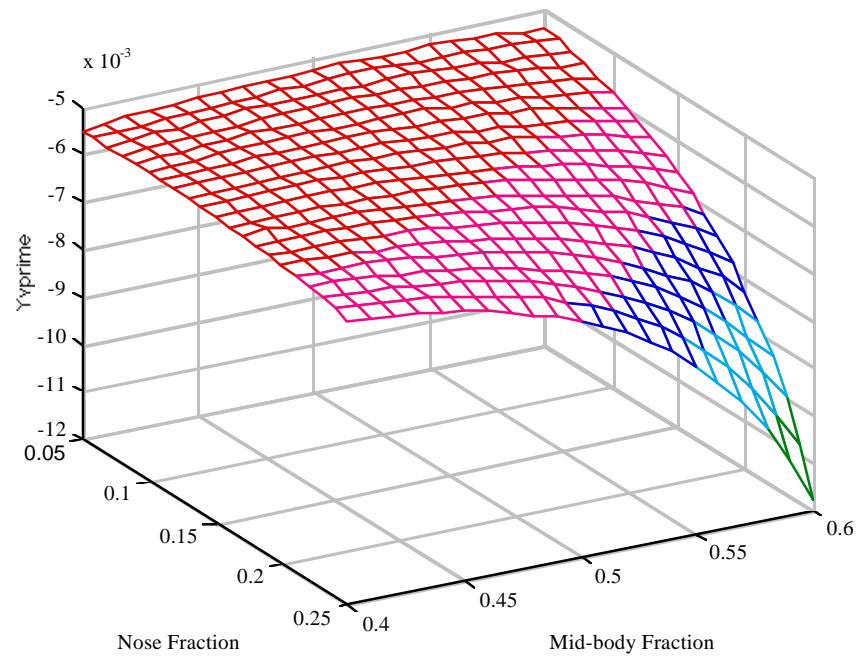
# $\dot{Y}_v$



**Variations with volume and length**

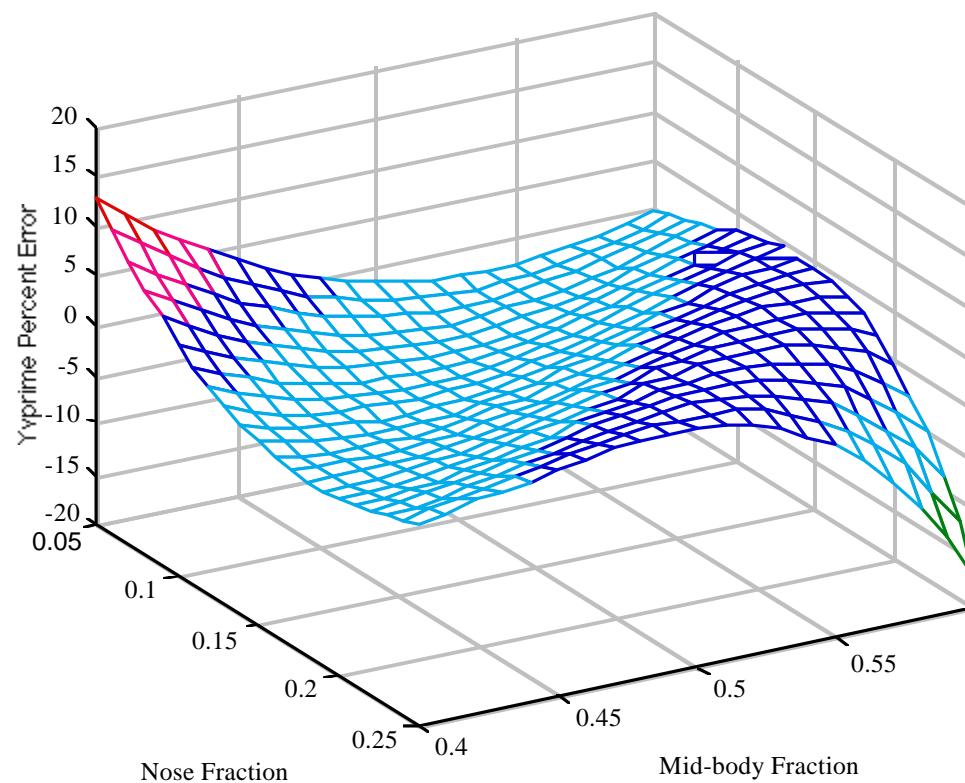
# Yvprime

---



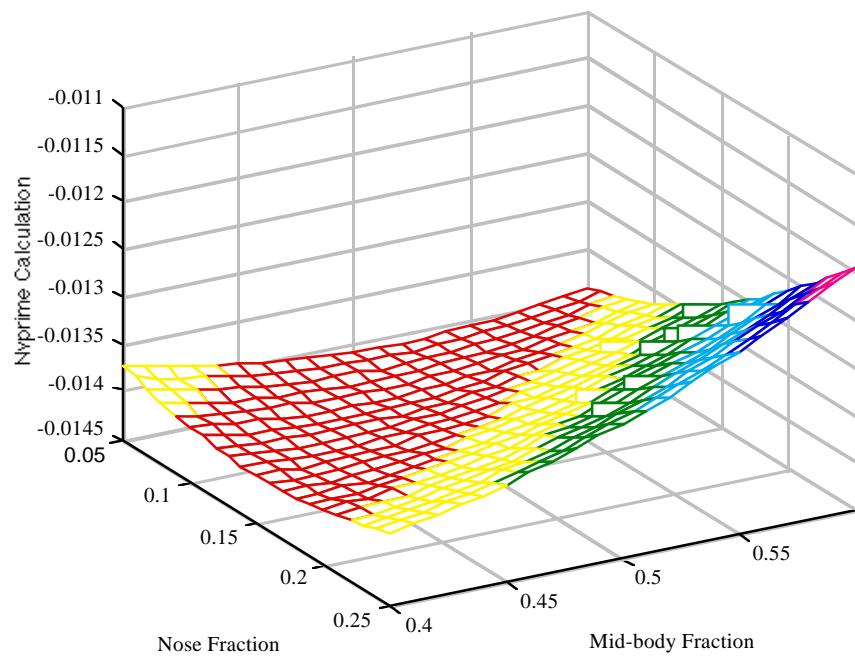
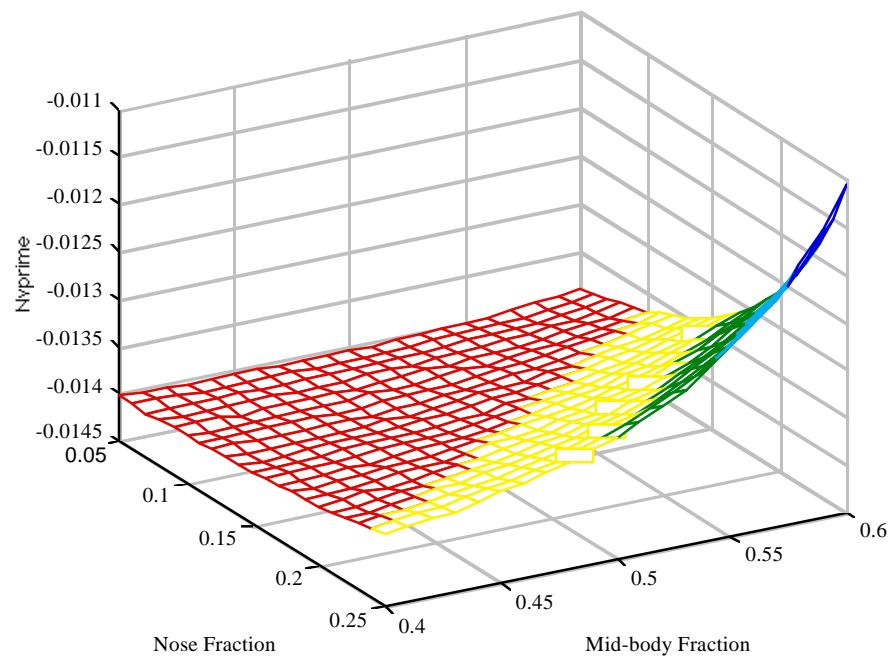
# $Y_{vprime}$ : Percentage Error

---



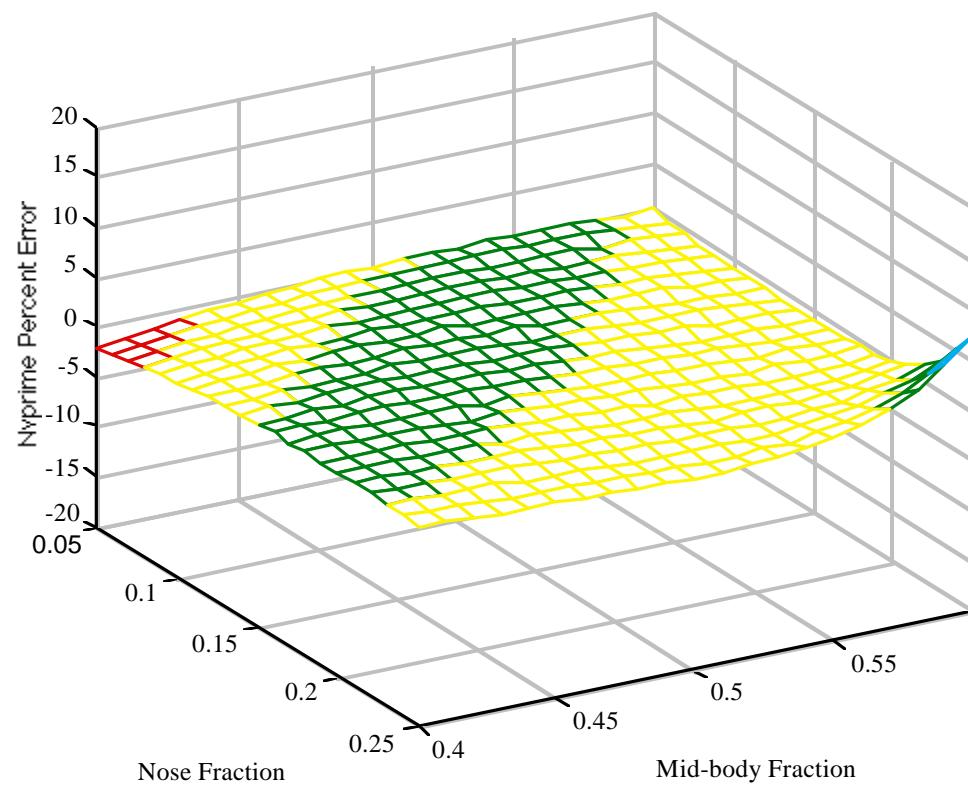
# N<sub>vprime</sub>

---



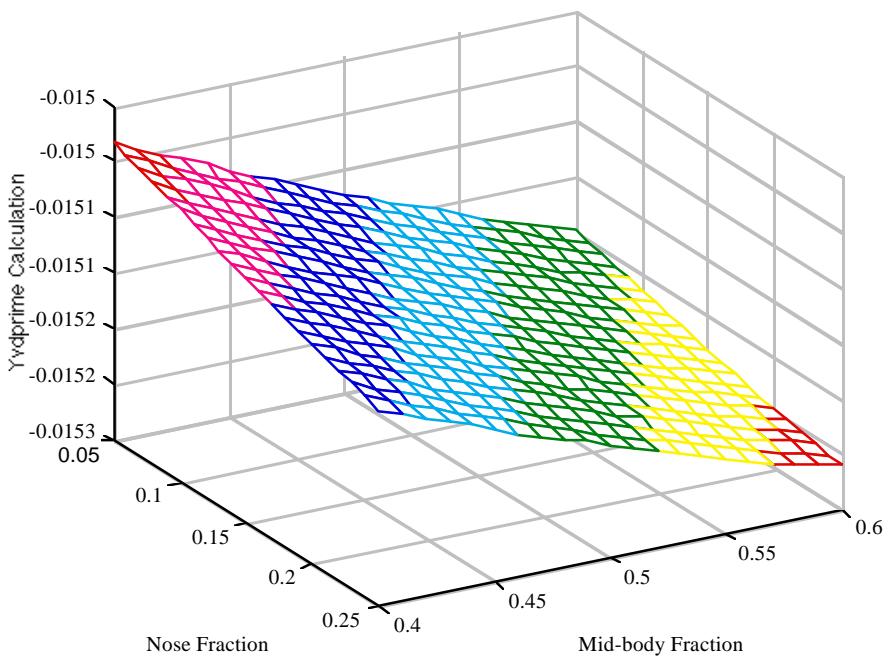
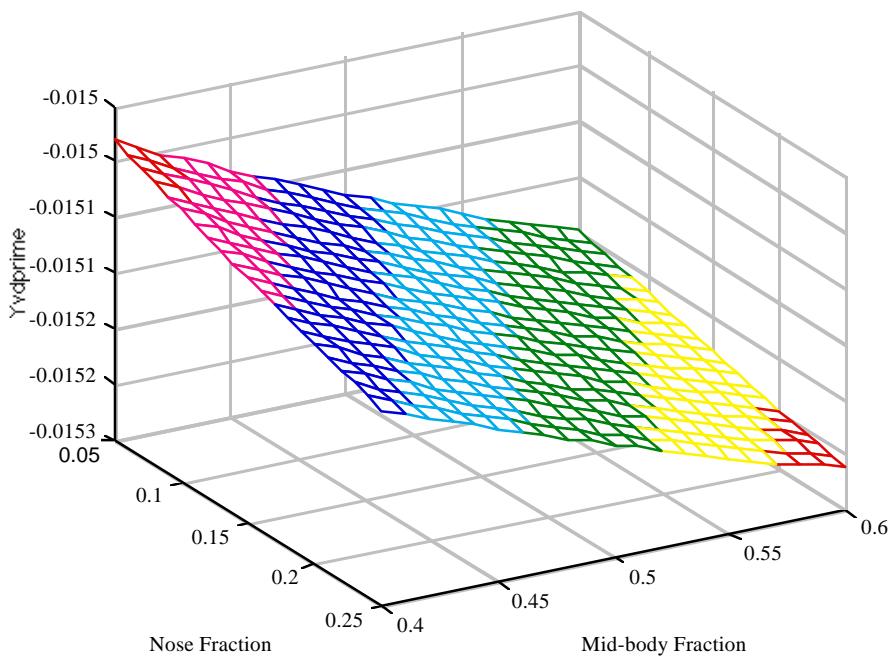
# Nvprime: Percentage Error

---



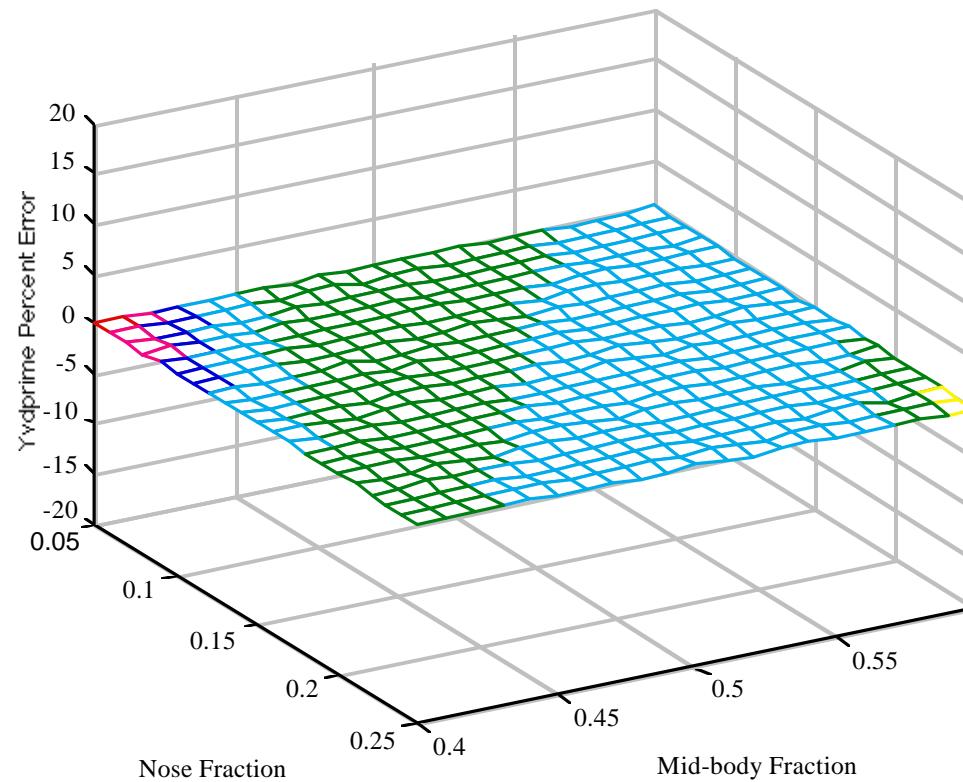
# $\dot{Y}_v$

---



# $\dot{Y}_v$ : Percentage Error

---



# Equation Functional Form

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$$HC = F\left(F_n, F_m, \frac{V}{L^3}\right)$$

$$HC = A_1 F_n^2 + A_2 F_n F_m + A_3 F_m^2 + A_4 F_n + A_5 F_m + A_6 + A_7 \left( \frac{V}{L^3} - C_1 \right)$$

# Conclusions

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¾ Parameter Behavior

- Non-dimensional Slenderness Ratio
- Non-dimensional Volume/Length<sup>3</sup>

¾ Hydrodynamic coefficient prediction

using geometric considerations

¾ Trends vary with fractional sections

¾ Higher Volume/Length<sup>3</sup> ratio resulted in  
a higher hydrodynamic coefficient value

# Recommendations

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- Modify the program to evaluate different shapes.
- Evaluate motion in the verticle plane.
- Calculate stability criteria and general maneuvering performance for the surface mesh functions.

# Lessons Learned

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$\frac{3}{4}$  Macintosh

$\frac{3}{4}$  Word, Excel, Powerpoint

$\frac{3}{4}$  Matlab

$\frac{3}{4}$  Legend

$\frac{3}{4}$  Encapsulated Postscript (-depsc2)

$\frac{3}{4}$  HP48G