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LEARNING BY FAILURES: THE "ASTURA II" CONCEPT CAR DESIGN PROCESS

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ABSTRACT

Accessibility has always been a problem in sport car. Very low car floors, small doors, almost horizontal seating position with upward cramped legs are the negation of comfort. In marketing clips long legged girls show their knickers for the joy of the potential buyer. In the old times there were rumors that the four seats, automatic transmission Ferrari was made for the Drake himself, who was "obliged" to own and drive a Ferrari. Yet the only place where people with impaired legs are identical to all the others is the car. However the sports cars are usually denied to people with problems of motion. The Ercolani's idea was to overcome these problems by several concurrent solutions. The idea proved to be nice, while the design approach from sketch to 3D-CAD proved to be a complete failure. The final project fulfils many of the requirements, but with a completely different style. This project proved the substantial unfeasibility of the outside-in approach in the automotive field.

Keywords: car design, ASTURA II.

INTRODUCTION

Vaguely related to the fashionable old Lancia Astura, this project came from Luca Ercolani's idea [1] to make a sport car for people with motory handicap. These people should enjoy a small sporty environmental friendly car that levels all customers. The driver's door slides to increase the side room in the parking place. An easy access even for persons using a wheelchair is obtained by several devices. The car has an active suspension system to increase the height of the car to the ideal value. The driver seats can be electrically moved outside the car. Then this seat rotates to offer the best position to the impaired person. Finally a handle can be opened to help use arms in the transfer from the seat to the wheelchair. The Ercolani brilliant idea turned into a sketch and a 3D CAD concept. Unfortunately, this outside-in approach proved to be technically unfeasible, a complete redesign took place in a long and painful process.

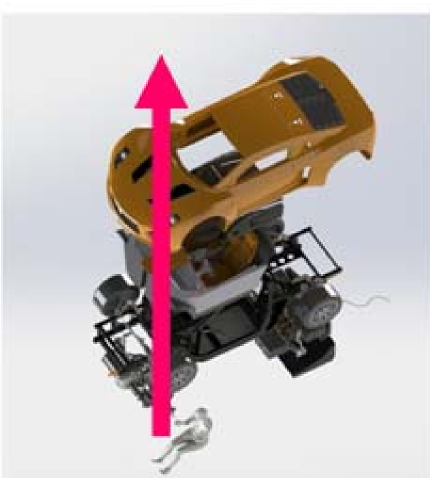

Figure-1. Inside out design process.

Ergonomics and room for the components proved to be impossible even into a scaled up version of the Ercolani's design. A long design process had to be carried out to design all the new internal components in the most convenient way. At the end a complete new car was designed around these new components with a very different design concept. This design was validated for crash, dynamic behavior, aerodynamic efficiency and stability through CAE simulations [2].

Inside-out design concept: the M60 main battle tank (Figure-1)

The M60 Patton first saw trials in 1957. It was designed to counter the existing reports of a new Russian tank armed with a 115mm gun. This fact provoked the urgent need to upgrade the then obsolete 90mm gun in the M-48 Patton, due to the threat posed by newer Soviet tanks starting to equip the Warsaw Pact Forces. At first the option to refit the M-48 with the new 105 mm gun was tested. However the restricted room inside the M48 tank proved the task impossible. The interior layout, based on the original design of the M26/46/47/M48, was the starting point for the new M60 tank. Since the US Army felt also the necessity to increase operational range and mobility also the powertrain was redesigned along with the track-wheel system. The crew compartment and the powertrain; compartments were then put together along with the new fuel tanks and the ammunitions storage. Steel cast armors for turret and hull where then tailored on the predefined inside. In particular, the hull was a one piece steel casting divided into two compartments, the crew in the front, and the engine at the rear. It was criticized for its high profile and limited cross-country mobility, but proved very reliable and underwent many updates over its service life. This was due to the interior layout that provided ample room for updates and improvements, extending the vehicle service life for over four decades. It proved to be a very

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successful design and over 15, 000 M60s were built by Chrysler Corporation. Production officially ended in 1983, but conversions to new variants ended in 1990. During its service life it was continuously updated thanks to the extremely rational design. This is a limit example of inside out design since the armor was tailored on the inside.

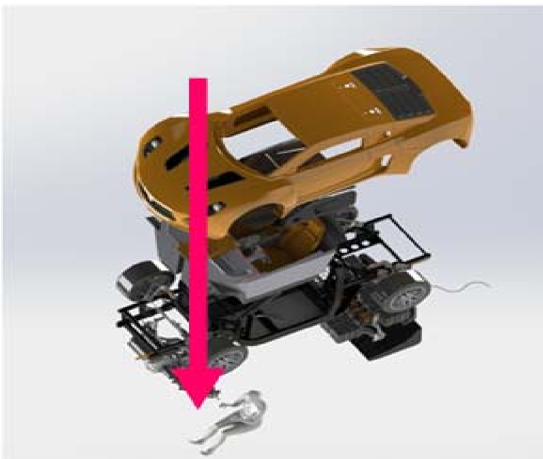

Figure-2. Outside inside design concept. The outside is designed first [3].

Outside-in design concept (see Figure-2): the Space Shuttle

When the Space Shuttle program was proposed to the Congress a very preliminary design was carried out. From this early study a mock up of the Space Shuttle was manufactured and costs were evaluated. Starting from these data the project was approved. However, despite the high efficiency demonstrated by NASA, the preliminary study underestimated several aspects, starting from engine size. This increased the cost by a factor 20. The outside-in design approach proved to be extremely expensive.

The NASA administrator James Fletcher told Congress in 1972 that the shuttle would have cost $5.15 billion to develop and would have been operated at a cost of $10.5 million per flight. NASA succeeded in keeping under control the development cost, but underestimated the cost of operating the shuttle by a factor 20. One of the main reasons for this was due to the fact that engines had a very high power density. In other words there was not enough room inside the space shuttle for durable engines. By the mid-1980s the scheduled launch expectations were reduced 50%. In fact the Space Shuttle Main Engines (SSMEs) were highly complex and maintenance-intensive, necessitating removal and extensive inspection after each flight. Before the Block II engines, the turbo pumps (a primary engine component) had to be removed, disassembled, and totally overhauled after each flight. Early in shuttle development, the expected launch rate was about 12 per year. Launch rates reached a peak of 9 per year in 1985 but averaged fewer thereafter.

Due to the predefined external silhouette and dimensions, an expensive engine design was needed, using more expensive materials, as opposed to existing and proven off-the-shelf alternatives (such as the Saturn V mains) increased ongoing maintenance costs related to keeping the reusable SSMEs in flying condition after each launch, costs which in total may have exceeded that of building disposable main engines for each launch. It is not a case that the Buran was significantly larger than the Space Shuttle and was designed to carry out missions with and without a human crew and therefore able to land autonomously. In fact it was never flown with astronauts on board.

The "Astura II" project: general requirements

The aim of the "Astura II" was to design a car that combines attractive design of sports model to the functional requirements of a car specifically designed for users with disabilities.The idea come from Luca Ercolani, a student [1]. The project should include up-to-date technological and construction technology. The result was to be a car of small size, lightweight, innovative, aggressive looking and at the same time elegant. An initial batch of 20 cars should be produced with as many commercial components as possible to contain costs.

The accessibility concept

The sliding door

A sliding door should reduce the necessity or lateral room in the parking place. The complete accessibility of the interior increases the comfort of a person who should access the car on the driver side with a wheelchair. The Ercolani's idea to make the door sliding towards the front is due to the fact that sport cars usually have a long nose and a short back. Another advantage is the fact that usually the car is accessed from the rear. In this case the slid door does not occupy precious room on the side.

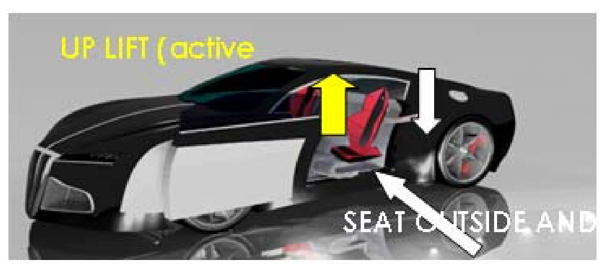

Figure-3. The sliding door: the seat is in the "entrance position", with the bar outside, the seat outside and rotated.

The main inconvenient of this solution is the fact that the door cannot be opened with the wheel steered. This is not a big problem in modern cars since the electric power steering system can be programmed to turn straight when the engine is off and the hand brake is on. However, since it is a battery operated system, the other door should be a standard hinged door in order to make it possible to exit from the car when the battery is low. This is a design constraint since hinged and sliding doors may have different geometries.

The variable height (see Figure-3)

A variable height system should be provided to the car or to the seat. As it will be seen the seat has many problems, while a variable height suspension system is readily available on the aftermarket. For this reason the car is lifted up for better accessibility.

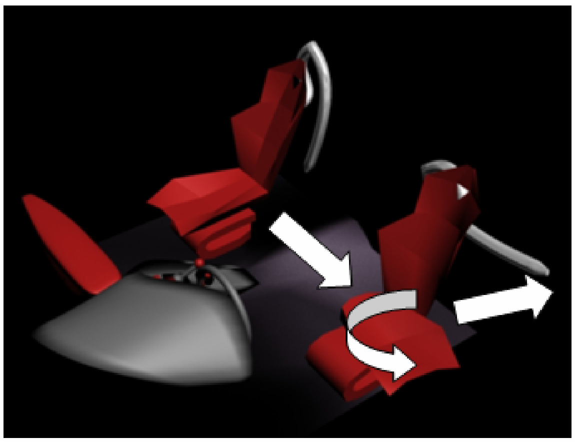

Figure-4. The driver seat moves electrically from the original position to the left side and then rotates outside. Previously the car was set on the upmost position by the active suspension system. The side arm (grey) is turned out from it downward position on the rear of the seat to provide a secure handle [1].

The sliding seat (see Figure-4)

The driver sets the car to the upmost position by activating the variable height suspension system. Through a lever, the seat slowly moves outwards on the side and then rotates outwards to facilitate the access. If the lever is released the seats remains blocked in the current position. The driver can manually move the grey handle to further enhance the access.

Design from sketch: Ercolani's "Astura II"

The design started from the sketch (Figure-5)

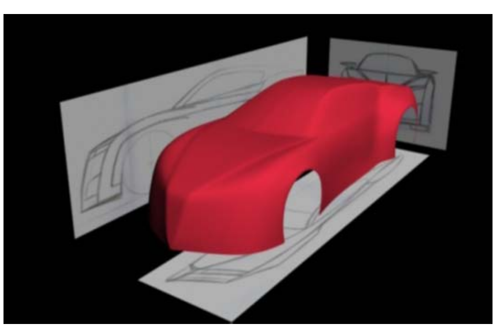

Figure-5. CAD the Astura II from sketch [1].

Figure-6. Astura 2 brilliant outside aspect [1].

The final result appeared to be brilliant (see Figure-6). However it cannot accommodate tall people (Figure-7). The Astura II had an attractive design, but it lacks of habitability: driver and passenger had little room in the vehicle. A first tentative has led to scale up the whole car body taking into account of habitability, accessibility; visibility, commercial components, crashworthiness, dynamic behavior, etc.

Figure-7. Tall people and the Astura II design [4].

This scaling operation seemed to be the obvious solution with the questionable result of Figure-8.

Figure-8. Scaled up Astura II [1, 5].

At this point a redesign took place, starting from the key element of the project: the seat.

The redesign process

The seat

A good sturdy and compact design of the seat is the one made by [5] (see Figure-9). This seat cannot rotate and it is still a bit too high. This solution would worsen the problem of the original Ercolani design.

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Figure-9. Sturdy, compact and simple design of the seat. Unfortunately this seat cannot rotate.

An alternative solution is the one depicted in Figure-10. This solution also avoids the active suspension system by elevating the seat with a quadrilateral linkage [6]. The size of this solution is unacceptable.

Figure-10. The size is unacceptable, plays and deformations are also an undesired side effect.

The adopted solution is the one of Figures 11 and 12), it uses commercial teflon slide collars on round bars. A slight interference eliminates undesired plays that may give an "unsafe" feeling to the driver. The stiffness is acceptable even if the seat may have a vertical displacement of 9 mm in the outmost position. Stresses are tolerable for medium quality steel with the necessary safety factor. The simulation of the crash tests for the homologation resulted in affordable stresses and deformations (Figure-13).

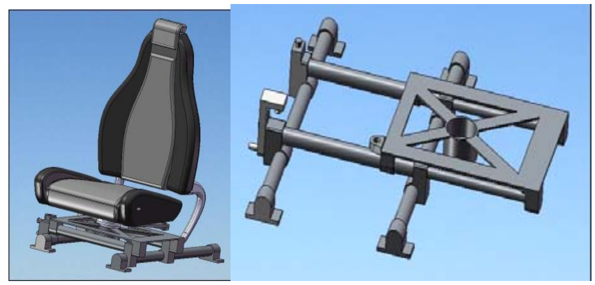

Figure-11 and 12. The final solution [7].

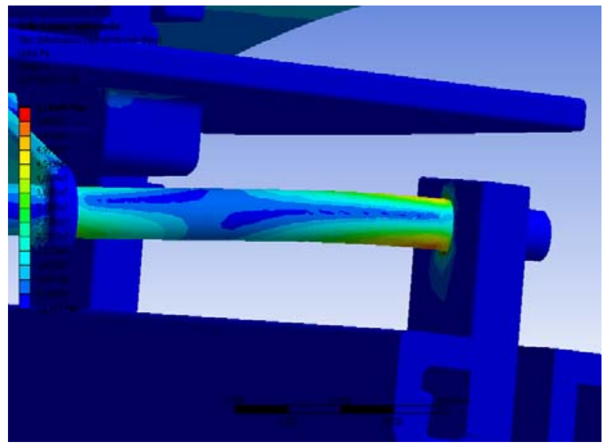

Figure-13. Displacement are under control.

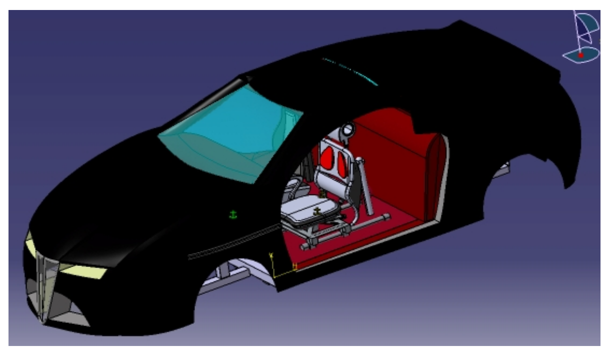

Figure-14. The final seat solution on a scaled up Ercolani's Astura II. The dark black color masks the stylistical shortcomings of this design.

It accommodates into the scaled up Ercolani's Astura II even for the tallest of the drivers (95 one hundredths). The additional mass is around 25 kg for each seat, all inclusive (Figure-14).

The sliding door

The design of the sliding door proved to be very easy [8, 9]. Aftermarket components were used. Only wirings and rear screen proved to be slightly problematic. For crashworthiness an additional bar was added (Figure-15).

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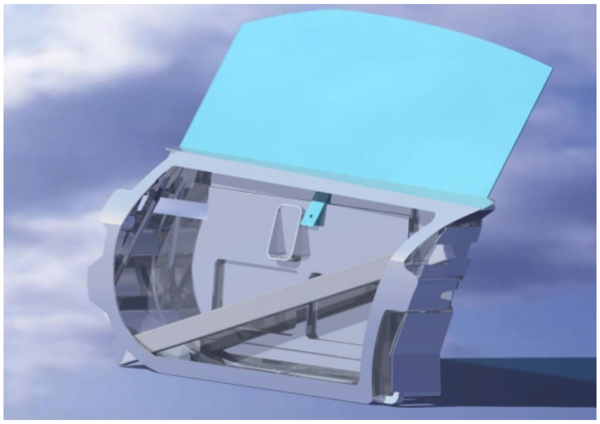

Figure-15. The interior of the sliding door.

The restyled car

A new restyled car with all the components inside was modeled by Marcoppido [MA]. The design result is terrible but it has everything inside (Figure-16). The inside is depicted in Figure-17. Note the natural gas thermal engine in the front and the electric engine in the rear. A continuous drive hybrid trasmission system was adopted. The crash test simulations [10] proved that the position of the natural gas reservoir was unsatisfactory. A more conventional position in the luggage compartment above the rear axis has then been adopted.

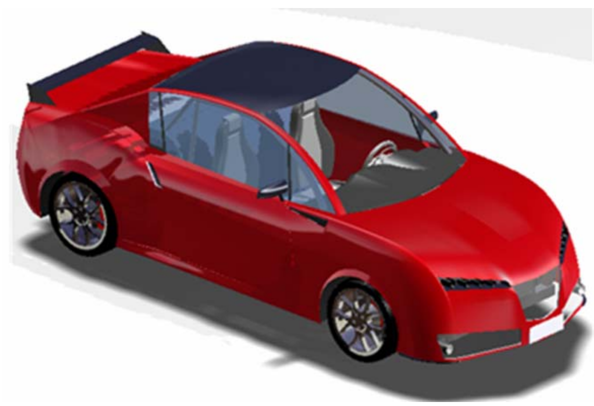

Figure-16. A fully functional but entirely restyled Astura II [MA].

This led to the interior of Figure-17.

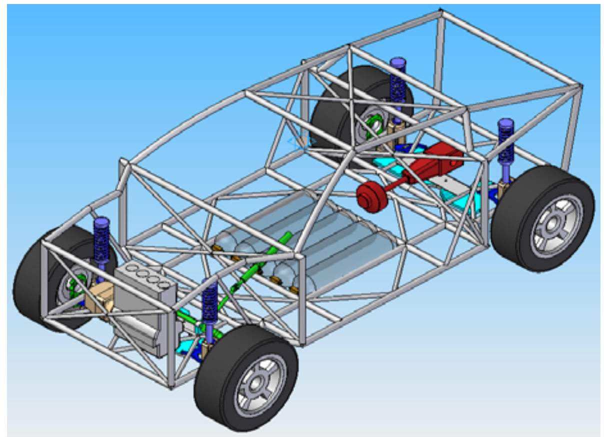

Figure-17. A tentative layout of the Astura II redesigned by Marcoppido [10].

Dynamic simulations were then performed with satisfactory results.

The final design

Starting from this new design several new styles were studied. The final solution was found by [11] (see Figures 18, 19). The problem on the original Ercolani's design was several. The car body was very high, so, car windows were narrow shaped, resulting in poor outside visibility. The wheels were very big with problems in tire commercial sizes and for steering. Third the nose was extremely long with problems in cockpit room. In addition, the new seat required more room than a normal "sport" seat, expecially in the vertical direction. A style more similar to a Mercedes SLK was require to fulfill the necessity to have a streamlined sporty small car. A compromise was then found by [m] with a high cockipt and a fashionable sporting line.

Figure-18. The final Astura design.

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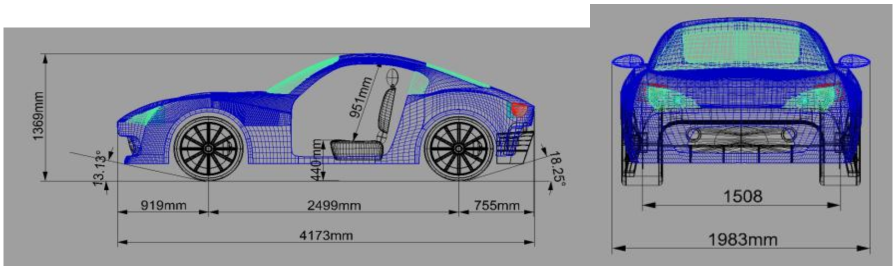

Figure-19. The final Astura II design overall dimensions.

The car is longer and higher than desired. However it passed the CFD tests satisfactorily, in particular for lateral wind loading.

CONCLUSIONS

The design process of the new concept car Astura II proved to be a very interesting failure. The initial style proved to be unfeasible both from the ergonomics and for the technical aspects. Ergonomics requirements along with new components prevailed over the initial design concept. A complete redesign of the components, of the interiors and several attempts for the exterior, finally led to a satisfactory result.

The process proved that the outside-in option is generally not feasible for car design.

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