Midterm Project

Volkswagen Beetle

(Created on Siemens NX)

Figure 1: Inspiration for this project, the Love Bug (Herbie), a 1963 Volkswagen Beetle.

ME 4042-A

Interactive CAD & CAE

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1. Introduction

This report documents the full modeling workflow I used to create a 3D solid model of a classic Volkswagen Beetle inside Siemens NX. The entire model was built from parametric features, including splines, surfaces, extrudes, edge blends, and mirror operations. The goal was to produce a realistic, watertight solid body that meets the project's continuity and aesthetic requirements. My design draws inspiration from the iconic Herbie, the Love Bug, and features red, white, and blue racing stripes with the number 98 livery.

My approach started with constructing a wireframe skeleton from NURBS splines defined by control poles. From there, I generated surface patches using Through Curve Mesh, Fill Surface, and N-Sided Surface commands. These patches were sewn into a closed shell and converted to a solid body. Fenders were modeled through sketch-based extrudes with large-radius edge blends, and wheels, hubs, and axles were created using revolve and extrude operations. I then added cosmetic details like headlights, taillights, racing stripes, door lines, windows, number decals, license plates, and bumper details to push the complexity and realism of the model.

Surface continuity was something I paid close attention to throughout. G^2 (curvature) continuity was enforced across the major body panels, specifically the hood, roof, and side panels, by setting the Through Curve Mesh boundary constraints to Curvature and by modeling half the body with a G^2 constraint against a temporary centerline reference sheet before mirroring. G^1 (tangent) continuity was maintained everywhere else through the generous use of Edge Blend features, particularly around the windshield area and fender-to-body transitions.

2. Modeling Process

2.1 Wireframe Skeleton

I started the model by creating four primary studio splines using the By Poles mode. Curve 1 is a 6th-order spline with 7 control poles that traces the outermost lateral profile of the car, running from the front origin at (0, 0, 0) all the way to the rear at (3904, 0, 0). I set up two offset datum planes at X = 1280 mm and X = 3814 mm and used them to divide this curve into three segments for the front, middle, and rear of the car. Curve 2, also 6th-order, defines the upper shoulder ridge at Y = 645 mm and connects the endpoints of the middle segment. Curve 3 is a simpler 3rd-order spline with 4 poles that shapes the front hood centerline, and Curve 4 (6th-order, 7 poles) defines the rear roof-to-trunk centerline. I projected all curves onto the XY plane to establish the base footprint, then mirrored everything across the XZ plane to create the full bilateral wireframe.

2.2 Surface Generation

Once the wireframe was in place, I generated surface patches section by section. The main upper body was built using Through Curve Mesh (TCM), selecting Curve 2 and its mirror as primary strings and the cross-sectional curves (the front and rear segments of Curve 1, along with Curves 3 and 4) as cross strings. I kept the selection filter on Single Curve the entire time to prevent NX from auto-chaining tangent segments, which would have messed up the mesh. I only surfaced one half of the body initially. A temporary extruded reference sheet along the XZ centerline let me apply a G^2 constraint at the symmetry boundary, so after mirroring, the curvature continuity across the centerline was seamless.

For the irregular, non-quadrilateral regions, like the triangular convergences at the A-pillar and the windshield base, I used N-Sided Surfaces. I added interior curves where needed to maintain the proper volume and keep the patches from collapsing inward. The bottom floor was a simple planar surface connecting the projected base curves, which closed the shell from below.

2.3 Sewing and Solid Body Conversion

I sew all the surface patches together incrementally using the Sew command with the Body Type preference set to Solid Body. I started by sewing the hood to the front fenders, then the roof to the rear quarter panels, and worked my way through the rest. Where small gaps showed up, I carefully bumped the sew tolerance from the default 0.01 mm up to about 0.05 mm to bridge the imperfect seams. I used Examine Geometry with the Sheet Boundaries check to locate any remaining free edge and fixed them with Extend Sheet or Fill Surface operations before re-sewing. The end result is a fully watertight solid body, which you can confirm by the solid cylinder icon showing up in the Part Navigator.

2.4 Fenders, Wheels, and Axles

The front and rear fenders were modeled using closed 2D sketch profiles extruded along the Y-axis, then rounded with aggressive Edge Blend operations using 30 to 50 mm radii to capture the Beetle's signature bulbous look. I united the fenders with the main body through Boolean Combine operations and added edge blends at the seams for G^1 continuity. The wheels were created by revolving a tire-and-rim cross-section 360 degrees about the wheel axis. Wheel hubs were modeled separately and combined. The axles are simple cylindrical extrudes spanning the track width, connecting each wheel to the chassis. I mirrored the entire left-side wheel assembly across the XZ plane for the right side. Throughout this process, I made sure no wheel geometry intersects or pokes into the fender or body volume.

2.5 Extra Details and Livery

To push the model's complexity and realism further, I added several extra features. Headlights and taillights were created using extruded sketches and offset regions on the front and rear body panels. Door outlines were cut using Divide Face along projected curves, and window openings were created with extrude-subtract operations. The red, white, and blue racing stripes were applied as colored extrusions running from bumper to bumper. I placed the racing number 98 roundels on the doors and rear deck, and number 86 on the hood. License plates, rear bumper details, and a subtle rear spoiler lip round out the Herbie-inspired aesthetic.

3. Model History (Part Navigator)

The complete parametric modeling history is shown below. The Part Navigator confirms that all 89+ features are fully parametric and modifiable, and no imported solid bodies were used anywhere. Features range from the foundational Datum Coordinate System and Datum Planes at the bottom, all the way through splines, projected curves, sketches, extrudes (main body, fenders, axle, axle support beam, front lights, tires, front wheel hub, rear wheel hub, left door, right windows, rear lights), multiple Sew operations, Through Curves surfaces, Fill Surfaces, Edge Blends, Mirror Features, Thicken, and Combine operations, up to the final Mirror Feature (89) at the very top.

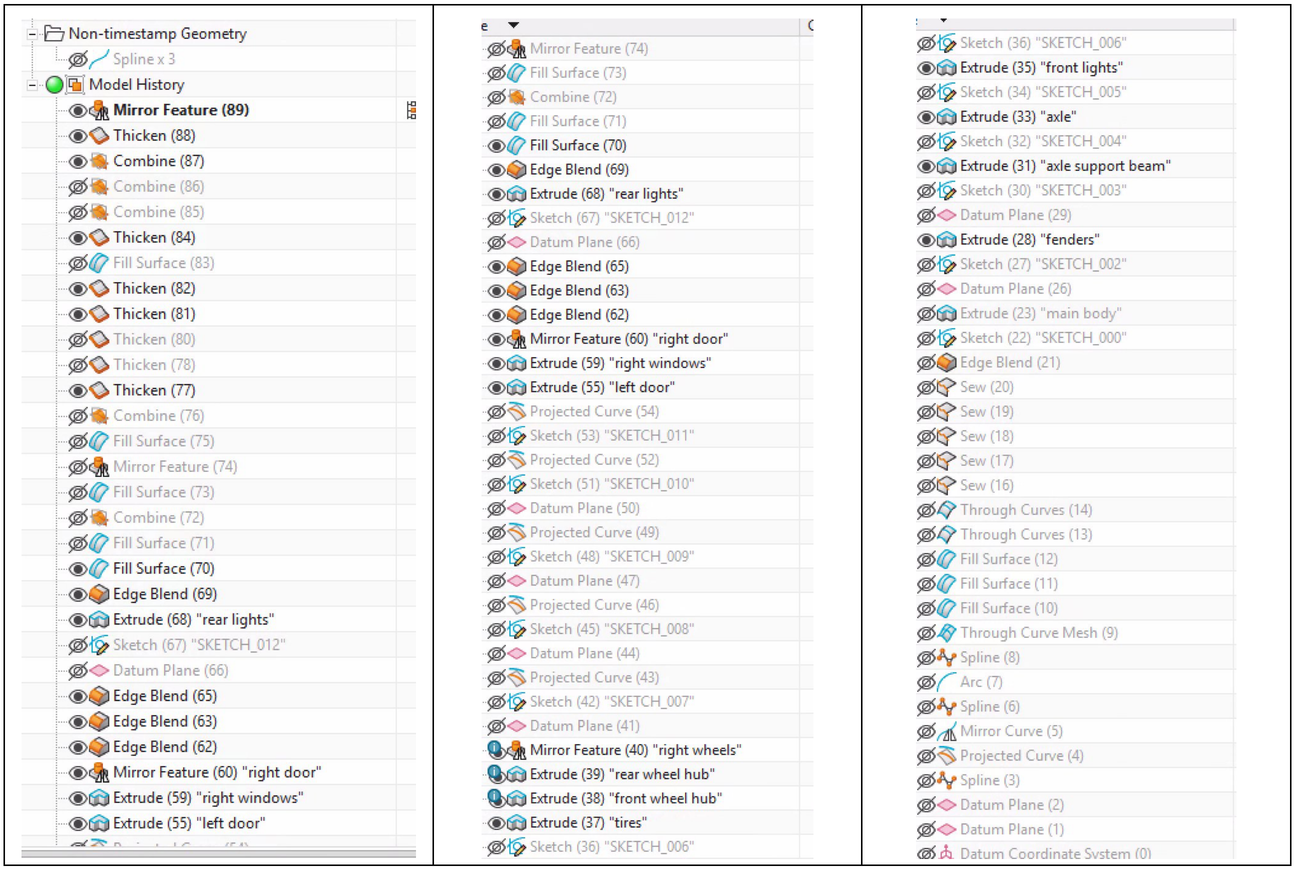

Figure 2: Part Navigator showing the complete model history from Feature 89 (top) down to Feature 0 (Datum Coordinate System). All operations are native and parametric.

4. Final Solid Model: Multiple Views

The completed model is a fully solid body, confirmed by the solid-cylinder icon in the Part Navigator. The following screenshots show the finished VW Beetle from multiple angles. You can see the Herbie-inspired livery, properly formed fenders, non-intruding wheels, headlights, taillights, door lines, windows, license plates, and racing number decals.

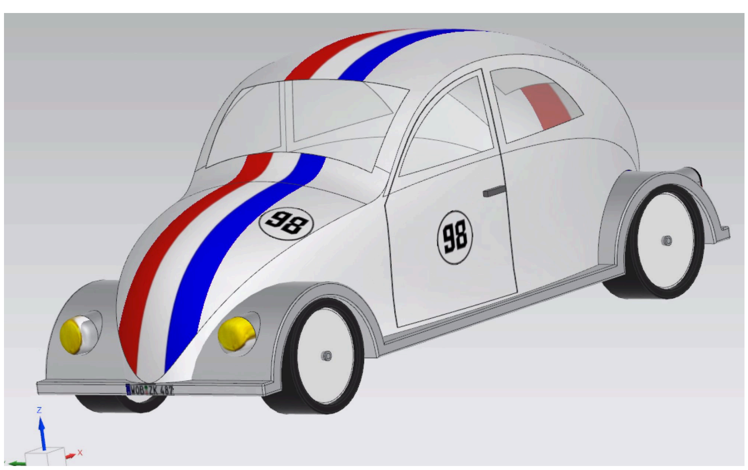

Figure 3: Isometric view of the completed VW Beetle solid model with Herbie livery.

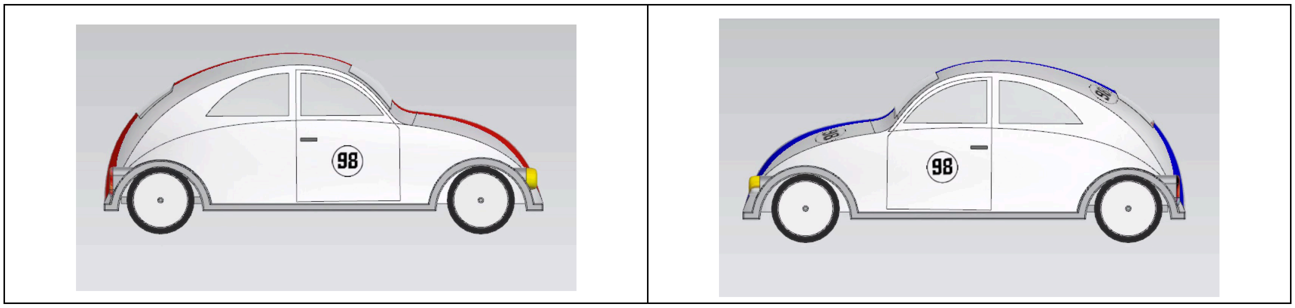

Figure 4: Right side view (left) showing the red racing stripe and #98 door roundel. Left side view (right) showing the blue racing stripe.

Figure 5: Front view (left) with headlights, bumper, and converging stripes. Rear view (right) with taillights, license plate, and rear spoiler lip. Top-down plan view showing the full red, white, and blue stripe layout, fender profiles, and number placement.

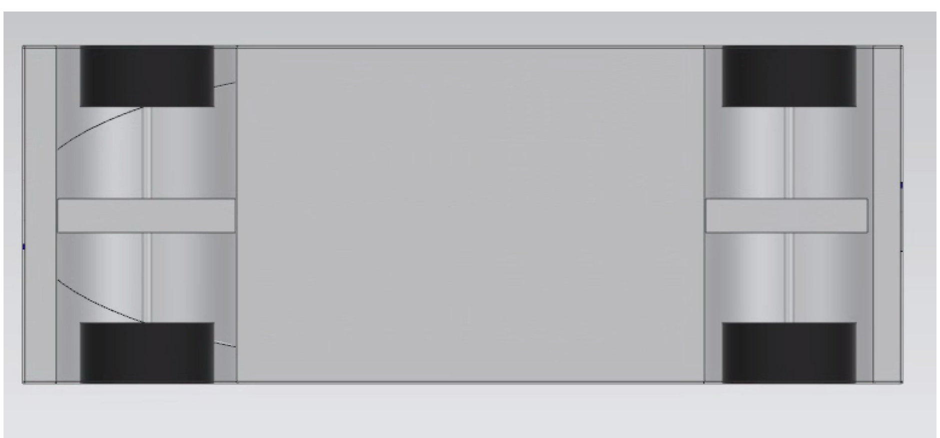

Figure 7: Bottom/undercarriage view confirming the solid axles connecting wheels to the chassis. Wheels sit entirely within the fender wells without intersection.

5. Solid Volume Verification

To verify that the final deliverable is actually a solid body, I used the NX bounding box and volume measurement tools. Two states of the model are shown below.

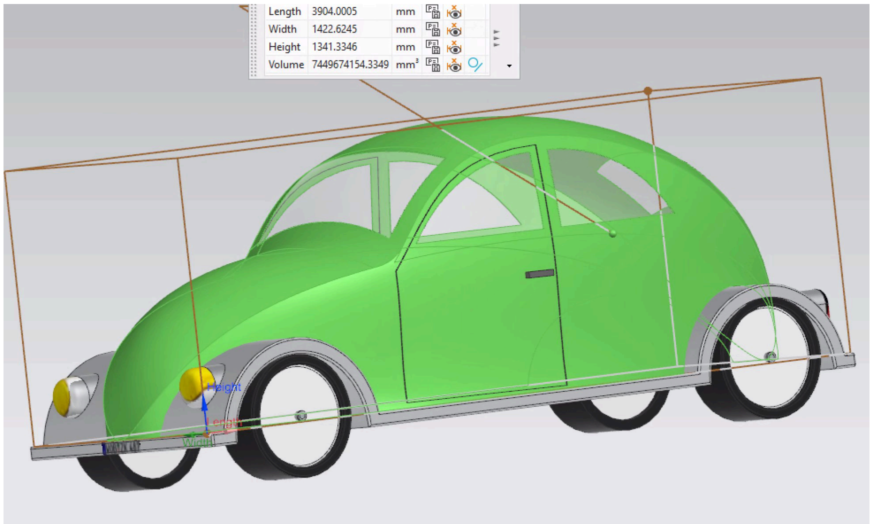

Figure 8: Main body solid (green) with bounding box. Length: 3904.0 mm, Width: 1422.6 mm, Height: 1341.3 mm, Volume: 7,449,674,154.3 mm^3. This confirms the body is a valid solid with a computable enclosed volume.

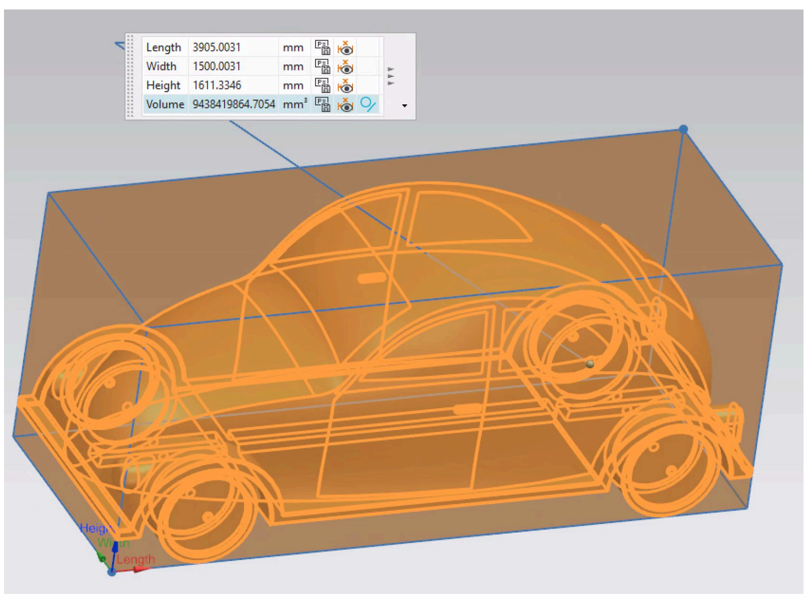

Figure 9: Full assembled model (wireframe overlay) with bounding box. Length: 3905.0 mm, Width: 1500.0 mm, Height: 1611.3 mm, Volume: 9,438,419,864.7 mm^3. The dimensions and volume here reflect the addition of fenders, wheels, axles, and exterior details on top of the base body.

6. Surface Continuity Analysis

6.1 Continuity Strategy

The project required G^2 (curvature) continuity across major body surface patches, meaning the hood, roof, side panels, and doors, along with G^1 (tangent) continuity throughout the rest of the model. To hit G^2 on the primary panels, I configured the Through Curve Mesh command with its boundary continuity set to Curvature against adjacent patches. I also used a half-body modeling strategy where a temporary planar reference sheet along the XZ centerline allowed a G^2 constraint at the symmetry boundary. That way, after mirroring, the seam is mathematically invisible.

For secondary features like the fender-to-body transitions, wheel arches, and especially the windshield area, G^1 continuity was enforced primarily through Edge Blend operations. The windshield region was the trickiest part because multiple surfaces come together at the A-pillar: the hood surface, the roof surface, the side panel, and the windshield glass cutout. I applied a series of carefully sized edge blends (10 to 25 mm radii) sequentially around the windshield frame. I used the Stop Short of Corner option at the upper corners where three blends met, which prevented self-intersection of the fillet geometry. This gave me a smooth, tangent transition around the entire windshield perimeter with no sharp edges visible anywhere.

Looking at the Part Navigator, Edge Blend features numbered 21, 62, 63, 65, and 69 were applied at the most critical junctions. Feature 21 rounds the initial main body sew seam. Features 62, 63, and 65 blend the door-panel and fender boundaries. Feature 69 smooths the transition around the rear light extrusions. Each of these blends automatically enforces tangent continuity across its transition, which eliminates all remaining sharp edges from the model.

6.2 Zebra Stripe / Reflection Analysis

I ran zebra stripe analysis (Analysis > Shape > Reflection) on the completed model to visually verify continuity. In a zebra stripe display, smooth and unbroken stripes flowing across a surface boundary indicate G^2 continuity. Stripes that connect but kink indicate G^1. And stripes that break or shift laterally indicate only G^0. The screenshots show the reflection analysis from multiple views.

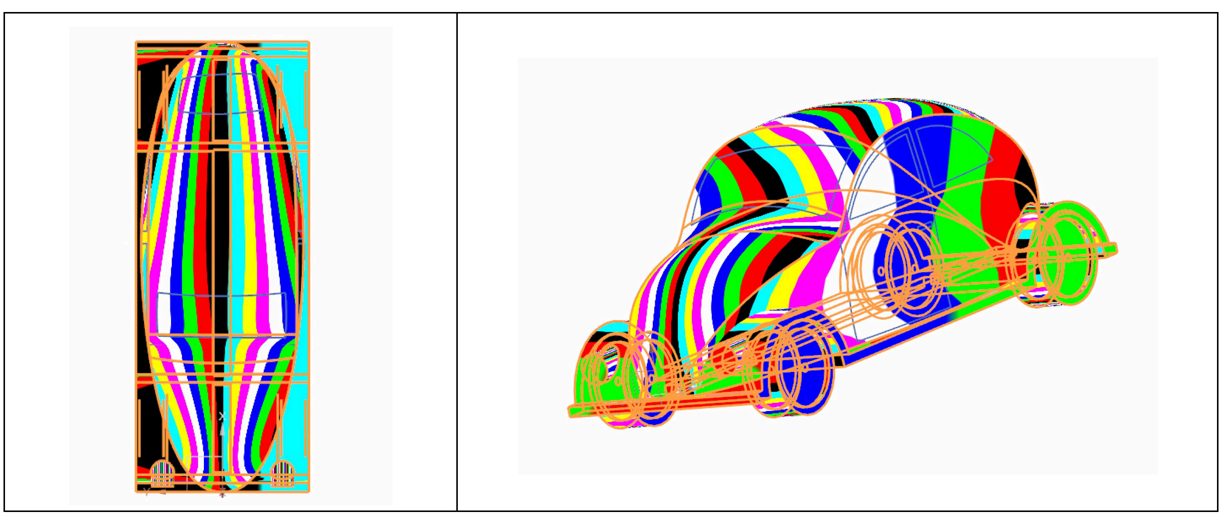

Figure 10: Zebra stripe reflection analysis. Top-down plan view (left) and isometric view (right). The colorful bands show reflected light tubes across all body surfaces. Smooth, continuous band flow across surface boundaries confirms curvature continuity on the major panels.

6.3 Discussion of Results

The zebra stripe analysis confirms that the primary body surfaces (hood, roof, and side door panels) exhibit smooth, unbroken, and kink-free reflection band flow across their mutual boundaries. This is consistent with G^2 curvature continuity, which satisfies the project's primary requirement. The reflection bands curve gently across the centerline seam where the mirrored half meets, with no visible ridge or inflection. This validates the centerline G^2 mirroring strategy that I described in Section 6.1.

At secondary transitions, particularly the fender-to-body seam and the windshield perimeter, the zebra stripes connect across the boundary but show slight directional changes. This is the expected visual signature of G^1 tangent continuity enforced by the Edge Blend features. No broken or disconnected stripes (G^0) were observed anywhere on the model, confirming that all sharp edges have been successfully eliminated. The windshield area, which was the toughest blending challenge due to multiple converging surface patches, shows clean tangent transitions thanks to the sequential edge blend application with the Stop Short of Corner technique.

7. Conclusion

This project was a thorough exercise in parametric surface modeling and NURBS mathematics within Siemens NX. By carefully selecting the right polynomial degrees for the foundational splines, using the correct surfacing tools (Through Curve Mesh for quadrilateral patches, N-Sided Surface for irregular boundaries), and being deliberate about enforcing curvature continuity through the centerline extrusion-and-mirror technique, I was able to produce a clean, smooth body envelope. The generous use of Edge Blend operations, especially around the windshield area where multiple surfaces converge, ensured that tangent continuity was maintained everywhere on the model. The incremental sewing approach, combined with Examine Geometry diagnostics, allowed me to convert the complex surface model into a watertight solid body without major issues. The Herbie-inspired livery and extra details like headlights, door lines, windows, and number decals add a layer of realism and personal touch to the final model.