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Manufacturing speed: A factory for the design of the formula one race car

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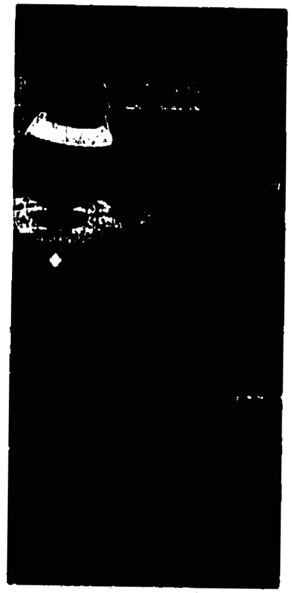
master thesis

MANUFACTURING S P E E D



a factory for the design of the formula one race car

KIRSTEN T. DOW

master's degree project

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THE UNIVERSITY OF CALGARY
FACULTY OF ENVIRONMENTAL DESIGN

The undersigned certify that they have read,
and recommended to the
Faculty of Environmental Design for acceptance,
a Master's Degree Project entitled

MANUFACTURING SPEED
A Factory for the Design of the Formula One Race Car

submitted by
KIRSTEN THERESE DOW

in partial fulfillment of the requirements for the degree
Master of Architecture.

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abstract

This document and subsequent design explore ideas and theories surrounding aspects of the Machine, Modernism and Speed in an attempt to coalesce the ever changing face of technology with our architectural position in a technological world. The theoretical exploration is then translated into the practical application of industrial architecture, while extending the preconceived boundaries of an architecture for industry. The Formula One racing industry is a catalyst for constant change in the design environment and as such proved an appropriate program for an architecture capable of responding to the same criteria.

The process of designing a factory for the design and manufacture of the Formula One race car involved an understanding of the changing face of industry and its relationship to the machine; providing the stage for the integration of industry and a reconstitution of the Modern ideological concept of the machine aesthetic. The interpretation of the machine aesthetic, as imagery contingent on the position of a society in a technological era, is therefore applicable to any cultural condition or imagery, despite its roots in Modernist theory. Ideas and products, generated out of high-tech industry redefine the scope of today's machine aesthetic and what can be deemed Modern architecture and lead to design representative of its place in a technological society, capable of responding to the ever changing needs of industry.

Force lines generated from site influences played a determining factor in the design's massing, landscaping and program distribution while the structure, construction and materiality of the factory design are directly indebted to the design and manufacturing processes established in the delineation of the Formula One car.

keywords

machine modern speed industry formula one high-tech architecture

M A N U F A C T U R I N G S P E E D

thanks to...

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Introduction

The geometric nature of our world is fashioned by mass and speed.

Albert Einstein

Since its definition, or more appropriately its manufacture, speed has afforded us an increased awareness of time and our place in it. Speed gives us an awareness of motion and its rate. Speed alters our perceptions of time and the space it occupies. Speed forces us to acknowledge that perpetual change and evolution, constants in the world, are ever present concepts which permeate all aspects of our lives. Living in a technological era nothing is ever standing still. Concepts such as time, beauty, efficiency, and 'state of art' are governed by speed, relegating them to a transient state upon which imminent change is incumbent. The minute we walk out the door with the newest computer or drive off the lot in a brand new car, they are already out of date, technically superceded by something more beautiful, efficient and 'top of the line'. Although speed is scientifically defined or measured as *distance/time*, the perception of speed, and therefore its qualitative definition changes dramatically with the persistent, changing and evolutionary world of technology.

A readily identifiable representation of speed in the face of changing technology is embodied in the automobile. As technology has changed, advanced, and progressed so has the design, engineering, performance and manufacture of the motor car. Current automotive design and engineering lies well ahead of the latest production models available for purchase. The technologies of the automotive industry change at such a rate that progress made during the first hundred years of motor car production have surpassed any technological changes made to the building industry in the thousands of years it has existed. A society's technological capacity is therefore not measured by its architecture per se, but rather by its industrial production. The motor car is a quintessential example of society's progress and a marker of society's place in the history of a technological era. The industrial success of the motor car documents not only important technological advance, but a crucial departure point for theoretical discourse reaching far beyond the realm of mechanical industry and into more traditional forums.

We draw near to the snorting beasts and laid our hands on their burning breasts. Then I flung myself like a corpse on a bier across the seat of my machine, but sat up at once under the steering wheel, poised like a guillotine blade against my stomach. [1]

F. T. Marinetti

This excerpt from the prologue of the 1908 Futurist Manifesto outlines a vivid description of an early motor race through the suburbs of Milan. This very pro-automobile reference, one of the first appreciations of the pleasurable aspects of motoring to appear in European literature, serves great cultural import in that in order to hold a motor race there needs to have been access to a fair number of working vehicles and drivers. It shows that by 1908 certain individuals were no longer passive recipients of technology but active participants. Mechanical equipment which was once the domain of the professional engine driver and "the ship's engineer" was now brought within the grasp of the wealthy amateur.[2]

Reyner Banham describes the automobile as being the symbolic machine of the First Machine Age.[3] With the automobile, ideas of mechanization and technology were brought to the power holding classes of society. Prior to the production motor car, mechanization had been localized in the hands of the working classes. With the dynamics behind a socially acceptable mode of mechanization came a changing view of mechanization, technology and the outward appearance of society. "The barrier of incomprehension that had stood between 'thinking' men and their mechanized environment throughout the nineteenth century was dissolving."[4]

The quick adoption of the motor car as a symbol of the machine age by Marinetti and his friends gave industry a psychological prestige which was rapidly manifest by a radical change over to a technologically minded society and the basis of Futurist thought, for which Marinetti was the founder. Since then the motor car stands as the best example of continuous product evolution in the history of technology, acknowledging tradition and history, yet freed from its servitude.

Attempts have been made in the past to reconcile the practice of architecture with the ongoing changes of technology and yet an architecture capable of evolution within a technological era seems sporadic at best. Throughout the course of this Master's Degree Project, involving the integration of a technological industry (Formula One Racing) with architecture (a factory for the design and production of the Formula One racing car) a reconciliation between the ever changing standards of technology and the time honored vocabulary of architectural practice will be explored. The investigation into ideas and concepts of speed as they relate to theories of the machine and to Modernism and ultimately, to architecture, acts as the foundation for this project as a basis for an architecture of industry.

The constantly changing face of industry as a representation of accelerating technology and its relationship to the machine provides the stage for the integration of industry and Modern ideology. The basis for Modernist thought in its response to the machine aesthetic will be extended past the readily acknowledged dates of Modernism to include ideas generally accepted as belonging to the realm of industrial design. These ideas and their products, generated out of high tech industries, will be shown to be a continuation of the basic premise of Modernist thought in its quest for a machine aesthetic, and therefore a continuation of the "Modern" in what is generally acknowledged to be a "Post-Modern" world. The scope of a Modern architecture is therefore expanded and redefined as an architecture truely representative of its place in a technological society, responding to changes forced upon it by the constantly accelerating speed by which we live.

MACHINE

the industrial machine

My history teacher, who defined the nineteenth century as the century of invention and industrialization, gave a quick definition of the factory as "a machine with a sheet-metal roof over it". [5]

Hans Kammerer

This 1930s description of a factory, for the most part, holds true today. "Bare, ugly walls that stretch for miles without beginning and without end, banal as a whole and, in detail, crude, superficial and unimaginative" is how Kurt Ackermann describes the conditions found within the industrial parks and urban framework of contemporary industrial cities and towns.[6] For the most part society sees industry as a necessary evil, a required institution of the modern industrial world, the presence of which must be borne with the knowledge that it is not the appearance of the factory itself that is of import, but the product, the monetary gain, and the employment opportunity which holds industry in its stead. But where or when in all of this did industry "gain the right to be ugly"? [7]

Reyner Banham states that industry is still seen as part of a context which lies outside of the popular confines of culture, and therefore is not subject to certain rules of decorum and restraint.[8] In other words, industry "gained the right to be ugly", because it was never held up to be anything but. Building for industry never appealed to an architectural sensibility and therefore was not held up to standards to which "architecture" must be accountable. The sensed priority of industry towards production, the apparent demand for functional buildings, a confusion between what is cheap and what is economical, tight deadlines and a plethora of regulations and conditions set by numerous authorities, has intimidated enough architects to turn away from an intensely dynamic opportunity to create an architecture worthy of its place in time.

In architecture, truth is product of the calculations made to satisfy known needs with known means.

Tony Garnier
"La Cite Industrielle"

Historically, the differences between the worlds of architecture and industry were made less dichotomous due to increasing concern with the quality and representation of industrial products and image. Progressive industries recognized the advantages of bringing together design and industry as witnessed in the German Werkbund and the AEG appointment of architect and designer Peter Behrens. National interest in local industry was buoyed, opportunities afforded to designers through industry were being recognized and design had been brought to the attention of the populace as a whole. The dissemination of ideas and the creation of opportunities for industrial "architecture" was born.

Economic, technical and cultural conditions have changed radically. Both technology and industry face entirely new problems. It is very important for our culture and society, as well as for technology and industry, to find good solutions. German industry, and indeed European industry as a whole, must understand and solve these specific tasks. The path must lead from quantity towards quality - from the extensive to the intensive.

Ludwig Mies Van der Rohe

Today, industrial architecture faces entirely new uncertainties. Due to growing urban frameworks, the rapid decline of heavy industry, and an awareness of increased environmental and ecological precariousness, doubts and growing ambivalence towards the benefits of industry, have created a cross roads for industrial building. Industry and in turn industrial architecture can bow out or it can adopt the role of a catalyst, promoting further discovery into the shaping of our environments and providing new solutions. When design takes an active role in the promulgation of industry, factories tend to fit into the framework of urban development and environmental concerns as the factory, and the mark it makes on the landscape, is treated with sensitivity. Different functions, arising out of different eras, require different spaces. Architecture in industry will forever involve dynamic change, allowing for design truly appropriate to its place in time.

machine theory and architecture

Industrialized building can mean either: "the mechanical production of building components in a factory; or the construction of a building using mechanical means".[9] Either way, industrial building is not a catalogue of fashions or whims but a fundamentally different mode of thought. The ever changing needs and functions fostered by technological advances and the demand for intelligent design have transformed the idea of an industrial architecture. Industrial architecture stands apart from other modes of architecture in that it becomes the product of how a given building task is approached and resolved using the logical and sensible innovations of the age to come up with a building, not valued for what it is, but for what it does and how well it does it.[10]

Otl Aicher explains that industrial architecture is never modern, it is only good or bad; much as modern cargo ships, airplanes, or cameras should never be modern, only good or bad.[11] He is referring not to their appearance as much as he is referring to their function or what they do. Aicher sees modern as a thought process not as a style. Industrialized building is a continuation of Modernism in its generation of a thought process. Much industrial architecture can be seen as highly functional in its solution to local technical problems. Examples of how the modern thought process operates are in the synthesis of form and function as it arises out of sensible and logical use of appropriate materials and methods of construction. As the world changes, the materials and methods of design and construction change. The cars, appliances and planes that were catalysts for design change in history are joined by space shuttles, off-shore drilling platforms, satellite communications facilities and other. They are the catalysts for change for both our perception of the world and for future design method. The fundamental aspects of new technologies, their manufacture and their aesthetics can be brought into architecture. Architecture belonging to a technological world builds on the foundation of machine based principles and relies on the support of an industrial base.

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History teaches us that change is inevitable. Only by taking risks, by daring to be new will we learn to understand—and control—the possibilities of the future.

Kurt Ackermann

Unprejudiced application of new construction techniques along with the experimentation of new materials form the basis for a machine based industrial architecture. To optimize a factory's production procedures, priority is most always given to a building's function. A logical form is then generated by the design of the structural system, the overall acceptance of new materials and innovative construction techniques. New methods of production and manufacture, with roots in mechanical engineering, help to develop the idea of the modular grid which then becomes the basis of the design. With the module as its concept, logical and consistent structure that is readily understood gives rise to new spatial concepts and the ideas of flexibility. New types of form and their construction create a new aesthetic. The possibility of investing an industrial building with high quality through its structure and the application of refined technology, creates a building deserving of the name architecture. Use, construction and form cohesively blend into one, something Sigfried Giedion called the "dream of Modernity".[12]

Industrial buildings, with their inclusion of new modes of construction and materials, create a system of technology transfer. New challenges faced by architecture are resolved using the technical means of the time. Industrial architecture and construction do not rely on the stylistic elements of an earlier architecture but continue to encourage new initiatives to solve problems which have no antecedents. The medium of architecture, in the sense of industrial architecture, is no longer the medium by which a message is delivered, but is itself the message. Marshall McLuhan notes that in a world with the infinite capacity to communicate by computer, telephone and satellite, in which ideas go back and forth in constant flashes, the medium has become the message of technology.[13]

Buildings should be allowed to change, to express a freedom for movement of people within and on the outside—an expression of the process of building—its system of manufacture, storage, transportation, erection and connection all within a clearly defined framework. Framework is able to change and adapt in answer to technical or client needs and the change becomes an integral part of the architectural expression.

Piano + Rogers
on the Centre Pompidou

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the technological machine

Time and Space died yesterday. We already live in the absolute, because we have created eternal, omnipresent speed.

F. T. Marinetti

Reyner Banham defines tradition as "the stock of general knowledge which can be seen as the ground of present practice and future progress"; and technology as "the method of exploring a potential which may at any moment make nonsense of all existing general knowledge and the ideas founded on it".[14] The line or trend of technology is therefore seen as only measurable as it relates to its immediate surroundings. Independent of space or time, technology exists in a universe of its own, constantly accelerating. An architecture that stays true to the advances of its society is dependent on that society to frame its truth by the available information and the prejudices held by it. An interpretation of Le Corbusier's writings in *Towards a New Architecture*, is that all of the great styles of architecture have been the equals of their contemporary technologies.[15] When the architecture of Le Corbusier and his contemporaries met the technology of its day, an architecture worthy of a place in the grand history of architecture, such as the Parthenon, would have been reached.[16] This is to say that the Parthenon is successful as an architectural marker in part because of its employment of the technological advances known at the time of its construction. An ideological premise such as this, could be achieved today through the idea of technology transfer: architects freed from historical precedent concentrate on the assembly of design, the identification of new materials and techniques to design an architecture which specifies them to a culture and a technological berth in time.

Those who are familiar with technology enough to control it, or at least understand it, continue to be fascinated by its potential. It is an ignorance of technology, and what it can bring to our stores of knowledge, that creates an anxiety of uncontrollability that is the root of technological fear. This has always been and will always be a problem. Technological "glitches" (i.e. mechanical failures, computer viruses) have played their part in diminishing the enthusiasm for technology. Technological improvements reduce the volume and immediacy of our machines by becoming more compact and disposable, therefore allowing for a distancing which can lead to fears of a threatening mechanical order. Our relationship with the world of technology, a world we have created and which functions within the framework of physical and chemical laws, still acts as an autonomous threat. Whether we are forced to

Was it worth it? No doubt at all. One day, shortly after the opening, I saw an old lady.. just sitting quietly, stroking the side of the gerberette. She was not afraid, not intimidated.

Peter Rice
on the Centre Pompidou

adapt our world to the world of technology or the other way around, technology is becoming farther removed from the understanding of the every day.

The creation of industrial architecture can play a role in the demystification of technology and its industrial product. Industry and factories can be made clear, something Ackermann refers to as "constructive intelligence"; the construction methods of most structural systems can be made to be understood; complexes can be organized so that forms can relate to the environment and so that operations can be conducted in an efficient and pleasant manner; the unapproachable made approachable."

machine aesthetic as precedent

The integration of technological advancement with architecture is marked by many milestones, all inherent to the development of the industrialization of building practice. The advent of cast iron in ancient machining; rolled steel and glass in the First Machine Age; and the use of computerized steel cutting and computer aided structural design today are advances in building conception and construction which have influenced both architecture produced at the time of the innovation and subsequent. Sir Joseph Paxton's *Crystal Palace* of 1851 can be held up as a precedent that influenced the exploration of glass and steel. The importance of the Crystal Palace to contemporary industrial building is reflected in its prefabricated and standardized parts, representational of the advances of technique and the potential of the materials employed.

Auguste Perret's work in reinforced concrete enabled advances in technology to gain aesthetical acceptance. Concrete was incorporated into the already established forms of accepted structure. This notion of replacing traditional building materials with newer materials was an idea, espoused by Auguste Choisy, that stretched back to Ancient Greece. In the history of building technologies wood was replaced by stone and in turn stone replaced with iron. By incorporating new materials into an already understandable format, technology was introduced at an early point into the building industry.

Where Perret brought new materials to established structural forms, Peter Behrens brought a new set of functional programs to accepted formal disciplines. His factory for the AEG shows how new industrial programs could be compatible with classicist form, easier to understand and therefore nonconfrontational. With Behrens, German architecture made progressive steps towards the promulgation of new ideas in architecture by forming organizations that would put the new architectural spirit into action. Rather than writing theories about the new mechanical age, attitudes and thoughts towards contemporary problems were discussed and then quickly translated into practice.

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While European architects and designers were exploiting the potentials of new materials and technical construction, American architects were exploring the use of flexible, industrialized space. Ezra Ehrenkrantz and his SCSD school prototypes were setting the standard for infinitely adaptable clear space between floor and roof planes through the use of space frames. Craig Ellwood and Charles and Ray Eames were developing systems of movable partitions, dividing space into infinite combinations of form and use, and Albert Kahn was adapting techniques used in mechanical engineering, automotive and aircraft construction for use in architecture. The importance of technically based industrial processes were seen suitable for architecture reliant on rapid erection, economic viability, and flexibility in form and function.

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the machine in architecture

...the spiritual and practical needs of our time are realized in constructive sensibility. The new possibilities of the machine have created an aesthetic expressive of our time, that I once called "the Mechanical Aesthetic".

Theo van Doesburg

The idea of the machine and its hold on the minds of the Modernist architect and theorist is unquestionable and the effects of its impact indisputable. The ideological expression of the machine and its technical innovation continues to play an important role in the development of design and how design is expressed through architecture. The graphic and visual potential of the machine, becomes at once poetic and a source capable of generating architectural imagery.

The concept of a machine aesthetic as it applies to architecture has dual connotations. Le Corbusier's now infamous adage of a house as a "machine for living" can have dual meaning. Distinction must be made between an architecture which draws upon machine like forms for inspiration and architecture which is treated as a machine, either in the way it is constructed or in the way in which it performs. The former, while producing an imagery fairly successful at achieving the appearance of a mechanical architecture, seemingly appropriate to an industrial age, can result in a symbolic, and very costly exploration, which ultimately sacrifices practicality to ideology.[14] The success of a machine based aesthetic is much more reliant on the underlying principles of its construction, rather than the sole representation of its form.

Mechanical beauty corresponds to the best use of materials according to the current state of technique. It follows that beauty can vary because the technique, upon which the utilization of material depends, is progressive.

Jean Gregoire

The idea of a machine age aesthetic was not an entirely new concept but rather a new way of dealing with the environment of an industrialized world. On one side were the Futurists, who proposed the discarding of any historical or traditional reference and to forge ahead equipped only with the sensibilities founded in the machine age. On the other side were architectural innovators, such as Auguste Perret or Tony Garnier, evolutionaries rather than revolutionaries, who felt that the new aesthetics should at least be indebted to the old. The theory and design of machine aged architecture became an amalgam of both the dynamism of Futurism and the acknowledgment of history. The Modernist dream of reconciling the machine aesthetic with architecture was to be realized with the embrace of a more flexible idea of machine production and a rejection of many accepted architectural tenets.

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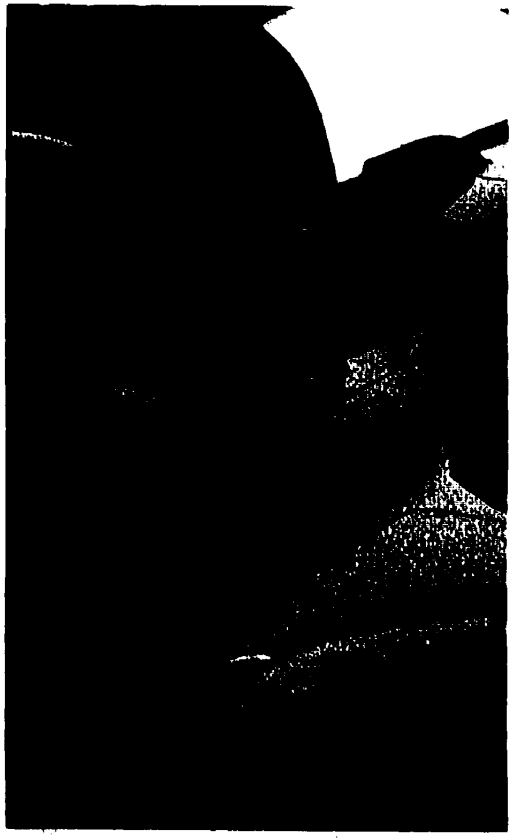

MODERN

futurist modern

We declare that the splendor of the world has been enriched by a new beauty—the beauty of speed. A racing car with its bonnet draped with exhaust pipes like fire-breathing serpents—a roaring racing car, rattling along like a machine gun, is more beautiful than the winged victory of Samothrace.[19]

F. T. Marinetti

This ideal of beauty, in essence a shift in perception from the ideals of traditional aesthetic consideration, to an appreciation of the machine and its place in the contemporary world, was to play a pivotal role in the creation and acceptance of the machine as not only a product but as a means of design.[20] The Futurist movement became a platform for forward minded individuals desiring to see a contemporary representation of the advancing world in which they lived. Futurism showed a new sense of appreciation for technical and mechanical advances, emphasizing motion and the upheaval of static canons of traditional aesthetic consideration. The movement spawned numerous treatises and manifestos, which became the stepping stones to the theories of the Modern movement and the adoption of the machine aesthetic in architecture.

Antonio Sant'Elia, perhaps the most well known theorist of the Futurist cause and a prophet of Modernist theory in architecture, wanted to raise architecture to a new level, playing on the benefits and advances discovered through science and technology. New forms, lines and reasons for the existence of architecture and society, could be discovered solely from the conditions found in modern living and the new aesthetic realizations it brought. The architecture produced for a society must be as new as the state of mind and culture of that society. It was Sant'Elia's belief that the modern city must be reinvented and rebuilt, continuously active, mobile and dynamic — the modern city and its building like a gigantic machine, changing and growing as available technologies change and grow. He was to affirm that "just as the ancients drew their inspiration in art from the elements of the natural world, we have created, of which architecture must be the fairest expression, the fullest synthesis, the most effective artistic integration" of the inspirations which face a mechanized world.[21]

An architecture such as this breeds no permanence, no structural habits. We shall live longer than our houses, and every generation will have to make its own city.

Antonio Sant'Elia

MANUFACTURING SPEED

modernism

As a word, "modern" evokes an image of newness, of contemporary ideals, thoughts, styles and lifestyles. As an architecture, "Modernism" evokes images of the International Style with its flat roofs, free plans and curtain wall facades, unornamented and unindebted to the canons of tradition. As a theory "Modernism" invokes a claim that life and all that that encompasses should clearly reflect its time and place in society and in the world in which it is found. Modernist ideology, at the roots of its inception, claimed that architecture too, should clearly reflect its time and that it should be appropriate to an industrial age — abstract, unornamented and functional, consigning past architectural tenets to oblivion.

A breach has been made with the past, which allows us to envision a new aspect of architecture, corresponding to the technical civilization of the age we live in. The morphology of dead styles has been destroyed, and we are returning to honesty of thought and feeling.[22]

Walter Gropius

Although Grouplus' statement is representative of the Modernist revolutionary stance against tradition, and representative of one of the basic principles of the movement, it is interesting to note that his interest in mechanical production and the industrialization of design, as typified in the work and teachings of the Bauhaus, was slow in realization. By the early 20s, when the ideology of the machine was being formulated, the Bauhaus teaching methods were inseparably bound to the ideas of craftsmanship, and it was from this that they now had to backtrack to realize the expanding advances of mechanical representation.[23] Concepts of mathematics and geometries, taken out of a larger body of scientific and technological work, became the main concern of these Modern theorists striving for a machine age; perhaps because they were easily correlated with existing academic or classicizing tradition, thus integrating previous teachings with the new age of industry. This is not to say that mathematics and geometry did not have an important role to play in the adoption of the machine age aesthetic, but it is this, in combination with technical aspirations, experimentation and a secure grasp of mechanical methods that was to produce the imagery that truly characterized the mechanical age.[24]

Critics of the Modernist account of the machine aesthetic denounce its ideology as perhaps beginning as a method of building, or architectural revolution, but quickly falling into a style— "thinking and reflecting gave way to the mimicking of a style".[25] Buckminster Fuller's critique of the Bauhaus and the International Style is in their incapacity to fulfill the ideas of a machine age when the opportunity of mechanical representation was clearly present. He denounced their lack of technological training and their questionable application of building science. If his Dymaxion House of 1927 had been built, it would have rendered Le Corbusier's Villa Savoye technically obsolete before it had even been designed.[26]

Reyner Banham presents a further example of how the Modernist attempt to capture the ideals of a machine aesthetic stopped short at symbolism: Walter Gropius' design of bodies for Adler motor cars, lacked an awareness of the revolution in vehicle form that was ongoing at the time. It incorporated such innovations as reclining seats and interior finishing, yet the body and mechanical aspects of the car remained the same as previous models. Meanwhile a secure grasp of technology was shown in streamlined Burney motor car designs which Fuller fully exploited a couple of years later in the Dymaxion Car.[27] The designs of all three men occurred within a period of three years. The difference shows a constantly changing aesthetic desire based on change, in turn based on technological progression. The Modernists were aware of the ideas surrounding change but only in so far as it would formulate a final type or norm, from which the rest could be based, not something which would change constantly and forever.

The ideas for Modern architecture which claimed to be of a machine age, stemmed from both Futurist and academic considerations, but only came into practice and built example when they drew closer to academic tradition and farther from the mechanistic ideals of Futurism.[28] Proponents of the International Style relied on Futurism for its prestige as a machine art but did not generally espouse its theory of the constant renovation of the built environment.

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This stand against the impermanence of any architectural expression moved them farther away from the world of technology and the "...unhaltable trend to constantly accelerating change".[29]

The Modernist ideology of the machine and the creation of the International Style, could only be communicated as a product of a mechanical age when "automobiles were visibly comparable to the Parthenon, when aircraft structure really did resemble elementarit space cages, when ships' superstructures really did appear to follow Beaux-arts rules of symmetry".[30] As soon as performance made it necessary to fit components and technologies into a streamlined shell, the visual links between the products of the International Style and the technological roots of the machine aesthetic were broken. Events in 1930s industrial design: i.e. German Formula One cars; Burney streamliners in Britain; the Heinkel He 70 research aircraft; and the Boeing 247D transport plane in the United States of America; belonged to a radically new world, even from those Modernist structures built in the same years.[31] If the International Style was indeed representative of a machine age, it probably should have showed some sort of sign of this change.

Modern architecture as a style may not exist anymore, but ideas surrounding the Modernist movement continue to exist as there is a desire to achieve the goals of a technological aesthetic, true to the climate in which architecture is found. The new Modern architecture therefore has a promising future ahead in order to achieve all of the goals it and the advances engineered structures hinted at long before the birth of the International Style. The pioneers of the Modern movement have radical successors and the process of producing technological architecture continues.

Modern architecture, then, has not yet drawn all the dividends on the capital of spatial, structural, formal, and functional concepts that were invested for it before birth, let alone the compound interest of new ideas and new techniques that has accrued to it since.

Reyner Banham

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new modernism

There continues to be architects who work in an atmosphere that can be deemed 'Modern', although in a much wider scope than that originally set out by the movement's pioneers. 1920s and 30s Modernism can be seen as a revolution in terms of design. Today's Modernism is more a product of evolution and the continual exploration of ideas concerning the machine in architecture. The future of this type of evolutionary Modernism has the potential to produce architecture richer and more representative of a technological aesthetic.

Charles Jencks states that the theories of the Modern condition and thought process have not been overturned so much as transformed into parts of the larger framework in which we currently function.[14] While we may currently exist in a post-modern condition or world view, the Modernist framework still keeps its identity. Modern ideology continues to exist and redefine itself with respect to post-modernism and the nature of the information age. While the machines of the Modernists have long been superceded, the machines of the information age continue to shape the current machine aesthetic.

Modernism has, therefore, been given too narrow a scope in the history of architecture. Beginning in the early twentieth century it reached its height in Europe in the 30s and in North America in the 50s, and slowly dwindled to its 'demise' in the 70s. Modernism as a style, with all of its symbolic attachments may have been surpassed, but Modernism as a doctrine and a set of ideas governing the architecture of a modern society can exist in perpetuity. As early as 1955 a visible shift in the work of Le Corbusier suggested that Modernism of one type was gone but Modernism of another was just beginning. All of Le Corbusier's work is representative of continuous development, therefore, why is it unreasonable to expect the same development and evolution of the movement itself?

The effect of today's machine aesthetic in architecture, has been to encourage the attitudinal stance of Modern ideologies rather than a commitment to a particular style. This architecture is Modern in its search for depth and meaning beyond that which is fashionable or symbolic; Modern by design that can improve life or society; Modern through the use of high performance materials and construction methods in an appropriate manner that makes better economical and ecological sense for industry; and Modern if the product is a building of an architect whose sensibilities are open to the possibilities of change and inconsistency. For Modern ideology to continue to be valid in today's 'post-modern condition', it must be capable of withstanding development and adaptation in response to new information and considerations. Post-modernism means the continuation of Modernism and its transcendence "a double activity that acknowledges our complex relationships".[33] The real purpose of Modernism, not so much the theoretical world with its manifestos and treatise, is to remain current with what is going on in the world at the time. As a style, Modernism is unique to the period in which the pioneers of the movement practiced. As a doctrine, Modernism reflects the society in which it finds itself, therefore capable of and possessing constant change.

For the Modern Movement to continue to be valid, it must be capable of development and adaptation in response to new information and considerations. It must learn from the past. Serious mistakes, rooted in the revolutionary optimisms of the first part of the twentieth century, such as the belief that science could solve all problems, must be corrected. But it would be even more foolish to conclude that because science alone is not sufficient, it is not necessary either.

Richard Rogers

M A N U F A C T U R I N G   S P E E D

modern flexibility

Today the factor of economy makes rationalization and standardization imperative...On the other hand the increased complexity of our requirements demands flexibility.

Mies van der Rohe

The difficulty for architects faced with the Modern obsession with mechanization has been the idea of mass production and industrialization. Most architects will agree that architecture can never become completely mechanized. However almost all of them, espousing some affinity with the machine, have struggled to make use of industrial benefits in the building environment while trying to retain an awareness of poetry. Purpose made components for a specific project can be standardized to assist in erection, improve the economics of construction and inform the design, but complete standardization of the building industry could lead to an architectural climate of uniformity and a loss of individuality. Most of the industrial architects who follow a degree of standardization in their practice, follow a more 'craft manufacturing' technique, where low cost budgeting can be accommodated and yet an individualized project is the result.[34] Mass production is not necessary, nor often desirable, to get the most out of an architecture for industry.

A building that is easy to modify has a longer useful life and uses its resources more efficiently. In social and economic terms, a building designed for flexibility enlarges the sustainable life of a society...when a society needs buildings that are capable of responding to changing requirements, then, I believe, we must seek to provide flexibility and search for new forms that express the power of change...Inflexible buildings hinder the evolution of society by inhibiting new ideas.

Richard Rogers

Ideas of flexibility and change, additions and expansions are different today than in the days of Thomas Wallis' Hoover Factory. The Hoover Factory was proud of its capacity for expansion and flexibility, yet that was merely a matter of a large building site enabling the construction of more buildings into which the various operations could expand. In the 1970s the RIBA slogan "long life, loose fit" stated that the best chance of addressing the technological, societal, and functional changes that would be faced by architecture, would be by avoiding definitive and fixed plans, therefore allowing for growth and change without resigning a building to obsolescence.[35] The idea of the 'non-plan' was born. Today site planning and the incorporation of the 'non-plan' idea with the choice of structural system, can be carried out in a way to allow for the easy expansion of a building without the disruption of existing operations.

M A N U F A C T U R I N G   S P E E D

Standardization, as borne out of the need and desire for flexibility, was seen by the Modernists as an ideal for which to strive. For engineers it was seen as a norm, standardized only for the moment in which it was conceived; the opposite of an ideal as it was a compromise between possible production and further development, which would see the creation of a new norm. This contradiction sets up what became the largest set back in the Modernist quest for a machine aesthetic. The nature of a machine aesthetic is that it is contingent on the development and production of ongoing changes to the mechanical environment. This would preclude the Modern inception of a standardized ideal, as there would never be a completed norm from which all machine aesthetics could be derived. Le Corbusier was aware of this contradiction in his theory when he said that "ephemeral beauty so quickly becomes ridiculous".[36] Things that are seen as beautiful, or the ideal one year, will be replaced by something else next year, and thereby bypassing the beauty of the first. Beauty in this sense becomes expendable. In the sense of a true machine aesthetic, it should.

What is owed to functional demands is most often the general arrangement of parts. But not conclusively; the choice of one method of construction against another, which may arise from quite separate considerations, will drastically affect the silhouette of that bulk against the sky, the facade it presents to the street. Ideally, form, function and construction should appear inevitable and indissoluble.

Reyner Banham

The task of building is sometimes perceived as a collection of its distinct parts, which in turn match their function in the building as a whole. Components are constructed according to the forces acting upon them and are brought together to act in the composition of a building: the means of construction becomes the basis of architecture.[37] The form of the building would follow logically from the technical means at its disposal.

Strictly functional, technology inspired innovations led to a more informed, design oriented architecture which was a more honest expression of the industrial era. Processes of standardization, prefabrication and methods of construction became the measurement of architecture which truly expressed the ideals of the machine aesthetic. The Modernist ideal of a machine aesthetic was left as a symbol of an industrial era, while examples of modern spatial design, served by the new technical solutions, became its representation.

M A N U F A C T U R I N G   S P E E D

high-tech modern

High technology is not an end in itself. Rather it is a means to social goals and wider possibilities.

Norman Foster

To discuss architecture as a task, a profession or an art, engulfed in purely theoretical notions of academia or ideology is currently impossible. Architecture is a product, like all else in this modern world, which is permeated by levels of today's pop culture, such as television, advertising, music videos, film sets, etc. Our world has a new mode of inference to which architecture must conform, adapt and evolve. Buckminster Fuller called this "anticipatory design science".[38] In a world, constantly transforming to the advances and innovations of science and technology, the architect needs to keep up with the pace of these advances in order to exist on the pinnacle of the new Modernism. Technological input, high performance materials, computer aided structural design, modular coordination and innovative construction techniques are essential elements to the creation of today's modern buildings — prototypes for industry.

1960s England saw the beginning of a decade of prosperity for the country that Harold Wilson was to call the "white hot heat" of the technological revolution — a decade of unprecedented questioning of societal norms and values in which 'tradition' became a pejorative term.[39] To coincide with the ongoing quest for the technological, the adoption of the categorization "High-Tech" was given to architecture, which previously had been called Modern. The economic revival in England, and the support of industry, gave High-Tech architecture the boost it needed.

Industrialization of the process of construction is a question of new materials...Our technologists must and will succeed in inventing materials that can be industrially manufactured and processed and that will be weatherproof, soundproof and insulating. I am convinced that traditional methods of building will disappear.

Mies van der Rohe

High-Tech characterizes a particular approach to architecture in which high-technology inspires the imagery of the design as well as the production and construction processes. It often serves as a prototype for building technologies which will eventually be fused with architecture responding to more traditional lines of reference and experience — the realization of Mies van der Rohe's hopes for the antiquated building industry.[40] Its use as a prototype creates parallels with the world of industrial design and manufacture, producing buildings that are designed and constructed in a manner similar to the way a car would be designed and developed; each element — cladding, structure, internal fittings, service modules, etc. being prototyped, tested and designed for production on assembly lines.

M A N U F A C T U R I N G   S P E E D

Advances in aeronautical, naval and industrial processes are drawn upon for substance, imagery and innovation in the design and performance of a High-Tech building. Such buildings are often built in laboratories, subject to inspection, quality control and continual performance evaluation. Genuine High-Tech architecture is not just the appearance of conduits, space frames and external structural members but a quest to push materials to their limits and to extract more performance from them and the spaces they create. Successful High-Tech architecture therefore combines technological advances and procedures with elegant, sleek and sensual form. Other buildings may incorporate similar technological advances but with less emphasis on the elegance of technological form and refinement. High-Tech is the fusion of efficient engineering displayed in sculptural form and an imaginative interpretation of program — architecture valued not so much for what it is, but for what it does.

High-Tech is nothing less than Modern architecture's most extreme attempt to transcend history, to escape from culture and all its irrational rituals, its time wasting formalities. The goal is buildings that do not so much shape—or even reflect—lifestyle as to be its willing servants, ever ready to be pushed around into different configurations and adjusted for optimal conditions.

Peter Buchanan

M A N U F A C T U R I N G   S P E E D

modern machine

The preceding discussions of the Machine, Modernism, and their relationship to technological change, sets the framework for discussing the Formula One Industry in the context of this project.

Industrial manufacture has as its base the most fundamental ideas concerning technology and transformation, yet the pace at which these forces develop and the impact they have on the manufactured product varies widely. Formula One is an industry based on the rapid adoption and manipulation of the most current technological advances in order to survive. Designing a competitive Formula One racing car requires the most up to date knowledge and application of techniques, materials and resources which constitute the highest level of technological integration with engineered design.

The application of the fundamental aspects of Modernism in its quest for a machine age aesthetic is reached in the design and manufacture of the Formula One car. By utilizing high technologies in the realization of a tangible product the Formula One car achieves the dream of Modernity. By reaching beyond the mechanical age and into the electronic age of information, it is ideally representative of its place in time, therefore exceeding anything the Modernists could have predicted yet still appropriately defined as a Modern Machine.

S P E E D

speed as an industry

In my day it was 75 per cent car and mechanic, 25 per cent driver and luck. Today it's 95 per cent car.

Juan Manuel Fangio

In almost 50 years of Formula One Grand Prix racing, the sport has seen many drivers, many teams, many engine suppliers and many new rules and regulations. What has remained constant from the start of the first World Championship in 1950 to current Grand Prix racing, is that nothing is ever static.

In the Formula One Industry multi million dollar decisions must be made in the blink of an eye and the leaders of today's F1 teams cannot hesitate to make them, lest they get left behind. It is not a case of getting to the top but a case of making the right choices to stay there. A driving force behind the F1 Industry is technology. The supremacy of Formula One in the motor sport world is achieved due to the constantly changing advances in current aerodynamic, aeronautical and engineering technologies; budgets upwards of £40 million; and the wherewithall to do something about it. The industry thrives in an environment of constant flux and speed. The design of a successful F1 team belongs to a long history of invention and re-creation of the design environment in its relationship to technological advancement.

The origins of the Formula One Industry rest not in high technology nor in the application of inventive genius, but in the ideas of basic "kit car" manufacture: a chassis teamed up with an engine. In the early days of the sport, chassis manufacturers would sell their designs and construction to privateers; the addition of an engine, often borrowed from existing machinery (an old fire pump engine was modified to create one of the original F1 engines, the Cooper-Climax), and the car was ready to race. In its basic premise, not much has changed. Most of today's F1 teams still rely on the principles of "kit car" manufacture, with a chassis manufacturer contracting an engine manufacturer for the design and supply of the car's power, albeit from the much more orderly and clinical environment of an automotive engineer than from the tinker shop of a mechanic. In 1967 Team Lotus changed the face of F1 car design when they asked Cosworth to design and build a custom engine. No longer would just any engine satisfy the desire to achieve success — the trend towards high technology had begun.

M A N U F A C T U R I N G S P E E D

There are many reasons for the advancing technology seen in motor sport. In the 1960s technical improvisation was driven by the sole purpose of achieving success.[41] That is still at the root of today's innovation, and yet the appearance of ingenius technical acuity and sophistication also plays a role, as does urging for ever increasing safety measures. Early racing drivers acknowledged the extreme personal risk associated with the sport. Racing periodicals printed weekly lists of obituaries. With increased media coverage of the sport, especially in the form of television broadcasting, which vividly showed all of the shunts with their subsequent injuries and deaths, the industry, spearheaded by its drivers, was urged to increase safety measures. Complex technological advances were found to produce safer cars because of improved design processes, superior manufacturing and sophisticated technological guarantees.[42] As technology progressed the incident rate in Formula One decreased. There are still as many, if not more, collisions in current Grand Prix racing as there were in the past, and yet drivers emerge unharmed from remarkable accidents which surely would have been fatal in the past.

> *The form is sleek and smooth, the guts...although beautifully detailed, largely hidden away from sight; the complete resolution of the flowing surface, the sense of visual inclusion, of togetherness, propriety, good manners.*[43]
>
> *Jonathan Glancy*

Whereas the above quote refers to Norman Foster's Sainsbury Center, it could be referring to the McLaren MP4/13 or the Arrows A19. The cars of Formula One are the epitome of design ingenuity; hiding the inner workings of some of the most complex and powerful engineering systems behind the sleekest of facades. They are a product of the latest technology, the most rapidly changing aspect of which is in the field of aerodynamics where the obsolescence of a design's aerodynamic potential is a fear even before it reaches the manufacturing stage. The science of aerodynamics did not really come into play in the F1 industry until 1976 with the first 'ground effects' car, the

Lotus 78. The ideas found in the wing structures of the Lotus 78 were generated from the inner wings of a British WWII Bomber which produced the effect of negative lift.[41] Negative lift, or downforce, became the driving principle behind the construction of a Formula One race car from that point on.

Downforce operates on the same principle that makes an airplane fly, but inverted so that instead of producing lift, it creates a vacuum which sucks the car to the ground. It is said that a modern F1 car generates enough downforce to enable it to drive upside down through the tunnel at Monaco![42] Downforce plays such an important role in the aerodynamic design of the F1 car because it increases tyre grip, therefore raising cornering speeds and overall performance. The key to aerodynamic balance is in the creation of enough downforce for maximum cornering speed while maintaining minimum drag for straight line speed. While the aerodynamic potential of the F1 race car depends on a complete package, including suspension, the majority of its aerodynamic effect is to be found in the design of the chassis.

Chassis design in Formula One is based on the principles of stressed-skin construction. In earlier Formula One manufacture, the chassis was constructed of an aluminum space frame enveloped by thin alloy sheet rivetted in place. Today's F1 vehicle is of monocoque construction, the frame and skin are merged into an integrally stiffened shell of carbon fibre, in which every component contributes towards the total structural capability of the car. The integrity of the chassis is not complete without the engine, which acts not only as the powerhouse, but as the final stressed structural member which holds the whole car together. The introduction of composite technology to the design and manufacture of the Formula One chassis is one of the major technological advances in the industry.

The development of fibreglass and polyester matrix resins during WWII, in response to possible aluminum shortages and the desire for lightweight aircraft materials, saw the beginning of composite construction technology. As composite materials advanced in the aviation industry, their advantages began to be seen by the more technologically aware teams in Formula One. With the 1962 Lotus 25's adoption of monocoque construction and the glass fibre lined aluminum chassis of the 1963 Cooper; to the use of carbon fibre panels in McLaren's MP4 and

Clearly we still have plenty to learn about the (construction) of racing cars, but equally obviously the rate at which we can acquire knowledge will depend to a considerable extent on the regulations governing the various categories. From this point of view, therefore, the fewer regulations, the better, but good motor racing means plenty of competition, and unrestricted design almost always gives the advantage to the firms with the most money.

Len Terry

the carbon fibre/Kevlar cloth construction of the Lotus 88 (1981); and the development of the 1985 Williams FW10 moulded carbon fibre chassis, the use of composite technology in the Formula One industry has been established. The advantage of carbon fibre was in its increased stiffness accompanied by substantial weight reduction compared to aluminum sheet or magnesium alloy. For example, 15,000 lbs/ft stiffness of carbon fibre would weigh the same as 8,000 lbs/ft of aluminum skinned honeycomb. With a reduction to a still stronger 12,000 lbs/ft, carbon fibre construction would yield a reduction of 25 lbs. in weight.[4] With ever advancing technology in the composition of carbon fibre and the improved strengths of its resins, the F1 chassis is designed to be stiff enough to minimize structural damage in a minor shunt and to absorb the maximum impact of forces in a major incident, thus protecting the driver. Carbon fibre technology has made possible the construction of a more efficient, safer and more impact resistant racing car than ever before. The technology behind composite construction has advanced beyond monocoque design into the brake discs, clutch, radiator, suspension wishbones and gearbox of the Formula One car to date. Other components are sure to follow.

While the Formula One industry relies on the adoption of new technologies, it also surpresses them. Some advances to car design are banned and innovative technologies discarded or put on hold. It is paramount to keep abreast of the latest technologies, but it is commonplace for the industry to keep the quest for new technologies in check.

The FIA (Federation Internationale de l'Automobile) is the international organization which represents the interests of motor sport. Its activities include the development and revision of technical and sporting regulations which govern Formula One. Each new regulation is based on the statistics and performance of the past racing season and forms the body of rules which determine next year's design. The motives of the FIA are generally to maintain as level a playing field as possible, while being constantly aware of issues regarding driver safety. Some of the teams have unlimited budgets which would mean an unfettered potential to adopt advanced and expensive, technologies, while other teams struggle to honor their racing commitments. While the aims of the FIA are true, the realities are no match for the speed at which technology accelerates. Design and engineering technologies from one season to the next have advanced far enough to render the changes imposed by new regulations to be minor and relatively

Formula One...where beating the regulations is as much a part of the sport as beating the opposition.

Brian O'Rourke

Ineffective in slowing the cars, therefore maintaining the status quo from season to season, rather than imposing severe new reductions to performance. For example: In 1987, restriction to turbo boost was imposed to decrease power to the engine thereby reducing speed; but by utilizing fuel composition and temperature technologies that had progressed during the season, relatively the same power output and speed was produced, despite the new restriction. In a more recent example the FIA required the introduction of grooved tyres in the 1998 season in an attempt to reduce cornering speeds and promote overtaking; but by improvements made to aerodynamics and increasing downforce, the speeds remained the same and overtaking became an even riskier manouever in the face of increased jet stream. While certain regulations can be imposed in one area of car manufacture the fact remains that improving technologies will continue to affect the performance of others. Yet while these regulations may not have produced their desired effect, they were successful in maintaining the status quo, in essence halting what could have potentially been a dangerous clash between too many advancing technologies.

While the purpose of the FIA is to monitor performance, keep budgets in check and try to maintain a level playing field for competitors, the goal of the Formula One designer is to produce the fastest, best performing, and most reliable car able to finish, if not win, races. Technology and knowledge play into the hands of the designer who is forever trying to work around the specific wording of the FIA regulations to produce a car capable of maximum performance, while technically staying within the guidelines. The decisions made by each performer in the Formula One circus revolve around the advances and failures of technology.

In the cockpit of today's Formula One car, with semi automatic gear selection, devices which effectively produce traction control, master switches and speed limitor buttons, it seems that Juan Manuel Fangio was right. Today it is 95 per cent car.

the architecture of speed

Through the discussion of the Formula One industry as a marker of constant technological change within the design environment, a challenge has been posed—in effect, a dare wagered.

To date the relationship of the design environment with technology has been one of reverence, deference and largely in the case of architecture, speculative denial. As an example the F1 industry holds up a standard for the integration of technology and design. Keeping pace with technology is the refusal to accept a standardized norm—a new design for every season, in effect, a new design for every race. Industry, such as Formula One, has proven that design environments can utilize the lexicon of technology to define a new standard of manufacture. To complete the integration of technology and design, continuous links throughout the design environment must be developed and processes redefined.

In the courting of sponsors, the factory for the Formula One car represents more than the place where the cars are manufactured. A successful facility integrating the technology of manufacture, efficiency of use, and architectural design imparts a commitment to high-tech design and performance to all aspects of the team structure. It is part of the public face of the industry and something which should be demonstrative of the standards set by it. To design architecture capable of partnership within the timeline of technology, participating in the evolution of design, it needs to appropriate the challenge posed by advanced industry and high technology. Architectural design process can be consistent with its place in a technological world and reflective of its perceived role in such a world. As such, a building for the design and manufacture of speed should not be a pastiche based on past tradition nor an impromptu tin shed, but representative of the architectural program contained within and a demonstration of the complex world of evolutionary design.

the formula one team

While this project was initially conceived of as a general application of theory in a design for the Formula One industry, and as such has implications for any Formula One team, it evolved from specific discussions with one of the current Formula One teams -- Arrows TWR.

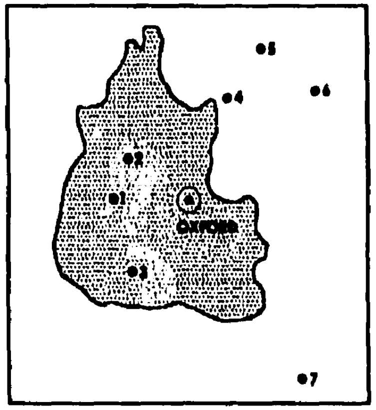
The following architectural design is based on requirements, specifications, and locations as they pertain to Arrows TWR. To this end, Arrows TWR has been adopted as theoretical client for the factory design and will be referred to as such in the following text.

a place for speed

the location of Oxfordshire within England

Formula One, despite its largely international flavor and appeal, is predominantly a European sport. All eleven of the current Formula One teams are European, based in Italy, Switzerland, France or England. Major Japanese automanufacturers have tried their hand at the sport, and may do so again, although the likelihood of a team based in Japan remains remote. There was even a Canadian team in the late 1970s, although team operations were conducted abroad.

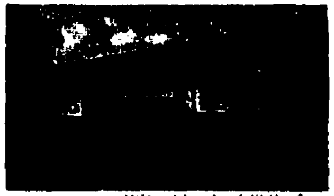
While the home of Formula One may be Europe, the heart of Formula One is in England.



the "Formula One Corridor". 1) Arrows TWR Grand Prix (Leafield, Oxfordshire); 2) Benetton Formula (Enstone, Oxfordshire), 3) WilliamsF1 (Grove, Oxfordshire), 4) British American Racing (Brackley, Northamptonshire); 5) Jordan Grand Prix (Silverstone, Northamptonshire), 6) Stewart Grand Prix (Milton Keynes, Buckinghamshire), 7) McLaren International (Woking, Surrey)

England plays host to some of the world's most advanced electronic, computer and automotive manufacturing technologies; becoming the premier location of innovative high-tech industry and the definitive locale for Formula One. In terms of the Formula One industry, seven of the current eleven Formula One teams, and numerous teams of the past, are based in England. High-tech industry is defined as " industry which bases an importance on research and development, or on scientific, engineering or technical components, unified by their common dependence upon scientific and engineering knowledge".[47] In England such industry is concentrated in what has become known as the "Western Crescent", the M4 Corridor, or more specifically in relation to this project, the "Formula One Corridor".[48] This band of high tech industry, located to the west of London, and cradling the seven British Formula One manufacturers, stretches from the Buckinghamshire city of Milton Keynes in the north, down through Northamptonshire, into Oxfordshire, ending in an upwards turn, in the southern county of Surrey at Woking. Three of the seven Formula One teams and the majority of British high tech industry is to be found in the county of Oxfordshire.

Contrary to the tendency for high tech industry to remain apart from traditional industry, Oxfordshire represents unique situation in which the quality and quantity of labor, existing physical infrastructure and assets of inherited industry all contribute to its being the hub of innovation in Britain.[49] Whereas, often the workforce follows the work, in Oxfordshire


McLaren International - Woking, Surrey


Arrows TWR - Leafield, Oxfordshire


Arrows TWR - Leafield, Oxfordshire

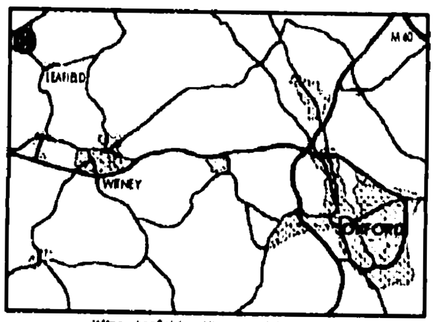
the industry follows the preferences of its workforce. A highly educated workforce in the areas of motor vehicle manufacture, scientific instrumentation and the aerospace industry provide an excellent basis for the high technology industry and the specialist requirements of Formula One. Along with a strong support base in the British Aerospace industry and contracts with the Ministry of Defense, the F1 industry is supplied with the materials, testing facilities, and highly educated and technically skilled workers found in Oxfordshire, and requisite to the creation of a successful operation.

Between 1976 and 1991 an Oxfordshire Structure Plan was created in an attempt to further protect the county's environment, culture and agricultural landscape from the continuous encroachment of industry.[50] The Structure Plan promoted a restraint in the development of central and southern Oxfordshire (Oxford City and Abingdon) and the promotion of the north and west (Banbury, Bicester, Witney and Didcot). Site selection for this project was concentrated in this area of the county involving precedent studies of the seven British Formula One team sites, visits to estate agents in Oxford and Banbury, and countless miles of driving through the Oxfordshire landscape.

While the site eventually chosen for this project is a green field site, that is not always the case for Formula One factories. McLaren International and Stewart Grand Prix are both located in industrial parks on the outskirts of towns. McLaren, the older of the two, is located in a small industrial estate in which Formula One is clearly the dominant industry. The factory building is surrounded by the supporting team industries (i.e. TAG electronics) and residential row houses. The impression is that although McLaren is but one industry in the estate, it clearly dominates, therefore providing the privacy required by the industry due to its sheer status in the area and the high security of the factory proper. Stewart Grand Prix is located at the southern end of Milton Keynes in one of many industrial parks. The factory, while architecturally significant, is on one of many plots and therefore obtains its privacy by blending into the general industrial atmosphere. British American Racing, located just off the highway circling Brackley, has a unique situation within the Formula One industry. BAR is located within Reynard Industrial Park. Adrian Reynard, one of the owners of the team, has interests in other car manufacturing and aviation industries and all operations are located within this small, private industrial estate. WilliamsF1 and Arrows TWR are located on previously owned sites on the periphery of small towns, and have been refit

Benetton Formula · Enstone, Oxfordshire

Benetton Formula · Enstone, Oxfordshire



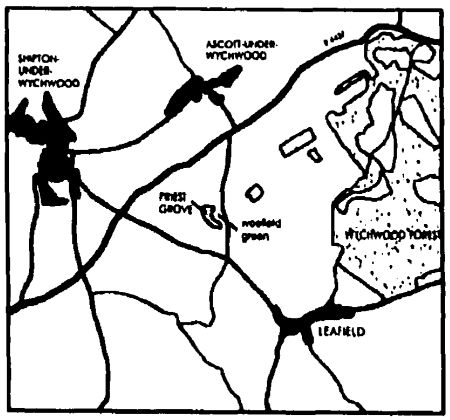
Witney, Leafield and the project site in their relation to Oxford

on the periphery of small towns, and have been refit to suit the standards of the Formula One industry. Jordan Grand Prix, although the smallest of the F1 factories, is privileged in its situation as it is located directly across the lane from the Silverstone racing circuit, making trips to testing sessions convenient. Although most of the F1 factories are located on sites which could generally be described as field sites, Benetton Formula is located in a secluded valley surrounded by pasture land, mostly hidden by vegetation and impossible to find without directions from the locals. The seamless integration of modern industrial building with the natural landscape, as found at Benetton, became the site precedent for this project.

The green field site chosen for the design of the proposed new Arrows TWR Formula One facility is in the civil parish of Leafield, approximately 20 km west of the city of Oxford and 12 km north of the town of Witney. Leafield civil parish rests in what is known as the Oxford Clay Vale between the hills of the Cotswolds to the north and Oxford Heights to the south. The hamlet of Leafield is on a plateau stepping down westward to a valley containing secondary highway B4437 which runs between the towns of Burford and Charlbury. To the northwest of the highway is the hamlet of Ascott-Under-Wychwood, named for its relative location to Wychwood Forest.

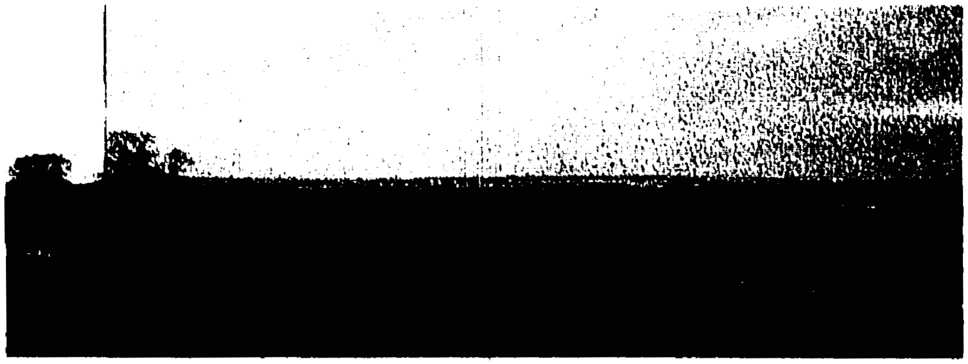
The site for the proposed Formula One facility is found on the slope of the Leafield plateau in a cradle formed by Priest Grove, a remainder of the once larger forest. The building site is east of the grove and bound to the east by an access road to the B4437. Currently called Woefield Green, a UK Charter horse jumping paddock, the site is demarcated by a single row of mostly coniferous trees. The trees extend beyond the stone fence of the site proper, across the road through the facing sheep pasture to the edges of the forest, thus further emphasizing the connection with the grove on the site. To the north of the site there is a spectacular view of the surrounding landscape with multicolored pastures, centuries old hawthorn hedgerows and the limestone buildings of Ascott-Under-Wychwood in the distance. To the south are the lands of Fairspear Farm.

place. Leafield and environs represent a timeline of diverse advancing development. From its origin as a primeval forest to cleared pasture land the area has nurtured the development of industry (i.e., the British Telecom Training Center and subsequent reuse of the facility by the TWR organization). And now the site is selected to be a center for the pinnacle of motorsport design and technology. Because of the interconnection and balance found between these vastly different 'cultures', a picture of the "unhaltable trend to constantly accelerating change"[51] can be seen and a true 'place for speed' defined.



site context

Priest Grove looking East



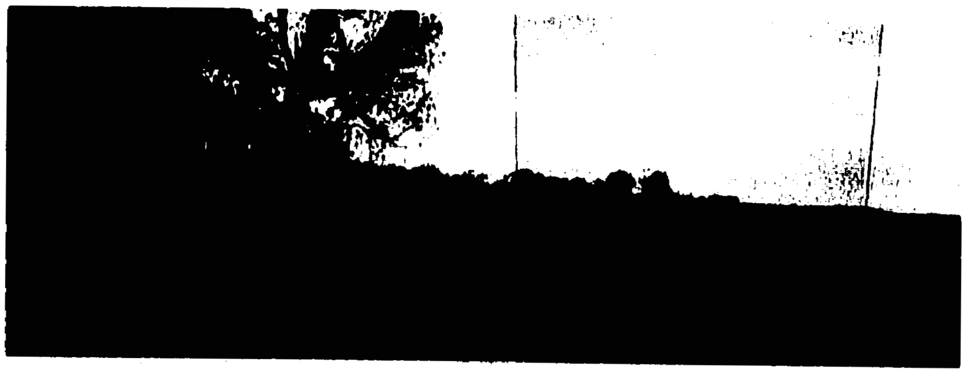
Northwest view from site towards Ascott-Under-Wychwood

Woefield Green

Northeast view from southeast corner of site

M A N U F A C T U R I N G   S P E E D

Southeast view from road



Northeast view of site as surrounded by Priest Grove

MANUFACTURING SPEED

site as circuit

The site for a Formula One car is the circuit on which it is tested and raced. The circuit serves as a containment facility for the cars as well as providing unsettledness, offering a challenge to its users. This balance between the safe harnessing of power and the encouragement to press the limits creates a dissonance in which the Formula One car thrives. In that the factory is to be a program specific facility catering to the needs and demands of the constantly changing Formula One industry and its product, the site is required to react to the building much in the same way as a circuit is to react to a car and vice versa.

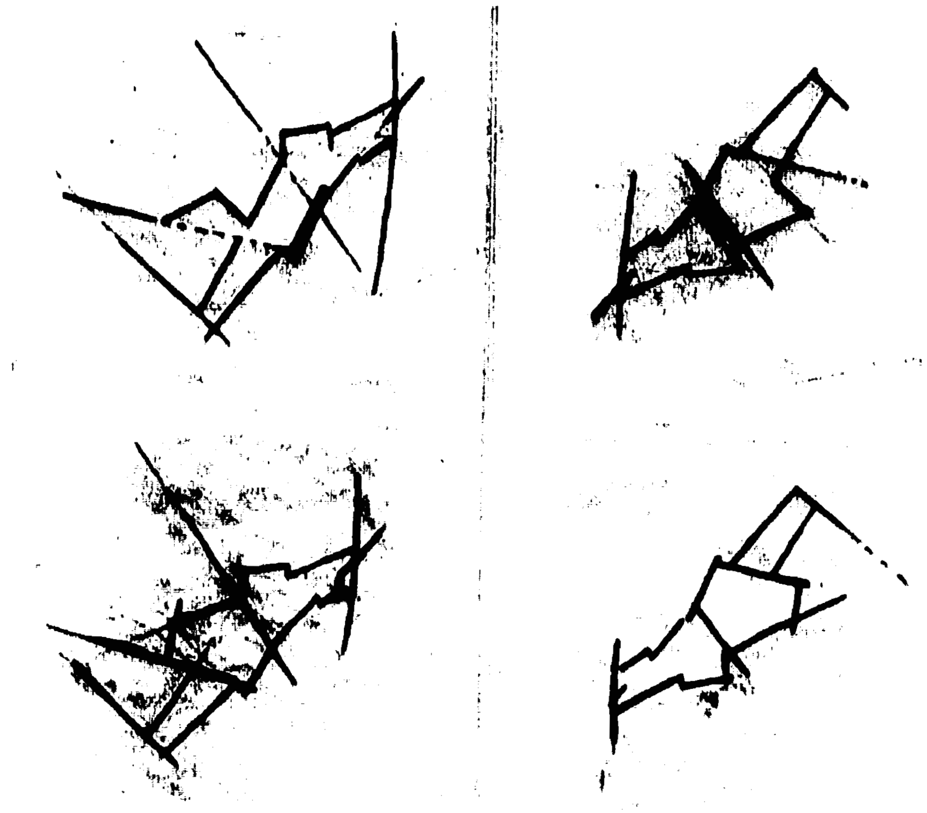
The balance between circuit and car is reflected in the discord established with the building on its site. As the design of the car changes, the circuit must be able to respond to these changes and to effect the same protective and unsettled qualities which pose a challenge to the car. As conditions of the circuit change, i.e. temperatures, rain, wind, etc. the car must be able to respond to the changes in order to achieve maximum performance, i.e. tyre changes, suspension set up, etc.. As requirements of the industry change, the flexible nature of the building to accomodate such changes requires in turn, that the site change, allowing for building expansion and the flexible nature of its use. The building must conform to site restrictions and utilize the natural occurences of light and wind protection to its advantage to create the balance with the site.

The protective yet unsettling forces found on a Formula One circuit are found in the topographical conditions of the building site. The site is cradled on the slope by the grove of trees, preventing its erosion into the valley and providing protection, while the crown provides the opportunity for a precarious balance between building and site.

a design for speed

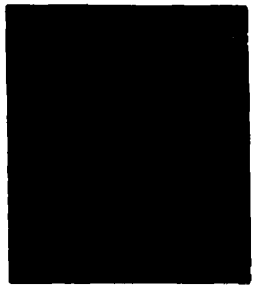
The following design for the Formula One factory has been established out of responses to theoretical research, the site, and the design of the Formula One car. Discoveries outlined in the theoretical exploration of the Machine and of Modernism and how these can best become manifest in industrial architecture helped to determine the building typology. Force lines established on site, the relationship of the site's crown to its slope, the protective grove, and ties to past site influences played a determining factor in the building's massing, landscaping and program location. The design, structure, and construction of the Formula One car are reflected in the spatiality, structure, construction and overall appearance of the factory design.

M A N U F A C T U R I N G S P E E D



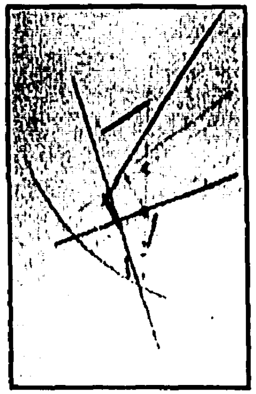
ARCHITECTURE

force lines and massing



Topographical model of larger site context

The site affords a dynamic interaction of a building with its site. The crown at the front edge of the site undulates between two elevated ground planes which meld at the rear and slope down into the grove at the western edge of the site. At the southern tip of the site, as the protective cradling of the grove dissipates, the landforms seem to swirl from the crown into the valley running behind the grove and down into the larger site context. The tendencies for the landforms to appear to sweep into the valley, held only in place by the grove, led to the creation of primary force lines on the site. Secondary force lines were established based on the site's connection to external site influences (i.e., the line of trees visually connecting the site to its origins as a primeval forest, lines through the site connecting it to surrounding industry and a line tying the site into its relationship with other branches of the TWR organization). The force lines exist as perceptual connections of the site to its surroundings. They impose an orientation of the site to its place and position on the landscape and are translated into the formal definition of the building, being directly reflected in the building mass and landscaping features.



Sketch of 'force lines' crossing site

Massing elements based on the force lines are directly correlated to the programmatic requirements contained within and their respective position within the Formula One Industry. The projecting volumes on the western edge of the building anchor the factory's position on the crown and respond to the force lines' tendency to erode the site contours into the grove. Programmatically they contain two of the 'life blood' departments of a Formula One team's existence. The larger of the two anchors contains the car bays for the testing and racing teams, signifying the end goal or product of the industry, without which the industry would cease to exist. The smaller, yet no less significant, anchor contains the research and development and prototype departments for the team. Without the constant investigation into technological improvements and their implications on the industry, the team would quickly lose its competitive edge, leading to the possible dissolution of the team. These two anchoring program elements stabilize the team in relation to the industry and in terms of massing, stabilize the production floor which runs the entire length of the building.

Rough massing as formed from 'force lines'

The massing of the factory's eastern edge makes reference to the instability of the crown. The two elevated landforms which comprise the crown are bridged by the volume containing the administrative departments of the team. The director's offices, accounting and public relations departments represent the importance of finesse in dealing with some of the most precarious operations within the industry. The building form in which they are contained shows the most tenuous connections to the site, representing not only the contingent nature of financial dealings, but also the unsettled balance achieved between the Formula One car and its circuit.

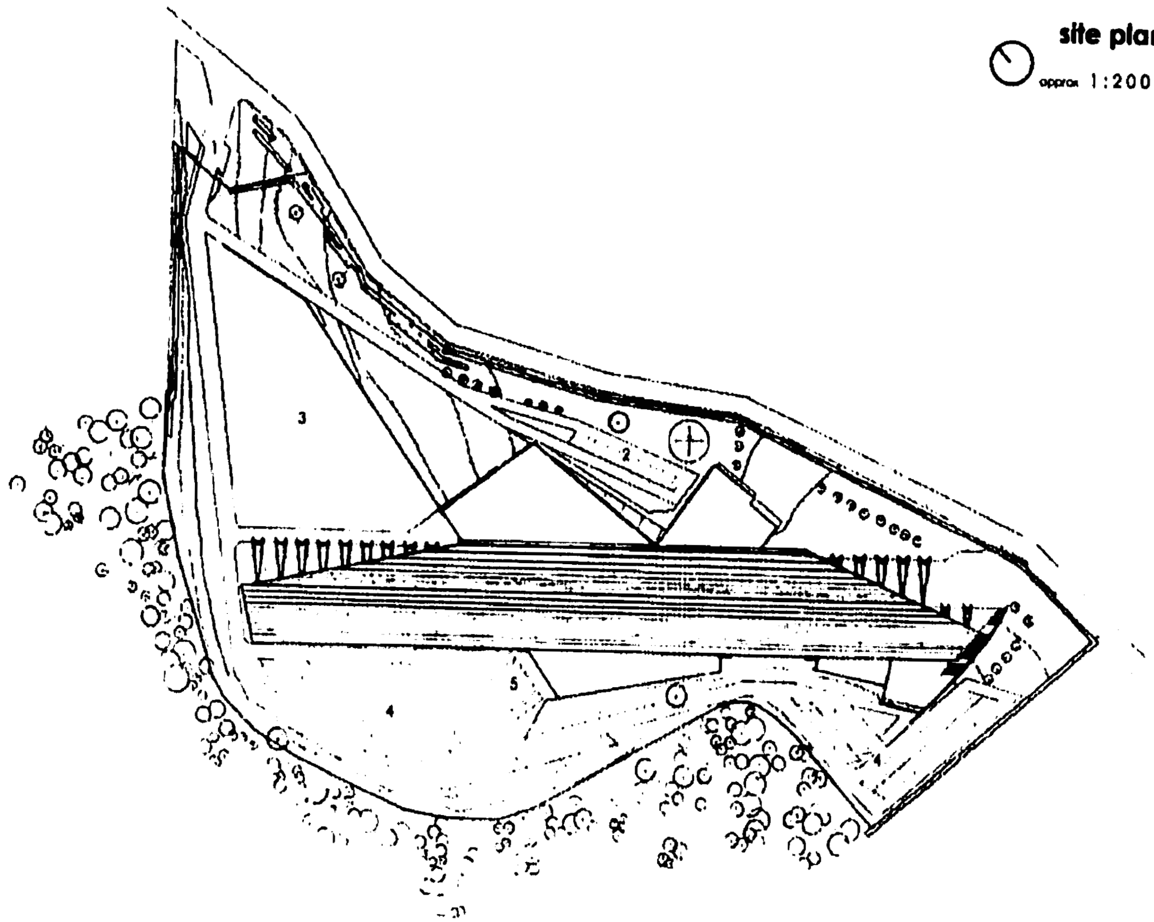
Bridging on the crown also takes place at the juncture between the building and the force line connecting the site with the single row of trees leading to Wychwood Forest. The line of trees, which originally ends to the east of the site is continued into the landscaping of the new factory. New planting leads to the edge of the public entrance, where a grated steel platform, raised above grade allows for a shift from the linear axis of the trees to the offset building entrance. This shift in axis allows for a bridge between the greater site context as one of ancient forest to the new potentials of high-tech industry.

Other massing features on the building site, which follow force lines include: the gatehouse at the northernmost tip of the site, located at the extents of force lines linking the factory concept as a whole; the curved retaining wall at the building's southernmost end, signifying the unanchored tendency to follow the landform; and the field at the northeastern end of the production wing, extending the force line containing the composites departments.

site plan

approx 1:2000

1 gatehouse
2 visitor parking
3 expansion field
4 employee parking
5 transporters

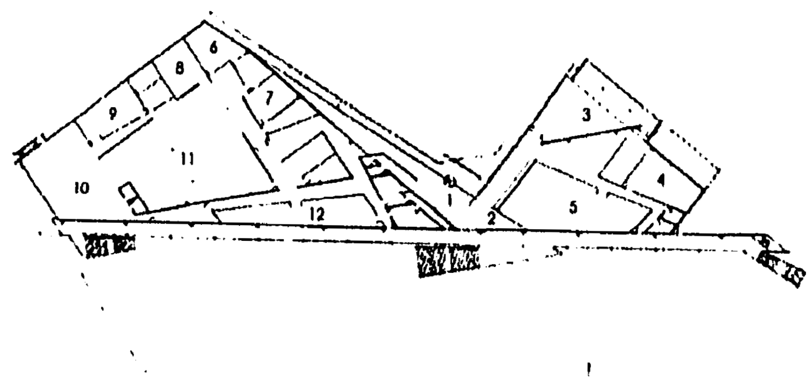


MANUFACTURING SPEED

plan level +5

approx. 1 : 1000

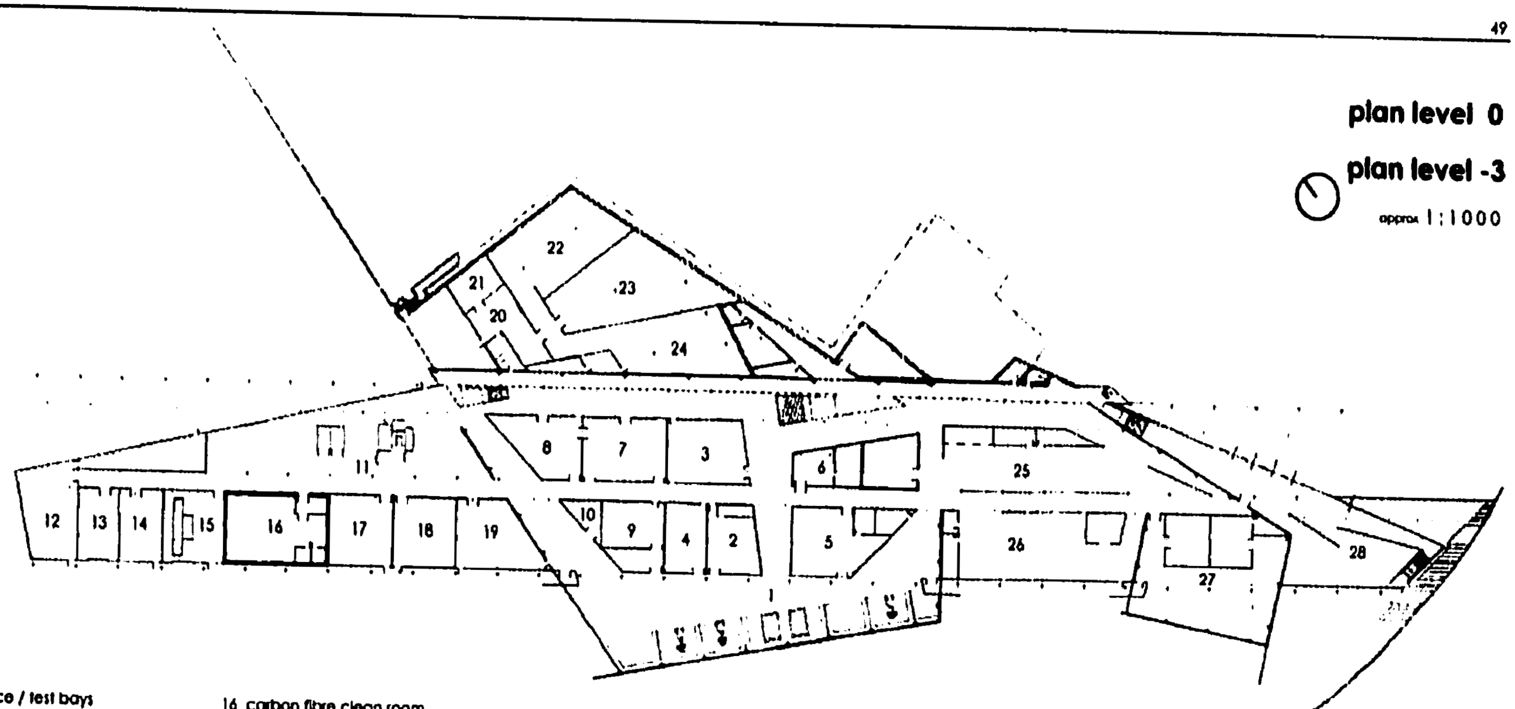
1 entrance hall / reception
2 gallery
3 presentation theatre
4 director
5 public relations / finance
6 technical director
7 operations manager
8 meeting room
9 print room
10 production offices
11 drawing offices
12 marketing



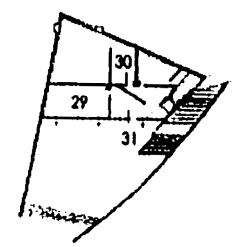
plan level 0

plan level -3

approx 1:1000



1 race / test bays
2 hydraulics
3 electronics
4 sub assembly
5 gearbox
6 parts cleaning / crack testing
7 graphics department
8 graphics store
9 race equipment store
10 engine supplier room
11 autoclaves / ovens
12 model shop
13 patent shop
14 patent workroom
15 Jo mach milling machine
16 carbon fibre clean room
17 carbon fibre trim room
18 carbon fibre bonding
19 carbon fibre inspection
20 receiving/goods in
21 fuel storage
22 tub store
23 composite store
24 parts store
25 metal shop
26 machine shop
27 research and development
28 canteen
29 gym
30 locker rooms
31 employee entrance



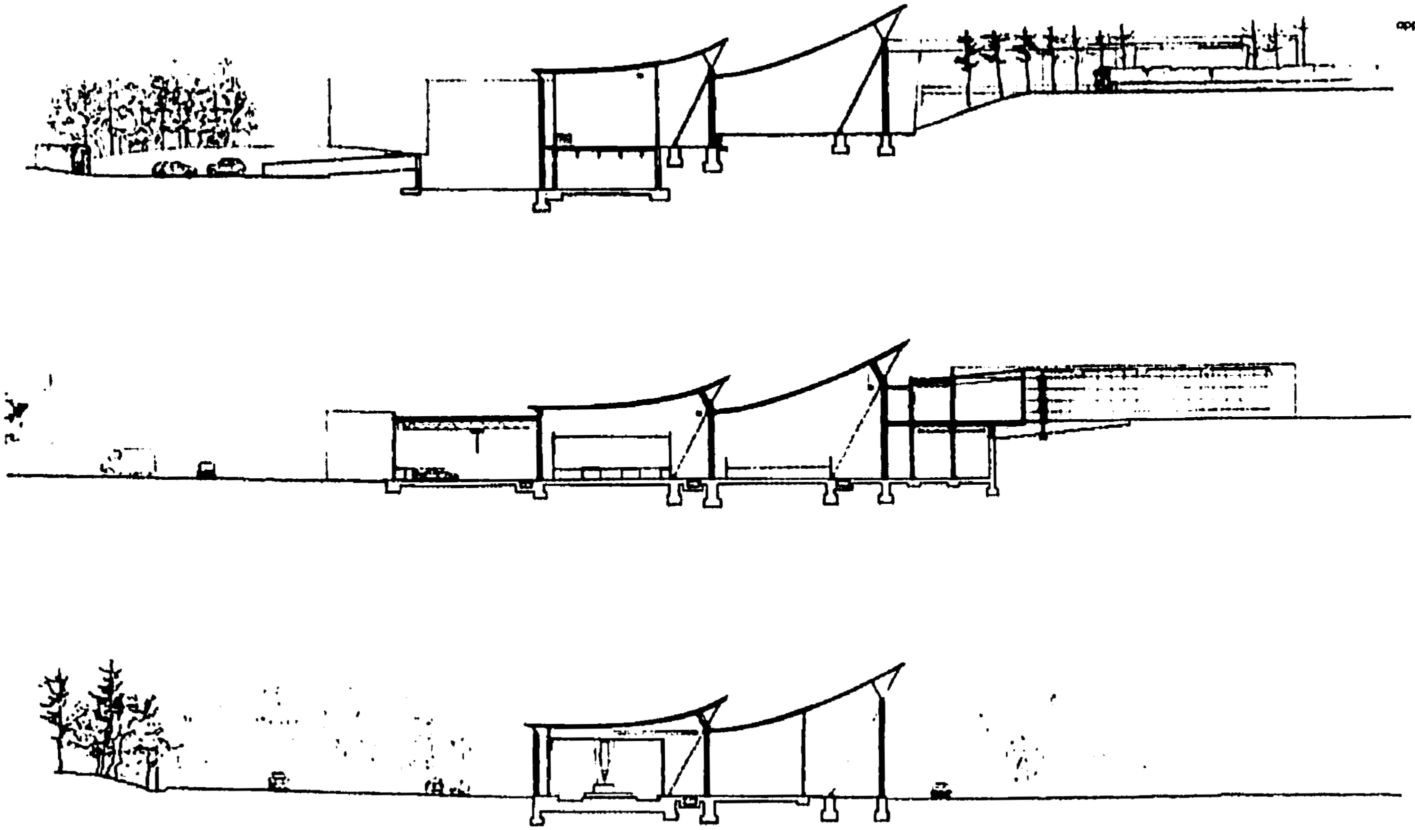
M A N U F A C T U R I N G S P E E D

section through level -3

section through race / test bays

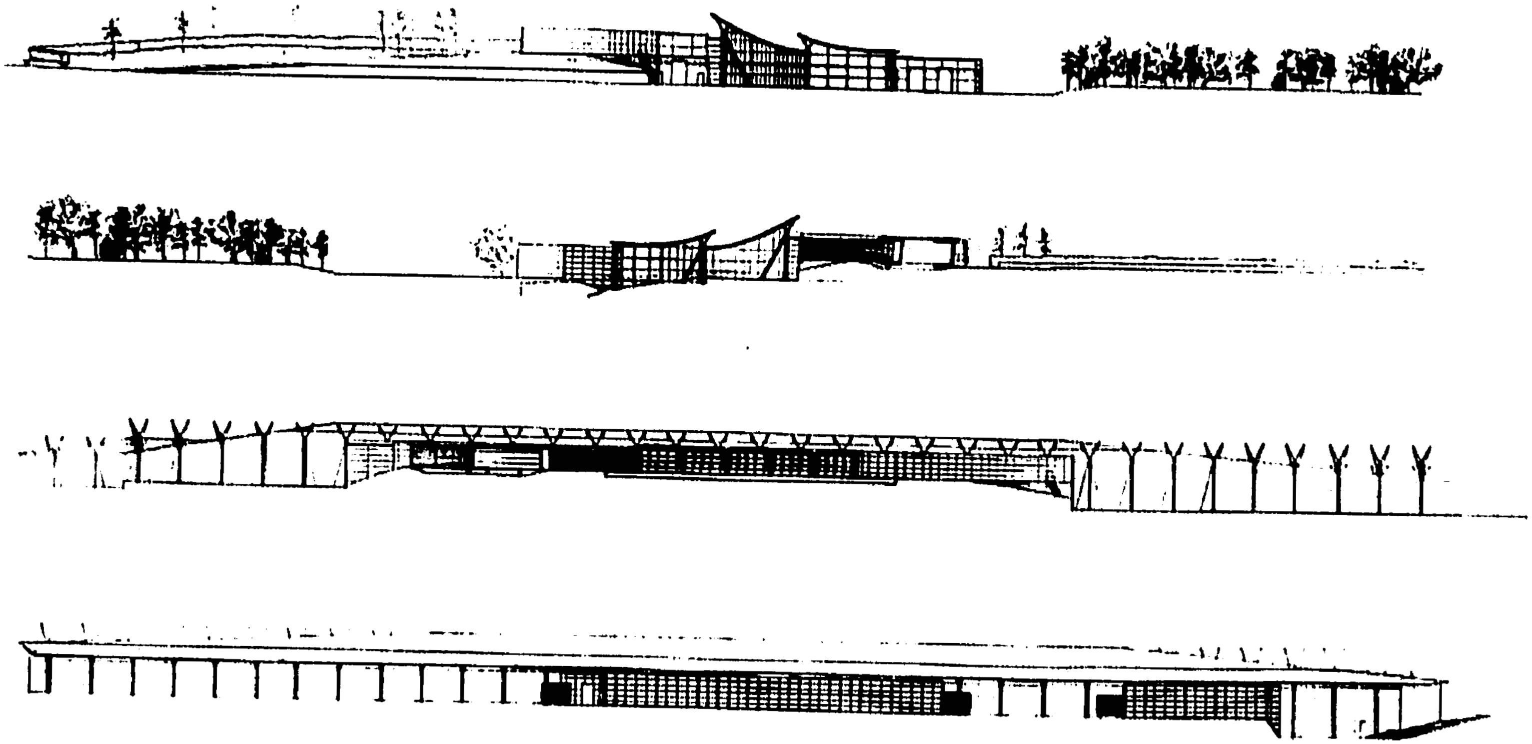
section through composites wing

approx. 1:500



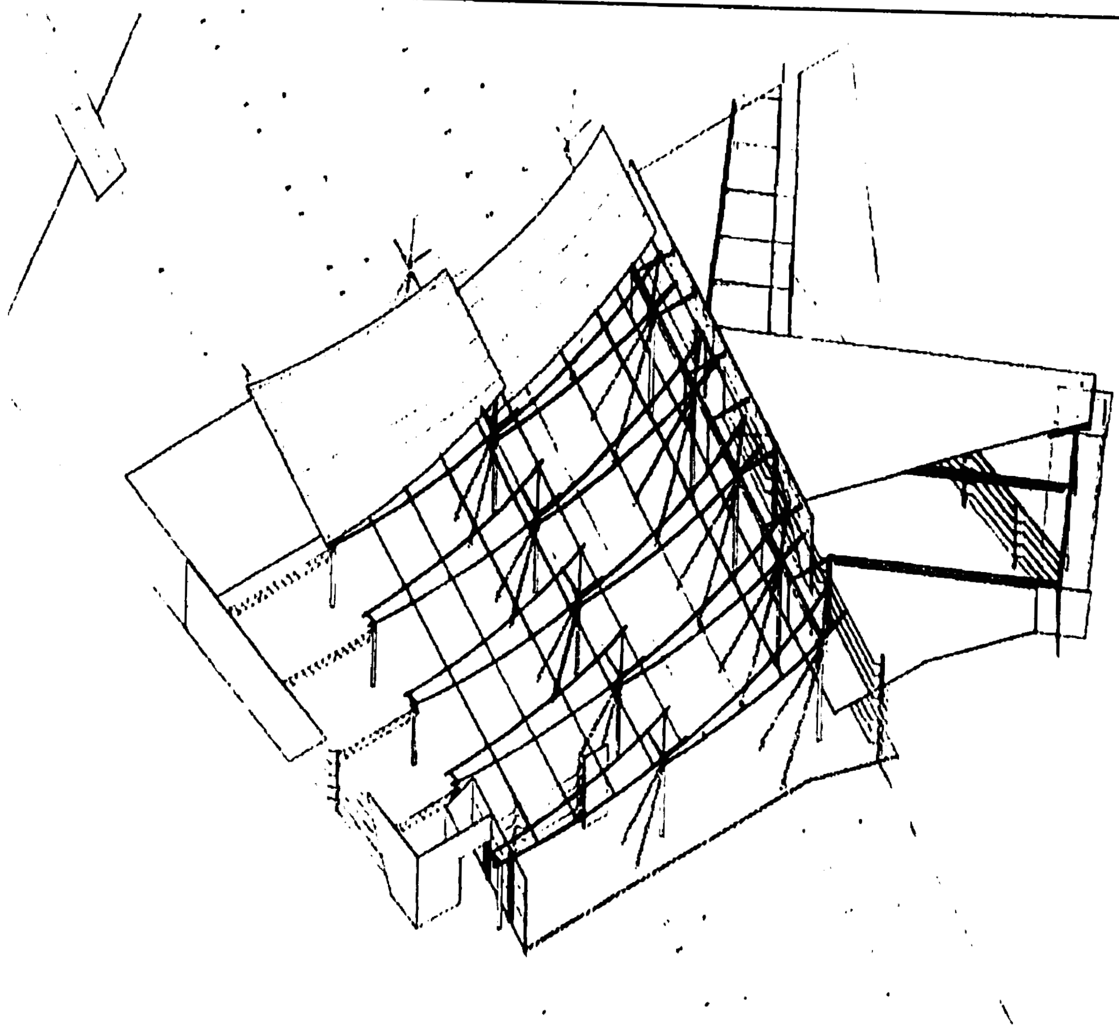
north elevation
south elevation
east elevation
west elevation

approx. 1:1000



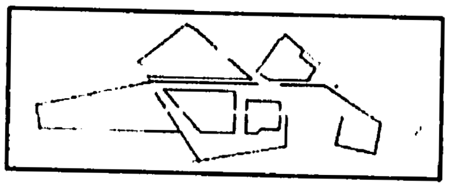
axonometric of structure

approx. 1 : 500

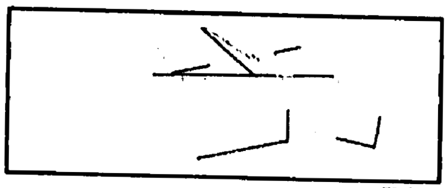


MANUFACTURING SPEED

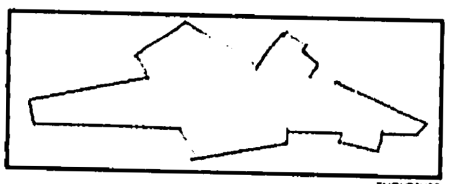
factory as speed



PROGRAM



STRUCTURE



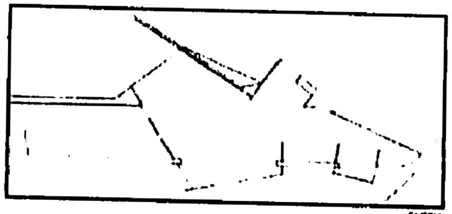
ENCLOSURE

The design of the factory took into account four interpretations and manifestations of speed: speed as an idea of constant change, always flexible, never static; speed in the aspect of movement or trajectory, and getting from point A to point B; speed in its ability to promote an unsettled balance or fragmentation of surrounding elements; and the awareness of speed through momentary pauses in motion.

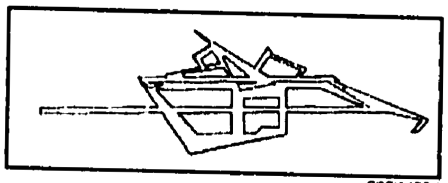
The idea of speed as constant change is most appropriate to the practice of making industrial architecture. As previously described, the most useful industrial buildings are designed utilizing a non plan structure, one that promotes the flexible interpretation of program and one that enables expansion with minor impact on established operations. The production floor of the factory is based on a grid module of 8 x 16 metres. Roughly a 33 metre width of floor allows for two bands of production space, separated by a corridor, above which run system conduits. Partitioning of the various programmatic elements (see appendix A) occurs with moveable, glass topped partitions, enabling the segregation of departments yet maintaining the experience of the production floor as a whole. Those departments requiring airlocks and/or specific dust extraction i.e. the carbon fibre clean room, are constructed in similar fashion with the exception of a lowered, sealed ceiling. Perceptually these departments would be experienced as objects within the whole of the production space.

The flexible grid in effect extends beyond the perimeter of the building envelope, as suggested by the continuation of the structural supports outside of the exterior wall. The exterior wall can be moved outwards towards the supports, and more supports added as building expansion is required. The northern wing of the production floor containing the carbon fibre composites departments, the area of most anticipated expansion, backs the aforementioned northern field. The landscaping of this field is designed to readily accept the construction of new structural supports, roofing and the extension of the building envelope as necessary.

M A N U F A C T U R I N G   S P E E D



ENTRY



CIRCULATION

Speed as movement or trajectory is most effective on an axis. The Formula One industry talks of straight line versus cornering speeds, the faster being the straight line. To facilitate the easiest and most efficient movment through the building, the corridor system maintains a largely axial trajectory running north - south, the full length of the building (see appendix C). The system involves three corridors, one which is permanent in its construction, the second is determined by adjacent partitions, and the third is an open space largely perceived as corridor.

The permanent corridor is located on level +5. This corridor runs the length of the production / drawing office wing, reception gallery, and the administrative wing. It terminates at junctures to the flexible production wing, with staircases leading to the production floor. Roughly centered to this corridor is the main stair leading to the production floor. While on axis with the building entrance and reception gallery, entrance to the corridor and main stair is limited. Staff and registered visitors enter the glazed volume by passing through an opening in a structural wall, the determining point between public and private areas. Open to the production floor below, this space becomes the main interaction space within the building, facilitating the connection of all departments within the team.

The other two corridors exist on the production floor at level 0. The smaller of the two lies underneath the glazed corridor, between the structural supports which frame the winged roof structure and the concrete elements retaining the building to the site. This corridor facilitates movement between the stores and building systems, tying them back into the production floor. The larger corridor runs at center, the length of the production floor. Its acknowledgement as a corridor is based on its path through the floor space, determined by the path of systems conduits cradled in the structure above. The structural supports limit the actual usable space by the production departments, and it is left open to facilitate movement between the departments and the transport of sub assemblies to the race/test bays.

Speed in its ability to promote an unsettled balance and to be observed while momentarily stopping, work together in the design of the factory, each forcing an acute awareness of the other. The unsettledness of the angle of certain building elements are given perspective only as they shift or change in direction, ending in doorways, walls, glass facades, partitions, staircases. The external force lines from the site materially fragment at the building envelope and are brought into the building via permanent wall installations which coalesce to form motion scoops. It is at these areas where the speed and motion of that which surrounds can be detected; a sort of 'freeze frame' of activity. The glass corridor ends in canted full height glazed walls, perceptually extending the experience of continuation along the axis, while making a determined shift, a momentary pause in the trajectory. The continuation of the exterior wall system of the western anchors of the car bays and research and development departments into the interior create another scoop, conceptually shifting and shielding movement away from the building's downward slide into the valley. Openings at the northern ends of these anchors then pick up the movement deflected off the wall surface and continue it, visually, along less precarious paths.

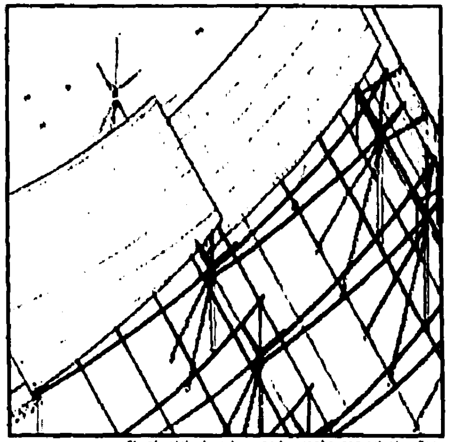
factory as car

As the site is a circuit, so the factory is a car. As discussed previously, there are certain forces which act upon a site or a circuit, causing or enabling the building or the car to perform. Design mechanisms exist which relate to both how this factory is to perform on its site and its correlation to the design and performance of the Formula One car. Figurative and literal connections between the factory design and the design of the car are used to emphasize the relationship between industrial architecture and its manufactured product.

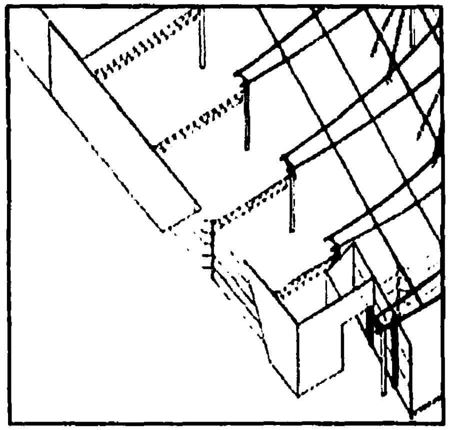
The aerodynamic design for a Formula One car can be separated into three constituent systems of structural organization and their connection to create a whole, whether it be parts of the car to one another, or parts of the car to the circuit: the monocoque, the suspension system and the wing. The structural organization of the factory utilizes these same three systems in the design of a complete building intrinsically connected to its site.

Monocoque construction, in which the finished surface acts as the structure, requiring no additional structural framework, is employed throughout the factory in the form of structural glass or composite fibreglass panels. Glass or fibreglass panels in either 2 x 4, or 1 x 2 metre dimensions wrap the building in a system which allows for privacy, natural light and ultimate flexibility. Panels of clear glass, frosted glass or fibreglass can be interchanged to the specifications of each programmatic department. These structural panels are fixed to the concrete subfloor by steel brackets, the edges sealed by gaskets. The panels are stacked atop one another, with only minimal horizontal steel stripping as a welding surface for the steel brackets, and continue to the roof. While this system is utilized throughout the factory, on the production floor monocoque construction fills the void between structural members which support the roof, therefore correlating the idea of the monocoque to the suspension system in a car, or how the building connects to the site.

M A N U F A C T U R I N G   S P E E D



Structural steel masts supporting roof over production floor



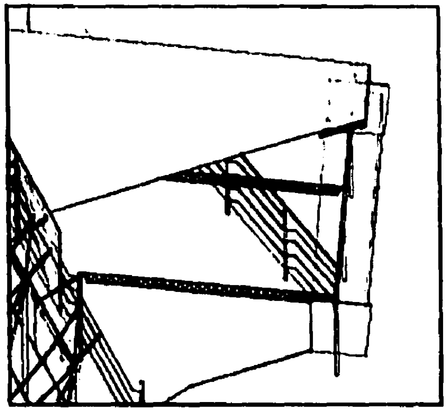
Brick plate wall of Race/Test bays

The suspension members of the building, or the connectors of the building to its site, exist in several forms. The first and most dramatic suspension system of the factory is the double row of masts which support the roof, enclosing the whole of the production floor. The second system of structure, on which the building is suspended is the angular permanent walls which divide the internal space. A third system of suspension bridges the two elevated sections on the site's crown and supports the protruding glass volume of the presentation theatre in the administration wing. A fourth system of external tension wires supports the covered glass entrance hall off of which is suspended the steel entrance grate.

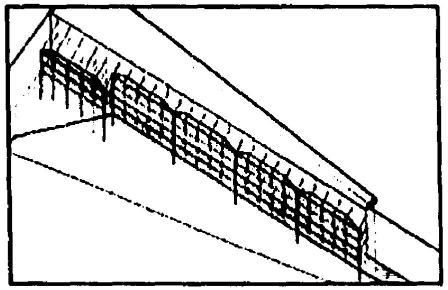
The structural steel masts, rising upwards of 10 metres on the eastern elevation not only support the double winged roof but make up the basis for the internal grid, its relationship to all of the other building elements, and the structural potential for the building's expansion. Each mast column supports a steel wishbone which in turn supports the surface membrane creating the inverted wing form of the roof. Three parallel rows of mast supports form the double wing of the roof, and create the large open volume of the production floor. Natural light is brought down into the production departments from clerestory windows located at the underside of the roof surfaces and supported by the thin, graphitic iron compression members of the masts.

Permanent internal structure is found in the steel supported brick plate walls which bring the external force lines into the building creating main programmatic divisions on the production floor as well as in the production / drawing office and administration wings. As mentioned above, these walls help to direct movement by creating thresholds and motion scoops within the building, separating public from private spaces on level +5 and organizing the structure of the western anchors on level 0. Columns with triangular angle arms support horizontal steel purlins onto which are fastened aluminum fired brick plates. The brick plates complete the finished side of the wall, while the structural members and connections remain visible from the other.

The western side of the administration wing is supported by four stainless steel columns. These columns elevate the protruding glass box of the presentation theatre from the ground plane, which naturally exists as a depression between



Administration wing - Presentation theatre



Tensile structure of entrance hall

the two higher land forms comprising the crown. Visually this connection of the building to the site is the most temporal, making symbolic reference to the transient connection of tyre to circuit.

The fourth structural system suspending the building on the site is found in the tensile system which supports the glazed entrance hall. The entrance hall exists as a separate structural system from the panel system enclosing the rest of the envelope. Extending on tapered steel beams from one of the permanent interior walls the glazed roof of the entrance hall extends outwards ending in a hanging glass wall. The structure of this glass wall is on the outside of the building and holds the glass in place with a system of small steel members and cable stays creating a type of removed space frame. The structure of the space frame is far enough removed from the surface of the glass wall to create a covered walkway. Its structure is supported through the steel grate which acts as a bridge between the building edge and the site, and forms the foot path of the walkway.

The defining visual signifier of the factory on the site is the stainless steel clad curve of the double winged roof (see appendix B). Rather than existing as a structural system of its own (it is dependent on the mast structure indicated above), it exists as a mechanical aid to the functioning of the space (its role is in the passive distribution of air movement by use of the Venturi effect). It exists as an integral form to the functioning of the factory space and signifies one of the most important elements of a car's aerodynamic performance and ultimate success — downforce; and a key element by which to obtain it — the wing.

If you imagine a bird flying you can instantly conceive the motion of its wing. It creates a downward curve. The effect which gives this wing lift has to do with the relative speeds and densities of moving air above and below the curve of the wing. At a very basic level, lift is created when these two separated masses of air come back together at the rear of the wing. The same idea is applicable to the wings of a Formula One car, but where the bird's wings make a downward curve, the car's wings make an upward curve. The result is negative lift, or downforce. Rather than becoming airborne the car is aerodynamically connected to the circuit upon which it races. In terms of the building, the visual representation of this wing connects the factory to its site.

than becoming airborne the car is aerodynamically connected to the circuit upon which it races. In terms of the building, the visual representation of this wing connects the factory to its site.

Visually the double winged roof has as much of a structural role in anchoring the building to its site as do the structural masts which support it. The western wing at a more shallow curve meets the higher eastern wing at the central mast column, separating the large axial surface of the form and enabling greater integration with the site. The wings skirt the topographical mass of the site connecting the separate levels of the factory into a whole and enabling tall interior heights. The wings seem to hover above the surrounding clerestory and due to glass topped partitions in the interior, the effect is uninterrupted. As the overall unifying element the winged roof brings together many ideas espoused in the factory design to create a whole. It connects the forms of the building together and it connects these forms to their site. It points towards conceptually infinite expansion with the guarded awareness of the unsettled balance of the industry and the potential for imminent change.

Through the design of this factory, "as a car", industrial building, once acknowledged only for its manufactured product, is shown to be a partner in the conveyance of a technological aesthetic through its own form and function. The form of the building is designed not only to function in the sense of performing the necessary requirements to fulfill the fabrication of a product, but also to function in the consideration of the building as a product of such industry. To these ends, the form, structure and materiality of the factory contribute not only to the industry of car manufacture but to the continuation of technology transfer in architecture: forms engineered for aerodynamic use in the racing car are transferred to architecture to function in the efficient distribution of air within the building; improvements to hardened steel (graphitic iron) for use in car manufacture are transferred to architecture providing for attenuated structure that combines the compressive strengths of iron with the tensility of steel; composite materials engineered for monocoque construction are transferred to architectural applications of structural cladding.Advances and improvements to materials, techniques and processes within the engineered environments of industrial manufacture are transferred to architectural design, producing a new type of modern architecture, capable of participation within a technological culture, and not just its symbol.

M A N U F A C T U R I N G   S P E E D

machine, modern, speed

It has been the aim of this project to give reason or purpose to an architecture of industry and to discuss it as warranting all of the accolades usually reserved for more traditional forms of architectural practice. Architecture for industry exemplifies the ideas of the machine aesthetic, espoused years ago yet never fully realized. It most fully reflects the challenges and impetus established by Modernist theory in its striving for an architecture demonstrative of its place in a technological world. It brings together the worlds of technology and design to create buildings capable of flexibility, standardization and high-tech materiality without sacrificing architectural process or vision.

As such, industrial architecture serves as a stage for the promotion of architecture as industrial design, integrating and updating accepted design tenets of architecture with the constantly accelerating speed of technological advance. The society of the machine age has been surpassed by the societies of the electronic age, the computer age and the age of information and yet architecture has been traditionally and erroneously exempt from the same evolution. As each subsequent technological era is experienced, the nature of the machine, its position in society and its position as marker of time changes. The catalyst for architecture representative of its place in time is therefore dependent on the nature of the machine.

The Formula One industry has reached far beyond the machine age of the Modern theorist, as have many other fields under the broad spectrum of industrial design. And while architecture is only starting to catch up to it, the perpetual acceleration and speed of the technological era continues unabated. The provision of an architecture representative of its time, the society it serves, the science it utilizes, and the industry it houses is the consequence of this project. It only serves as a glimpse into the fleeting nature of change and the undoubted obsolescence attributed to speed.

To paraphrase Jacques Cochin, if we look closely at both Formula One and the making of architecture, we find that racing cars and buildings conjure up in our minds many differences and many similarities. Together they provide us with a new way of seeing, and understanding our times.[57]

MANUFACTURING SPEED

endnotes

1 Reyner Banham, *Theory and Design in the First Machine Age*, p. 102.

2 Banham, p. 104.

3 Banham, p 102.

4 Banham, ibid.

5 Kurt Ackermann, *Building for Industry*, p. 40.

6 Ackermann, ibid.

7 Ackermann, p. 64.

8 Banham, *Age of the Masters*, p. 74.

9 Ackermann, p. 104

10 Deyan Sudjic, *Norman Foster, Richard Rogers, James Stirling*, p. 43.

11 Ackermann, p. 212.

12 Ackermann, p. 67.

13 Colin Amery, *Architecture, Industry and Innovation*, p. 10.

14 Banham, *Design By Choice*, p. 84.

15 Banham, *Age of the Masters*, p. 14.

16 Banham, ibid.

17 Ackermann, p. 148.

18 Sudjic, p. 49.

19 Banham, *Theory and Design in the First Machine Age*, p. 103.

20 Chris Abel, *Renault Center Swindon, 1982*.

21 Banham, p. 129.

22 Sudjic, p. 33.

23 Banham, p. 278.

24 Banham, p. 328.

25 Ackermann, p. 211.

26 Banham, p. 327.

27 Banham, p. 329.

28 Banham, p. 327.

29 Banham, Ibid.

30 Banham, p. 328.

31 Banham, Ibid.

32 Charles Jencks, The Post-Modern Reader, p. 11.

33 Jencks, Ibid.

34 Abel, Renault Center Swindon, 1982.

35 Sudjic, p. 91.

36 Banham, Design By Choice, p. 90.

37 Ackermann, p. 67.

38 Peter Buchanan, *High-Tech: Another British Thoroughbred*, The Architectural Review, p. 16.

39 Sudjic, p. 17.

40 Martin Pawley, p. 90.

41 Alan Henry, The Quest For Speed.

42 Henry, Ibid.

43 Jonathan Glancy, *The Eagle Has Landed*, The Architectural Review, p. 33.

44 Sal Incandela, The Anatomy and Development of the Formula One Racing Car from 1975.

45 Jonathan Noble, *The Appliance of Science*, Autosport, p. 118

46 Henry, p. 30.

47 Helen Lawton Smith, The Location of Innovative Industry, p. 2.

48 Smith, p. 10.

49 Smith, Ibid.

50 Smith, p. 16.

51 Banham, Theory and Design in the First Machine Age, p. 327.

52 Jacques Cochin, *Haute Couture*, F1 Racing, p. 85,

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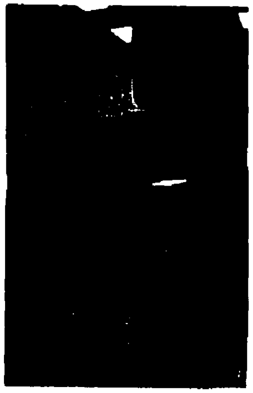
cover page	_IWR Torque: IWR Group Newsletter_. Summer 1998. p. 4.
page 4	Darren Heath. _Stewart Ford: The Inside Story of a New Grand Prix Team's Race to the Formula 1 Grid_. Supplement. 1997. p. 29.
page 14	_IWR Torque: IWR Group Newsletter_. Summer 1998. p. 4.
page 27	Bernard Asset. _F1 Racing_. December 1998. p. 61.
all other photographs	K. Dow.

appendices



appendix A

architectural program

level 0

model shop / patent rooms / carbon fibre composites

model shop	approx. 144 m²
patent shop	approx. 104 m²
patent workroom	approx. 104 m²
jo mach (5 point milling machine)	approx. 143 m²
carbon fibre clean room	approx. 260 m²
carbon fibre inspection	approx. 176 m²
carbon fibre trim room	approx. 156 m²
carbon fibre bonding	approx. 156 m²
autoclaves	approx. 488 m²

systems assembly

hydraulics	approx. 104 m²
electronics	approx. 176 m²
gearbox	approx. 195 m²
sub assembly	approx. 104 m²
parts cleaning / crack testing	approx. 78 m²

race / test bays

race bays	approx. 196 m²
test bays	approx. 152 m²
set up patches	approx. 128 m²
race equipment store	approx. 96 m²
race bay store	approx. 40 m²
engine supplier room	approx. 32 m²
chief mechanic offices	approx. 42 m²

metal / machine shop

metal shop	approx. 420 m²

machine shop	approx. 468 m^2
material store	approx. 66 m^2

research and development

research and development	approx. 405 m^2
prototype room	approx. 72 m^2
analytical equipment store	approx. 81 m^2

storage

parts store	approx. 300 m^2
composites store	approx. 450 m^2
tub store	approx. 260 m^2
fuel store	approx. 54 m^2

graphics

graphics department	approx. 176 m^2
graphics store	approx. 154 m^2
canteen	approx. 300 m^2
shipping and receiving	approx. 54 m^2
building systems	approx. 104 m^2

level -3

gym	approx. 75 m^2
men's locker room	approx. 130 m^2
women's locker room	approx. 45 m^2

level +6

design / operations

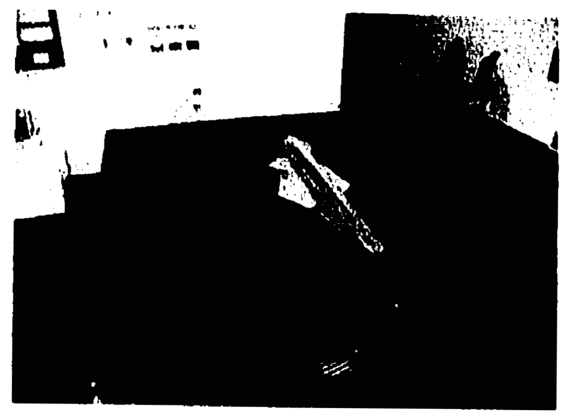
technical director	approx. 45 m^2
technical director's secretary	approx. 24 m^2
drawing offices / aerodynamics / electronics / track data / race engineering / calculations / simulations	approx. 396 m^2
print room	approx. 66 m^2
small offices	approx. 30 m^2

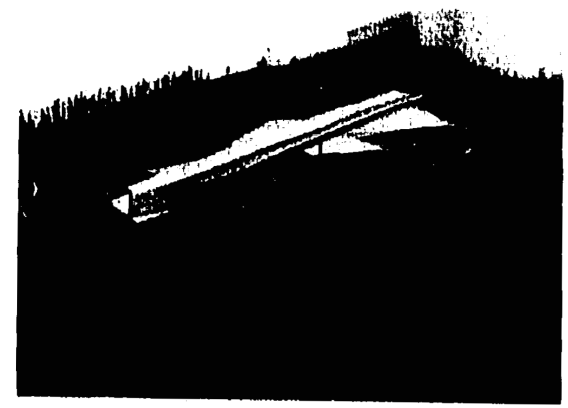
M A N U F A C T U R I N G   S P E E D

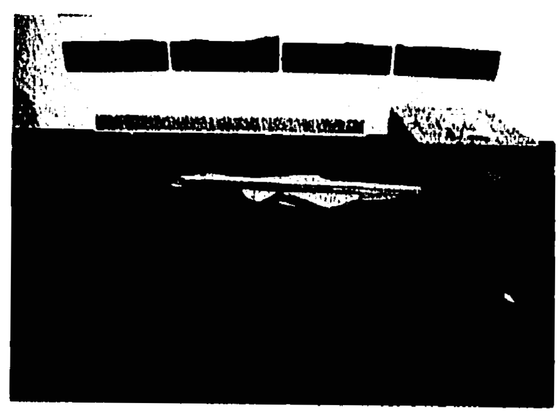
operations manager	approx. 42 m²
operations manager's secretary	approx. 27 m²
<u>production</u>	
production offices	approx. 156 m²
meeting room	approx. 56 m²
<u>marketing / public relations / finance</u>	
marketing offices	approx. 104 m²
public relations offices	approx. 100 m²
presentation theatre	approx. 136 m²
finance offices	approx. 50 m²
<u>administration</u>	
director	approx. 84 m²
director's secretary	approx. 30 m²
reception	approx. 50 m²
gallery	approx. 33 m²

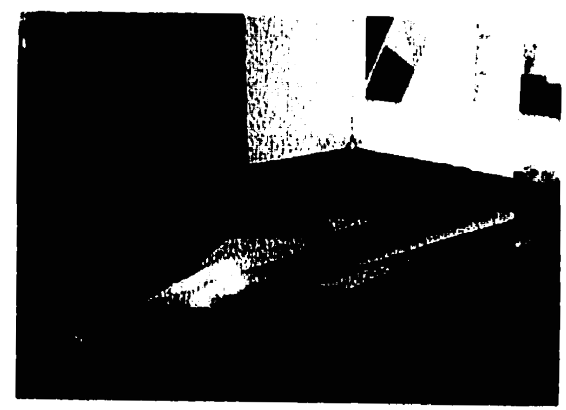
appendix B

model photographs





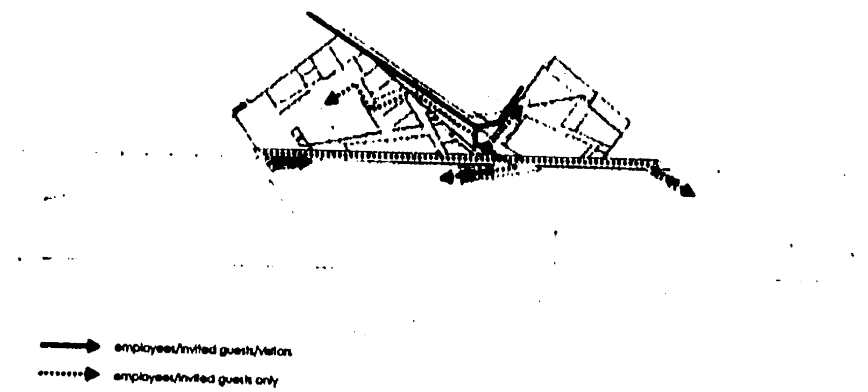




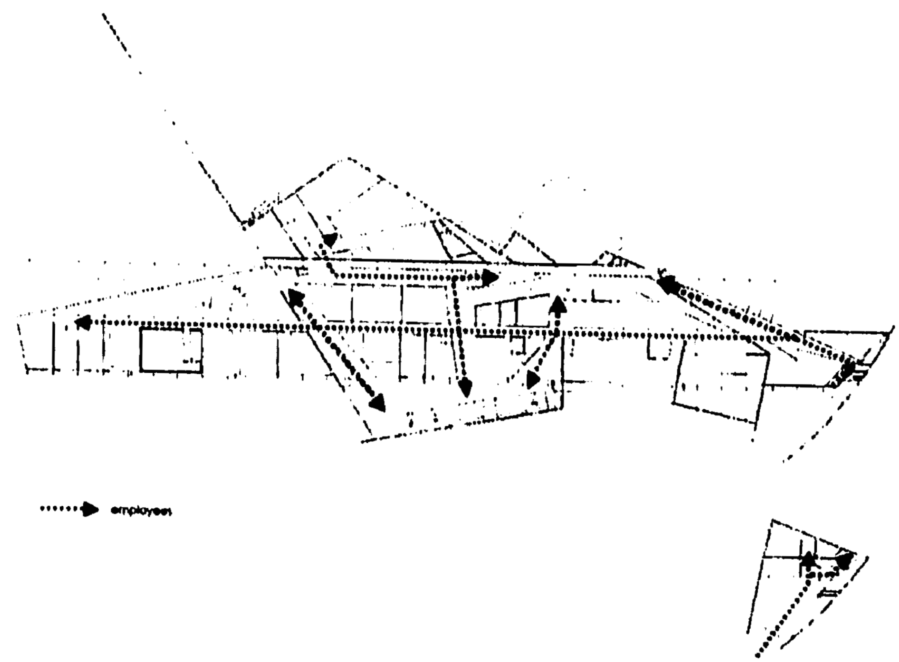
M A N U F A C T U R I N G   S P E E D

appendix C

employee/invited guest/visitor circulation on level +5



employee circulation on production floor (level 0) and level -3



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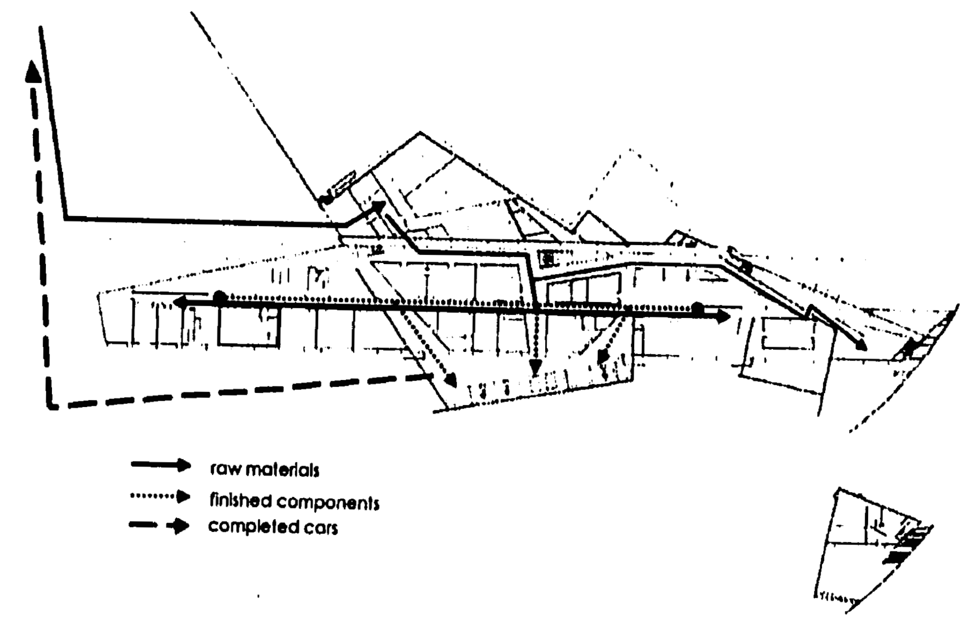
raw material/component/car circulation on level 0



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