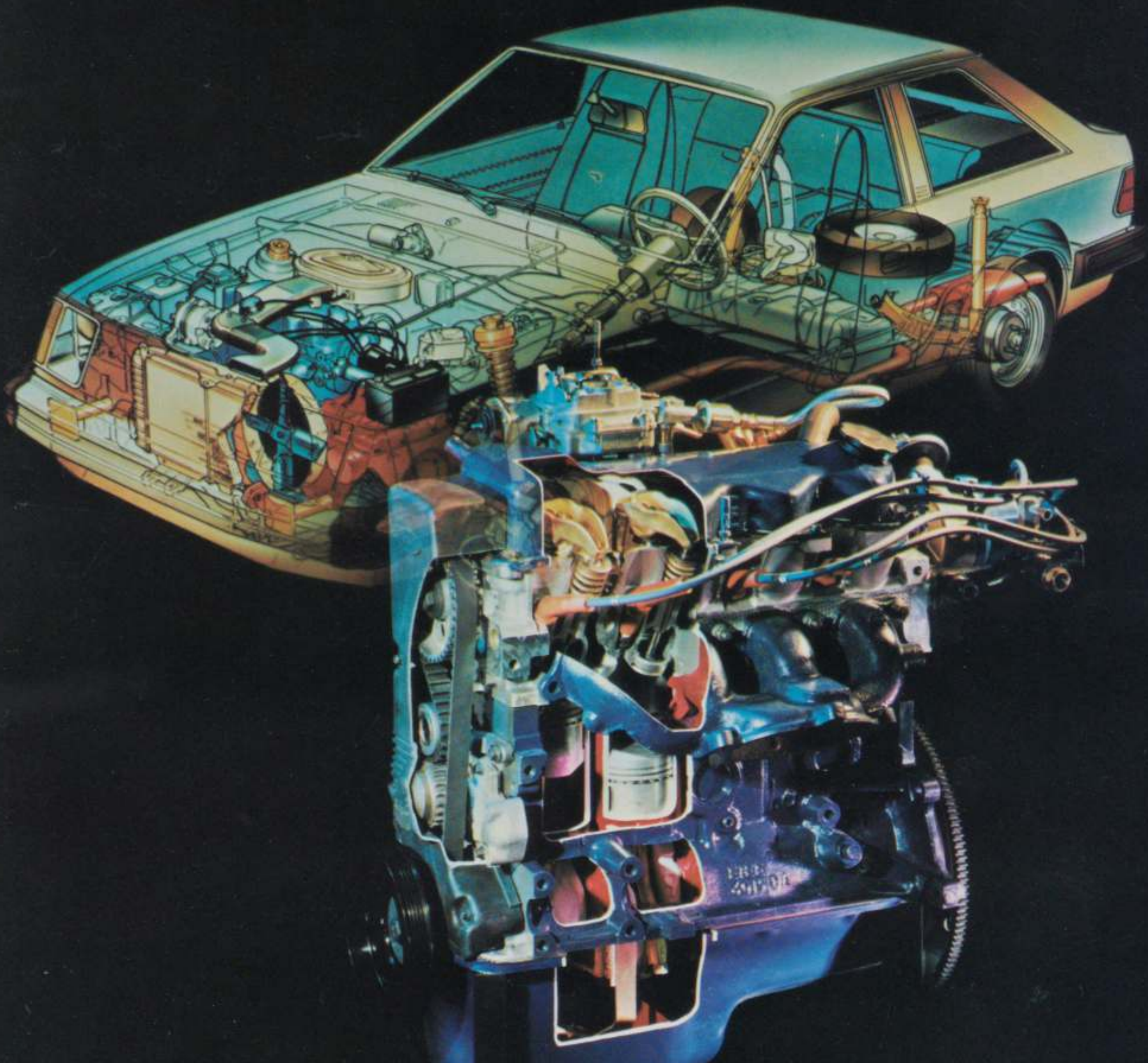
WORLD CAR

A dramatic automotive concept for the '80's



Ford

THE COVER

The high technology of Ford Motor Company's new World Car is represented by the montage on the cover—a photo of the new CVH engine in a special cutaway version that displays its innovative engineering features, and a schematic illustration highlighting the car's front-wheel-drive and independent rear suspension.

"We have applied the best brains and talents from this wide world of Ford to enable us to manufacture the very best North American small car ever."

Philip Caldwell
Chairman of the Board
Ford Motor Company

During the past four years, Ford Motor Company has marshaled its worldwide design and engineering expertise to develop an exciting, all-new car absolutely right for these times.

Starting with a fresh piece of paper, a bundle of ideas and the most modern automotive technology available, Ford people have produced a new small car that delivers good fuel economy, surprising interior roominess—and the kind of ride and handling that puts the fun back into driving.

Because it is the result of the knowledge, experience and hard work of Ford people all over the globe, we call it Ford's World Car. But the car sold in North America has 95% of its parts produced here, and it is built here. The know-how is worldwide. The muscle is American.

The car carries two nameplates in the U.S. and Canadian markets —Ford Escort and Mercury Lynx. There are some differences between the two, as there always are between Ford Division and Lincoln-Mercury Division vehicles. There also are differences between the North American Escort and Lynx and a sister car, also called Escort, built and sold in Europe. But each qualifies unreservedly as a Ford World Car.

The cost to bring Ford's World Car to market has been set at $3 billion—enough dollar bills to circle the globe at the equator 11 times.

Setting the stage for Ford's World Car

The actions leading to the development of Ford Motor Company's World Car were triggered by a series of events that began in the mid-1970's.

First came the 1973-74 oil embargo, which quadrupled the price of imported crude oil. The embargo sparked a national energy crisis, underscored by shortages of gasoline and fuel oil in many parts of the country.

Long lines sprang up at gas stations—and fuel prices began a rise that would shock Americans into the realization that plentiful, 30-cents-a-gallon gasoline was gone forever.

Almost overnight, sales of larger cars plummeted. Miles per gallon suddenly became uppermost with car buyers, and the market tipped sharply toward smaller vehicles, which used less gas.

Although the embargo was lifted in mid-1974, its impact magnified an economic downturn that had begun earlier in 1973. The recession continued into 1975, keeping auto sales well below normal trends.

By 1976, the economy would regain its vigor—and the auto industry its usual balance of large-to-small-car sales.

But in December 1975, Congress passed a law that irrevocably staked out a course toward smaller cars in all segments of the North American automotive market. Called the Energy Policy and Conservation Act, the law set a scale of fuel-economy standards that rises each year through 1985.

The standards have a name—Corporate Average Fuel Economy, or CAFE for short. Each auto company's CAFE is calculated on the basis of the mileage delivered by all the various-sized cars it sells in a specific model year.

CAFE standards took effect with 1978 model year cars (introduced in the fall of 1977) and were set at 18 mpg. By 1985, the requirement would be 27.5 mpg.

The only way to meet that level was to build smaller, more fuel-efficient cars—and Ford engineers, researchers, product developers and designers began the massive, awesomely expensive task.

Particular attention was given to an innovative engine idea that had been under development by Engineering and Research Staff's powertrain research group since 1972. The engine would prove to be the key element in bringing Ford's World Car to market.

Meanwhile, something was happening on the other side of the Atlantic that would further the World Car concept.

The Ford companies in Europe, whose markets already were attuned to smaller cars because of higher gas prices, narrower roads and shorter average travel distances than in North America, were putting the final touches on a brand-new small car—the Fiesta.

Introduced to the public in September 1976, Fiesta was nimble, peppy, seated four in comfort, and delivered excellent fuel economy. It was an instant success—and went on to become the best-selling new car in the history of the European automobile industry.

Several of Fiesta's virtues sprang from its front-wheel drive. In addition, its engine was mounted crosswise—or east-west, as the engineers like to say—rather than north-south, which is usual in rear-wheel-drive cars. East-west mounting eliminates the need for a long hood or front overhang (the body area from the front wheels to the front of the car). That means the passenger compartment can be roomier.

The short front end pays another bonus: it cuts the weight of the car by reducing the amount of sheet metal. If there is a single factor automotive engineers and product designers seek in trying to boost fuel economy, it is the elimination of pounds. The less a car—or anything, for that matter—weighs, the less energy it takes to get it moving.

European Ford executives were so pleased with Fiesta that they immediately proposed building a somewhat larger companion car that would incorporate—and, if possible, improve on—Fiesta's many strong points.

The program for the new car, which would bear the developmental code name Erika, was approved by corporate management and introduction was set for the fall of 1980.

Meanwhile, Ford North American Automotive Operations (NAAO) was well along on its task of introducing new and more fuel-efficient cars, such as Ford Fairmont and Mercury Zephyr. It also was deeply involved in completely redesigning Mustang, Capri, Ford LTD, Mercury Marquis, Thunderbird, Cougar XR-7, Lincoln Continental, Mark VI, and the entire line of F-Series light and medium trucks. The undertaking was the largest and costliest in the history of Ford Motor Company.

Still, there was more to come.

NAAO was pressing ahead on a new small car unlike any it had ever built—a car that would use the latest technology to demonstrate that economy, efficiency and overall excellence can still go hand in hand with the joys of motoring.

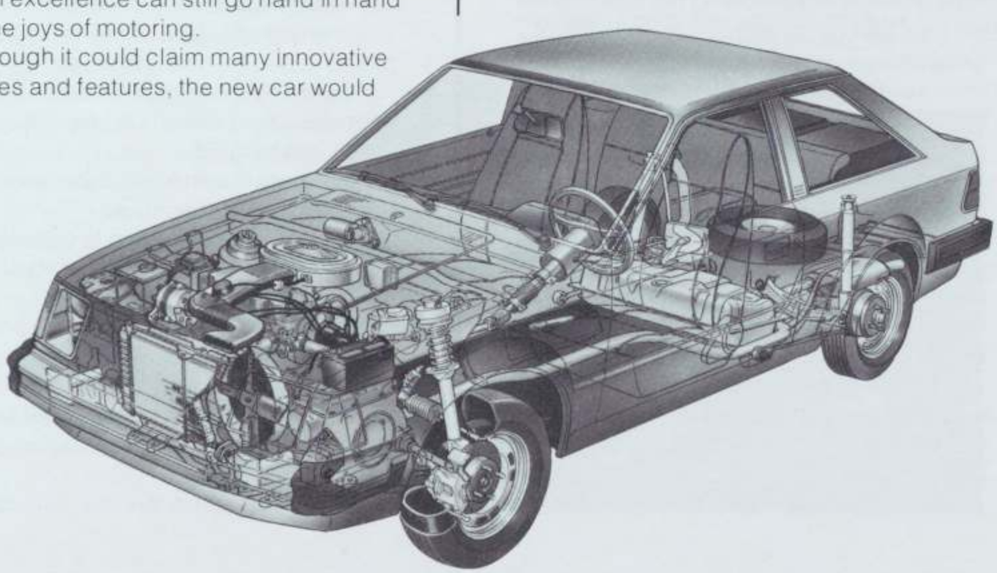
Although it could claim many innovative qualities and features, the new car would have as its most significant element an advanced-concept engine—a power plant offering economy, performance and low exhaust emissions.

The exciting new engine was the key to realization of the World Car concept. The basic design of the engine was proved out in Ford's prestigious Research Center in the United States, but it was developed and engineered for production by the Ford companies in Europe, which have unparalleled records as builders of both small engines and small cars sold on the Continent and in more than 100 countries around the world.

The new engine would be built both in Europe and in the U.S. And it would power both the new Ford car in Europe and the new Ford car in North America.

Having drawn on its best automotive talents and skills on two continents to produce the new engine, it was only logical for Ford corporate management to take the next step: Produce the North American and European cars under a joint program which would allow flexibility for varying appearance, performance and regulatory needs in the two markets.

And so in mid-1977 Ford Motor Company's World Car moved from concept toward reality.



The project is launched

Seconds after he asked his question, a data communications specialist at Ford's Engineering Computer Center in Dearborn watches an answer from Ford of Britain march across a screen.

Ford European Automotive Operations (EAO) was approximately one year ahead of Ford North American Automotive Operations (NAAO) in developing the Erika, as the Ford World Car was code-named in its design stage. EAO, therefore, became the initial source of information in defining the vehicle's concept.

American engineers went to Europe to develop vehicle assumptions for the NAAO program directly from EAO assumptions. "Assumptions," in this case, refers to all the dimensions and performance characteristics that make up a vehicle, such as interior and exterior measurements, wheelbase, suspension, acceleration, etc.

The extensive interaction between the two Ford operations required an exceptional communication system. Its key components were:

- A transoceanic cable hook-up and data-processing system that uses the most sophisticated commercial engineering computer available (the CYBER 176).
- A liaison task force of people from the engineering, manufacturing, product planning and purchasing areas.
- Quarterly meetings of chief engineers, alternately held in the U.S., Germany and the United Kingdom.
- Frequent cross-Atlantic journeys by engineers to resolve issues.
- Installation of a system to transmit facsimile copies of written material via telephone lines.
- Establishment of a special mail-pouch system (in cooperation with the British and German post offices, scheduled airlines and Ford's own intercompany mail service) that cut mail delivery time from the usual 10 days to three or four.

The key element in this international effort was the engine, an advanced concept using innovative combustion techniques. It originated in Ford's Research and Engineering Center in Dearborn, where the powertrain research group was seeking a new, lightweight, four-cylinder engine that would provide good economy and performance and low emissions.

Because of its long-term experience with four-cylinder engines, EAO was assigned to develop and engineer the new power plant.

The European engine specialists worked closely with the U.S. engineers and, via a virtually instantaneous data telecommunications system, shared the massive computer technology of the company's new Engineering Computer Center in Dearborn.

For its part, NAAO was responsible for developing the hardware for emissions control, cooling, accessory drive, ignition system and other related functions.

The resulting engines, although built in different countries on different continents, are basically the same.

Because of its experience with automatic transmissions, NAAO was assigned to design, develop and manufacture a new automatic transaxle (ATX) as an option.

NAAO powertrain engineers came up with a highly efficient design unique enough to warrant a patent of its own. The ATX has features found in no other automatic transmission on a front-wheel-drive vehicle anywhere—and it is the world's first automatic designed to approach the fuel economy of a manual transmission.

The NAAO four-speed manual transmission, based on the Fiesta's, has several notable characteristics, including tapered roller bearings for improved bearing life, a single-rail shift mechanism requiring no adjustment, and wide-ratio gearing for optimized performance and fuel economy. It will be produced by Toyo Kogyo, a Japanese company partially owned by Ford.

EAO and NAAO suspension designs are similar. The MacPherson front suspension and independent rear suspension (IRS) design systems reflect EAO's experience with sophisticated small-car suspensions.

The split-diagonal braking system is common in design between EAO and NAAO.

With minor differences, the interior dimensions of the two are the same, reflecting EAO's lead and experience in small-car packaging.

Although the overall NAAO "package" is based on the EAO design, sheet metal and body parts of the two are tailored to meet the needs of the different markets. For example, the NAAO version has to meet federal safety, damageability, emissions and noise standards. In addition, NAAO models have additional comfort and convenience options, including air conditioning, power steering, automatic transmission and entertainment systems.

The Engineering Computer Center's sophisticated equipment also was central in analyzing body structure, with a space-age technique known as Finite Element Structural Analysis.

Using a "light pen," a research engineer summons a computer-graphics model of Ford's World Car to a video screen. The technique was used in developing structural integrity and maximizing fuel economy.

Using visual display terminals resembling a television set, engineers can design a mathematical model of a vehicle, then put it through simulated road tests to measure the strength and durability of the potential design. More than one trillion mathematical computations were made in developing the Ford World Car before the first prototype was built.

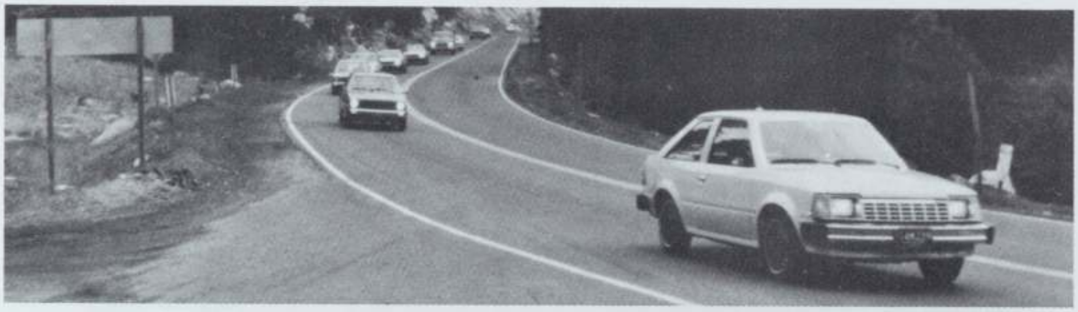
Another advanced computer technique —Modal Analysis—enabled engineers to predict vibration characteristics during the design stage, thus eliminating much time-consuming and expensive prototype testing at a proving ground.

Another remarkable new analytical technique was used in perfecting the design. Double-pulse laser holography takes three-dimensional photographs of the slightest vibration in a component. These pictures are "played" back so an engineer can see a before-and-after view of a surface change—at the same time!

During its development, the World Car got plenty of on-the-road testing, too. The NAAO version was subjected to 1,250,000 miles of engineering, development, durability and emissions testing under weather conditions ranging from below-zero temperatures in northern Minnesota to a sand-blown 100-plus in the Arizona desert.

It also underwent 4,500 hours of corrosion testing at the company's Arizona Proving Ground and in a new environ-

Race-car champion Jackie Stewart (left) helped evaluate Ford's World Car on an engineering trip in Florida.

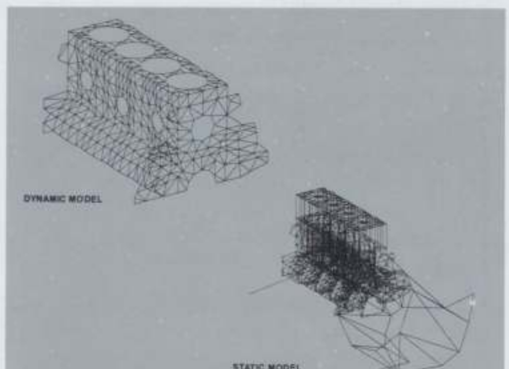


mental test chamber in Dearborn's Body Engineering Building. That equals more than five years of corrosion exposure in regions where salt and other chemicals are used to clear roads of ice and snow in winter.

From the outset of the program, durability, quality and reliability received special emphasis. NAAO teams visited EAO to get Fiesta field experience data and to construct a cross-index of EAO/NAAO warranty listings. The Fiesta experience was used to establish reliability objectives for the World Car, when components had similar design.

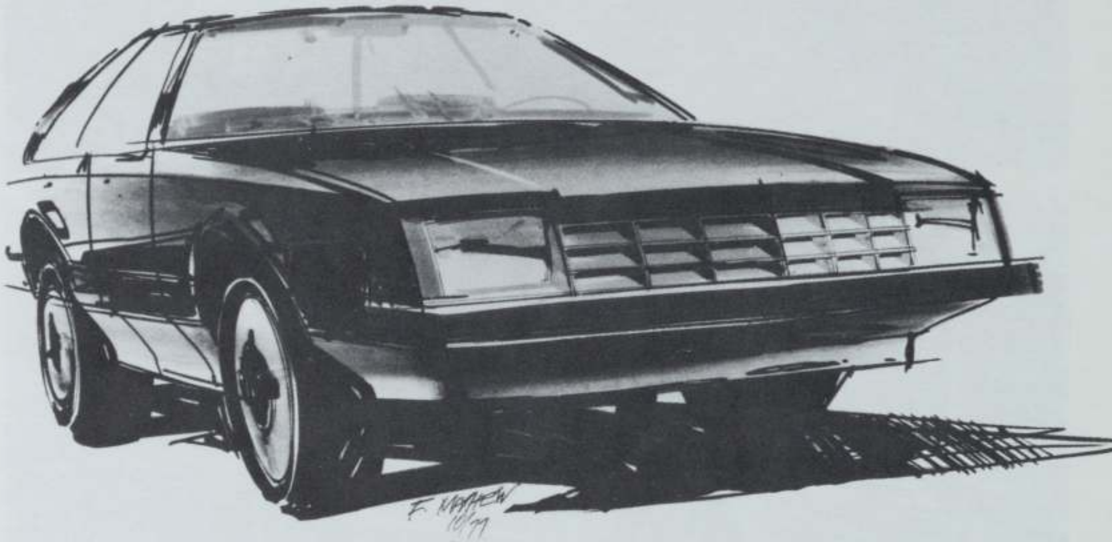
EAO durability results from the Lommel Proving Ground in Belgium and NAAO results from the Romeo and Dearborn (Mich.) Proving Grounds were regularly exchanged so the combined experience would result in a better World Car, wherever it is built.

A caravan of prototype Ford Escort and Mercury Lynx cars (top) moves along a Northern California highway at dawn. Above: the steep hills of San Francisco provide a real-world testing ground for the new cars.



Engineers studied computerized models of the World Car's new four-cylinder "hemi" engine in both dynamic (under stress) and static modes to develop the optimum balance of strength and weight.

Shaping the car of the future



Early design sketch was dramatic if not really practical. Still, it did lend some styling notes to the World Car design that ultimately emerged, notably the sloping front and recessed headlamps.

In keeping with the overall approach toward Ford Motor Company's new World Car, designers, engineers and product planners from European and North American automotive operations held several joint strategy sessions in 1977.

From these meetings emerged several key objectives: Give the car an identity of its own. Make it stand apart—not only in appearance but in all the ways an automobile's character and quality are measured by the public. Above all, let it clearly demonstrate that a small car can provide far more than basic, unrefined transportation.

Separate design studies were launched at Ford studios in three locations—Dearborn, Mich.; Merkenich, Germany, and Turin, Italy. Each design center was to develop three versions of a sedan—a hatchback, a notchback and a "three-box" approach, which accented hood, roof and rear-deck design.

Work at the U.S. Design Center in Dearborn was headed by the same team of four design executives that had developed the highly successful new Mustang and Capri introduced in the 1979 model year. Two of the design chiefs had had extensive experience in Europe, where they were responsible for the design of the Fiesta and the European Granada.

While there was clearly a spirit of competition among the three studios, designers freely exchanged visits, drawings and specifications on their respective projects. Each studio even duplicated the others' cars to maintain a continuing evaluation of how things literally were shaping up.

By the summer of 1977, Ford was ready to take its ideas to its future customers so they could help design the car of the future. This was done by means of market research clinics at which the models produced by the three studios were shown to selected cross-sections of small-car buyers.

The NAAO versions were shown in Los Angeles, San Francisco and Dearborn. The models from Merkenich and the Ford-owned Ghia Studio in Turin were shown in Nuremberg and Dusseldorf, Germany; Lausanne, Switzerland, and London and Manchester, England.

The NAAO models were taken to Germany and the European versions were brought to America for additional clinics. Participants even were flown from England to Nuremberg to insure representative European reaction to the designs.

At the clinics, which lasted up to three hours, participants rated such factors as exterior appearance, exterior size and proportions, interior space and convenience features. They also rated the models against competitive vehicles, which were displayed alongside the Ford models.

Both the NAAO and EAO models fared well in the research tests. And there was some special satisfaction in the fact that they were better received in Nuremberg than Germany's own Volkswagen Rabbit, one of the comparison vehicles.

The strong showing of both the EAO and NAAO executions enabled corporate management to permit some variation between the two versions. Each serves a different market, with somewhat differing tastes, differing needs and differing regulations to satisfy.

But if the two versions of Ford's new World Car were not to be identical twins, they certainly were fraternal ones. Genetically, if the term can be applied to motor vehicles, they are far more alike than they are different. Clearly evident in each is the same high level of worldwide automotive expertise and experience abundant in a global company such as Ford.

The final design of the NAAO version of Ford's World Car, set for introduction in the fall of 1980, was approved in April 1978.

It comes in two models—a three-door hatchback and a four-door liftgate. The World Car has a full-bodied, rugged look, yet its large window area and sprightly shape give it a bright, free-spirit flavor.

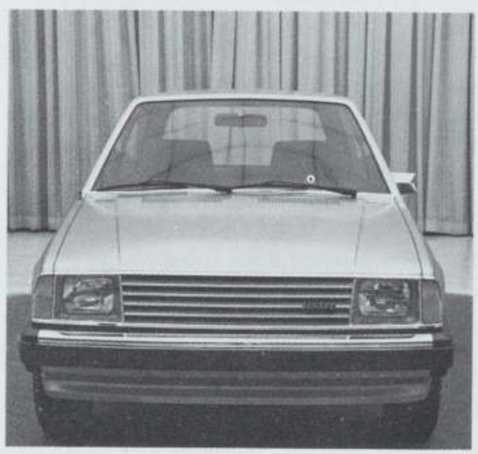
Some of its design features:

- A distinctive short rear deck with a functional "bustleback" appearance on the hatchback.
- A slant front end with a functional air-dam spoiler that makes the car extremely aerodynamic.
- A low beltline.
- Thin C-pillars.
- An overall "glassy" look (which gives good visibility).
- Bold wraparound tail lamps.

Among the new car's attractive interior features are its bucket seats. They provide excellent lateral support—in the tradition of European cars.

The interior is extremely roomy. Head, leg, shoulder and hip room are excellent.

This was one of the proposed versions of the Ford World Car shown to a cross-section of the public at market-research clinics.



Two of the car's most important engineering features—front-wheel drive (FWD) and independent rear suspension (IRS)—contribute to the interior roominess. FWD allows a flatter floor, while IRS permits the rear seat to be placed further back. It also allows the rear floor to be 2½ inches lower, providing more luggage space.

Another major factor in the design of the new World Car was aerodynamics, or Airflow Management, as Ford terms it. Designers had to make sure that air would flow over the body with high aerodynamic efficiency so the World Car would deliver

A market-research participant notes her opinion about the rear-end treatment of one of the models.

Going with the flow

Airflow Management—effectively managing the flow of air over a moving vehicle to minimize wind resistance—has become a key element in the design of Ford cars and trucks. The reason: Cutting air drag is the most cost-effective way to boost fuel economy.

It was once believed that drag had a negative effect only at very high speeds. But recent research has revealed that even at speeds as low as 50 mph, a 10% reduction in drag can produce a 5% increase in fuel economy.

Ford regards Airflow Management as an extension of the science of aerodynamics, which deals with all aspects of air flow—over, around, under and through the vehicle. The term Airflow Management reflects both the active nature of the development process and the elements beyond drag that are involved—vehicle lift, engine-cooling, the interior, and overall appearance.

Applying the Airflow Management process to Ford's World Car began very early in the program. Virtually every opportunity was capitalized on to integrate aerodynamic refinements into the car's body.

The refinements resulted largely from extensive wind-tunnel testing. Much of it was done with 3/8ths-scale models at the University of Maryland wind tunnel, but Ford also used a full-size clay model in airflow testing at the Lockheed Aircraft wind tunnel in Georgia.

Early testing helped determine the overall shape of the car and specifically resulted in the "bustleback" design of the backlight (rear window) and rear deck. This configuration is lower in drag by about 3% than a fastback or squareback design. And it offers the added advantage of keeping the back window cleaner than the other designs because of the way the air flows over it.

the best possible mileage as well as driving stability.

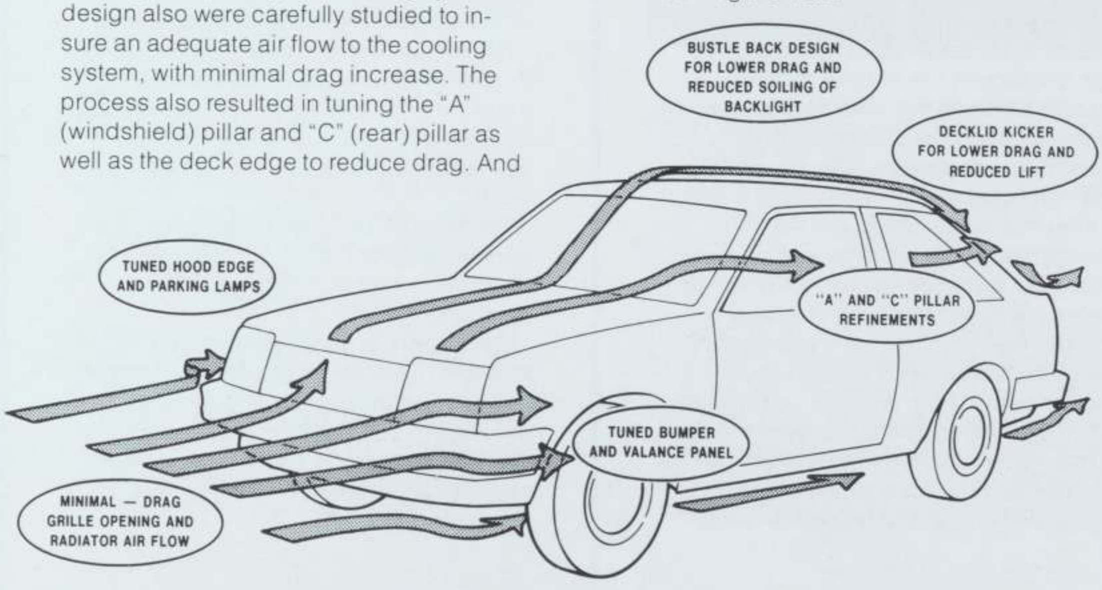
Three-eighths-scale clay models, full-size clay models and prototypes were tested in wind tunnels for nearly 500 hours. The effort resulted in numerous design refinements that cut air drag by 14%. That reduction translated into a projected boost of one mile per gallon in Metro-Highway fuel economy.

The wind-tunnel testing also showed that the new car has an air-drag coefficient rating of .40—making it more aerodynamic than any of its major competitors.

The Mercury Lynx represents the final design that emerged from the North American World Car program.

Other wind-tunnel testing resulted in fine-tuning the hood edge, parking lamps, front bumper and valance panel under the bumper for better airflow.

The grille opening and cooling system design also were carefully studied to insure an adequate air flow to the cooling system, with minimal drag increase. The process also resulted in tuning the "A" (windshield) pillar and "C" (rear) pillar as well as the deck edge to reduce drag. And the designers and aerodynamicists gave the deck edge an upturned "kicker," which works in concert with several other changes to reduce vehicle lift, helping the car hug the road.



The CVH—an engine with fresh ideas

The heart of the new World Car is its high-technology, four-cylinder engine—the Ford Compound Valve Hemispherical (CVH) engine.

Its new combustion concepts make it the most fuel-efficient automobile power plant ever built by Ford.

The principal advantages of the overhead-camshaft, aluminum-cylinder-head engine are its excellent fuel economy and performance and its low emissions. But it also provides exceptionally low noise levels. It is quick, clean and quiet.

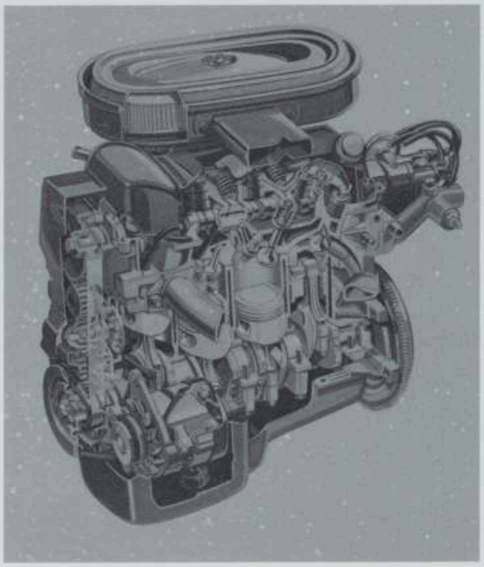
These were precisely the qualities Ford Motor Company sought when it formed an engine research team in the early 1970's to develop new concepts to meet the needs of the 1980's.

The group consisted of top people from every discipline of advanced engine development, including several who had been instrumental in making powerhouses out of stock engines for Ford's racing program during the 1960's.

The researchers considered a variety of options, then zeroed in on the classic hemispheric ("hemi") combustion chamber. The efficient hemi, long associated with large and powerful racing engines, offered many advantages. But major design challenges would have to be resolved, including the need for a single overhead camshaft, rather than the complex twin camshaft ordinarily used with hemi engines.

After intensive studies, the team developed—or, to put it more accurately, invented—a unique solution for which patents have been filed in the U.S. and Europe. The most important elements of the breakthrough are the hemispherically shaped combustion chamber, compound valve angles and contoured piston heads.

The machined hemisphere of the combustion chamber contributes to both the high power output and efficiency of the engine. A chamber of this shape, combined with the angling of the valves, makes it possible to maximize the valve size, thus allowing maximum air flow into the chamber—and resulting in greater power.



Cutaway drawing unveils the engineering wizardry within Ford's brand-new, four-cylinder CVH engine.

The plane of each valve is canted so that the port and valve are offset from the longitudinal and traverse center lines of each cylinder bore, permitting large intake valves and an individual cam lobe for each valve.

Location of the spark plug close to the geometric center of the combustion chamber contributes to more efficient combustion.

Each fully machined piston head is contoured so it forces the gas/air mixture from the outer edges of the cylinder toward the center of the combustion chamber and toward the spark plug, which makes the mixture fire very evenly—and the engine operate very efficiently.

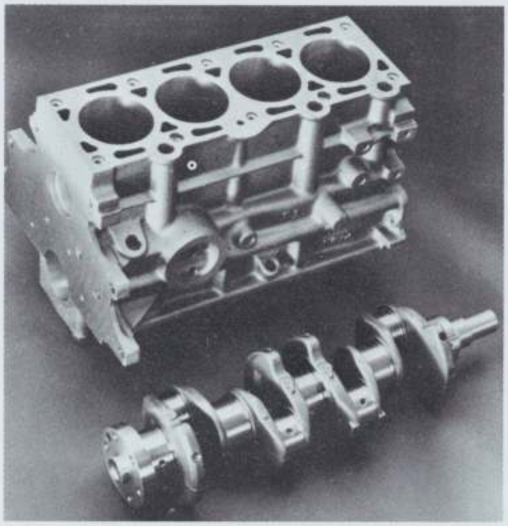
Although they had established a design concept they believed to be superior, the researchers didn't want to overlook anything. They went out and bought 25 of the best engines on the market from Britain, Germany, Italy, Japan and the U.S. The engines were torn down, weighed, measured and analyzed in special comparison tests.

The study led the engine researchers to conclude that the stiffest competition to the CVH design would be either a prechamber combustion engine or a conventional wedge-head design.

They then built research versions of all three engines. Each design used the same block assembly and a belt-driven overhead camshaft operated with hydraulic tappets. Each head was designed to be cast in aluminum.

By the end of 1975, the pre-chamber, wedge-head and CVH engines had been built and dynamometer testing had begun.

It was at that point that "engine mapping"—a highly sophisticated technique developed by the Ford Research Staff—became invaluable. The process uses a computer to plot a graphic representation of an engine's potential, in terms of speed, torque, emissions control, fuel consumption and overall performance.



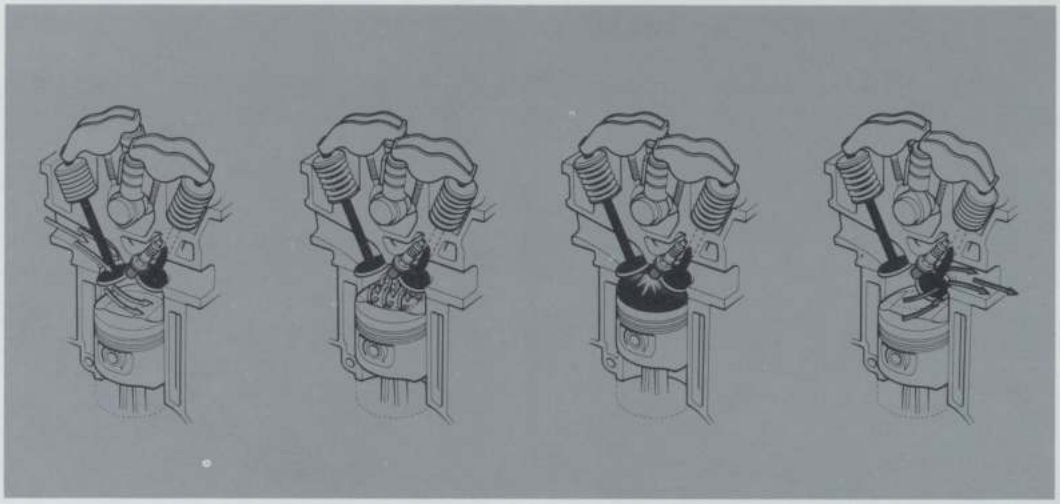
Close-up of engine block and crankshaft (top). Each piston's head is contoured so it forces the fuel/air mixture toward the center of the combustion chamber, boosting engine efficiency.

A multi-dimensional map of emissions and fuel consumption is constructed at each speed-torque point. Researchers can adjust the engine calibration at each point to balance emissions, fuel economy and other objectives.

With the optimum calibrations established, control systems are designed and vehicle tests conducted to verify the computer projections.

The comparison program confirmed the original choice. In March 1977, the results were reviewed by corporate management and the CVH engine was transferred to the production activity for development in 1.3- and 1.6-liter capacities for the North American market. (For markets outside North America, there also is a 1.1-liter version.)

Because of EAO's extensive experience with small engines, the bulk of the initial development work was done in Europe.



Sketches show the operation of the CVH's uniquely designed combustion chamber.

Ford of Germany worked on basic engine design. Ford of Britain handled performance development, plus design and development of the various engine systems.

A six-member NAAO task force was established to coordinate with EAO. In addition to engine engineers, an aluminum castings expert from Casting Division and a machine tooling engineer from Engine Division were on the task force. Four members of the team worked out of Cologne, Germany; the other two handled their responsibilities from Ford of Britain's technical center at Dunton. All six reported to EAO's chief engine engineer in Cologne.

Their primary duties were to:

- Help achieve as much commonality as possible between the NAAO and EAO engines in order to capitalize on worldwide technology and resources, and
- Combine the technologies and experience of the two organizations into a single design, development and testing program.

The joint effort worked well; the development program was completed in just two years—16 months less than it normally takes to bring out an all-new engine.

Meanwhile, production specialists were at work on the two major manufacturing facilities which would build the engine. A new, $400-million engine plant for the CVH engines had been built at Bridgend in South Wales, on a 200-acre site.

Like its U.S. counterpart—the Dearborn Engine Plant, which was completely revamped and retooled for the new engine at a cost of $650 million—the Bridgend Plant was tailored to ensure the highest possible production quality.

At full capacity, the two plants will be able to produce CVH engines at a rate of more than 1 million units a year each.

But even before the first engine powered a new Escort or Lynx, well over 2,000 CVH prototypes were built and tested. And CVH-equipped test vehicles have completed close to 10 million miles on proving grounds and public highways.

The price tag for the CVH engine program exceeds $1 billion—more than it cost to launch an entirely new car in the not-so-distant past.

Two new transmissions for the new car

In a front-wheel-drive car, the transmission is integrated into a compact component called a transaxle. The transaxle does the work normally performed by a rear-wheel-drive car's transmission and rear axle—and eliminates the need for a drive shaft running through the center of the car.

For its FWD World Car, Ford developed two new transaxles, both delivering excellent fuel efficiency.

One is a slick-shifting manual (MTX) with fourth-gear overdrive. The other is an innovative automatic (ATX) offering gasoline mileage approaching that of the manual.

The ATX is available as an option with the 1.6-liter CVH engine. The MTX is standard equipment with either the 1.3L or 1.6L engine.

The major reason for the ATX's fuel efficiency is a new "split-torque" concept patented by Ford.

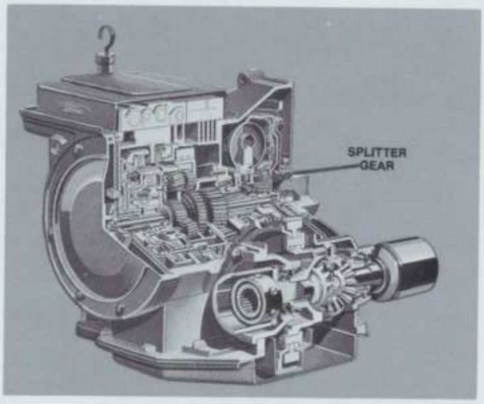
This "splitter" design transmits a large part of the engine's power output (torque) by direct mechanical means in the second and third gear range. The rest of the torque is transmitted from the engine to the transmission by hydrokinetic (fluid motion) means, as is conventional with most automatic transmissions.

Ford's split-torque concept eliminates most of the power loss that results from torque-converter slippage—the loss that's primarily responsible for making automatic transmissions less fuel efficient than manual transmissions.

ATX efficiency is greatest in third gear, where the split is 93% mechanical and only 7% hydrokinetic.

In first and reverse gears, the ATX transmits all torque hydrokinetically through the converter.

Another factor in the ATX's fuel efficiency is wide-ratio gearing, which optimizes tradeoffs between fuel efficiency and performance. This gearing provides maximum start-up performance in low gear and a numerically low final-drive ratio for highway economy.



Cutaway sketch of the innovative automatic transaxle (ATX) Ford designed for its World Car. Unique "splitter" gear is the key to its greater efficiency.

Aside from its fuel-economy qualities, the ATX design was selected over many others that were considered—including 11 other Ford designs and seven outside proposals—because it fit best within the highly compact World Car package.

The ATX is only 14 inches long from rear face of engine block to pump cover. The distance from the center of the crankshaft to the center of the differential measures only 7.6 inches.

Several other technical innovations and refinements help the ATX operate with the quietness and smoothness customers expect of automatic transmissions. These include a torsional damper, new Ford CJ fluid, and special shift-control components.

The ATX is being produced at a new $530-million plant in Batavia, Ohio. The 2.1-million-square-foot plant can build more than 500,000 transaxles a year.

It is fitting that the ATX, itself an example of the latest engineering technology, is built with the most up-to-date manufacturing technology.

Electron-beam welding is used in critical assembly of the stamped carrier which houses the planet gears.

Automatic electro-optical laser inspection detects missing parts and insures accurate installation of thrust-needle bearings in the two planet carriers.

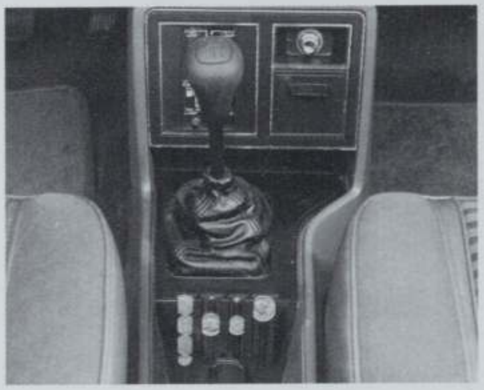
Optical scanning of the transaxle assures that all oil pan face holes are located at their critical positions.

The companion MTX is a four-speed unit patterned after the Fiesta transaxle. But several important improvements have been designed into it. Among them:

- Closed-end case construction, eliminating a potential oil leak path.
- Tapered roller bearings instead of ball bearings for improved bearing life.
- A single-rail shift mechanism that requires no adjustment.
- Wide-ratio gearing for the best possible performance and fuel economy.
- Greater torque output capability.

The MTX's fourth-gear overdrive feature permits engine speed to be cut by 20%, compared to a conventional transmission. The overdrive gear ratio is 0.8-to-1.

A number of design and manufacturing features promote smooth, quiet operation of the MTX. An internal-gated shift plate, for instance, defines each gear position precisely. This plate also permits use of a "no-adjustment" external shift mechanism, resulting in excellent shift feel and reliability.



The World Car's manual transmission (MTX) has fourth-gear overdrive that lifts fuel economy.

The MTX also has significant serviceability features. For example, service adjustments for clutch disc wear during normal vehicle operation have been eliminated by use of a self-adjusting clutch linkage.

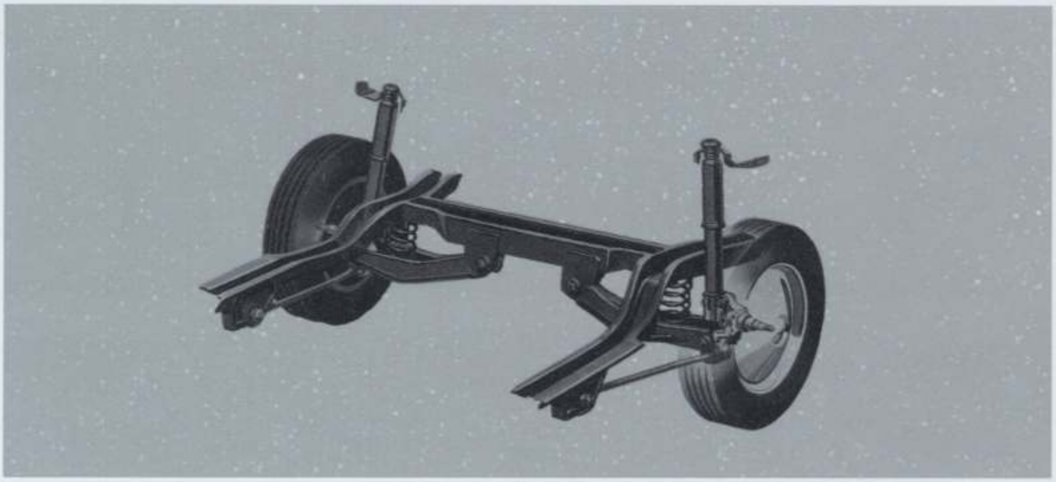
The manual transaxle will be built by Toyo Kogyo in a new plant in Hiroshima, Japan. The facility employs a number of state-of-the-art manufacturing, testing and inspection operations to ensure optimum quality.

Patenting Ford's newest 'better ideas'

As a measure of the World Car's technological innovation, the U.S. Patent and Trademark Office has granted Ford Motor Company 14 patents relating to components of the new vehicle—and 21 more are pending. Among the 35 better ideas:

- Split-torque automatic transaxle
- Hemispherical-head engine and compound-angle valve train
- Thin-walled exhaust-gas-manifold casting structure
- Engine cooling system air-venting arrangement
- Radiator-valve assembly
- Exhaust-gas recirculation control
- Carburetor automatic-choke construction
- Multiple-ratio power transmission mechanism
- Self-adjusting clutch release mechanism
- Locking structure for electrical connectors

A suspension 'borrowed' from costly cars



The car's independent rear suspension (IRS) system enables each rear wheel to move individually.

Perhaps the most important ride feature of the new World Car is its independent rear suspension (IRS)—a sophisticated system ordinarily found only on more expensive imported sedans and sports cars.

With IRS, there is no cross-car, solid axle linking the rear wheels. Thus, each rear wheel's movements are controlled individually, as are the movements of each front wheel. The Ford World Car has, in fact, four-wheel independent suspension.

But it is IRS that makes the difference. IRS helps the car hug the road and contributes to its excellent performance in tight and bumpy turns. The ride is supple, the handling deft, the grip on the road tenacious.

The Ford IRS system consists of a one-piece forged spindle attached to a transverse arm, a tie rod, a shock strut and a coil spring. The transverse arm and the tie rod provide lateral and longitudinal control. The shock strut counters the braking forces and provides suspension damping.

A coil spring is mounted on the transverse arm.

The rear shock struts are a new twin-tube design. The upper mounts and jounce and rebound valving are tuned for optimized suspension damping and control.

The rear suspension caster and camber are set permanently during assembly, using precise component tolerances and sophisticated manufacturing and assembly techniques. This translates into fewer adjustments and reduced maintenance costs.

The lower control arm, a one-piece stamping, is made of galvanized steel for improved corrosion resistance.

IRS brings something else to the new car—increased interior space. With no solid axle, the rear floor can be lower (by 2½ inches), thereby providing more luggage-carrying capacity. In addition, the rear seat can be placed farther back, making it easier for passengers to get in and out of the rear compartment.

While IRS unquestionably is the most dramatic new chassis feature, many other components also contribute importantly to the car's qualities.

Consider, for example, the front suspension with its new full MacPherson strut system, including a forged control arm, drag strut/stabilizer bar and cast knuckle with integral brake anchor plate. As in the rear, the front caster and camber are preset at the factory. In addition, the control arm ball joint incorporates a "lubed-for-life" feature similar to that used on other Ford products built in North America.

Consider also the new, high-efficiency manual steering rack-and-pinion gears, which are set for positive response and ease of handling and maneuverability. Lightweight Delrin yoke and urethane rack bushings are used for quieter gear operation, and the lightweight outer tie rod ends are lubed for life.

The power-steering gear also is new for this car. While it shares a common body mounting system with the manual gear, its hydraulic valve and power systems are derived from those introduced in Ford Fairmont and Mercury Zephyr.

Another major contribution to ride and handling comes from the tires. The new World Car's tires are P-metric, steel-belted radials with European-type wraparound tread patterns. P-metric tires provide improved fuel economy because of their increased inflation pressure capability (up to 35 pounds per square inch), lighter weight, and the reduced rolling resistance of their tread components.

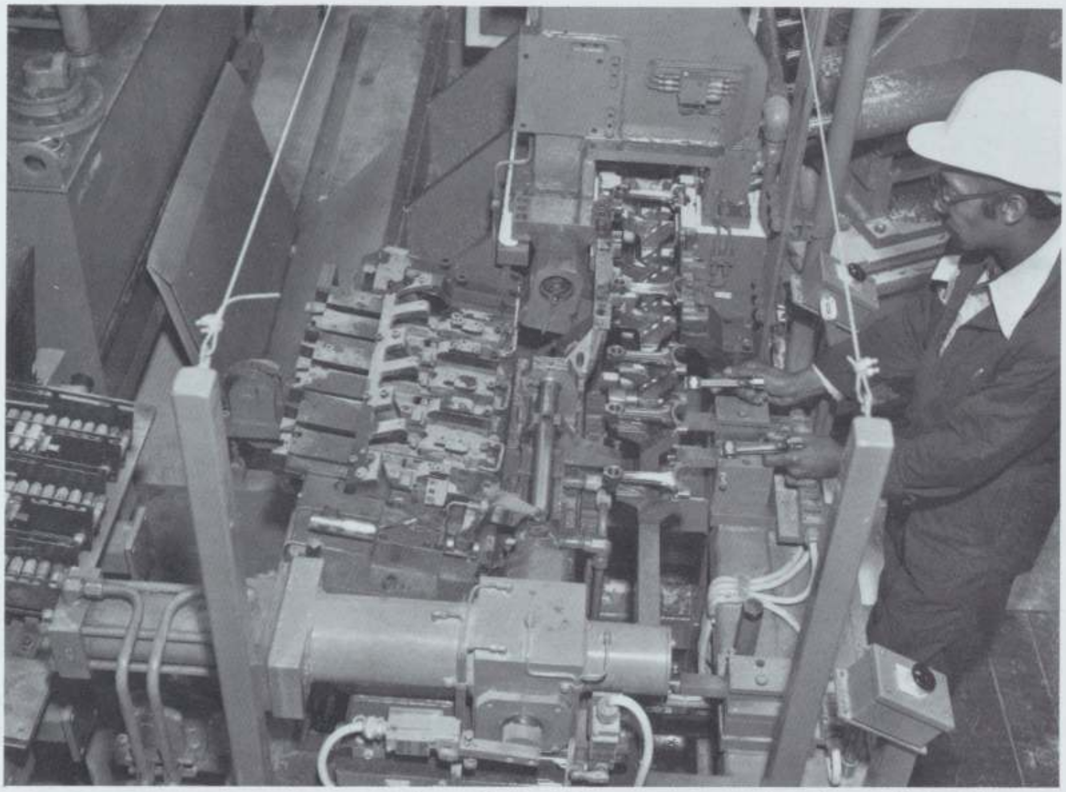
The braking system employs an aluminum master cylinder and differential/proportioning valve, which represent a nearly four-pound (50%) weight saving over conventional materials.

The new car is equipped with a more compact version of Ford Motor Company's successful pin slider-type front disc brake system. The design offers minimum brake drag, reduced weight, more tolerance to dimensional variations, improved pedal feel, greater reliability and easier assembly, compared with conventional "Vee" slider brake systems.

The power brake booster is a 220-mm high-output type, similar to that used on some other Ford cars, and the rear brake design offers improved stability and system balance.

IRS helps Ford's World Car hug the road, also contributes to the roominess of its interior.

The North American plants that build the car



At the revamped Dearborn Engine Plant, a Ford employe operates a machine that precisely drills lubrication holes in CVH connecting rods.

Five Ford Motor Company plants are key to the NAAO World Car's production. They are:

- Batavia (Ohio) Transmission Plant, source of the automatic transaxle (ATX).
- Dearborn (Mich.) Engine Plant, which produces the CVH engines.
- Metuchen (N.J.) Assembly Plant.
- Wayne (Mich.) Assembly Plant.
- St. Thomas (Ontario) Assembly Plant, where the 1981½-model sporty coupe version will be assembled, starting in early 1981.

Ford invested $1.1 billion to build the new Batavia Plant and to completely update the Dearborn Engine Plant. And $125 million more was spent to upgrade Metuchen and Wayne for World Car assembly.

Batavia

The 2-million-square-foot Batavia Plant is Ford's newest manufacturing facility. Located 30 miles east of Cincinnati, it is equipped with the latest manufacturing, assembly and quality-control machinery and systems.

Batavia will employ some 3,500 hourly and salaried Ford people when producing at full capacity. It is geared to produce more than 500,000 automatic transaxles each year.

Its highly automated final assembly system has 156 stations—some fully automatic, some semiautomatic and some manually operated—where more than 875 individual pieces come together to form the ATX. Completed units are automatically fed into one of 14 computerized final test stands, where each is tested for quality accept-reject decisions under simulated operating conditions.

In addition, a special 28-mile road course is used to evaluate Batavia transaxles in a real-world environment that includes hills and straightaways.

Dearborn Engine

Renovation of the Dearborn facility, part of Ford Motor Company's enormous Rouge industrial complex, was the largest manufacturing plant conversion in the company's history—and cost $650 million.

Erected in 1941 to mass-produce aircraft engines for the World War II bombers Ford then was building, the plant later switched to V-8 automobile engines. Most recently, it produced high-horsepower truck engines.

To make way for the new machinery, tooling and systems needed for the CVH four-cylinder engine, which is a radical departure from the plant's previous products, the building was stripped and gutted. Even the old floors were dug up and replaced with what seemed to be an ocean of concrete.

Besides reworking the 1.3 million square feet of existing space, Ford erected a 700,000-square-foot addition.

The plant then was fitted out with the most modern equipment and tooling in the industry—a total of 387 new machines and 176 pieces of additional equipment.

The refitted plant began producing CVH engines in the spring of 1980. The 1.3L and 1.6L share the same cylinder head, intake manifold, camshaft, and oil and water pump. They have different cylinder blocks, crankshafts, connecting rods and pistons.

Extending the length of 10 football fields, the final assembly system has 67 automated machines designed to produce optimum product reliability. Major torquing stations are equipped with an innovative Ford system that monitors the quality of a fastened joint, tracks rejected engines into the repair area, identifies the failed fastener and confirms corrections.

Ford considers the plant's cylinder-block manufacturing system the most sophisticated of its type in the world. It includes 27 major machines on two lines capable of automatically switching all but two operations from one engine block to the other.

CVH engine testing at the plant is based on experience gained at two Ford engine plants in Ohio. Six cold-test stations are designed to set engine timing automatically within one degree. These machines also monitor oil pressure, manifold vacuum and noise levels, and identify problems before hot testing.

The hot-test system consists of 34 fully automated test stands. Each stand has a programmable controller and a computer for diagnostic testing.

By 1981, when the plant is expected to reach its full production potential of 1.1 million units annually, employment will total about 4,600.

Assembly Plants

Both the Metuchen and Wayne plants have been expanded to accommodate World Car assembly.

A $65-million program at Metuchen added a new facility for unloading parts and supplies, and more space to the existing plant to house new automatic presses for underbody and front structures.

Wayne added 17,500 square feet for tool-tryout programs at a cost of $16 million. Total investment was $60 million.

Besides the expansions, both plants have installed new body shops which include special facilities unique to production of front-wheel-drive cars.

Quality—top priority from start to finish

A Ford Escort plows through a pool of brine to test its salt resistance at the Arizona Proving Ground.

Because its World Car is the newest offering in the highly competitive small-car market, Ford management knew from the outset the car would be compared to a great number of foreign and domestic models. It had to excel.

Quality, therefore, was a top priority.

Extremely tight quality objectives were set. And equally demanding objectives were set for durability and reliability. Ford regards all three factors—durability, quality and reliability, abbreviated as DQR—as the major contributors to what car-buyers generally perceive as dependability.

Ford has specific definitions for the three factors.

In Ford terms, *quality* means meeting engineering and design specifications for function, fit and appearance. The obvious goal is zero deviations from these specifications.

Ford defines *durability* as a measure of acceptable operation of a vehicle without abnormal repairs during its expected lifetime.

Reliability relates to the frequency of repairs to a vehicle during a specific operating period, measured either in time or miles (as in 12 months or 12,000 miles, 36 months or 36,000 miles, etc.).

The company-wide effort to give the Ford World Car the highest possible level

Members of a Ford dependability/reliability team review a new window-lift mechanism the company developed for its new World Car. The full team met more than a dozen times in perfecting the design of the lift.

of quality starts with the designers and engineers and continues through every phase of manufacturing and assembly. Even after the cars roll out of assembly plants and are loaded onto haulaway trucks or trains for shipment to Ford or Lincoln-Mercury dealerships for delivery to customers, carefully obtained feedback is used to develop improvements.

The new World Car is the first major Ford North American vehicle produced under the quality-oriented concepts initiated by the company's recently established Product Assurance Office.

Under the new approach, representatives from the engineering, manufacturing, purchasing, assembly and service activities are assigned to separate quality and durability/reliability teams for most of the vehicle subsystems.

The task of the durability/reliability teams is to assure that effective DQR actions are taken before production begins. They analyze historic and potential subsystem repairs and develop preventive action plans. The quality teams are responsible for assuring that effective DQR actions continue through the car's production cycle.

For the Ford World Car, particular emphasis is on the factories where the key components are made—the Dearborn Engine Plant and Batavia Transmission Plant—and those where the vehicles are built—the Metuchen Assembly Plant and Wayne Assembly Plant. (The St. Thomas Assembly Plant will add to World Car production in the spring of 1981.)

In each plant, the company has installed state-of-the-art automotive manufacturing technology to assure the highest possible quality levels. This technology applies to the machines, the support equipment and the systems, many of which are computer-controlled.

Additional quality-control measures also are being taken.

At Dearborn Engine, quality-control systems verify the quality of parts and materials purchased from outside sources, monitor the plant's quality performance both on an in-process and outgoing basis, and provide feedback so any needed corrections can be made promptly.

At Batavia, months of planning and training went into the development of the most extensive and thorough quality-control system in Ford's Transmission and Chassis Division. Its bible is the "Quality Systems Manual," which contains all pertinent information about parts and processes involved in building transaxles. It is supplemented by the "Supplier Quality System Agreement Manual."

In addition, an aggressive Production Validation Program included 100% inspection of critical parts of the first 5,000 ATX units produced there.

There is also a Quality System Audit Procedure designed to exceed even the high requirements set by the Transmission and Chassis Division.

Ford's Automotive Assembly Division is using a number of methods in its efforts to attain high quality in the new cars.

To test toughness against corrosion, prototype World Cars covered with salt spray and road dirt were parked in a "steam bath" chamber at 120 degrees and 95% humidity for 22-hour periods.

Among the procedures at Metuchen, which underwent an $8.5-million program to improve quality control, is the Uniform Quality Audit. Under this system, 50 fully assembled cars a day undergo extensive mechanical testing and visual inspection by special five-man teams for each of the car's five major subsystems.

Similar teams are assigned to Wayne, the lead plant, where a full-time staff provides technical support to assure prompt action on any production deviations. Normally limited to a new car's launch period, this procedure will be ongoing at Wayne.

The Metal Stamping Division also plays a very important role in World Car quality. It has developed two programs to assure that great care is given to sheet-metal dimensions and surface quality:

- A new surface-scanning system automatically checks surfaces for dings and dents on outer "skin" panels. The system checks the surface of each outer-door panel on a production-press line, quantifies any dimple, marks its location and provides an analysis and printout of the data so prompt corrective action may be taken.
- Computer-controlled in-line checking fixtures dimensionally inspect 100% of the doors. If a door doesn't pass, lights flash and an alarm sounds.

Like most auto companies, Ford buys a significant number of components for its vehicles from outside suppliers. Recognizing that the overall quality of a car or truck is tied to the quality of each component, the company has stepped up efforts to make sure suppliers devote the same attention to quality that it does. To that end, Ford has held quality seminars for its North American suppliers. During the past year, 1,500 firms sent nearly 4,000 representatives to 18 regional seminars.

In stiffening its requirements, Ford has asked suppliers to:

- Establish quality at the highest possible level from the very start of production.
- Provide a system that assures a continuing level of quality and that prevents out-of-specification products from ever reaching the car buyer.
- Track the quality performance of their components by using in-plant and field feedback reports furnished by Ford.

Engineered for serviceability

When it comes to service and cost of ownership, the Ford World Car is gentle on its owner's time and pocketbook.

Scheduled maintenance will average less than one hour a year. And scheduled maintenance costs—projected at less than $160 during the first five years or 50,000 miles—are among the lowest of any competitive car, foreign or domestic.

Moreover, with some 6,400 Ford and Lincoln-Mercury dealers in the U.S. and 750 dealers in Canada, getting that service—or any other needed work or parts—isn't a concern for people on the move.

The World Car was engineered so that many of its components never have to be checked or adjusted. The front-wheel bearings, front suspension and steering linkage, for example, are lubricated for life.

In addition, there is a maintenance-free battery, the manual transaxle has a self-adjusting clutch cable mechanism, the fluid in the automatic transaxle never has to be changed in normal use, no band adjustments are needed on the automatic transaxle in normal use, there is no need to adjust the front-end caster and camber during normal service, the engine's hydraulic valve lifters don't require periodic adjustment, the carburetor choke and idle fuel mixture settings are preset, and the brakes are self-adjusting.

Routine fluid checks are easy to do—an important factor in this era of self-service gas stations when it's often hard to find someone to check under the hood. Easily checkable are the engine oil, transaxle fluid, power-steering fluid, brake fluid, windshield-washer fluid, and radiator coolant.

Front brake-pad wear can be examined by removing a front wheel, and the rear brake lining can be checked by removing a rubber plug in the brake backing plate.

Other do-it-yourself work can be handled with no tools at all or, at most, very simple tools. Easily replaced are fuses, engine oil, oil filter, air filter, spark plugs, engine coolant, windshield wipers, exterior light bulbs and headlamps. The battery also is easy to get at, and even the exhaust system presents no problem to remove when the time comes to replace it.

Replacing the air filter and many other under-the-hood components is an easy matter.

When more complex work is needed, the World Car's design helps dealership service technicians get many jobs done easier and faster. For example:

- The ATX valve body, governor and throttle valve linkage may be serviced from under the hood.
- The differential assembly may be removed without taking off the transaxle assembly.
- Steering column-mounted switches (turn signal, horn dimmer, wiper/washer) may be serviced without removing either the steering wheel or column.
- The radio speakers and the optional clock can be serviced without removing any other major component.

Designed with safety in mind

Finite Element Structural Analysis—the sophisticated computer technology used by Ford in engineering strength and durability into the new World Car—also played an important role in helping the new vehicle meet required safety standards.

Engineers used the computerized system, for example, to help design the car's rear structure so it would meet the federal 30-mile-per-hour rear impact standard (FMVSS 301).

Ordinarily when a new vehicle is being developed, its various components are designed, then built by hand before being crush tested. Building the pieces takes two to three weeks, depending on their size and complexity.

Setting up the test—using a huge, hydraulic ram called "The Crusher"—takes another week, even though the impact itself is over in a matter of a fraction of a second.

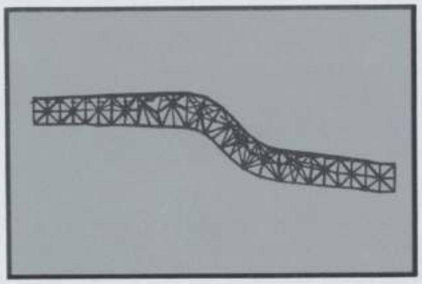
Then the results must be analyzed to see if the parts—in this case, the body rails, the floor pan and various braces and supports—have adequately withstood the 12,000-pound crush force.

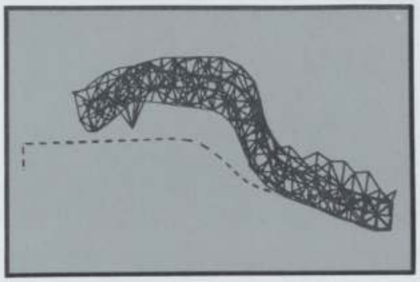
If not, the failed parts are redesigned, built and then retested—and three more weeks pass.

With the computerized method, engineers develop what they call a model of the component. This model appears on a TV-like screen. With the push of a series of command buttons, the model undergoes the computer-world version of the real-world crush. If the part doesn't pass the test, the engineers analyze the situation, punch in some new information that strengthens the simulated part—and run another test.

Such testing and changing can be done in a day or less—drastically reducing engineering and design time.

Computer testing isn't the end of it, of course. After the computer simulation has achieved the required impact-resistance, engineers build the real hardware, which has to withstand The Crusher. The Finite Element Structural Analysis technique proved to have better than 90% correlation with Crusher test results—well within the acceptable variance.





A computerized test shows how one structural element of a car would crumple under enormous pressure. There is a close relationship between the theoretical crunch and what happens when Ford engineers subject a real-world component to the thrust of "The Crusher."

After passing the crush test, components are installed in a prototype—an individually built version of the car that eventually will be mass produced—for further testing. Prototypes are given a scientifically planned series of body blows to make sure they meet the standards for front, rear, angled and side crashes.

Prototypes of the new World Car underwent 19 barrier crashes alone. Barrier crashes are controlled versions of real-world "accidents" in which speeding vehicles slam into the equivalent of a brick wall in a special test facility at Ford's Automotive Safety Research Center in Dearborn.

Lifeguard Design Safety Features

Automotive engineers and designers have two safety goals when they develop a new vehicle. Their first aim is to help the driver avoid accidents. The second is to help minimize injuries to occupants should an accident occur.

Many of the features that make a car a solid performer under normal driving conditions also help it do well in hazardous situations.

In Ford's World Car, for instance, the MacPherson front suspension and independent rear suspension provide road-hugging stability. Its responsive rack-and-pinion steering provides excellent maneuverability, and its braking system includes a compact version of Ford Motor Company's proven pin slider front disc brakes. In addition, its large window area not only contributes to the car's good looks but also provides excellent visibility.

As offered for sale in the United States and Canada, Ford's World Car incorporates all the Lifeguard Design Safety Features built into every North American Ford Motor Company car. And, of course, it meets every one of the Federal Motor Vehicle Safety Standards for passenger cars in the U.S. and Canada.

The chart highlights some of the Ford Lifeguard Design Safety Features built into the World Car:

Premium sound and many other options

Another conceptual element that separates Ford's World Car from most of its competitors is its broad selection of optional equipment.

Ford management knew that people who traditionally buy larger cars would be attracted by the high technology, fuel economy, performance and roominess of the new car. But they also knew that such buyers want a high level of optional equipment. Thus, the new World Car was specifically designed with a full complement of appearance, convenience and comfort options.

Even at its most basic level, the car is far from spartan. Standard equipment includes halogen headlamps, semi-styled steel wheels, bright bumpers and trim, AM radio, high-back front bucket seats, folding rear seat, 10-ounce cut-pile carpeting, glove box, color-keyed instrument panel with built-in coin trays, dome light and front-door courtesy light switches, among others.

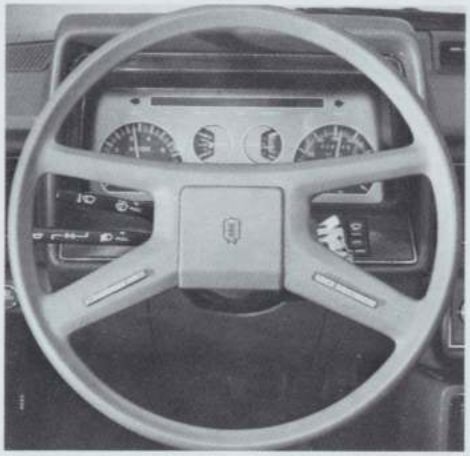
But it is in its selection of optional features that the new World Car excels. The list rivals that of the Lincoln Continental.

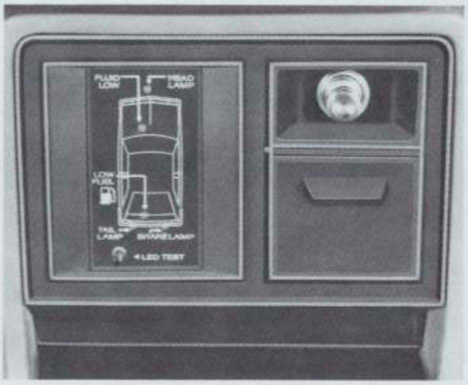
It has a greater selection of premium sound options than any other car in its class. And it offers the widest selection of interior trim in its class.

Speed control, a feature usually associated with larger cars, also is available, as are reclining front seats in either high- or low-back styles.

Here is a complete list of the optional features planned for the new World Car:

1.6-liter CVH engine with four-speed manual transaxle
1.6-liter CVH engine with three-speed automatic transaxle
Air conditioner, manual
Air deflector, roof (4-door liftgate only)
Battery, heavy-duty
Belts, heavy-duty color-keyed deluxe
Bodyside protection, lower





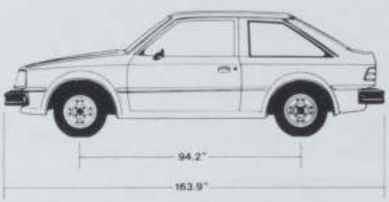
Examples of some of the World Car's many options include (top) Speed Control and Instrumentation Group, console-mounted Graphic Warning Display (bottom).

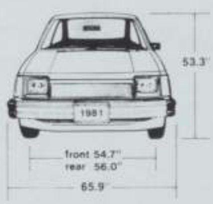
Bracket, front license plate
Brakes, power front disc/rear drum
Bumper guards, front
Bumper guards, rear
Bumper rub strips, front and rear
Carpet, load floor
Clock, electronic digital
Console with graphic warning display
Consolette (with manual transaxle)
Defroster, electric rear window
4.05-1 final drive ratio (1.3 engine only)
Fuel tank, extended range

Glass, tinted complete
Heater, engine block immersion
Instrumentation Group
Liftgate release, power
Light Group
Luggage rack, deluxe
Mirror, left-hand remote-control sport
Mirror, right-hand remote-control sport
Mirrors, dual remote-control sport
Moldings, bodyside with vinyl insert
Paint/tape, tu-tone
Premium Sound System
Protection Group, Appearance
AM radio, delete for credit
Radio, AM with dual rear speakers
Radio, AM/FM monaural
Radio, AM/FM monaural with dual rear speakers
Radio, AM/FM stereo
Radio, AM/FM stereo with cassette tape player
Reclining front seat backs
Roof, flip-up open air
Seats, low-back bucket
Speed control, fingertip
Squire Wagon Option
Steering, power
Suspension, Handling
Tires, P155/80R13 white sidewall, P165/80R13 black sidewall, white sidewall or raised white letters
Trim rings, wheel
Wheels, cast aluminum
Windows, pivoting front vent
Windows, remote-control quarter (3-door only)
Windshield wipers, interval
Wiper/Washer, rear window

WORLD CAR DIMENSIONS	**3-Door Hatchback**	**4-Door Liftgate**
	(Dimensions in inches unless otherwise stated)	
Wheelbase	94.2	94.2
Overall length	163.9	165.0
Overall height	53.3	53.3
Overall width	65.9	65.9
Tread, front	54.7	54.7
rear	56.0	56.0
Front head room	38.0	38.0
shoulder room	51.5	51.5
hip room	52.0	52.0
leg room	41.5	41.5
Rear head room	37.0	37.8
shoulder room	51.5	51.5
hip room	44.4	44.4
leg room	35.8	35.8
Luggage capacity (cu ft)	30.6*	—
Cargo volume (cu ft)	—	61.0*
Curb weight (lbs)	1,989	2,112

*With rear seat down





Produced by Public Affairs
Ford Motor Company
Dearborn, Michigan

Printed in U.S.A.