The State of Innovation in the Automotive Industry

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THOMSON REUTERS
INTRODUCTION

Since the turn of the 20th Century, almost from the time they were first invented, automobiles have been actively dreamed about, and speculated upon in works of science fiction. The most persistent of these stories was the idea of the flying car, which has been a staple of science fiction for more than a hundred years, and even led Henry Ford in 1940 to remark, “Mark my word. A combination airplane and motor car is coming. You may smile. But it will come.”

While the world may still be waiting for a mass-produced flying car, there has been a tremendous amount of innovation in the automotive industry since these vehicles were first invented. Looking back over the last five years, a significant amount of technology has been introduced into the ever-evolving automobile. In terms of innovation activity, worldwide patent filings in the automotive industry ranks third overall across the top 12 technology sectors, just barely behind Telecommunications and trailing industry leader Computing and Peripherals, according to the latest Thomson Reuters innovation data. While the automotive industry ranks third in the list of the sectors covered, it had the highest percent change in patenting volume of all areas between 2013 and 2012.

Today, innovation related to alternative powered vehicles, navigation systems, and safety top the list of automotive technology improvements. The automotive industry is extremely progressive, leading some in the field to claim that the car may well be the most technologically advanced product that most consumers will ever buy. A 2014 Center for Automotive Research report, entitled Advanced Information Technology Solutions: An Engine of Innovation, summarizes this sentiment by saying: “The industry is transitioning from a primarily mechanical-based industry to a software-based industry. In fact, some would argue that the industry is transitioning from a transportation focus to a technology focus.”

This report examines recent patenting trends in the automotive space, including the companies doing the innovating and segments that have been growing the fastest over the last five years. Collecting and organizing patent data can help analysts compare companies by their areas of investment in technology, and how they may have changed over time. As an example of this, several companies and their patent filing practices will be studied. Finally, a few hot topic areas of interest will be explored, identifying the technologies and companies that are filing patents today, for the new features that consumers will buy in their vehicles tomorrow.

3 http://www.cargroup.org/?module=Publications&event=View&pubID=107
The automotive industry has experienced a period of consistent, high growth in the number of innovations filed around the world over the past few years, as can be seen in Figure 1. Year on year, over the past five years, the automotive sector has been growing by double-digit figures.

While it is useful and important to look at the trend for the industry as a whole, a true sense of the real growth areas within the field can be better illustrated by dividing the sector into categories, and looking at the filing trends associated with each individually. At a very high level, the automotive industry can be divided into five broad categories as seen in Table 1.

**TABLE 1: FIVE BROAD CATEGORIES IN AUTOMOTIVE INDUSTRY**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>DEFINITION</th>
<th>VEHICLE COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propulsion</td>
<td>Systems and components of automobiles responsible for generating motion, or movement of the vehicle</td>
<td>Engine Design, Transmissions, Alternate Power Systems, Powertrains</td>
</tr>
<tr>
<td>Navigation</td>
<td>Systems and components dedicated to determining where the vehicle is located and how it interacts with other vehicles</td>
<td>GPS, Dedicated Short Range Communications</td>
</tr>
<tr>
<td>Handling</td>
<td>The aspects of automobiles responsible for determining the direction and velocity of the vehicle</td>
<td>Braking Systems, Steering Systems, Suspension Systems</td>
</tr>
<tr>
<td>Entertainment</td>
<td>Systems and components for occupying passengers and for allowing them to interact with internet based systems</td>
<td>Smartphone Integration, Heads Up Display (HUD), In-Car Communication</td>
</tr>
</tbody>
</table>

Source: Thomson Innovation & Thomson Reuters Derwent World Patents Index
Looking at these categories over the past five years, as seen in Figure 2, it can be determined that the main driver for technology development in the automotive industry is investment in propulsion systems.

**TOP AUTOMOTIVE INNOVATORS**

With recent government emphasis on fuel economy, which will be discussed in more detail in the Hot Topics section, and a growing market for hybrid and alternately powered vehicles, it is no surprise that propulsion is a category of high interest to the auto industry. Generally, all of the categories are seeing growth, but none has experienced the rapid rise seen in propulsion.

In addition to developing categories within the automotive industry, this study also looks at the organizations generating the most innovations in each field. The companies that file the most automotive patents represent the groups that are investing the most in new technology, and provide a glimpse into the areas of innovation in which they are most interested. Figure 3 shows a chart of the top 25 most frequent invention filers in the automotive industry.

**TOP INNOVATORS BY CATEGORY**

Returning to the individual categories, it is also possible to identify the top companies in each of the more detailed areas in the automotive industry. Figures 4 through 8 highlight the top 10 companies within each category.

**FIGURE 2: AUTOMOTIVE INVENTIONS BY PUBLICATION YEAR**

There are representatives from Japan (Toyota, Honda, Denso, Seiko Epson, Mitsubishi), Korea (Hyundai), Germany (Bosch, Daimler, Continental) and the United States (GM) in the top 10.

Many of the companies in the top ten here are also in the top ten overall since propulsion is the largest of all of the categories. Notably, Hyundai is seventh in this category but third overall, suggesting that propulsion may not be the major focus of its portfolio.

**FIGURE 3: TOP AUTOMOTIVE PATENT ASSIGNEES (2009 - 2013)**

In Navigation, Japanese electronics company Seiko Epson is at the top of the field, joined by other electronics companies including Semiconductor Energy Lab, Panasonic, Fujitsu and Aisin.

While Toyota is the top filer overall, and leads many of the individual categories, it is listed fourth for the handling category. This is contrasted with Hyundai, which is the top inventive company in this category and plays a prominent role in most of the other categories as well.

**FIGURE 4: TOP 10 PROPULSION ASSIGNEES**

**FIGURE 5: TOP 10 NAVIGATION ASSIGNEES**

**FIGURE 6: TOP 10 HANDLING ASSIGNEES**

**FIGURE 7: TOP 10 SAFETY & SECURITY ASSIGNEES**

**FIGURE 8: TOP 10 ENTERTAINMENT ASSIGNEES**
Looking over all five categories, only three companies, Toyota, Bosch and Hyundai, are in the top 10 in all of them. Toyota has been a perennial leader in automotive innovation, but Hyundai appears to be an up-and-coming organization that may be worth paying more attention to in the future from an innovative standpoint.

The emergence of Hyundai can be seen clearly in Figure 9, which looks at the top 10 companies and their filing history over the last 10 years.

Some new companies begin to make a top 10 appearance in the safety & security category including Autoliv Development, Tokai Rika and Takata, second, seventh and ninth, respectively.

Surprisingly, in contrast to the navigation category, which included several electronics companies as the top innovators, the entertainment category is led by traditional automotive companies, with the exception of Panasonic and Fujitsu.

When looking at Hyundai, on the other hand, it appears that handling might be its area of highest interest from Figure 10, yet it has dramatically decreased its rate of filing there. While handling still remains an area of interest, it is the propulsion and navigation areas that are driving recent growth in its portfolio. With the exception of entertainment, the increase in pace of innovation at Hyundai appears to be spread across all of the categories.
Looking at the automotive industry at a relatively high level provides insight into the rate of innovation occurring in the sector, what new areas are generally being explored, and which companies are expressing the most interest. To gain a greater understanding of where the automotive business is headed in the future, it is also possible to drill into the individual categories. These drill downs provide a lens on specific instances of innovation that may be unveiled in the near future. Table 2 provides a list of the hot topic areas, their definitions, and the categories to which they correspond.

Table 2—List of Hot Topic Areas, Definitions, and Corresponding Categories
Source: Thomson Innovation & Thomson Reuters Derwent World Patents Index

<table>
<thead>
<tr>
<th>TOPIC AREA</th>
<th>DEFINITION</th>
<th>CATEGORY</th>
</tr>
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<tbody>
<tr>
<td>Fuel Economy</td>
<td>Also known as fuel efficiency, or the maximization of the distance traveled on a unit of fuel</td>
<td>Propulsion</td>
</tr>
<tr>
<td>Telematics</td>
<td>Global Positioning System technology integrated with computers and mobile communications technology in automotive navigation systems</td>
<td>Navigation</td>
</tr>
<tr>
<td>Autonomous Driving</td>
<td>Automobiles that are capable of driving themselves without input from a human passenger</td>
<td>Handling</td>
</tr>
<tr>
<td>Driver Assistance</td>
<td>Various systems such as auto braking, lane departure warning, and traffic sign recognition that help the driver become aware of and avoid road hazards</td>
<td>Safety &amp; Security</td>
</tr>
<tr>
<td>Heads-Up Displays (HUDs)</td>
<td>Systems for displaying data from a smartphone to the windshield of an automobile so a driver can keep his/her eyes on the road</td>
<td>Entertainment</td>
</tr>
</tbody>
</table>

Table 1: HOTTEST AREAS OF AUTOMOTIVE INNOVATION
While alternate power systems get a lot of the attention in the propulsion category, innovations to increase the fuel efficiency of internal combustion engines is also an area of intense interest and innovation. Motivation for increases in fuel economy have been provided by different countries, including President Obama in the United States when he mandated that cars and light-duty trucks by Model Year 2025 have an equivalent fuel economy of nearly 55mpg. Additionally, Obama continues to look for efficiencies and has suggested that standards for heavy-duty vehicles will also soon be adjusted.

An illustration from US20110160020A1 filed by GM showing how a torque converter can help with fuel economy
Source: Thomson Innovation

In Figure 13, the top 10 companies and the number of patent publications by year from 2009 to 2013 associated with innovations in fuel economy are provided.

While Hyundai is once again a leader in this area, which suggests that it may be more interested in fuel economy than alternative power, the next two companies, GM and Ford, are based in the U.S., as should be expected based on the standards President Obama set forth for 2025. GM is listed in the top 10 companies overall in the segment, but this is the first appearance of Ford in a top 10 list. Ford is number 16 in the overall list of automotive companies.

An illustration from WO2011136456A1 filed by LG demonstrating the principles of telematics
Source: Thomson Innovation

Telematics is defined as an interdisciplinary field encompassing telecommunications, vehicular technologies, road transportation, road safety, electrical engineering (sensors, instrumentation, wireless communications, etc.) and computer science (multimedia, Internet, etc.). It involves the integrated use of telecommunications and informatics for application in vehicles and with control of vehicles on the move. Some of the specific technologies involved in telematics include:

- Dedicated Short Range Communications (DSRC) – a two-way, short-range wireless communications technology designed for the auto industry.
- InteliDrive – a plan to put wireless communications similar to Wi-Fi on every new car, which that car will use to broadcast its “heartbeat” continuously, including basic facts such as speed, location and direction.

The list is populated by some of the usual suspects, as well as some new entrants, including the Electronics and Telecommunication Research Institute and the United Parcel Service (UPS), neither of which has been seen in a list to this point. Hyundai once again appears as an organization on the rise in this particular topic area.

An illustration from WO2011136456A1 filed by LG demonstrating the principles of telematics
Source: Thomson Innovation

Figure 14—Automotive Patent Filings Reduced to One Document per DWPI Family Charted by Company and the Publication Year of the Earliest Family Member for Fuel Economy Innovations
Source: Thomson Innovation & Thomson Reuters Derwent World Patents Index

Figure 14—Automotive Patent Filings Reduced to One Document per DWPI Family Charted by Company and the Publication Year of the Earliest Family Member for Telematics Innovations
Source: Thomson Innovation & Thomson Reuters Derwent World Patents Index

TELEMATICS

FUEL ECONOMY
Cars that drive themselves are part of the science fiction landscape discussed at the beginning of this report, but recent advances, most publicly by Google, demonstrate that the future of autonomous driving may be closer than previously thought. Experts claim the technology is still decades away from being viable in all traffic conditions, but there has still been a great deal of innovation taking place in the field, as evidenced in the listing of the top companies in Figure 15.

While Google may get the majority of the headlines related to autonomous driving, it is actually Toyota, GM and Hyundai that are filing the most patents in this area. GM, in particular, has shown an amazing increase in interest with the most documents published in 2013.

Telematics allows cars to communicate with one another while on the road, while autonomous driving allows a vehicle to be driven without input from its passengers. These areas, along with driver assistance, are similar to one another, but in this topic area the driver is fully in control of the vehicle but is provided with assistance in certain tasks or circumstances should he/she become distracted. Specific technologies associated with driver assistance include:

- Rear-mounted radar
- Automatic high-beam control
- Back-up assistance
- Blind spot detection
- Pedestrian detection
- Lane departure warning (LDW)
- Intelligent braking
- Traffic signs recognition
- Active cornering headlight
HEADS-UP DISPLAYS (HUDs)

Harkening to the floating displays of the movie “Minority Report,” or the advanced information and targeting systems associated with Tony Stark’s armor in “Iron Man,” the idea of HUDs, and their ability to allow operators to keep their eyes forward while interacting with contextual information from the outside world, has been sought after for some time. These systems started with the display of vehicle information on the front windshield, but have evolved to include input from a driver’s cell phone, such as directions, and incoming phone calls that are displayed on the front window. Some systems also allow the driver to use voice commands or simple motions to interact with the system without picking up the phone.

![An illustration from WO2013168396A2 filed by Yazaki Technologies on a HUD system. Source: Thomson Innovation](image)

Figure 17 shows that of all the categories and topics discussed to this point, HUDs have by far the most rapid, recent growth in patent publications. The topic is also led by non-automotive companies with four of the top five companies coming from outside the traditional automotive field. The converging leaders in this area are Universal Display and Johnson Controls, neither of which have appeared in the list of top assignee companies thus far.

CONCLUSION

The automotive industry is one of the most innovative industries in the world and was recently described as making the transition from being mechanically based to being software based. Technology is most certainly playing a key role in developing next generation automobiles that will be more fuel efficient, safer, and fun to drive. During the course of this report looking at the patenting trends associated with the automotive industry, the following observations were made:

- American companies are leading the way in increasing fuel economy.
- While Google grabs the headlines in autonomous driving, it’s Toyota, GM and Hyundai that have the most filings.
- Bosch is the undisputed leader in the area of driver assistance.
- HUDs have seen the most recent and rapid rise in patent publications of any category or topic in this study.
- Hyundai has taken a lesson from its Korean colleagues, Samsung and LG, and is becoming a major patent force in the automotive industry.

- The top 10 companies are responsible for 20 percent of the filings in the segment.
- The propulsion category is responsible for most of the recent growth in the segment.
- The top three companies are responsible for most of the recent growth within the top 10 companies.
- Toyota’s primary interest is in propulsion, and it has been consistent over time.
- Hyundai is an up-and-coming player, and while its interest was originally in handling, it has transitioned to an interest in propulsion but maintains a balanced portfolio over all five categories.
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Data for this report were aggregated using the Thomson Reuters Derwent World Patents Index® (DWPISM) to identify global innovation activity in the automobile industry. Within each category, researchers analyzed the total number of unique inventions (each invention was counted only once) issued in published patent applications and granted patents during application year 2009 to July of 2014. The analysis focused on five overarching categories of automotive industry R&D representing the majority of new inventive activity within the sector during the studied time period. Each unique invention was assigned to a primary category, and this designation was used for the subsequent analyses to eliminate repeats and overlap between different technology areas.

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