Airbus/WSU Wingbox Challenge
(Open Category)
2018-19

Showcase your aviation heritage
Design, build, and predict the performance of the lightest, strongest, and stiffest Wingbox possible!

Prize money
1st Prize : $2000
2nd Prize : $1000
3rd prize : $500

Deadline : February 22nd, 2019
The Challenge

Using balsa sheets and sticks, **design**, **build**, and **predict** the performance of the lightest\(^A\), strongest\(^B\), and stiffest\(^C\) wingbox. The wingbox should withstand a minimum \(P=20\) lbs. to qualify.

A. Minimize the weight
B. How much force it can withstand
C. Higher stiffness implies smaller deflections and twist
Initial loads of $Q=2\text{lbs}$ will be applied. While holding this load, the force $P$ will be increased until failure occurs.
The extension behind station $S_0$ will be cast (potted) in epoxy resin to provide the necessary end support condition. You should NOT do the end casting. This will be done by WSU.

The skins, spars and stringers must extend behind station $S_0$ till $S_{-2}$. Failure to do so will result in rejection of wing box from the competition.
Wingbox Challenge Rubric

\[ \text{Score} = S_{\text{performance}} + S_{\text{analysis}} + S_{\text{report}} \]

\[ S_{\text{performance}} = 0.5 \frac{P_{\text{max}}}{W_{\text{wing}}} + 0.1 \frac{Q}{\delta_Q} + 0.05 \left[ \frac{P_{20}}{\delta_{20}} + \frac{P_{20}}{\theta_{20}} \right] - 10 \frac{W_{\text{Wing}}}{1.5} - 10 \frac{W_{\text{glue}}}{W_{\text{wing}}} \]

\[ S_{\text{analysis}} = 10 \left( 1 - f \left( P_{\text{max}}, P_{\text{pred}}, 0.1 \right) \right) + 10 \left( 1 - f \left( \delta_Q, \delta_{Q\_\text{pred}}, 0.1 \right) \right) + 10 \left( 1 - f \left( \delta_{20}, \delta_{20\_\text{pred}}, 0.1 \right) \right) \]

\[ f \left( A, A_{\text{pred}}, \beta \right) = \begin{cases} 
0 & \frac{|A - A_{\text{pred}}|}{A_{\text{pred}}} \leq \beta \\
\frac{|A - A_{\text{pred}}|}{A_{\text{pred}}} - \beta & \text{otherwise}
\end{cases} \]

Note: The tolerances for strength and stiffness are based on variability in material properties.

- \( W_{\text{glue}} \) ~ weight of glue (lbs)
- \( W_{\text{WING}} \) ~ weight of wingbox (lbs)
- \( P_{\text{max}} \) ~ Measured failure load (lbs)
- \( P_{\text{pred}} \) ~ predicted failure load (lbs)
- \( P_{20} \) ~ P=20 lbs (+Q=2lbs)
- \( \delta_{20} \) ~ Measured end deflection (along load) at P=20 lbs (+Q=2lbs)
- \( \delta_{20\_\text{pred}} \) ~ Predicted end deflection (along load) at P=20 lbs (+Q=2lbs)
- \( \delta_Q \) ~ Measured end deflection (along load) at Q=2 lbs
- \( \delta_{Q\_\text{pred}} \) ~ Predicted end deflection (along load) at Q=2 lbs
- \( \delta_{\text{max}} \) ~ Measured end deflection at failure
- \( \theta_{\text{max}} \) ~ Measured end twist at failure (degrees)
Wingbox Challenge Rubric...

- $W_{\text{glue}}$ is the weight of the glue (adhesive) used. You may weigh each of the balsa parts used before assembling them and their sum gives you the total weight of balsa wood. This should be documented in your report. Weigh the completed WingBox and use it to estimate $W_{\text{glue}}$. If the weight of glue is not reported, for scoring purposes, $W_{\text{glue}}=0.25 \, W_{\text{wing}}$ will be used.

- $S_{\text{report}}$ : (Maximum of 50 points for the report). The report shall include,
  - Drawing with dimensions and list of parts (10 points)
  - Itemized weight of Balsa/wood parts and glue (10 points)
  - Details of analysis (eqns, FEA models, etc) (20 points)
  - Summary of activities (5 points)
  - Design philosophy (5 points)
Teams (2018-19)

• H & H
  – H. Ramdial & H. Shahverdi

• HAW Hamburg
  – J. Lehnert, C. Schröder, A. Jüngling, M Herberhold

• Team Ivanov
  – D. Ivanov

• Dreamers
  – A.V. Karuppiah, S. Whitmore, A. Karuppiah
WingBoxes...
Results

• 1<sup>st</sup> PLACE
  – Team IVANOV

• 2<sup>nd</sup> PLACE
  – HAW

• 3<sup>rd</sup> PLACE
  – H & H
Summary of Measurements and Predictions

<table>
<thead>
<tr>
<th>Team</th>
<th>$S_{\text{performance}}$</th>
<th>$S_{\text{analysis}}$</th>
<th>$S_{\text{report}}$</th>
<th>$S_{\text{total}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dreamers</td>
<td>11.13</td>
<td>17.95</td>
<td>0</td>
<td>29.08</td>
</tr>
<tr>
<td>H &amp; H</td>
<td>25.14</td>
<td>29.76</td>
<td>45</td>
<td>99.90</td>
</tr>
<tr>
<td>HAW</td>
<td>26.88</td>
<td>26.82</td>
<td>50</td>
<td>103.70</td>
</tr>
<tr>
<td>Ivanov</td>
<td>56.57</td>
<td>26.57</td>
<td>48</td>
<td>131.14</td>
</tr>
</tbody>
</table>