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Shifting car makeup shakes up OEM status quo: Software strength is critical

With every new model, automobiles become more software-driven, creating a host of new opportunities for automakers. Yet, original equipment manufacturers (OEMs) might miss the chance to reduce costs, increase customer satisfaction and realize more revenue unless they can cultivate the sophisticated software capabilities that their evolving product lines – and today's competitive marketplace – demand.

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Contents

The drive to be different

Over the past few years, new-vehicle sales around the world have remained fairly flat. And, unfortunately, forecasters don't expect much change in the foreseeable future. With overall demand holding steady, automakers are fighting for market share, searching for ways to stand out in a crowded marketplace. Since Henry Ford's first competitor arrived, vehicle design has been the primary battleground where OEMs have fought for customer affection. Indeed, at the industry's outset, design options probably seemed limitless. But today, after nearly a century of mass production and new model introductions, automakers are finding it increasingly difficult to differentiate. After all, physical and mechanical design features have limits in terms of differentiation; how many different door designs can automotive engineers invent before the distinctions are no longer apparent – or important – to consumers?

Now, thanks to in-vehicle software, OEMs have a much broader repertoire for differentiation. Software offers automakers the ability to:

- *Improve customer satisfaction* (and reduce warranty costs) through electronic diagnostics and remote repair
- *Create innovative new functions and features* that make driving more intuitive, enjoyable and personalized
- *Establish a platform for services* with the associated recurring revenue streams.

The software shift

Software allows OEMs to make vehicles – and vehicle ownership – more problem-free. Rather than wait for consumers to experience and report problems, automakers can use a full complement of electronic tools – sensors, electronic data collection, diagnostic equipment and software upgrades – to identify and rectify potential problems *before* they occur.

Future view: Problem diagnosis and repair

Jane Doe has brought her new car to the servicing center for routine 15 000-mile maintenance. Jane hands her coded key card to the technician, Fred, and waits patiently in the comfortable lounge area. While the tires are being rotated and the filters changed, Fred inserts the coded key card into the car and types his password to switch from “driver” to “maintenance” mode. Fred chooses to first identify and repair any known software defects by cross-referencing the car’s software components against the OEM’s defect database. He pinpoints three down-level components and upgrades them. He then runs the entire vehicle system through a rigorous set of virtual-reality tests to identify any potential software malfunctions. Fred then accesses the driver-usage database to pinpoint potential drivetrain upgrades and recommended software-feature activations. (Jane has given the automaker permission to use her vehicle-usage information for safety reporting and improved service recommendations.) The driving analysis shows that, in the last 5 000 miles, one of the car’s drivers has been driving frequently in hilly terrain while towing some type of one-ton trailer. The data also indicates that a second driver typically drives in heavy traffic. The convenience and comfort analysis shows that her family has been purchasing satellite radio service on a per-session basis more than four times a week for some time and has recently accessed a few in-car pay-per-view movies.

After about 30 minutes, Jane is summoned to an online kiosk. Here Fred explains which software upgrades have been performed and suggests that her key card be coded to increase power and traction for her towing needs and to switch over to the hybrid electric fuel cells for her heavy traffic driving. He also suggests that she consider monthly movie and satellite radio services to save entertainment costs. Jane agrees to the upgrades but chooses to activate the radio service only. (The movies were a temporary diversion on a recent vacation.)

Jane drives home, pleased to know that potential problems have been averted and her car has been optimized to suit her family’s driving needs — all in only 45 minutes. During this routine visit, Fred diagnosed and corrected all known problems before Jane ever experienced them, plus he sold two new software upgrades and a monthly subscription service. Jane’s data — aggregated with that of other consumers — offers the automaker a more-accurate view of vehicle reliability, driving-system usage, convenience-services usage and vehicle-performance patterns, which helps the OEM make its next model even more innovative and valuable to its customers.

Scenarios like this demonstrate the impact that electronic diagnosis and remote repair can have on customer satisfaction, brand loyalty and, ultimately, corporate revenue. But, there's an added bonus here: by equipping vehicles and service centers to handle product issues preemptively, the OEM reduces the risk of recalls and costly warranty claims.

In-vehicle software also promises to make driving safer and easier. Night-vision systems that help drivers see three to five times farther than today's low headlight beams provide extra reaction time, helping to prevent accidents. When an impending, unavoidable crash is sensed, advanced collision-warning systems can now automatically remove slack from seat belts, tilt seat cushions to the rear and mold interior door panels around passengers like protective shields. Voice-activated dashboards allow drivers – or even backseat passengers – to adjust temperature, change radio stations or start playing a DVD without having to reach for the controls.

Automakers are pioneering a world where consumers can "stay connected" regardless of their location. In-vehicle software provides a platform for a host of new wireless voice and data services, generally referred to as *telematics*. Once reserved for luxury cars, telematics capabilities are expected to be present in over 50 percent of all new cars made in North America by 2006.[1] Initial concerns expressed about driver distractions are quieting as software steps in again with voice-recognition applications that allow drivers to interact with telematics systems without having to take their hands off the wheel.

Back in 1968, the Volkswagen Squareback initiated the move toward in-vehicle software with the first electronically controlled fuel injection system.[3] Now, over thirty years later, some German luxury cars sport over one hundred interconnected electronic component units (ECUs), controlling a variety of driving features such as intuitive shifting, a speed limiter and cornering brake control.

With software affording so many opportunities to strengthen brand image and increase customer loyalty, it's no surprise that electronic content in the average automobile is on the rise. In low-end vehicles, the number of microcontrollers has more than doubled since 1998 – from 6 to 14. And, in luxury autos, the totals are much higher, now averaging over 105 microcontrollers in each vehicle.[2] Simply stated, the car is moving from a *mechanical* machine to an *electronic* one.

This metamorphosis from being mechanically controlled to software-driven represents a fundamental industry shift. And, although most automobiles have raced through this transition, many automakers have not.

Warning indicators

OEMs have some painful reminders that today's processes are not adequately addressing the challenges introduced by rising software content. Today, automakers pay over US$500 in warranty costs per vehicle,[4] with total North American warranty costs pegged at over US$10 billion per year.[5] IBM research suggests that over 30 percent of these costs are attributable to software and electronics defects and this portion of warranty cost is growing fast. This means software and electronics-related warranty costs exceed US$3 billion per year.

"Telematics has reached the sweet and sour reality … However, we continue to see opportunity and immediacy to strengthen and define new ways to connect and relate to our customer." — *Automotive Executive.*

Quality issues continue to eat away at automakers' profits. In 2000, warranty payments associated with its Mercedes-Benz luxury-car unit cost DaimlerChrysler US$1.5 billion – roughly equal to what Mercedes-Benz spent on development that same year.[6] Ford Motor Company missed out on US$1 billion of profit in 2000 due to delayed product launches and quality glitches. Even more disconcerting, investment analysts suggest that, although Ford's billion-dollar loss is high, other OEMs have fared worse.[7]

Possibilities in telematics sound exciting, and, in many cases, have already proven technically feasible. But, given the massive investment that is required for OEMs to position themselves to provide these types of services, an important question remains: Who will pay? Automakers have learned that business models based solely on consumer subscriptions will not always work, and they are evaluating alternative methods of funding such as:

- *Cost savings* – Using funds that were previously devoted to development and production, which have been reduced through process improvement. At an average North American auto company, reducing software-related vehicle production costs by 10 percent could make up to US$2.2 billion available each year.[8]
- *Sponsorship from related industries* – Providing a "vehicle" for companies in complementary industries – such as insurance, security, financing – to advertise, offer co-branded services or collect data. Seventy-seven percent of customers indicated a willingness to accept advertising if that would reduce or eliminate telematics service charges.[9]
- *Commercial offerings* – Fleet operators – such as emergency-response organizations (police, fire, ambulance), school districts, large companies that provide vehicles for their employees and taxi services – can justify expenditures on telematics through the gains in flexibility, speed and efficiency of their fleet dispatch. During 2000, commercial vehicle telematics generated nearly US$900 million in revenue across the U.S. and Western Europe.[10]

“It takes automakers up to four years to bring a vehicle from concept to execution, but so-called cycle times in the electronics industry average about six months. That means the most cutting-edge embedded electronics would be stale long before a vehicle rolled off the assembly line.”[11]

“During the life cycle of a product, there are literally tens of thousands of changes made. As a change is made, it may take as much as 90 days to communicate that change throughout the organization.”– *Automotive executive.*[12]

Lack of interoperability in engineering data costs the automotive industry US$1 billion per year.[13]

Stuck in slow gear

Although the case for change is compelling, for many automakers the obstacles seem equally strong. Automakers face a variety of inhibitors that can stall progress as they move into more sophisticated software arenas.

Inefficient development processes

Even the most streamlined automotive development cycle typically stretches across multiple years, where as the electronics industry launches new products almost every six months. Development techniques like rapid versioning, software reuse, continuous feedback loops and configuration management that are standard practices in the software industry are less common in automotive design. Complicating the situation further, vehicle design and development involves multiple layers of concurrent development with different processes, operating on different timetables, at several different companies – from OEM to tier *n* supplier.

Integration between vehicle design subteams – braking and steering for instance – and between OEMs and their suppliers remains a challenge. Continuous rounds of changes to clarify misunderstandings and misaligned designs cause redundant engineering, wasting time and delaying development schedules. Exacerbating the problem, automakers often suffer from cumbersome and slow change-management processes.

Insufficient interoperability

Although most OEMs are interested in developing standards, as evidenced by multiple initiatives backed by leading manufacturers in various parts of the world, geographic differences and competitive business cultures have thwarted efforts to settle on standards. Even within individual organizations, different design subteams employ incompatible architectures, interfaces and data formats, leaving little room for reuse.

Skills shortages

According to a study by the Office for the Study of Automotive Transportation (OSAT) at the University of Michigan, the three types of individuals most in demand in the automotive industry – and the most difficult to find – are information technology (IT) systems support personnel, software specialists and product engineers.[14] Automotive manufacturers often find themselves competing with their peers and suppliers for the same scarce resources. For automakers, it is increasingly difficult to attract and retain employees with critical software skills.

According to a 2002 study sponsored by the National Institute for Standards and Technology (NIST), 50 percent of the automotive companies studied had experienced "significant software errors" in the previous year. The costs associated with inadequate software testing were estimated to be US$1.8 billion.[15]

Overwhelming complexity—from development through service

Growing software complexity can put undue strain on existing development processes and techniques. For example, as imbedded electronics become more powerful (4-bit architectures giving way to 32-bit), a single electronic component unit (ECU) may support more than one function, creating a host of new functional possibilities, multiplying the number of testing paths to exercise and overwhelming traditional testing methods.

The complexity does not end when the completed vehicle rolls off the line. Many service centers are ill-equipped to service a software-laden vehicle. ECUs are more interconnected than ever, with the performance of one ECU affecting the actions of another. As complexity rises, diagnosing a problem accurately – and quickly – becomes more difficult, requiring new skills, tools and methods of sharing information. Too often, service centers fail to receive critical information upfront, relegating them to search out the requisite knowledge after the fact, as problems arise.

Software "engine" overhaul

As automakers' products become more software-driven, the resulting complexity strains existing processes and management practices. Over the past thirty years, companies have tried to adapt to the unique demands of software, making additions to processes and systems originally built and optimized for mechanical design. As the volume of process add-ons and alterations mounts, defects start to slip through, product development cycles slow and it becomes more difficult to get products to market on time. Companies eventually reach a threshold where a more fundamental "overhaul" is required to develop products effectively. By reexamining processes through a software-focused lens, automotive companies can identify critical weak points that require improvement (see Figure 1).

Program management

Design and develop

- Provide traceable, unambiguous, maintainable design specifications
- Implement a realtime system for tracking, managing and communicating engineering changes
- Develop application code reuse and system-level design methodologies to encourage component interoperability
- Make software maintainability a key design requirement to reduce complexity and lower service cost.

Test and launch

- Use automated, iterative testing processes to pinpoint software problems more quickly:
  - – Subsystems running on a single ECU
  - – Subsystems of a particular function spread across multiple ECUs
  - – Entire ECU network, including buses
- Implement virtual testing facilities to increase coverage and thereby quality
- Provide a realtime feedback mechanism between testing and design teams.

Service

- Provide software configuration and repair data to service centers upon product launch:
  - –Through a centralized repository
  - – As part of formalized transition planning
- Feed field data from maintenance records and warranty claims into reliability, design-failure and diagnostic models
- Extend problem-tracking mechanism so that field-detected software problems are reported to design and development.

Knowledge management

Figure 1. Improvement opportunities exist across the automotive software development life cycle.

Source: IBM Institute for Business Value.

Keeping some common themes in mind can help executives hone in on which changes will have the most impact.

Collaborate better

- *Start early*—Involve key suppliers as soon as possible while the design concept is still fluid.
- *Interact often*—Find ways to encourage more frequent and more timely communications. Speedy communication is particularly critical with engineering changes.
- *Use software to make software*—Electronic collaboration tools and common software development environments—that span the combined OEM-supplier team—can offer much needed standardization, structure and speed.
- *Connect tools*—Establish links between disparate enterprise systems and design tools so that different teams, and even separate organizations, can work together more easily and develop end-to-end, closed-loop processes.
- *Consolidate communication methods*—Pick a few communication methods and use them consistently. Don't leave teams wondering where to go for what information. Make methods as efficient and realtime as possible—which most likely means using the Internet.
- *Bridge boundaries*—Use communication tools to overcome artificial barriers created by linear, brand-based reporting structures. Encourage cross-partner communications by implementing Internet-based communication methods.

Reuse, recycle, but don't reinvent

- *Communicate the reason*—Educate teams on the importance of effective knowledge management. Create incentives that encourage distribution and exchange of information between design, development, service, quality and reliability teams—whether OEM or supplier.
- *Create the means*—Build an integrated knowledge-management methodology and mechanism for software that spans the entire automotive supply chain and product life cycle. Include sufficient security features to protect proprietary information, but do not let those features impede regular, legitimate use.
- *Make it easier to find than invent*—Engineers often redo because it takes too much time to find what they need. Make sure that design and manufacturing knowledge libraries are up-to-date and easy-to-use.

Strive for interoperability

- *Decide where it matters most*—Determine where interoperability will offer the most payback and invest appropriately. Identify which software features should be commodities (mature enough to be moved to a common development standard), customizable (off-the-shelf modules developed collaboratively but customized by brand) or proprietary (brand differentiators that require focused, in-house development). (See Figure 2.)
- *Save to spend*—Apply savings (in terms of reduced costs and increased speed) from use of commodity and customizable features toward development of new or improved proprietary features.

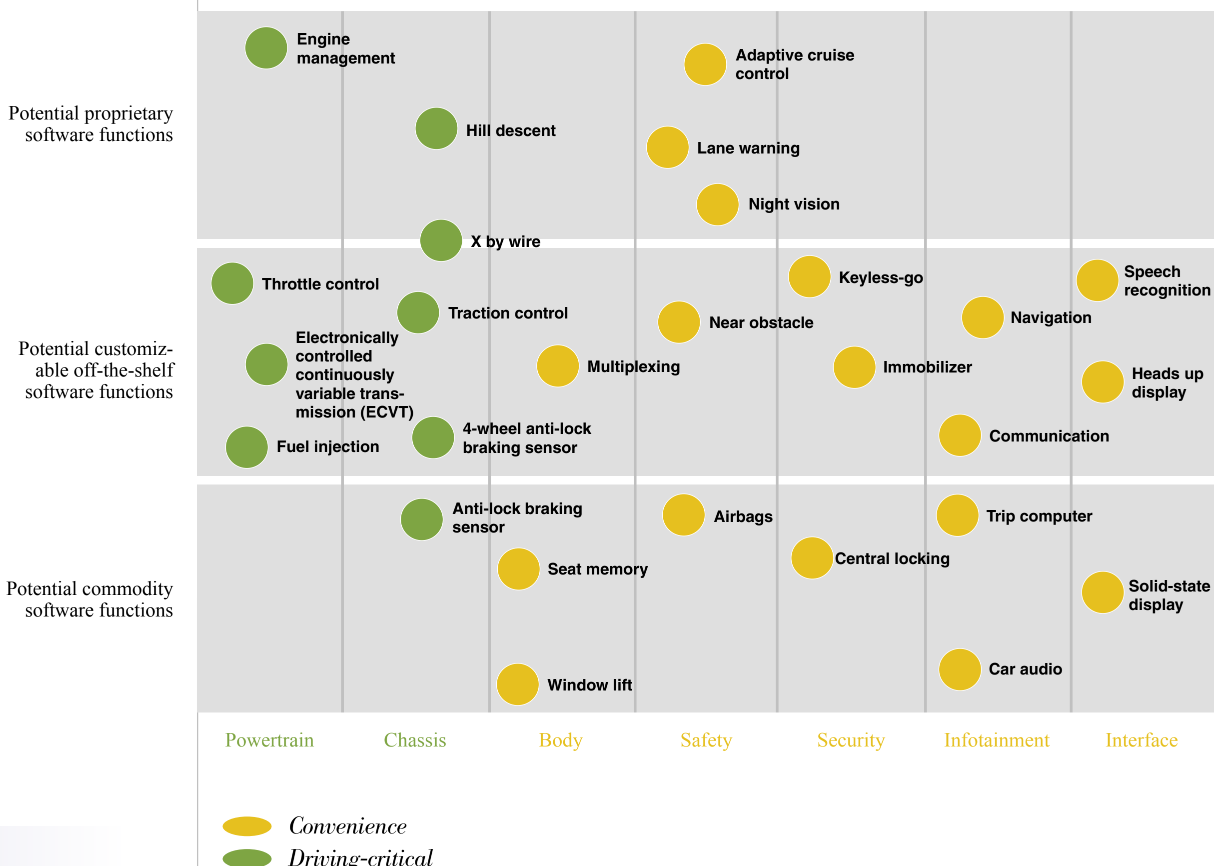

Figure 2. Creating customizable software functions will provide flexibility for OEMs to focus on developing new proprietary differentiators.

Source: IBM Institute for Business Value.

Make organization an asset

- *Establish a vantage point* – Create a program management office (PMO) to oversee all automotive software-development projects to provide cross-vertical visibility into best practices and synergistic opportunities.
- *Accentuate process not product* – Organize teams by process (in addition to product) to further company-specific goals: For example, a supplier-management team to coordinate administrative issues with suppliers, a knowledge-management team to support asset creation and reuse and an architecture team to enforce compliance with interoperability guidelines (see Figure 3).
- *Make success mutual* – Link PMO measurements with those of the vertical-line executive to encourage cooperation and better-integrated software-investment planning.

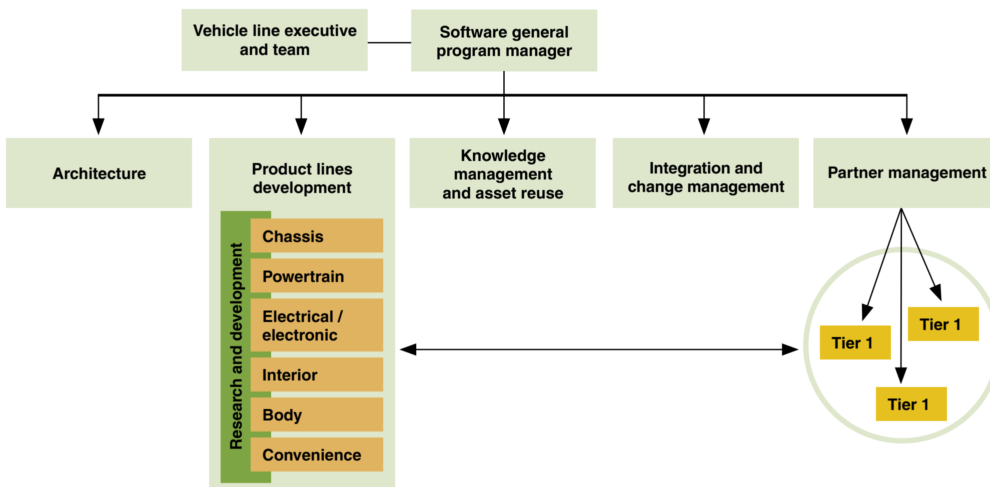

Figure 3. Linking development teams will create better synergy and knowledge reuse.

Source: IBM Institute for Business Value.

Gauging your software savvy

As an automaker, are you adequately prepared to produce the next generation of automobile where each customer's vehicle carries its own unique "style" enabled by the particular combination of software features selected? Or, has the onslaught of in-vehicle software unsteadied your existing strategies, processes and support systems? Take a few minutes to think through the following questions and assess your readiness for a software-driven future:

- How have our software-based features and functions contributed to the positive perception of our brand?
- Have we reduced software-related warranty claims significantly over the past year? Are our warranty figures declining consistently?
- How does the quality of our software-centric parts and services compare to the rest of the industry (for instance, in the J.D. Power and Associates Initial Quality study)?
- Where have we been able to benefit from software-development standards and common platforms?
- How often do direct customer interactions lead to specific software improvements? Do we have an effective way of analyzing and using customer feedback in the design process?
- Are software-development suppliers involved consistently throughout development and share responsibility for the overall quality of the end product? Do we exchange information bilaterally?
- Do we have the capabilities to leverage and exploit new car software technologies? Have we prioritized these opportunities and made the proper investments?
- Which software functions and features no longer offer sufficient differentiation and could be converted to an industry standard to cut costs and development time?
- How have we changed our service approach given the increase in software complexity?

The vision made possible by software is lofty: vehicles that are practically "trouble free" thanks to electronic diagnostics and remote repair, are "recyclable" with ECUs that can be easily reprogrammed to provide new model features and functions, and are "at your service" providing in-route assistance to their drivers. Although no one can predict exactly what tomorrow will hold for in-vehicle software, the automakers who make fundamental business adjustments now to address the unique demands and opportunities from an increasingly software-driven product will be in the driver's seat as the future unfolds.

To discuss how IBM can help you address the challenges presented by this automotive industry shift, please contact us at *bva@us.ibm.com*. To browse through other resources for business executives, we invite you to visit our Web site at:

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