

Special Vehicle Operations: An Activity-Based Plan for Improving the Automotive Vehicle Development Process

Gregory K. Scott*
Doctoral Candidate
Behavioral Sciences Area
Organization Studies Group
Sloan School of Management
Massachusetts Institute of Technology

This brief paper considers the New Product Development (NPD) strategies and practices recently employed by the Ford Motor Company as a base for a substantial, near-term improvement in automotive vehicle development performance. The recognition of current industry "best practices" in lean design and manufacturing coupled with consumer desires for niche vehicles provides an opportunity to significantly reduce the time-to-market for new vehicle designs. This paper proposes that a Special Vehicle Operations plant be established as an ongoing facility to develop and manufacture technology demonstration vehicles for corporate research use and public sale. Such a facility, a manufacturing "proving ground" akin to vehicle test facilities, would support the more rapid introduction of advanced vehicle technologies by routinizing design experiments in a quasi-mass production setting. The expected result would be a steadier and more continuous introduction of advanced processes into mainstream products. The scheduling, technical, financial, and quality risks inherent to such introductions would be lessened as well. The research foundation of this paper is an International Motor Vehicle Program-sponsored report supervised by Professor Michael Cusumano of MIT on the NPD practices under implementation by the Ford Motor Company. Other primary source materials include articles on advanced product development initiatives taking place in the automobile industry.

*Please address any and all comments to:

Gregory K. Scott, Sloan School of Management, MIT,
50 Memorial Drive, Room E52-501, Cambridge, Massachusetts, 02142
or by electronic mail to gkscott@mit.edu

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Introduction

Many recent public accounts have trumpeted the "rebirth" of the American automobile industry. Reports of strong new vehicle sales and record profits may lead the casual observer to the belief that US automakers are firmly in control of their own destinies, able to put forth continued streams of excellent products and to reap increased global market share. In both business and product development terms, this view is suspect.

Much of this nation's "newfound" market strength is the result of events outside the manufacturers' control and prediction such as large foreign exchange rate movements and tectonic market demand shifts to minivans, sport utility vehicles and light trucks. While the exchange rate effects may likely persist for some time, foreign firms are coping by reducing costs and in some cases content on their offerings while maintaining their customers' quality and value expectations. Foreign firms, the Japanese and Germans in particular, are also relying more heavily on operations outside their home countries to reduce production expenses. As to shifts in market demand, Chrysler's success in popularizing the minivan has spurred that vehicle segment globally. The substantial growth in sales of sport utility vehicles and light trucks allows US firms to exploit a product area that has been uniquely American for many years. That market dominance is not guaranteed for the foreseeable future, and is increasingly being challenged on a variety of design fronts and vehicle price points. US firms have, to their credit, made diligent efforts to lessen their costs and narrow a substantial design and manufacturing gap with their most able foreign competitors, the Japanese. Closing this gap is not enough to ensure continued prosperity given cyclical market downturns that will surely occur.

With the exception of a few development projects, US automakers generally are considered to lag behind their best competitors in new product development performance. In terms of time to market for new products, the cost and engineering hours expended, new-model production changeovers, and the ability to leverage component systems and platforms across multiple projects, American firms are still not the world's best.

This paper attempts to address one means by which an automotive firm, or any business which manufactures large volumes of highly engineered products, can attempt

to substantially strengthen its product development activities and competitive positioning. It proposes setting up a dedicated product design and manufacturing environment geared towards early adoption and market introduction of advanced product and process technologies and techniques. By testing, refining, and routinizing advanced methods under the pressure to produce large, yet sub-normal (for a major automaker) volumes of saleable products, a firm applies a racing philosophy to the production environment. Such a product development "incubator" offers many firmwide benefits including:

- Demonstration of Technological Dexterity and Leadership
- Greater understanding and control over the Project Cycle
- Stronger Project Planning Networks Within/Without the Company
- Reduced Technology Risk for Full-Scale Production Projects
- Reduced Financial Risk for Full-Scale Production Projects
- More rapid progression down Production Learning Curves
- A continuing stream of Halo Niche Products and Marketing Experiments
- Challenges for the "best and brightest" Corporate Personnel

Such benefits are not without cost, especially in terms of redefining the organization's structural orientation to support agile development and manufacturing. The decision to expend the substantial funds needed to create a special vehicle plant must be based on more than the value of the vehicles produced. At its heart, a special vehicle plant as described in this paper is a continuing effort to stay at the forefront of vehicle development by routinely using, not just studying, advanced methods, then driving proven concepts into the organization at large. Meeting this goal requires a major investment.

The special vehicle plant goes beyond the industry habit of building "special editions" of existing models using aftermarket parts installed on the production line or at subcontracted supplier facilities. It goes beyond the normal practice of introducing new component technologies as add-on options. A special vehicle plant would likely be a cross between an industrial design house, a racing fabricator, and a highly automated, modular assembly plant. While no major US automaker except possibly Chrysler (with its Viper and Prowler projects) has attempted to develop an on-going capacity to build low-to-medium volume production vehicles, a number of foreign automakers have conducted in-house or joint venture arrangements to produce batches of highly modified versions of their normal mass-production offerings or entirely new vehicles for racing or

sale. For example, BMW's M Division produces complete specialty models, does customization work on production models for BMW and end users, and develops advanced engines for its own racing use and for outside firms like McLaren. British industrialist Tom Walkinshaw produced the XJ-220 supercar under contract to Jaguar. He is now in the process of setting up a production operation in an underutilized Volvo plant to annually make perhaps twenty thousand coupes and convertibles based on Volvo's 850 series. Cosworth Engineering develops highly modified performance versions of Ford products, is a world-class engine builder for Grand Prix and Indy Car racing, and does advanced powertrain engineering design and development for a number of automakers. Porsche, in addition to racing and customization work on its own offerings, has developed and produced high-performance, specialty vehicles for Mercedes Benz and Audi. Renault will open its Technocentre in 1996. This Parisian facility will support all the company's new vehicle development and include a pilot factory.¹ Such efforts are a good starting point for a special vehicle plant, lacking only the commitment to radically different vehicle designs and manufacturing methods.

The challenge for a major US automaker is to develop an in-house organization that is not just a low volume production facility geared to making a long, slow run of a niche vehicle like the Viper. The envisioned facility must be able to deploy the most advanced design and production processes used at any part of the vehicle development and manufacturing cycle while aiming to approximate the mass production environment. The express intent is too be able to run operations at, or as close to normal production cycle times as possible, even for ultimate production runs of no more than a few thousand vehicles. The batches produced would be expected to vary in terms of their differentiation from a company's normal production. At the beginning, the vehicles made by the new organization might reflect the addition of a major new technology such as a hybrid chemical-electric powertrain or an active suspension, for example, to an existing platform sourced from elsewhere in the company. Later production runs might incorporate more fundamental changes in vehicle architecture and construction methods, such as composite or aluminum-intensive body and chassis structure. A fully-qualified plant could be expected to routinely turn out "clean-sheet" vehicles of its own design.

For the purpose of this paper, the Ford Motor Company presents a suitable candidate for such a special vehicle operation. Ford is currently undertaking an

¹Norman Martin, Christopher A. Sawyer, and Marjorie Sorge, "Towards World-Class." Automotive Industries, September 1995, p. 88.

extensive restructuring of its vehicle operations and corporate culture known as Ford 2000. The main thrust of this effort is to combine formerly (and formally) separate North American and European operations into the globally-oriented Ford Automotive Operations (FAO). Product development for FAO now takes place in five Vehicle Centers, four in North America, one in Europe. Each Center has global responsibility for a particular range of vehicles grouped by size/purpose and drive type. One of the major goals is to reduce development costs by at least \$2 to 3 billion annually by eliminating duplicate engineering efforts to produce similar types of vehicles on both sides of the Atlantic. The 1995 *Harbour Report* estimates that Ford spent about \$785 in development cost for each vehicle produced, much higher than Chrysler (\$471) and about forty percent more than benchmark Toyota.² Ford must diligently work to slice its product and process costs to remain competitive.

Another element of the Ford 2000 restructuring was the creation of the company's Advanced Vehicle Technology (AVT) organization. AVT encompasses a staff of approximately eleven thousand persons, and is responsible for Ford's advanced and production vehicle engineering, motorsports, alternative energy, and scientific research initiatives.³ It is also the home organization for Ford's Special Vehicle Team, an engineering group that makes limited-edition, high performance versions of existing production models. That very organization would likely be the catalyst for an expanded Special Vehicle Operations (SVO) activity. [The name Special Vehicle Operations was originally used in the 1980s for an earlier Ford team that built similar high-performance products, though on a more limited scale than the current SVT structure.]

Of the Big Three US automakers, Ford is less burdened than General Motors by an extensive bureaucracy that hampers the creation of an interdisciplinary structure like SVO. There are just seven management levels between first line supervisors and Ford Chairman Alex Trotman. Ford also retains the strong central technology and research organizations that the smaller Chrysler has de-emphasized in distributing the great majority of its engineering resources to the platform teams and suppliers that develop its line of vehicles. The Ford Motor Company has also been engaged in a program called World Class Timing, an initiative intended to substantially improve its product development operations, and one which would dovetail quite well with SVO.

²Marjorie Sorge, "Editorial: Ford's Hot Spot," *Automotive Industries*, October 1995, p. 9.

³Ric Bohy, "The Invisible Power," *AutoWeek*, May 1, 1995, p. 20-1.

World Class Timing

In Ford's own parlance, World Class Timing is:

*a specific plan for establishing more efficient ways of working together in our quest to develop products that provide the highest level of satisfaction to our customers.*⁴

The plan is based on a recognition that during the 1980s the time Ford took to develop new products increased by about one quarter and that Japanese producers were ahead of the company in terms of timing, cost, and quality. To address these shortfalls, World Class Timing focuses on using time as a strategic resource at every step of the New Product Development (NPD) process. With customer satisfaction as the driver, the guiding philosophy is to assess the magnitude and complexity of each program's information needs, then go through the hoops of the development process as quickly as possible. An initial concept is developed through five steps: selection of powertrain, defining the model as two-door, four-door, etc., development of the vehicle within the product team, final styling, and production engineering to Job 1. The target project team size that the company aims for ranges from about fifty people at the first official program step to about five hundred for the last two steps.⁵ So far, that level of leanness has been difficult to achieve.

Ford employs a variety of approaches to establish targets and control programs during the NPD process: benchmarking, milestones, checkpoints, simultaneous processing, deliverables. There is no specific limit on timing, no "standard" length of time for activities, merely a commitment to continuously improve the vehicle development process.

Normal operations under World Class Timing include an annual product cycle plan update and segment strategy update, as well as periodic segment reviews, typically twice a year. Throughout these planning activities there is a greater emphasis on meeting customer needs, overcoming a reputation for dated products, and generating visionary, yet marketable, new-vehicle concepts, through comprehensive, timely market analysis and brainstorming. The approach is to understand the "voice of the customer". Towards that end, Ford is attempting to make better use of such management techniques as Quality Function Deployment (QFD) to determine what combinations of

⁴Ford Motor Company World Class Process Group and The Emdicum Group, Inc., World Class Timing Overview Reference, Version 4.0, November 15, 1992, p. 3.

⁵Kathy Jackson, "Strategy at Ford: develop cars fast," Automotive News, November 16, 1992, p. 1, 42.

features and attributes are really important to the vehicle purchaser. It has developed a Quick QFD methodology by which design teams can assess a twenty-by-twenty matrix of features and amass meaningful data rather than the more common, yet more cumbersome, one hundred-by-one hundred matrix. Seven years ago, Ford also created a Breakthrough Products Team, an interdisciplinary group of about thirty product development specialists, designers, engineers, and manufacturing experts. According to one account, the group has not consistently lived up to its name, but has generated a number of valuable ideas related to product development issues.⁶ For its efforts, Ford would ultimately like to be able to target and fill a vehicle niche within three years. Several Japanese manufacturers have demonstrated this level of performance when creating new models that use structural elements and component systems from current vehicle platforms. They are approaching this level of performance for completely new platforms.

As Ford illustrates in its *World Class Timing Overview*, the vehicle development process may be reduced to four basic sets of activities: *planning, design, development, and production*. These sets of activities are broken into a series of milestones, each with customer-driven targets and specific customer, business, and technical deliverables. Across the entire set of activities, the company aims to achieve a fast cycle time, which it defines as "the ongoing ability to identify, satisfy, and be paid for meeting the customer's needs faster than anyone else".

A complete cycle of World Class Timing will take a vehicle from concept to customer in the minimum possible time. The cycle includes pre-program definition activities including powertrain declaration, program definition, and a sequence of nine steps culminating in a program status review six months after production Job #1. The sequence is outlined as follows for a vehicle with a single bodystyle. [Ford currently presses hard to beat the full, five-year development cycle described below.]

⁶Alex Taylor III, "Iacocca's Minivan: How Chrysler succeeded in creating one of the most profitable products of the decade," *Fortune*, May 30, 1994, p. 63, 66.

World Class Timing Milestones

<p>Powertrain Declared - <PT></p> <p>60 Months before Job #1</p>	<p>Segment Director declaration of powertrains for proposed vehicle program and initiation of funding for new or major-change engine or transmission programs.</p>
<p>Program Definition - <PD></p> <p>43 Months before Job #1</p>	<p>Board of Directors Product Planning Committee approval of program strategic intent, range of alternatives, and total vehicle targets. Approval of Segment Strategy at the January President's Meeting and the March Final Cycle Plan Meeting.</p>
<p>Program Implementation - <PI></p> <p>37 Months before Job #1</p>	<p>Board of Directors and Product Planning Committee approval, with NAAO Executive Committee consensus of a single architecture within approved targets.</p>
<p>Theme Decision - <TD></p> <p>33 Months before Job #1</p>	<p>Design Committee approval of a single Interior/Exterior Theme. Release of additional long-lead engineering funds if needed.</p>
<p>Theme Confirmation - <TC></p> <p>31 Months before Job #1</p>	<p>Vehicle Program Team confirms 100% feasibility of Interior/Exterior Surface. Vehicle Program Team confirms Theme can meet targets.</p>
<p>Program Confirmation - <PC></p> <p>24 Months before Job #1</p>	<p>Commitment of total organization to meeting program objectives on 18-panel charts. Program Planning Committee approves program objectives and Board of Directors approves total program funds after NAAO Executive Committee reaches consensus on program.</p>
<p>Prototype Readiness - <PR></p> <p>21 Months before Job #1</p>	<p>Program Manager's approval of Job #1 design, the manufacturing processes, and Purchasing plans.</p>
<p>Sign-Off - <SO></p> <p>7 Months before Job #1</p>	<p>Certification by Program Manager that the vehicle product development and manufacturing capability meet Job #1 customer requirements and quality, emissions, and other objectives.</p>
<p>Launch Readiness - <LR></p> <p>3 Months before Job #1</p>	<p>Program Manager's approval of the start of the integrated launch. Completed demonstration of Design, Process, and Quality Intent for parts and equipment.</p>
<p>Job #1 - <J1></p>	<p>Integrated launch completed. Program Manager approval to start mass production.</p>
<p>Program Status - <PS></p> <p>6 Months after Job #1</p>	<p>Program Manager reports Program Status versus 18-panel objectives and customer assessment of quality objectives. Integration of lessons learned for continuous process improvements.</p>

Organizational and Process Intent - Regardless of the organizational changes that might come about due to the creation of Ford Automotive Operations and its five Vehicle Program Centers, the basic activities of the World Class Timing process are likely to remain intact. They are a good foundation for an SVO initiative. Through World Class Timing, Ford, like Chrysler, has consciously attempted to place vehicle design authority in the hands of a collocated team rather than at the mercy of component groups in many locations. It differs from Chrysler in the scope of activities assigned to the team. The collocated Ford teams are expected to do a lot of the planning, some of the systems engineering, and only a small amount of component engineering for each vehicle. Ford's view is that systems and component engineering are best left back in home organizations to foster smart, yet commonly usable designs. Now a part of FAO, its Automotive Components Group (ACG) is one of a number of Ford units that is very deep in terms of the number of systems developed in-house. ACG manages approximately thirty systems at the vehicle module level and 120 at the next lower component level.

Core technology groups are doing more strategic technology work such as putting basic system specifications in place for use across multiple projects. When the complexity of vehicle integration issues dictates, crossfunctional module teams are brought together to drive the technology into a given vehicle program. For example, the new Taurus has a brand new steering gear. There is a core technology group developing the component for general use along with a chassis group working on its specific integration into the Taurus.

Several Ford product development managers said that in the future they expected collocated teams to perform more planning and systems engineering work prior to component engineering in functional areas. They expected increasing dedication, but not necessarily collocation, of functional people to the vehicle development teams. They recognized an increasing need to "cross chimneys" at the supervisor level to better foster interdisciplinary functional cooperation and coordination with the teams. Toward that end, former program managers are being moved to operations roles in functional areas. The company has additionally addressed the issue of not having designated team champions upstream in the corporate managerial hierarchy by placing vice president-level executives in charge of each of the Vehicle Centers. Initial indications are that the five executives in this position will become the equivalent of managers that Toyota has placed over its "heavyweight" project managers, its *shusas*.

The Special Vehicle Operations Model

The Special Vehicle Operations model is an optimized simultaneous engineering and manufacturing environment. It attempts to integrate a long list of innovative product development and manufacturing practices under one organization. Brief descriptions of some of the major elements are as follows:

Virtual Enterprise. There must be seamless, intensive linkages between the most creative and advanced technical personnel within the automaker and its supplier community. Where appropriate, there should also be customer links as well. There must be an information technology architecture that allows any project participant to view and comment on any relevant issue to help maximize cross-functional participation and promote overlapped design phases. The aim is to maximize real-time involvement in integrated, concurrent product and process development and provide decision-makers with assistance in choosing from project alternatives. In addition to the expected CAD, CAM, CAE, DFM, and DFA resources, the electronic environment should include capable project management software that supports front-end planning, AHP, resource-allocation, critical path scheduling, "what-if" technical and financial analysis, and process engineering/reengineering for multiple, simultaneous projects.⁷ Other IT requirements include systems for design simulation and efficient logistical tracking. The OEM must support design data exchange with the supplier by adopting such conventions as STEP, the Standard for the Exchange of Product model data. The overall intent is to provide for interaction within the physical confines of SVO facility, at all other participants' work locations, and at other parts of the company that will benefit from knowledge transfers.

Flexible Manufacturing System. A true FMS includes a number of sub-elements and should be integrated with the virtual enterprise. A digital manufacturing process system is the computer nerve center of the production operation. An effective digital manufacturing process system can decrease manufacturing lead time by up to twenty-five percent and improve plant utilization rates by providing such features as: virtual plant layout, construction, and modification; animated simulation of the assembly line in action including equipment activity, logistics, and materials handling; automated scheduling of production, maintenance, and product/plant changeover; and manufacturing decision support. The fabrication machinery in the SVO plant itself should primarily consist of more basic, robust machinery rather than purpose-built, specialty machines and unique fixtures. This will better support more easily reprogrammed, modular manufacturing cells rather than a relatively inflexible dedicated production line. According to Mikio Kitano, president and CEO of Toyota Manufacturing USA, the "New Assembly Line" must support three precepts: "arranging the vehicle's structure, function, and assembly to promote the workers' understanding of the nature of their work and place in the entire team"; demonstrating with each subsequent design a maturation of current steps, not a replacement of them; and the use of machines and

⁷Stephen W.T. O'Keeffe, "Chrysler and Artemis: Striking Back With The Viper," Industrial Engineering, December 1994, p. 15-7.

equipment to compensate for the physical weaknesses and limited range of worker movement.⁸

Set-based design versus Point-based design. Toyota's experience indicates that the design of a vehicle can occur more rapidly and be more responsive to changing customer requirements when it is built up from a set of flexible component specifications and known design alternatives that are demonstrated on a relatively large number of prototypes. The developed systems and concepts can be mixed or matched in a final vehicle specification and also provide more data for future consideration or use. The more widely used, point-based method produces a set of sequential decisions that rigidly fix a design much earlier in the development process, limiting opportunities for market or technology-driven change.⁹ Instead of many possible solutions to a problem, point-based design generates one solution with greater market risk. Set-based design helps lower this risk by allowing the automaker to set final specifications as close to market introduction as possible without compromising quality or the Job 1 date. It does force the automaker towards improvements in digital modeling, prototyping, and standardized component design that can quickly be applied to new projects.

Kozokeikaku, or K-4 development. This Japanese term refers to a development philosophy extensively used at Toyota and is, "a prescribed method of looking at vehicle engineering relationships and how the whole structure goes together."¹⁰ In a nutshell, the practice involves understanding the history of a design and leveraging that knowledge with each subsequent use in a new product. Development teams design for the future with an extensive, critical understanding of current and past designs. Designers and engineers have a firm, quantifiable understanding of how a new design reflects a number of component and system variations from an existing design even before final component drawing, tooling, or preparation of prototypes. The degree to which the Big Three US automakers and other firms avoid beneficial reuse of system and component families is a major reason that these firms are hard-pressed to match the product cycles of competitors that build on each preceding vehicle generation.

Effective customer and supplier databases. The SVO must have the capability to anticipate technological and market opportunities. Maintaining active databases helps the organization look outward and manage the strategic and tactical planning underlying all operations. In particular, this knowledge capability supports improved concurrent engineering of products and their attendant manufacturing processes. A cross-functional team of generalists and specialists should habitually sift disparate streams of information from within and without the auto industry to target continuous improvement activities.¹¹

Clear Project Imperatives. The success of the SVO concept is dependent upon preserving its "marketable production experiment" mindset. Each batch of vehicles produced must incorporate one or more clearly identifiable changes from past development practice, either design content or production process. The intent is to

⁸Martin, Sawyer, and Sorge, "Towards World-Class," *Automotive Industries*, September 1995, p. 86.

⁹John McElroy, "Toyota's Product Development Paradox," *Automotive Industries*, August 1994, p. 46, 48.

¹⁰Martin, Sawyer, and Sorge, "Towards World-Class," p. 84.

¹¹Michael J. Tracy et al, "Achieving agile manufacturing in the automotive industry," *Automotive Engineering*, November 1994, p. 22.

enact a multi-project vision for precedent-setting vehicle development prowess, a vision that can be disseminated to the rest of the company by example and by effective transfer of knowledge learned. Heavyweight program management, in the form of a chief engineer or vehicle executive, is important to provide an effective arbiter of design decisions when consensus is not attainable and to make sure that an empowered development team keeps to each project's imperatives.

Personnel Structure and Movement Policies. To insure that those imperatives move out from the SVO after each completed project, a rigorous system of effective personnel staffing and movement should be in place. There should be a very small staff of long-term SVO participants who are dedicated to facilities and information management, personnel orientation and training, and maintaining the living and recorded archives of SVO. A small group of vehicle executives would be expected to spend no more than about five years each managing a series of projects then returning to other areas of the company. The majority of employees would rotate through the SVO, participating on one-to-three specific projects. Everyone would be expected to participate in open debriefs of each project after completion.

Niche-Vehicle/Niche-Market Orientation. The Special Vehicle Operations plant should build vehicles to supply both Niche-Vehicle (NV) and Niche-Market (NM) requirements while showcasing the corporation's advanced engineering and styling capabilities.¹² In fulfilling NV requirements, the plant should produce completely new vehicles that might be outside Ford's normal portfolio of volume offerings as well as technology-intensive derivatives of existing vehicles. An example of the former might be an electric citycar or a special run of active suspension vehicles, while an example of the latter might be a run of aluminum structure versions of the new Ford Taurus. Niche-market status implies that no single vehicle run would exceed perhaps twenty thousand vehicles in a year. Such a limit encourages the SVO to always be looking toward the next project; truly successful designs could be ported to other plants. It also helps allay some financial risk in that a premium can be charged for collectible vehicles and the logistics of supporting them can be more easily managed using outside suppliers. It will likely be advisable to market SVO products through specially certified Ford dealers that have very high customer satisfaction scores. These dealers would be qualified to act as antenna shops, bringing customers into the SVO's design innovation process.¹³ Customers would help gather technical-market research and test concepts.

The above "features list" is just a small portion of the design and policy attributes needed to implement an SVO. The technology management challenge is to insure that the wealth of structures, systems, and tools do not get in the way of rapid vehicle development. The right people, the right tools, and the right projects form a critical mass. The technology "keepers" within the company must establish an appropriate list of development ideas to test, presumably based on Expert Choice or similar means of

¹²Ray Windecker, "Niche Vehicles," *Automotive Industries*, June 1995, p. 62.

¹³Antonio S. Lauglaug, "Technical-Market Research -- Get Customers to Collaborate in Developing Products," *Long Range Planning*, Vol. 26, No. 2, 1993, p. 81-2.

choosing from alternative projects. The SVO plant is not just a pilot production plant that can produce a small run of prototypes or pre-production vehicles to validate a random idea. It is a complete, yet lean vehicle development center that supports the testing of concepts which have potentially strategic importance.

Bringing technology innovations and applications to mainstream corporate use is imperative if Ford or any other automaker is to remain world-class. The SVO concept can be an effective means of feasibility testing, introducing, and transferring new technologies before they are overtaken by still newer technologies. The short-term nature of each individual SVO production project coupled with the repetitive nature of on-going SVO activities will greatly assist the automaker in mastering the technology project management cycle of invention, development and innovation, and obsolescence.¹⁴ As the SVO undertakes a variety of production experiments, it will be a critical source of feedback and feedforward information to the rest of the company's vehicle development efforts.

¹⁴Ernst G. Frankel, Project Management In Technology Innovation, Application and Transfer. Paper presented at Project 2000, Jubilee Seminar, Norwegian Institute of Technology, Trondheim, Norway, 1 November 1993.

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