Project Goal
The goal of this work was to design a T-based lathe to face a 5/8” diameter aluminum part with a maximum flatness error of 20 micron with a depth of pass of 0.1 mm.

Design Strategy
From the design requirements for this project, I proceeded the following way:

- Constructed a list of functional requirements for the overall machine
- Estimated the apportionment of the total error for each axis and each source of error (Geometric and Load-induced)
- Divided the machine in several modules: Linear motion slides, Leadscrews, Spindle & Tool post
- From this basic layout of the overall machine, constructed an error model using HTMs to define the stiffness and geometric error requirements for each module,
- Similarly, for each module:
  o I constructed a list of functional requirements based on the above calculations
  o Generated a series of design concepts
  o Made an analytical model to size the different elements, predict and compare the different concepts’ performance to the functional requirements
  o Built, tested the best concept and closed the loop on the model (measured VS predicted)
- Assembled, tested the entire machine and compare the results to the model.

<table>
<thead>
<tr>
<th></th>
<th>TARGET</th>
<th>PREDICTED</th>
<th>MEASURED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatness Error (min-max) [um]</td>
<td>&lt;20</td>
<td>5.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Depth of pass [mm]</td>
<td>&gt;0.1</td>
<td>-</td>
<td>0.1</td>
</tr>
</tbody>
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*Figure 1: T-based lathe assembly (left), faced test parts (right)*
Test and results
The flatness of the 0.1mm test cuts were then measured on a ZYGO white light interferometer, exhibiting a maximum height difference on the face of $3.4 \pm 0.2$ microns, and a misalignment between the two linear motion axes of $0.89 \pm 0.05$ mrad matching our design requirements and our predictions of 5.7 microns load induced errors.

Discussion
The T-based lathe performed as expected and this project was valuable in teaching me a deterministic and rigorous design process that includes: defining the functional requirements, concept generation, thorough analysis with a clear statement of the assumptions, testing and reflecting on the model.