A Reassessment of Automobile Assembly as a Model for Architecture Construction

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"In the automobile works, all the various phases of the execution process come together. It is a great school for any architect."

Renzo Piano

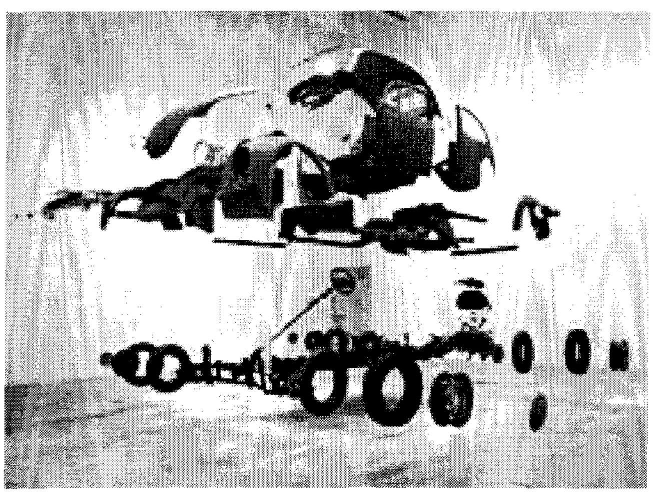

Fig. 1. Damian Ortega, Untitled, 2002.

PRE-MANUFACTURING: AUTOMOBILES VS. ARCHITECTURE

With the advent of the assembly line process for producing automobiles, Henry Ford changed the way manufacturers approached the production process. The efficient use of standardized parts and continuous assembly line production allowed for a great reduction in costs over a custom built product.[1] Builders have attempted to reproduce the technique. As far back as 1926 Theo Van Doesburg wrote, "presently building is already assuming the characteristics of an assembly line: the assembling of normalized, machine-produced parts. Just like our cars, our dwellings will be factory produced within the foreseeable future."[2] This has not quite happened as forecast. Certain structures such as pre-manufactured housing, mobile homes, and trailers employ ideas from car production with mixed results. However with escalating costs of new home construction and the development of new construction techniques, architects may find answers by revisiting techniques of the automotive industry.

Previous attempts at mass-producing entire buildings reveal the impediments. These include the uniqueness of each architectural design and the nature of their construction materials and techniques. Most architectural designs are done from scratch to meet a client's specific program and site. It can be difficult to adapt a standardized framework to meet complex needs. "Architects design a prototype every time they propose a building: components are put together in new ways each time, and new solutions to problems are found. The car industry works in the opposite way"[3] Each car design is reproduced repeatedly and there are many shared characteristics between different models. At the same time there are a range of features with which to "customize" each car. Choices between various colors, interior fabric, wheel style, etc. allow the consumer to at least think they are getting a 'one-of-a-kind' automobile. Most architecture clients want to have many choices. They desire a unique design that reflects their personal image. Housing developers try to accommodate this by making each of their repetitive designs look different from its neighbors. Like an auto manufacturer they alter minor aspects like color, finish materials and gable shapes but it is basically the same house as others on the street. While some people are willing to accept a house that is similar to their neighbors, most still prefer a wider range of choices for their home than for their car.

The materials and techniques used in traditional building construction are also an issue. Many materials (i.e. brick, stone, concrete) are very heavy and therefore are not cost-effective to transport as pre-assembled structures. However we are moving away from what Frampton refers to as the "wet" techniques of building construction towards the "dry" techniques.[4] We rarely build monolithic masonry bearing walls out of 'wet' bricks, mortar and plaster but instead most of our construction systems today start with a steel frame precut in the factory. Systems that provide enclosure, interior finishes and mechanical functions are then bolted and hung onto the frame. The assembly technique for most automobiles resembles this "dry" method of construction. The car structure is usually based on either a skeletal chassis or an exoskeletal "unibody" construction. To it are attached the systems that seal out the weather, create a comfortable interior environment and power it. In this way the two objects are similar. "Just as architecture involves many technical environmental and human aspects fused in a single design, so a car combines many mechanical, ergonomic and safety requirements"[5]

Although there are some serious concerns about producing buildings on an assembly line, there are still positive things we can learn from studying car construction. The success of the Design/Build industry has demonstrated the desire of clients to build more quickly and cost efficiently. Building construction in general is a rather inefficient operation. "Anybody who has ever been employed in an architect's office, worked on a building site or simply watched a house being erected will realize that the process of getting a building built is a fragmented, confused and often wasteful set of operations. Wasteful in labour, time and money."[6] Incorporating disciplined automotive assembly processes into building construction may produce both higher quality and more time and cost efficient architecture. Pre-manufacturing at least some components could be an answer because of its efficiency and quality control. "The certainties derived from prefabrication mean it is no longer viewed with the contempt it once was. Over the years society has become less tolerant of defective products.... Maybe this heightened expectation has been driven by our experience of cars and their production values."[7]

Interchangeable parts also pay off in terms of the sustainability of automobiles. Currently the German government requires all car manufacturers to take back their automobiles after a specified number of years.[8] As the parts must be dismantled and recycled, using a component system makes this process simpler. It also likely encourages manufacturers to use more easily recycled materials since they know they will need to deal with them in the future. If the life cycle cost of architectural components is taken into account, the quality and sustainability of materials may also improve. "As far back as 1909, Walter Gropius noted that 'only the standardization of component parts could "satisfy the public desire for a home with an individual appearance"'.[9] Because of their interchangeable properties that allow for some level of customization and their light weight that makes them easier to transport, a component system for architecture may be the best approach to pre-manufacturing.

ARCHITECTS AND AUTOMOBILES

From the work of early masters such as Wright, Gropius and Corbusier to the futuristic designs of Fuller, Prouve and Bel Geddes, architects have been interested in automobile design. "Since the earliest days of the motorcar, architects have realized that to propose an automobile is an opportunity for an exercise in miniature architecture, the design of a detachable mobile room. It is a way for them to perfect the synthesis of art, design and the latest technology."[10] While many designs were little more than exercises in style, the superimposition of a sculptural shell over a standard chassis, some approached car design with a blank slate. The pre-manufacturing experiments of Buckminster Fuller with his Dymaxion House are well documented. A more recent example came in 1978 when Fiat asked Renzo Piano and Peter Rice to start from scratch to analyze the way it designed and manufactured its cars and to propose a prototype for the next decade.[11] The main objectives were to reduce weight and improve durability, safety and comfort. After observing car assembly in the factory for 6 months, Piano came up with a system of interchangeable components attached to an overall structural framework; a skin and skeleton system. By making the individual body panels out of lightweight polycarbonate separate from the structural framework, he was able to reduce the overall weight of the car by twenty percent. Another advantage of separating the systems was that the panels could

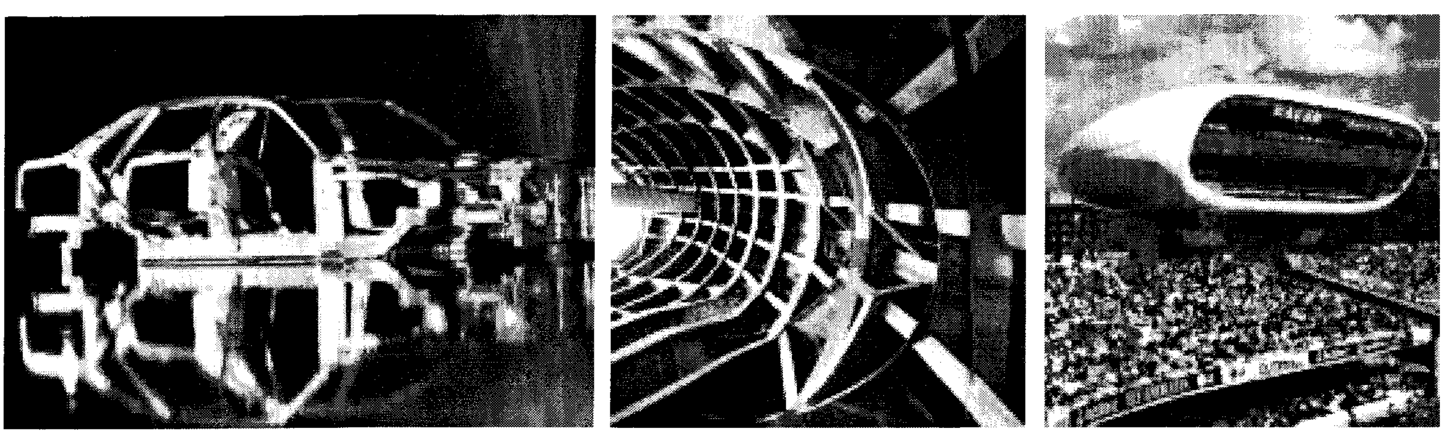

Fig. 2. Comparison of Automobile and Building Skeletons.

be interchanged to produce different styles on the same framework. Because he approached the challenge of car design in the same way as architectural design, "from a deep knowledge and understanding of the materials and process used to make an object", he has been able to transfer many of these ideas into his own building designs.[12]

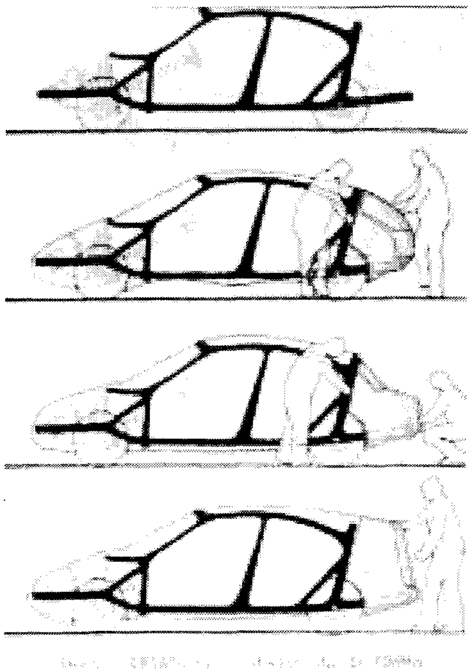

Fig. 3. Renzo Piano.

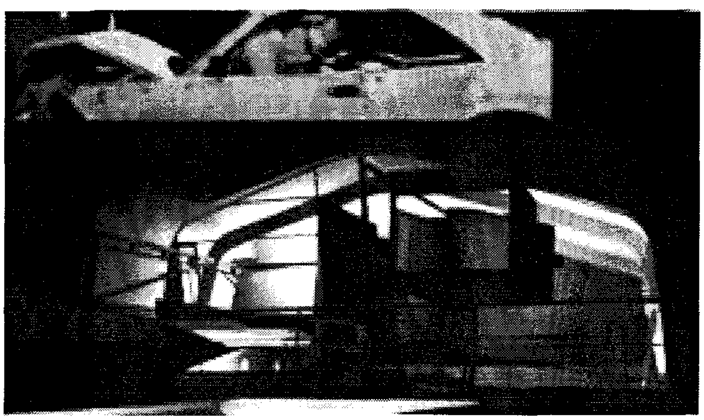

Fig. 4. Neil Denari.

The computer has altered the way architects approach form to more closely resemble the way car engineers approach design. Because of CAD's three-dimensional capabilities, architects have become more willing to explore forms off the orthogonal grid. The multi-curvilinear shapes that are now simple to produce via computer drafting software were avoided in the past because they were difficult to construct. Now CAD-CAM has the ability to cut and draw sections at any point quickly and accurately and feed the design data directly into computer-guided machinery. In many cases drawings are obsolete and skipped all together. By looking at the double-curved forms in the work of architects like Frank Gehry, the connection between architecture and automobile is more apparent. It is well known that Gehry uses software originally developed for the aircraft design industry as no architecture design software could handle the complex geometries. In Gehry's, like most multi-curvilinear buildings, the systems are divided into distinct layers that come together at the perimeter of the building. In his earlier work the relationship between the curving skin and the structural frame was quite crude. The steel framework was made up of straight beams that only vaguely mimicked the exterior form and left many dead spaces in between.[13] This was partly due to the steel industry's inability to manufacture the complex curves. Now on his most recent work the exterior and interior envelopes more closely trace the line of the structural frame, much in the same way as automobile construction.

INVESTIGATING AUTOMOBILE SYSTEMS

To test if an investigation of automotive systems could be useful as an analogy for building systems, I developed a project for my fourth-year design studio that compared the component systems of a car to those of a building. To establish a system to compare the two construction techniques, I divided them into four basic categories that are also common to cars. These were defined as Structural, which provides the support, Exterior Envelope, which keeps out the weather, Interior Envelope, which provides comfort and Mechanical, which provide utilities.

Experiments were conducted on two scales, the scale of the model and full-size car. To understand the diversity of parts that go into the production of a car, the students were asked to purchase a die-cast metal car model that was very detailed in its assembly. Before assembly they first color-coded the graphic images on the model's assembly instructions to match the four categories. By seeing how the colors were distributed throughout the page, the students learned how the four systems were distributed throughout the whole car. They then assembled the model and using a metal-cutting band saw, cut it into approximately 3/4″ thick sections to reveal the inner workings at various points. Through this exercise they were able to view the relationships between systems and how closely or loosely they interacted with each other.

This brief exercise prepared the students for the main part of this project, the disassembly and categorization of the systems of a full-size car. The main goal was to understand the how the parts and systems that comprise an automobile fit into the four established construction categories. I first procured a 1979 Chevrolet Chevette as a tax-deductible donation. The car was documented in photographs in its original state and then the disassembly process began. By treating the process as a

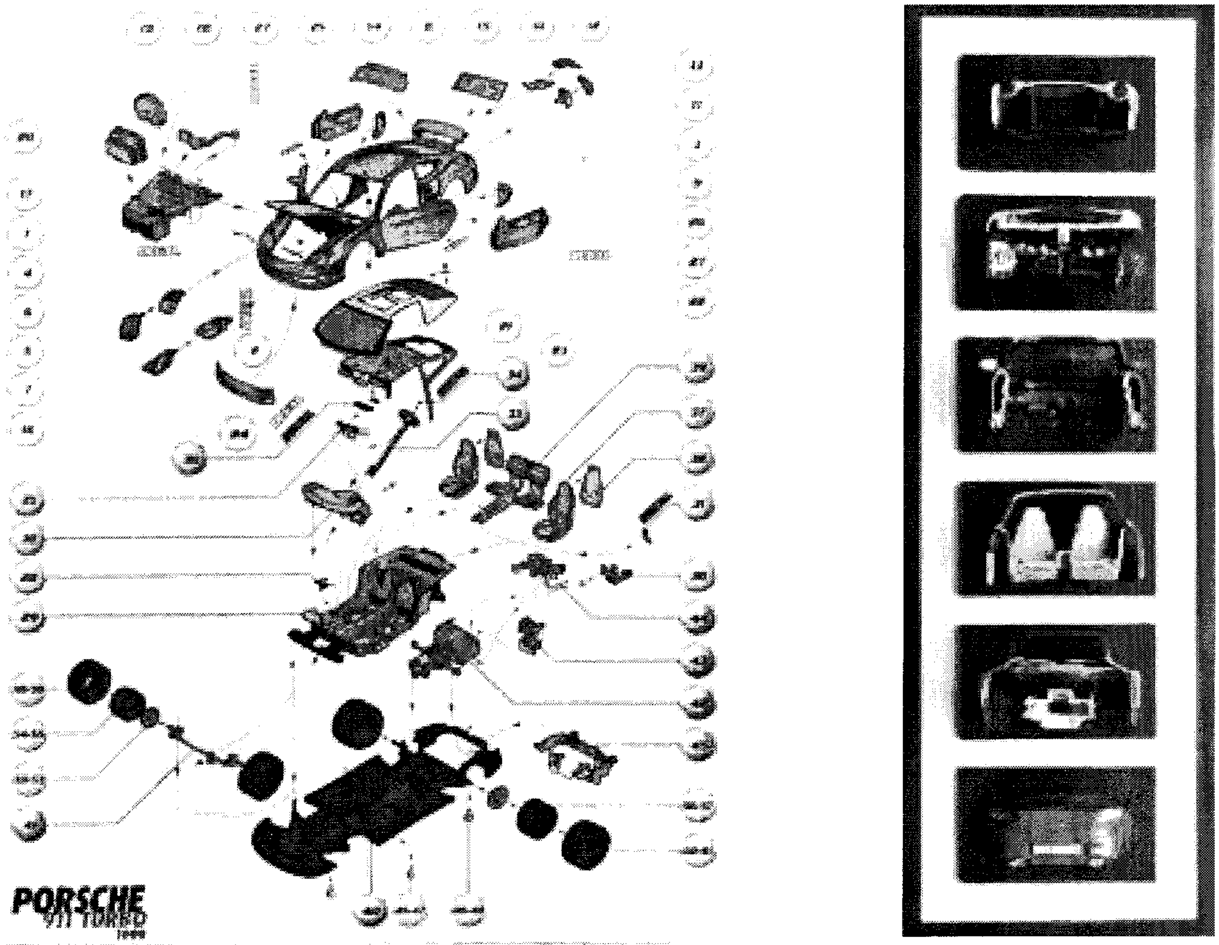

Fig. 5. Car Model Exercise: Instruction Sheet and Dissected Model.

'dissection' we could keep track of what each piece was and where it had been located. The process took about three work sessions to disassemble the entire car, except for a series of obstinate bolts that prevented removal of the front axle.

The next step was to group all parts into the four separate categories of Structure, Exterior Envelope, Interior Envelope and Mechanical. Because we were comparing a movable object with a static one, we thought it might be difficult to find appropriate groups for some of the parts. Except for the mirrors,

Fig. 6. Automobile Disassembly.

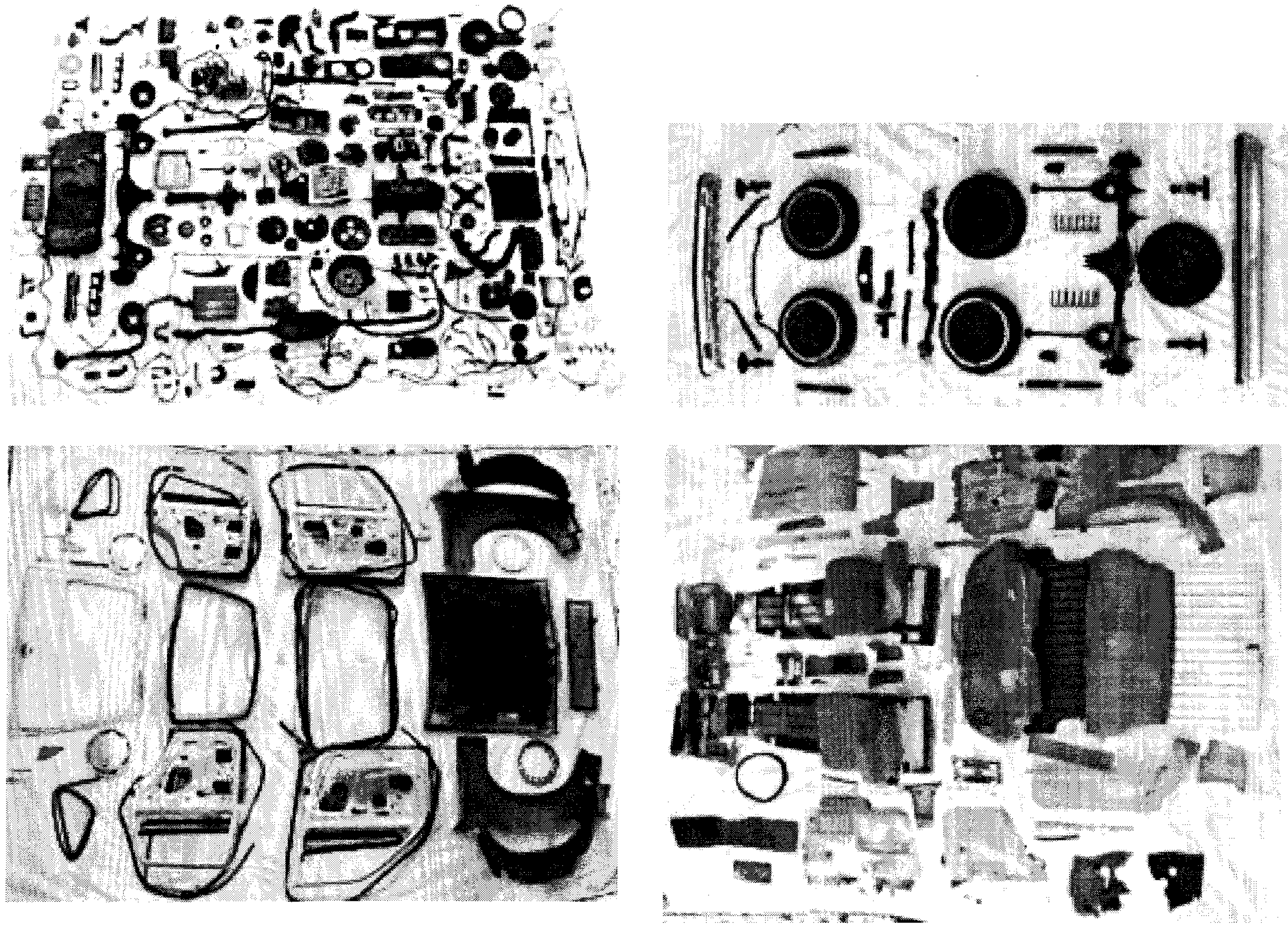

Fig. 7. System Categorization: Mechanical, Structural, Interior Envelope, Exterior Envelope (clockwise).

most pieces were easy to categorize. As the 'Uni-body' shell fit into two categories, Structural and Exterior Envelope, it was kept separate from the other parts. The entire process had been documented by photograph and now the four groupings of materials were also documented.

A sub-goal of this project was to understand joinery techniques through disassembly. Each type of connector, bolt, screw, or rivet, was saved during the process. Afterward each distinct type was mounted on a board to display the range and diversity of connectors. It was surprising to see such a broad range of similar bolts in a pre-manufactured object. Even the custom-built construction industry uses a far smaller set of connectors.

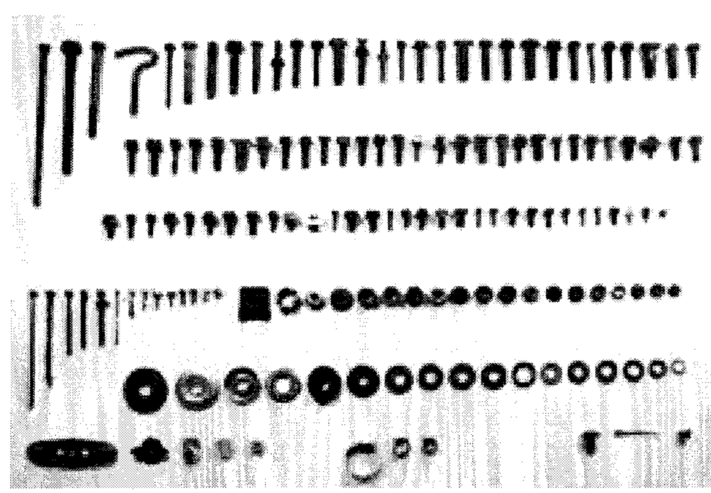

Fig. 8. Connectors.

CONCLUSION

Studying the automobile as 4 categorized sets of building systems makes it easier to find links to building construction and produces a 'dialect' of ideas that might be easier to translate between disciplines without the need for a complex technical language. Each must deal with a complex interweaving of component parts that need to work together efficiently in a crammed, thin perimeter space. As cars are mostly made of steel and glass, they serve well as an analogy for the complex metal and glass wall systems so prevalent in today's buildings. While this language would be too restrictive for individual architectural designs, it could be applied to mass-produced building construction that could be built in the same amount of time but of a higher design and material quality.

NOTES

[1] Batchelor, Ray. *Henry Ford: Mass Production, Modernism and design*, (Manchester, Manchester University Press, 1994)

[2] Margolius, Ivan. *Automobiles by Architects*, (London, Wiley-Academy, 2000)

[3] Margolius

[4] Kenneth Frampton. *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, (Cambridge, Massachusetts: MIT Press, 1995)

[5] Margolius

[6] Bell, Jonathon. *Carchitecture*, (Basel, Birkhauser, 2001)

[7] Bell

[8] Marcus, George. *"What Is Design Today?"*, (New York, Harry Abrams Publishers, 2002)

[9] Bell

[10] Margolius

[11] Margolius

[12] Margolius

[13] Cheng, Rene, Master *Architect Redux: How the Digital Process Helped Restore the Role of Master Architect*, Proceedings of the 89th ACSA Annual Meeting, Washington, ACSA Press, 2001