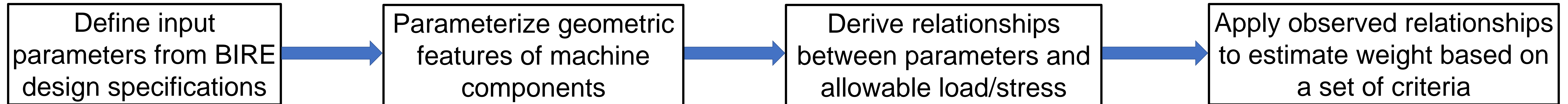


Generating Low Order Weight Models for Mechanical Design of an Aircraft with a Bio-Inspired Rotating Empennage

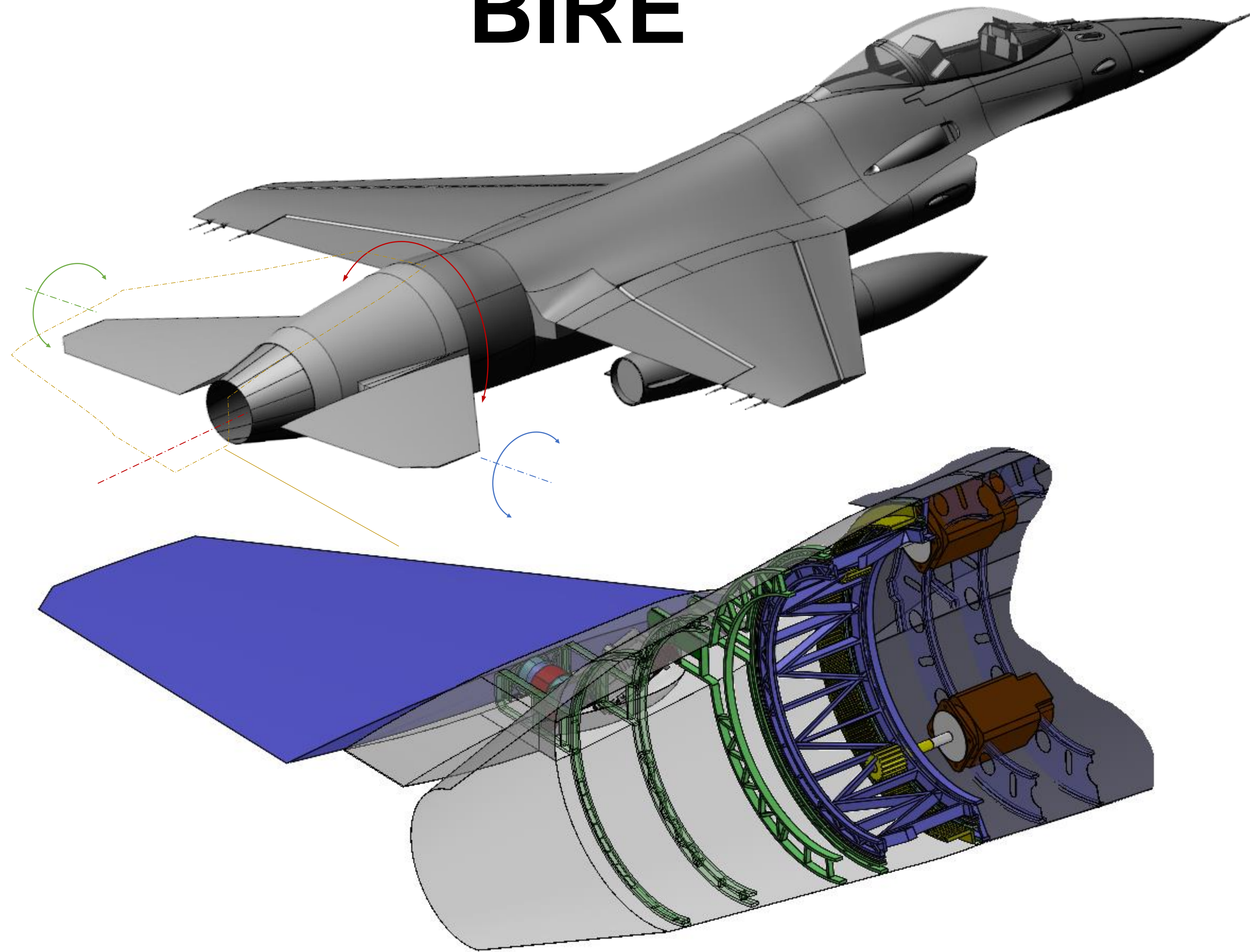
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Objective: To develop low order models for accurate and rapid estimation of critical mechanical component weights to optimize the control of a Bio-Inspired Rotating Empennage (BIRE).



BIRE



BIRE with cutaway view of internal mechanisms

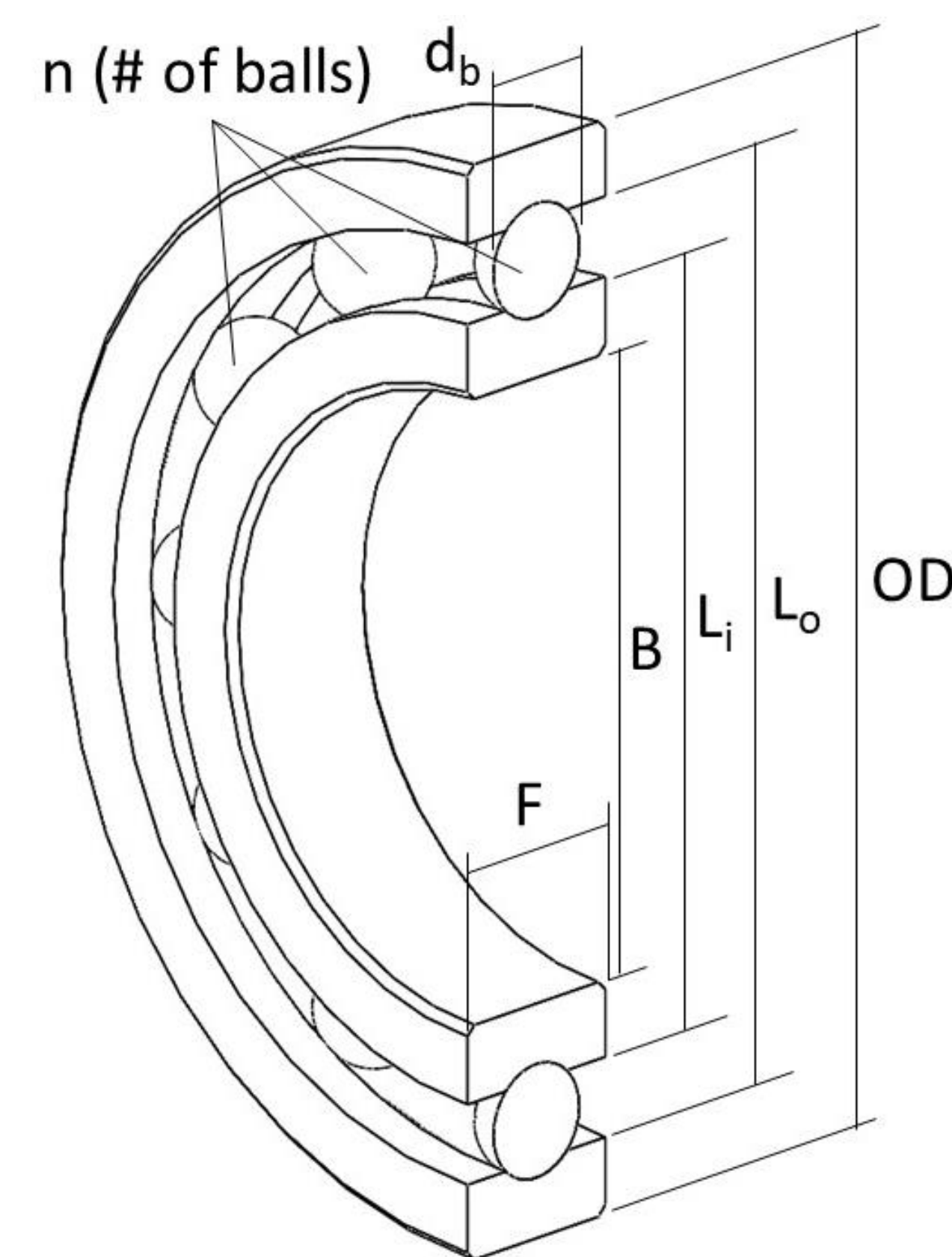
- Vertical stabilizer is removed on fighter aircraft to improve fuel efficiency
 - Reduces weight
 - Reduces drag
- F-16 with rotating empennage to control agile maneuvers of the aircraft

Bearings

Define inputs:

- OD
- Bearing load

Compute contact stress on bearing balls

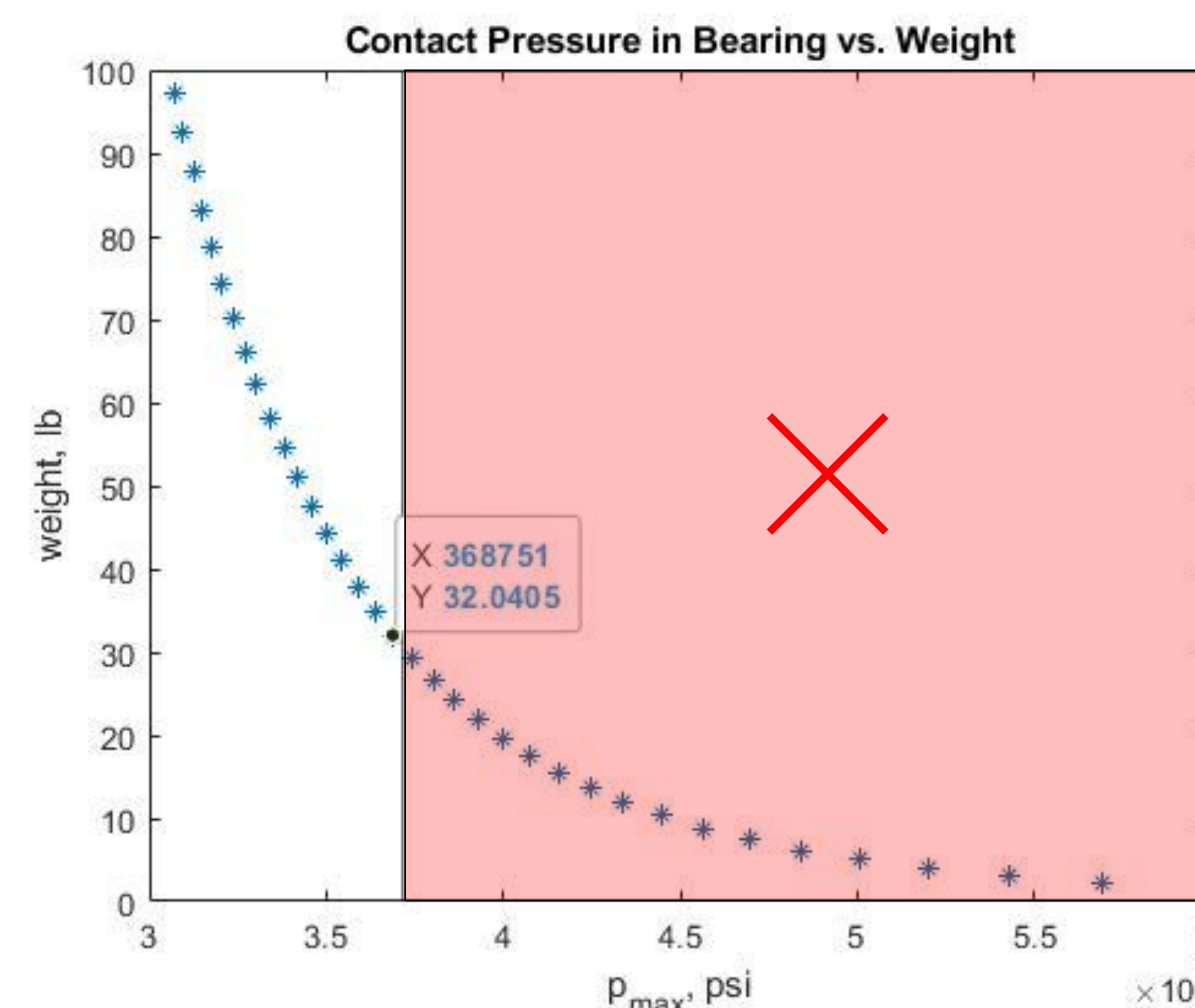


Parameterized bearing

Outputs: $B, l_0, l_i, d_b, B, n, F$

Approximate weight via geometry from outputs

$$m_b = \rho\pi\{B[OD^2 - (OD - l_0)^2 + (d + l_i)^2 - d^2]/4 + N_b d_b^3/6\}$$



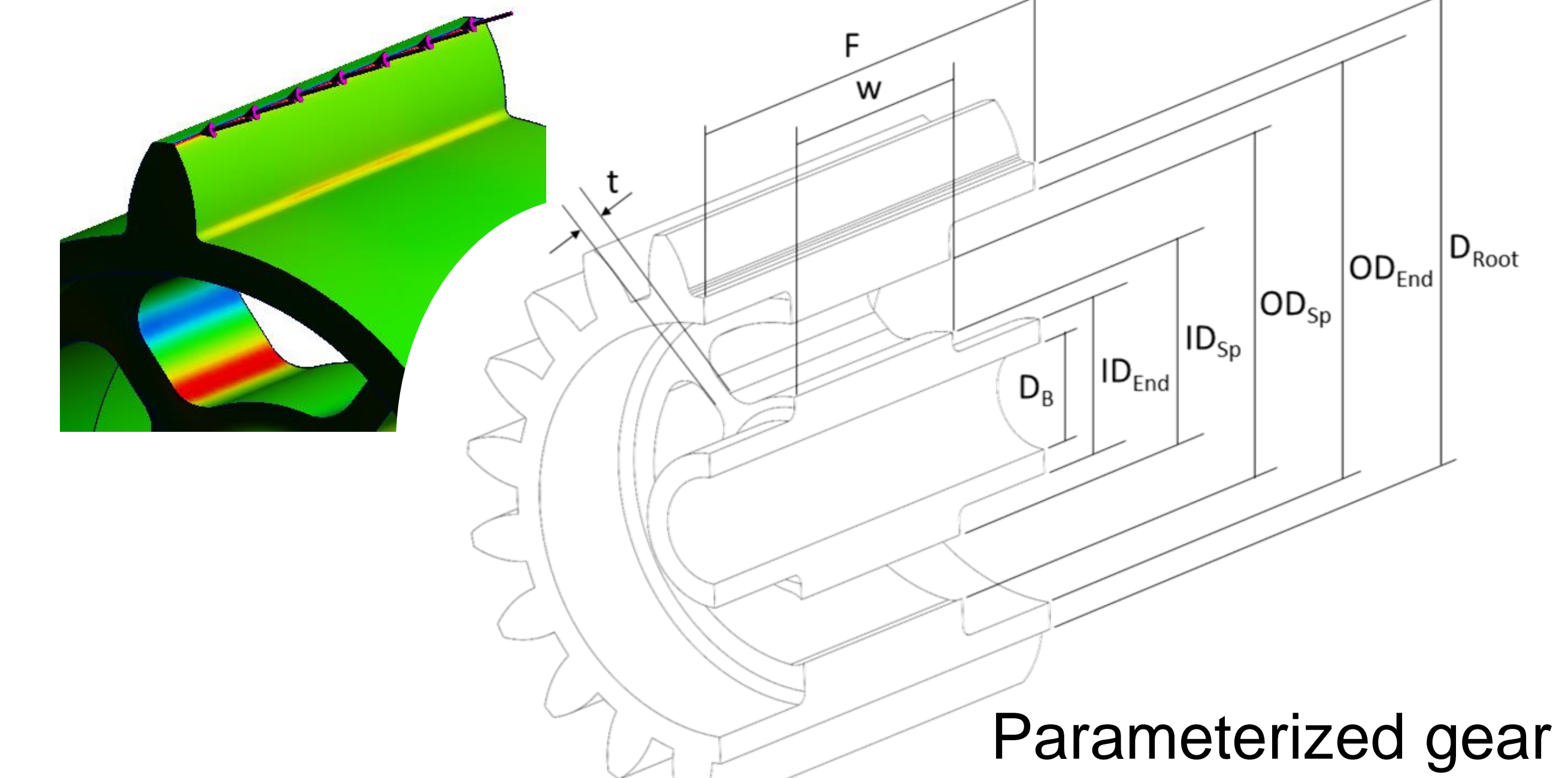
Predicted stress plot with suitable bearings

Gears

Define inputs:

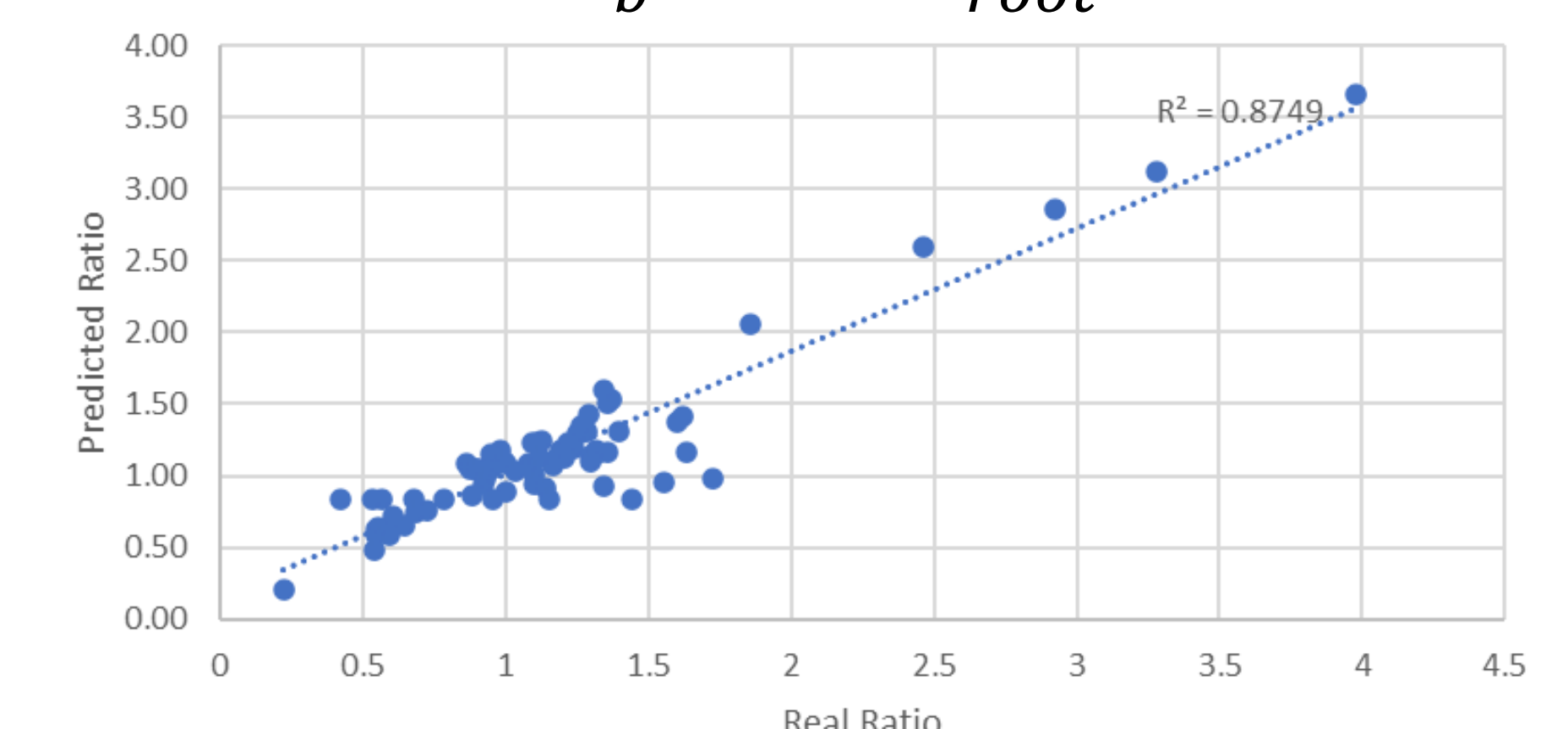
- Ring gear OD
- Number of pinions
- Applied torque

Correlate tooth and spoke bending stresses



Parameterized gear

$$\frac{\sigma_{tooth}}{\sigma_{spoke}} = C_0 + C_1 \frac{OD_{end}}{d_{root}} + C_2 \frac{OD_{spoke}}{d_{root}} + C_3 \frac{ID_{spoke}}{d_B} + C_4 \frac{ID_{end}}{d_b} + C_5 \frac{t}{d_{root}} + C_6 \frac{w}{F}$$



Approximate weight via geometry from outputs

$$m_g = \rho \left[\left[\pi (d_p/2)^2 F \right] - \left(\pi (F - w) \left((OD_{end}/2)^2 - (ID_{end}/2)^2 \right) \right) - w \left(\pi \left((OD_{sp}/2)^2 - (ID_{sp}/2)^2 \right) - 5t (OD_{sp} - ID_{sp})/2 \right) \right]$$