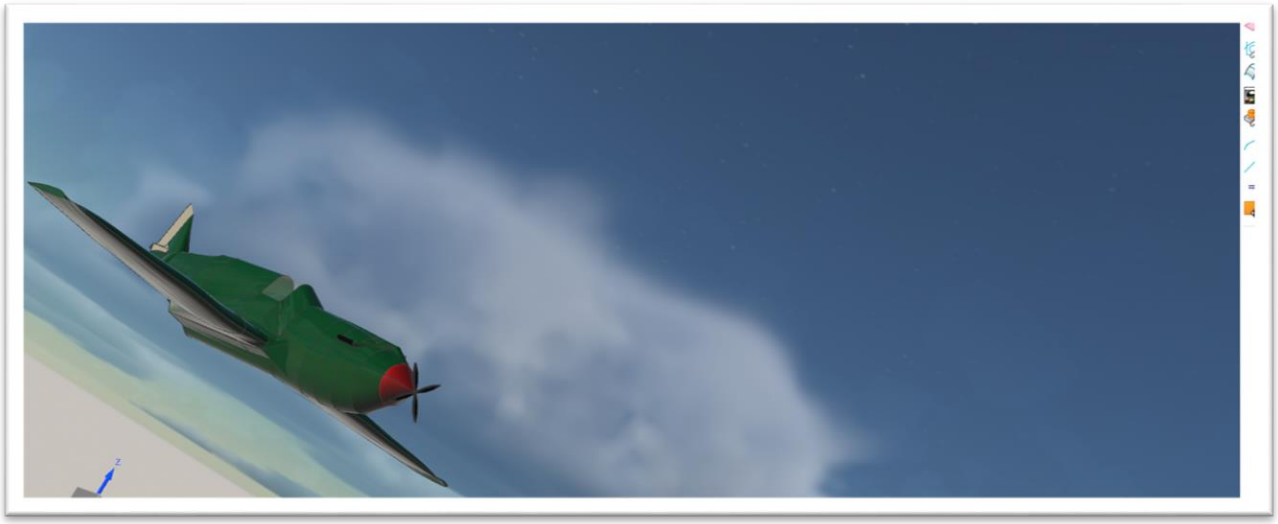
Adam Skarre 12/08/24

Professor Ilies ME 3225

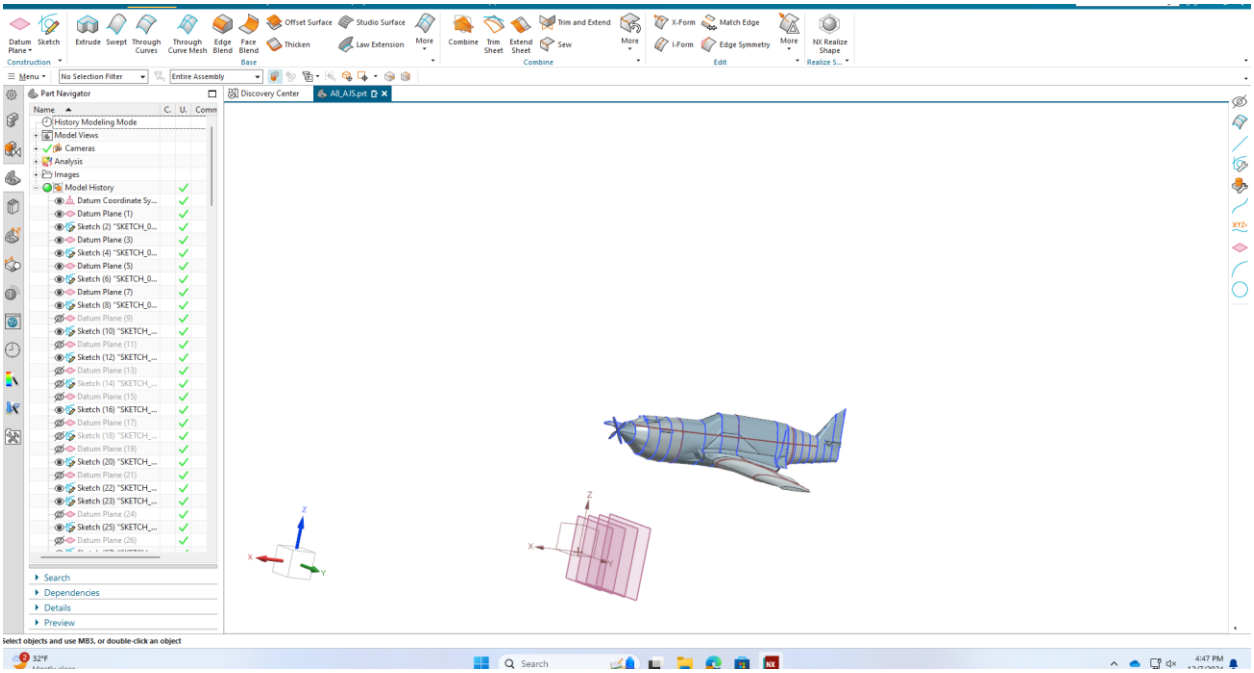
Assignment 4: **P-40B Tomahawk: Surface Design and Analysis**



Introduction

The goal of this project was to construct the fuselage and wings of the P-40B Tomahawk aircraft using Siemens NX. Utilizing surface modeling tools, I developed smooth, watertight surfaces designed for both functionality and aerodynamic performance. The final model was analyzed to ensure geometric fidelity, surface smoothness, and optimal curvature properties.

Aircraft Surface Description



1. Intrinsic Properties

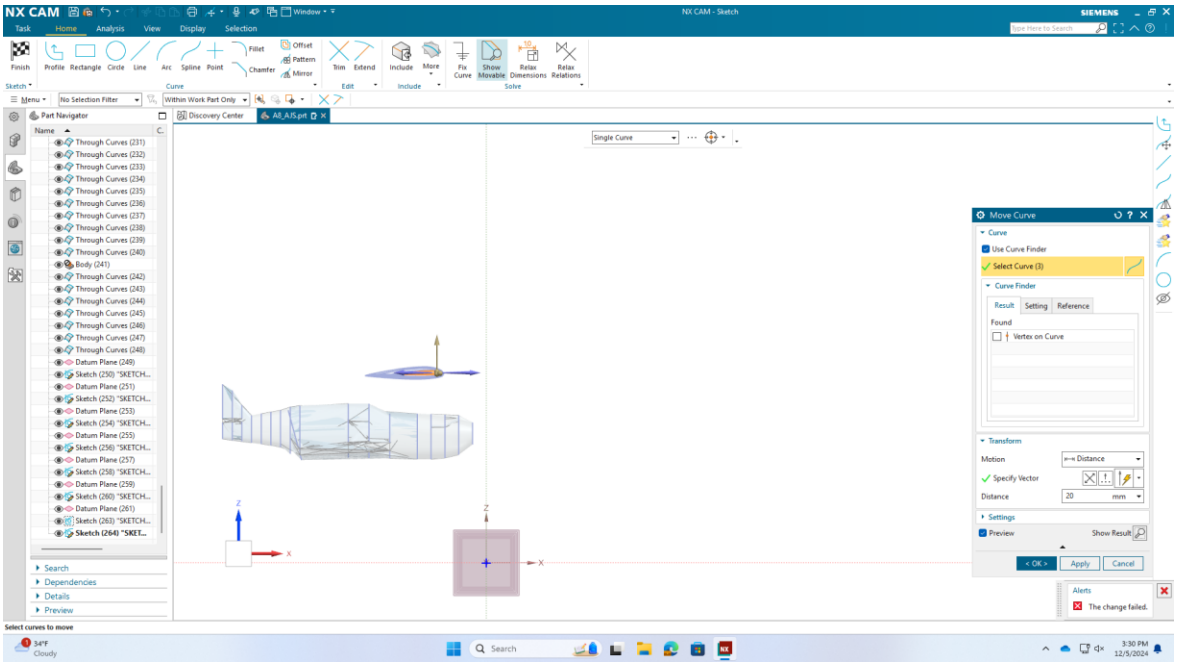
- **Topological**: The aircraft comprises continuous surfaces that are blended to form a single watertight structure, ensuring aerodynamic functionality.
- **Differential**: The surface curvature analysis was performed using Gaussian and iso-parametric grids to ensure smooth transitions, avoiding unwanted bulges or depressions.
- **Geometric**: Cross-sectional curves were digitized from provided data, ensuring alignment and accurate interpolation of the fuselage and wing profiles.

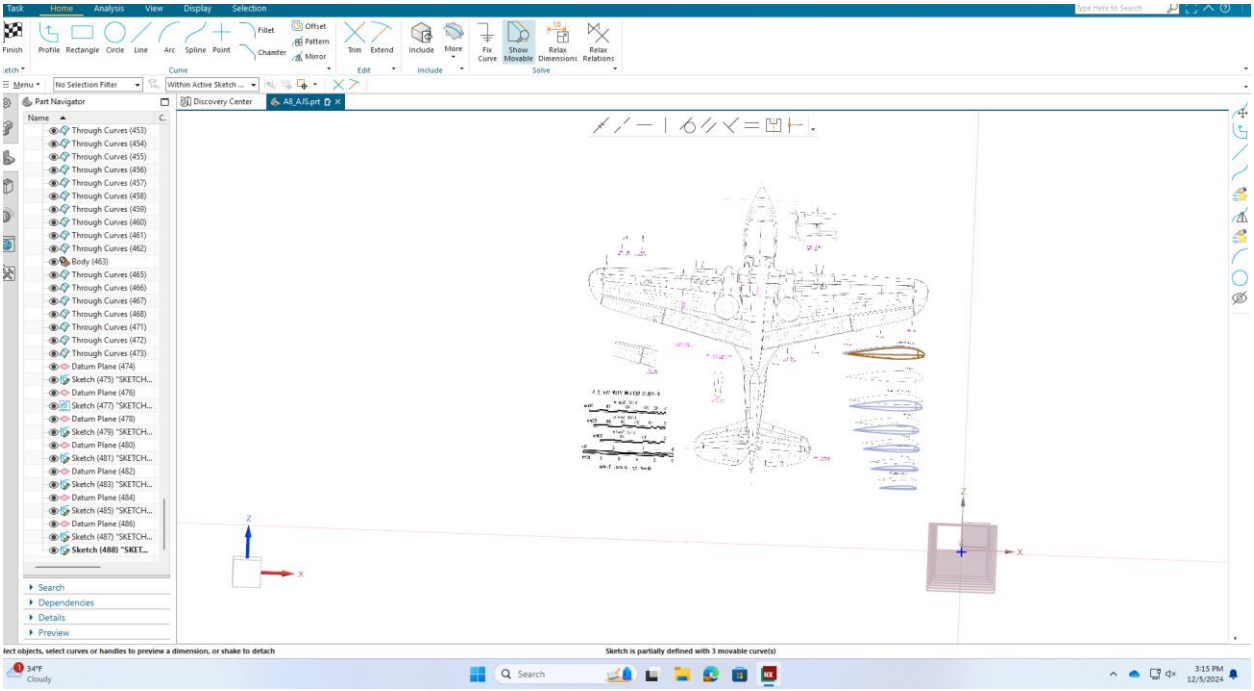
Construction Process

1. Curve Creation and Positioning

- The provided cross-sections were traced as splines in Siemens NX.
- **Steps Taken**:
    - Imported the aircraft drawing as a raster image.
    - Placed curves on designated datum planes using spline tools.
    - Moved curves to appropriate spatial locations using transformation operations.

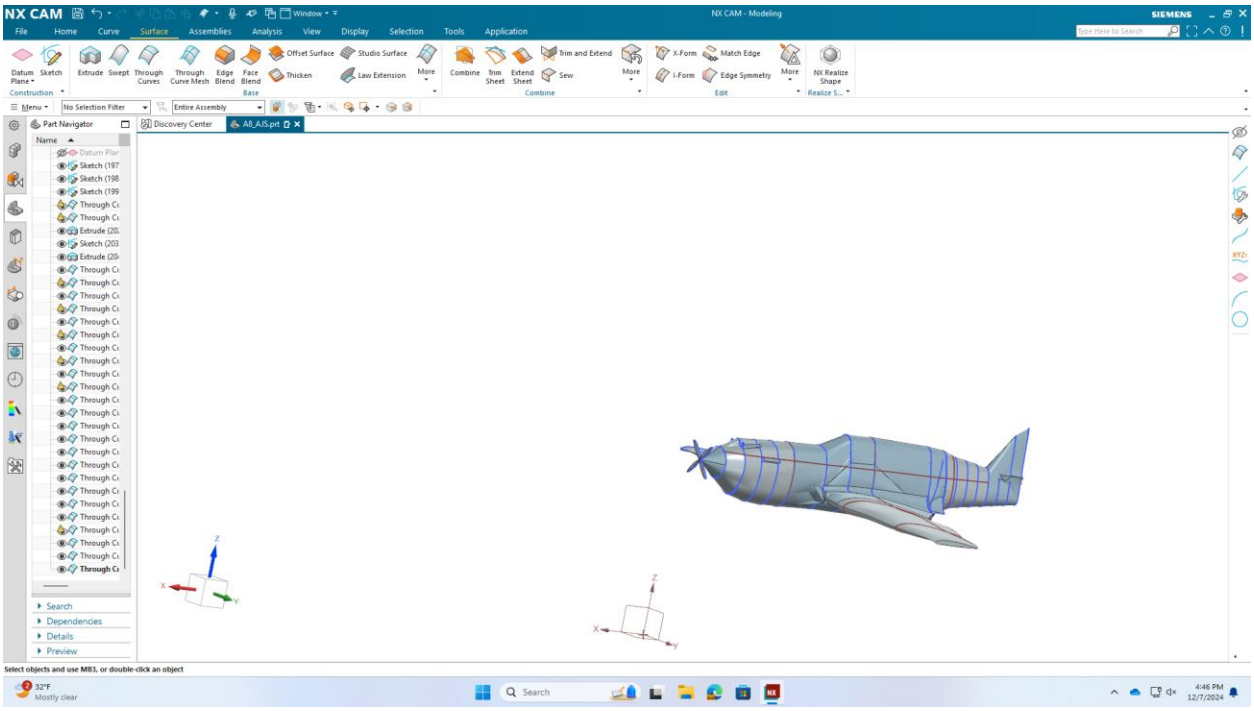
- Spaced out datum planes based on the raster images, and angled when applicable





2. Surface Creation

- Used **Through Curve** to generate surfaces from the digitized curves.
- Checked for surface continuity and watertightness by blending fuselage and wing junctions.



Problems Encountered

1. Alignment of Cross-Sectional Curves

Issue: Slight misalignment between cross-sections caused uneven surface transitions during the surface creation process.
Solution: Adjusted spline points and minimized the number of control points to maintain smoothness while adhering to the original cross-sectional data.

2. Surface Irregularities

Issue: Unwanted curvature fluctuations created local depressions that negatively impacted surface smoothness.
Solution: Conducted iterative curvature analysis using NX tools to refine spline weights and reposition control poles for better transitions.

3. **Challenges with Surface Continuity**

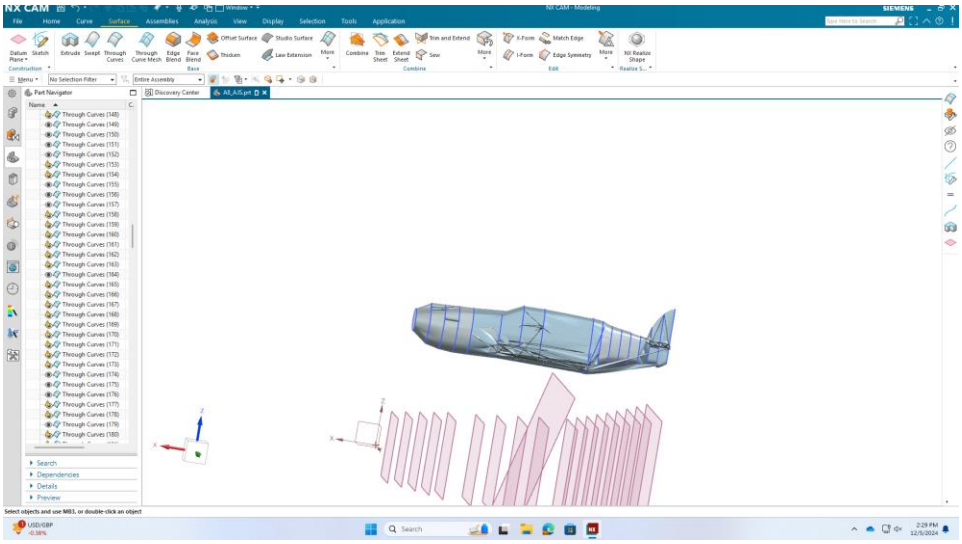
Issue: Discontinuities between blended surfaces created minor gaps.

Solution: Utilized NX's **Edge Blend**, **Bridge Surface**, and **Sew** tools to eliminate these gaps and ensure a watertight model.

4. **Through Curve Challenges**

Issue: The Through Curve feature occasionally produced unwanted twists in the generated surfaces.

Solution: Realigned input curves and constrained guide curves to refine surface generation.



(Challenges with Through Curve Implementation)

Analysis and Results

1. Surface Curvature Analysis

- **Gaussian Curvature**: High curvature regions were identified using NX curvature maps, particularly around the fuselage nose and wing roots. These areas exhibited sharp transitions that required smoothing to prevent turbulence and maintain aerodynamic performance.
    - **Action**: Smoothed transitions in these areas to prevent turbulent flow and ensure aerodynamic performance.

- **Section Analysis**: Conducted using iso-parametric grids to evaluate curvature needles and section lengths.

- **Observation**: No inflection points were detected, confirming the quality and flow continuity of the surfaces.

2. Highlight Lines

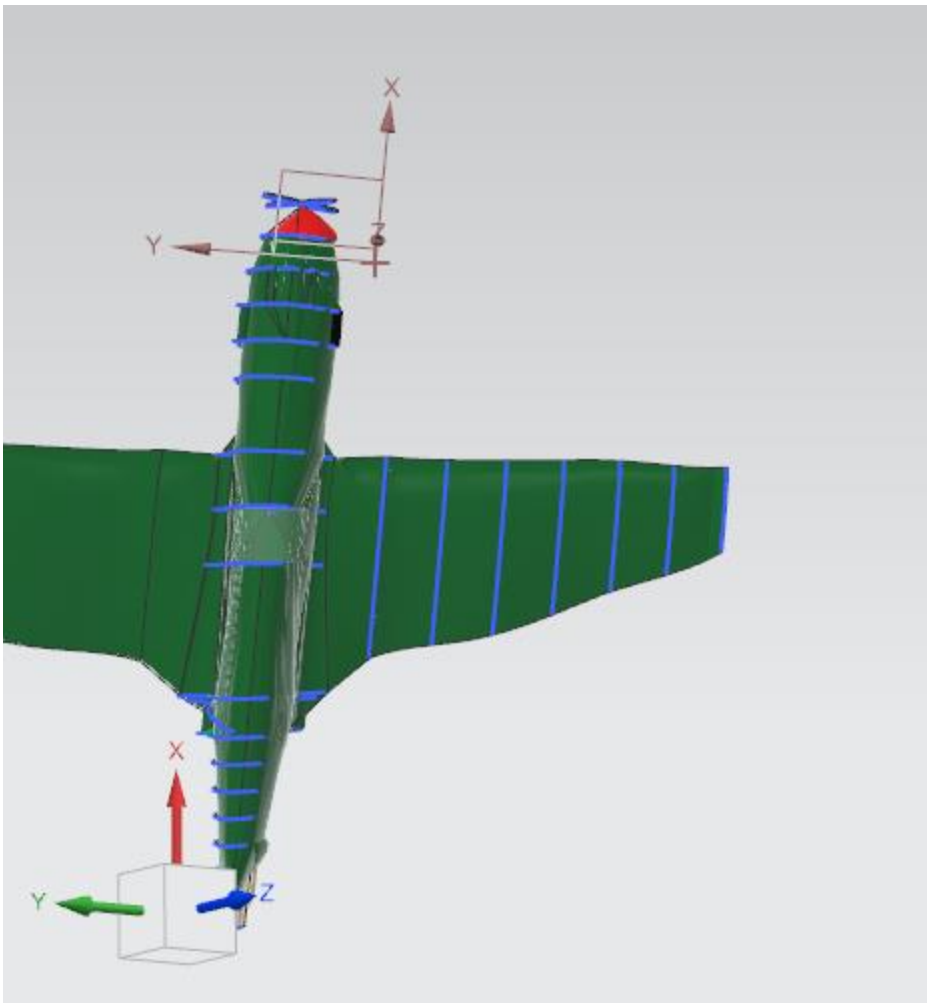
- Used highlight line tools to assess surface flow continuity.
  - **Result**: Achieved smooth transitions across all surfaces, crucial for maintaining aerodynamic performance.

3. Surface Metrics

Property	Result
Watertightness	Yes
Maximum Curvature (1/m)	+100(fuselage)
Minimum Curvature (1/m)	-100 (fuselage)
Inflection Points	None Detected

4. Optimization

- Removed unnecessary bulges through curvature needle adjustments using curvature reinforcement tools
- Reduced surface area while ensuring faithful adherence to the provided cross-section geometry.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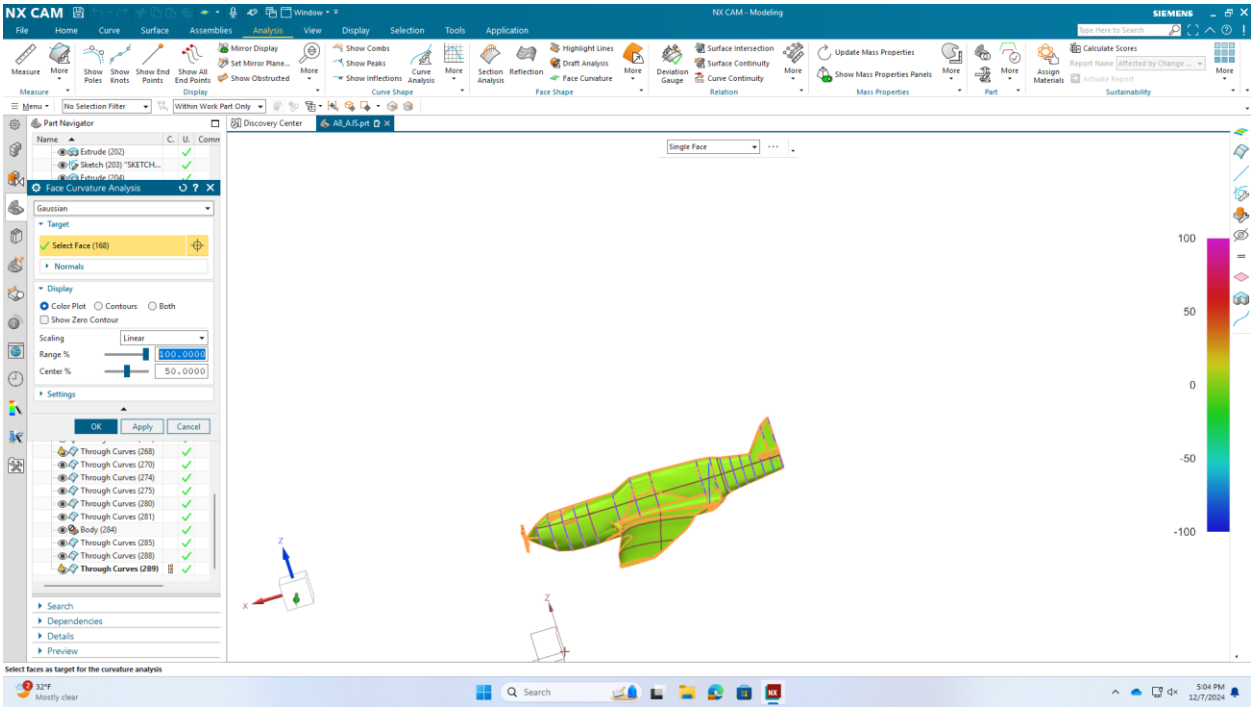
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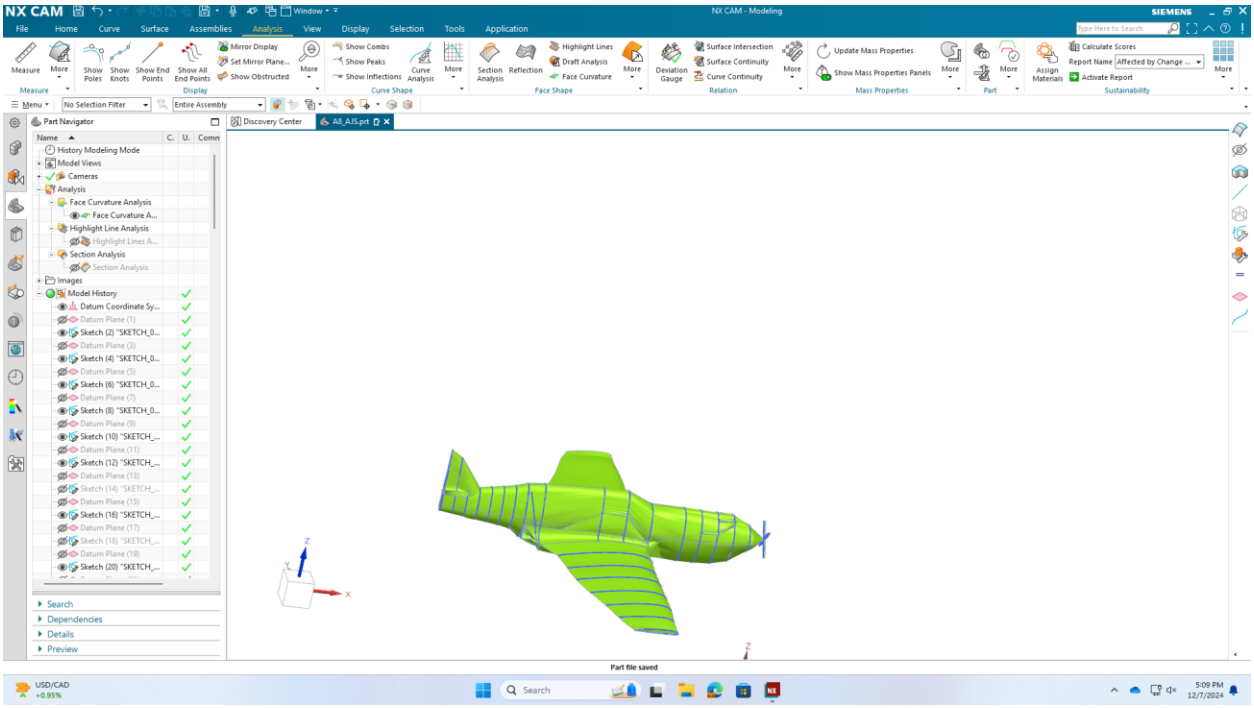
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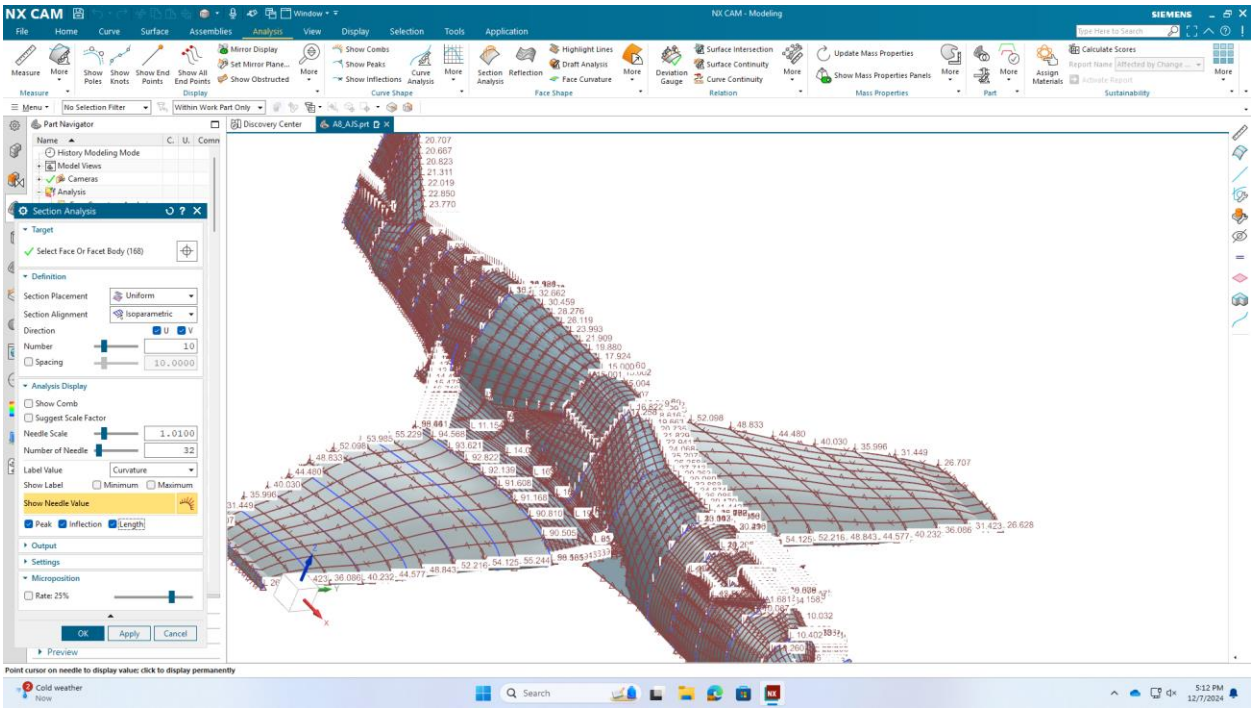
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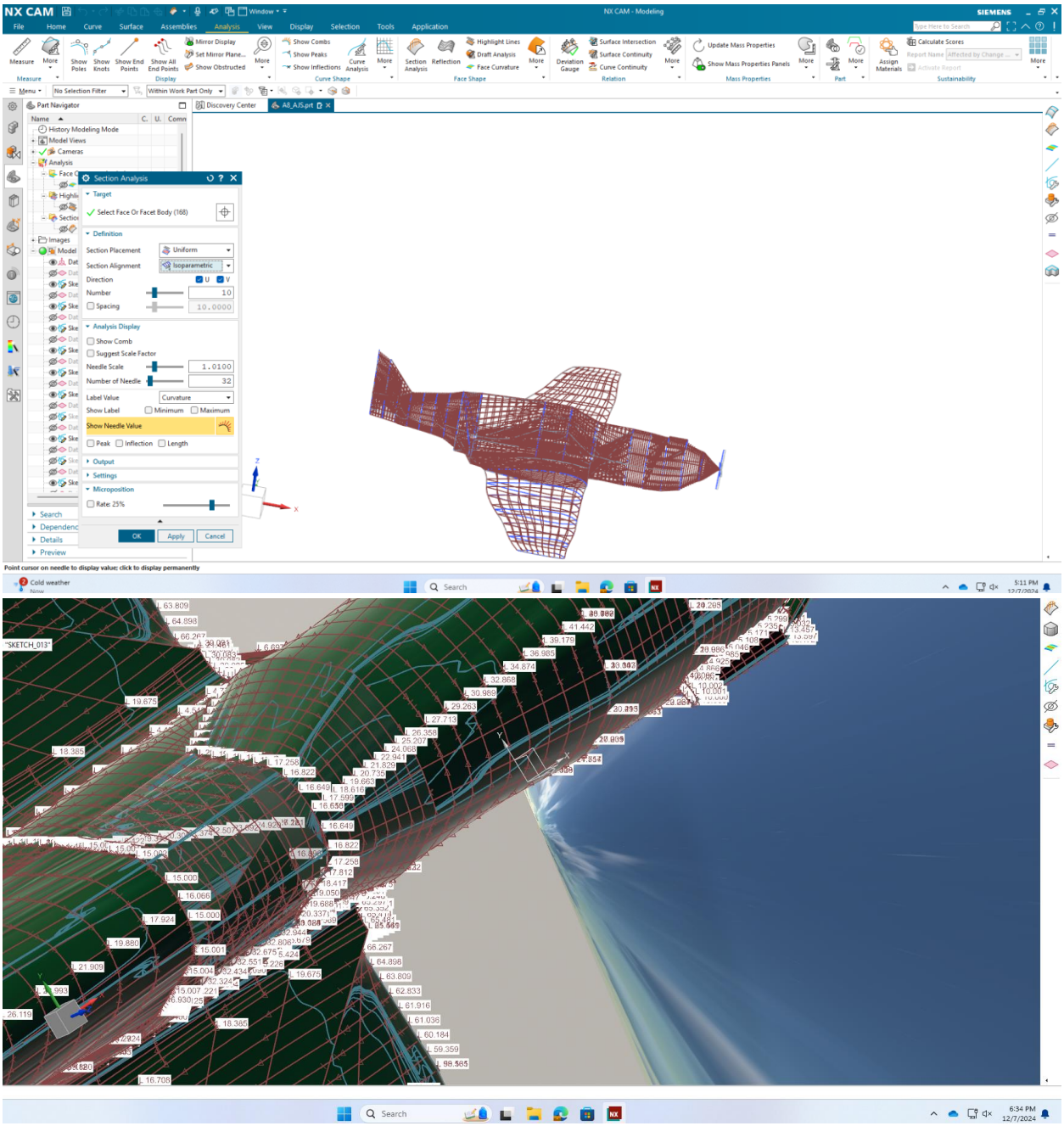
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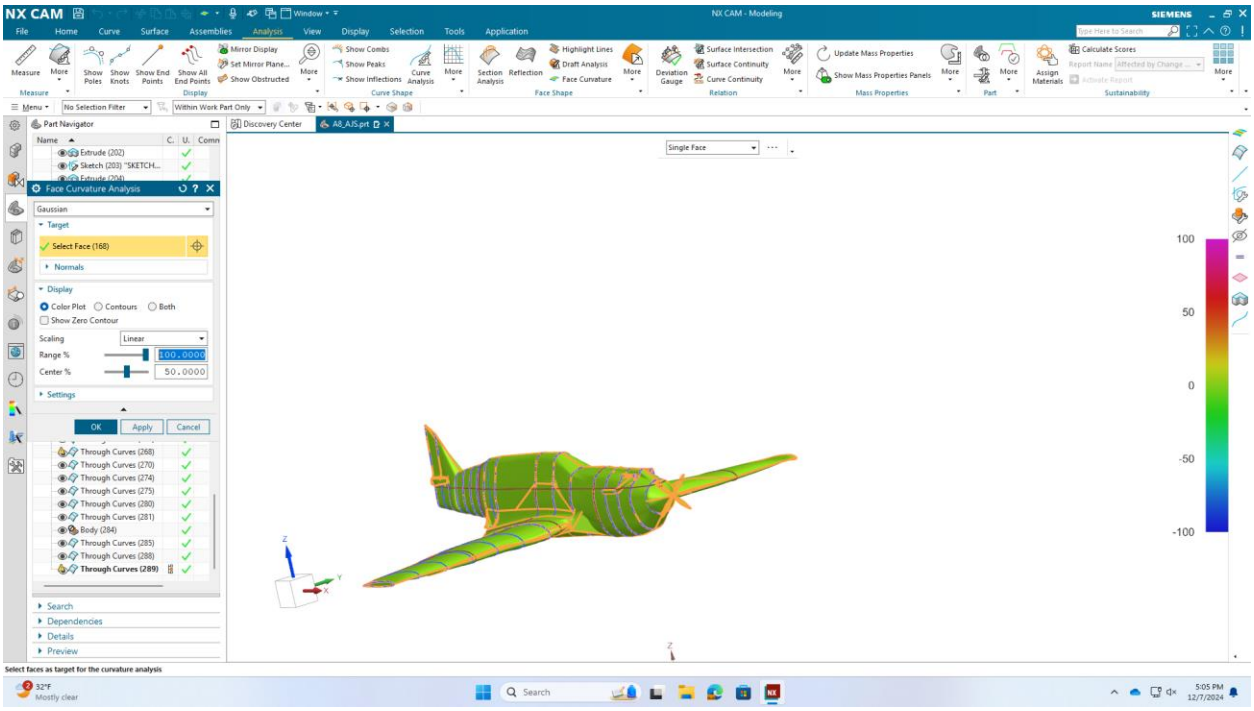
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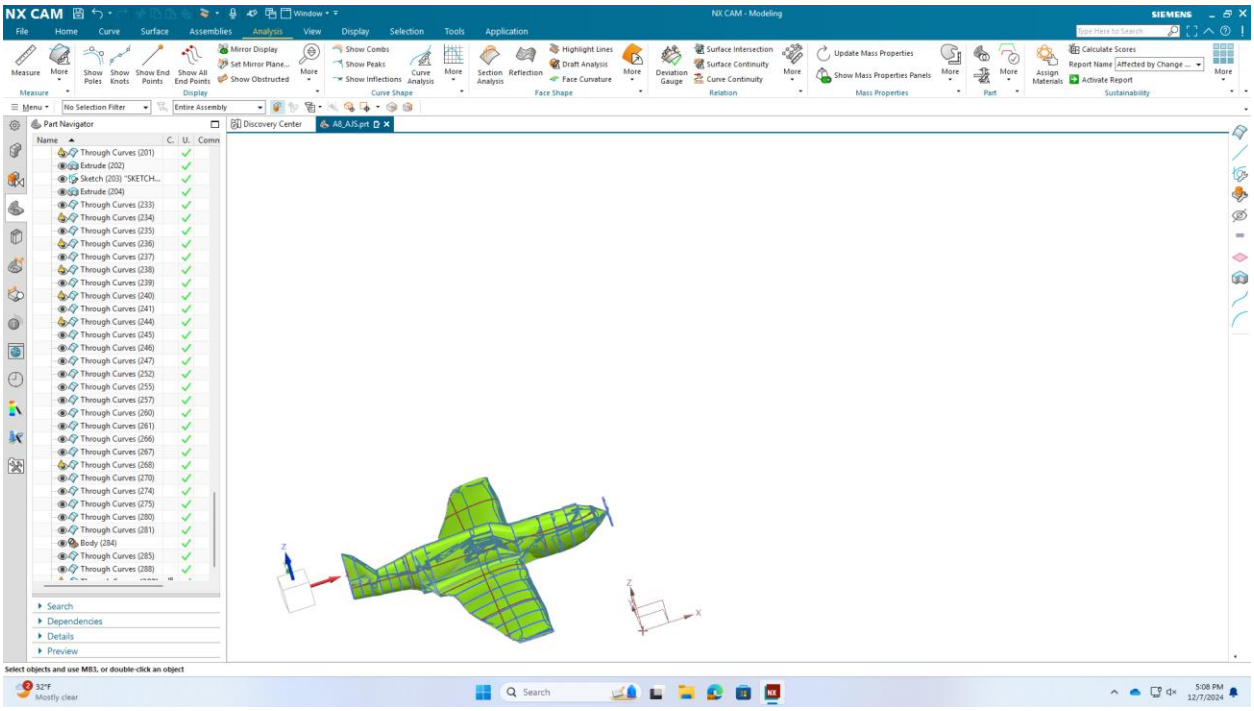
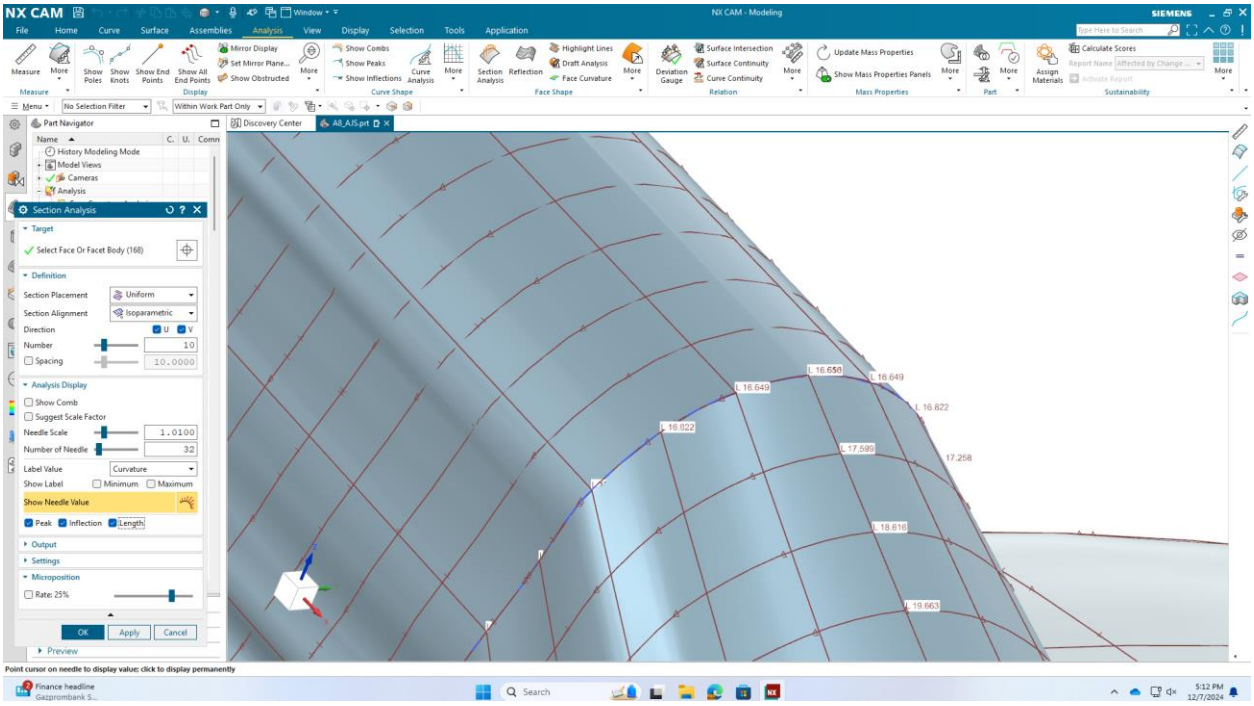




Key Interpretations

1. Accuracy and Symmetry

- The model closely resembles the provided cross-sectional data, ensuring faithfulness of representation.
- Symmetry was maintained by modeling half of the structure and mirroring it.

2. Surface Smoothness

- Differential curvature analysis confirmed no sudden changes, ensuring smooth flow critical for aerodynamic efficiency.

3. Final Adjustments

- Scaled and refined curvature using suggested factors from NX to optimize aerodynamic properties.

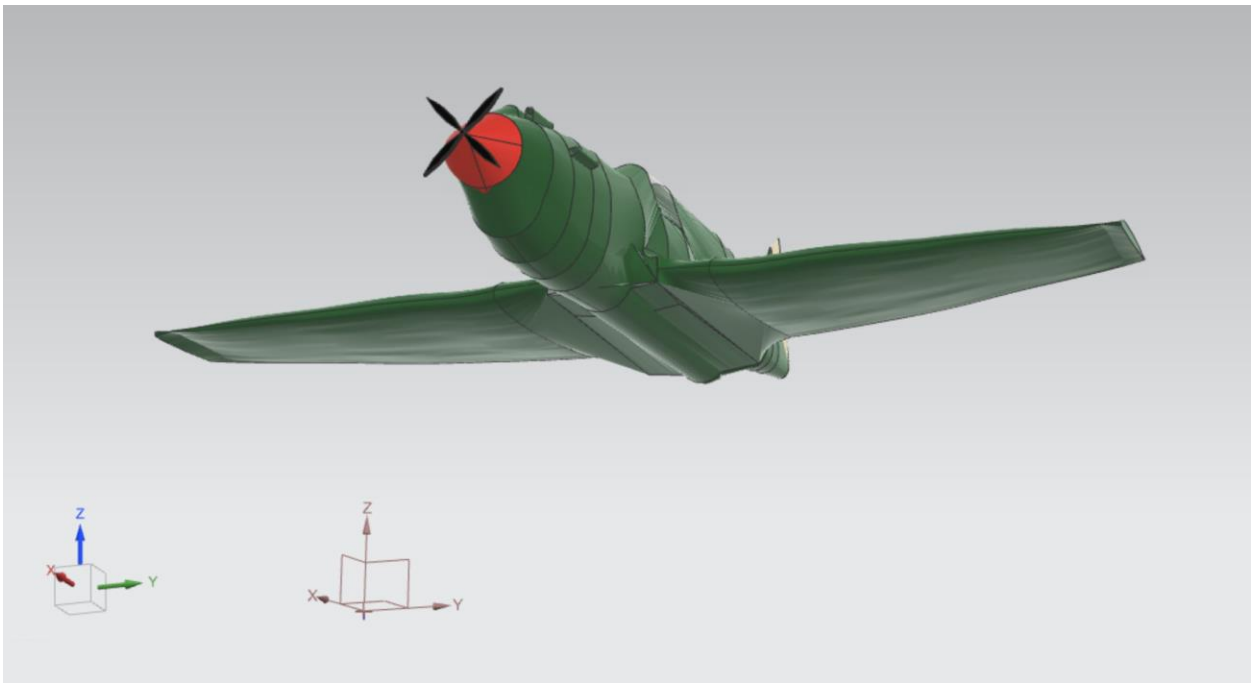
Conclusion

The final P-40B Tomahawk model adheres to all geometric and functional requirements. Surface analysis confirmed watertightness, smoothness, and optimal curvature properties, ensuring aerodynamic performance. NX tools provided comprehensive insights, facilitating iterative improvements and a successful outcome.

Snapshots:

Refer to attached screenshots for step-by-step illustrations of the construction and analysis process.

NX File: Uploaded as per submission guidelines.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