



U.S. Department  
of Transportation

**National Highway  
Traffic Safety  
Administration**

## ODI RESUME

**Investigation:** EA 09-013  
**Prompted by:** PE09-020  
**Date Opened:** 08/18/2009  
**Investigator:** Derek Rinehardt  
**Approver:** Frank Borris  
**Subject:** Vehicle Rollaway Allegations

**Date Closed:** 02/12/2013  
**Reviewer:** Jeff Quandt

### MANUFACTURER & PRODUCT INFORMATION

**Manufacturer:** Ford Motor Company  
**Products:** MY 2002 - 2005 Explorer / Mountaineer, MY 2003 - 05 Aviator  
**Population:** 1,500,000 (Estimated)

**Problem Description:** Drivers are alleging vehicle rollaway after the transmission is shifted to Park or the driver perceives the vehicle is in Park.

### FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
<b>Complaints:</b>	3	33	36
<b>Crashes/Fires:</b>	2	12	14
<b>Injury Incidents:</b>	1	6	6**
<b>Number of Injuries:</b>	1	6	6**
<b>Fatality Incidents:</b>	0	0	0
<b>Other*:</b>	0	144	144

\*Description of Other: Warranty Claims

\*\* Total eliminates duplicates received by ODI and manufacturer.

### ACTION / SUMMARY INFORMATION

**Action:** This Engineering Analysis is closed.

**Summary:**

This investigation is being closed based on several considerations. By the most inclusive counting of all alleged rollaway incidents (i.e., counting all alleged rollaway incidents and assuming a singular failure mechanism), the incident rate is low, however during EA09-013, ODI identified a number of different failure mechanisms in 180 incidents related to the alleged defect. The highest rate for any particular failure mechanism, the failure of the Automatic Transmission Parking System, was 4.4/100K. The next-highest failure rate was for the BSI System, at 3.4/100K. For all identified failure mechanisms there has been a drastically declining trend including very few incidents occurring in recent years.

Accordingly, this investigation is closed. The closing of this investigation does not constitute a finding by NHTSA that a safety-related defect does not exist. For additional information regarding this investigation, see the complete closing resume in the document file for EA09-013.

The ODI reports cited above can be reviewed at [www-odi.nhtsa.dot.gov/complaints](http://www-odi.nhtsa.dot.gov/complaints) under the following identification (ODI) numbers: 10168454, 10279630, 10280078.

## EA09-013 Closing Report

**SUBJECT:** Vehicle Rollaway

**EA No.:** EA09-013

**OPENED DATE:** 18-Aug-2009

**CLOSED DATE:**

**SUBJECT VEHICLES:** Model year (MY) 2002 - 2005 Ford Explorer / Mercury Mountaineer and MY 2003 – 2005 Lincoln Aviator



**Ford Explorer**



**Mercury Mountaineer**



**Lincoln Aviator**

**Figure 1**

### **VEHICLE POPULATION:**

Model	Model Year				Total
	2002	2003	2004	2005	
<b>Ford Explorer</b>	491,364	300,479	294,797	196,687	<b>1,283,327</b>
<b>Mercury Mountaineer</b>	77,975	45,900	50,553	32,402	<b>206,830</b>
<b>Lincoln Aviator</b>		27,051	26,992	18,850	<b>72,893</b>
					<b>1,563,050</b>

**Table 1**

**ALLEGED DEFECT:** Vehicle rollaway while the vehicle is in Park (or the driver believes the vehicle is in Park), or difficulty shifting the steering column shift lever into the Park position.

**BASIS:** The Office of Defects Investigation (ODI) opened Preliminary Evaluation (PE) 09-020 to investigate allegations of vehicle rollaway after the transmission is shifted to Park, or the consumer perceives the vehicle is shifted to Park, in MY 2002 through 2005 Ford Explorer and Mercury Mountaineer vehicles. By the conclusion of PE09-020 ODI had identified 200 alleged incidents (or a rate of 13.4/100K) of vehicle rollaway. Of these incidents, ODI identified 85 allegations of crashes and 32 allegations of injuries. ODI also identified 883 reports of consumers alleging difficulty or inability to shift the vehicle into Park. Accordingly, ODI upgraded the investigation to an Engineering Analysis (EA), which was expanded (for reasons discussed below) to include all MY 2003-2005 Lincoln Aviator vehicles. During the EA, ODI further investigated whether the reported

## EA09-013 Closing Report

incidents were related to the alleged defect, as well as the potential causes (failure mechanisms) that led to these incidents.

**DESCRIPTION OF RELEVANT SYSTEMS AND COMPONENTS:** Many vehicle components function in combination to park a vehicle and prevent vehicle rollaway. Based on analysis of consumer reports to ODI and data submitted to ODI by Ford, ODI identified several potential failure mechanisms. As described below, ODI identified the Brake Shift Interlock system and the Automatic Transmission Parking System as having significantly higher failure rates than other vehicle component systems.<sup>1</sup>

### The Brake Shift Interlock System

The subject vehicles are equipped with a Brake Shift Interlock (BSI) system. The BSI prevents the vehicle from being shifted out of Park unless the brake pedal is depressed. The BSI operates regardless of the starting system key position.<sup>2</sup>

Varying BSI designs exist across the automotive industry. In the Ford Explorer and Mercury Mountaineer, Ford utilizes a design that incorporates the BSI into the steering column, as shown in Figures 2-3. The Lincoln Aviator has a different design as its gear selector is mounted on the floor, not the steering column.



Figure 2

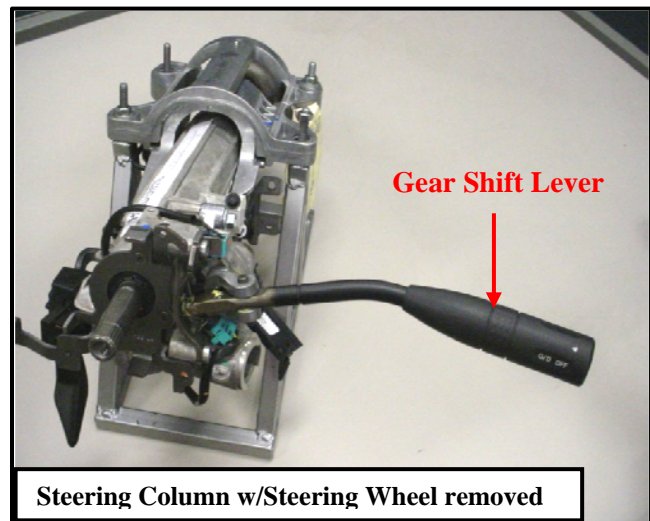


Figure 3

<sup>1</sup> See the “Failure Report Summary” section beginning on page 8 of this report.

<sup>2</sup> On March 30, 2010, NHTSA amended Federal Motor Vehicle Safety Standard 114 to require a BSI system on all passenger cars and certain trucks. See <https://www.federalregister.gov/regulations/2127-AK38/fmvss-no-114-theft-protection-and-rollaway-prevention->.

## EA09-013 Closing Report

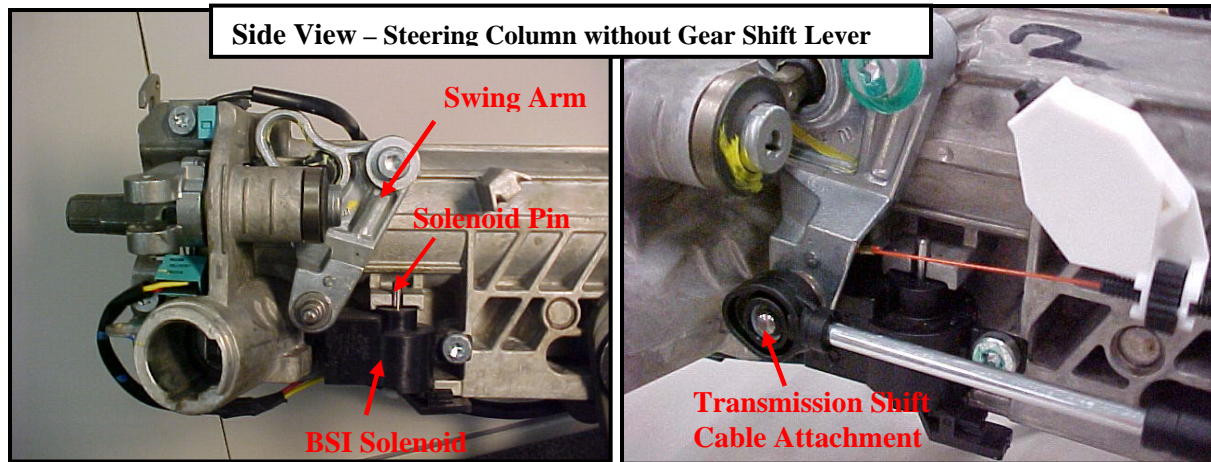


Figure 4

The BSI utilizes a “swing arm” and a solenoid (See Figure 4). The gear shift lever is connected to the swing arm. Attached to the swing arm is the transmission shift cable that connects the steering column/shift lever to the transmission. When the vehicle is in Park, the swing arm (and thus the gear shift lever) is prevented from moving by the BSI solenoid pin unless the brake pedal is applied (see Figure 5). When the driver applies the brakes, the brake lights are activated, and, at the same time, the brake light switch sends a signal to the BSI solenoid to retract the pin. Once the BSI solenoid pin is retracted, the swing arm is allowed to rotate freely, and the driver can shift out of Park. The pin is design to retract within 0.4 second after the brakes are applied. The swing arm is also designed with a ramp that depresses the BSI solenoid pin (see Figure 6) allowing the driver to shift to Park under any of the following circumstances: (1) the brakes are not applied before shifting to Park; (2) the driver applies the brakes and shifts before the BSI Solenoid pin has retracted; or (3) the vehicle loses electrical power such that a signal is not received for the pin to retract.

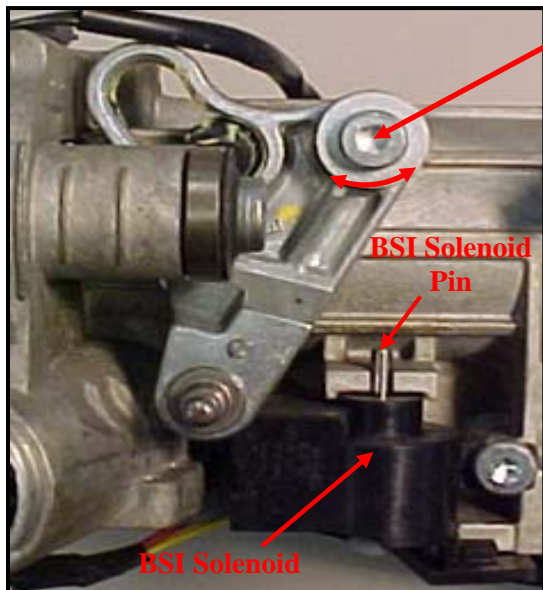


Figure 5

The “swing arm” rotates about this pivot point when shifting to and from Park.

The BSI solenoid pin retracts when the brakes are applied allowing free movement of the “swing arm”.

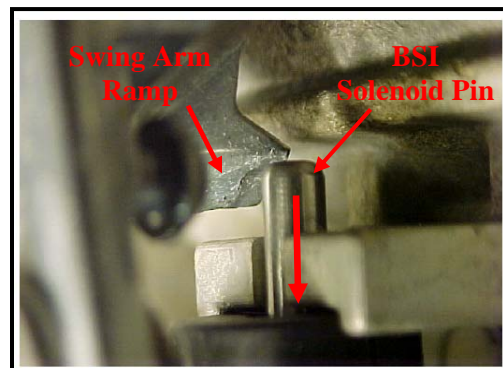


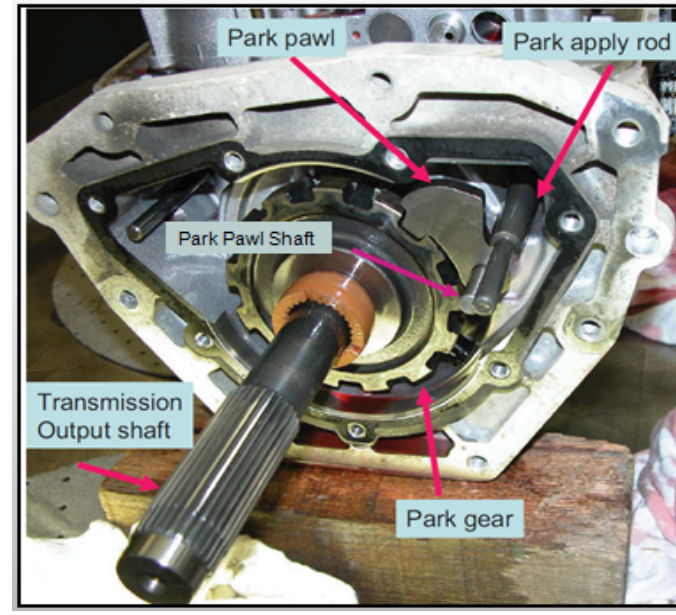
Figure 6



## EA09-013 Closing Report

### Automatic Transmission Parking System Components:

When the driver shifts the vehicle into Park using the gear shift lever, at the transmission end of the park system the park apply rod (shown in Figure 7) moves the park pawl into position to engage the park gear. As the transmission output shaft rotates, the park gear also rotates. When one of the park gear notches align with the cog of the park pawl, the park pawl locks in place, preventing the transmission output shaft from rotating. Torque (or rotation) from the transmission output shaft provides power to the wheels (through drive axles – not shown). Thus, once the transmission output shaft is locked, vehicle movement is prevented.



**Figure 7**

### **FAILURE MECHANISMS**

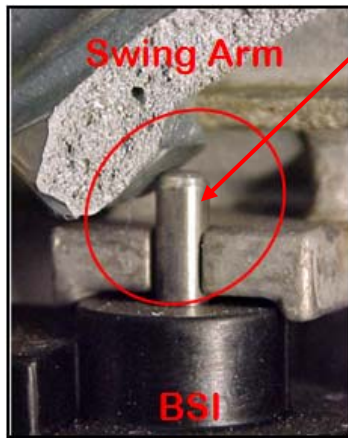
#### Brake Shift Interlock System:

When production of the subject vehicles began in MY 2002, incorporated into the design of the BSI solenoid was a delay in the retraction of the BSI solenoid pin of up to 0.4 second from the time the driver applied the brakes. This delay in the retraction of the pin was implemented to resolve a rattle issue created by the BSI solenoid that was discovered during pre-production.

Drivers who apply the brakes and shift from Reverse (or Drive / Neutral) to Park within the 0.4 second time frame (or drivers who do not apply the brakes at all when shifting into Park) may experience a condition where there is contact of the pin to the steering column swing arm ramp because the BSI solenoid pin has not retracted (see Figure 8.) Repeated contact of the BSI solenoid pin to the swing arm ramp can create a deformation of the swing arm. (See Figure 9.) Depending on the size of the deformation, the BSI solenoid pin can become caught in the deformation, resulting in an increased amount of force required for the driver to shift to Park or, if the deformation is deep enough, the inability of the driver to shift to Park. As explained below, in this situation the gear indicator (the PRNDL) on the dashboard will indicate that the vehicle is not in Park.

## EA09-013 Closing Report

On the other hand, if the driver applies the brakes and shifts more slowly (greater than 0.4 second) the BSI solenoid pin will retract without contacting the swing arm. As a result, the swing arm does not become deformed, and the previously described failure mechanism does not occur.



**Figure 8**

**BSI Solenoid Pin**

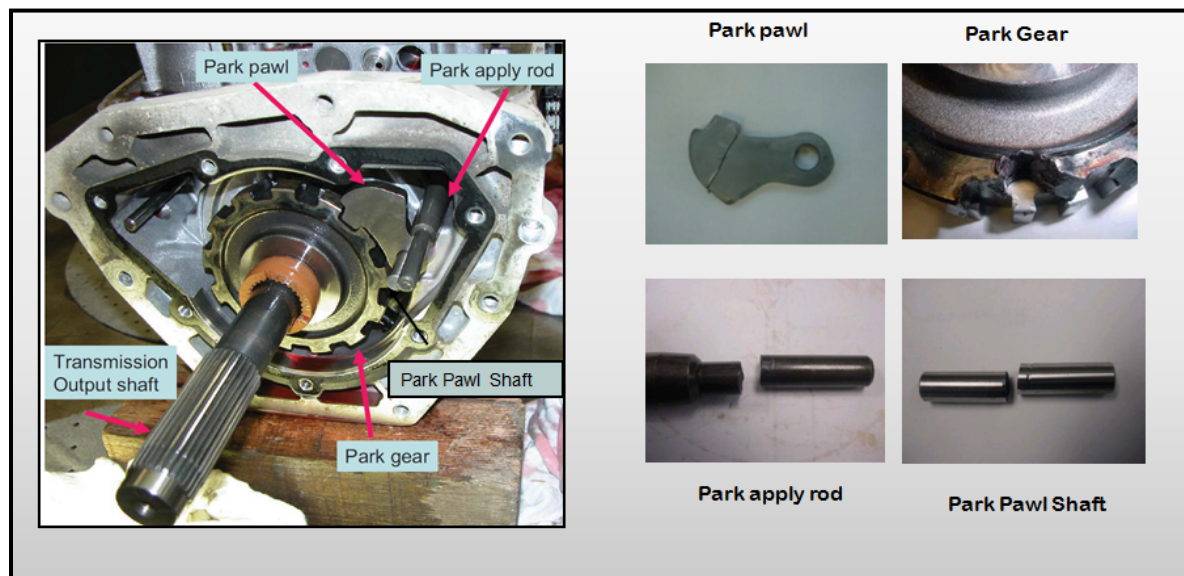


**Figure 9**

**Deformation created in the swing arm.**

### Automatic Transmission Parking System

Multiple components of the automatic transmission parking system, including the park pawl and the park apply rod, can be damaged (as shown in Figure 10 below) as a result of impulse loading during transit by rail or a car hauler if the park brake is not applied. Failure of one or more of these components can result in a failure to prevent rotation of the transmission output shaft. As a result, the vehicle is able to move, even though the PRNDL indicates to the driver the vehicle is in Park (see Figure 11 on the following page).



**Figure 10**

## EA09-013 Closing Report



**Figure 11**

On February 27 2004, Ford issued Quality Bulletin #171 to the vehicle assembly plants that manufactured Explorer platform-based vehicles. The bulletin emphasized the requirement that the parking brake must be fully applied once vehicles are loaded, constrained and prepped for shipment on rail or car haulers. The bulletin explained that full parking brake application decreases the drive line torque (rotation of the transmission output shaft) that stresses the transmission park system during impulse loading events as seen during rail or car hauler shipment.

### **FAILURE MODES:**

#### **Brake Shift Interlock System**

After repeated shifts to Park (within 0.4 seconds after applying the brakes) resulting in contact of the BSI solenoid pin with the swing arm, the deformation described above may increase in depth. The depth of the deformation depends on the force and the rate at which the driver applies it to the gear shift lever. The deeper the deformation, the greater is the force the driver needs to apply to the gear shift lever to place the vehicle in Park. Thus, a driver may experience difficulty shifting the gear shift lever to Park. If the deformation is deep enough, the driver may not be able to shift to Park at all.

If the driver is not able to shift into Park, the vehicle will be placed in the following state: (1) the PRNDL will show the vehicle is not in Park (“P”) (Figure 12.1); (2) the transmission parking pawl is not engaged with the parking gear (Figure 12.2), potentially allowing the vehicle to move; and (3) the key cannot be removed from the ignition because the vehicle is not in Park (if the gear shift lever is not in contact with the Park Detection Switch, the key cannot be removed) (Figure 12.3). A vehicle in this state may rollaway unexpectedly, particularly if the driver does not observe the PRNDL and believes the vehicle to be in Park. For example, one warranty claim states that the “transmission selector will not go into park at times. The vehicle started rolling back thinking it was in Park.”<sup>3</sup> The technician road tested the vehicle and “verified that the shifter won’t go into park all the time removed the steering column trim, the steering column and replaced the shifter lock solenoid.”

---

<sup>3</sup> Warranty Claim #10685013.

## EA09-013 Closing Report



Figure 12.1



Figure 12.2

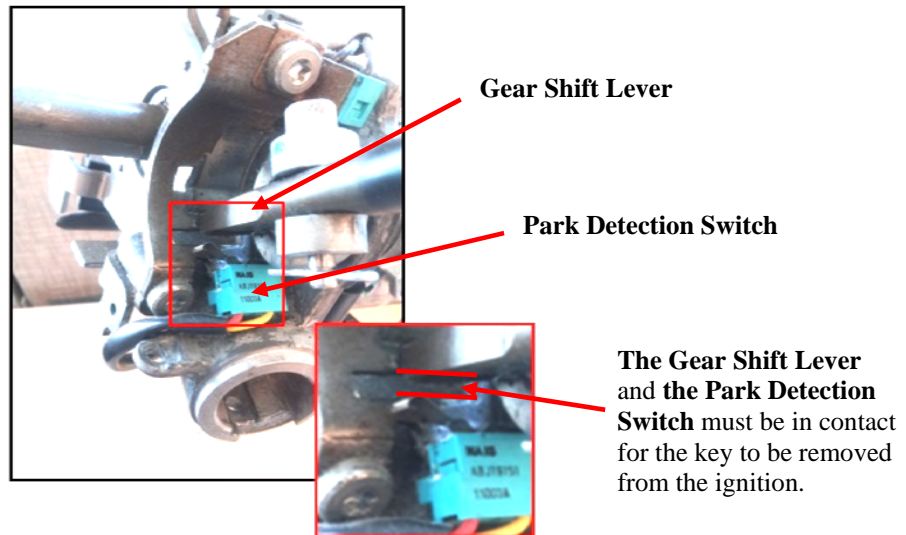


Figure 12.3

### Automatic Transmission Parking System

Failure of one of more of the automatic transmission parking system components (previously shown in Figure 10) can prevent the parking pawl from engaging the parking gear, resulting in the transmission output shaft being free to rotate. As a result, the vehicle will be able to move, even though the PRNDL indicator indicates that vehicle is in Park. For example, one warranty claim that reported this concern stated that “with the vehicle in Park, the vehicle free rolls back and forth.”<sup>4</sup> The technician verified the concern, disassembling the transmission and replacing the broken parking pawl.

### **DESIGN CHANGES:**

#### Brake Shift Interlock System

On June 14, 2004, Ford released into production a BSI Solenoid with the pin retraction time (from when the brakes are applied) shortened from 0.4 to 0.03 seconds. This was also the date the revised BSI Solenoid was released as a serviceable component separate from the steering column

<sup>4</sup> Warranty Claim # 2165134 (58 miles).



## **EA09-013 Closing Report**

(prior to this the entire steering column was been replaced to address a BSI / Swing Arm interaction condition). In production, this change affected only MY 2005. According to Ford, the change was made as a quality improvement to address consumer reports of difficulty shifting.

### Automatic Transmission Parking System

Ford made design changes related to strengthening the transmission parking system components. On November 20, 2000, the park pawl shaft length was increased from 34 mm to 59 mm in order to increase the strength and distribute the loads of the mating components. On January 9, 2001, the geometry of the park pawl was revised (a notch removed), increasing the strength of the component. On January 21, 2001, a tempering process was added to the manufacturing process to improve toughness. The dates noted above are the dates on which the design change became effective; however the precise implementation dates into vehicle production are not known. These design changes do not appear to have reduced the transmission parking system failures (see Figure 14 below).

### **TECHNICAL SERVICE BULLETINS:**

#### Brake Shift Interlock System

On November 15, 2004, Ford released Technical Service Bulletin (TSB) 04-22-12.<sup>5</sup> The TSB stated that some 2002-2005 Explorer 4dr/Mountaineer vehicles may require a greater effort to move the gear shift lever to Park, possibly due to a time delay with the BSI solenoid pin retraction. The recommended action was to replace the BSI Solenoid with a shorter Pin retraction time.

#### Automatic Transmission Parking System

No TSBs were released to the dealer network. An internal Quality Assurance Bulletin (#171)<sup>6</sup> was sent to assembly plants and logistic personnel on February 27, 2004 to emphasize the requirement that Parking Brake must be applied to the maximum when shipping the subject vehicles.

### **VRTC TESTING:**

NHTSA's Vehicle Research Test Center (VRTC) conducted a consumer survey, vehicle testing, and component testing to further assess the scope and the potential safety consequences of the alleged defect. The test report in its entirety can be viewed in the public file of this investigation.

#### Vehicle / Component Inspections

VRTC obtained a MY 2003 Ford Explorer that was the subject of VOQ 10274814 for inspection and testing purposes. In the description of the incident the complainant stated that "My 2003 Ford Explorer sometimes will lock the shifter at Reverse as I move it to park. It feels like it

---

<sup>5</sup>A copy of the TSB can be found in the public file of documents associated with PE phase of this investigation, PE09-020. The document is titled "[INRD-PE09020-38948P.pdf](#)"

<sup>6</sup>A copy of the Quality Assurance Bulletin can be found in the public file of documents associated with the PE phase of this investigation, PE09-020. The document is located on page 5 of the document titled "[INRD-PE09020-38950P.pdf](#)."

### EA09-013 Closing Report

went all the way to park, but it really stops (and won't move) at Reverse. Letting off the brake, assuming it is in Park, causes the vehicle to roll backwards.” The vehicle inspection showed that a small divot and gouge existed in the steering column swing arm (see Figure 13 below) and that the divot was making it difficult to engage Park unless the brake pedal was depressed to activate the BSI solenoid.



**Figure 13**

Further inspection showed that, under normal operating conditions (ignition on, then depress the brake pedal) the BSI solenoid pin had a delay of  $\sim\frac{1}{2}$  second from the time that the brake was depressed until the BSI solenoid pin retracted.

In addition, VRTC also inspected a vehicle belonging to a questionnaire respondent. Upon inspection, the vehicle was extremely difficult to shift into Park without depressing the brake. Removal of the steering column showed a larger divot than any that had been previously found on other vehicles (see Figure 14 below).



**Figure 14**

After installing this steering column into the test vehicle, an attempt was made to determine the force/movement characteristic. When the mechanical device (see Figure 15 below and the complete test report) could not push through the divot on the swing arm, a hand-held mechanical force gage was used and force was manually applied in an attempt to push the divot area on the swing arm past the BSI. Several loadings of 50 lb. failed to push through the divot, consistent with

## EA09-013 Closing Report

the consumer's experience of having difficulty getting the vehicle in Park. The vehicle owner did not allege a rollaway incident.



Figure 15

### **FAILURE REPORT SUMMARY:**

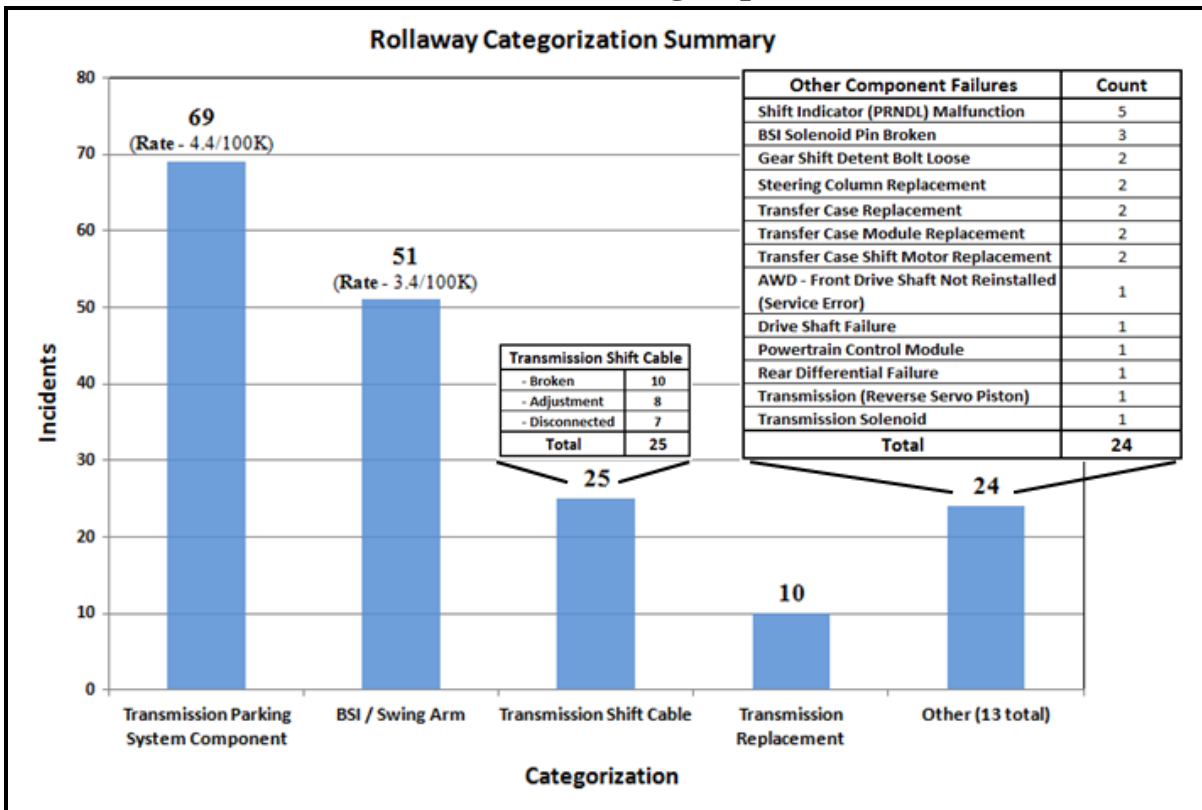
ODI reviewed consumer reports and data submitted by Ford to ODI, including warranty claims, complaints, field reports, and lawsuits. The analysis focused on allegations of vehicle rollaway and incidents of difficulty shifting the gear shift lever to Park.

#### **Vehicle Rollaway**

From all the above-mentioned data sources combined, ODI identified a total of 580 reports that “alleged” vehicle rollaway or unintended movement. 520 allegations were related to Explorer / Mountaineer vehicles and 60 allegations were related to Aviator vehicles. After further analysis during the EA, ODI identified 180 (11.5/100K) rollaway incidents associated numerous failure mechanisms.

In order to identify the failure mechanism(s) that were relevant to the present investigation, ODI categorized these 180 incidents into the failure mechanism that, based on ODI's review of the available evidence, was the most likely cause of the incident. As shown in the summary in Figure 16, the BSI System and the Automatic Transmission Parking System accounted for the vast majority of the rollaway incidents. In addition, there were multiple transmission shift cable conditions, including shift cable breakage, shift cable adjustment and shift cable disconnection from the transmission or the steering column. Individually, each of these conditions related to the transmission shift cable had a failure rate of less than 1.7 / 100K. Therefore, the investigation focused on incidents associated with either the Automatic Transmission Parking System or the BSI System.

## EA09-013 Closing Report



**Figure 16**

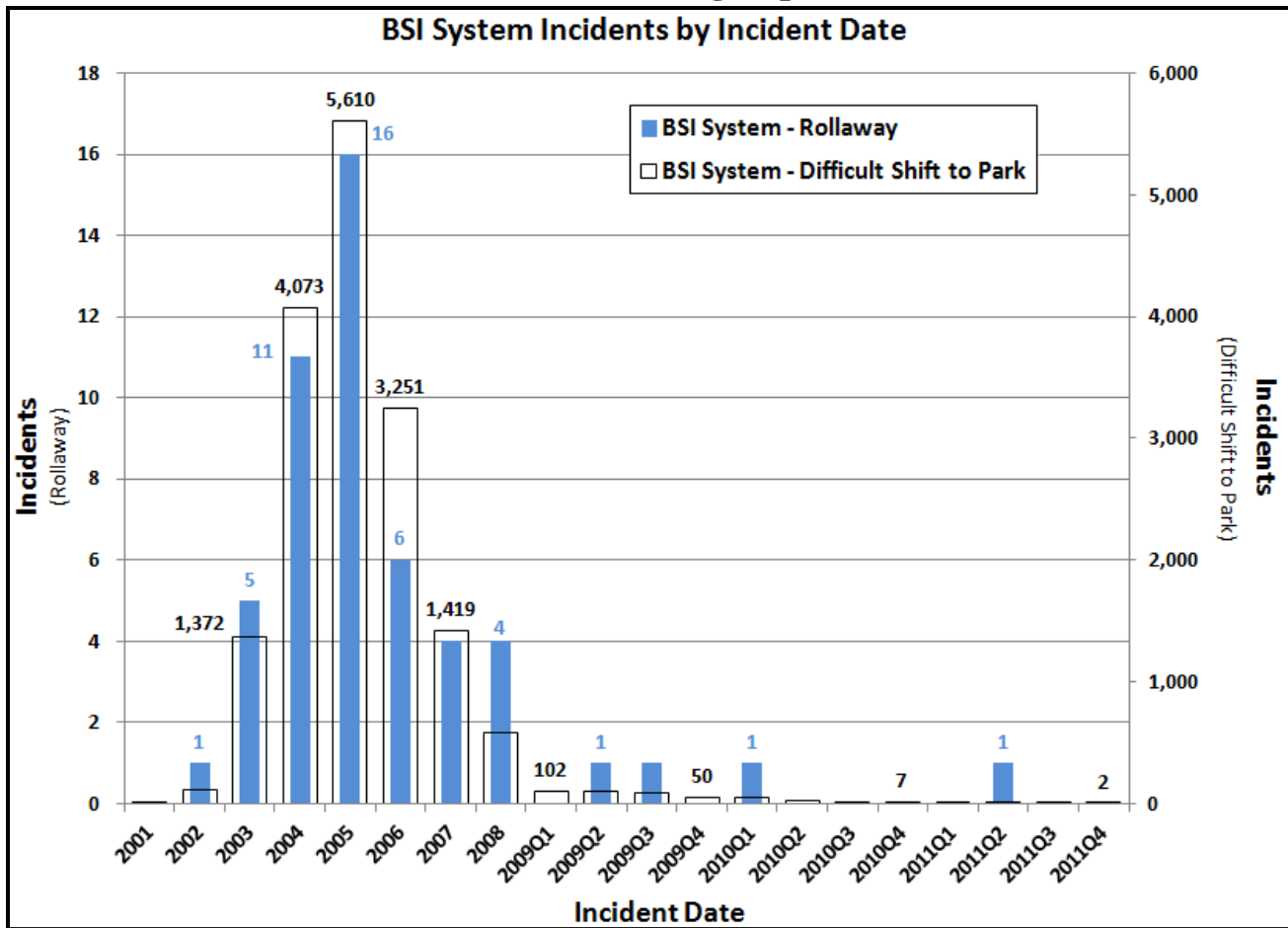
\* The BSI /Swing Arm data is applicable only to the Explorer / Mountaineer vehicles that have a steering column mounted gear selector.

### Brake Shift Interlock System Data Summary

The data analysis in this section of the report is related only to the Explorer and Mountaineer, which have a steering column-mounted gear shift lever. ODI identified 51 rollaway incidents in a population of over 1.49M vehicles that are likely related to the failure of the BSI system. This equates to a very low rate of 3.4 / 100K of the subject vehicle population. ODI also identified 16,872 (~1.1% of the vehicle population) incidents in which drivers reported difficulty shifting to Park however none of these reports alleged vehicle rollaway. As shown in Figure 17 below, the incident rate drastically decreased after calendar year 2008 for both conditions.



## EA09-013 Closing Report

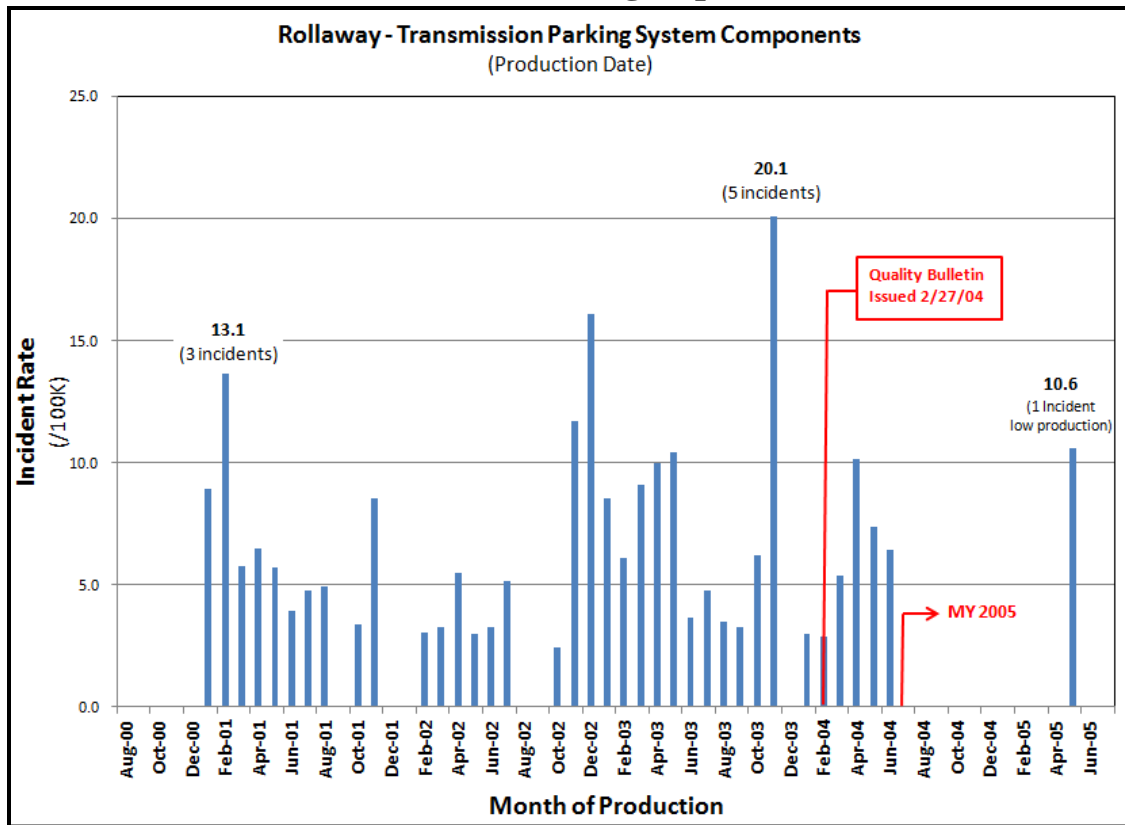


**Figure 17**

### Automatic Transmission Parking System Data Summary

ODI identified 69 incidents in the population of over 1.56M vehicles that are likely related to failure of one or more of the Automatic Transmission Parking System components. Overall this equates to a very low failure rate of 4.4/100K. After issuance of the Quality Bulletin during the latter part of MY 2004, MY 2005 showed a drastic reduction in incidents (see Figure 18 below).

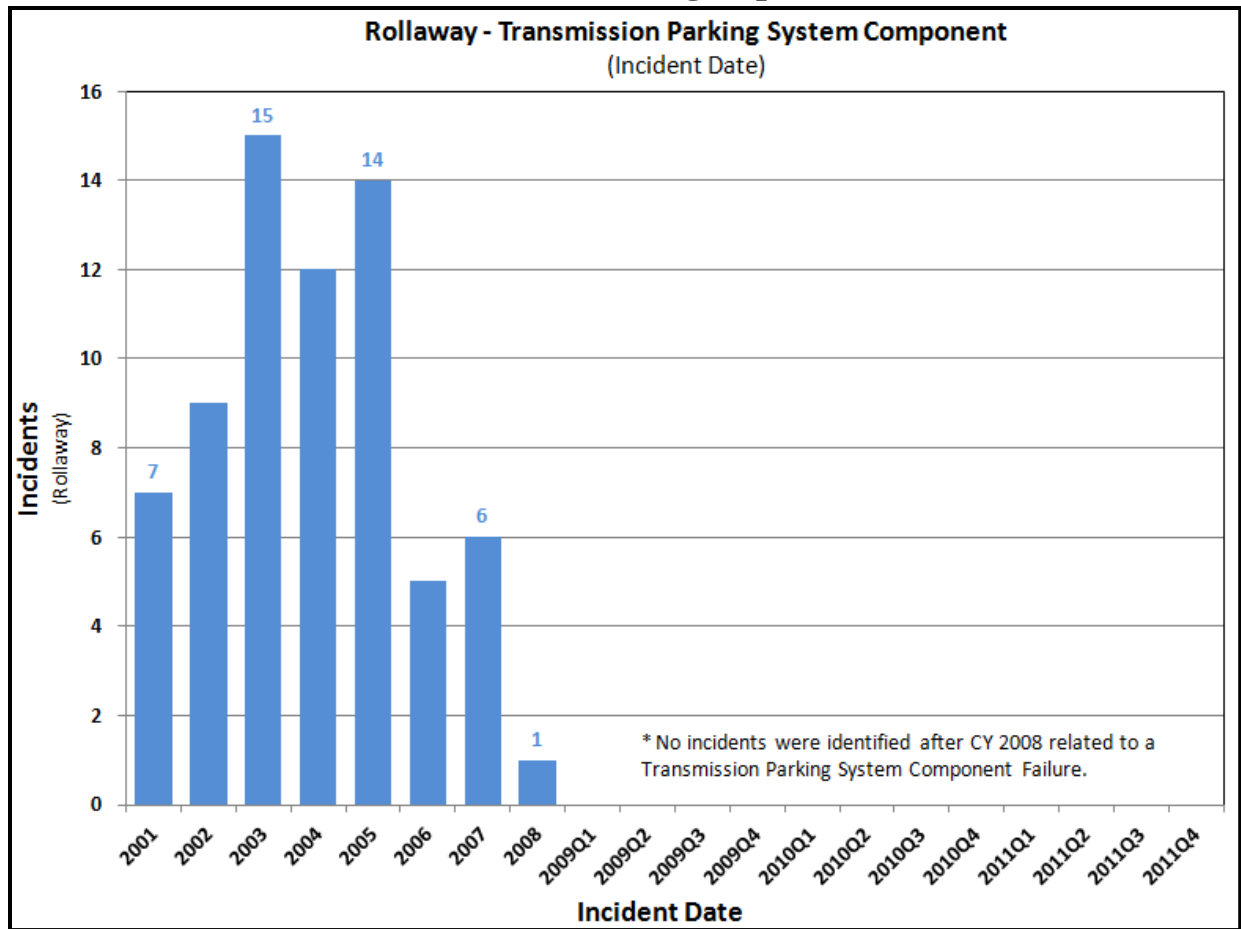
## EA09-013 Closing Report



**Figure 18**

Regarding incident occurrence, there have been no reported incidents since calendar year 2008 (see Figure 19 below) related to a Transmission Parking System component failure.

## EA09-013 Closing Report

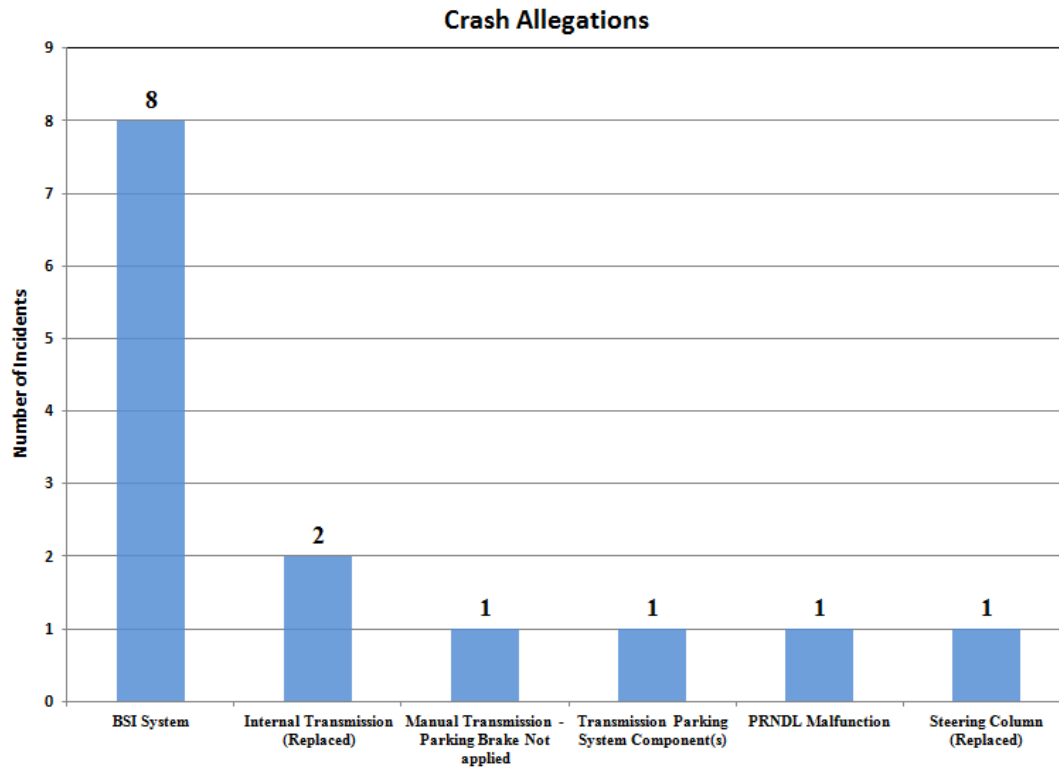


**Figure 19**

### Crash Allegation Summary:

Of the 180 rollaway incidents, 14 involved a crash. Eight of these incidents were likely related to a BSI System failure, and one was related to a failure of the Automatic Transmission Parking System (See Figure 20 below.)

## EA09-013 Closing Report



**Figure 20**

Four of the 8 BSI-related incidents involved an allegation of injury. The nature of the injuries ranged from cuts and bruises to a fractured rib.

### **REASON FOR CLOSING:**

This investigation is being closed based on several considerations. By the most inclusive counting of all alleged rollaway incidents (i.e., counting all alleged rollaway incidents and assuming a singular failure mechanism), the incident rate is low, however ODI identified a number of different failure mechanisms for the alleged defect. The highest rate for any particular failure mechanism, the failure of the Automatic Transmission Parking System, was 4.4/100K. The next-highest failure rate was for the BSI System, at 3.4/100K. Moreover, there has been a drastically declining trend associated with both of these failure mechanisms, including very few incidents occurring in recent years.

Accordingly, this investigation is closed. The closing of this investigation does not constitute a finding by NHTSA that a safety-related defect does not exist. The agency will continue to monitor complaints and other information relating to the alleged defect in the subject vehicles and take further action in the future if warranted.

#