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Faculty of Engineering Technology,
Mechanics of Solids, Surfaces
and Systems

Body Buck Design of an Aston Martin DBS

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M.Sc. Internship at Noble House
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Preface

This report serves as the completion of my internship at Noble House B.V. as part of the Master's programme Mechanical Engineering, department of Mechanics of Solids Surfaces and Systems, at the University of Twente. The main objective of the internship was to implement the knowledge and skills gathered in the Bachelor and Master at the university in a real work place environment and to obtain experience in working in a company setting. My assignment was to develop a surface model and body buck for the Aston Martin DBS.
The aim of the report is to provide the reader insight in my work placement and activities during the internship. My sincerest hope is that it is found useful to Noble House, as a basis for the final production of the body buck for the Aston Martin DBS, or as a reference for future similar projects.
During the assignment, I would have liked to have done more in terms of testing one of the concepts. Mostly due to time, this was not feasible. This prohibited a final decision in concepts, which I hope will be resolved at a later stage by the R&D department.
First and foremost I would like to thank my supervisor and colleague at Noble House, David van Pelt for helping me with all the way through this interesting and challenging assignment. I would also like to thank Kees and André Huis in 't Veld for providing this unique opportunity for the internship and providing me with everything needed to execute it successfully. All of Noble House's specialists also deserve a word of thanks, with their extensive knowledge of the cars that they were eager to share, which really helped with my progress throughout.

Summary

Noble House is a company that repairs, restores and even rebuilds mainly classic, hand-build, Aston Martins. As parts become harder to come by, in-house production of these parts becomes more appealing. A large part of the restoration process is the body of the car. Noble House is currently working on a so-called 'body buck' of the Aston Martin DB5. This is a hammer and fitting tool in the shape of the car's body, on which the aluminium plates are formed in the correct shape. This report describes the design process of such a body buck for the Aston Martin DBS. This includes every step between the physical car and the final body buck design.

The physical car's body needs to be converted to digital data first, this is done with a 3D-scanner, the Artec Eva, and accompanying software, Artec Studio 12. The car is scanned and the raw scan data is processed and exported to Computer Aided Design (CAD) program, Geomagic. Here, the scan is aligned to the chassis. The alignment and quality is compared to an earlier made scan, a choice is made based on quality, alignment and measurements. The chosen scan is exported to another CAD program, SolidWorks. Here, the surface model of half the car is made, since this enforces symmetry in the final design.

Once the surface model is done, concepts for the body buck are defined and evaluated. In correspondence with production companies MVM and Nedcam, two concepts are selected as viable. Nedcam could produce a (untested) composite body buck with a nearly uniform thickness and a steel subframe. For this, a slightly altered version of the surface model is needed. The cost of this concept is estimated at €29.000. MVM, being the producer of the DB5 body buck, could produce a body buck out of milled polyurethane (PUR) blocks and a wooden box and timber subframe. This concepts has an estimated cost of €32.000. The design process of the latter is described in more detail in this report.

The surface model forms the basis of the body buck design, it is therefore converted to a solid model. The PUR blocks are expensive and should take up as little volume as possible. The body is divided into blocks and each individual block is assessed to make it as small as possible. Next, the boxes are made as a subframe, supporting most of the upper blocks from underneath. The space between the unsupported blocks and the boxes are filled with a timber frame. This way, the PUR blocks can be further away from the box, thus making the blocks smaller, while still being supported. All blocks are glued to each other and to either the box or the timber frame.

The result is a body buck build from 87 PUR blocks, 4 boxes and a timber frame. $1.1m^3$ is needed of the PUR blocks before milling. The option for the composite body buck is still open, but should be tested first. If the result of the test is found satisfactory, choosing this concept is recommended. Before production is initiated, performance of the current body buck of the Aston Martin DB5 should be carefully assessed, since this follows the same basis in approach. This means that the result of the offset of the aluminium panels on the body buck are not taken into account. Which is found to be a potential problem in the closing stages of this assignment.

Contents

1 Introduction

Noble House is one of the thirteen Aston Martin Heritage Dealers in the world. This Heritage Dealer Network is selected to keep the hand-build cars in original condition. This includes everything from complete restoration to maintenance and repairs. Being able to deliver on the high demanding expectations of this niche market requires constant expansion of deliverable parts. Every day the availability of parts becomes sparser and the demand becomes higher. Producing the parts in-house would not only circumvent this problem for restoration projects, but also allows Noble House to produce these parts to sell to customers and other Heritage Dealers. This does not only include small parts, but also entire bodies. The body panels for these handcrafted cars can be recreated using a so-called 'body buck'. A body buck is a physical reference frame for the body of a car. It serves as a forming tool (hammering mould) for the aluminium plates. The body buck is essentially a bust of the car's body. This way of producing bodies is comparable to the original forming process of Aston Martin. After having produced and worked with a (partial) body buck for the Aston Martin DB5, Noble House is looking to expand on this with a design for a body buck for the Aston Martin DBS, an example of which can be seen in Figure 1.

In this report, the design process of such a body buck is described. The process consists of translating the physical car to a 3D-model and then conceptualising and realising a final body buck design. This should of course be the most economically sound design. Since the bodies were handcrafted, the cars are notorious for having large tolerances. To compensate for this, (digital data of) multiple cars are made available by Noble House.

The report is structured as follows. The work flow of translating the physical car to a usable 3D Computer Aided Design (CAD) model is described in Section 3. This Section also contains the decision making process for the body buck design. Section 4 contains the overarching analyses done during the design process. The section ends with the final body buck design. Conclusions and recommendations on the design can be found in Section 5. In Appendix A.1, a personal reflective essay on the work placement can be found. Appendix A.2 displays a log of daily activity during the Internship.

Figure 1: Aston Martin DBS

2 Problem Definition

There are no blueprints or original moulds available for the Aston Martins that were hand made over 40 years ago. Body parts of these old cars for restoration projects need to be bought in. Being able to produce these in-house would be beneficial. In order to achieve this, a body buck for a car is needed. In case of this assignment, the Aston Martin DBS. Measuring the car's body by hand is a labour intensive and difficult process, the shapes of the body are very complex. A 3D scanner provides an alternative for this. Such a scanner tracks geometry and texture and puts out a 3D cloud of points. This cloud can then be compared to a scan that was previously made of a different Aston Martin DBS. Since the bodies were hand crafted, a difference is expected. But

only the quality of the scan is of importance at this stage.
When the point clouds are acceptable, they must be exported as a mesh. The meshes can then be aligned to a digital model of the chassis. Only one half of the car is needed since it is meant to be symmetric, this can be done perfectly in a CAD program. When one half of the two cars is selected, this mesh can be imported into a CAD program. In the CAD program, a surface model of the body can be made. This forms the basis for the design of the body buck. The challenge in this phase is that it is important to stay as true to the scan as possible, while not copying unwanted dents and other features. The main lines of the car should be used as the corner stones of the design.
When the surface model is complete, concepts for the body buck will need to be developed. The surface model of the actual body of the car is needed as well, not only for production of the body buck. The goal is a body buck which is, in general, slightly larger than the chassis, and slightly smaller than the actual body. This is because the resulting body needs to fit around the chassis, but also, the aluminium will take up some space around the body buck, thus adds 1-2 mm. Intuitively, when holes are considered, these need to be smaller then the chassis and larger then the actual body. Since the bodies of Aston Martins of old are handcrafted, a tolerance of 15 mm is not uncommon. For this reason, the added 1-2 mm for the body buck is expected to fall within this tolerance and is not made a hard requirement for the body buck. Though, extra care must be taken for panel gaps and fit to the chassis.

3 Work Flow

3.1 Scanning

Two scanners are available, the Artec Spider and the Artec Eva, displayed in Figure 2. The Artec Spider can make a detailed scan of very complex objects, but is fairly slow and creates very dense point clouds. The Artec Eva is faster and makes less dense point clouds, making it more suitable for large objects. These scanners make pictures of the object and because they use multiple cameras, they can map the pictures in a 3D space.

Figure 2: Artec Eva(left) and Artec Spider(right) scanners [Artec 3D]

The Aston Martin DBS can be considered as a big object, therefore the Artec Eva is used in combination with the program Artec Studio 12 Professional is used. To make sure that the scan will be aligned properly, the floor around the DBS and the wheels are marked with tape, see Figure 3. By scanning the ground and the wheels in the first scan, a base line for the car is set, a straight model is more easily achieved this way. The car is divided into subsections that will each be aligned individually, first to itself, then to the wheels. This ensures a smooth fit of the scans to the geometry and that the different subsections will be aligned to each other properly.

Figure 3: Taped wheels and ground

The car is scanned in three different sections, the front, the middle and finally the rear. All individual scan sections need to have some overlap to allow for proper alignment. Later on, the parts are combined into one final assembly and a global analysis fits all parts together as logically as possible. The scans are aligned based on both geometry and texture using the global registration function. This means that Artec Studio analyses both the scanned geometry and the texture of the surface and aligns the scans appropriately. When this is done, the frames that the program was not able to place correctly are analysed manually. The frames that could not be aligned and are not essential to the scan are deleted. When the scans are properly aligned, some post processing is required. Some scattered noise around the scan is removed using the outlier removal function. Now the scan is ready for a fusion. These are both done with a resolution of 1.5 mm, this parameter defines the minimal space unit where the polygon of the model will be build in. A sharp fusion is made of the scans, which makes a polygonal 3D model. This can be directly exported as an .STL-File. Since the fusion is made from a lot of different scans with a lot of total overlap, the file would be very large. The size of the fusion can be reduced using the mesh simplification tool. This will allow for smoother operations in the programs used afterwards. In Figure 4, the scan results are viewed, with (left), and without (right) wheels and ground.

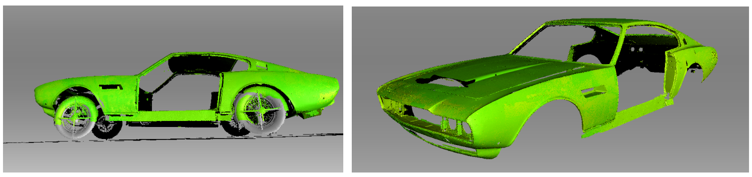


Figure 4: Final scans

3.2 Model Preparation

Next, the polygonal 3D model is loaded in Geomagic. Here, the scanned model, a previously scanned model and the chassis are aligned. This is done by manual operations until a satisfying fit is found for both scans separately with respect to the chassis, see Figure 5. This will also align the origins of the models. Now, a choice has to be made which scan will be used.

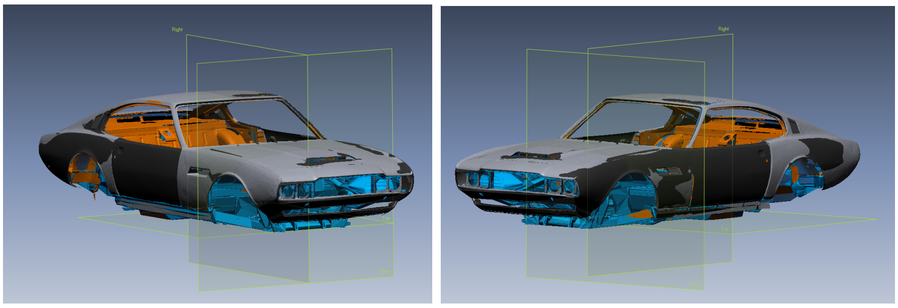


Figure 5: Alignment of previous scan(black) and new scan(grey) and chassis(orange and blue)

Therefore, the door frame is measured in all the available cars of the DBS model. The measurement is done by hand and then compared to the scans. Since the car is supposed to be symmetric, only one half of the car is needed, thus all four options are checked. Two cars are measured, the right side of an almost finished blue car (Blue R). And the 2 sides of the currently scanned car (Red R & L). Furthermore, the scan-data of the currently made and previously made scan is used (C_ and P_ scan respectively). These are measured in 4 different places, these are viewed in Figure 6.

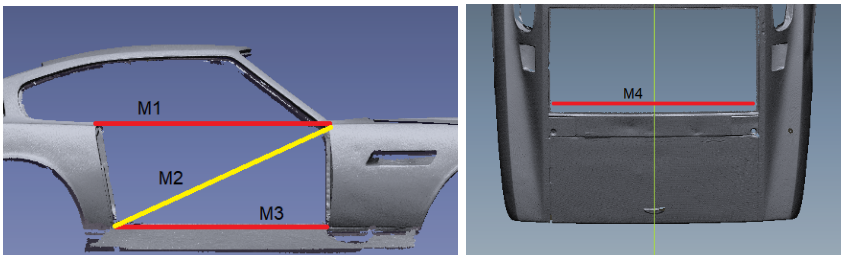


Figure 6: Indication of measurements M1,M2 and M3(left) and M4(right)

From these measurements, averages (AVG) are taken and then compared to the original measurements (dM1, dM2, dM3 and dM4). The results are listed in Table 1.

Table 1: Measurements in $[mm]$

	Blue R	Red R	Red L	C_Scan R	C_Scan L	P_Scan R	P_Scan L	AVG
M1	1230	1235	1225	1226	1226	1227	1219	1227
M2	1250	1265	1250	1263	1257	1269	1252	1258
M3	1135	1135	1130	1161	1158	1154	1152	1146
M4	1170	1180		1176		1177		1176
dM1	3	8	2	1	1	0	8	-
dM2	8	7	8	5	1	11	6	-
dM3	11	11	16	15	12	8	6	-
dM4	6	4		0		1		-

Using the results from this table, the general quality of the scans and the fit to the chassis, a final half is chosen. The current scan's left side is a relatively good fit, but the main line of the car continues on the door, which is not scanned in this version. It is not strictly necessary for the final buck but incorporating the door in the stages in between is preferable. The previous scan's left side seems to have no extreme off-value, however the scan has some poor quality surfaces on that side. The previously made scan has a good right side and does align well with the chassis. This side is chosen to use for the surface model. However, some information is missing in the side rear window frame. This can however be used from the current scan, see Figure 7.

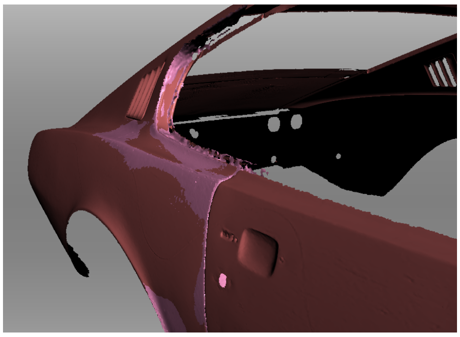


Figure 7: Window frame addition(pink)

Next the model is imported to SolidWorks. The mesh is made interactive with the mesh prep wizard using the Scanto3d plugin. From this point on, SolidWorks and Geomagic are used side by side. The lines and planes can be easily extracted from Geomagic and imported into SolidWorks, this provides a rough line to follow in SolidWorks when making splines for the surfaces.

3.3 CAD Process

The symmetry of the car means that only half the car has to be modelled in CAD. The surfaces can then be mirrored over the right plane to create the final complete surface model.
The primary difficulty of making the surface model is the continuous choice between a smooth surface and a tight fit to the scan. This means that for every surface, the amount and placement of guide curves has to be chosen with care. Less guide curves means a smoother surface, but generally a worse fit to the scan. More guide curves means a better fit to the scan, but generally less smooth surfaces. If the resulting surface is not smooth enough, it will be visible in the final body buck. This would require a lot of manual labour such as sanding the body buck, before it can be used. However, if the fit is not tight enough, the resulting body may not fit on the chassis or the separate panels will not fit.
Another recurring choice to make during the design of the surfaces is whether the connection between parts is sharp or smooth. If the transition is supposed to be smooth, making one large surface is preferable. If a sharp line or connection is required, it preferably made from separate surfaces.
After trying out some different approaches, it was decided to start with the roof. For the connection between the roof and the upper part of the side, after trying both a sharp and smooth line, the sharp transition is chosen. Obviously, the two surfaces do share a common line, the roof line towards the rear. Here, another important choice had to be made, the roof line toward the rear end has a slight angle with respect to the right symmetry plane in the scan. Choosing this line to be straight would result in a sharper rear view. This would also allow for a spline sketched in a 2D plane, it's curvature and shape is easier to control than a 3D spline. This does however result in a worse fit with respect to the scan.

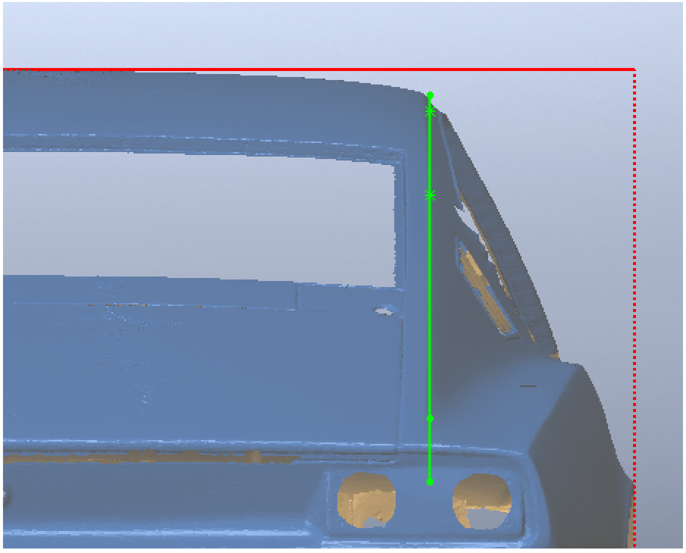


Figure 8: Straight roof line

In this case, the sharper line is preferred over the tighter fit, the green line in Figure 8 does not completely align to the roof. For the surface of the roof, the middle line is used in combination with 5 cross-section lines. For the upper part of the side, the so-called main line is used. This line has gone through multiple revisions to make it as smooth as possible. This is the most important line regarding the 'look' of the car. These lengthwise lines are connected with just 4 cross-section lines, the dashed line in Figure 9 is not used.

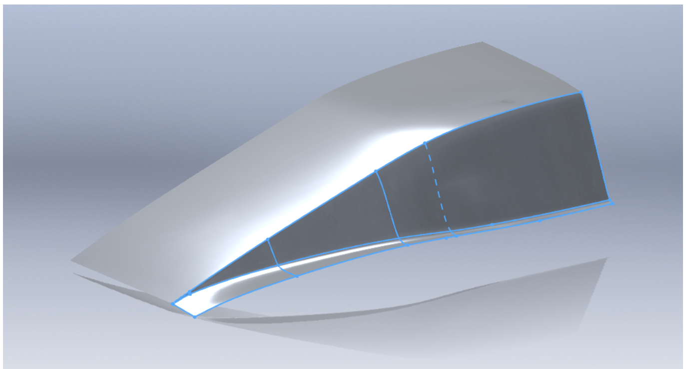


Figure 9: Section lines of the upper part of the side

Next, the roof is finished by adding the front part. The upper part of the side must now be extended smoothly around the A-pillar and form the basis for the windshield. The smooth transition and the fit to the A-pillar are most important here, that is why multiple guidelines close together can be seen in Figure 10. If the A-pillar is not the correct shape, both the door and the windshield will not fit. Simultaneously, the transition from side to A-pillar to front end of the roof must be smooth. In the final surface model, some parts will be left out, for instance the door itself, the side windows and the windscreen. However, these parts must still be modelled as smooth as possible. This will result in a better final model and will make it easier to make features like the drain channels later on.

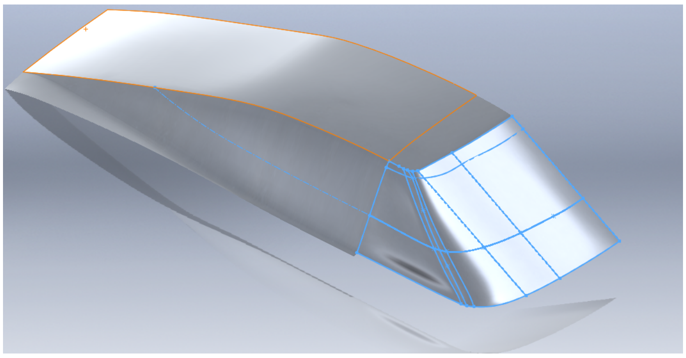


Figure 10: Windows and A-pillar

The connection to the bonnet part of the car can be made better if the bonnet part itself would already exist. This will provide smooth edges as a reference to attach tangentially to. The bonnet part is a very large surface, where the bonnet scoop is not yet accounted for. Again, one guide curve is the middle line of the car, and one is the main line. Only 4 cross-section lines are used. The surface does not reach all the way to the front yet. This part has a more complex shape with steeper curves. To illustrate this, a part of the bonnet line is shown with curvature combs in Figure 11. In SolidWorks, this only works well in 2D. The line is considered smooth if the curvature combs show continuous behaviour.

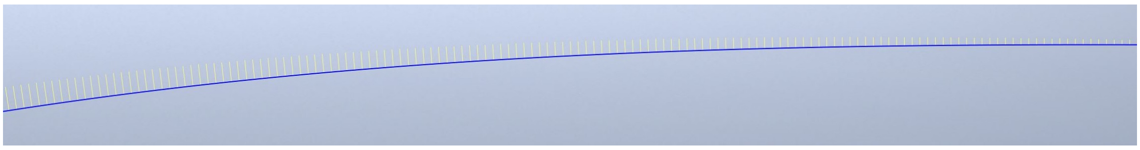


Figure 11: Curvature of bonnet sketch

Connecting the bonnet shape with the upper part of the side is difficult to comprise of a single SolidWorks feature. Common practice is to trim features partially and use multiple features to patch it back up. This is done for the base of the A-pillar, as can be seen in Figure 12.

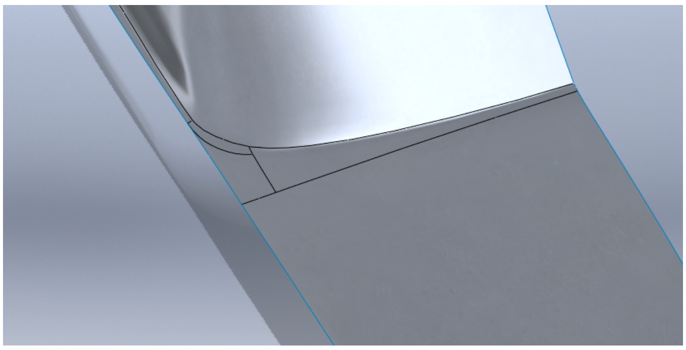


Figure 12: Connection to bonnet part

For the front end of the car, the outline for the grille is used as a starting place, as can be seen in Figure 13. This relatively thin surface is cut from a large surface that was created from three section views, parallel to the right plane.

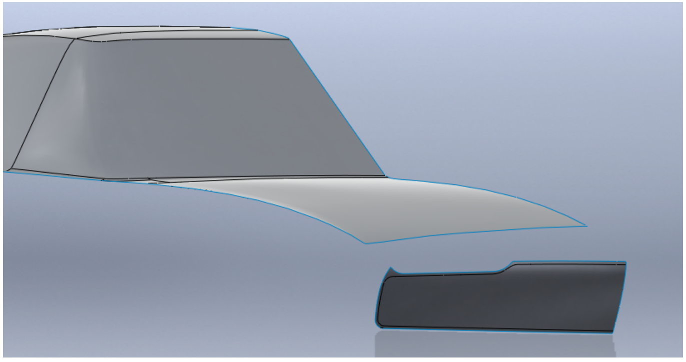


Figure 13: Front end

Subsequently, the resulting surface is connected to the bonnet surface. The connecting surface is smoothly connected to the bonnet surface, and sharp to the grille surface. Another very important line for the car is the tapered sharp edge where the grille raises in the middle. This evident line is the black line in Figure 14.

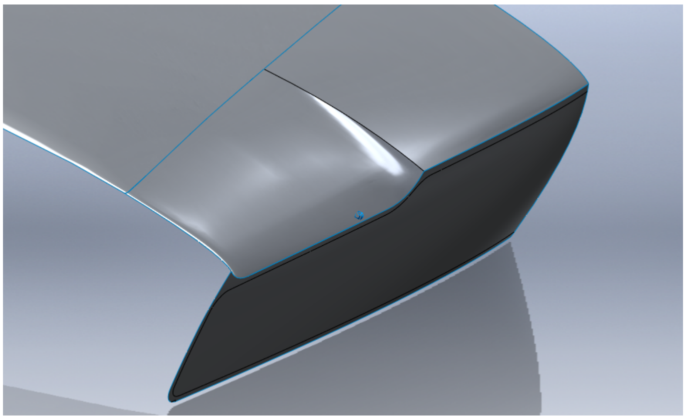


Figure 14: Grille line in front end connection

The next surface is the main side part. The main line is the upper boundary, the lower boundary is based on the edge of the chassis underneath the door. The surface spans almost the entire length of the car, the furthest front and rear parts are not yet surfaced. This is because this allows for the smoothest surface on the side, whilst keeping control of how the surface needs to bend in the corners. Another important line of the car is the very slight change in curvature in the middle, which splits the top from the bottom half of the side. This line is hard to see in the scan, but distinctly visible on the actual car. After due consideration it is chosen to be sharply connected since it is a very blunt angle, yet a very distinct line. On the left in Figure 15, a light shift in light indicates the line.

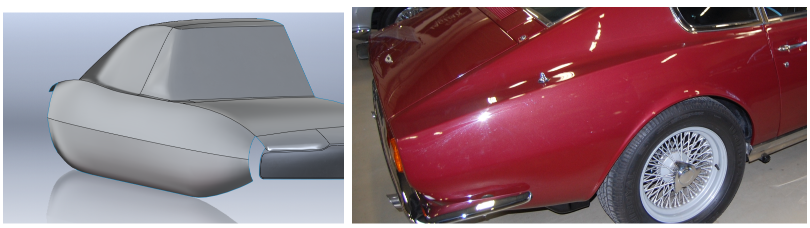


Figure 15: Side with characteristic line

The side and the front end can now be connected. Also, the underside of the front end is made. This is done without the air dam at this point.

Before the same can be done on the rear, the rear end needs to be surfaced. This is done with the underside of the rear in one surface. Again, this is done without the bumper mount or other features. Now both the side and the rear surfaces are extended along their guide lines. The surfaces are extended beyond intersection and then cut at the intersection. Next, the air dam and the bumper mount are added by extruding part of the existing surfaces, as seen in Figure 16.

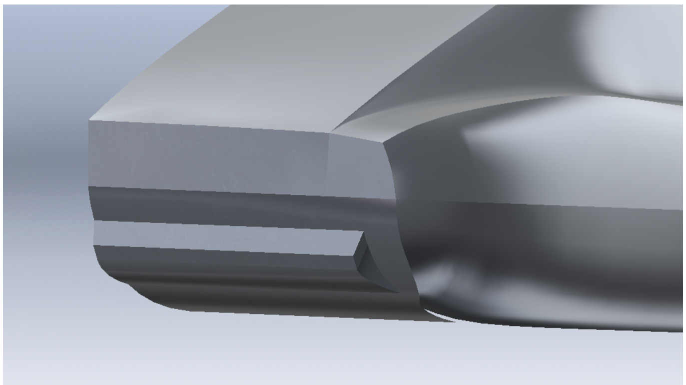


Figure 16: Rear corner

Now the rough shapes of the car are done, some detailing can be done. First the rear end is detailed with the proper lines. The most important part here is the connection plate for the tail-light. This plate must be big enough so the unit can fit. This is evaluated further later on in Section 4.2.2. Here, multiple surfaces are made and then partially deleted again to achieve the complex shape of the rear end. Some surfaces are considered not smooth enough, especially at connections to other surfaces. The corners of the main side part are resurfaced for this reason. As seen in the lighting in Figure 16 and on the left of Figure 17, the continuity is found not good enough. This is redone to achieve a smoother surface, as seen on the right in Figure 17.

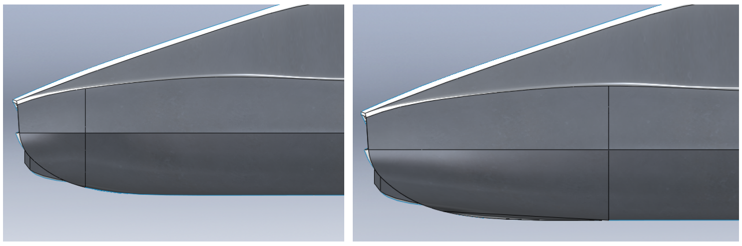


Figure 17: Revision of the side surfaces

Next, the split lines for the door and the windows are made. These are extensively measured on the available cars and chassis. Next some other details are added to the side of the model. Like the wheel arches and the characteristic side vents. At this stage the connection between the side and the front end is also overhauled for a smoother, larger surface. The result can be seen in Figure 18.

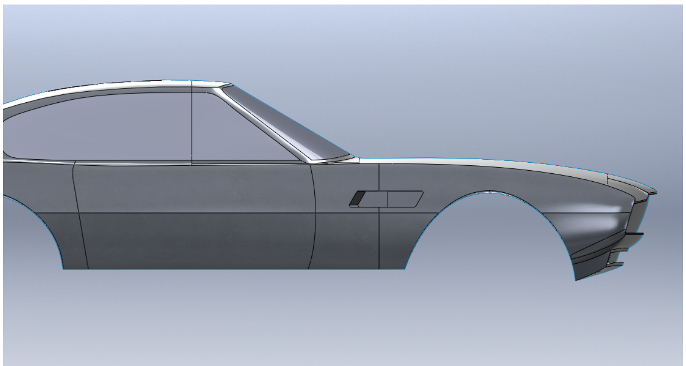


Figure 18: Side with features

Now the indentations for the window frames are made. Including the split lines for the filler flap, which is on both sides of the car and thus should be added before mirroring. Also, a wheel arch like feature above the side windows is placed. This is an outside drain channel on which a piece of trim will need to be placed. Finally the air scoop and bonnet lines are added. Now the base surface model is complete regarding features, the result is viewed in Figure 19. Large fillets are placed on some edges to follow the scan more closely. Small fillets are placed on sharp edges to prevent tearing of the aluminium plates when formed.

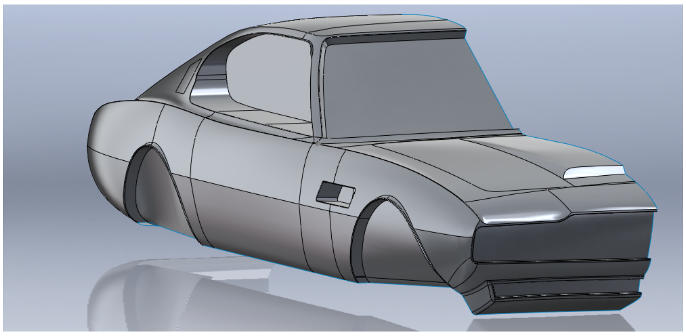


Figure 19: Model with closed windows

Lastly, the model is mirrored and made watertight. This is one of the final versions of the full model, seen in Figure 20. This is now saved separately, the fitting, size and shape of the doors, bonnet and boot lid will be dependent on this.

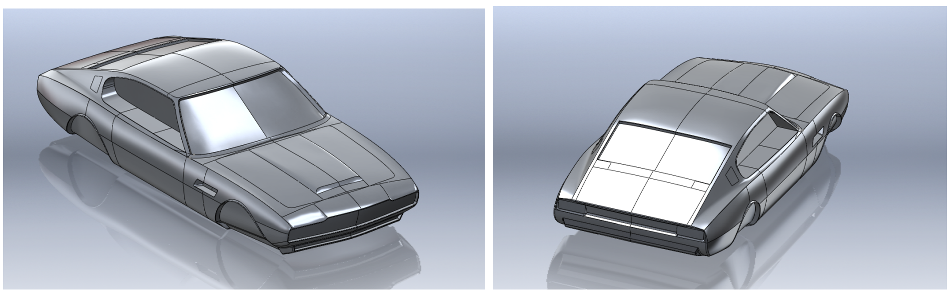


Figure 20: Watertight model

Now, these loose panels are removed from the model. This allows for modelling of the drain channels. Most of these will partially be included in the final body buck, the final design will thus be derived from that model.
First, things like the bonnet scoop are taken out, also most fillets are removed to improve the lines. Then the bonnet is removed and the drain channel is added, this drain channel is aligned on the

sides with the chassis. The rear edge is straight and the front edge is an offset of the front edge of the bonnet itself. Finally, a ruled surface around the cut-out is made. In Figure 21 the rear end of the drain channel can be seen.

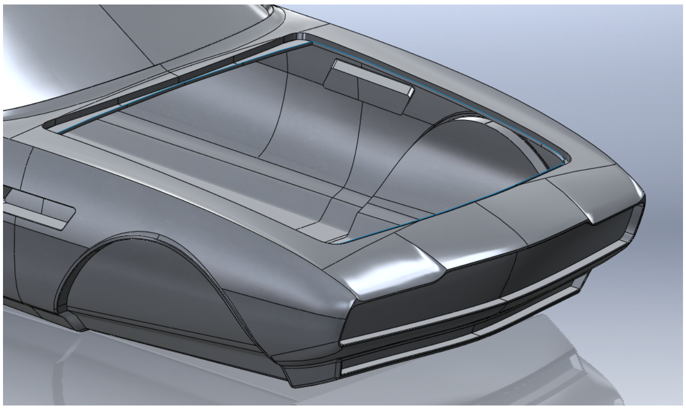


Figure 21: Drain channels in bonnet

Next the boot lid is removed, this is not only the top, but also a small part of the rear, this is showed in Figure 22. When the resulting hole is patched, the split line for the boot is made. Again, a ruled surface finishes the drain channel.

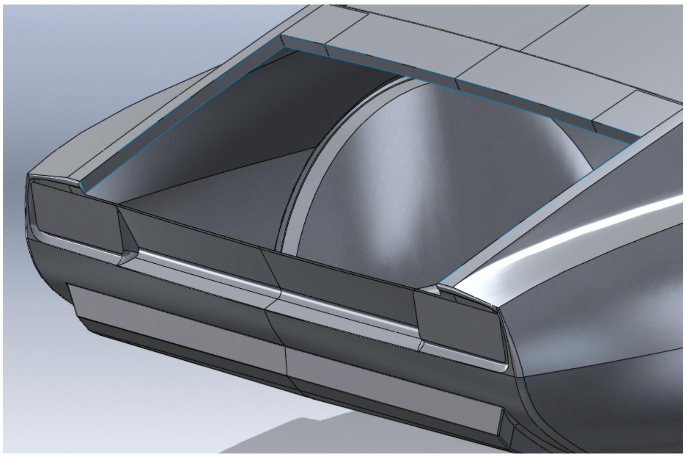


Figure 22: Removed boot lid

The rear window only needs to be deepened and given a small lip. When this is done, the door has to be removed. For this, the model is cut in half again. This simplifies the use of split lines. The drain channels around the side windows and door are very complex. The shape, length and angle change along the edge. Also the arch-like lip for the trim, discussed earlier, is important in these measurements. Another important part is the connection to the backplate of the door. This backplate is different in certain types of the DBS. In general, in the type that is scanned, the body just bends around the lip of the backplate. This shape is known, thus could be drawn exactly. However, for the purpose of the buck, it is preferred if there is more room than just the lip of the backplate. Therefore, this plate is extended in this version.
Finally the plate for the fuel filler flaps needs to be formed. This is, again, dependent on the type and optional extras of the car. The so-called series 2 has a separate panel with vents, that is screwed on. The series 1, the scanned car, does not have this, and has a panel on par with the rest of the body. The differences between the series is distinguished in [1]. The fuel filler flaps are bolted to the chassis and are not part of the body. An indentation is made where the flaps will be. These are kept closed, the cut-out will be made per chassis and is thus not included in the version for the body buck.

The model is mirrored and made watertight again, see Figure 23. Important here is that the ruled surfaces that are used as the drain channels are removed. It is not preferable to have these in the body buck, since it greatly affects the workability. Without the surfaces, there is more room for hammering and tooling. Extra tooling is necessary for these ruled edges.

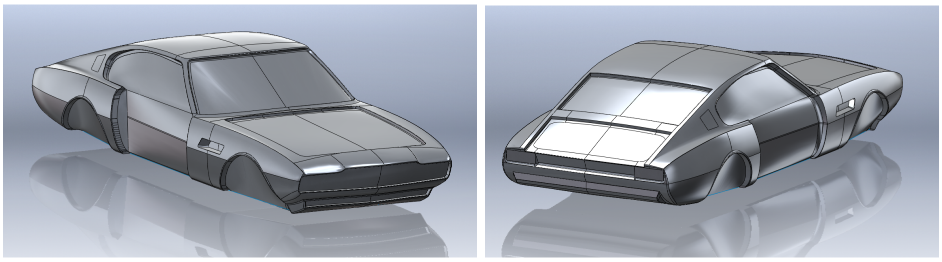


Figure 23: Watertight model with drain channels

3.4 Body Buck Design

Now the final surface model is done, the model must be prepared for conversion to solid. This is done by removing certain surface and patching the resulting holes. Once a cleaner watertight model is reached, it is converted to solid. Now the actual design for the body buck can start. Important factors in choosing the body buck concepts are:

- Cost
- Production
- Toughness
- Clamping

The cost should obviously be as low as possible to make it a feasible design. The production of the buck itself cannot be done by Noble House, which means another production company is needed with the necessary knowledge and experience in the way the buck will be produced. Also, a high level of precision is preferred. The toughness is important since the buck should last for more than just one or two bodies. Clamping is specific to Noble House's sheet metal worker's work flow, he clamps the aluminium plates to the buck with C-clamps. This should be accounted for in the design. The different concepts are explained below.

Concept 1: Current buck

The first concept is based on the way the current body buck of the DB5 is made, seen in Figure 24. This is made of a timber frame of milled multiplex plates that slide into each other. On this frame, blocks of birch wood and blocks of polyurethane (PUR-blocks) are fixed. These blocks are individually milled to the correct specification. The blocks are then bolted to the multiplex frame. This concept saves costs by using cheaper wood instead of only the expensive PUR-blocks. Also, the buck is assembled in-house. This concepts leaves a lot of room for implementing tooling and places for C-clamps. However, individually milling the blocks is expensive and the assembly by hand sometimes leaves a less than perfect fit.

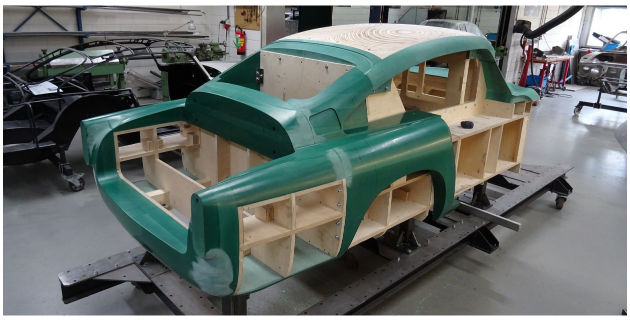


Figure 24: Current body buck of the Aston Martin DB5

Concept 2: Foam and Paste
The second concept is based on a technique where the model is milled out of foam and a special tooling paste. Foam blocks that exceed the final dimensions of the model are glued in a structure. The foam is then milled down to slightly smaller than the rough shape of the final model. Next, a tooling paste is applied. When this has hardened, the final model is milled from the paste. This is preferentially done in one session. This concept has the advantage that if it is milled from 1 part, the tolerance is as tight as possible. Also, making it in 1 session is more cost effective since it only has to be aligned in the machine once. The downside is that the paste might not be thick, hard or strong enough to endure the production process of the bodies. Also, allowing room for clamping is more difficult to implement.

Concept 3: Box and blocks
The last concept is a combination of the previous two concepts. In this concept a wooden box is made in the (very) rough shape of the car. PUR-blocks are fitted to the box, and the entire construction is milled. This could be done in multiple session and thus with multiple boxes. This concept cuts costs by milling it in as little sessions as possible, while keeping possibilities for clamping relatively open. Making a combination of blocks of birch wood and PUR-blocks is however more difficult.

The mayor part in the decision is the cost. It is in the company's best interest to have the cheapest buck produced. Obviously durability of the body buck is as important in this decision, since the buck will be used for multiple bodies. Production is assessed next.

3.5 Production

3.5.1 Orientation

In order to make a decision on which concept to chose, correspondence with production companies was needed. The previous body buck for the DB5 was produced by a company called MVM in Hengelo. Also, a previous partner who saw the body buck at Noble House referred to Premier Composite Technologies (PCT) in Dubai, who might also be able to produce a body buck. After some research on internet, a list of 8 companies was comprised.

Table 2: Production Companies

Company	Location	URL
Premier Composite Technologies	Dubai	http://www.pct.ae
MVM	Hengelo	http://www.modelvormmakerij.nl
Nedcam	Heerenveen	http://www.nedcam.nl
VDL	Roden	http://www.vdlwientjesroden.nl
Doornekamp woodspecials	Waddinxveen	http://www.woodspecials.nl
Bakers Patterns	Telford	http://www.polystyrenemodels.co.uk
Formlab	Bratislave	http://www.formlab.sk
Modelárna Liaz	Liberec	http://www.medelarna-liaz.cz/en/

The main criterion for the production companies is the size of the milling machines they use, since the buck is preferred to be milled in as little sessions as possible. After discussing with management, 4 companies would be approached for an initial cost evaluation. Since there was already correspondence with PCT and MVM, these companies were selected immediately. VDL and Nedcam were also approached.
The project manager of MVM visited Noble House to discuss some new approaches to the production of the body buck. This proved helpful and their CNC milling expert estimated a cost of roughly €32.000. This method is based on Concept 3. After some phone calls and email correspondence with Nedcam's sales engineer, a different approach was proposed with an estimated cost of €19.000. This approach, comparable to Concept 2, is however untested in toughness and hardness. VDL did not believe their machine could produce the body buck. After much email

correspondence with PCT, the commercial manager had to pull out because the production technique used at Noble House was not expected to work well with their method. This left Nedcam and MVM as the remaining two production companies interested in building the body buck in different ways.
Following up on Nedcam's offer, a visit to the company was arranged. After elaborating on their approach of Concept 2 and some discussion, the initial idea for a foam substructure with three glass fibre filled epoxy composite layers and a final layer of tooling paste was deemed unfit. The tooling paste suggested by Nedcam was found to be too brittle and too soft for the application, according to their material supplier. After a tour through the factory, showing their possibilities, an alternative was comprised. A thick epoxy composite layer around a steel wire frame. This is more expensive then the previous approach, since a negative mould must be made first, after which the mould must be layered with glass fibre mats. This would result in a mould with a (nearly) uniform thickness, allowing for easy clamping. A steel frame will support the composite structure, so weak parts like the a-pillars will not fail when hammered upon. The estimated cost for this approach was set at approximately €29.000, making it comparable to MVM's approach.

3.5.2 Comparison

For both approaches, more in-depth cooperation between Noble House and the companies was needed. Since the actual production of the body buck is not within the foreseeable future, this cooperation is not yet initiated. Therefore, a final choice in production method and company cannot be made yet. MVM's method is proven to work, but the box in the middle might bring some new difficulties. Nedcam's approach is very interesting, but not yet proven. This method must first be tested with a sample, this test is however not cheap and is therefore not yet undertaken. When the production of the body buck is approved, the sample should be made to test the method. MVM's approach is based on the box model, PUR-blocks are glued to a wooden box, which has the very rough shape of the body. The main advantage here is that MVM offered to design the box and decide on the optimal distribution of the PUR-blocks. This would reduce the pre-mill operations and therefore costs. This will also reduce design time for Noble House significantly. The proposed concept can be seen in Figure 25. The main disadvantage is that this approach will use a large amount of material. Especially at the front and rear end, a lot of material is needed to reach from the box to the outer corners of the model. Another disadvantage is that, according to their concept, the large amount of material in combination with the box does not allow for easy clamping. This can of course be discussed if MVM is chosen, but this does mean that more design time from Noble House is required. Making the design time less of an advantage. The large amount of material used also makes the concept more expensive.

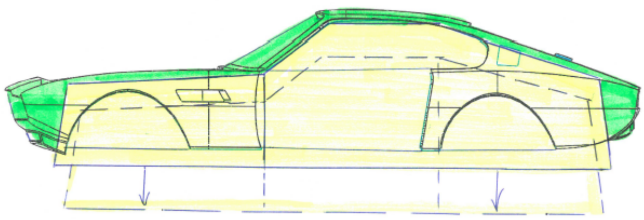


Figure 25: Body buck concept MVM

Nedcam's approach is somewhat cheaper than MVM's approach. The main advantages of this concept is that it results in a body buck with an almost uniform thickness. This allows for easy clamping of the aluminium. The buck will also be produced in one seamless piece. Nedcam only needs the surface model for this, see Figure 26, the only thing that needs to be discussed further is the size of the flanges and the design of the steel frame to accommodate the needs of the sheet metal worker. The disadvantage is that this approach is not tested. The toughness and hardness of the material may be too low, even the whole structure might not be strong enough. This should all be tested with a sample, durability of the resulting body buck remains relatively uncertain. The uncertainty in this is the main disadvantage of the concept.

Figure 26: Body buck concept Nedcam

The comparison of the concepts is summarised in Table 3. In this comparison, another design is added where a combination of the box and blocks model and timber frame model is made. Where material cost is reduced, clamping improved with respect to MVM's approach and design is done in house. Obviously, the cost and toughness of the body buck are most important, thus have the highest weight factor. The design time is the time after this project necessary to come to the final body buck that will be produced. Nedcam's design is not yet proven in strength which is why this is not yet rated.

Table 3: Concept Comparison

	Weight	MVM	Nedcam	Own Design
Cost	3	1	3	5
Toughness	3	5	1-5	3
Design Time	1	1	3	3
Clamping	2	1	5	3
Total		21	25-37	33

If Nedcam's approach would prove to be insufficient, they would also be prepared to make the buck similar to MVM's approach. A cost estimation is not made for this approach before the first approach is tested. Knowing this, a body buck will be designed for the own design ,described above, of the box and blocks approach. This will give Noble House both options when production is started, since Nedcam's first approach only needs the most recent surface model of the final body. Only some flanges will have to be added to this, keeping the steel frame in mind. This will not take much design time and must be done in cooperation with Nedcam. If MVM's approach is more expensive or generally not preferred, they could also use this approach to the body buck. The design approach of the body buck itself is described in Section 4.6. The surface model for Nedcam's production approach is however finalised to roughly the same extend, since this does not differ much from the final surface model, this is not further elaborated upon in this report.

3.6 Material Choice

For the current body buck, Necumer's Necuron 1050 is used in combination with birch wood and a timber frame. Comparable sample blocks were tested, after a test sample was made, the choice for Necuron 1050 was made, mainly for its hardness. This was especially needed on the edges of the body buck, which suffer the most hammer strikes. In between the edges of the body, the high hardness of the Necuron is not necessary. Since it is a relatively expensive material, the birch wood on the large flat areas is a good solution.
For the body buck of the Aston Martin DBS, the material is assessed again, since the manufacturer of the current buck mentioned the material cost was 25% of the total cost. A re-evaluation is therefor a potential cost saver. The material comes in so-called working boards, these can be bought-in in various dimensions. After some research, four main producer of these materials are found and compared. The most important factor is the hardness Shore D, this should be around 80 to be comparable to the current material. Furthermore, the density (in g/cm^3), flexural strength (in MPa) and compressive strength (in MPa) are taken into account. The results can be found in table 4.

Table 4: Materials

Manufacturer	Working Board	Density	Shore D	Flex. Str	Comp. Str	Price per m^3
Necumer	Necuron 1050	1.15	82	81	82	~€8.000
Huntsman	RenShape BM 5112-2	1.5	80-85	100-110	90-100	~€13.000
	RenShape BM 5166	1.6	85-90	55-65	90-100	~€12.000
Sika	Sikablock M700	0.7	66	26	25	-
	Prolab 65 XL	0.73	70	34	28	-
	Biresin	1.1	76	50	47	-
RAMPF	RAKU-TOOL WB1222	1.22	75-85	70-80	60-70	~€8.800
	RAKU-TOOL WB1404	1.40	85-90	80-90	85-95	~€8.400
	RAKU-TOOL WB1600	1.60	85-90	55-65	90-100	~€9.400

The cost of Necumer is estimated between the price from supplier Girrbach and the 25% mark of MVM. Huntsman's material costs were obtained from VIBA via email. Scabro's tooling consultant visited Noble House to advise on which RAMPF working board would be suitable. The corresponding prices are estimated on a bulk purchase of 1.5 m^3 by Scabro.
The actual cost of the material is dependent on the manufacturer of the buck. Like MVM, they usually order in bulk which reduces the price per cubic meter. The manufacturer of the buck also prefers a certain material over another with regards to the milling process. As of this stage in the project, a definite selection cannot be made. But from the selection two options can be selected: Necumer Necuron 1050 and RAKU-TOOL WB1404. These two have a very high hardness and are the cheapest. The already familiar Necuron is a solid option, preferred by MVM. For Nedcam, a final material selection has not been made. But a supplier for RAKU-TOOL, Scabro, was contacted and a price indication obtained. If no material is preferred by Nedcam, this option can be selected. For Nedcam's composite body buck concept, the material is already selected by them in correspondence with their supplier.

4 Analysis & Results

Throughout the process described in the previous chapter, analyses had to be done on multiple occasions. This consisted mostly of measurements of parts. When the body buck is actually made, it is of the utmost importance that the resulting body fits to the chassis, but also that other components fit to the body. In this chapter some of these components are mentioned and the steps to ensure the fit are described. Furthermore, the result of the final body buck design is elaborated upon.

4.1 Scan Fit

The main goal of the surface model is to recreate the shape of the car as close as possible. This model can then be used as a reference frame when bodies are recreated or repaired. After every added surface, the scan overlay is turned on to check whether the surface is a close fit to the scan. If the surface is also smooth, it satisfies the main requirements. Since not the entire car is modelled, but only one half, it is important to check the final (mirrored) body with respect to the scan. As can be seen in Figure 27, the model is sometimes outside (grey) and sometimes inside (blue) the scan. This indicates a fairly close fit, on both the right and left side.

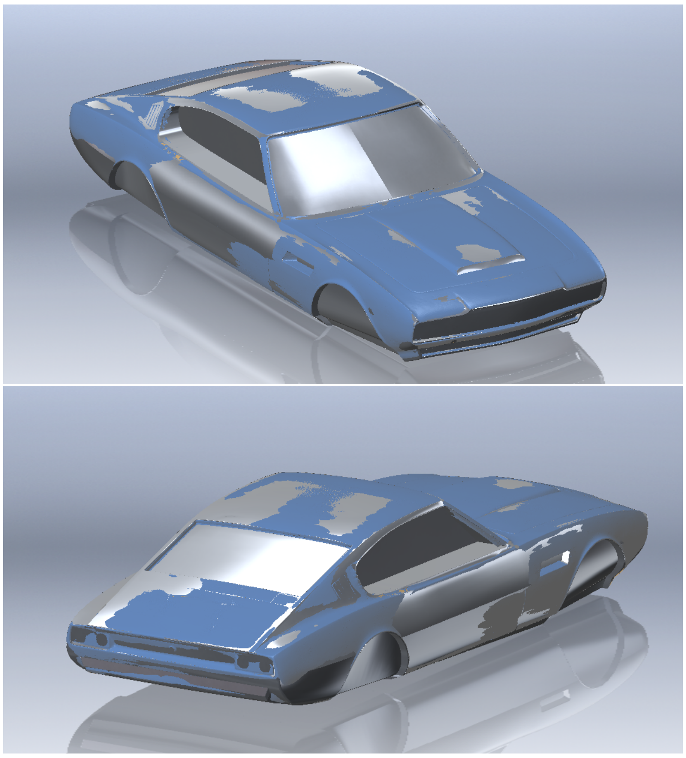


Figure 27: Scan fit

4.2 Measurements

When modelling the surfaces, not only does it need to fit the scan, other panels, parts and trim pieces need to fit on the resulting body. Some of these measurements are mentioned below.

4.2.1 Grille

The front of the car has a complex shape that makes it instantaneously recognisable, the gap in the front houses the single piece grille with the double headlamps. This part has to be very tightly modelled, since the body will need to fit in the hole in the chassis, but also, the grille needs to fit inside the gap in the body. This leaves little room for error. The chassis and grille were already modelled in SolidWorks. By placing these parts in an active assembly with the surface model, changes could be directly implemented and analysed. On top of that, two grilles were measured by hand. This lead to the realisation that the grilles also differ from each other. The angle of curvature of the grille and some imperfections in symmetry should not be accounted for, as suggested by the mechanics that worked on many of these cars. The grilles are made to fit the car, if the body fits the chassis as closely as possible, the grille should fit. In Figure 28 the assembly fitting can be seen.

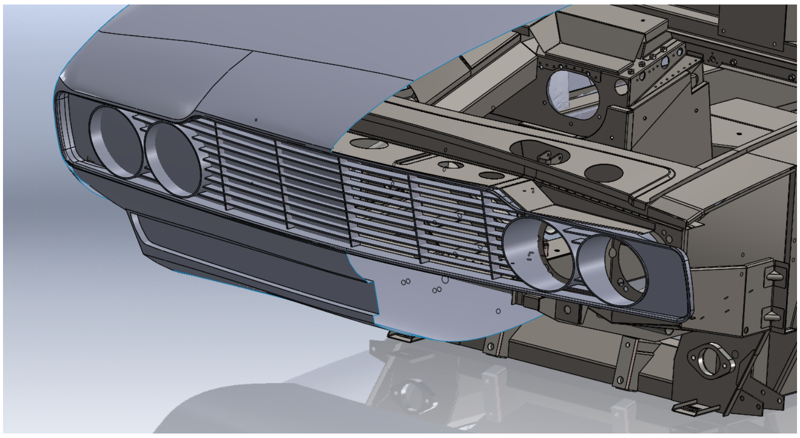


Figure 28: Grille alignment

4.2.2 Tail Light

The main features on the rear end of the car are the tail light units. These are fitted on a flat plate in the otherwise fairly rounded rear end. Since a tight fit of these lights is important for both safety and sealing, it must be made sure that the unit fits. The unit was not modelled in SolidWorks, so the main measurements were taken from a spare unit and a rough model was made. After some alterations, the unit fitted nicely on the plate. the result can be seen in Figure 29.

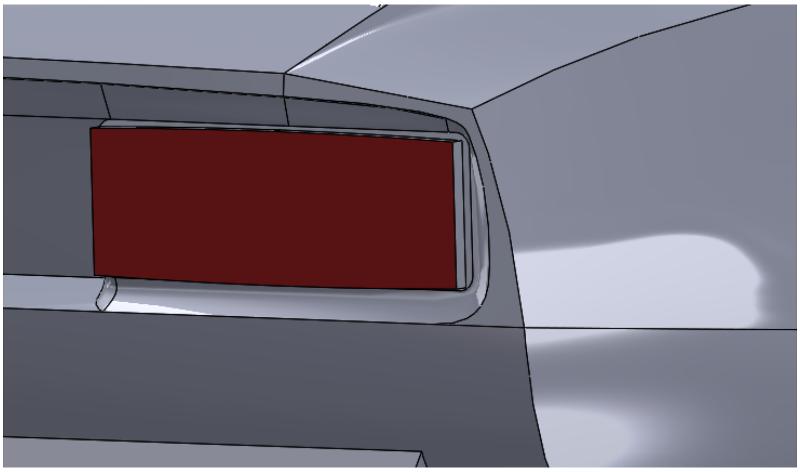


Figure 29: Tail light alignment

4.2.3 Side Window and Door

When making the cutting lines on the side of the model, there are a few important parts. The window line must be smooth and must make sure the window fits inside. Also, the door must be cut out. The window line can be split in two, the rear side window and the window on top of the door. The rear side window is a very important part to get right, since it must fit well on three different sides directly to the body. For this reason, a spare window is sprayed with a special scanning spray and scanned. It is then manually aligned to the body scan in Geomagic. It is not a straightforward angle, and as mentioned earlier the body scan is not optimal in this region. When a satisfying fit is found, it is exported to SolidWorks. The lines are not directly copied, but the window is fitted and the lines are adjusted manually. The chassis scan is also used, see the right side of Figure 30, to make sure the scanned window also fits in there.

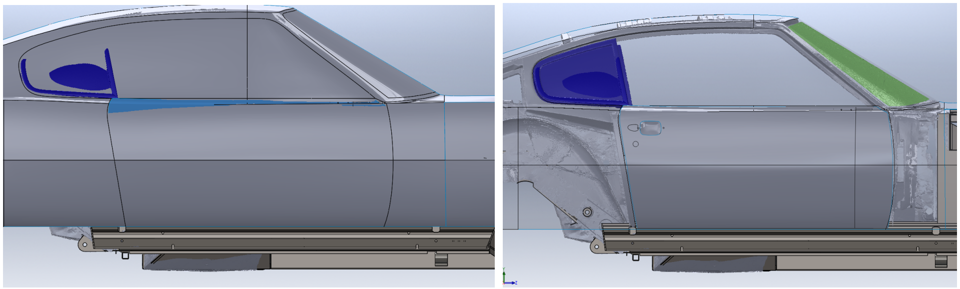


Figure 30: Door and side window alignment

The door lines can be retrieved from the scan, but are not very clear. At the start of the project, a model of the door was made to get familiar with the software. This can now be used to check the shape of the door, seen on the right in Figure 30. Since this is only one scan, the door holes of 2 different cars is also measured by hand, in the same way as in Section 3.2. To make sure the window above the door also fitted, another door with this window is scanned and fitted to the scan of the car. An average, keeping in mind the shape of the scans, is then used for the final dimensions of the door.

4.2.4 Front and Rear Shield

It is also very important that the other windows in the car also fit. The front and rear shields are more standardised in dimensions than the body panels. These windows have to fit the way they are because no changes can be made to them. The freedom in placement for these parts is in the placements of the clamps for the rubber seals around the windshield. Again, the chassis is also a leading factor in the design of the holes. To make sure the windows will fit, they were tightly wrapped in paper and then individually scanned. They are then manually aligned to the body scan in Geomagic. This was difficult to judge since no thickness could be included in the scan. Also, the hole in the body is much wider all around to accommodate for rubber seals. When a satisfying fit from multiple directions was found, the surface was imported in SolidWorks and the holes for the windshield could be made, seen in Figure 31. The same was done for the rear. Both were also measured by hand, both the hole on the car and the screens themselves to ensure a fit. The placement of the seals will determine the actual fit.

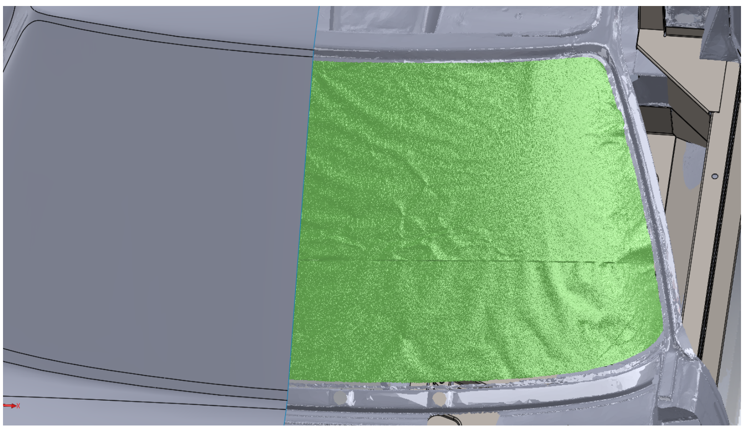


Figure 31: Windshield alignment

4.3 Window Arch

When reviewing the model and discussing with colleagues, attention was drawn to the sill around the window arch. This lip that serves as an outside drain channel and fits a piece of trim, will be around 6 mm thick in the final body. It was concluded that this would be too weak in the current state. This would result in such a thin lip in the final body buck that this is expected to shear off too easily. Some durable solutions were conceptualised to reinforce the lip.

Concept 1:
The first concept consist of an extra tooling block which clamps an aluminium plate to the window sill. The plate can be hammered to the roof without fear of breaking the lip since a lot more material is behind the roof part. The resulting part can then be welded to a plate spanning the rest of the roof. Figure 32 shows the block and body buck in dark grey and the aluminium plate clamped in between in light grey.

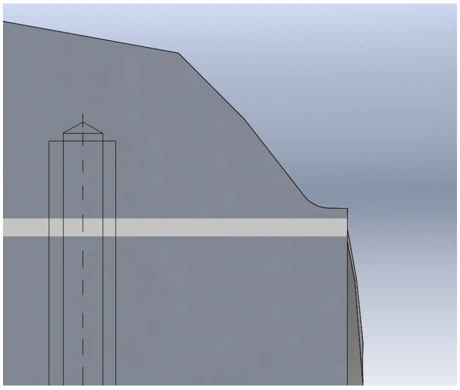


Figure 32: Concept 1

Concept 2:
For this concept, a cutout where the lip will be has to be made in the body buck. This will leave space for a 3 mm thick steel strip. This strip will have to be laser cut and then bend. This strip will then be bolted to the buck, using inserts. The resulting sharp edge between the roof and the steel strip can be filled with glue of the same material as the body buck. The inserts need to be drilled deep inside the buck. Also, room for a clamp is necessary to stop the material from bending back when hammered under the roof.

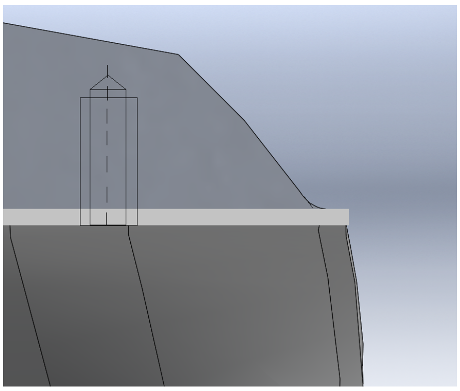


Figure 33: Concept 2

Concept 3:
Finally the thickness of where the sill will be can be 'extended' down the window. The bend can be made and extended along the window. This will have to be cut off where the sill ends. Then, when the body will be fitted to the chassis, a separate strip can be welded on.

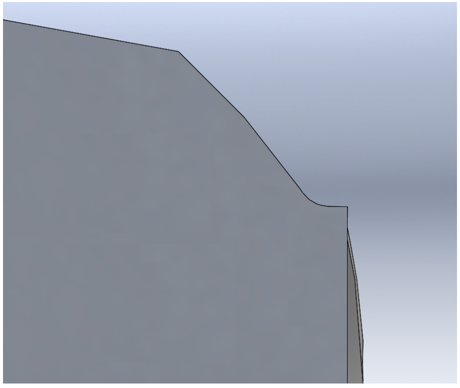


Figure 34: Concept 3

After discussing these concepts, the steel strip of Concept 2 was chosen. This would be the easiest to use and produce. Also, it is expected to result in a better looking finished product than the welded option. To test this, a sample is made in cooperation with the sheet metal worker. A wooden block that represents the roof is sanded to roughly the correct shape, it is then bolted to a scrap steel strip of 3 mm thick. The result is show in Figure 35. The resulting aluminium strip has the desired shape, the solution is found satisfying.

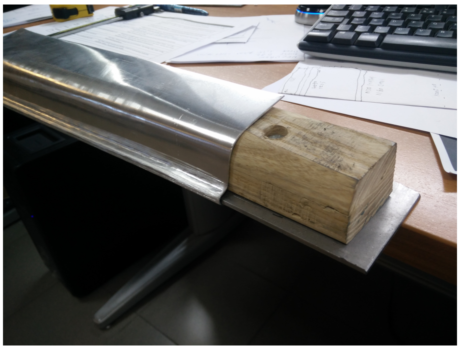


Figure 35: tooling test specimen

4.4 Front End Replacement

While modelling the car, the physical car was checked for reference regularly. At the front, it was found that the characteristic point on the corner was flattened in the scan. After checking multiple cars on this, the point in the scan was deemed too stump, see the left in Figure 36. For this reason, the front end of a different car was scanned again. The point of this version was more aesthetically pleasing. This did introduce some problems in the design. The model was relatively far along, the main line, which ends in the tip of the point, was already sketched. The new scan fitted reasonably well, apart from the hole for the grille, seen on the right in Figure 36.

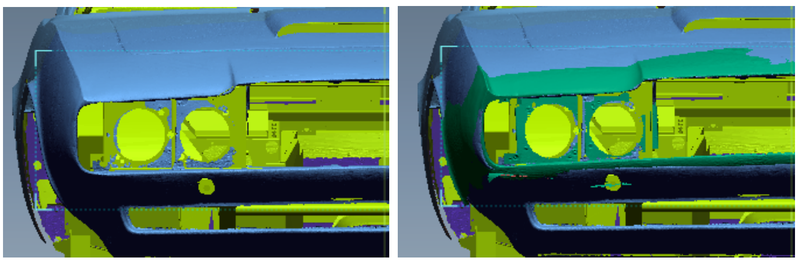


Figure 36: New nose

4.5 AM V8 Modularity

Before the final buck was developed, future possibilities were discussed. The Aston Martin DBS shares its chassis with its replacement, the AM V8. Noble House also has some AM V8s from clients in house for restoration. The idea was sparked to make the final buck modular, if the AM V8 shares enough panels with the DBS. The best way to find the differences between the AM V8 and the DBS would be to scan an AM V8 and compare the scans. But first, some internet research was done.

First of all, the research is limited to the standard AM V8 and the AM V8 Vantage, not including the American specs. Distinction between the different models is difficult because the Aston Martins Owners Club (AMOC) refers to series for the mayor changes. These changes were gradually introduced in the factory and no series numbers were used in company records or chassis/engine numbers. Furthermore, the production numbers differ per source. The production numbers from Schäfer [2] and the AMOC's series distinction were used to navigate the different models, distinguished in [3].

The standard AM V8 is divided in 5 main series, series 1 being the DBS V8, of which 402 were made, see [4]. The series 2 introduced the single headlamp front end, the rear remained the same. This iteration was only produced for a little over a year in which 288 were produced. The series 3 was fitted with Weber carburetors, which required a larger air intake in the bonnet. Also, a small lip on the panel between the fuel filler flaps was introduced. Bumper over-riders were also standard from this point on. This version is by far the most common with 967 produced. The series 3 is also known as the Oscar India. The Oscar India introduced an integrated spoiler, thus with a redesigned rear end. The large air intake was closed off and made lower. Many cars were also fitted with extra driving lamps in front of the grille. 291 Oscar Indias were made. The final version introduced electronic fuel injection, completely removing the need for a raised bulge in the bonnet. No further cosmetic changes are mentioned. Only 61 were produced. All standard AM V8s had black headlamp trim and a black mesh grille.

In the final year of production of the standard series 3 the AM V8 Vantage was introduced. This higher performance car needed more downforce, which lead to a hastily made flip tail spoiler, which became more integrated later in the same series. Also, a large front air dam was fitted. The air intake and grille were closed off. In these versions, the grille and the headlamp trim were painted in the body colour. For the Vantage models, the bumper over-riders were dropped. Of this series 1 Vantage, only 38 were made, of which 23 with the integrated spoiler. The series 2 came together with the standard Oscar India. The Vantage Oscar India also got the better integrated spoiler of the standard Oscar India. The main difference with the standard Oscar India are the much wider wheel arches, adding 60 mm to the total width of the car. 181 Oscar India Vantages were made. The series 3 of the vantage is also referred to as the X-pack. The main difference is under the bonnet, cosmetically, only the wheels differ. 137 of this final X-pack were made.

Throughout the production, bumpers, air dams, indicator locations were interchanged on certain models, making it sometimes hard to identify which version it is. Concluding the research, it is clear that within the AM V8 model, a lot of difference appears. The objective of this project is not to model this modularity but to allow for it in the future. This means deciding which part of the DBS body buck should be made detachable. The difficulty here is that, as can be read above, there are a lot of differences and not every change is documented clearly. It could however be very cost effective to only have to produce the front end of a V8 and make it interchangeable with the DBS front end. Scanning all different iterations of the V8 would be too time consuming and difficult, since there is no access to all iterations mentioned above.

The modularity is not taken into account at this time. A total scan of the AM V8 is due to time and other reasons not a reasonable goal. In the final body buck design, the possibility for modularity is taken into account, but only for the front end. The split line for this is estimated with reasonable assumptions on the differences and similarities. This factor is not made a leading factor in the design, but is only kept in mind while designing the final body buck.

4.6 Final Body Buck

4.6.1 Design Process

For final design purposes, the body buck will be made of several blocks of RAKU-TOOL WB-1404, since the available block size is known. These will be mostly glued to each other and to the boxes which form the main frame. This will however not be sufficient for some parts, which is why between the boxes and the blocks, some timber frame pieces will be used. The solid model will be split up into pieces which will represent the milled down blocks. It is chosen to stick to 100 mm thick blocks as much as possible, while keeping the total volume as low as possible. If it is not appropriate to use the 100 mm block, a 50 mm block will be used. Also, minimal saw operations on the blocks will be kept in mind, but this has a lower priority than overall volume used. For the boxes and timber frame, 22 mm multiplex will be used.
It is chosen to first make the block model, then the boxes for the main frame are designed and lastly the timber frame in between. Splitting up the model is done from the side view at first. The parts that span the entire width of the buck, like the front end, windshield frame, roof, rear window frame and rear end, will be split up later. This provides a global view of what the block model will look like, see Figure 37. The split blocks are then assessed individually on the necessary size of the block it will be milled from. If the size is found unsuitable, the split lines are changed. The blocks are split in straight lines as much as possible to reduce difficult fit and saw operations. The main exception made is the roof, which is under a 6^o angle.

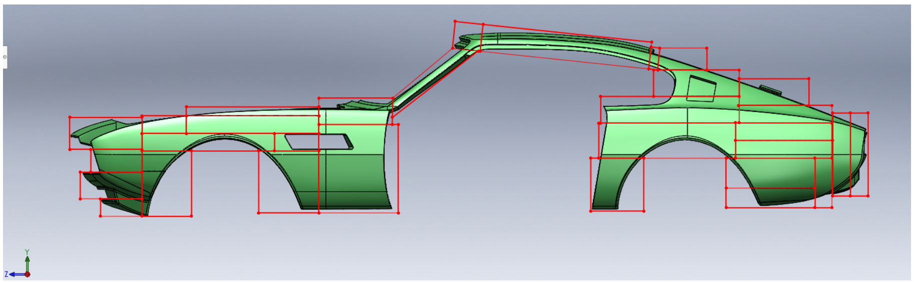


Figure 37: Cut lines side

The full blocks are made next, with as little excess material as possible. This reduces overall milling time and necessary block material. If the smallest edge of the unmilled block is between 50 and 100 mm, the block is set to 100 mm to reduce pre-mill operations. The result can be seen in Figure 38. The milled parts have a combined volume of approximately 0.5 m^3, while the 87 necessary unmilled blocks are take up approximately 1.1 m^3.

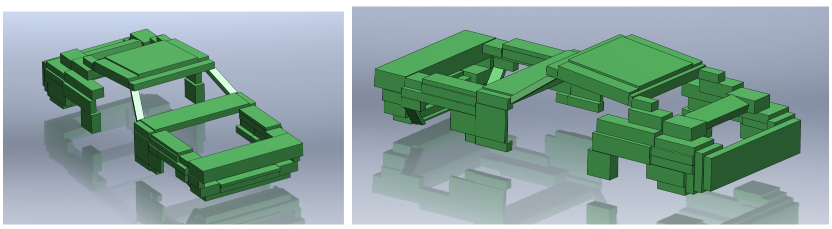


Figure 38: Unmilled block model

For the boxes in the middle, it is preferable to have it make contact with the blocks as much as possible. This is somewhat unfavourable for clamping, holes in the box are needed to allow for this. The buck is split in four sections of boxes. A simple box is preferable, but the alignment with the blocks is deemed more important. The front two boxes can be simple, the rear two have a simple base box, with a more complex shaped, smaller box on top, a cross section can be seen in Figure 39. The first box (at the front) does not share blocks with the second box, making AM V8 modularity still a possibility on this end. The front two boxes support the blocks around the bonnet and the blocks to the side.

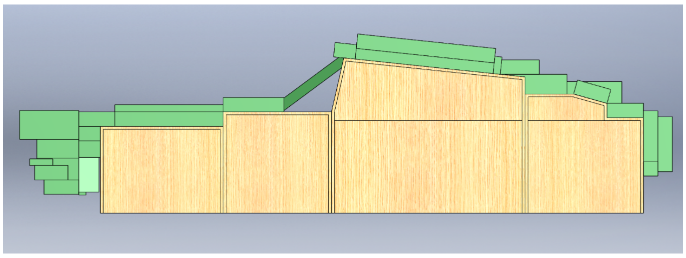


Figure 39: Cross section Box model

The front end of the car is not well supported, this requires a timber frame, keeping clamping possibilities in mind. Also, the angled blocks and underside of the front will need some help with alignment and some reinforcement. This is all realised with six length-wise placed planks, slotted in the front plate of the first box. To these planks, a width-wise directed plank is placed. To secure this plate even more, five small reinforcing planks keep it in place, the result can be seen in Figure 40. The sides, just behind the wheel arch are also reinforced. The horizontal plank allows for easy alignment. Again, the planks are slotted inside the box.

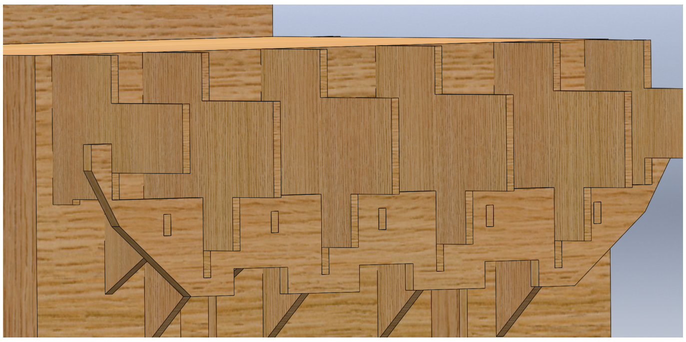


Figure 40: Front timber frame

The A-pillars are the most fragile part of the block construction. The blocks are cut under different angles and placed under another angle. The blocks will also be milled almost completely around. It must however be supported underneath. Therefore, four triangle shaped planks are placed in the length-wise direction, between them, two width-wise oriented planks. The triangles are slotted in the boxes. The outer two are reinforced with an extra plank between the box and the the triangle. The middle two are reinforced with two glue blocks. The middle section of the roof is glued to the front rear and side beams, which in turn lean directly in the box. It is further reinforced with three length-wise oriented planks.
The rear most box is the smallest, and had a lot of room between it and the rear fender blocks on the sides. This is filled in with multiple vertical planks and a horizontal plank. These are all once again slotted and glued into the box itself. The rear most blocks are supported by five vertical planks, which are hooked on top of the box. These planks are on their turn supported by a glue beam on the rear side of the box. A width-wise vertical plank serves as a large glue area for the heavy blocks. The total box and timber frame design can be seen in Figure 41.

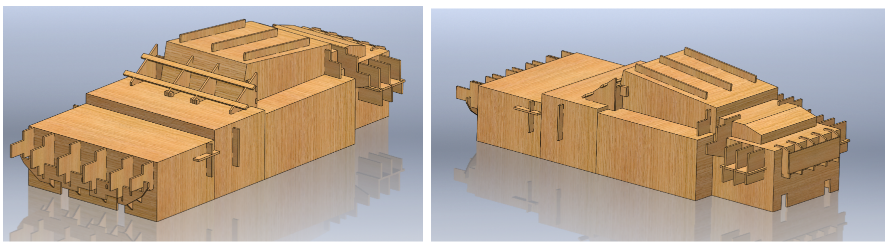


Figure 41: Box and timber frame model

Now the model contains all the components, the produceability is checked. This means that a gap tolerence of 0.1 mm is used for the holes in the boxes and timber frame. Also, the planks used will be milled in a 2D-mill, which means that straight inside corners will always have the mill radius. To overcome this, circular holes are cut out in the inside corners. The planks that form the boxes are milled in such a way that they slot into each other like puzzle pieces at the edges. Finally all edges are given a fillet of 2 mm.
Finally, the steel inserts, conceptualised in Section 4.3 are added to the model, seen in Figure 42. The total structure is supported by two beams that span from the front to the rear. The final milled down body buck can be seen in Figure 43.

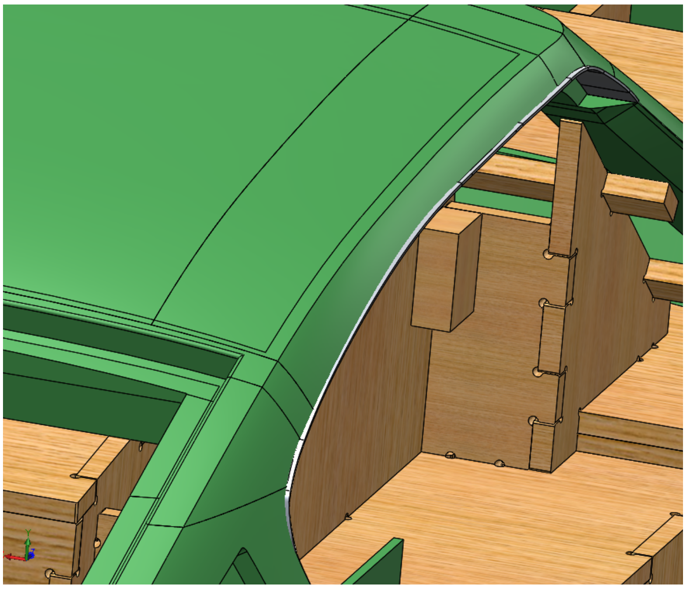


Figure 42: Steel insert

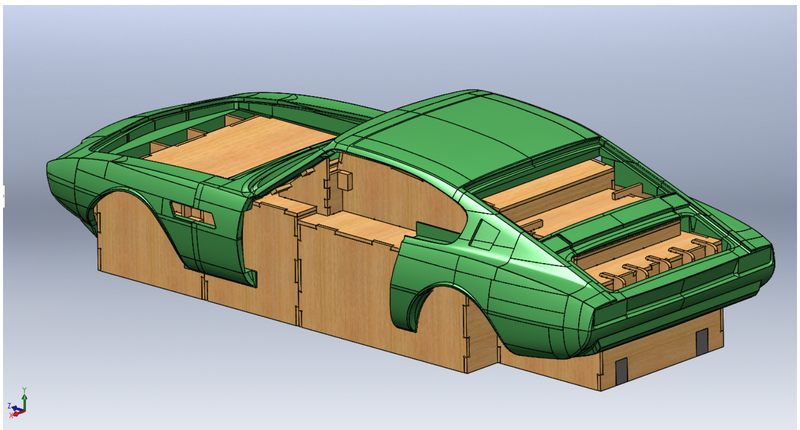


Figure 43: Final Body Buck

4.6.2 Separate Panel Tools

The final body has drain channels in the gaps for the bonnet and the boot. The upright edge at the end is not linear to the outside of the gap. To make this, tooling is required. For this, it is chosen to make the tooling from 3 mm MDF. It spans slightly more then half the gap to allow for some overlap. The plate can then be hammered or welded or both in the right place. The tooling for the bonnet and boot drain channels can be ssen in Figures 44 & 45 respectively.

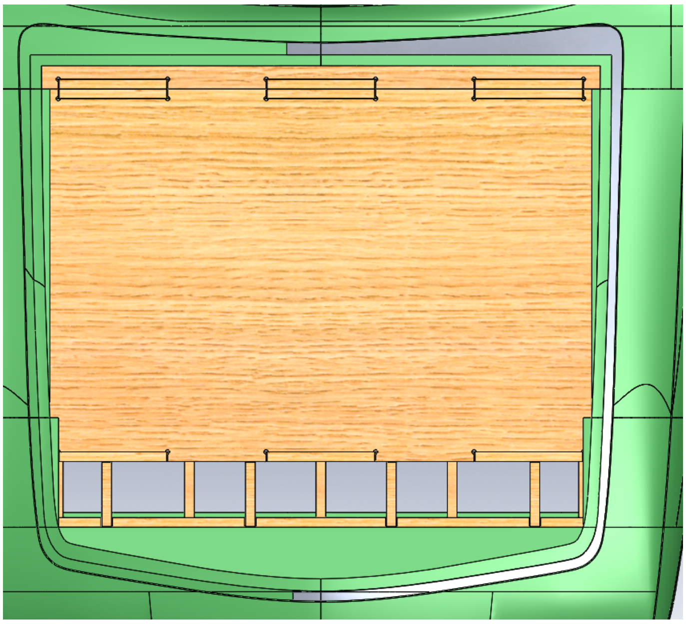


Figure 44: Bonnet drain channel tool

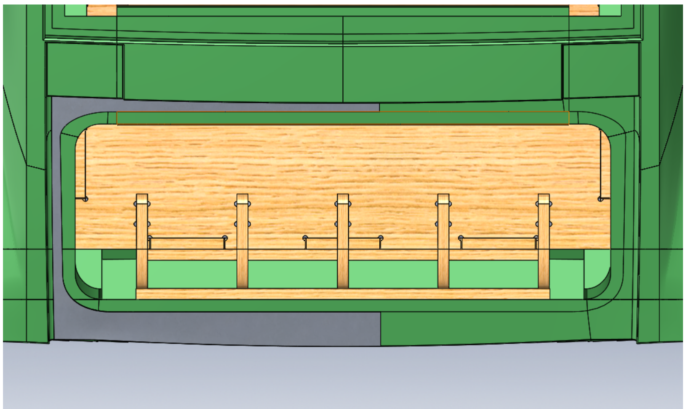


Figure 45: Boot drain channel Tool

To make sure all panels of the car fit, the separate panels need to be producible as well. Producing these panels from the same surface model ensures that all lines and surfaces connect as smoothly as possible, resulting in the best possible complete body. Firstly, the bonnet tool is made. This is a fairly large surface, milling it completely out of PUR would make it unnecessarily expensive and heavy. Making only the edges from PUR (green in Figure 46) and the middle parts from birchwood would save significantly on these factors. The air scoop is an important shape with a sharp connection to the bonnet. This edge is therefore also made of PUR, since this place will also need to endure a lot of hammering.

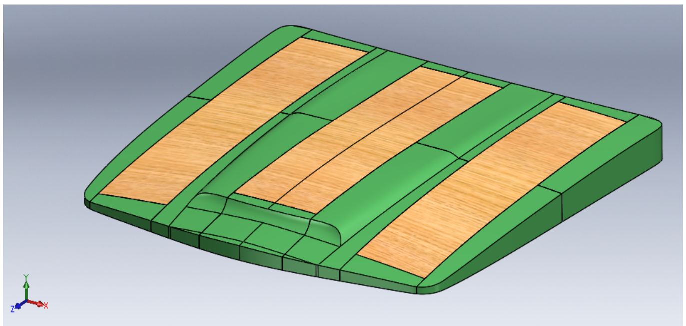


Figure 46: Bonnet Tool

The same philosophy is used for the door, the middle section is milled from birchwood instead of PUR. The main line of the car spans the door, this makes it very important that the door for the resulting body should also come from this tool. Another important factor in the door is the place for the handle. A small dent is made here. An insert of PUR is placed here to ensure this part can be hammered in the door without problems, as can be seen in Figure 47. In Figure 48, the tool for the production of the boot lid is shown. The most important part from this tool is that the tool is bent over the edge, it is therefore made in such a way that at both ends, the aluminium can be clamped.

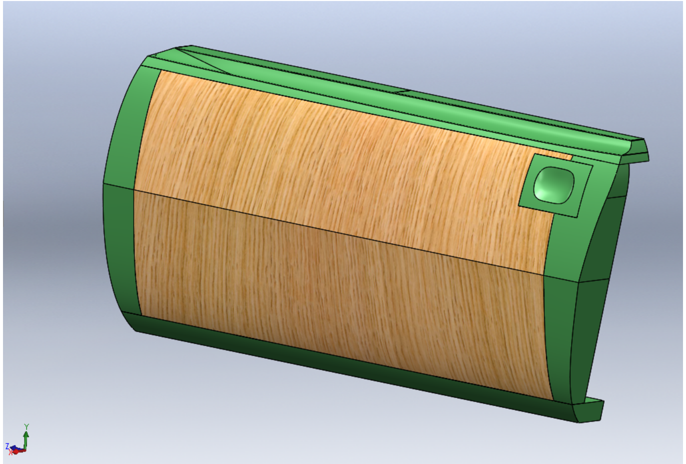


Figure 47: Door Tool

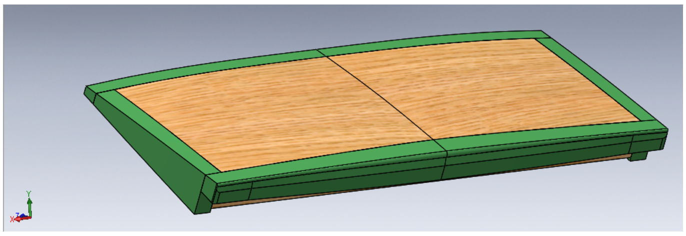


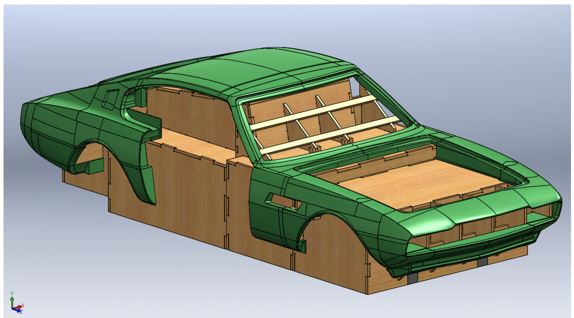
Figure 48: Boot tool

5 Conclusions & Recommendations

The report shows the design process for the body buck of the Aston Martin DBS. Nobel House is now in possession of a surface model of the body of the Aston Martin DBS. This model can be used as a reference when production of the body panels is up and running. The report also leaves

Noble House with two options for the production of the body buck. One unproven concept of a composite mould with a steel frame from Nedcam, see Figure 49a, for approximately €29.000, and one block model comparable to MVM's approach, see Figure 49b, with a wooden box and timber frame with an estimated cost of €32.000. The latter being developed in more detail in this report. Both concepts need little more design time from Noble House to start production, some correspondence with the respective manufacturer is recommended.
The surface model for Nedcam is finished, only the flanges around the edges need to be discussed with Nedcam's engineer directly. Nedcam designs the steel subframe which needs the flanges to join the subframe to the composite mould. In the price mentioned above, a flange of 100 mm is assumed, good design can greatly reduce this in many places in the design, resulting in a smaller total surface and thus a lower price, the given cost estimate is the upper boundary. Modularity can however not be implemented if this concept is chosen.
For MVM the main discussion is whether the block division described in this report will be used, or to let MVM make their own. This freedom makes assembly much cheaper, but possibly increases the amount of material used.
If Nedcam's composite body buck concept proves to be strong enough, this approach is recommended. The design is superior when it comes to clamping of the aluminium panels and being made out of one piece ensures a seamless body buck. Also, it is the cheapest option in the current configuration.
During the finishing stages of the project, the slight offset of the resulting body from the body buck of the DB5 was found to be more problematic than expected. Ideally, the body buck produces body panels that fit the original panels. This is however difficult to ensure due to the notorious tolerances within these hand made cars were build. The original panels have differences between them in the order of 15 mm. Making the body buck closer to the original by taking into account the 1.5 mm aluminium layer is a possible solution to look at in the future. Ideally, elastic springback would also be included. This is however not very realistic since the production technique differs per panel, large areas are bend with an English Wheel, while other shapes are hammered on the body buck. Some plates then receive a heat treatment and undergo long term clamping to achieve a certain shape. The panel production remains hand work, unexpected tolerances will occur. The offset is therefore only partially taken into account in this design.
When this process is undertaken again, for a different car for example, the same steps taken in this report are recommended. The work flow can differ in staring point of the CAD model, however the steps before and after should remain.
A time frame and budget for production are recommended when another body buck will be designed. Clearer boundary conditions allow for less surprises between R&D and management and more direct and unambiguous correspondence with production companies.

(a) Composite Body Buck Concept (Nedcam)



(b) Block Body Buck Concept (MVM)

Figure 49: Final Concepts

References

[1] Ph.C. (2011, September) Series 1 / Series 2. 28-07-2017 http://www.dbsvantage.com/en/pages/technical-data/series1series2.html

[2] Schäfer, M. *Typenkompass Aston Martin & Lagonda serienmodelle seit 1948*, Motorbuchverlag.

[3] Cottingham, T. Newport Pagnell V8's. 28-07-2017 http://astonmartins.com/car-category/amv8/

[4] Cottingham, T. DBS (6 cylinder). 28-07-2017 http://astonmartins.com/car/dbs/

A Appendix

A.1 Reflection

Here, I will talk about my personal experience of my internship at Noble House. With me being interested in the automotive industry for year, I really wanted to experience this work field during my internship. My interest in this field already lead me to Noble House once, years ago on an excursion organised by my study association W.S.G. Isaac Newton. At this point, some students from the University where also interning here. Their work and the tour through the building sparked my interest in Noble House.

Noble House is a company that mainly focuses on restoring, repairing, maintaining and reselling classic English cars, mostly Aston Martins. Since they have a unique position in the Netherlands regarding Aston Martins; their Heritage Dealership. All the work done by the mechanics and sheet metal workers is supported by the R&D department. This department has had fluctuated in occupants a lot in the past years, depending on the acquired projects. I was welcomed into this department by the currently only member, Ing. David van Pelt. At that point, he was busy finalising the body buck for the Aston Martin DB5. He could offer me a similar project, but for the Aston Martin DBS. The assignment was perfect for the length of the internship, an estimated 4 months, and it meant I could get hands-on experience with a project that could actually be realised one day. This, in combination with the opportunity of working on such beautiful and exclusive cars at such a unique company made it a great internship for me.

During the second meeting, when my acceptance was definite, I was immediately introduced to all the colleagues, who were all very welcoming and interested in my internship. On my first day, I very much appreciated the preparation for my arrival. I got assigned a desk with computer and licenses were leased for me and I had an already setup email account. A car was fetched from storage and placed in a dedicated area for me to scan it. Of course, first I needed to familiarise myself with the equipment, the roughly €20.000 3D-scanner was put in my hands without hesitation. I really appreciated this confidence and it made me eager to start.

During the internship I frequently visited the workshop, sheet metal shop and the storage. Here I could look at and measure cars and parts as reference, but also ask my colleagues with tons of hands-on, practical experience for help. They were very eager to share their extensive knowledge with me and were always happy to help. Communicating with the Slovakian sheet metal worker Martin Manak was sometimes difficult, but I learned a lot from him about the practical aspects of sheet metal forming. Sometimes I had to help with different projects, like measurements or assembling a part list. This gave me an insight in the dynamic aspects of working in a supporting department.

I had regular meetings with André and sometimes Kees Huis in 't Veld, discussing the progress and activities of the R&D department as well as my assignment. Allowing me to contact potential manufacturers and resume contact with PCT was very motivating. They were confident in that I could appropriately represent the company. This even lead to a visit to Nedcam with my supervisor. Which was a nice experience where I felt that I was truly experiencing every aspect of working at Noble House's R&D department.

I think that all in all, I learned a lot and feel like the automotive industry is definitely something I would like to return to. I am sure that having interned at Noble House will help me with that in the future. The applied work experience really helped with my expectations of the ins and outs of working at a company. It being a fairly small company I have had a lot of attention and opportunity to develop myself, for which I am grateful.

A.2 Log

Week	Date	Activity
1	08-5-2017	Familiarising with hard- and software + 3D-scanning small object
	09-5-2017	3D-Scanning door of DBS
	10-5-2017	Creating SW surface model of scanned Door
	11-5-2017	Preparations for scanning DBS + emptying car + taping ground scan
	12-5-2017	Scanning front of DBS + merging with ground
2	15-5-2017	Scanning door frames of DBS and merging
	16-5-2017	Scanning rear end of DBS and merging + aligning total scan
	17-5-2017	Post-Processing scan data
	18-5-2017	Aligning scans and chassis and choosing scan+side
	19-5-2017	Testing different surfacing methods + main lines drawing
3	22-5-2017	Surfacing the roof
	23-5-2017	Surfacing bonnet and front end
	24-5-2017	Helping measuring misfitting body (DB5) + resurfacing and smoothing out main lines
	25-5-2017	-
	26-5-2017	-
4	29-5-2017	Roof and windows resurfacing with smoother lines
	30-5-2017	Roof to bonnet surfaces connection
	31-5-2017	Surfacing front end up to grill
	01-6-2017	Scanning better front, scanning side rear window + alignment + adjusting mainline
	02-6-2017	Surfacing side
5	05-6-2017	-
	06-6-2017	Grill alignment + measurement + resurfacing front + meetings
	07-6-2017	Implementing grill + resurfacing front based on grill placement resurfacing between it, bonnet and side
	08-6-2017	Smoothing surface patch between the side and front, rough surface rear end
	09-6-2017	Detailing surface rear end + connection to bumper + front under bumper + researching series I and II
6	12-6-2017	Refining front bumper + patch for measured taillight
	13-6-2017	Smoothing rear end surfaces + drawing door line and side window + scanning windshield
	14-6-2017	Aligning, measuring and drawing windshield + Model clean up
	15-6-2017	Smoothing out side surface + drawing trim and wheel arch lines
	16-6-2017	Refining roof lines + extrusion holes windows + Split lines boot, trim and filler flaps
7	19-6-2017	Split lines bonnet + scanning bonnet + scoop + start fillets
	20-6-2017	Resurfacing between a-pillar and bonnet, fitting bonnet, fillets + watertight model.
	21-6-2017	Researching possible partners for production of the buck + model clean up + start with drain channels
	22-6-2017	Drain channels of boot lid and bonnet
	23-6-2017	Drain channels of doors and side windows + Contacting potential buck manufacturers

Week	Date	Activity
8	26-6-2017	Finishing surface model + fillets + First tests with solid conversion + testing buck concepts
	27-6-2017	Scanning and aligning full door + Reporting
	28-6-2017	Thinning solid prepared model + conceptualising tooling and
	29-6-2017	Concepting arch tooling
	30-6-2017	Contacting production companies + rebuilding arches + searching inserts + Reporting
9	03-7-2017	Concepting window arch further
	04-7-2017	Searching model companies + testing and finalising window arch tooling + Reporting
	05-7-2017	Rear edge refinement + repairing model
	06-7-2017	Finalising surface model + render + DB5 review
	07-7-2017	Basis for solid model + conceptualising with MVM
10	10-7-2017	Creating concepts for final buck
	11-7-2017	Reporting
	12-7-2017	Researching and comparing materials
	13-7-2017	Researching materials and researching AM V8
	14-7-2017	Researching AM V8
11	17-7-2017	-
	18-7-2017	-
	19-7-2017	-
	20-7-2017	-
	21-7-2017	-
12	24-7-2017	-
	25-7-2017	-
	26-7-2017	-
	27-7-2017	Start-up approach AM V8 implementation
	28-7-2017	Reporting
13	31-7-2017	Material selection + reporting + testing buck approach + Scabro visit
	01-8-2017	Testing new buck approach
	02-8-2017	Buck design blocks front end
	03-8-2017	Buck design blocks rear end and visit Nedcam
	04-8-2017	Buck design roof + blocks and volume calculation
14	07-8-2017	Refining block model with block availability
	08-8-2017	Filling block model front end
	09-8-2017	Completing block model, conceptualising box model
	10-8-2017	Adjusting blocks and making box model + Helping colleague with fuel system parts
	11-8-2017	Adjusting blocks + start timber frame
15	14-8-2017	Finalising basic timber frame
	15-8-2017	Reinforcements in timber frame + Reporting
	16-8-2017	Adjusting surface model for Nedcam model + separate panel tools
	17-8-2017	Reporting + start box reinforcement
	18-8-2017	Box reinforcements + adjusting timber frame + tooling
16	21-8-2017	(Visit) reporting + discussion on progression and plan for final weeks
	22-8-2017	Implementing tolerance and producability to box model
	23-8-2017	Finalising box model on produceability
	24-8-2017	Reviewing model + Reporting
	25-8-2017	Reporting
17	28-8-2017	Archiving documents and emails + Reporting
	29-8-2017	Reporting
	30-8-2017	Reporting + Discussing draft
	31-8-2017	Reporting + Finalising internship
	01-9-2017	-