Logout

GlobalWarranty

July 16, 2012

Global Warranty Management: Main > Interface With Customer > **View Vehicle Summary**

INTERFACE WITH CUSTOMER

View Vehicle Summary

This screen allows IVH users to view the Summary of Vehicle Information, Field Actions, Service Information, Applicable Warranties, Transaction History, Service Contract(s) if applicable, Warranty Block, Branded Title information and OnStar and XM Radio information (if applicable).

Vehicle Information

VIN: 1G2ZH57N784[redacted]
Model: 2ZH69-2008 G6 GT SEDAN

Service Contract: No
Branded Title: No
Warranty Block: No
PDI Status: No

Order Type: 70 - RETAIL - STOCK

Field Actions: 0 Open

REQUEST ANOTHER VIN

Required Field Actions

Open field actions are highlighted

Vehicle has no current record of required field actions.

Branded Title

*The VIN information contained herein and information derived therefrom is the proprietary property of The Polk Company and is to be used only for the purpose of warranty verification and shall not be used for any other purpose whatsoever.

Vehicle has no current record of branded titles.

Warranty Block

Vehicle has no current record of warranty block.

Service Information

Vehicle has no current record of outstanding service information.

OnStar and XM Satellite Radio Information

Refer to Help page for details. For OnStar contact 888.ON.STAR1 (888.667.8271) and for XM Radio contact 877.GET.XMST (877.438.9677 Canada) and in the USA:800-556-3600.

OnStar Equipped: Y
OnStar Status: Active

XM Equipped: Y
XM Radio ID: RUV3Z0WT
XM Status: Active

OnStar Vehicle Diagnostics: Y
DMN Enabled: N

Applicable Warranties

Valid warranties are highlighted

Valid	Description	Warranty Add Date	Start Date	Effective Odometer	End Date	End Odometer
	Powertrain Limited Warranty	02/25/2010	06/30/2008	197 MI	06/30/2013	100,197 MI
	Bumper to Bumper Limited Warranty	02/25/2010	06/30/2008	197 MI	06/30/2011	36,197 MI
	Corrosion Limited Warranty	02/25/2010	06/30/2008	197 MI	06/30/2014	100,197 MI
	Emission Select Component Ltd Wty	02/25/2010	06/30/2008	197 MI	06/30/2016	80,197 MI

For this vehicle:

- → View Vehicle Summary
  - → Service Contract
  - → Branded Title
  - → Warranty Block
- → View Vehicle Build
- → View Vehicle Component Summary
- → View Vehicle Transaction History Detail
- → View Vehicle Delivery Information

Service Contract

Vehicle has no current record of service contracts.

Transaction History

View Details

Job Card Date	Job Card Number	Transaction Type	Transaction Adjustment	Labour Operation	Odometer Reading
03/28/2012	6066908	ZREG----Regular Vehicle Transaction		H2642 - Sensor, Brake Pedal Position - Replace	77,330 MI
06/21/2011	6049971	ZREG----Regular Vehicle Transaction	Partial Debit	H2642 - Sensor, Brake Pedal Position - Replace	62,736 MI
06/21/2011	6049971	ZREG----Regular Vehicle Transaction	Full Debit - Reversal	H2642 - Sensor, Brake Pedal Position - Replace	62,736 MI
06/21/2011	6049971	ZREG----Regular Vehicle Transaction		H2642 - Sensor, Brake Pedal Position - Replace	62,736 MI
03/18/2011	6044071	ZREG----Regular Vehicle Transaction		N9595 - BCM C2 Connector Repair	57,092 MI
10/06/2010	6033791	ZREG----Regular Vehicle Transaction		E0722 - Tire Pressure Indicator Sensor Replacement	46,810 MI
09/09/2010	6032092	ZPTI----Part Transaction - Service Agent Installed		H2642 - Sensor, Brake Pedal Position - Replace	45,660 MI
09/08/2010	6032018	ZREG----Regular Vehicle Transaction		C8870 - Inflatable Restraint Passenger Seat Suppression Module Replacement	45,581 MI
08/09/2010	6030247	ZREG----Regular Vehicle Transaction		D4450 - A/C System Analysis	43,301 MI
08/09/2010	6030247	ZREG----Regular Vehicle Transaction		J3500 - Engine Coolant Thermostat Replacement	43,301 MI
08/09/2010	6030247	ZREG----Regular Vehicle Transaction		N0110 - Battery Replacement	43,301 MI
08/09/2010	6030247	ZREG----Regular Vehicle Transaction		H2642 - Sensor, Brake Pedal Position - Replace	43,301 MI
05/25/2010	6025559	ZREG----Regular Vehicle Transaction		C0121 - Front Side Door Window Inner Sealing Strip Replacement - Left Side	38,548 MI
05/25/2010	6025559	ZREG----Regular Vehicle Transaction		B1302 - Radiator Upper Grille Replacement	38,548 MI
01/13/2010	017262	ZREG----Regular Vehicle Transaction		N9595 - BCM C2 Connector Repair	31,138 MI
01/13/2010	017262	ZREG----Regular Vehicle Transaction	Add Credit	H2505 - Electronic Brake and Traction Control Module Replacement	31,138 MI
01/13/2010	017262	ZREG----Regular Vehicle Transaction		H2505 - Electronic Brake and Traction Control Module Replacement	31,138 MI
01/13/2010	017262	ZREG----Regular Vehicle Transaction		Z5000 - DEALER/RETAILER TRADE(PART OBTAINED LOCALLY)	31,138 MI
09/29/2009	010785	ZREG----Regular Vehicle Transaction		E7700 - Intermediate Steering Shaft Replacement	25,237 MI
09/29/2009	010785	ZREG----Regular Vehicle Transaction		H2642 - Sensor, Brake Pedal Position - Replace	25,237 MI
09/29/2009	010785	ZREG----Regular Vehicle Transaction		B4660 - Rear Side Door Lock Replacement - Right Side	25,237 MI
09/29/2009	010785	ZREG----Regular Vehicle Transaction		R0943 - Radio Front Side Door Speaker Replacement - Left Side	25,237 MI
09/17/2009	010077	ZREG----Regular Vehicle Transaction		H2642 - Sensor, Brake Pedal Position - Replace	24,819 MI
02/22/2008	A29105	ZPDI----Pre-Delivery Inspection		Z7000 - Pre-Delivery Inspection - Base Time	0 MI

Global Warranty Management: Site Map

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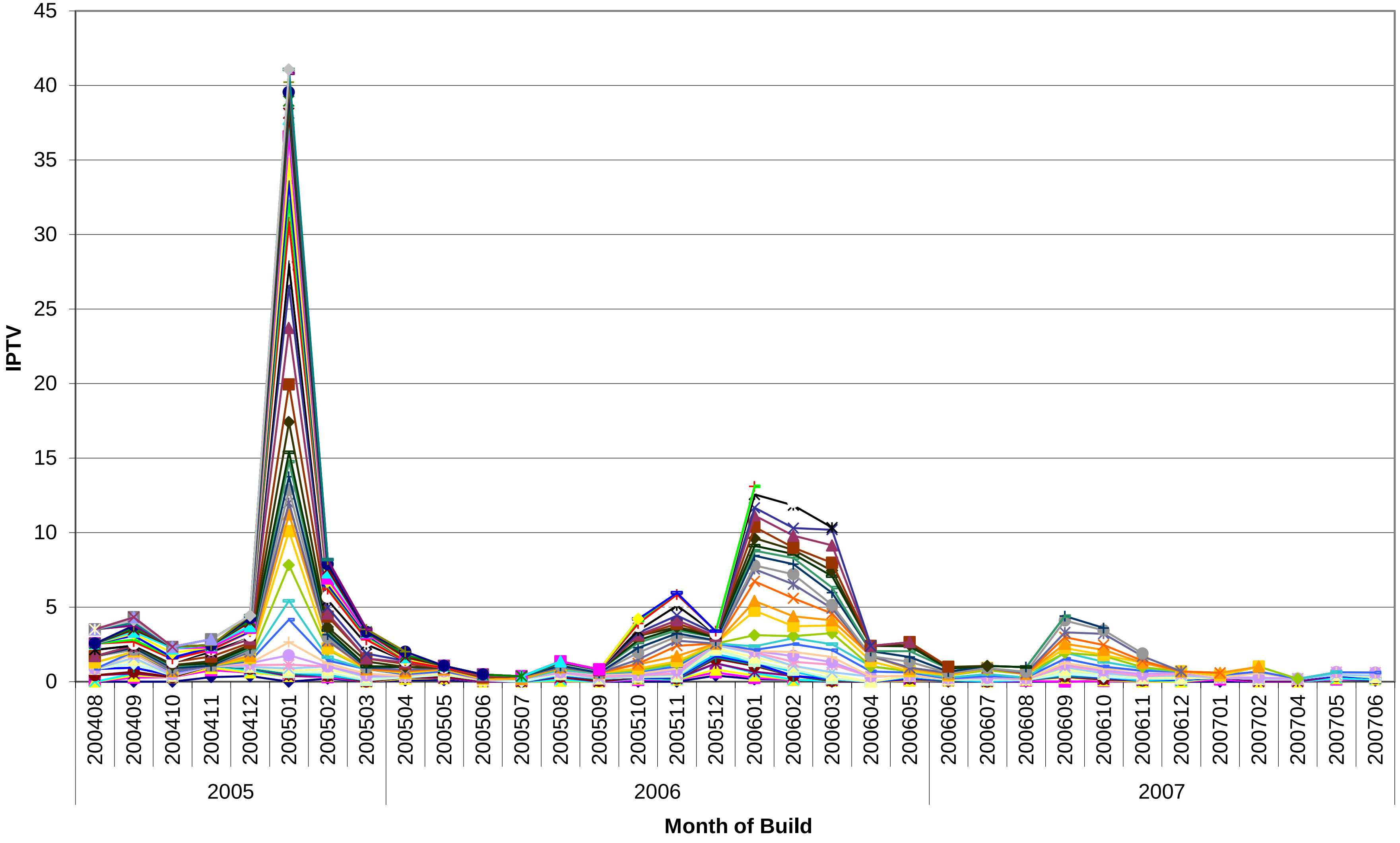
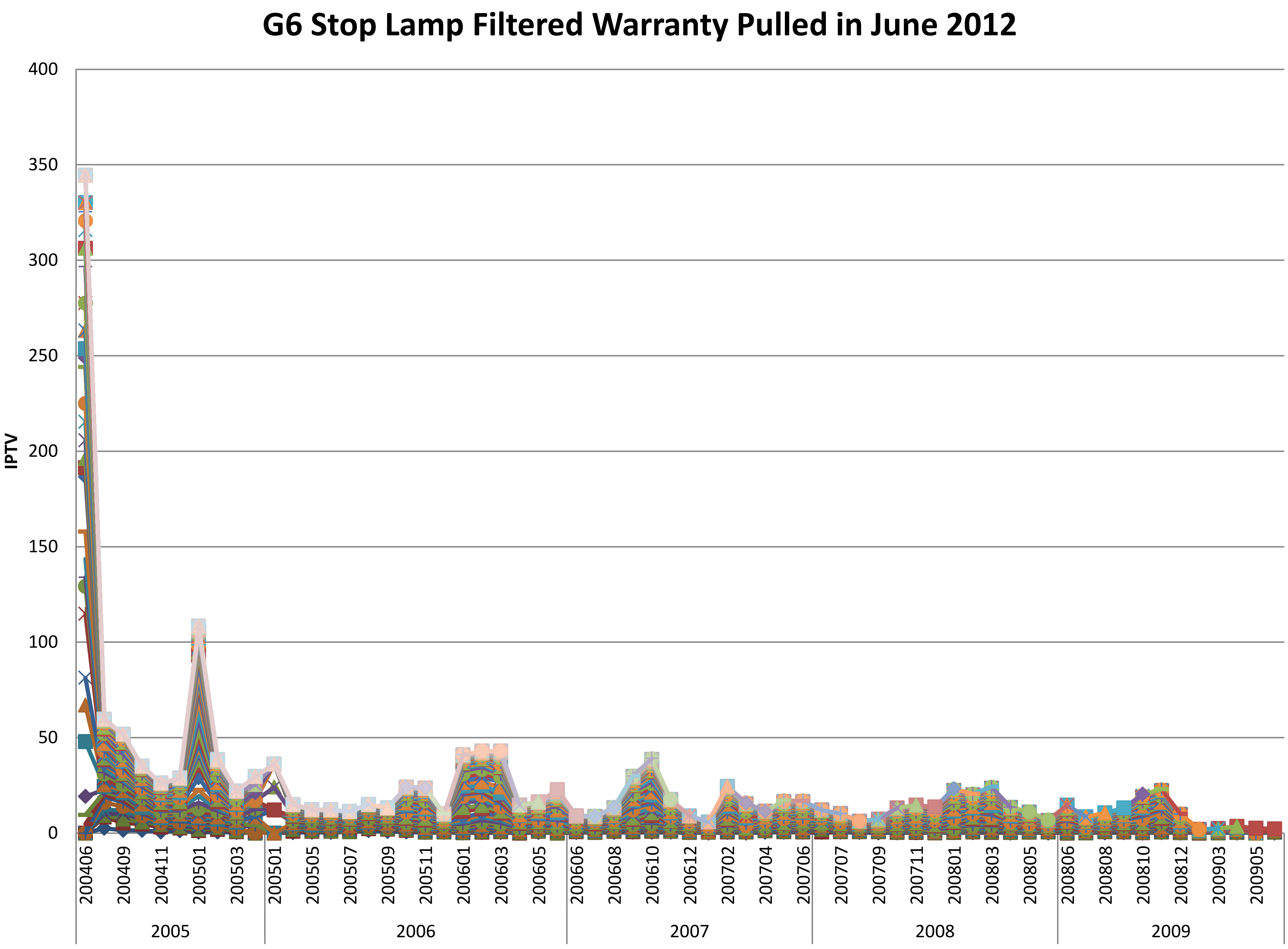
2005 to 2007 G6 Filtered Stop Lamp Warranty Data Reported in January 2009




G6 Stop Lamp Filtered Warranty Pulled in June 2012
IPTV
400
350
300
250
200
150
100
50
0
200406
200409
200411
200501
200503
200501
200505
200507
200509
200511
200601
200603
200605
200606
200608
200610
200612
200702
200704
200706
200707
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2005
2006
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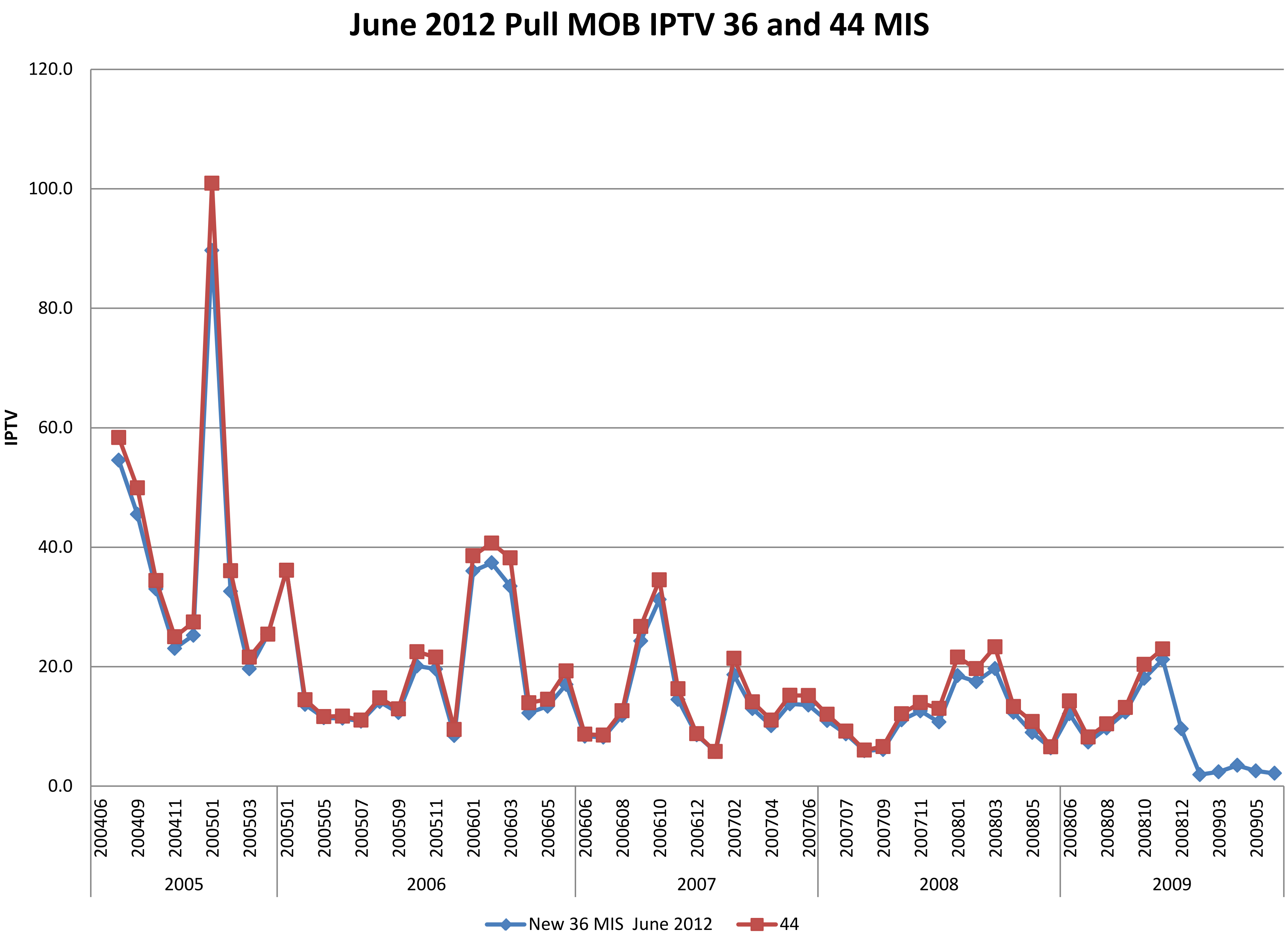

June 2012 Pull MOB IPTV 36 and 44 MIS
IPTV
120.0
100.0
80.0
60.0
40.0
20.0
0.0
200406
200409
200411
200501
200503
200501
200505
200507
200509
200511
200601
200603
200605
200606
200608
200610
200612
200702
200704
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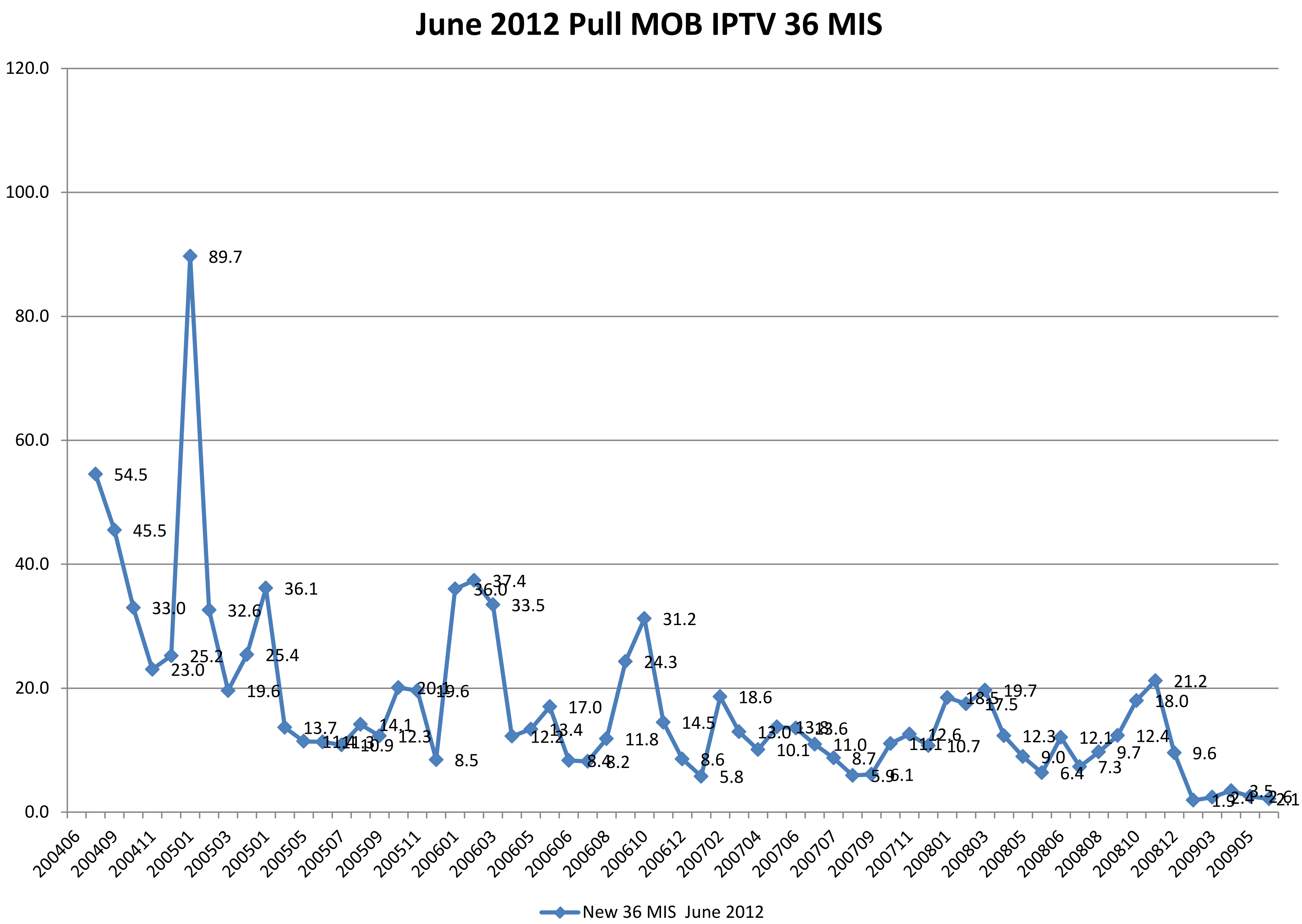
200707
200709
200711
200801
200803
200805
200806
200808
200810
200812
200903
200905
2005
2006
2007
2008
2009
New 36 MIS June 2012
44



June 2012 Pull MOB IPTV 36 MIS
120.0
100.0
80.0
60.0
40.0
20.0
0.0
54.5
45.5
33.0
23.0
25.2
89.7
32.6
19.6
25.4
36.1
13.7
14.1
10.9
12.3
20.1
19.6
8.5
36.0
37.4
33.5
12.2
13.4
17.0
8.4
8.2
11.8
24.3
31.2
14.5
8.6
5.8
18.6
13.0
10.1
11.0
8.7
12.6
10.7
18.5
17.5
19.7
12.3
9.0
6.4
12.1
7.3
9.7
12.4
18.0
21.2
9.6
1.9
2.4
3.5
2.6
2.1
200406
200409
200411
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200702
200704
200706
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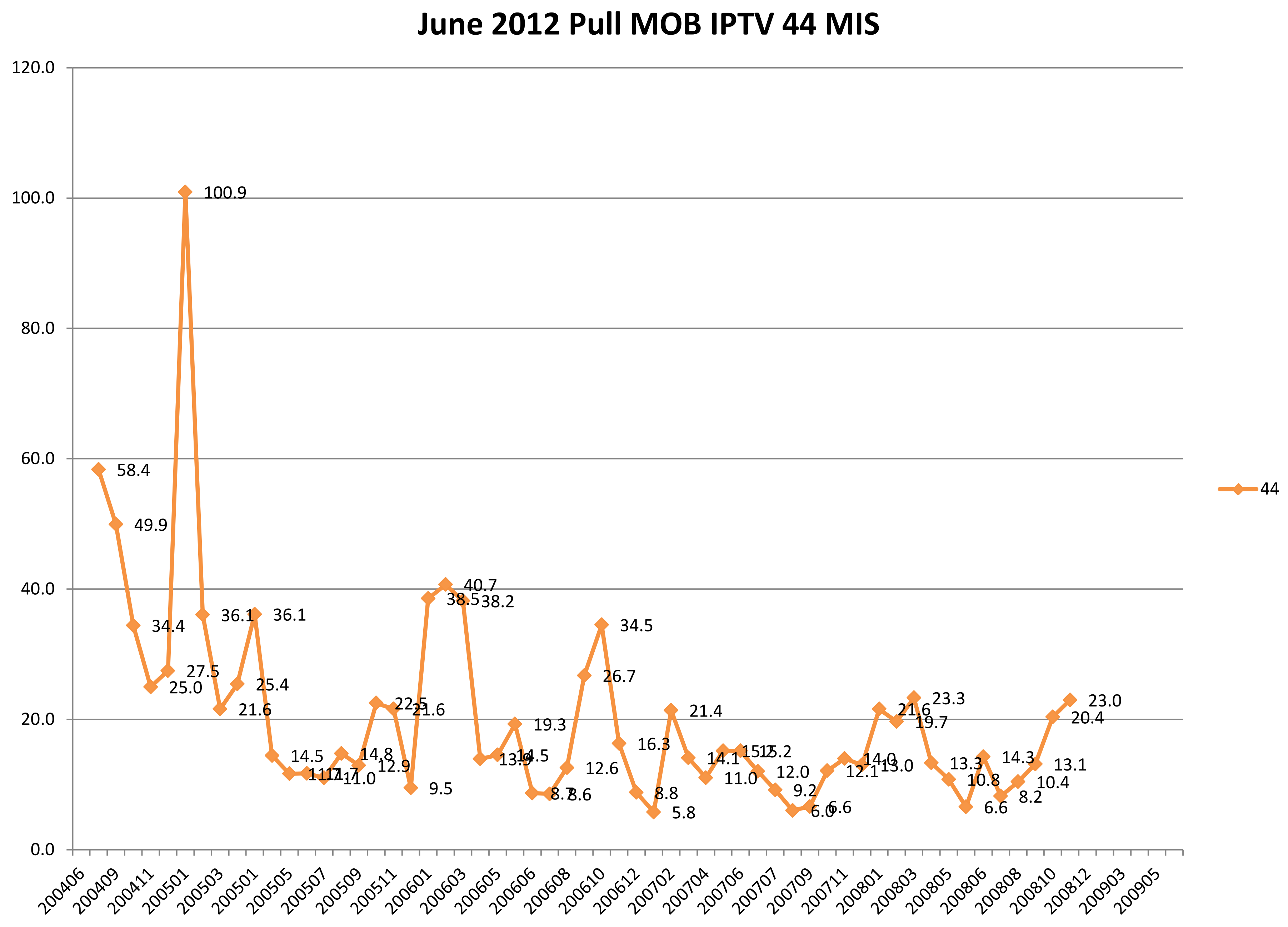
200903
200905
New 36 MIS June 2012



June 2012 Pull MOB IPTV 44 MIS
120.0
100.0
80.0
60.0
40.0
20.0
0.0
100.9
58.4
49.9
34.4
27.5
25.0
36.1
36.1
25.4
21.6
14.5
11.7
11.7
11.0
14.8
12.9
22.5
21.6
9.5
40.7
38.5
38.2
13.9
14.5
19.3
8.7
8.6
12.6
26.7
34.5
16.3
8.8
5.8
21.4
14.1
11.0
15.2
15.2
12.0
9.2
6.0
6.6
12.1
14.0
13.0
21.6
19.7
23.3
13.3
10.8
6.6
14.3
8.2
10.4
13.1
20.4
23.0
200406
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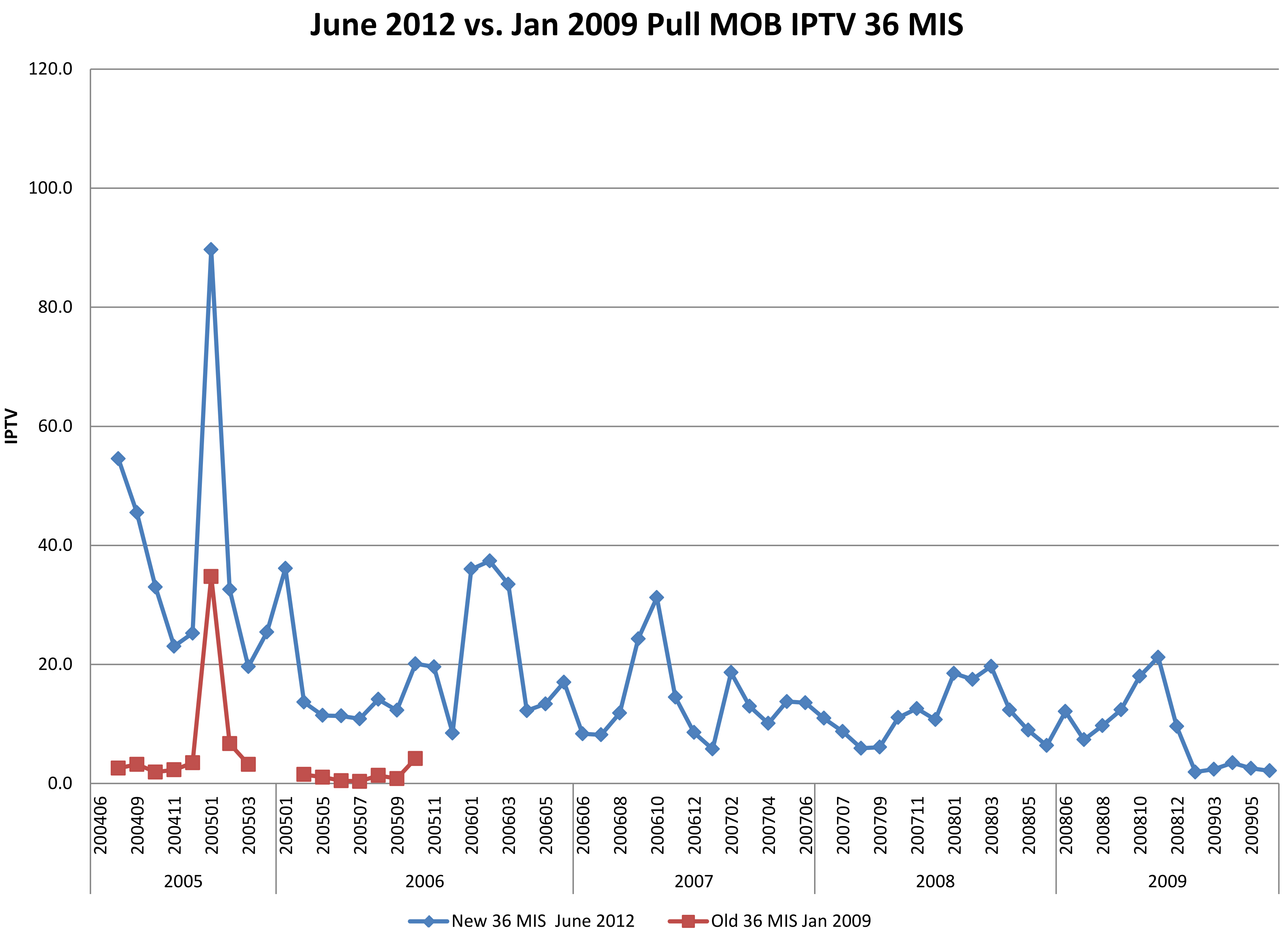
44



June 2012 vs. Jan 2009 Pull MOB IPTV 36 MIS
IPTV
120.0
100.0
80.0
60.0
40.0
20.0
0.0
200406
200409
200411
200501
200503
200501
200505
200507
200509
200511
200601
200603
200605
200606
200608
200610
200612
200702
200704
200706
200707
200709
200711
200801
200803
200805
200806
200808
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200812
200903
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2009
New 36 MIS June 2012
Old 36 MIS Jan 2009

GM	WORLDWIDE ENGINEERING STANDARDS	General Specification Electrical/Electronics	GMW3172

General Specification for Electrical/Electronic Component Analytical/Development/Validation (A/D/V) Procedures for Conformance to Vehicle Environmental, Reliability, and Performance Requirements

1 Scope

This document is the GM World Standard for Electrical and Electronic validation. The use of the defined Analytical, Developmental, and Validation procedures is intended to be cumulative in nature, with the intent of generating as many learning cycles as possible during the product evolution process.

This document provides the reliability and validation requirements for most electrical aspects of a product. Product specific performance requirements and failure mechanisms not covered by this document, such as mechanical wear, shall be specifically identified and addressed in the Component Technical Specification (CTS) or the Sub-System Technical Specification (SSTS). The Component Technical Specification and Sub-System Technical Specification shall take precedence over this document.

In the event of a conflict between the text of this specification and the documents cited herein, the text of this specification takes precedence.

Nothing in this specification supersedes applicable laws and regulations unless a specific exemption has been obtained. In the event of a conflict between the English and the domestic language, the English language shall take precedence.

These requirements and methods are intended for electrical and electronic equipment for use on passenger vehicles, crossover vehicles, and light to medium duty trucks. The included process flow and test flow charts must be used to insure the effectiveness of this specification.

The **Analysis** procedures are used to aid in designing reliability into the product during the time when physical product is not yet available. This should be the earliest activity in the ADV process and provides the earliest product learning and improvement opportunity.

The **Development / Evaluation** tasks are to be performed on first samples to provide the earliest opportunity to qualitatively evaluate and improve physical product. These activities may use only a single sample to differentiate between the relative weaknesses within the product. HALT is a typical example of this type of test.

Design validation tests that are expected to be of high risk as a result of the DRBFM and AFD should also be run early during the development phase to maximize the number of learning opportunities in areas where the expected need is greatest.

The **Design Validation** (DV) section of this standard describes environmental, durability and capability tests for electrical and electronic equipment. The design validation tasks are to be executed on prototype parts. This section describes common test procedures, based on mounting location in the vehicle. The location-coding requirement is an essential element in the use of this document and must be specified in the CTS or SSTS.

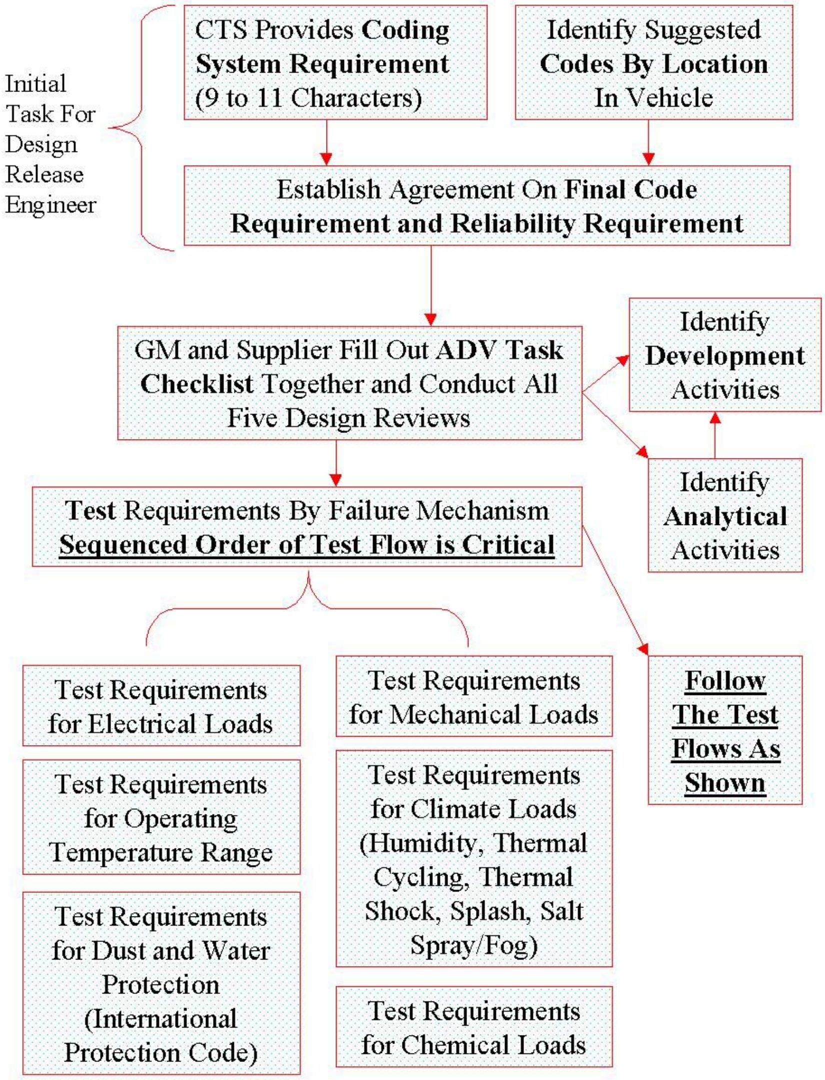
The **Product Validation** (PV) section of this standard requires that only a sub-set of the (DV) tests be rerun. The minimum requirement includes the vibration test with superimposed thermal cycling, the DV specified humidity tests, the frost test, and the shipping vibration test. Additionally, any Design Validation tests that exhibited less than desired performance for DV should be rerun for PV. The process validation tasks are to be run on pilot or production parts. The possible use of Audit Screening during production is to be determined by the end of this phase.

1.1 Mission/Theme

This standard is intended to document all generic A/D/V procedures for automotive E/E devices. Specific tasks, unique to the device technology (i.e. relays, solenoids, motors, etc.), are not addressed in this document.

1.2 How To Use This Document

Figure 1 How To Use This Document



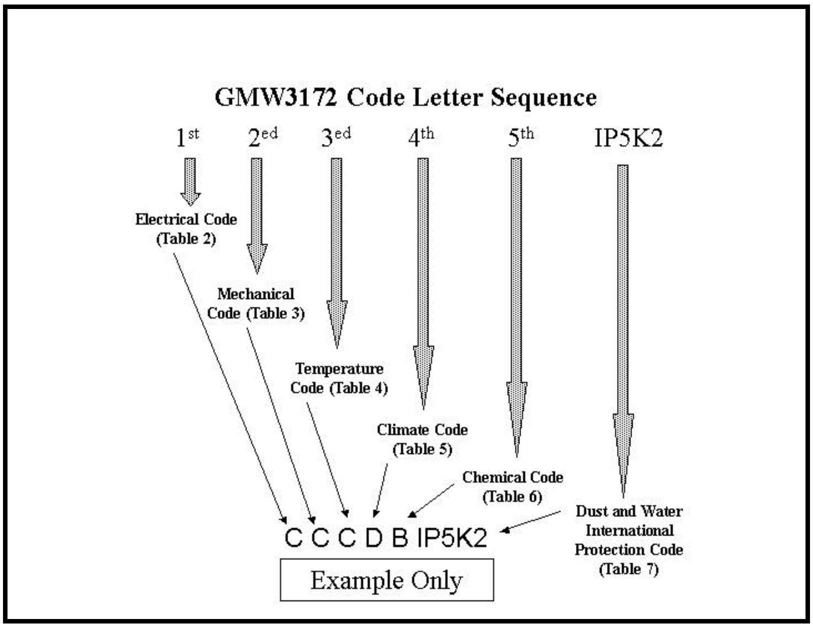
1.3 Quoting Requirements In Documentation

Example CTS Reliability Paragraph:

”The analytical, developmental and validation mandatory tasks identified in GWM3172 must be performed to ensure adequate product maturity by the end of the product development life cycle. The component shall pass the Design Validation and Product Validation environmental and durability requirements of GMW3172. These requirements shall be clearly identified through use of the GMW3172 Coding System resulting from the location of the product in the vehicle. The code for this product is: ________________. A product reliability of at least 97%, with a statistical confidence of 50%, shall be demonstrated on test as described within GMW3172 for product subjected to vibration and thermally induced fatigue. The demonstration of 97% reliability on-test corresponds to a field reliability of 99.5% under the assumption of a Customer Variability Ratio of three. The Process Flows and Test Flows identified in GMW3172 must be followed with any exception receiving prior approval before establishing the ADV plan. The supplier must attain world-class reliability for this product. The test requirements contained in this document are necessary but may not be sufficient to meet this world-class field reliability requirement. The supplier is responsible for assuring that other actions are taken such that world class field reliability requirements are met.”

The requirement code for this product must be clearly assigned in the CTS or SSTS. Supplemental testing for failure mechanisms not covered by GMW3172 must be specified in addition to GMW3172. These additional failure mechanisms may include wear or mechanical fatigue.

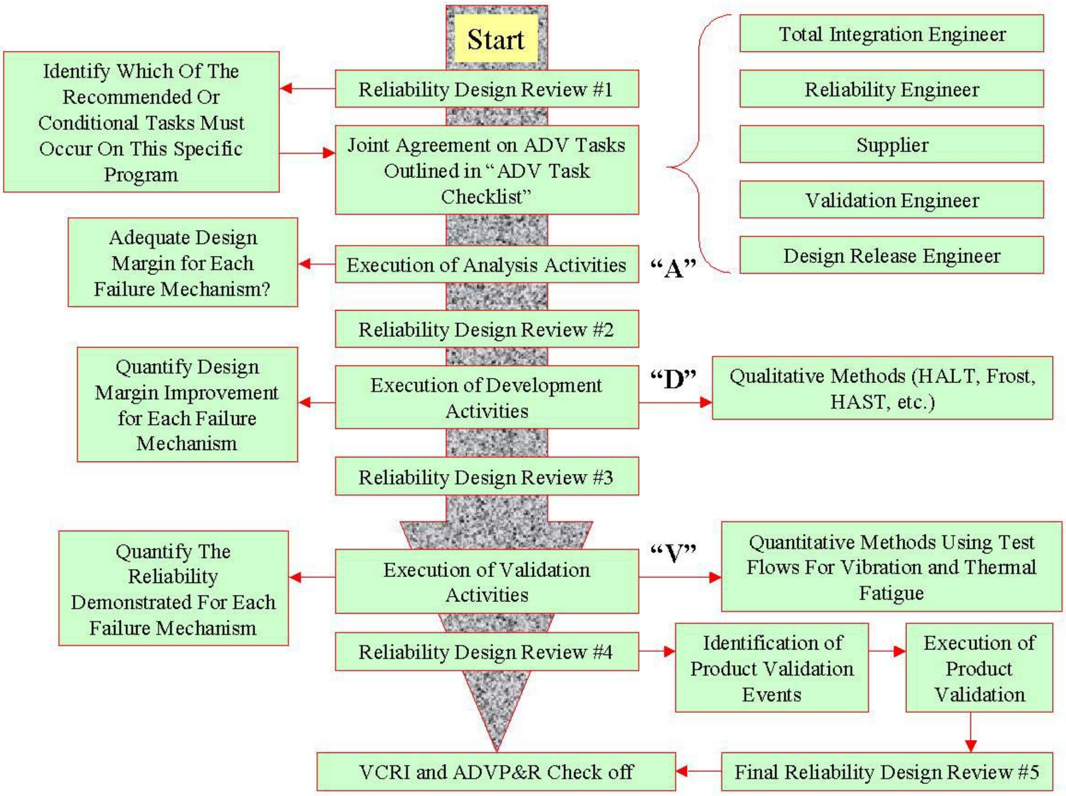
Figure 2 Character Sequence For Quoting (Requirement Code)



Operating Types as noted in *table 8* apply during the test activities described under each of the above noted sections

1.4 How GMW3172 Integrates Into The Supplier ADV Process

Figure 3: Integration Into The Supplier ADV Process



1.5 GMW3172 A/D/V Task Checklists

Definitions:

M ----- Mandatory for electronic modules

R ------ Recommended - shall be conducted but may be waived only by GM under special circumstances. Recommended activities becomes Mandatory when so identified by General Motors

C ----- Conditional task based on presence of feature, technology, risk, or vehicle location

M/C --- Mandatory when condition or design feature exists

GMW3172 A/D/V Task Checklist – ***Establishment of Requirement***

Subject	Recommended	This Program
Reliability Required by This Program – The sample sizes and test durations shown on the example test flows relate to a "reliability on test" of 97% with 50% confidence. This "reliability on test" value corresponds to" reliability in the field" of 99.5% for 100,000 miles or 10 years. The value of 50% confidence is used in the sample size and test duration calculation. The relationship of confidence and reliability should be expressed as follows: "I am 50% sure that the reliability is at least 97% as demonstrated on this test". When the lifetime or reliability requirement is different from above, the sample sizes and test durations must be adjusted for those failure mechanisms using the success-run demonstration method. No increase in sample size is necessary for vibration when the test to failure method of Appendix "B" is used. Truck usage is sometimes noted as 10 years and 200,000 miles. The following adjustments should be made for this longer life requirement: • Truck – Vibration – Use the longer calibrated test time as described in the text. This test time will be a function of the "miles" requirement in the VTS • Truck – No adjustments are necessary for any other tests	**M**	
Reliability Design Review #1 Using "DRBFM - Analysis of Change", and "Anticipatory Failure Determination"	R	
Date = ___________________	R	
Identify Which Of The Seven Test Flows Will Be Used:_______________	M	

GMW3172 A/D/V Task Checklist – ***ANALYTICAL*** Procedures

Electrical Loads Analysis (SABER/SPICE)		
E/E Circuit Performance Analysis	Recommended	This Program
Nominal Performance Analysis	M	
Short/Open Circuit Analysis	C	
Electrical Interface Models	M	
Mechanical And Thermal Loads Analysis		
Circuit Board Resonant Frequency and Displacement Analysis Resonant Frequency = __________________	R	
Thermal Fatigue Analysis: Identify risk when using surface mount technology to join large elements with significantly different coefficients of thermal expansion	C	
Snap Lock Fastener Analysis: Ensure that the elastic limit is not exceeded when snapfit attachments are maximally stressed during assembly (Use the worksheet in Appendix "A")	M/C	

Crush Test Analysis: Identify clearance to components when loaded with either a human elbow or foot	R	
Lead-Free Solder Checklist (A product that is to be manufactured with lead-free solder must be reviewed against this checklist and should be reviewed with the GM lead-free reliability expert)	M/C	
Reliability Design Review #2 – Analysis Identify what design margins are known and Identify what should be learned during development	R	
Date = ________________	R	

GMW3172 A/D/V Task Checklist – ***DEVELOPMENT*** Procedures.

Electrical Performance Development/Evaluation Procedures	Recommended	This Program
Circuit Performance at Room Temperature	R	
Over/Under Voltage, Jump Start and Reverse voltage Evaluation	R	
Short Circuit Evaluation	M	
Flash Programming Sensitivity to Ground Lead Inductance	M/C	
Electromagnetic Compatibility (EMC) Development – GMW3097	M	
Mechanical And Climatic Loads Development/Evaluation Procedures		
Crush Resistance of the case of the device	R	
Free Fall Endurance Development	R	
Ruggedization Development for Vibration and Temperature – HALT per GMW8287 (1-2 days only) Performance at and below the minimum temperature requirement – assess design margin Performance at and above the maximum temperature requirement – assess design margin Sensitivity to broadband random vibration at and above the requirement – assess design margin *Note: Required for electronic devices but should be considered optional for simple Bused Electrical Centers	R/M*	
Sensitivity to Extended Humidity – HAST per JEDEC STD 22-A110 for 48 hours	C	
Frost Test for Moisture Susceptibility (1/2 day)	R	
Localized Circuit Board Over-Heating Using Thermal Couple Method Or Infrared Imaging Method	C	
Reliability Design Review #3 – DRBTR during Development How well have we reacted to what we have learned and what risks remain going into Validation	R	
Date = _________________	R	

GMW3172 A/D/V Task Checklist – ***DESIGN VALIDATION*** Procedures

Use the following task checklist in conjunction with the test flows. “Stars” are used in the test flows to denote points where the product must be evaluated for degradation or loss of function. The ADV team must decide if “Room-Temperature-Tri-Voltage”, Room-Temperature-Nominal-Voltage, Tri-Temperature-Tri-Voltage”, or “Five-Point” evaluation is to apply at each “Star” when continuous monitoring is not the requirement. The suggested type of “Evaluation” is explained within each test section; however, unique products may dictate an alternative from the suggested form of evaluation. All evaluations must be accompanied with close visual examinations to detect the onset of a problem.

Electrical Loads - Select Supply Voltage Code: A B C D E F Z **Code:__________**	Recommended	This Program
Vehicle Electrical Transient Tests		
Parasitic Current Test	M	
Jump Start	M	
Over-Voltage	M/C	
Power/Ground Test	M	
Reset Behavior at Voltage Drop Test	M	
Battery Voltage Dropout Test	M	
Superimposed Alternating Voltage	M	
Short or Open Circuit Tests		
Short Circuit Endurance	M/C	
Load Circuit Over Current	M/C	
Short to Battery	M	
Short to Ground	M	
Open Circuit Test	M	
Altitude Analysis or Test For Reduced Heat Transfer: Are there any heat generating devices on the circuit board that may overheat from reduced air density at higher altitudes with the vehicle operating? (an analytical alternative is provided and is preferred)	M/C	
Isolation Evaluation Tests		
Isolation Resistance	R	
Puncture Strength	R	
EMC (detailed requirements in GMW3097 documentation)	M	
Connector Tests		
Terminal Retention Force	M/C	
Connector Mating Force	M/C	
Connector Retention Force	M/C	
Connector Disengage Force	M/C	
Connector Crush Test	M/C	
Mechanical Loads		

Select Mechanical Loads Code: A B C D E F Z Code:____________		
Steady State Loads		
Crush Test for Device Housing: Select Method A or B or Both		
Method A (Elbow loads during plant assembly)	R	
Method B (Foot loads during plant assembly)	R	
Altitude Test: Low Air Pressure Concern: Are there any sealed devices that could be adversely affected by the reduced low air pressure during high altitude shipping?	M/C	
Vibration Test: Mandatory - Conduct One Of The Vibration Tests		
Enter reliability to be demonstrated with 50 % confidence.	%	
Engine/Transmission Mounted	M	
Sprung Mass	M	
Unsprung Mass	M	
Shock Loading		
Mechanical Shock: Tests 1 (Simulating potholes with 25 gs – operating type 3.2 may be required if concern for inadvertent operation during shock loading - ie. wiper system or window switch)	M	
Mechanical Shock: Tests 3 -100 g. Represents minor collisions at (15.3) miles per hour as measured on the body or chassis. All axes required when the product may be mounted in different orientations. Vertical axis is not required when the product will always be mounted in the same orientation.	R	
Closure Slam Test Using Vibration Equipment	M/C	
Free Fall	M	
Climatic Loads - Select Operating Temperature Range Code: A B C D E F G H I Z Code:__________		
Time At Temperature Extreme Tests		
Low Temperature Testing with recovery from off state	R	
High Temperature Durability – Select 500 or 2000 Hours (long term diffusion based failure mechanisms)	M	
Thermal Fatigue - Enter reliability to be demonstrated with **50 %** confidence.	**97%**	
Thermal Shock in Air – Number of Cycles = _____________	M	
Power Temperature Cycle Test – Number of cycles = __________	M	
Extended Thermal Shock Design Margin Evaluation Using Degradation Analysis	R	
Thermal Shock/Splash Water	C	
Corrosion And Humidity Tests		
Salt Mist or Salt Spray Test		
Interior Cabin Location Test Using Salt Mist (6 day test using ISO16750-4)	M	

Exterior Lesser Severity Test Using Salt Spray (10 day test) – Duration of test can be extended to 20 days for special situations	M	
Exterior High Severity Test Using Salt Spray (20 day test) - Duration of test can be extended to 40 days for special situations	M	
Humidity Tests		
Humid Heat: Cyclic (forced motion of humidity from changes in temperature)	M	
Humid Heat: Constant (long term diffusion into components)	M	
Dew Test (effect of condensing moisture on circuit boards – see Test Flow Charts for intended usage)	M/C	
Moisture Susceptibility (Frost Test)	M	
Corrosion Test with Flow of Mixed Gas (Optional – may be required when the device includes a switch and components containing silver)	C	
Colorfastness Test (Weatherometer Xenon-Arc)		
Method A: GM Europe	C	
Method B: GM North America	C	
Tests for Enclosures Code:___________		
Dust Tests: Enter IP dust code:___________	M	
Water Tests: Enter IP water code:____________	M	
Seal Evaluation (Immersion Test)	C	
Chemical Loads		
Fluid Compatibility Requirements	M/C	
Flammability Test	M	
Reliability Design Review #4 – DRBTR during Validation Document that all concerns have been resolved and the tests (based on failure mechanisms) that should receive special attention during Product Validation Date = ________________	M	

Note: High Risk Tests should also be run during the Development and Evaluation Phase.

GMW3172 A/D/V Task Checklist – **Product *Validation*** Procedures

Note: Product Validation assumes that the product was *made reliable* during Analysis and Development, and that Design Validation *confirmed that the required levels of reliability and performance were achieved*. Design iterations should occur during the Analysis and Development portions of the ADV process, and possibly during Design Validation. The intent of Product Validation is to *detect for any significant degradation* that may result from changes in tooling, processing, or last minute changes following Design Validation. *Product Validation is not intended to be a second iteration of Design Validation and is not intended to quantify variability resulting from manufacturing variation.*

Product Validation – Other tests may be added if significant uncertainty still exists from Design Validation	Recommended	Program
Vibration - Success-Run Vibration Test (large sample size) <u>or</u> Vibration Test-To-Failure (Preferred - small sample size) both with superimposed thermal cycling. This test evaluates possible loss of fatigue life from changes in processing that may have created unexpected stress risers.	M	

Method Chosen:_____________		
Shipping Vibration Test (damage from interaction with packaging)	M	
Humidity Tests - Repeat the humidity and the frost tests that were run for DV to evaluate ionic contamination and coating effectiveness.	M	
Frost Test	M	
Humid Heat: Cyclic	M	
Humid Heat: Constant	M	

Dew Test (For Door or High Moisture Locations)	M	
Audit Screening Activity – ESS or HASA per GMW8287 High Frequency Audit During Production Startup Continuous Audit During Production	 R C	
Final Reliability Design Review #5 – Product Validation **Even though the product has been validated, the final design review must identify the product characteristics that are most sensitive in producing product weaknesses from the analysis and test results. These product characteristics must be controlled in production (KPC). Additionally, these weaknesses should direct the type and extent of screening to be conducted during startup and production. Date = ____**	M	

Fill out a Design Validation Checklist for tests that have to be repeated.

1.6 Coding Designation By Location In The Vehicle

This document distinguishes between the following mounting locations and defines the minimum Electrical, Mechanical, Thermal, Climatic, Chemical, Water and Dust Protection requirements. Other mounting locations are possible. The set of requirements can be created by a new code letter combination as described in Section 2 (Quoting Requirements).

Table 1 Code Letters Based On Location Within The Vehicle

Mounting Location	Test Flow To Be Used	Electrical Loads	Mechanical Loads	Operating Temperature Range	Climatic Loads	Chemical Loads	Dust and Water Protection
		Code letter Per Table 2	Code letter Per Table 3	Code letter Per Table 4	Code letter Per Table 5	Code letter Per Table 6	Code letter Per Table 7
Engine compartment							
Hi location, remote from engine and heat sources	3, 6	A – F Typically C	C	F	C	E	IP6K9K
Hi location, close to engine or heat sources	6	A – F Typically C	C	H	A	E	IP6K9K

Mounting Location	Test Flow To Be Used	Electrical Loads	Mechanical Loads	Operating Temperature Range	Climatic Loads	Chemical Loads	Dust and Water Protection
At/in engine, normal temperature load	7	A – F Typically C	A or B	H	A	E	IP6K9K
At/in engine, high temperature load	7	A – F Typically C	A or B	I	A	E	IP6K9K
At/in transmission	7	A – F Typically C	A or B	I	B	E	IP6K9K
Low mount	6	A – F Typically C	C	H	B	E	IP6K9K
Passenger compartment							
(Under dashboard) low temperature load	1	A – F Typically C	C	A-C	E	A/B	IP5K2
(Dashboard display or switch) normal temperature load	1	A – F Typically C	C	D	D	E	IP5K2
(Top of dashboard with sun load) high temperature load	1	A – F Typically C	C	E	D	A	IP5K2
Low mount/under seat	1, 2	A – F Typically C	D	A	E-F	B	IP5K2 IP5K8
Other Locations							
Trunk	1	A – F Typically C	C or D	A-C	F	D	IP5K2
Doors and hatches (wet area)	2	A – F Typically C	E	B-C	H	B	IP5K3
Doors and hatches (dry area)	2	A – F Typically C	E	B-C	E-D	A	IP5K2
Exterior splash area	6	A – F Typically C	C	A-C	J	F	IP6K9K
Chassis and underbody	5	A Typically C	C	A-C	I-J	F	IP6K8 or IP6K9K
Unsprung mass	5	A – F Typically C	F	A-C	I	F	IP5K4K or IP6K9K
Sealed body cavities	1	A – F Typically C	C	A-C	E	B	IP5K2
Unsealed body cavities	5,6	A – F Typically C	C	A-C	I-J	F	IP5K4K

Mounting Location	Test Flow To Be Used	Electrical Loads	Mechanical Loads	Operating Temperature Range	Climatic Loads	Chemical Loads	Dust and Water Protection
Exterior at the base of the windshield inside the Plenum or inside the engine compartment	6	A – F Typically C	C	E-G	G Use underhood PTC requirement	E	IP6K6K Also run Seal Evaluation if in Plenum
Roof mounted inside the vehicle cabin	1	A – F Typically C	C	D	E	B	IP6K2
Z location (to be completed by GM)							

1.7 Code Letter For Electrical Loads

The following table defines the 12 V system's nominal, steady state voltage range and minimum and maximum test voltage as measured at the E/E device. The table should also be used in specifying the E/E device criteria requirements unless otherwise specified in the CTS.

For 42 V vehicle electrical systems, see ISO 21848-2, "Road Vehicles – Electrical and Electronic Equipment for a 42 V Network –Part 2: Electrical Loads"

Table 2 Code Letter For Electrical Loads

Nominal Voltage (V_{nom}): The nominal voltage shall be 14 volts (± 0.1) V. The letters in the table "A" through "C" represent the <u>F</u>unctional <u>S</u>tatus <u>C</u>lassification											
Steady State Supply Voltage (in V)	**-13..<0**	**0..<4.5**	**4.5..<6**	**6..<9**	**9..<10**	**10..<12**	***12..<16***	**16..18**		**Test Voltage (in Volts)**	
Code Letter	**FSC**	**FSC**	**FSC**	**FSC**	**FSC**	**FSC**	**FSC**	**FSC**		**V_{min}**	**V_{max}**
A	C	C	A	A	A	A	A	C		4.5	16
B	C	C	C	A	A	A	A	C		6	16
C (most common)	C	C	C	C	A	A	A	C		***9***	***16***
D	C	C	C	C	A	A	A	A		9	18
E	C	C	C	C	C	A	A	C		10	16
F	C	C	C	C	C	C	A	C		12	16
Z (As Agreed Upon)											

<u>How to Use This Table:</u> Identify the columns that span the range of steady state supply voltage provided to this device. Identify the row corresponding to the Code Letter in the far left column. The intersection of the identified columns and row provides the Functional Status Classification that applies to each partitioned interval of voltage during testing. The test voltages are shown in the far right side of the code letter row. Example: Code letter "C" is specified and the supply voltage is 9 to 16. The FSC is "A" from 9 to 10 volts, "A" from 10 to 12 volts, and "A" from 12 to 16 volts.

<u>Special Note:</u> Vehicles that employ Regulated Voltage Control* shall use 14 volts for durability testing purposes. Performance evaluations, especially when motors are involved, should be conducted with V_{nom} redefined as 50% of the time at 12.8 volts and 50% of the time at 14.5 (± 0.1) volts.

***** Regulated Voltage Control is designed to monitor and control the vehicle system voltage. An on-board computer is used to maximize the effectiveness of the generator, manage the electrical load, improve battery state-of-charge, improve battery life, and improve fuel economy. The operating voltage at the battery will typically range between 12.5 and 15 volts.

Functional Status Classification

The purpose and scope of the FSC classification is to provide a general method for defining the functional performance status classification (FSC) for the functions of automotive E/E devices upon exposure of test conditions or real world operation conditions.

The classification was originally intended to classify function performance status during exposure of EMI disturbances or test conditions. In this context, however, it will be used generically for classification of function performance status during any conditions (i.e. also all normal or special driving conditions). Therefore, the wording *exposure to a disturbance* and *exposure* should be interpreted as exposure to any defined condition.

Class	Definition of FSC Class
A	All functions of an E/E device/system perform as designed during and after exposure to a disturbance.
B	All functions of an E/E device/system perform as designed during exposure; however, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions must remain class A.
C	A function of an E/E device/system may not perform as designed during exposure but returns automatically to normal operation after exposure is removed. Electronic subsystems/components shall not output any false actuation signals or erroneous serial data messages without setting Diagnostic Trouble Codes or other erroneous I/O commands or states when the voltage is inside the range defined.
D	A function of an E/E device/system may not perform as designed during exposure and does not return to normal operation until exposure is removed and the device/system is reset by simple “operator/use” action.
E	One or more functions of an E/E device/system do not perform as designed during and after exposure and may not return to normal operation without repairing or replacing the E/E device/system. Functions must still meet all transient voltage performance requirements

Special Note: The device must not create a hazard when operated with voltages outside of the design intent. This is applicable to all classes of FSC described above.

1.8 Code Letter For Mechanical Loads

Table 3: Code Letter For Mechanical Loads

	Requirements				
Code Letter	**Crush Test**	**Random Vibration**	**Mechanical Shock**	**Closure Slam**	**Free Fall**
A	Method A	Envelope 1	Yes	No	Yes
B	Method A	Envelope 2	Yes	No	Yes
C	Method A	Sprung	Yes	No	Yes
D	Method A & B	Sprung	Yes	No	Yes
E	Method A	Sprung	Yes	Yes	Yes
F	Method A	Unsprung	Yes	No	Yes

	Requirements				
Z (as agreed upon)					

Crush Test Note: Method "A" is a test that simulates resting ones elbow on the center of the DUT cover. This may occur during manufacturing or service. Method "B" is a test that simulates stepping on the device, and may damage the device or the connections leading into the device. This may occur during manufacturing, service, or during special functions performed by the customer.

Random Vibration Note: "Sprung" refers to all portions of the car above the springs and vehicle suspension. "Unsprung" refers to attaching locations on the suspension, wheels, brakes, or tires.

1.9 Code Letter For Temperature

Code letter for minimum/maximum operating temperatures.

Table 4: Code Letter For Operation Temperature Range

Code Letter	T_{min} °C	T_{max} °C	$T_{max\ PH}$ °C (Soak Back: 30 min)	$T_{max\ RP}$ °C
A	-40	+70		+95
B	-40	+80		+95
C	-40	+85		+95
D	-40	+90		+95
E	-40	+105		+95
F	-40	+105	+120	+95
G	-40	+120		+95
H	-40	+125	+140	+95
I	-40	+140		+95
Z (as agreed upon)				

Temperature Definitions:

Temperature	**Symbol**	**Definition**
Minimum	T_{min}	Minimum limit value of the ambient temperature at which the system and/or E/E device are required to operate.
Maximum	T_{max}	Maximum limit value of the ambient temperature at which the system and/or E/E device are required to operate.
Post Heating (soak back)	T_{maxPH}	Maximum limit value of the ambient temperature which may temporarily occur after vehicle cut-off and at which the system and/or E/E device may be operated for a brief period, e.g. on the engine and in its environment.
Repaint	T_{maxRP}	Maximum temperature which can occur during re-painting, but at which the system is not operated.

1.10 Code Letter for Climate

Table 5: Code Letter For Climate Requirement

Code Letter	High Temp Durability (Hours)	Equivalent Number Of PTC Cycles Of Thermal Fatigue With A Sample Size Of 15	Water Splash	Seal	Salt Mist* or Salt Spray (Days)	Cyclic Humidity	Constant Humidity	Xenon Arc
A	2000	2465	NO	NO	10	YES	YES	NO
B	2000	2465	YES	YES	20	YES	YES	NO
C	500 to 2000	1396	No	No	10	YES	YES	NO
D	500	873	NO	NO	6*	YES	YES	YES
E	500	873	NO	NO	6*	YES	YES	NO
F	500	873	NO	YES	6*	YES	YES	NO
G	500	873	Yes	YES	10	YES	YES	NO
H	500	873	NO	NO	20	YES	Yes + DEW	NO
I	500	575	NO	YES	20	YES	YES	NO
J	500	873	Yes	Yes	20	YES	YES	NO
Z (as agreed upon)								

Note: The equivalent number of PTC cycles listed above corresponds to a sample size of 15. The damage level should be accomplished using a mix of Thermal Shock followed by PTC. The "mix" should be quantified using the calculations contained in the section entitled "Guidelines for Power Temperature Cycling and Thermal shock Tests".

Note: High Altitude Testing or Analysis (optional) may be required in all code letter categories

1.11 Code Letter For Chemical Loads

Purpose

The purpose of this test is to determine if the DUT is able to meet specification requirements when exposed to fluids that could be encountered in the automotive environment.

This test is representative of four exposure conditions.

Method a - Normal cleaning.

Method b - Accidental exposure that may cause surface damage.

Method c - Accidental exposure that may cause internal damage, device not powered during exposure.

Method d - Accidental exposure that may cause internal damage, device powered during exposure.

The CTS shall define the code letter of the device, the fluid exposure test methods to be run, and the associated column(s) of the Environmental Fluids Table chemicals and oils to be used for this test. Tests methods c and d are only to be run if the CTS require them.

Effect On Performance

These tests are intended to evaluate possible degradation of the surface finish and/or damage to the function of the device.

Procedure (Operating Type 1.1)

Method a.

Normal Cleaning. For exposed, passenger compartment E/E devices, GM9900P – "Cleaning/Solvent Resistance of Automotive Components During Normal Customer Use", Procedure A is to be used with the addition of windshield washer solvent to the list of cleaners to be tested.

Method b.

This test evaluates the potential damage to surface material. The brush method of GMW3431 "Procedure for Testing Switches" shall be used for the locations specified with a b in the Automotive Environmental Fluids Table. More than one fluid may be applied to the DUT, but not at the same location. Residues from fluid may be removed if the unit is to be used for subsequent tests.

Method c.

This test evaluates the potential internal damage to an unpowered E/E device. The DUT shall be tested per *the pour method* of GMW3431.

Method d.

This test evaluates the potential damage to a powered E/E device with a splash test. "Splash" is described as follows: Fill a coffee cup with 200 ml of tap water. *Splash the exposed surfaces* of the DUT with the cup contents in one sweeping motion. Continue to monitor the DUT while powered up for an additional 10 min.

Criteria:

Method a.

The exposed surface shall have a satisfactory rating as defined in 5.3 of GM9900P.

Method b.

The DUT shall operate after exposure to the fluids. The fluid shall not melt, crack, craze, or crystallize the surface of the part. Graphics and labeling appliqués shall not chip, crack, dissolve, or be removed upon application of the fluid.

Method c.

The DUT shall pass the Functional/Parametric Test and experience no inadvertent operation, shock hazard, or thermal stress.

Method d.

The DUT under test does not need to operate properly during or after the splash. The part shall not create a shock hazard or thermal incident.

Table 6: Fluid Compatibility

Letters in the table denote the method of application, condition of powering, and acceptance Criteria Note: Use similar products when the specific product is not available in your area.		**Code letter**					
		A	**B**	**C**	**D**	**E**	**F**
	Chemical/Oil	**Cabin Exposed**	**Cabin Unexposed**	**Door Mounted**	**Trunk**	**Under Hood**	**Chassis Mounted**
1	Ammonia Based Cleaner (Windex™ or Equivalent)	a	b	b		b	b
2	Carpet Cleaner	a					
3	Coffee (10 oz, .5 oz cream, 2 tsp. Sugar)	b,c	c	c	c	c	c
4	Cola (Coca Cola™)	b,c	c	c	c	c	c
5	Fingernail Polish Remover	b					
6	Grease, Electrical Connector	b	b	b	b	b	b
7	Hairspray, (Aqua Net™)	b					
8	Hand Cleanser, (Goop™)	b					
9	Hand Lotion, (Vaseline Intensive Care™)	b	b	b	b	b	b
10	Insect Repellent (DEET 7%)	b					

Letters in the table denote the method of application, condition of powering, and acceptance Criteria Note: Use similar products when the specific product is not available in your area.		Code letter					
		A	B	C	D	E	F
	Chemical/Oil	Cabin Exposed	Cabin Unexposed	Door Mounted	Trunk	Under Hood	Chassis Mounted
11	Lubricating Oil (WD40™)	b				b	b
12	Soap and Detergents (Fantastik™ or Formula 409™)	a	b	b			b
13	Sun Tan Lotion (high protection factor)	b			b	b	b
14	Vinyl Cleaner (Armor All™ Cleaner,	a					
15	Vinyl Plasticizers (Armor All™ Protectant)	a					
16	Tap Water	d					
17	Windshield Washer Solvent	a					b
18	Acid Rain (GM9625P)			c	b	c	b
19	Salty Water 5% (GM3431)			c	c	c	c
20	Grease	b		b		b	b
21	Undercoating Material (Ziebart™)			b	b	b	b
22	Wash and Wax Concentrate	b		b		c	
23	Brake Fluid	b				b	b
24	Cleaner/Degreaser	b				b	b
25	Diesel Fuel	b				c	
26	Engine Coolant, 50% (Dex-Cool™) Water Mixture	b				c	
27	Engine Oils	b				c	b
28	Ether (Starting Fluid)					c	
29	Gasohol (approx. 10%)	b				c	
30	Gasoline	b				c	
31	Power Steering Fluid					c	b
32	Paint (Enamel & Lacquer)					c	b
33	Transmission Fluid					c	b
34	Lubricant, Hypoid Gear, Fuel Efficient						b
35	Tire Cleaner	b					b

Method	Procedure	Notes
a	Normal Cleaning	Spray, Wait, and Wipe Off
b	Brush Test	Things that may come off of a person's hands – customer or mechanic
c	Pour Test	Things spilt (area receiving the spill is not electrically energized)
d	Splash Test	Things splashed in the interior like soft drinks in the cup holder (splashed device is electrically energized)

1.12 Code Letter For International Protection By Enclosures

The vehicle location International Protection (IP) requirements are defined *Section 6*. These IP codes are to be used unless the CTS specifies differently. The product should be powered immediately following the completion of the water test.

The structure of the IP code system is defined in *Table 7*. For a complete review see IEC 60529 and DIN 40050 Part 9.

Table 7: Dust And Water International Protection Codes

	IP	1	L	2	L	L	L
Code Letters	■						
First code number (0 to 6 or letter X), **0 to 4 not used by GM**		■					
First supplementary letter (K)			■				
Second code number (0 to 9 or letter X)				■			
Second supplementary letter (K)					■		
Third supplementary letter (A,B,C,D), **not used by GM**						■	
Fourth supplementary letter (M,S), **not used by GM**							■

Current usage:

First code number and supplementary letter pertain to **<u>Dust</u>**:

X .... Not required

5K .... Dust protected, function not affected

6K .... Dust Tight

Second code number and supplementary letter pertain to **<u>Water</u>:**

X……….Not required

1……….Vertical drops

2……….Drops at 15 degree angle

3……….Light water spray

4……….Water spray

4K……..Water spray, higher pressure

5……….Water jet

6……….Strong water jet

6K……..Strong water jet, higher pressure (125 PSI car wash)

7……….Short-term immersion

8……….Long-term immersion

9K……...High-pressure/steam jet cleaning (1200 P.S.I. steam cleaning)

Examples:

IPXX… No Enclosure Requirement

IP5K2… Protected against dust and water droplets

IP5K6K... Protected against dust and high-pressure water jet from a car wash

IP6K9K… Dust tight and high-pressure/steam jet cleaning (underhood applications)

IP6K8… Dust tight and protected from long-term submersion (seal evaluation test required)

Table 8: Operating Types For Validation

Para-graph Number	Test Title	Operating Type
	Parasitic Current measurement	2.1
	Jump Start and Reverse Voltage	3.2
	Over-Voltage	3.2
	Power/Ground Test	3.2
	Reset Behavior at Voltage Drop Test	3.2
	Battery Voltage Dropout	2.1
	Superimposed Alternating Voltage	3.2
	Short Circuit Tests	3.2
	Open Circuit Tests	3.2
	Isolation Evaluation Tests	1.1
	Connector Tests	1.1
	Crush test, method A	1.1
	Crush test, method B	1.2
	Vibration	3.2
	Mechanical Shock	1.2 or 3.2
	Door/Trunk/Hood Slam	3.2
	Free Fall	1.1
	High Temperature Test	3.2
	Power-Temperature Cycle	3.2
	Thermal Shock/Air to Air	1.1 or 1.2
	Thermal Shock/Water Splash	3.2
	Salt Spray and Salt Fog	2.1 or 3.2
	Humid Heat, Cyclic	3.2
	Humid Heat, Constant	3.2
	Dew	1.1 and 3.2
	Low Air Pressure, Test 1	1.1
	Low Air Pressure, Test 2	3.2
	Mixed Gas Corrosion	1.1
	Colorfastness	1.1
	Dust	1.2
	Water	2.1
	Thermal Shock/Water Immersion	3.2
	Fluid Compatibility	1.1 or 2.1
	Flammability	1.1

Table 9: Definitions Of Operating Type

Operating Type	Electrical State
1.1	Not connected electrically and no voltage applied.
1.2	Connected according to vehicle installation, but no voltage applied.
2.1	The DUT is electrically connected as in the vehicle. All inputs shall be supplied with the specified signals as in a shut-off vehicle (sleep mode). All outputs that are used under this condition shall be originally loaded.
2.2	The same conditions as 2.1, however, the DUT is electrically operated with nominal voltage.
3.1	Simulated engine running condition, all connections and loads in place but device not activated.
3.2	Conditions of 3.1, however, the device is activated

1.13 Reliability Design Reviews

Five separate Reliability Design Reviews are to be conducted separately from other design reviews to ensure that proper attention is given to the resolution of product reliability weaknesses. The five different reviews should be conducted over the life cycle of product development and they should occur in chronological order as graphically shown in Section 3. The Reliability Design Review process should be structured to answer the following questions:

- Product Change Assessment Using "Design Review Based on Failure Mode" (DRBFM) – Design Review #1
    - What aspect of this design is different or represents change from previous designs
        - What concerns result from this change
        - What impact will the "different-from-previous" have on the final customer or on other inter-related components in the system
        - What measures will be taken to ensure that the concern does not become a real problem
- Anticipatory Failure Determination[9] (AFD)™ – TRIZ based methodology - Design Review #1

This method is to be used to quickly draw attention to potential weaknesses in the product and help in formulating the best ADV plan. AFD is a technique of inverting and accentuating the problem formulation. Normally in DFMEA one would ask: "How might this product fail?". This embodies a natural "denial phenomenon" and does not help identify the mechanisms that would cause failure to occur. The AFD method inverts the basic question, so that instead of asking how could it fail, one asks: "How could we make it fail", and then: "How could we make it fail consistently". Subsequent questioning explores what conditions would be necessary to ensure that failure did occur consistently. The identification of these conditions leads to the identification of the most risk prone failure mechanisms and the conditions that must be managed to prevent failure. This process will also ensure that weighted attention is given to failure mechanisms that are believed to have a dominant effect. Special attention should be given to these failure mechanisms during test planning and product dissection following the test. While the name is trademarked, the general concepts of this method are in the public domain and can be used without contracted assistance.

- Does the test plan accommodate all of these failure mechanisms?
- How will we assess the design margins for these failure mechanisms?

- The management of problem prevention communication between elements of the Supply-Chain must be managed through the Design Review Process. The extent of this communication should extend to at least the Tier 3 level when possible. A documented communication process must be evident, and concerns between tiers must be communicated to the GM engineering team through the design review process. Example: If we begin to use lead-free solder at the Tier 1 supplier level, which results in a melting point increase of 30^0 over tin-lead solder, how will this be communicated to the Tier 2 suppliers that will be supplying discrete components that must now see this additional temperature rise? What is the risk feedback from the Tier 2 supplier for this situation?
- Design Reviews Between ADV phases using "Design Review Based on Test Results" (DRBTR) – Design Reviews #3-#5
  - Detailed dissection of the tested products is essential to uncover all available information
    - Looking for what is not obvious is essential and the results must be reviewed with General Motors
  - How much design margin exists for each failure mechanism?
    - How sensitive are the dimensions or processing parameters that affect the weak points in our design that limit our design margin
    - How can we minimize the effect of variation on these parameters to the design margin
    - How will these parameters be controlled in production
  - What improvements can be made at each stage of product development for areas with low design margin and how/when will we know that these improvements were effective?
  - How should the test plan be modified in the next phase based on the results learned in the previous phase?

1.14 (1a) Test Flow – Design Validation For An Interior Module

Figure 4 Durability Test Flow For An Interior Module

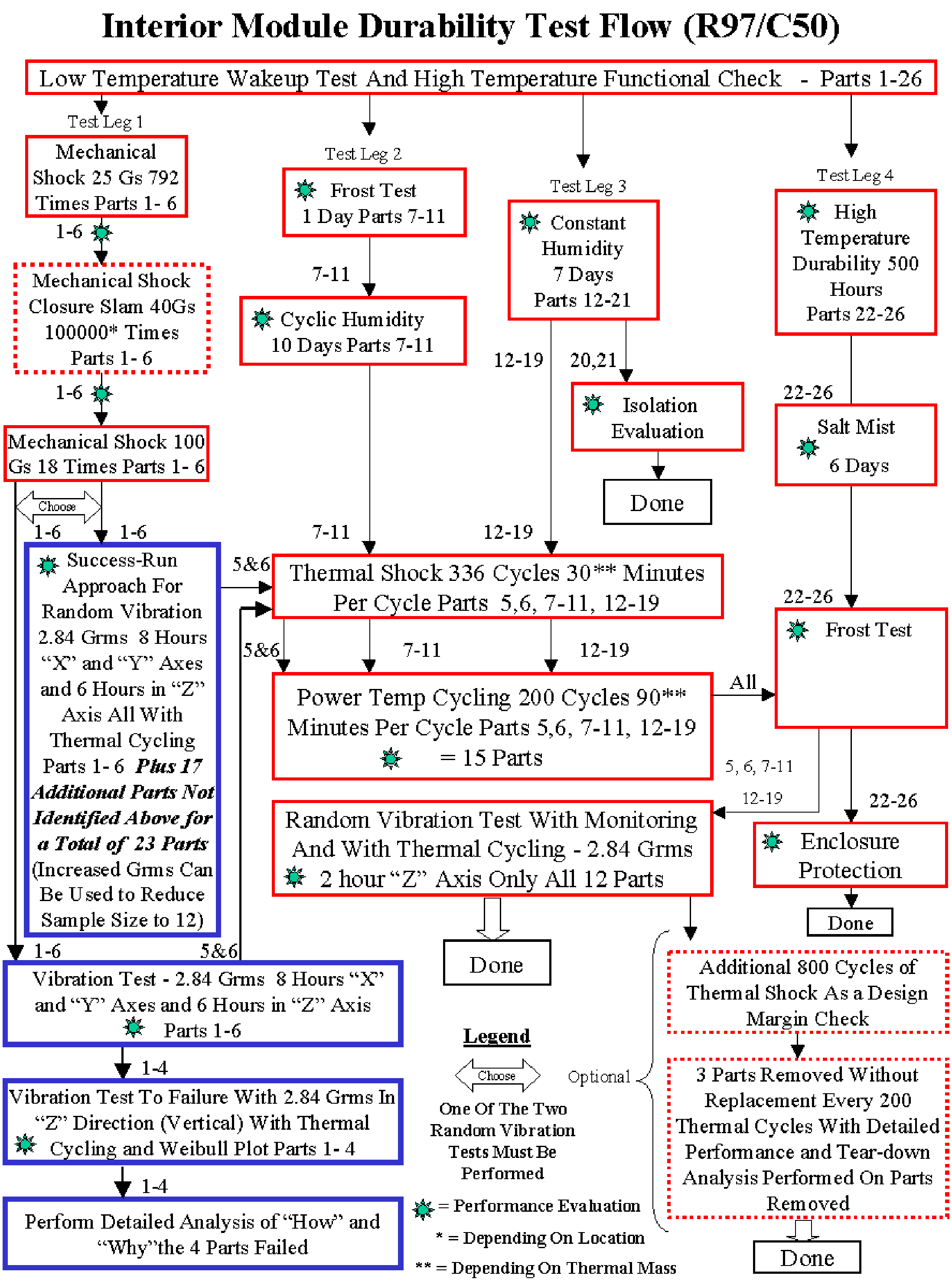
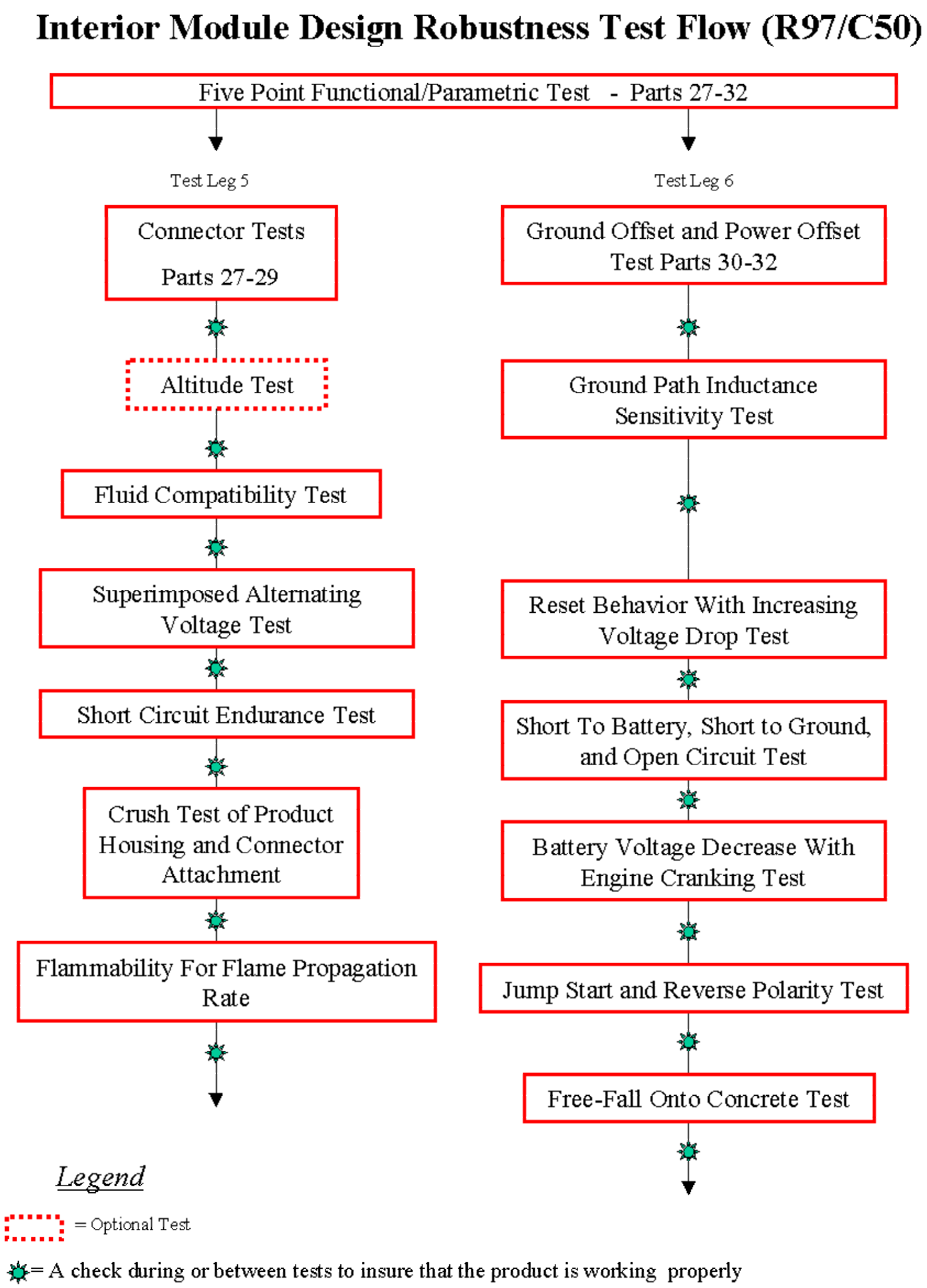


Figure 5 (1b) Design Robustness Test Flow For An Interior Module



1.15 (2a) Test Flow – Design Validation For An Interior Bused Electrical Center

Figure 6 Durability Test Flow For An Interior Bused Electrical Center

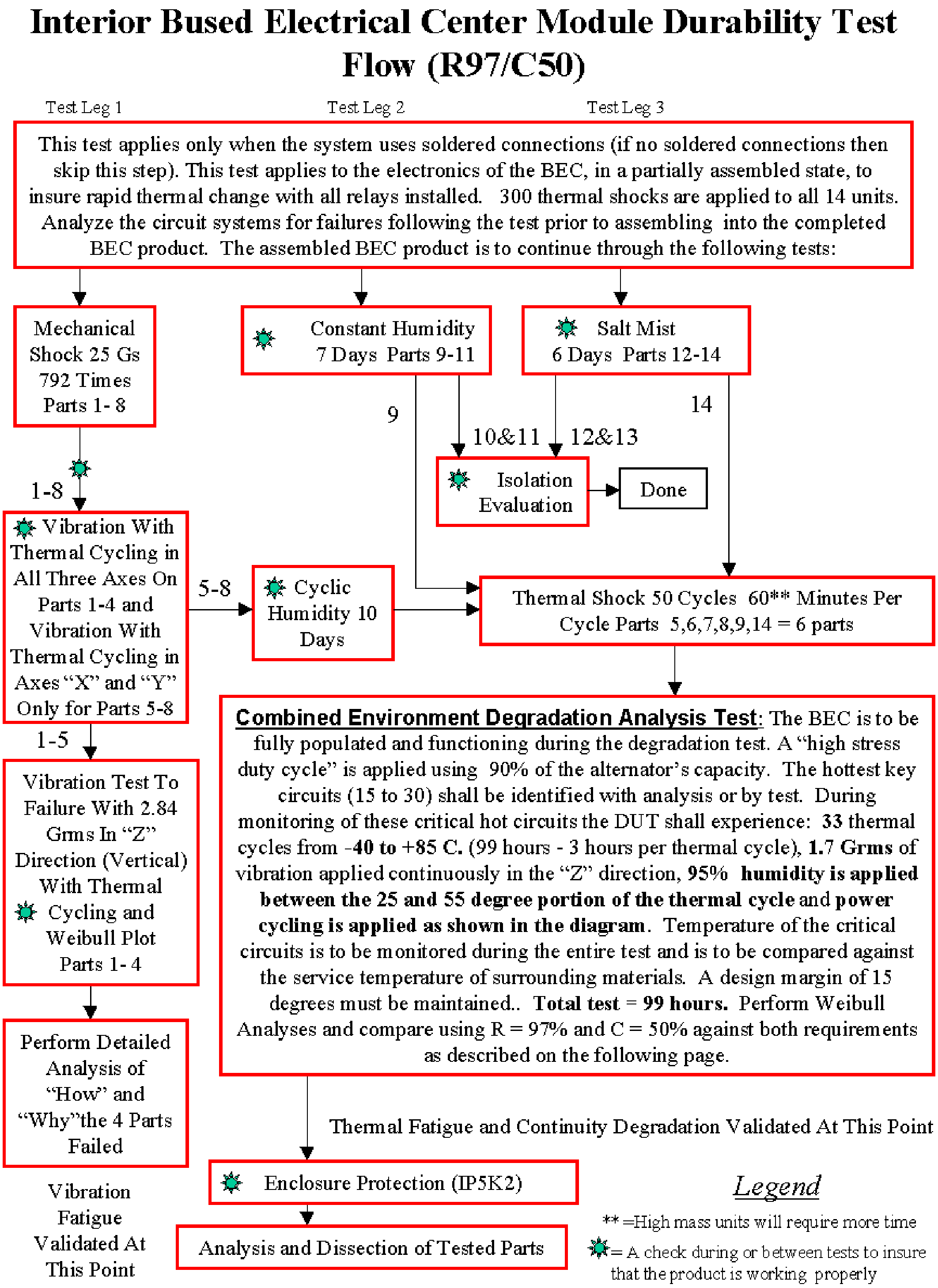
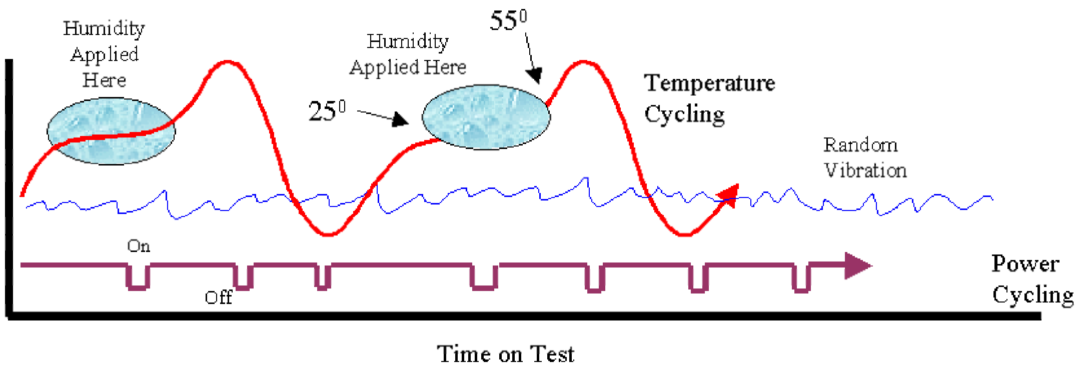


Figure 7 (2b) Test Profile And Analysis For An Interior Bused Electrical Center

Interior Bused Electrical Center Test Profile And Analysis (R97/C50)

Bused Electrical Center Test Profile Of Combined Stresses

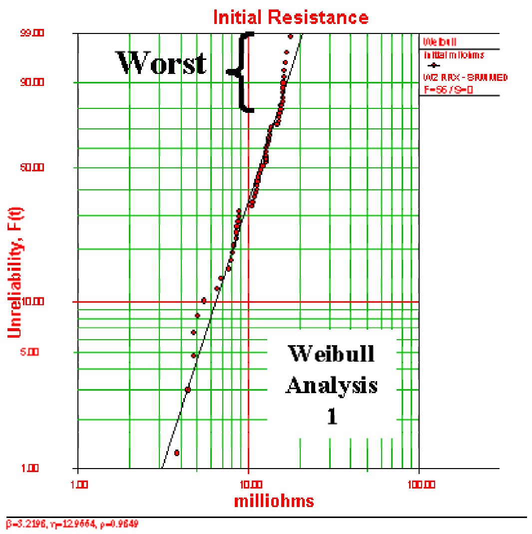
Humidity Is Not Applied at Maximum Temperature to Preserve Fuse Integrity



Weibull Analysis Process of Bused Electrical Center Resistance Data

- Perform Weibull analysis across all of the circuits in each BEC for initial resistance and fractional increase during the Combined Environment Test. This will identify the worst circuits (top 20%). This is shown with Weibull analysis 1 and 2 below.
- Perform additional Weibull analyses (not shown) on these top 20% circuits using the 6 different BEC samples (six data points per Weibull plot, two Weibull plots per circuit).
- Any of the top 20% circuits that **exceed an initial resistance of 20 milliohms** or exceed an **increase factor greater than 3** at the **97% reliability and 50% confidence level** must receive additional investigation and resolution.

$$Fractional\ Increase = \frac{R_F - R_I}{R_I}$$



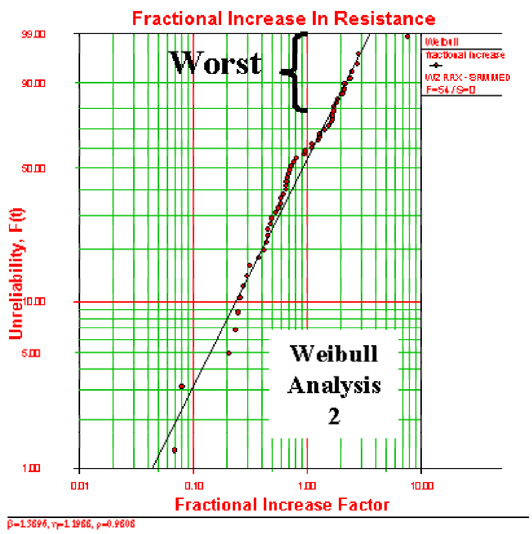
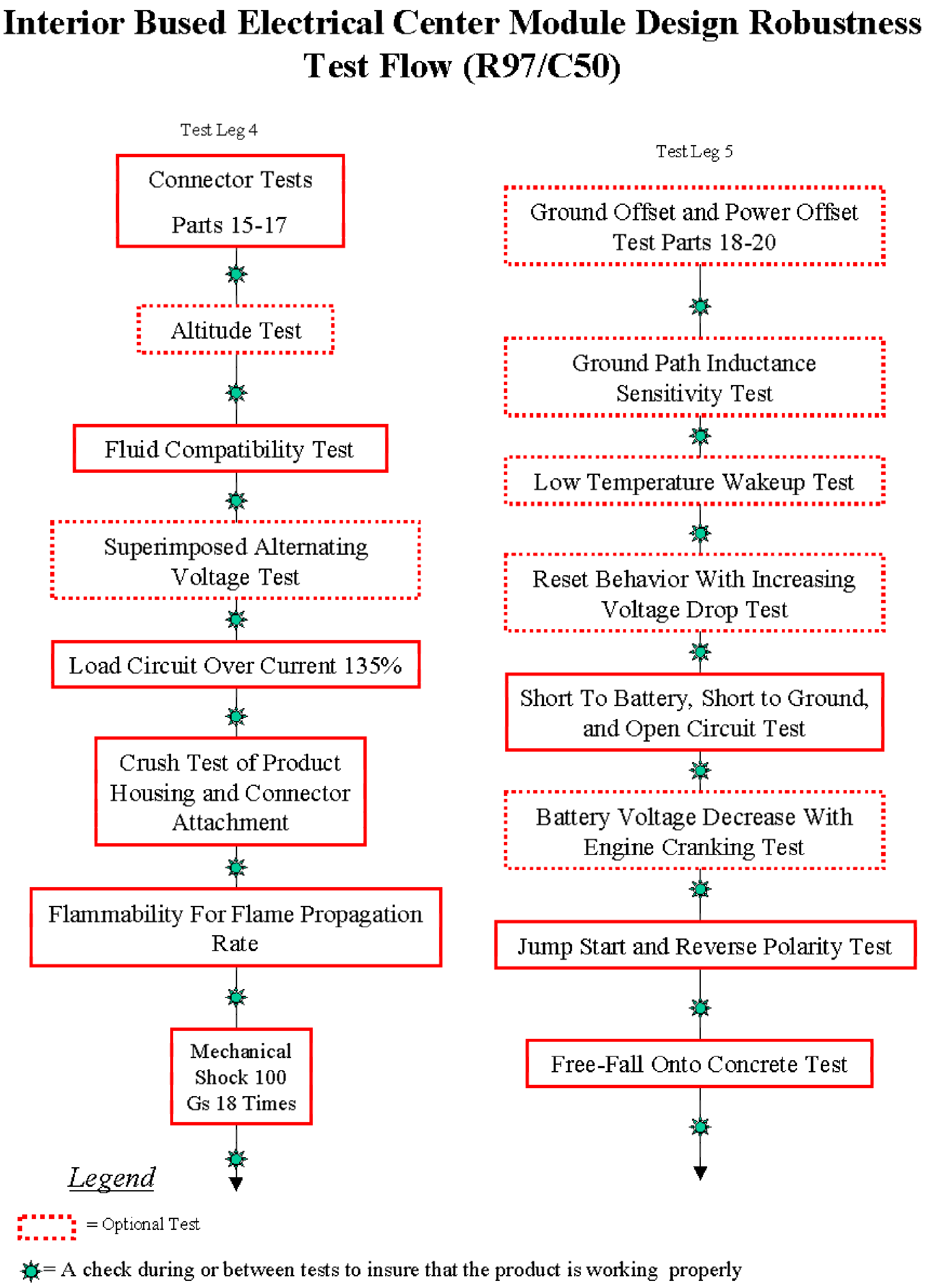


Figure 8 (2c) Design Robustness Test Flow For An Interior Bused Electrical Center



1.16 (3a) Test Flow – Design Validation For An Underhood Bused Electrical Center

Figure 9 Durability Test Flow For An Underhood Bused Electrical Center

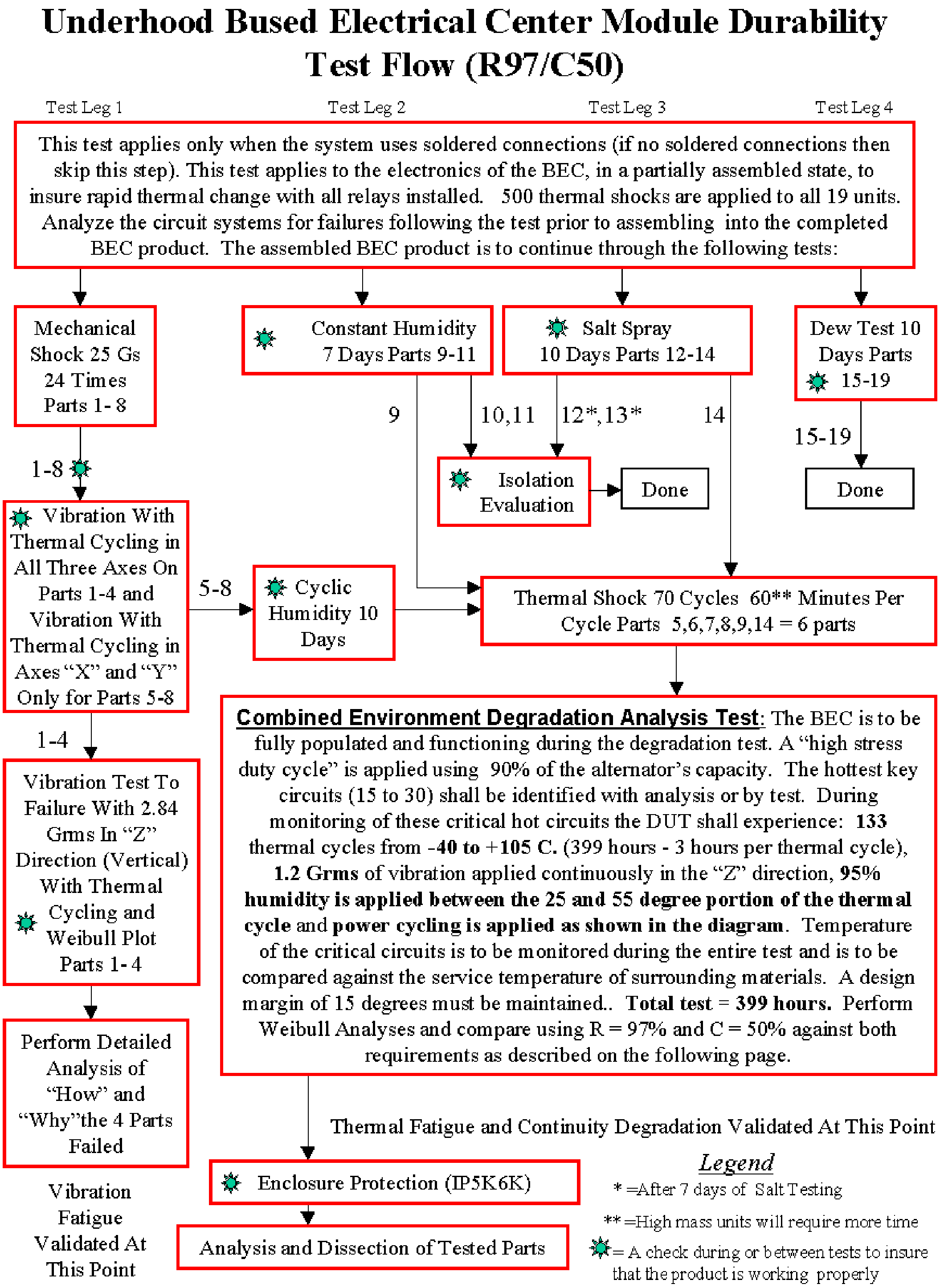
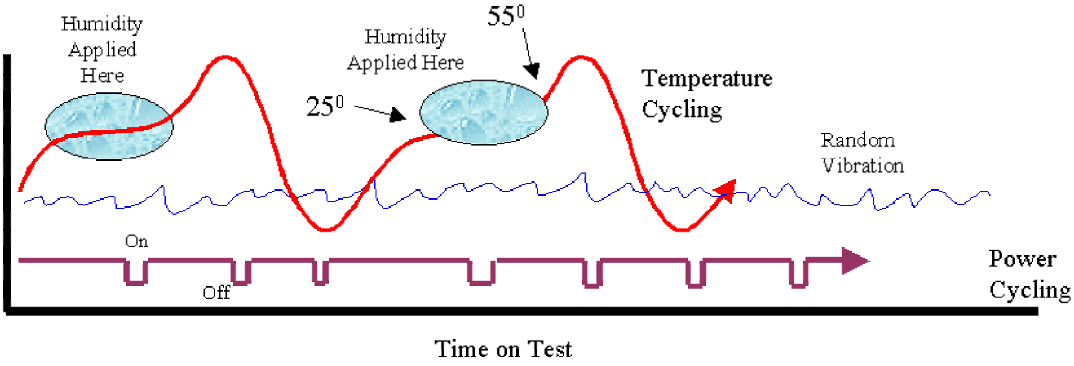


Figure 10 (3b) Test Profile and Analysis For An Underhood Bused Electrical Center

Underhood Bused Electrical Center Test Profile And Analysis (R97/C50)

Bused Electrical Center Test Profile Of Combined Stresses

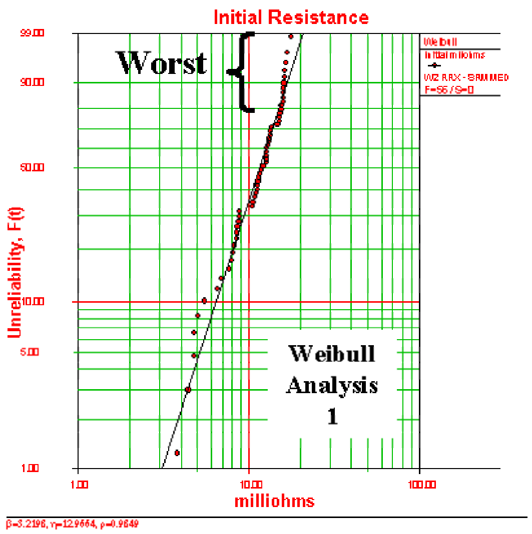
Humidity Is Not Applied at Maximum Temperature to Preserve Fuse Integrity



Weibull Analysis Process of Bused Electrical Center Resistance Data

- Perform Weibull analysis across all of the circuits in each BEC for initial resistance and fractional increase during the Combined Environment Test. This will identify the worst circuits (top 20%). This is shown with Weibull analysis 1 and 2 below.
- Perform additional Weibull analyses (not shown) on these top 20% circuits using the 6 different BEC samples (six data points per Weibull plot, two Weibull plots per circuit).
- Any of the top 20% circuits that **exceed an initial resistance of 20 milliohms** or exceed an **increase factor greater than 3** at the **97% reliability and 50% confidence level** must receive additional investigation and resolution.

$$Fractional\ Increase = \frac{R_F - R_I}{R_I}$$



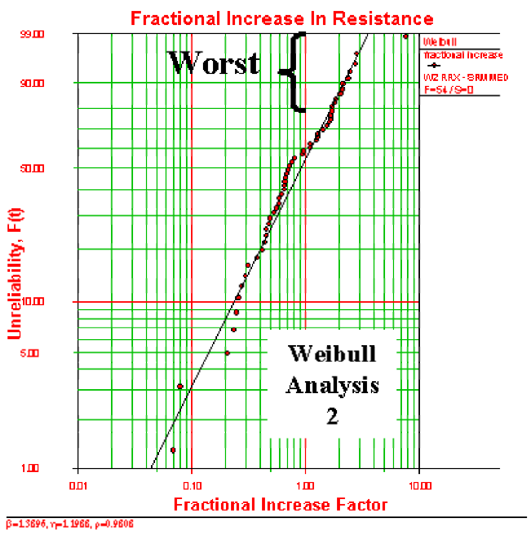
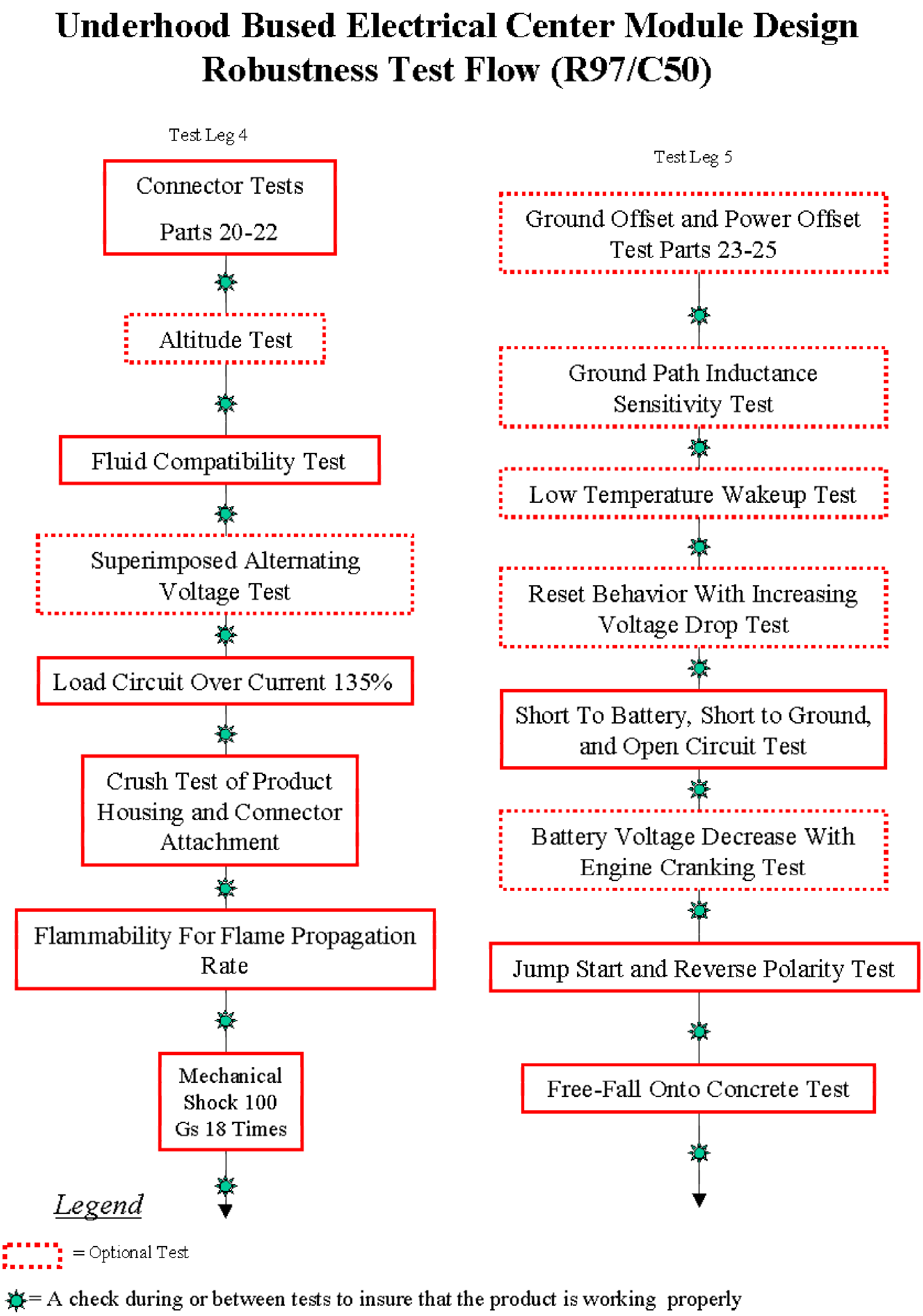


Figure 11 (3c) Design Robustness Test Flow For An Underhood Bused Electrical Center



1.17 (4a) Test Flow – Design Validation For A Door Mounted Exterior Module

Figure 12 Durability Test Flow For A Door Mounted Exterior Module

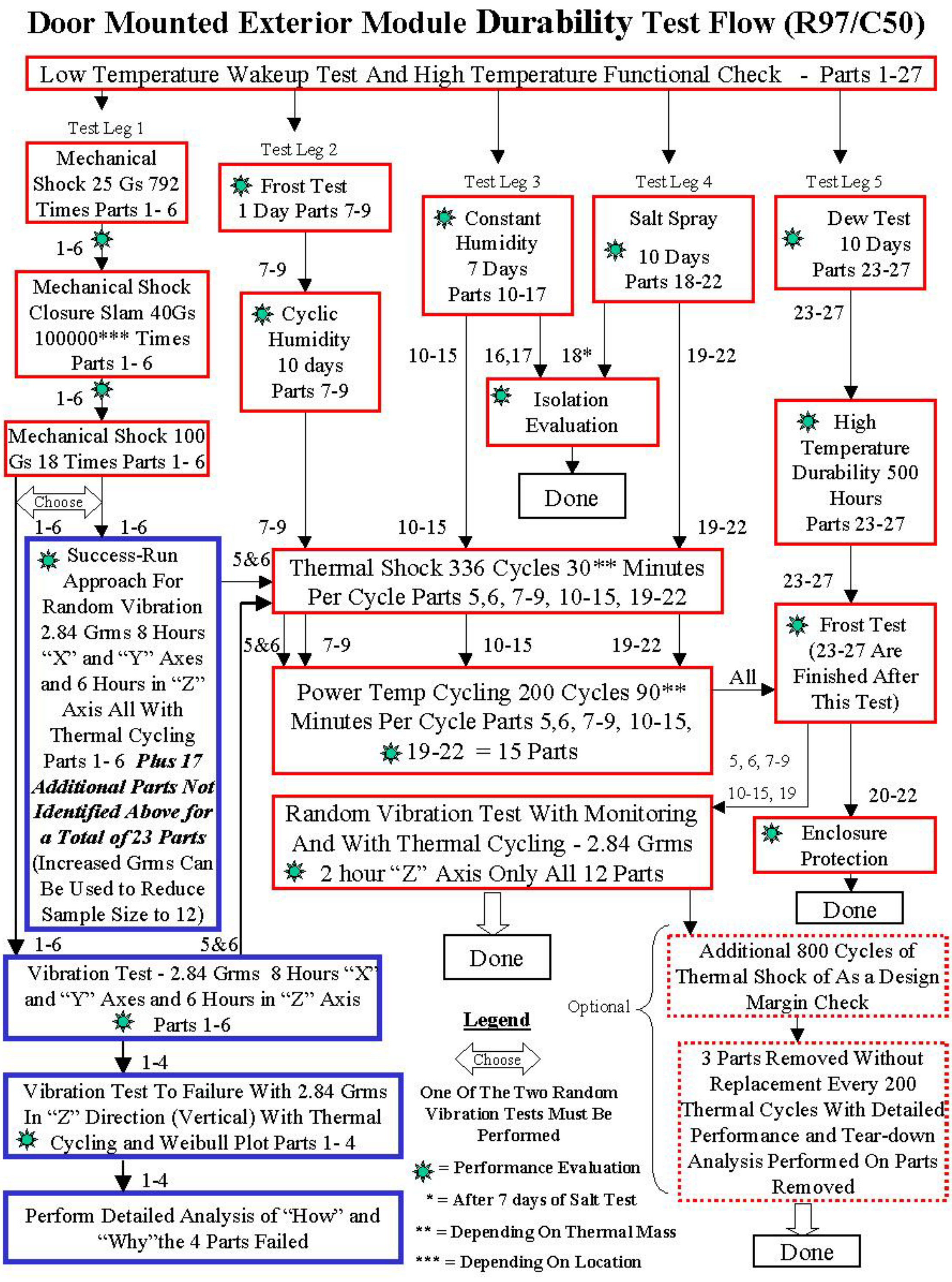
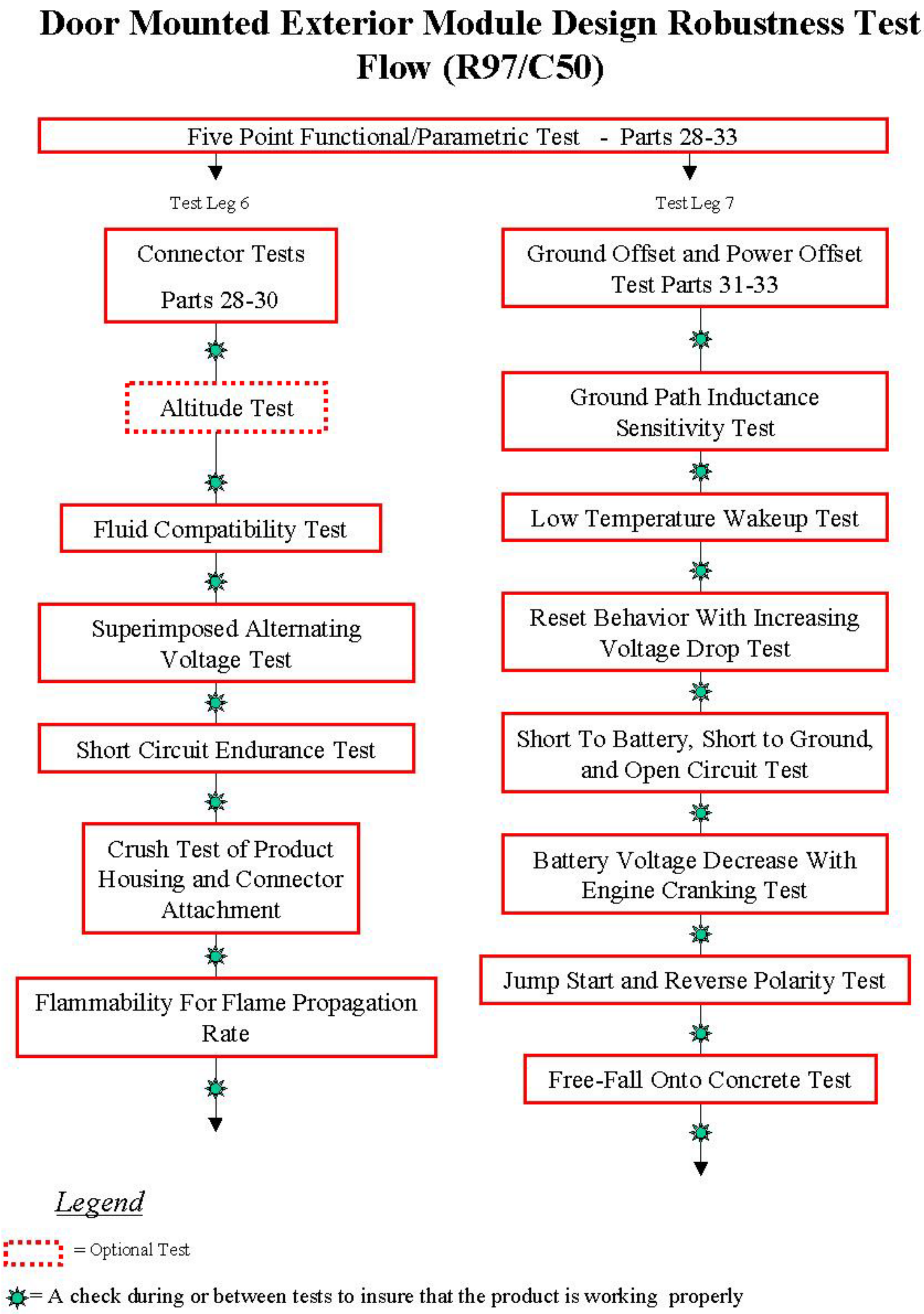


Figure 13 (4b) Design Robustness Test Flow For A Door Mounted Exterior Module



1.18 (5a) Test Flow – Design Validation For A Low Mounted Exterior Module

Figure 14 Durability Test Flow For A Low Mounted Exterior Module

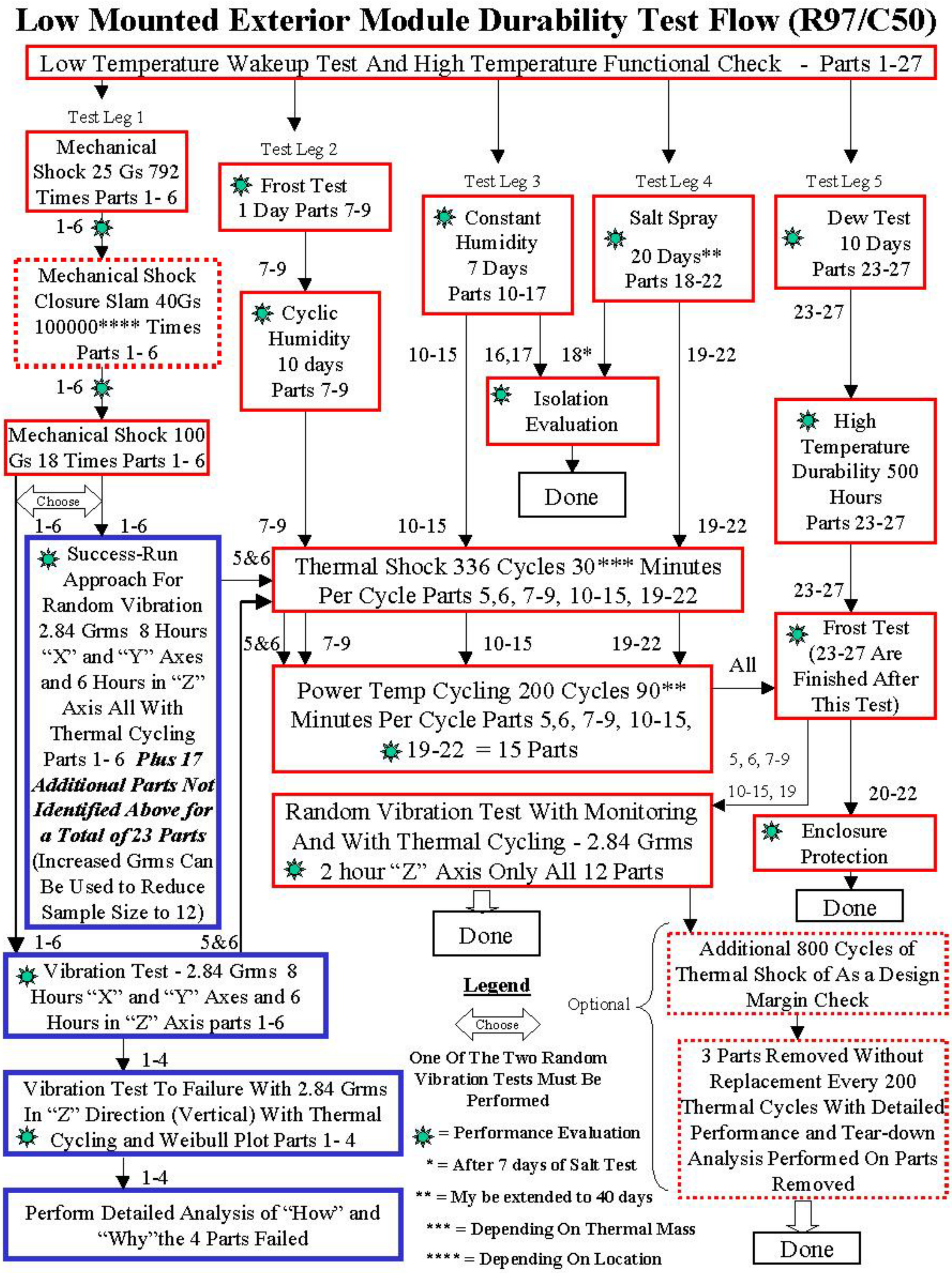
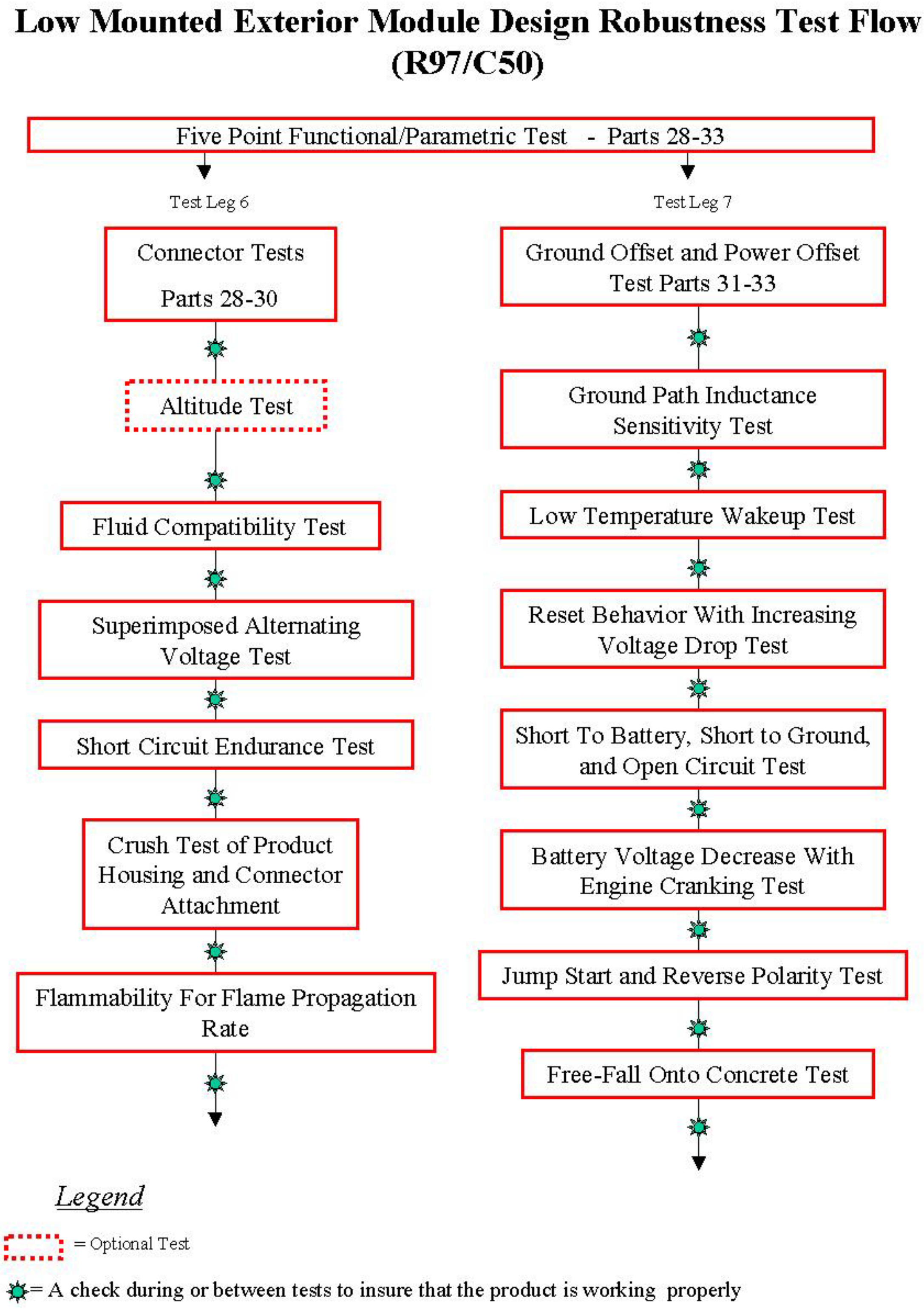


Figure 15 (5b) Design Robustness Test Flow For A Low Mounted Exterior Module



1.19 (6a) Test Flow – Design Validation For A High Mounted Exterior Module

Figure 16 Durability Test Flow For A High Mounted Exterior Module

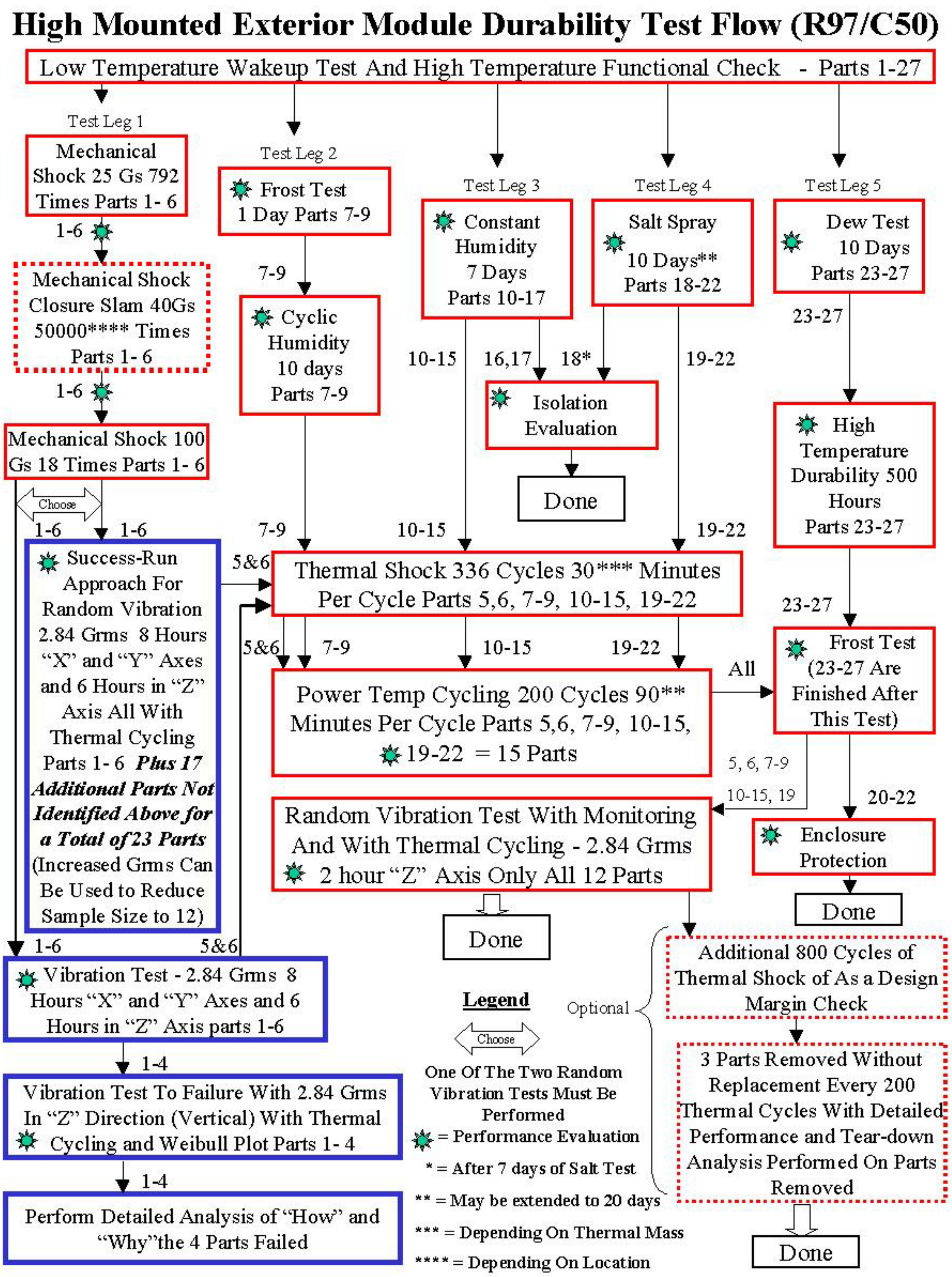
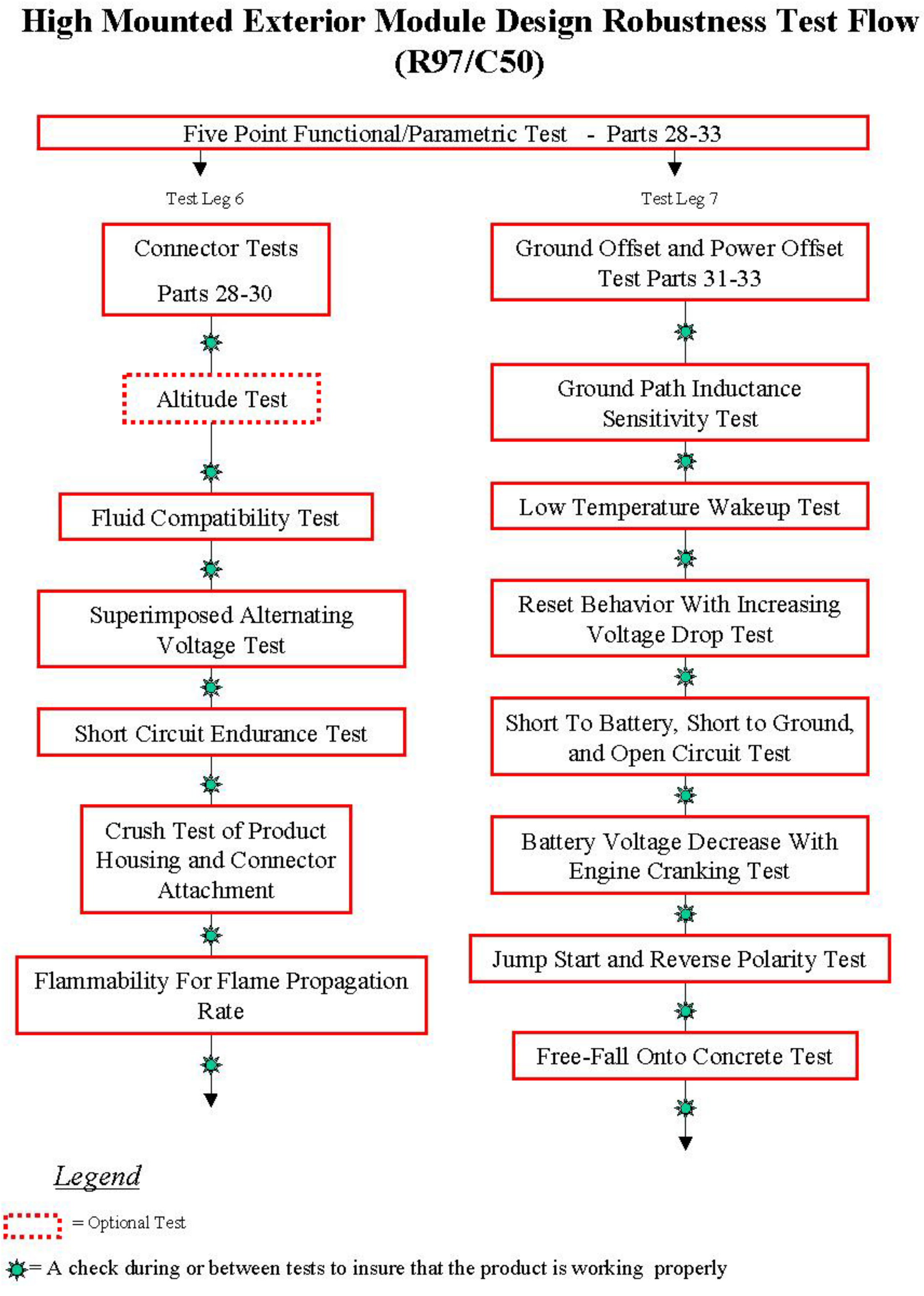


Figure 17 (6b) Design Robustness Test Flow For A High Mounted Exterior Module



1.20 (7a) Test Flow – Design Validation For An Engine Mounted Module

Figure 18 Durability Test Flow For An Engine Mounted Module

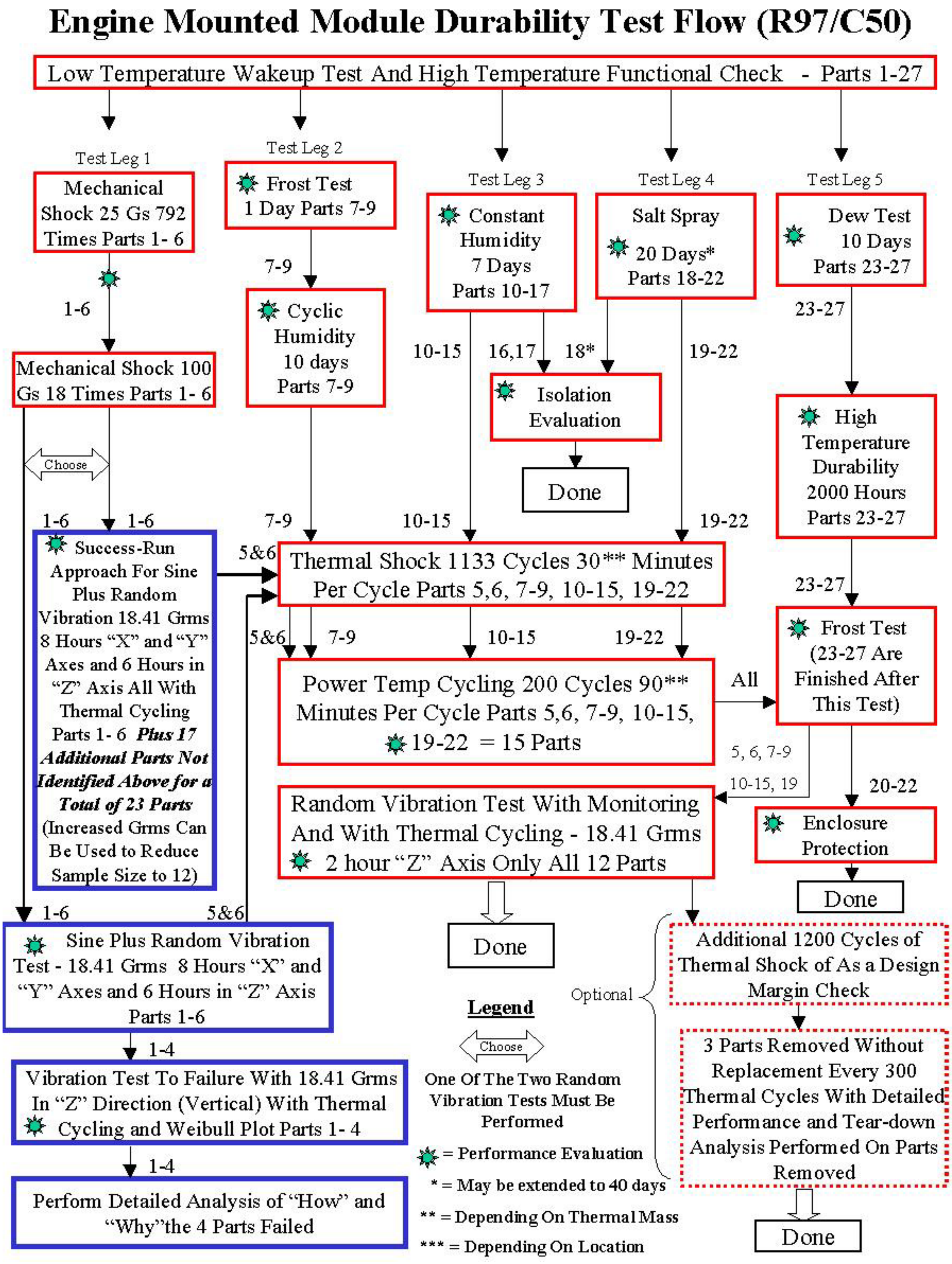
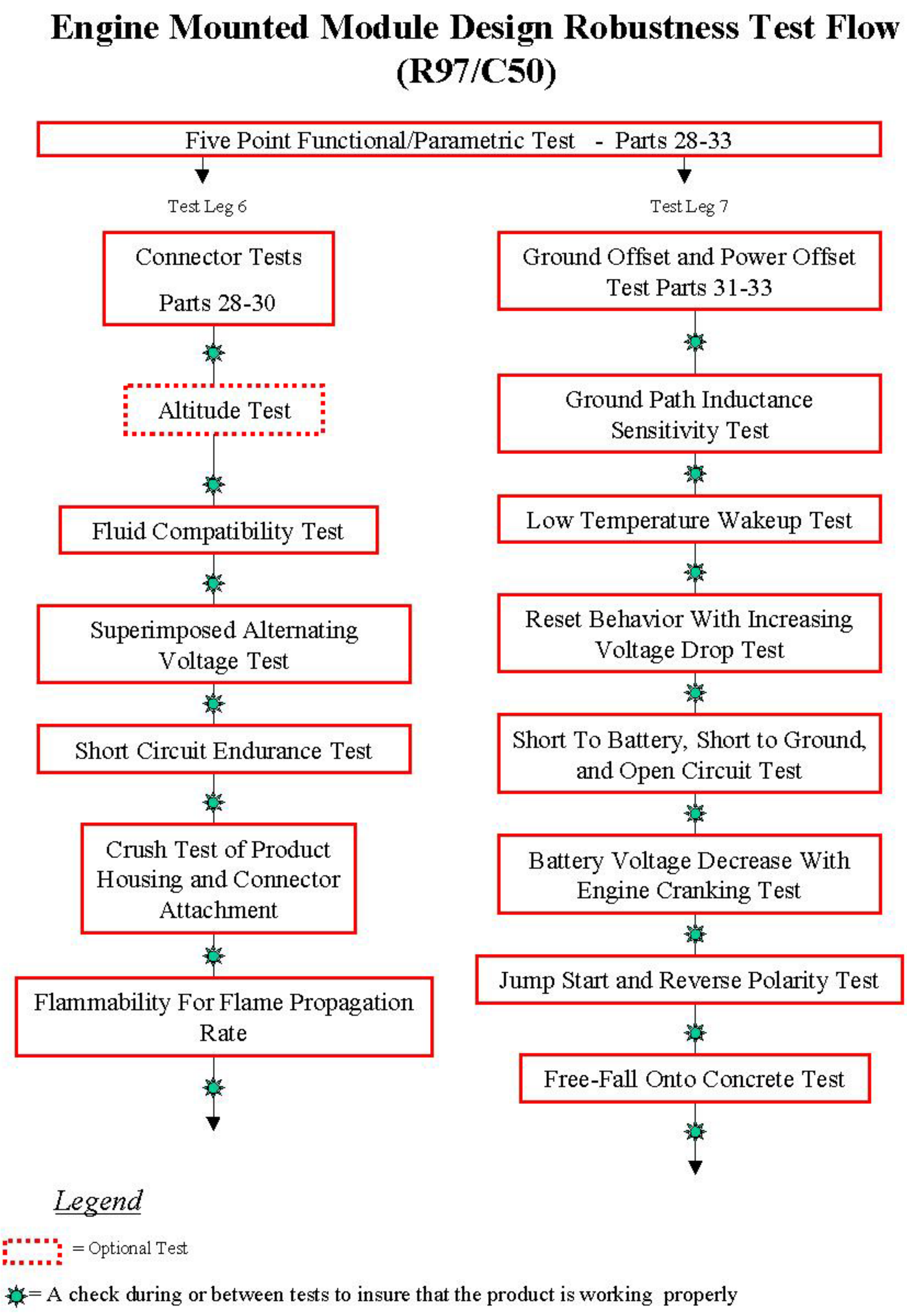


Figure 19 (7b) Design Robustness Test Flow For An Engine Mounted Module



1.21 Test To Field Reliability

The tests included in this specification are based on a severe user. The reliability that is required (.97) is based on these “severe user“ tests. The expected reliability of the product in the hands of the normal array of users is greater than what is demonstrated on test. Benchmarking activities where used to identify the level of reliability that was required in the field (.995), and the reliability on test (.97) was derived from that benchmarking effort. The following table provides an example of the test-to-field correlation for electronic products:

Example:

Assume the situation of a test designed for the “severe user”, with a CVR of 3, and a failure distribution Weibull Slope of 2. Passing the reliability requirements of 97 % on test, converts to a reliability in the “field” of 99.5 %. The “field” is composed of a wide array of severity users, some severe and some not so severe. The reliability in the field will, theoretically, be better than the reliability that was demonstrated on test.

Table 10 Field To Test Reliability Relationship

Definition: The following operating types are distinguished.									
Test is equivalent to a “severe user” under field conditions									
Adjusted **Field** Reliability at One Life	**Test Reliability** at One Test Life								
	Customer Variability Ratio (Severe User/Median User) – CVR								
	1	**3**				10			
	All Slopes	Weibull Slope on Test (Beta)				Weibull Slope on Test (Beta)			
		1	1.5	**2**	3	1	1.5	2	3
0.9999	0.9999	0.99973	0.99958	0.99937	0.99876	0.99927	0.99854	0.99749	0.99484
0.99975	0.99975	0.99932	0.99895	0.99844	0.99689	0.99827	0.99652	0.99404	0.98777
0.9995	0.9995	0.99865	0.99790	0.99686	0.99379	0.99660	0.99319	0.98833	0.97605
0.99925	0.99925	0.99797	0.99685	0.99530	0.99068	0.99493	0.98986	0.98262	0.96449
0.999	0.999	0.99730	0.99580	0.99373	0.98759	0.99327	0.98651	0.97696	0.95292
0.995	0.995	0.98652	0.97913	**0.96896**	0.93905	0.96689	0.93431	0.88924	0.77950
0.99	0.99	0.97314	0.95855	0.93861	0.88087	0.93461	0.87197	0.78735	0.59188
0.98	0.98	0.94670	0.91825	0.87995	0.77251	0.87238	0.75632	0.60883	0.31225
0.97	0.97	0.92068	0.87910	0.82395	0.67442	0.81321	0.65239	0.46181	0.14366
0.96	0.96	0.89507	0.84108	0.77055	0.58600	0.75695	0.55950	0.34324	0.05658
0.95	0.95	0.86987	0.80418	0.71970	0.50672	0.70357	0.47703	0.24967	0.01879

1.22 Reliability By Analysis

The reliability of the device can be demonstrated analytically for the failure mechanisms of vibration and/or thermally induced fatigue. This analytical effort will allow a reduction in validation test activity through agreement with General Motors. Special note: Weaknesses that were not anticipated during analysis may exist in the product and cause premature failures. Testing must occur to ensure that unexpected weaknesses are not present.

Vibration:

The analysis process must simulate the vibration procedure in the design validation section to demonstrate the vibration reliability.

Thermal Fatigue:

The analysis procedure must simulate the thermal shock and power temperature procedures in the design validation section to demonstrate the reliability requirements.

Design Margins:

The analytical procedure must account for design variability. One method of accounting for variability is to assure that the life consumed during the simulation is less than the value in the following table.

Table 11 Design Margin Guidelines

Test Reliability	Weibull Slope	Maximum Life Consumed during Simulation of DV Test	Minimum Design Margin for Simulation of GMW3172 Test
0.97	**2**	**0.20**	**5.1**
.97	**3**	**.34**	**2.9**
0.97	4	0.45	2.2
0.97	5	0.56	1.8
0.97	6	0.59	1.7
0.98	2	0.16	6.2
0.98	3	0.30	3.3
0.98	4	0.42	2.4
0.98	5	0.50	2.0
0.98	6	0.56	1.8
0.99	2	0.11	8.8
0.99	3	0.24	4.1
0.99	4	0.35	2.9
0.99	5	0.44	2.3
0.99	6	0.50	2.0

Typical values are shown in bold

1.23 Reliability By Test

The CTS Reliability Requirement is demonstrated for three separate failure causes.

- Vibration with superimposed temperature cycling.
- Thermally induced fatigue.
- Failures due to the number of product usage cycles (only when this produces a legitimate failure mechanisms).

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications

DIN 40050	IEC 60068-2-60
IEC 60068-2-1	IEC 60068-2-64
IEC 60068-2-2	IEC 60529
IEC 60068-2-6	ISO 12103-1
IEC 60068-2-13	ISO 16750- (1-5)
IEC 60068-2-14	ISO/IEC 17025
IEC 60068-2-27	ISO 21848-2
IEC 60068-2-29	QS9000
IEC 60068-2-38	SAE J726
IEC 60068-2-56	SAE J1885

2.2 GM Standards/Specifications

GM9900P	GMW3098
GME3191	GMW3103
GME60206	GMW3232
GME60292	GMW3431
GMI12537	GMW8287
GMI60211	GMW8288
GMW3091	GMW8288

2.3 Additional References

[1] Steinberg, Dave E.: Vibration Analysis For Electronic Equipment, Second Edition, John Wiley and Sons, 1988.

[2] Hobbs, Gregg K.: Accelerated Reliability Engineering – HALT and HASS, John Wiley and Sons, 2000

[3] Lipson, Charles and Sheth, Narendra J.: Statistical Design and Analysis of Engineering Experiments

[4] Nelson, Wayne: Accelerated Life Testing, John Wiley and Sons, 1990.

[5] Peck, D. Steward: Comprehensive Model for Humidity Testing Correlation, IEEE Catalog # 86CH2256-6, 1986.

[6] Technology Report #5 Fundamental Concepts of Environmental Testing in Electricity and Electronics, Tabai Espec Corp., 1998.

[7] Azar, Kaveh,: Electronics Cooling – Theory and Applications, Short Course, 1998.

[8] White, F.M.: Fluid Mechanics, Second Edition, Pg. 60, McGraw-Hill, New York, 1986.

[9] Clark, Dana W.: AFD and Inventive Troubleshooting, Ideation International Inc., 2000.

[10] U.S Military Standard: Mil-Std-810F Annex B", U.S. Government Publication, January 2000.

General Motors: GP-11 A/D/V Plan.

GM Material and Fastening Center: Analysis Guidelines defined in: Fundamental of Snap Fit Design, Version 2.0 or later.

General Motors: NAO Corporate Class 2 Functional Communications Specification.

3 Test Preparation And Evaluation

3.1 Resources

3.1.1 Facilities

The test facilities shall be QS9000 and/or ISO/IEC 17025 certified.

3.2 Test Samples

The test samples shall be production intent design and materials for design validation and manufactured on production tooling, with production materials and processes for product validation.

3.3 Conditioning

See the SSTS or CTS for special requirements.

3.4 Documentation

Samples of E/E devices or material released to this specification shall be tested for conformity with the requirements of this specification and approved by the responsible GM Department prior to commencement of delivery of bulk supplies.

Any changes, e.g. design, function, properties, manufacturing process and location of manufacture must be approved by GM engineering and may require retesting.

It is the sole responsibility of the supplier to inform the customer, unsolicited, with documentation of all adjustments, modifications of parts and/or processes and to apply for a new release.

If not otherwise agreed, the entire release test shall be repeated and documented by the supplier prior to commencement of delivery of modified bulk supplies. In simple cases a shorter test can be agreed upon between the responsible GM Department and the supplier.

3.4.1 Test Results

All test results shall be included in a test report. This report shall be delivered to the responsible GM department. All running records of data collection shall be retained and made available to GM if requested.

3.4.2 Deviations From Procedure

Deviations from the requirements of this procedure shall have been agreed upon prior to the start of testing. Such requirements shall be specified on component drawings, test certificates, reports, etc.

3.5 Parameters

3.5.1 Parameter Tolerance

Unless stated otherwise, the following shall define the test environment parameters and tolerances to be used for all validation testing:

Table 12 Parameter Tolerances

Parameter	Tolerance
High Ambient Temperature	$T_{max} \pm 3$ °C,
Room Ambient Temperature	(+23 ± 5) °C
Low Ambient Temperature	$T_{min} \pm 3$ °C,
Test Time	Spec. $^{+2}_{-0}$ %
Room Ambient Relative Humidity	(50 ± 20) %
Chamber Humidity	Spec. ± 5 %
High Operational Voltage	Table 2 ± 0.1 volt
Nominal Operational Voltage	Table 2 ± 0.1 volt
Low Operational Voltage	Table 2 ± 0.1 volt
Voltage	Spec. ± 0.1 V (as measured at the module)
Vibration	Spec. ± (0.2 X g_n) or spec ± 20 % (whichever is greater)
Shock	Spec. ± 20 %
Frequency	Spec. ± 1 %

3.6 General Test Procedures

3.6.1 Functional And Parametric Tests

The supplier is responsible for developing Functional/Parametric, Continuous Monitoring, and Functional Check Tests for the E/E device. The Functional/Parametric Tests are procedures, which verify the functional, and parametric requirements defined in the CTS. The Continuous Monitoring Tests verify that the functional requirements are met while the DUTs are being exposed to the test environment. These procedures are to be approved by General Motors prior to testing.

The Functional/Parametric Tests Shall:

1 Validate functionality by monitoring and recording that all outputs (both hardware and on vehicle communications) are in the correct state for a given set of inputs and timing conditions.

2 Validate parametric values by monitoring and recording the specific voltage, current, and timing levels for all inputs and outputs and ensuring that these levels meet specification requirements.

3 Selected parameters shall be statistically analyzed to evaluate whether build variations result in an acceptable degree of performance variation across the sample set. The distribution of the measured values shall not result in a skewed distribution stacked up against a tolerance limit.

4 Selected comparisons shall be made between parametric measurements made on the E/E devices when new, prior to testing, and when the DUTs complete the test sequences. Comparisons to the original measurements, individually and as a group statistically, shall be made to identify and quantify any performance degradation. If degradation limits are not specified in the CTS, the supplier and the GM Release engineer shall collaborate to define the degradation acceptance/failure Criteria

The Continuous Monitoring Tests Shall:

1 Validate functionality, while the parts are exposed to the test environment, by continuously monitoring and recording exceptions to all outputs (both hardware and on vehicle communications) not being in the correct state for a given set of inputs and timing conditions. Sampling on a frequent basis is an acceptable form of continuous monitoring. The sampling rate shall be reviewed with and approved by GM Engineering. The Sampling rate during PTC and vibration should reflect a reasonable degree of discrimination relative to the duration of one thermal cycle. Constant monitoring for Power-Temperature-Cycling and Vibration Testing should occur approximately every 3-6 seconds, but can be extended to once every minute when limitations on data collection dictate.

2 All DUT inputs/outputs (including on vehicle communications) shall be continuously cycled and monitored for proper functional operation over all applicable power modes and battery voltages.

3 The input/output cycling and monitoring shall be automatic and shall not require human intervention or observation at any time during the test to detect and record a nonconformance to specification requirement issue. The test system shall have an automated nonconformance detection alert system. This may be visual or audible.

The Functional Check Shall (Operating Type 3.1):

1 Check functionality, while the DUTs are exposed to the test environment.

2 The DUT shall be powered up from a shut down power mode to a normal operation power mode. All DUT inputs/outputs (including on vehicle communications) shall be cycled and monitored for proper functional operation. The functional check shall be time limited to prevent self-heating of the device while being exposed to specific test environments.

3 The input/output cycling and monitoring shall be automatic and shall not require human intervention or observation at any time during the test to detect and record a nonconformance to specification requirement issue.

3.6.2 Test Criteria

The supplier is responsible for developing a detailed test criteria list, which will define the following:

How and which functional operations will be verified and/or continuously monitored.

1 The list of key parameters to be measured and recorded.

2 The list of build variation related parameters to be statistically analyzed.

3 The list of degradation related parameters to be statistically analyzed.

4 The nominal and range limit values for the measured parameters to ensure performance in accordance with the CTS.

The procedures must be submitted for approval to GM Engineering. After approval, the document shall be under change control and any future changes must be submitted for approval to GM Engineering.

Examples of key parameters to be measured for verification of performance, variation, and/or degradation are:

1 Device or system voltage and current draw.

2 The voltage and current of outputs.

3 The comparison of analog input voltages to their digital conversion values via the data link.

4 Frequency or duty cycle responses.

5 The response timing output relative to their triggering inputs.

The Functional/Parametric Test shall be performed where specified in the Validation Test Flow section. The Functional/Parametric Test may be waived if the DUTs are continuously monitored during the test. Any Functional/Parametric Test results that do not meet specification requirements shall be considered a validation nonconformance issue.

3.6.3 Room Temperature, Multi-Voltage Functional/Parametric Test

The Functional/Parametric Test shall be performed at room ambient temperature and at multiple power supply operational voltages. The number of different supply voltages should be selected to verify each function at its required voltage limit. The minimum number of voltage values should be V_{min}, nominal and V_{max}.

The power supply shall be capable of supplying sufficient current to avoid current limiting under high in-rush conditions. All Functional/Parametric Tests must be conducted with actual vehicle loads or simulated loads. Simulated loads require the approval of GM Engineering.

3.6.4 Room Temperature, Nominal Voltage Functional/Parametric Test

The Functional/Parametric Test may be performed at room temperature and only the nominal voltage with the approval of GM Engineering.

3.6.5 Tri-Temperature, Multi-Voltage Functional/Parametric Test

The Functional/Parametric Test shall be performed at three different ambient temperatures (low, room and high) and at multiple power supply operational voltages. The number of different supply voltages should be selected to verify each function at its required voltage limit. The minimum number of voltage values should be V_{min}, nominal and V_{max}. As a minimum, this test shall be performed at the beginning of each test leg and at the end of all test legs. The temperature shall be stabilized for at least 0.5 hours prior to the Functional/Parametric Test. The power supply shall be capable of supplying sufficient current to avoid current limiting under high in-rush conditions. All Functional/Parametric Tests must be conducted with actual vehicle loads or simulated loads. Simulated loads require the approval of GM Engineering. Stabilization for 0.5 h at the repaint temperature, without a functional/parametric test, is required if the high temperature is less than the repaint temperature.

Sequence of Tri-Temperature, Tri Voltage Functional/Parametric Tests		
Sequence	Temperature	Voltage
1	Room Temperature	Nominal
		Maximum
		Minimum
2	Minimum Temperature	Minimum
		Nominal
		Maximum
3	Repaint (If required)	No Voltage Applied
	Maximum Temperature	Maximum
		Nominal
		Minimum

3.6.6 The Five Point Functional And Parametric Test

The Functional/Parametric Test may be performed at only five points with the approval of GM Engineering.:

1. (T_{min}, V_{min})
2. (T_{min}, V_{max})
3. (T_{room}, V_{nom})
4. (T_{max}, V_{min})
5. (T_{max}, V_{max})

3.6.7 Dimensional Test

The Dimensional Test shall be performed at room ambient temperature where specified in the Validation Test Flow section. All dimensional and physical requirements, including labels, on the GM released part drawing shall be validated and documented unless indicated otherwise by GM Engineering. Any Dimensional Test results that do not meet the part drawing requirements shall be considered a validation nonconformance issue.

3.6.8 Device Inspection

The E/E device Internal & External Inspection is a visual microscopic review of the device's case and internal parts at the completion of reliability testing as specified in the Validation Test Flow section. The purpose of this inspection is to identify any structural faults, material/component degradation or residues, and near to failure conditions caused by the reliability testing. The inspection shall use visual aids (i.e., magnifiers, microscopes, dyes, etc.) as necessary. The following are examples of items the inspection shall examine for:

a **DUT Mechanical and Structural Integrity:** Signs of degradation, cracks, melting, wear, fastener failures, etc.

b **Solder/Component Lead Fatigue Cracks or Creep of Lift:** Emphasis on large integrated circuits, large massive components or connector terminations (especially at the end or corner lead pins). Also, components in high flexure areas of the circuit board.

c **Damaged Surface Mount Components:** Emphasis on surface mount components near circuit board edges, supports or carrier tabs. Also, surface mount components located in high flexure areas of the circuit board and near connector terminations.

d **Large Component Integrity and Attachment:** Leaky electrolytic capacitors, contaminated relays, heat sink/rail attachments, etc.

e **Material Degradation, Growth, or Residues of Corrosion:** Melted plastic parts; degraded conformal coatings, solder masks or seals; circuit board delaminations, lifted circuit board traces, signs of dendritic growth across circuit board traces, corrosion such as black silver sulfide spots on chip components, organic growths, or environmental residues due to dust, salt, moisture, etc.

f **Other Abnormal or Unexpected Conditions:** Changes in appearance or smell**.**

A summary of each DUT's condition shall be documented and reported to GM engineering. The supplier may be required to perform further investigation to determine the degree or type of degradation. GM engineering will decide as to the necessity of corrective action.

3.7 Hardware Stage Classifications

The hardware stage classifications are:

Pre-prototype:

This refers to components that may be made with non-production tools and non-production processes.

Prototype and Prototype Match / Check:

This refers to components that use production design intent parts made with non-production or production tools and processes to demonstrate final vehicle design. This level of design is to be used for Design Validation and must include the same flux, chemicals and material types as intended for production.

Pilot/Production:

This identifies components that are built on production tools with production processes. All parts within the component are PPAP qualified and all production intent tools, jigs, fixtures, and processes in place and used throughout. Production intent Quality Control Gate operations are used throughout. Assembly plant process validation is conducted using pilot components.

4 Analytical Phase of ADV Procedures

Analysis tasks are to be completed prior to the design freeze for building pre-prototype level hardware.

The supplier shall document in formal reports the assumptions, models, tools, results, conclusions and recommendations of each analysis. Analysis reports shall be prepared and maintained in a manner similar to the supplier's validation test reports; copies shall be provided and reviewed with the PDT. When an analysis identifies design deficiencies that cannot be promptly resolved by the supplier, the issue(s) shall be documented in an Incident Report (IR) and presented to the product development team for joint resolution. The resulting corrective action(s) shall be documented in the IR, copies shall be provided to GM.

After source selection, a joint Supplier/GM Analysis Development Validation (A/D/V) planning team shall select the analytical tasks to be performed and balance or augment them with physical development and validation tasks as needed. The checklist provided is to be used for selecting the A/D/V tasks. These tasks shall be documented and tracked in the "GP-11 A/D/V plan". The team shall select value added tasks appropriate to the requirements, technology and features of the device and balance resource availability with program timing. Emphasis is to be placed on reducing risk for new or challenging design features, achieving program timing and reducing costs. If CAE Simulations are used, the Saber (U.S.) or Spice (Europe) modeling tool set is preferred to facilitate use of the GM's modeling system and existing models. Use of other circuit modeling programs requires GM's review.

4.1 Nominal Performance Simulation

Purpose:

Performed to verify that the design of the circuit is capable of producing the required output response. Recommended for new, high risk, high accuracy or performance critical circuits.

Procedure:

Use a circuit analysis program to analyze nominal circuit conditions.

Criteria:

Verify that the design of the circuit is capable of producing the required output response at nominal circuit conditions.

4.2 Short/Open Circuit Analysis

Purpose:

Performed to analyze how a circuit or systems response to potentially disruptive shorts to battery/supply voltages, short to ground and open circuit conditions. Also performed to verify ability of components and conductors to survive short/open conditions.

Procedure:

Use a circuit analysis program to perform the Short/Open Circuit Analysis.

Criteria:

Verify ability of components and conductors to survive short/open conditions.

4.3 Electrical Interface Models

Deliverable:

As required the supplier shall provide copies to the buyer of existing electrical interface circuit models or create them for use in vehicle and subsystem modeling. E/E interface models shall represent the device's electrical loading characteristics, equivalent resistance, for typical, worst case and parasitic load conditions for battery, ignition and other inputs/outputs for use in vehicle energy management analysis. When required the models shall be dynamic and be valid over the device's specified voltage and temperature ranges. Interface models shall also include documentation of the model's relative accuracy, limitations and any modeling assumptions.

4.4 Vibrational Flexure Analysis For Circuit Boards

Purpose:

Performed for devices with internal printed circuit boards. Vibration and shock, structural dynamics modal analysis is performed to determine the fundamental frequency of the circuit board and the resulting maximum board displacement. Low resonant frequencies and the resulting high displacement will cause excessive fatigue damage to interconnect wires and junctions.

Procedure:

Quantify the resonant frequency of the circuit board either by formal modal analysis or through the more simple models provided in reference 1 (Steinberg).

Criteria:

The resonant frequency of the circuit board must exceed 150 Hz. And should exceed 250 Hz. Low resonant frequencies represent increasing risk of fatigue failure from increased board displacement.

4.5 Thermal-Cycling Analysis

Purpose:

The differential expansion and contraction rates of circuit board elements result in fatigue stress to the junctions involved (solder and lead wires).

Procedure:

Identify the leaded and leadless components on the circuit board that are "most at risk" from thermally induced fatigue damage. The identification process is as follows:

- Identify the largest surface mounted component on the circuit board
- Identify the components who's Coefficient of Thermal Expansion (CTE) differs the most from the circuit board on which it is attached.

Perform analysis on the corner junctions of the components identified above. These corners, nearest the diagonals of the component, are most affected by the differential CTE of the component and the substrate on which it is attached. Using analytical methods, determine the percent of life consumed for the thermal shock and power temperature cycles required by this specification. This cyclical stress (fatigue) can be modeled with the empirical models detailed in reference 1 (Steinberg), or through Finite Element Analysis for more complex situations.

Criteria:

Modify the components and board geometry until the life consumed is less than the value defined in the table for Design Margin (Table 11).

4.6 Snap Lock Fastener Analysis

Purpose:

The analysis of plastic snap lock features is performed to ensure the following:

- Adequate retention force
- Acceptable ergonomic forces for assembly
- Designed in compliance mechanisms to prevent rattles
- Adequate design margin to ensure that flexing during installation does not exceed the elastic limit of the plastic.

Procedure:

Complete the Snapfit Design Worksheet in *Appendix "A"*. Additional resources to assist in completing this worksheet are: The GM Material and Fastening Center Analysis Guidelines defined in "Fundamental of Snap Fit Design".

Criteria

Use the criteria as noted on the Snapfit Design Worksheet in *Appendix "A"*.

4.7 Crush Test Analysis

Purpose:

Perform a finite element analysis of the case that is used to contain the circuit board to ensure that elbow or foot loads on the case will not cause damage to components on the circuit board.

Procedure:

Use finite element analysis to insure that the requirements for crush test, as defined as a physical test, is met. The intended load must be identified as being stemming from a person's elbow or foot.

4.8 Lead-Free Solder Checklist

The global move to restrict or eliminate the use of lead in consumer products has growing applicability to the automotive industry. Lead-free solders, on the whole, perform slightly better than lead based solders under vibration, thermal fatigue, corrosion and fretting corrosion environments. The lead-free solders also show better electrical and mechanical properties than their lead based counterparts. However, lead-free solder posses additional risks as outlined in the following. The following checklist should be reviewed with the supplier to prevent potential problems:

- Lead-free solders have higher melting points compared to lead-solders such as Sn37/Pb (34^0C. increase in temperature over lead based solder). This leads to electronic components being exposed to higher temperatures during assembly. *Early discussions and reviews with the Supply Chain of component manufacturers must be conducted to prevent temperature related problems.*
- Lead contamination in lead-free solder leads to intermetallic formation and reduction in fatigue life of the joints. Hence, mixing of leaded and lead-free technologies on the same circuit board, or within the same manufacturing environment, must be avoided. This problem is most acute when Bismuth is added to lead-free solder to reduce its melting point. The Bismuth combines with lead and tin to form a ternary phase with a very low melting point of only 96^0C. This low melting point material is formed at attachment points. The addition of Bismuth (Bi) is also discouraged since it is a by-product of the lead mining industry.
- The fundamental nature of lead-free solders (Tin/Silver = Sn/Ag or Tin/Silver/Copper = Sn/Ag/Cu) and the inclusion of Zinc (Zn) or, other additives, lead to increased variation in the material property of the solder. The Weibull slope for "time to failure" of lead-free solder is approximately three. This can be compared to a Weibull slope of six for lead based solders. Hence, a comprehensive Failure Modes Effects Analysis (FMEA) must be performed to identify and address solder-specific failure mechanisms under the rated environmental conditions.

- A detrimental Tin based phenomenon, known as “Tin Whisker Formation”, is most noticeable in lead-free solder. Internally developed stresses from the cooling process can cause whiskers to form without any special environmental condition being imposed. Parts “on the shelf” will develop the whisker formation almost as quickly as parts in service.
- A second Tin based phenomenon, known as “Tin Pest”, is also possible when the Tin is not protected with lead. Wart-like formations on the Tin will begin to appear at cold temperatures and will degrade into a gray powder. This phenomenon is cold temperature driven starting at -13^0C., and reaches a maximum reaction rate at -30^0C.
- Lead-free solder becomes brittle at a temperature of -30^0C, unlike leaded solder. This can be a potential problem in high mechanical shock areas like the door and unsprung mass locations.
- Flux residues from lead-free solder may be more inclined to produce ionic contamination and special attention should be given to frost and humidity testing of lead-free solder.

5 Development/Evaluation Phase Of ADV Procedures

5.1 General

The design validation tests should be reviewed to determine if any of these tests should be run during the development phase.

The development tasks have proven to be beneficial to the development of automotive E/E products. This list is not all-inclusive; the supplier or product team may propose alternative or additional tasks. The procedures can be used to support or confirm the accuracy of the analytical and simulation tasks, or to further new design capability or reliability growth, program risk reduction and/or validate requirements. These tasks may include comparison procedures to select the best materials or components for the design, or to confirm the accuracy of the analysis, or involve obtaining data to refine analysis assumption such as confirming key properties of materials. Development procedures may also be required to fill in gaps where analytical procedures or resources were not available.

The selection of the initial physical development tasks to be performed on devices shall be determined by a joint supplier/GM A/D/V planning team after source selection. The team shall work to create an efficient/lean physical development plan using tasks appropriate to the module’s technology and components. All development tasks cannot be anticipated at the start of a program. Design creation and analysis tasks may reveal issues that will require experimentation for design growth to continue. Therefore, during the program the results of analysis, FMEA and design reviews, etc. shall be used to update the physical development tasks list in the A/D/V plan.

The majority of physical development tasks are to be performed on pre-prototype hardware. High-risk issues may require earlier developmental evaluations performed at the component or functional mock-up circuit level. As the design develops or changes, analytical tasks may need to be repeated on later hardware levels to assess the impact of the changes. Similarly, development assessments capable of fully verifying requirement compliance need not be repeated in later hardware stages provided the related design features have not been fundamentally changed or affected by other changes. The selected tasks and their timing shall be documented and tracked in the program’s A/D/V plan.

5.2 Circuit Performance At Room Temperature

Purpose:

Pre-prototype hardware shall be used to optimize the internal and external circuit electrical performance and to demonstrate and document compliance of the design to electrical and interface requirements. The number of device samples to be evaluated shall be determined by the supplier. These early electrical assessments are first meant to verify design capability or identify discrepancies of the device without the effects of manufacturing variation. For new or high risk circuits the supplier shall perform early developmental assessment on hand built or breadboard level circuit sub sections prior to the design freeze date for pre-prototype level circuit boards.

Procedure:

The evaluations shall be performed under laboratory test bench conditions at room temperature with the devices connected to actual or simulated vehicle interfaces and loads. The supplier shall use appropriate calibrated instrumentation (such as multi-meters, oscilloscopes and data recording devices) as needed to measure/verify the performance of the device's circuits. Key circuit performance parameters shall be measured with the supply voltage set at low, nominal and high operating conditions (unless specified otherwise in the CTS) and compared to the requirements and any circuit analysis/simulation results. The ability to vary interfaces from minimum to maximum loading conditions is desirable but not always achievable or appropriate for physical testing, therefore interface test load conditions (minimum, nominal, maximum, or variable) if not defined by the electrical portion of the CTS shall be defined by the GM release engineer working with the supplier's circuit designer to identify the critical conditions and parameters to be measured.

Criteria:

Any circuit whose measurements deviate from their expected or analytical predictions or cases of inadequate or marginal performance shall be investigated and resolved. Since this evaluation is performed on a small sample size to confirm basic performance capability this procedure alone cannot be used to fully validate conformance to requirements over manufacturing variation tolerance stack up conditions. Validation for variation factors can be achieved by using the results of this procedure in combination with either the E/E Parameter Tolerance Sensitivity Analysis requirements of section or by repeating this procedure during product validation on a statistically significant sample size from a build lot off of production tooling.

5.3 Over/Under Voltage, Jump Start And Reverse Voltage Evaluation

Purpose:

At least one pre-prototype unit shall be used to evaluate/verify that over voltage and reverse protection features correctly function and prevent damage to the device.

Procedure:

This evaluation shall be performed under lab test bench conditions. The appropriate calibrated instruments to measure and verify the performance of the device's circuits shall be used. The short circuit procedure shall only be applied to the circuits (includes components, internal wiring, circuit traces, etc.) specified as needing protection against these conditions. Actual or simulated interfaces and loads that duplicate the vehicle's interface and fusing/protection conditions as per the component technical specification shall be used.

Criteria:

Apply the same criteria as Jump Start and Reverse Polarity and Over-Voltage Test Criteria

5.4 Short Circuit Evaluation

Purpose:

At least one pre-prototype unit shall be used to evaluate/verify that short circuit, protection features correctly function and prevent damage to the device.

Procedure:

This evaluation shall be performed under lab test bench conditions. The appropriate calibrated instruments to measure/verify the performance of the device's circuits shall be used. The short circuit procedure shall only be applied to the circuits (includes components, internal wiring, circuit traces, etc.) specified as needing protection against these conditions.

Actual or simulated interfaces and loads that duplicate the vehicle's interface and fusing/protection conditions as per the component technical specification shall be used.

Note: If the short circuit conditions are to be current limited to match circuit protection/fusing limits it is desired that actual fuses or circuit breakers be use instead of a current limited power supply. If a current limited supply must be used, it is required that the current limit be set to the trip current of the protective device as per the time-current curve of the device. The devices listed UL (Underwriters Laboratory) current rating (which is the current value the device can be loaded to under UL test conditions without tripping) is not to be used as the limit current for short circuit testing. Because actual trip currents are typically 135 % of rated current for fast blow devices, and may be as high as 200 % of rated current for slow blow devices. Thus testing at only the UL rating will not load the device to full field current stress conditions.

Note: This procedure, which evaluates the operation of short circuit protective features, will not by itself evaluate durability under continuous or repetitive short conditions or measure the stress thermal or electrical stress level experienced during shorting conditions.

Criteria:

Apply the same criteria as is used in the short circuit tests.

5.5 Electromagnetic Compatibility (EMC) Development

Pre-prototype hardware shall be used to evaluate the capability of the device to meet the requirements of GMW3097 and GMW3091.

5.6 Module Groundpath Inductance Sensitivity Test

Purpose: Quantify potential problems that result from the natural inductance developed in the length and routing of the ground wire system. Inductance can prevent proper programming of flash memory in the vehicle. This phenomenon may not be observed in a bench test unless the inductance consideration is included.

Procedure: Place a 5 micro-henry inductor in the groundpath of a bench test to evaluate the proper function of flash memory programming.

Criteria: Programming should occur properly with the inductance in place.

5.7 Free Fall Endurance Development

Purpose:

At least one pre-prototype unit shall be used to evaluate/verify that the device will meet the free fall requirements.

5.8 HALT – Highly Accelerated Life Test For Design Margin Evaluation

Purpose

A "HALT"[2] test exercises the DUT's failure mechanisms by utilizing all-axis-vibration and rapid temperature change to detect latent weaknesses by applying stress levels beyond normal specifications. This process will also allows for the detection of weaknesses in software performance as component parameters change from temperature and stress. The stresses induced by vibration and temperature change can be exercised independently, or at the same time, within this unique test chamber. This is a Qualitative test, and uses a step stress approach to differentiate between strengths and weaknesses. The product must be constantly monitored during this test. Constant monitoring proves essential as intermittent failures are often produced under unique combinations of vibration and temperature. Design and process problems will be quickly revealed with this test, which usually takes 1-2 days.

Procedure:

General Motors requires the supplier to perform at least one HALT test on pre-prototype level assemblies during Development. The earlier the better, provided the design level could be adequately trusted to warrant design improvement. Additional HALT tests will be required to confirm all improvements if new weaknesses are continuously uncovered. A HALT test plan must be established prior to the actual test and must be reviewed with appropriate GM engineers. The engineers from General Motors and the supplier are expected to jointly participate in the test process.

The complete HALT process is explained in detail in GMW8287.

Criteria:

The HALT test is not a pass or fail test but rather a qualitative "quickly learning method" to identify product weaknesses or operating limits from vibration and temperature. The extreme levels of stressed applied in this test will evaluate design margin for hardware and will bring forth errors in software-hardware interaction as component values change with temperature and stress. Software-hardware interaction problems at temperature extremes are expected to be resolved. Professional level hardware failure analysis is expected. Resolution of product improvement will be arrived at jointly through a design review with General Motors. The data required for determining this resolution is:

- Identification of all operating limits and design margins
- Complete understanding of all hardware and software failures.
- Identification of how the design margins could be improved.
- Identification of the barriers to increasing the design margins.
- "Return on Investment" justification for limiting the increase in design margins when stopped short of the limit of the technology.

5.9 Highly Accelerated Humidity Test

The effect of Humidity results in a mixture of failure mechanisms that are intrinsic to automotive use. HAST is a highly accelerated humidity diffusion test that can only operate above 106^0C. This test is intended for electronic circuit boards and electronic components. This test is not intended for plastic-electronic assemblies because the temperature in this test exceeds the service temperature for most common plastics.

Purpose:

HAST[5,6] (Highly Accelerated Stress Testing) employs increased temperature and pressure to elevate the vapor pressure of a non-condensing high humidity environment. This high stress environment will accelerate the effects humidity and temperature according to the Arrhenius-Peck relationship as shown below. The acceleration factor for this type of test is approximately:

- 1 day of HAST is equivalent to 21 days of 85^0/85%
- 1 day of HAST is equivalent to 97 days of 65^0/85%
- 1 day of HAST is equivalent to 1414 days of 35^0/85%

Ten years of the effect of humidity for the ingress of water vapor into components and circuit boards can be accomplish in approximately two days of HAST testing at 130^0C and 90+% R.H.

Procedure:

Conduct HAST per EIA/JEDEC Standard JESD22-A110-B with the following exception: The test duration should be 48 hours at 130^0C. The use of the Arrhenius-Peck[5] stress-life math model suggests that this is equivalent in damage to 4656 hours of 65^0C at 85% R.H., or 194 days of constant humidity testing, as defined in this document. Equally damaging tests of "lower-temperature-longer-durations" are permitted through use of the Arrhenius-Peck relationship as noted below:

Figure 20 Arrhenius-Peck Accelerated Temperature and Humidity Equation

$$Accel\ factor = Exp\left(\frac{E_A}{k} \times \left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right) \times \left(\frac{Humidity_{low}}{Humidity_{high}}\right)^{-2.66}$$

Where:

k = Boltzmann Constant = (1.380 658 ± 0.000 012) x 10^{-23} J/K or **k = (8.6173 X 10^{-5} eV·K)$^{-1}$**

E_a = Average Conservative Activation Energy = 1.28 x 10^{-19} J **E_a= (0.8 eV)**

T_2 = Higher Temperature (on test)

T_1 = Lower Temperature (ambient)

Temperature is in Degrees Kelvin (Celsius plus 273) and humidity is in "% RH"

Criteria:

The DUT shall not exhibit unacceptable levels of current rise during the 48 hour test and should function properly following cool-down after the HAST test. Test results must be reviewed with General Motors.

5.10 Thermal Performance Thermocouple Method

The appropriate evaluations may be performed, if required, on at least one pre-prototype. Optimization/ corrective actions investigations shall be performed when measurements greatly deviate from any analytical predictions or in cases where required performance or the acceptance criteria is not achieved or is marginal.

5.11 Thermal Performance Alternative (Infrared Thermography)

These methods may be used to enhance or replace the thermocouple methods. This method may also be used to locate and visualize hot spots during short circuit conditions.

Purpose:

Infrared Thermography is used to locate and visualize the DUT hot spots.

Procedure:

Perform the evaluation per the procedure in GMW8288.

Criteria:

Modify the design, if necessary, per the guidelines in GMW8288.

6 Design Validation

6.1 Scope Of Design Validation

This standard describes environmental, durability and capability tests for E/E equipment for passenger vehicles and light duty trucks. The standard describes common test procedures, based on mounting location, for E/E devices. The Electro-Magnetic Compatibility Tests are in a separate document.

In current and future vehicle concepts, E/E devices are mounted in almost any vehicle location. Also, each location has a distinct set of environmental loads.

As examples:

- The underhood temperature range is greater than the passenger compartment.

- The on-engine vibration profile is both sinusoidal and random. Other vehicle locations only utilize a random vibration profile.
- E/E devices installed in doors and hatches are subject to a high number of mechanical shocks.

It is desirable for the vehicle manufacturer to group the different environmental load types and levels into a reasonable number of standardized requirement sets. This strategy makes it possible to carry over E/E devices without retest.

The concept of this section is to define requirement classes for each type of load: **electrical, mechanical, thermal, climatic and chemical**. For each load type several requirement classes are defined. A specific code letter determines every requirement class. Defining the code letter combination creates the complete environmental requirement set. The environmental code letters are defined in the respective sections of the document. Additionally *table 1* defines the code letters for typical mounting locations. For normal applications these code letters shall be used. If an application is very specific, such that the given code letter combination cannot be used, it is possible to create new code letter combinations to serve this Purpose In the case that none of the given code letters are sufficient, new levels can be created by using the code letter Z. In this case the specific requirements need to be defined separately but it is desirable not to change the test methods.

These procedures are optimized for testing complete E/E devices. They are not optimized, and sometimes not appropriate, for validation of the E/E device's internal components and materials as suitable for a specific application. The device supplier is responsible for definition and validation of internal component requirements that incorporate the application specific performance, usage, and environmental durability needs.

These procedures do not include all requirements for evaluation and validation of the system that the device is incorporated in. For example, the electromagnetic compatibility and connector requirements are defined in other documents.

The supplier is required to support and participate in subsystem or vehicle level test and validation tasks as specified in the Statement of Requirements (SOR), CTS, or by GM Engineering.

6.2 Design Validation Section Mission

The Design Validation Section of this standard is intended to document all generic environmental and durability tests for automotive E/E devices. Specific tests, unique to the device technology (i.e. relays, solenoids, motors, etc.), are not addressed in this document. The intent is that a family of documents, containing unique tests and test flows for the device technology, will be created.

6.3 Test Plan Development

The test flows shown in this document represent the cumulative experience and knowledge gained from many products over many years. The strategy underlying this series-parallel flow is based on the concepts of "physics of failure" with correlation to field usage. The correlation to field usage is established from many years of data collected by The General Motors Product Usage and Measurement Group.

6.3.1 Supplier Responsibilities

The supplier shall create a test sequence and submit it to GM for approval. The sequence is to simulate one life of usage through a combination of thermal cycling, functional cycling, and environmental and mechanical exposures. The intent is to exercise all of the failure mechanisms. The plan shall demonstrate the reliability requirement, which is specified in the technical specification.

Sample Size:

A minimum of three samples shall be used for each test. The DUT can be used for more than one test. For reliability demonstration the appropriate sample size shall be used.

Reliability Demonstration:

The reliability requirement of the CTS must be demonstrated for the wear out failure mechanisms as well as the usage cycles. For an electronic module wear out will be due to thermal- and vibration-induced fatigue. The DUT typically is exercised for the required number of 1-life electrical operational cycles during the Power–Temperature-Cycling (PTC) test. When there is inadequate time during PTC to exercise all of the usage cycles, the usage cycles may also be accumulated during the High Temperature Durability, Vibration, and Humidity Test. Additional testing for wear or fatigue of mechanical portions of the product is not covered by this specification and should be addressed elsewhere in the CTS.

Success Based Plan:

For electronics the validation test procedure is typically success oriented. The test flow and sample size are set up to demonstrate the reliability requirements without failure on test. If a DUT doesn't meet the established criteria, GM Engineering will decide if the entire test sequence, or a portion of it, will be repeated to satisfy the validation requirement.

Test to Failure Plan:

This document uses test-to-failure to quantify reliability for vibration. A detailed explanation is provided in Appendix "B".

6.3.2 Guidelines for Power Temperature Cycling and Thermal Shock Tests

This section is used to determine the duration of power temperature cycle (PTC) test and the thermal shock (TS) test. To optimize the total test time, a trade off between these tests is also illustrated. The duration of these tests is based on the service life of the E/E device and the number of samples that are available for testing. The service life is first converted to the test life. The appropriate sample size to demonstrate the required reliability at the required confidence is chosen. If the sample size is too high, increasing the number of lives to be tested can reduce it. A reduction in the test time can be achieved by trading off power temperature cycles for thermal shock cycles while maintaining the minimum cycle count for each of the tests. The following steps illustrate the process.

Step 1: Conversion of one service life to one test life

Service Life: The life of the E/E device is assumed to be 7300 thermal cycles with a service temperature change of 50 °C for passenger compartment, 70 °C for underhood, and 100 °C for on-engine applications. The 7300 cycles for one life is based on two cold starts per day for ten years (10 x 365 x 2) and applies to inside as well as outside the passenger compartment.

The number of power temperature test cycles is derived from the following equation.

Where:

$N_{PTC\ (1\ life)}$ = The number of test power temperature cycles that represents one service life.

$\Delta T_{service}$ = The service (or field) temperature change in °C.

ΔT_{test} = The test temperature change = $T_{max} - T_{min}$ in °C.

m = Exponent for the field failure mechanism. 2.5 for solder fatigue.

Figure 21 Equation For Accelerated PTC Test

$$N_{PTC(Life)} = 7300 \times \left(\frac{\Delta T_{service}}{\Delta T_{Test}} \right)^m$$

Values for "m" the Coffin-Manson Exponent

Table 13 Coffin-Manson Exponent Values

Material	m
316 Stainless steel	1.5
316 SS WaspAlloy, 4340 steel	1.75
Solder (97Pb/3Sn) Crossing 30^0C	1.9
Solder (37Pb/63Sn) Cross 30^0C	2.27
Solder (37Pb/63Sn) if T < 30^0C	1.2
Solder (37Pb/63Sn) if T > 30^0C	2.7
Lead-Free Solder (97Sn/3 Ag & 91 Sn/9 Zn)	**2.4**
Cu and Lead frame alloy (TAB)	2.7
Al wire bond	3.5
Au4Al fracture in wire bonds	4
PQFP Delamination /Bond failure	4.2
ASTM 2024 aluminum alloy	4.2
Copper	5
Au wire Downbond heel crack	5.1
ASTM 6061 Aluminum alloy	6.7
Alumina fracture-bubble memory	5.5
Inter layer Dielectric cracking	5.5+/-0.7
Silicon fracture	5.5
Si fracture (cratering)	7.1
Thin Film cracking	8.4

Table 14 Number Of Power Temperature Cycles For Sample Size Of 23

E/E Device Location	$\Delta T_{service}$	ΔT_{test}	$N_{PTC\ (1\ life)}$
Passenger Compartment or unheated exterior area	50	125	**739** (with 23 samples)
Underhood Compartment	70	145	**1182** (with 23 samples)
On-Engine	100	165	**2087** (with 23 samples)

Step 2: Sample size reduction

For example, if it is required to demonstrate a test reliability of at least 97 % with 50 % statistical confidence, then twenty-three (23) samples, completing the test without any failures, are required. If there is a desire to reduce the sample size for the thermal induced fatigue test reliability demonstration, it can be achieved by testing for more than one life. The multiplier for the increase in number of lives can be derived from the following equation.

Figure 22 Equation For Multiple Life Testing[3]

$$L = \left(\frac{\ln(1-C)}{n \times \ln(R)} \right)^{\frac{1}{\beta}}$$

Where:

R = Required reliability to be demonstrated

C= Confidence level

n= Reduced number of samples to be tested on the life test

L= Number of lives to be tested = $N_{Test}/N_{PTC\ (1life)}$

β = Weibull slope (suggested value: between 2 and 3)

For the example test sequences in the beginning of this document, the suggested number of samples for the thermal shock and power temperature cycling tests is 15. To achieve the above-mentioned reliability and confidence levels for 15 samples, with an assumed β value of 2.5 one has to test to 1.18 lives.

$$L = \left(\frac{\ln(1-.5)}{15 \times \ln(.97)} \right)^{\frac{1}{2.5}} = 1.18$$

$$N_{test} = L \times N_{ptc(1life)} = 1.18 \times N_{ptc(1life)}$$

Table 15: Number Of Power Temperature Cycles For Sample Size Of 15

E/E Device Location	Number of PTC for test with 15 samples N_{Test}
Passenger Compartment or unheated underbody areas	**873** (with 15 samples)
Underhood Compartment	**1396** (with 15 samples)
On-Engine	**2465** (with 15 samples)

Step 3: Determining Cycle Count For PTC And Thermal Shock By Trade Off

The number of cycles of PTC testing can be reduced by substituting thermal shock to generate much of the thermal fatigue (within the same temperature limits). Each thermal shock test cycle is twice as damaging as a power temperature test cycle. The above relationship was derived using analytical tools to measure thermal fatigue of solder joints that is the predominant failure mechanism observed during these tests. The Norris-Landzberg Equation provides this relationship and provides a value of approximately (2) for most automotive situations.

Figure 23 Norris-Landzberg Equation For Accelerated Thermal Ramp Rates

$$Acceleration\ Factor = \left(\frac{\Delta T\ rate_{high}}{\Delta T\ rate_{low}} \right)^{\frac{1}{3}}$$

Using the previous symbols and definitions the tradeoff equation is:

Figure 24 Approximate Relationship Between Thermal Shock and PTC

$$N_{test} = N_{ptc\ test} + \left(2 \times N_{ts\ test}\right)$$

Where:

$N_{PTC\ test}$ = Number of test cycles of power temperature cycling.

$N_{TS\ test}$ = Number of test cycles of thermal shock.

The number of power temperature cycles and the thermal shock cycles can be varied while exceeding the minimum number of cycles to be tested. This trade off can be made if the power temperature cycling test and the thermal shock test are done sequentially. It is required that the power temperature test be done after thermal shock test. Thermal shock will precipitate potential problems and the power-temperature-cycling will further precipitate and detect the problem.

Table 16 PTC And Thermal Shock By Location

Note: The table shows the values for testing necessary with two levels of sample size, 15 and 23. Within each level of sample size two extremes for combining PTC and Thermal Shock are shown. Two hundred PTC cycles is the preferred mix and no fewer than 50 PTC cycles should be used in any test plan.

Temp Code	Temperature Difference		#-PTC-Test	Cycle Time – min		Sample Size n	PTC Cycles Needed with sample size	Number of Cycles		Test Time
	Service	Test		Thermal Shock	Power Temp			Thermal Shock	Power Temp	Days
Interior or Exterior										
A (-40…+70) °C	50	110	1017	30	90	15	1201	500	200	23
	50	110	1017	30	90	15	1201	575	50	15
	50	110	1017	30	90	23	1017	406	200	21
	50	110	1017	30	90	23	1017	481	50	13
C (-40…+85) °C	50	125	739	30	90	15	872	336	200	20
	50	125	739	30	90	15	872	411	50	12
	50	125	739	30	90	23	739	267	200	18
	50	125	739	30	90	23	739	342	50	11
E (-40…+105) °C	50	145	510	30	90	15	602	201	200	17
	50	145	510	30	90	15	602	276	50	9
	50	145	510	30	90	23	510	154	200	16
	50	145	510	30	90	23	510	229	50	8
Underhood										
E (-40…+105) °C	70	145	1182	30	90	15	1396	598	200	25
	70	145	1182	30	90	15	1396	673	50	17
	70	145	1182	30	90	23	1182	488	200	23
	70	145	1182	30	90	23	1182	563	50	15
Engine Mounted										
H (-40…+125) °C	100	165	2087	30	90	15	2466	1133	200	36
	100	165	2087	30	90	15	2466	1208	50	29
	100	165	2087	30	90	23	2087	939	200	32
	100	165	2087	30	90	23	2087	1014	50	25

6.3.3 Guidelines for Vibration Tests

This section is used to determine the sample size for the vibration tests *if a success-run plan is chosen instead of the preferred test-to-failure method explained in Appendix "B"*.

$$Test\ Hours_{reduced\ sample\ size} = Test\ Hours_{normal\ sample\ size} \times \left(\frac{\ln(1-C)}{n_{reduced} \times \ln(R)} \right)^{\frac{1}{\beta}}$$

Figure 25 Success-Run Equation[3]

$$R = (1-C)^{\frac{1}{n}}$$

Figure 26 Sample Size From Success-Run Equation

$$n = \left(\frac{\ln(1-C)}{\ln(R)} \right)$$

Where:

R = the required reliability to be demonstrated on test.

C = the Confidence level.

N = the sample size.

$N_{reduced}$ = the new reduced sample size

For example:

If R = 0.97 and C = 0.50, then n = 23.

If the testing of 23 samples is not desirable due to program timing or the supplier's facilities then the sample size can be reduced if the test duration is increased.

The Test Acceleration Factor (TAF) for a reduced sample size is:

$$TAF_{ss} = \left(\frac{\ln(1-C)}{n_{reduced} \times \ln(R)} \right)^{\frac{1}{\beta}}$$

The reduced sample size will increase the test duration, and then one can increase the "energy level" of the test, *through higher Grms values, to reduce the test time back to a desired duration.*

For R = 0.97, C = 0.5, assumed Weibull slope of 2.5, and n = 12 (Two sets of six samples before and after temperature cycling) and the standard test time of 8 hours along each of the 3 each axis:

$$Hours_{new} = Hours_{old} \times \left(\frac{\ln(1-.5)}{n_{new} \times \ln(.97)} \right)^{\frac{1}{2.5}}$$

$$Hours_{new} = 8 \times \left(\frac{\ln(1-.5)}{12 \times \ln(.97)} \right)^{\frac{1}{2.5}} = 10.33$$

Thus, a reduction in sample size from 23 to 12 results in an increase in test time from 8 hours to 10.33 hours while the stress level (Grms) remains the same. Now one can reduce the test time back to 8 hours, or even less if we choose, with a necessary increase in energy level (Grms).

The following example (sprung mass for a car vibration profile) uses the Accelerated Vibration Testing Equation to allow a reduction in test time through an increase in vibration energy level:

Figure 27 Equation For Accelerated Vibration Testing

$$\left(\frac{G_{accelerated}}{G_{normal}} \right)^m = \left(\frac{Test\ Time_{normal}}{Test\ Time_{accelerated}} \right) = TAF$$

Where:

G_{normal}= The normal loading (Car example: 2.84 Grms)

$G_{accelerated}$= The accelerated test loading

m = Material Fatigue Constant, (**6.4** for aluminum leads[1] in electronic assemblies, **5** for an overall usage value[10], **4** for general metal fatigue, or connector fretting[1] problems per Steinberg[1]). The supplier is responsible for documenting the source of the material fatigue factor used for the DUT.

$$Grms_{accelerated} = Grms_{normal} \times \left[\sqrt[m]{\frac{Test\ Time\ Normal}{Test\ Time\ Accelerated}} \right]$$

$$Grms_{accelerated} = 2.84 \times \left[6.4\sqrt{\frac{10.33}{8}} \right] = 2.96$$

The results of this car example show the following:

- 23 parts need from Success-Run Equation.
- 12 parts will be used with a resulting increase in test time from 8 hours to 10.33 hours.
- Test time reduced back to 8 hours with a resulting increase in Grms on test from 2.84 Grms to 2.96 Grms.

The Power Spectral Density values can be proportionately adjusted upward to generate the desired accelerated Grms value by using the Adjustment Factor defined in the following equation:

Figure 28 Adjustment Factor For Scaling PSD To Grms

$$\left(\frac{Grms\ accelerated}{Grms\ normal} \right)^2 = Adjustment\ Factor$$

This Adjustment Factor is multiplied times each frequency set point level to establish a new overall energy level increase to match the new required Grms value of (2.96).

The constraint to proportionally increasing Grms is the maximum displacement possible with an electro-dynamic shaker. Most electro-dynamic shakers can produce a maximum peak-to-peak displacement of one inch. A safety factor of reduction from this value should be used to prevent damage to the shaker device.

The peak-to-peak displacement of an electro-dynamic shaker is calculated with the following equation using the lowest frequency of the required spectrum:

Figure 29 Maximum Shaker Displacement

$$D = 42.8 \times \sqrt{G^2 / Hz. \Big/ f_{lowest}^{\ 3}}$$

6.3.4 Guidelines For High Temperature Durability Tests

Running the test at a temperature higher than T_{max} can reduce the test time of 500 h or 2000 h for the high temperature durability test. The test acceleration factor, TAF, can be determined from the Arrhenius relationship.

Figure 30 Arrhenius Equation For Accelerated Temperature Testing

$$TAF = \exp\left(\left(\frac{1}{k} \right) \times E_a \left(\frac{1}{273 + T_{max}} - \frac{1}{273 + T_{test}} \right) \right)$$

Where:

k = Boltzmann Constant = (1.380 658 ± 0.000 012) x 10^{-23} J/K

E_a = Average Conservative Activation Energy = 1.28 x 10^{-19} J = 0.8 eV

Example:

For T_{max} = +85°C, T_{test} = +105°C and a test time of 500 h

$$TAF = \exp\left(\left(\frac{1.28x10^{-19}}{1.38x10^{-23}} \right) \times \left(\frac{1}{273+85} - \frac{1}{273+105} \right) \right) = 3.94$$

$$500 \big/ 3.94 = 127\ hours$$

The test time can be reduced from 500 h to 127 h if the temperature is increased from +85°C to +105°C. If this method is used, the supplier is responsible for documenting the source of the activation energy.

6.4 Vehicle Electrical Transient Tests

6.4.1 Parasitic Current Measurement

Purpose:

All of the functions that consume energy from the battery while the vehicle is in an ignition off state must be known and approved. Parasitic current is defined as the current drawn by electrical devices when the vehicle ignition switch is in the OFF position and all electrical accessories are turned OFF. This test defines the measuring method and the maximum acceptable level for the average parasitic current of an electronic component.

Effect On Performance:

Possible vehicle battery drain due to excessive parasitic current.

Procedure:

Monitor the current in all of the DUT supply lines and choose an appropriate current measuring device. The current measuring device must have a sampling frequency that is ten times higher than the smallest current peak the module creates, and the highest value of the peak generated by the DUT must be within the capability of the measuring device. The DUT should be equipped as installed in the vehicle. All inputs, outputs, and sensors are to be electrically connected and in their normal inactive state.

1. Connect the DUT to a variable power supply and adjust the input voltage to (12.6 ± .1) volts. The system should be at a temperature of 25^0C.
2. Place the system into OFF mode.
3. Measure the current in the system over a time frame for a period that is ten times longer than the longest expected periodic repeated event of the module. Certain modules may experience periodic or occasional wakeups when OFF (OFF-Awake). The current when in OFF-Asleep and under all OFF-Awake conditions should be recorded. This data will be used to calculate the average parasitic current experienced over a 40-day period.
4. While measuring the current, decrease the supply voltage by 1 volt/minute until zero volts are reached. The criteria must be met throughout the decreasing voltage process.
5. The test should be repeated for the various methods in which the DUT can enter the OFF-Asleep state.

Criteria:

The average parasitic current should be calculated as the average current flow over a 40-day period. The maximum allowable average parasitic current shall be 0.250 mA if not provided in the CTS.

Additionally, after the key is turned to the OFF position, a module may still continue to operate for some time period when used in a GMLAN environment. For example, if the ECU is part of a Virtual Network such as Lighting, the Virtual Network may stay alive, and in turn keep the ECU alive, to support keeping the interior lights illuminated for some time period. Average parasitic current calculations should include this added load.

The test report must include the following information: a) Parasitic current draw when in OFF-Asleep, b) Parasitic current draw under all OFF-Awake conditions and their time period, c) Calculated average parasitic current draw over 40 days, and d) Parasitic current over the voltage range from 12.6 down to 0 volts.

Example Average Parasitic Current Calculation:

An ECU is turned OFF and follows the schedule shown below. Assume for this example that the ECU is not part of any Virtual Network that remains active after the key is switched to the OFF position.

6. One hour after the OFF power mode the ECU is powered for 1 minute.
7. 24 hours after the OFF power mode the ECU is powered for 1 minute.
8. 5 days after the OFF power mode the ECU is powered for 1 minute.
9. 2 weeks after the OFF power mode the ECU is powered for 1 minute.
10. 4 weeks after the OFF power mode the ECU is powered for 1 minute.
11. 6 weeks after the OFF power mode the ECU is powered for 1 minute.

During the time the module is on it draws 350 mA. When off the module draws 0.200 mA. Both current ratings apply at 25^0C and 12.6 volts. The answer sought in this example is: “What is the net parasitic current draw over the 40-day period?”

Answer: Parasitic current = (current when on* duty cycle) + (current when off * (1-duty cycle))

First, 6 weeks is equal to 42 days, so this current level is not used in estimating the average parasitic current. There are five, 1-minute intervals (1-5 above) when the ECU is powered in the 40 day interval and therefore (57,600 – 5) minutes when it isn’t. (40 days = 57,600 minutes) Thus, the average parasitic current is:

= (350 mA * (5/57600)) + (0.200 mA * (57600-5)/57600)
= 0.230 mA.

6.4.2 Jump Start And Reversed Polarity Test

Purpose:

This test specifies the procedure for testing the immunity of E/E devices to positive over-voltage and reverse polarity voltage on the power inputs of the device.

Effect On Performance:

This test evaluates possible damage to the device from jump-starting (momentary excessive voltage) and reversed voltage.

Procedure:

Operating Type 2.1 and 3.1 following:

Functional Status Classification = C.

This test requires a DC power supply with the following requirements:

The continuous supply source shall have an internal resistance less than 0.01 Ω DC. The output voltage shall not deviate more than 1 V from 0 to maximum load (including inrush current) and shall recover 63 % of its maximum excursion within 100 µs. The super-imposed ripple voltage shall not exceed 0.2 V peak-to-peak and have a minimum frequency of 400 Hz.

If a standard power supply (with sufficient current capacity) is used to simulate the battery, it is important that the low internal impedance of the battery is also simulated. When a battery is used, a charging source may be needed to achieve the specified reference levels.

The test setup of the DUT shall represent the actual setup and function of the E/E device in the vehicle. Fuses of the type and rating anticipated for vehicle use should be included in the test setup. Fusible links shall not be used. If a fuse type and rating is not specified, the 20 A fuse will be used. The value of any fuse used in the test setup shall be indicated in the test report. Unless otherwise specified, the interconnection cable between the power supply and the DUT injection point shall not exceed two meters in length and shall be 4.0 mm^2 or larger.

- Perform a Functional/Parametric Test prior to application of each over and reverse voltage event.
- Connect the power supply to the battery inputs of the DUT and all loads that have battery inputs.
- Turn on the power supply and subject the DUT to the required test voltage for the required test time.
- Turn off the power supply.
- Connect the power supply to the battery inputs and the switched battery inputs of the DUT and all associated loads (if the DUT contains On/Off switches, the switches shall be placed in the On position).
- Turn on the power supply and subject the DUT to the required test voltage for the required test time and perform a Functional/Parametric Test.

Criteria:

The DUT shall comply with the following requirements:

Test Voltage (V)	Test Time (min)
+26 ± 0.5	1
-13.5 +1/-0.5	2

No damage to the system or DUT is allowed. A blown fuse shall be considered a deviation unless otherwise stated in the CTS. All functions needed to start the engine must be available at +26 volts, if not stated differently in the CTS.

Note: This test is not applicable to alternators or devices that have an exemption stated in the CTS.

6.4.3 Over-Voltage

Purpose:

The over-voltage test addresses two conditions: the ability of the Vehicle Alarm Systems (VAS) to resist the intentional application of over-voltage on the power inputs with the intent to disable the system, and the ability of the device to withstand the effects of high rate battery charging with over-voltage.

Effect on Performance

This test evaluates possible damage to the E/E device with the application of excessive voltage.

Procedure:

Operating Type 3.2.

Functional Status Classification = C

This test requires a DC power supply with the following requirements:

The continuous supply source shall have an internal resistance less than 0.01 Ω DC and an internal impedance for frequencies less than 400 Hz. The output voltage shall not deviate more than 1 V from 0 to maximum load (including inrush current) and shall recover 63 % of its maximum excursion within 100 µs. The super-imposed ripple voltage shall not exceed 0.2 V peak-to-peak and have a minimum frequency of 400 Hz.

If a standard power supply (with sufficient current capacity) is used to simulate the battery, it is important that the low internal impedance of the battery is also simulated. When a battery is used, a charging source may be needed to achieve the specified reference levels.

The test setup of the DUT shall represent the actual setup and function of the device in the vehicle. Fuses of the type and rating anticipated for vehicle use shall be included in the test setup. Fusible links shall not be used. If a fuse type and rating is not specified, the 20A fuse shall be used. The value of any fuse used in the test setup shall be indicated in the test report. Unless otherwise specified, the interconnection cable between the power supply and the DUT injection point shall not exceed two meters in length and shall be 4.0 mm^2 or larger.

- Perform a Functional/Parametric Test prior to application of each over-voltage event.
- Connect the power supply to the battery inputs of the DUT and all loads that have battery inputs.
- Turn on the power supply and subject the DUT to the required test voltage for the required test time as noted in the following table. Note that the type and range of voltage used in the test depends whether over voltage protection is provided
- The E/E-device shall withstand, without damage, system voltages within the High Voltage Range +16 to +18 V for at least one hour with FSC = **C** (Electrical load code letter D states continuous operation and FSC = A).
- An E/E-device that has an automatic hardware driven switch off function for supply sections or MOSFET gate drivers in the +16 to +18 V range shall be tested with slow (1 volt per minute) variations of the supply voltage around the designed switch off point. The reason for this test is to avoid problems caused by running switch transistors in analog range mode with switch losses in a catastrophic state.
- Turn off the power supply.
- Connect the power supply to the battery inputs and the switched battery inputs of the DUT and all associated loads.
- Turn on the power supply and subject the DUT to the required normal test voltage (14 volts) for the required test time and perform a Functional/Parametric Test.

Note: VAS testing shall be performed in both set and unset modes.

- *Set* means the state of the system in which an alarm condition can be transmitted to warning devices.
- *Unset* means the state of the system in which an alarm condition cannot be transmitted to warning devices.

Criteria:

The DUT shall operate without any failure under the following conditions:

Test Voltage (V)	Test Time (min)
Sweep between +16 to 18 ± 0.2 at 1 volt per minute for devices that are over voltage protected	60 minutes
Provide a constant 18 volts when no over voltage protection is provided	60 minutes

A blown fuse will be considered a deviation unless otherwise stated in the CTS.

6.4.4 Power/Ground Test

Purpose:

Determine if the device is able to suffer no damage due to incomplete power/ground connections and to determine if the part functions properly immediately after the completion of the power/ground connections.

This test shall also determine if the device functions properly when subjected to power offsets of ± 1.0 V, ground offsets of ± 0.8 V between platform modules, ± 1.0 V between platform modules and the powertrain or as specified in the CTS.

Communication devices, Class 2, and CAN (Single and Dual Wire) shall meet the requirements defined in “NAO Corporate Class 2 Functional Communications Specification” and GMW3098, “GM Local Area Network System Requirements for Serial Data Communication in GM Vehicles”, respectively.

Effect on Performance:

Possible sensor misreads, communication errors and/or missed messages.

Procedure:

Power/Ground Connection.

Operating Type 3.1.

Perform all possible combinations of the following power/ground connections and determine if the DUT immediately returns to normal operation after all connections have been completed.

- With all inputs/outputs connected to vehicle loads, apply power (battery [B+] or switched ignition [e.g. ignition, switched ignition, accessory ignition, and run1] with each/all ground(s) disconnected.

- Reconnect the ground(s) and perform a Functional/Parametric Test.

- With all inputs/outputs connected to vehicle loads, apply ground with each/all power feed(s) (battery and switched ignition) disconnected.
  - Reconnect the power feed(s) and perform a Functional/Parametric Test.

Ground Offset Test:

Operating Type 3.1.

The Ground Offset test applies to ground lines. The offset shall be applied to each ground line separately and simultaneously. The voltage values shown apply to all interfaces of a module supplied with a nominal 14 volts.

- **Ground offset between platform modules:**
  1. Apply V_{min} to the DUT.
  2. Subject ground line to a +0.8 V offset relative to the DUT ground.
  3. Perform a Functional/Parametric Test under these conditions.
     - Repeat for next ground line.
     - Repeat for lines simultaneously.
  4. Repeat for a –0.8 V offset relative to the DUT ground.
  5. Repeat (1) through (4) at V_{max}.

- **Ground offset between platform modules and the powertrain:**
  1. Apply V_{min} to the DUT
  2. Subject ground line to a +1.0 V offset relative to the DUT ground.
  3. Perform a Functional/Parametric Test under these conditions.
  4. Repeat for next ground line.
  5. Repeat for lines simultaneously.
  6. Repeat for a –1.0 V offset relative to the DUT ground.
  7. Repeat (6) through (9) at V_{max}.

Power Offset Test:

Operating Type 3.2.

The Power Offset test applies to battery (B+) and switched battery lines (e.g. ignition, switched ignition, accessory ignition, run1). It also applies to I/O lines that are connected to an inductive load where that load is fed by B+ or switched battery. The offset shall be applied to B+, each switched battery lines and each I/O line separately. In addition, B+ and switched battery lines shall be tested simultaneously.

1 Apply V_{min} to the DUT.

2 Subject the applicable power line to a +1.0 V offset relative to the DUT power.

3 Perform a Functional/Parametric Test under these conditions.

- Repeat for next applicable line.
- Repeat for lines simultaneously.

4 Repeat for a –1.0 V offset relative to the DUT power.

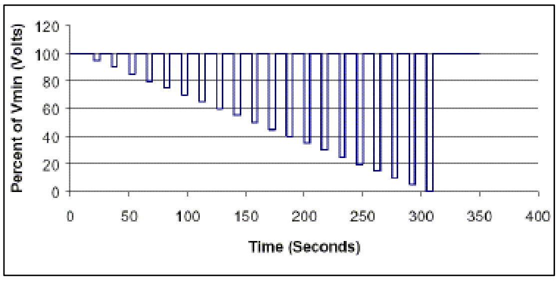
5 Repeat (1) through (4) at V_{max}.

Criteria

The DUT shall suffer no damage, degradation in performance or inadvertent actuation of any function. The DUT shall pass all Functional/Parametric Tests.

6.4.5 Voltage Drop Test

Figure 31 Reset Behavior Voltage Drop Test



Purpose:

Verify the proper reset behavior of the device. It is intended primarily for E/E devices with a regulated power supply or a voltage regulator.

Effect On Performance:

Possible E/E device power supply resets.

Procedure:

Operating Type 3.1.

1. Perform a Functional/Parametric Test.
2. Apply the test pulse of Figure 1 to all relevant inputs and check the reset behavior of the DUT. Decrease the supply voltage by 5 % from V_{min} to 0.95 V_{min}. Hold this voltage for at least 10 seconds and perform a functional test.

Raise the voltage to V_{min}. Hold V_{min} for at least 10 seconds and perform a functional test. Then decrease the voltage to 0.90 V_{min}. Continue with steps of 5 % as shown in Figure 1 until the lower value has reached 0 V. Then raise the voltage to V_{min} again.

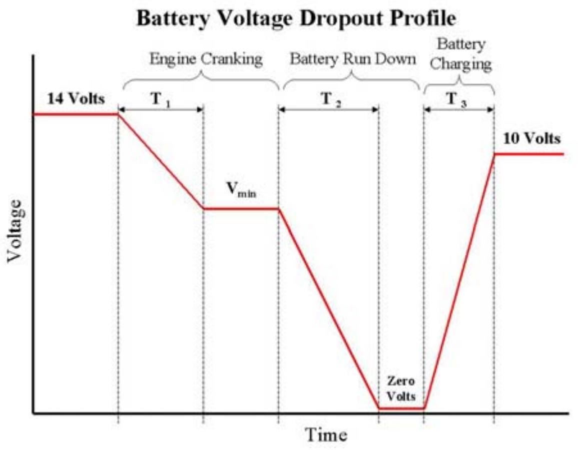
3. Perform a Functional/Parametric test during each step as described and at the end of the test sequence.

Criteria

The DUT shall pass all Functional/Parametric Tests. The DUT shall meet the specified FSC during each and every pulse.

6.4.6 Battery Voltage Dropout Test

Figure 32 Battery Voltage Dropout Profile



	Time (s)		
Variations	**T_1**	**T_2**	**T_3**
A	0.01	10	1
B	0.1	600	10
C	0.5	3600	120
D	1	28800	7200

Purpose:

To determine if the E/E device is immune to decreases (engine cranking and battery rundown) and increases (battery charging) in the battery voltage. This test is intended primarily for E/E devices with a regulated power supply or a voltage regulator.

Effect On Performance:

Possible E/E device power supply resets.

Procedure:

Operating Type 3.1

1 Perform a Functional/Parametric Test.

2 Soak the DUT un-powered until its temperature has stabilized to T_{min}.

3 Set up the battery voltage dropout waveform.

4 Power up the DUT and inject the battery voltage dropout test waveform with the following parameters from variation A:

5 Perform a Functional Check at V_{min}, between the t_1 and t_2 time intervals

6 Perform a Functional/Parametric Test after the t_3 time interval at 10 volts.

7 Repeat steps (1) through (6) three additional times for the following times for the variations B, C, and D.

8 Repeat steps (2) through (7) at T_{max}.

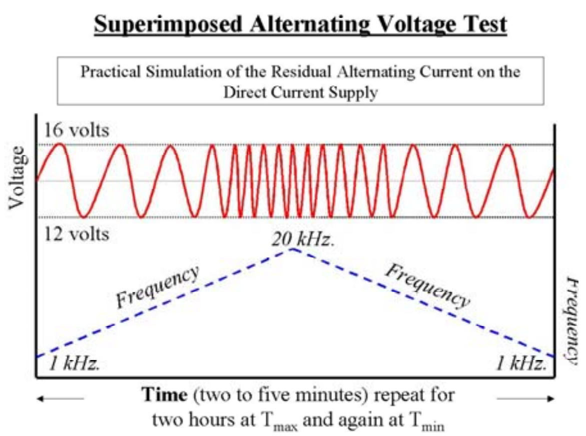
Note: The zero volt value can be changed to 1 volt to check for power reset functionality. This would be appropriate for micro controller devices and external ee-prom memories.

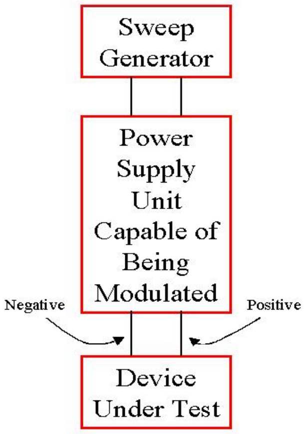
Criteria:

The DUT shall suffer no damage, degradation in performance, or inadvertent actuation of any function. The DUT shall pass all Functional/Parametric Tests.

6.4.7 Superimposed A/C On D/C

Figure 33 Superimposed Alternating Current Ripple Sweep Test





Purpose:

To verify the performance of the E/E device when the supply voltage is super-imposed with a sinusoidal alternating voltage. This simulates the output of a poorly damped alternator over a full range of engine RPMS.

Procedure:

Operating Type 3.1.

The following procedure is similar to that described in ISO1670-2.

1 Perform a Functional/Parametric Test.

2 Raise and stabilize the chamber temperature to T_{min} or as specified in the CTS.

3 Set up the Super-imposed Alternating Voltage Test. A sweep time of 2 min to 5 min is to be used.

- Internal resistance of the power supply should be less than or equal to 100mΩ
- Apply the waveform to all applicable inputs of the DUT

4 Power the DUT and inject the specified waveform for 2 h.

5 Perform a Functional/Parametric Test upon completion of test.

6 Repeat step 2 to step 5 with a chamber temperature of T_{max}.

Criteria:

The DUT shall suffer no damage or degradation in performance. The DUT shall pass all Functional/Parametric Tests.

6.4.8 Short Circuit Endurance Test

Purpose:

To determine if the E/E device is able to meet specified requirements when subjected to both intermittent and continuous short circuit conditions. This test is only required for outputs that are specified to be short circuit protected by the means of electronic current limiting.

Procedure Operating Type 3.2.

This test shall be performed on one of each type of short circuit protected outputs per DUT. Any inputs/outputs in an incorrect state or any incorrect on vehicle communications messages shall be considered a non-conformance.

Connect all inputs and outputs of the device under test in sequence for a duration described below to Vmax (see table 2) and to ground. Perform the test with:

- Supply voltage and ground connected with the outputs active and then inactive
- Supply voltage disconnected
- Ground disconnected

Place the DUT in an environmental chamber per the Validation Test Preparation section. Attach a thermocouple to the inside of the DUT.

Note: Care shall be taken to avoid erroneous test results due to the failure of exercising circuitry, interconnecting cables or mounting devices not designed for the intended test stress levels.

6.4.8.1 Test for Intermittent Short Circuit

1. Raise and stabilize the chamber temperature to T_{max}.
2. Apply V_{max} to the DUT
3. At **t** = 0 s, power mode the DUT from Off to On. The outputs under test shall be activated no later than t = 5 s.
4. At **t** = 15 s, apply all of the short circuit conditions described during a 5 minute period and then remove all short circuits for 2 minutes and 45 seconds (the combination of steps 3 and 4 should equal 8 minutes).
5. Power mode the DUT from On to Off.
6. Repeat 3 through 5 until 60 cycles are complete (total short circuit time equals 8 hours).
7. After completing the 60 cycles, perform any required recycle/reset/cool down conditions

and confirm the correct operation of the outputs with normal loads.

8. Adjust the battery voltage to V_{min} and repeat steps 3 through 7.
9. Stabilize the chamber temperature to T_{min} and repeat steps 3 through 7.

6.4.8.2 Test for Continuous Short Circuit

This test is required for short circuit protection output types that periodically recycle the output using mechanisms other than power mode changes. If multiple shorts are applied simultaneously, then the supplier shall make sure that the test is valid for single shorts as well.

1. Lower and stabilize the chamber temperature to T_{min}.
2. Apply V_{max} to the DUT.
3. Apply an 8 h continuous short circuit condition.
4. Remove the short circuit condition and perform all required recycle, reset and cool down conditions and confirm the correct operation of the outputs with normal loads.
5. Raise and stabilize the chamber temperature to T_{max}.
6. Apply and 8 h continuous short circuit condition to the previously tested outputs.
7. Remove the short circuit condition and perform all required recycle, reset and cool down conditions.

Criteria:

Confirm the correct operation of the outputs with normal loads. The DUT shall suffer no permanent damage or degradation (i.e., no burnt, damaged or failed circuit board traces, connections, components or materials). The external short circuit fault shall not prevent any other interface from meeting requirements. It is also required that the tested outputs be included in parametric measurements. These measurements shall be capable of detecting potential output degradation such as unacceptable current draw and voltage drop changes.

6.4.9 Load Circuit Over-Current Test

Purpose:

The purpose of this test is to determine if the DUT is able to meet specified requirements when subjected to maximum current allowable by the protection fuse.

Procedure:

1. Lower and stabilize the chamber temperature to T_{min}.
2. Apply V_{nom} to the DUT.
3. Apply a short circuit condition to the output per GM design engineering requirements so that the load current is 1.35 x I_{RP}. (use a shunt to accommodate the over-current condition.
4. Apply a short circuit condition to the output per GM design engineering requirements so that the load current is 2 x I_{RP}.
5. Apply a short circuit condition to the output per GM design engineering requirements so that the load current is 3.5 x I_{RP}.
6. Raise and stabilize the chamber temperature to T_{max} and repeat 3 to 5.

The test duration shall be derived from the corresponding fuse protection characteristic curve, considering the upper tolerance plus 10%.

Load Circuit Over Current Procedure For Bused Electrical Centers:

1. Perform the test at T_{max} and 135% of rated current
2. Apply current to target circuits one at a time with all other circuits at normal load.
3. Record fuse blow times and verify that they are within the fuse specification.
4. Repeat with shunts in place of fuses and hold current to upper fuse specification blow time limit.

Criteria:

The DUT shall suffer no permanent damage or degradation (i.e., no burnt, damaged or failed circuit board traces, connections, components or materials). It is also required that the tested outputs be included in parametric measurements. These measurements shall be capable of detecting potential output degradation such as unacceptable current draw and voltage drop changes. These measurements shall be made and compared to the same output types not tested under this Procedure

6.4.10 Short-To-Battery Test

Purpose:

Verify immunity of the E/E device to short-to-battery voltage.

Procedure:

Operating Type 2.1.

This test shall be performed on all DUT inputs and outputs except those specific inputs and outputs previously tested in the short circuit endurance test or the load circuit over-current test. The testing shall include all untested inputs and outputs of the same circuit type. DUT battery and ground feeds shall not be tested. All outputs shall be in their active state when tested.

Apply (14.0 ± 0.1) V for 2 min, to all inputs and outputs unless specified otherwise in the CTS.

Perform a Functional/Parametric Test.

Criteria:

The DUT shall return to normal operation as specified in the CTS after the short circuit condition is removed. The short to battery fault shall not prevent any other interface from meeting its requirements. The DUT shall pass all Functional/Parametric Tests.

6.4.11 Short-To-Ground Test

Purpose:

Verify immunity of the E/E device to a short-to-ground condition.

Effect on Performance:

The test evaluates the possible damage of shorting to ground on the E/E device.

Procedure:

Operating Type 2.1.

This test shall be performed on all DUT inputs and outputs except those specific inputs and outputs previously tested in the short circuit endurance test or the load circuit over-current test. The testing shall include all untested inputs and outputs of the same circuit type. DUT battery and ground feeds shall not be tested. All outputs shall be in their active state when tested.

1 Apply ground for 2 min, unless requirements in the CTS specify otherwise, to all inputs and outputs.

2 Perform a Functional/Parametric Test.

Criteria:

The DUT shall return to normal operation as specified in the CTS after the short circuit condition is removed. The short to ground fault shall not prevent any other interface from meeting its requirements. The DUT shall pass the Functional/Parametric Test.

The DUT shall pass the Functional/Parametric Test.

6.4.12 Open Circuit Test

Purpose:

Check for system anomalies.

Procedure:

Operating Type 1.2.

This test shall be performed on all DUT inputs and outputs. DUT battery and ground feeds shall not be tested. All outputs shall be in their active state when tested.

1. Apply an open circuit for 2 min, unless CTS requirements specify otherwise, to each input and output.
2. Reconnect the circuit.
3. Perform a Functional/Parametric Test.

Criteria:

The DUT shall return to normal operation as specified in the CTS after the open circuit condition is removed. The open circuit fault shall not prevent any other interface from meeting its requirements. The DUT shall pass the Functional/Parametric Test.

6.4.13 Isolation Resistance

Purpose:

The loss of insulation quality due to reduced spacing of traces or the degradation of dielectric material can create performance problems. This test quantifies the resistance between critical elements after the degrading effects of moisture. Higher voltage circuits near low voltage circuits are of most importance, however, this test applies to the entire DUT.

Procedure Operating Type 1.1

This test shall be performed after each humid heat test. All drying activities are intended to prevent surface moisture and are not intended to dehydrate the base dielectric material.

1. Air the DUT for ½ h at room temperature after the humid heat test.
2. Heat the DUT in a hot air oven to +70°C. to insure that surfaces are free of standing

moisture. Remove the DUT from chamber and immediately perform the following tests:

3. Apply a test voltage of 500 V DC for 60 s to the DUT as follows:
   - Between electrically isolated and adjacent terminals,
   - Between electrically isolated terminals and electrically isolated metal housing,
   - Between electrically isolated terminals and an electrode wrapped around the housing (i.e. metal foil. Sphere bath) in the case of plastic material housing. All pins would be tested under this situation.

Criteria:

Measure the current flow with 500 volts applied and calculate the resistance. The isolation resistance shall be > 1 Million Ω.

Special Note: The resistance value is the criteria of interest. Less voltage (<100) can be used with electronic devices to prevent damage to susceptible components such as capacitors.

6.4.14 Puncture Strength

Purpose:

Verify the electrical design of the device.

Procedure Operating Type 1.1

1. Heat the DUT in a hot air oven to T_{max}.
2. Apply a test voltage of 500 V_{eff} ac with a frequency of 50 Hz for a duration of 2 s to the DUT as follows:
   - Between electrically isolated and adjacent terminals,
   - Between electrically isolated terminals and electrically isolated metal housing,
   - Between electrically isolated terminals and an electrode wrapped around the housing (i.e. metal foil, sphere bath) in the case of plastic material housing.

Criteria:

There shall be no puncture or arcing.

6.4.15 Electromagnetic Compatibility

The E/E device shall meet the requirements of GMW3097 and GMW3103.

6.5 Connector Tests

All connectors shall meet the requirements defined in GME3191. The following test shall be run on the DUT.

6.5.1 Terminal Retention Force

Purpose:

Determine if the E/E device's connector terminals meet the retention force requirements.

Procedure Operating Type 1.1.

Apply 40 N, in both directions, to each terminal along the axis defined by the centerline of the terminal at a rate of (50 ± 10) mm/min.

Criteria:

The terminals shall be fully retained by the connector and shall not sustain permanent deflection exceeding 0.1 mm.

6.5.2 Connector Mating Force

Purpose:

Determine if the mating force for the harness connector to header connector interface meets requirements.

Procedure Operating Type 1.1.

Run per GME3191 "Connector to Connector Engage Force" test.

Criteria:

The connector mating force shall meet the GME3191 requirement.

6.5.3 Connector Retention Force

Purpose:

Determine if the retention force (*with the connector lock engaged*) for the harness connector to header connector interface meets requirements.

Procedure Operating Type 1.1.

Run this test per GME3191 "Locked Connector – Disengage Force" test.

Criteria:

The connector retention force shall meet the GME3191 requirement.

6.5.4 Connector Disengage Force

Purpose:

Determine if the disengage force (with the connector lock disengaged) for the harness connector to header connector interface meets requirements.

Procedure Operating Type 1.1.

Run this test per GME3191 “Unlocked Connector – Disengage Force” test.

Criteria:

The connector disengagement force shall meet the GME3191 requirements.

6.5.5 Connector Crush Test

Purpose:

Procedure:

Method A. Operating Type 1.1.

The DUT shall be set up to allow testing on all external surfaces with a 13.0 mm or larger diameter area. Subject the DUT to an evenly distributed 110 N force about any 13.0 mm diameter area for 1.0 s. A Functional/Parametric Test shall be performed at the end of test.

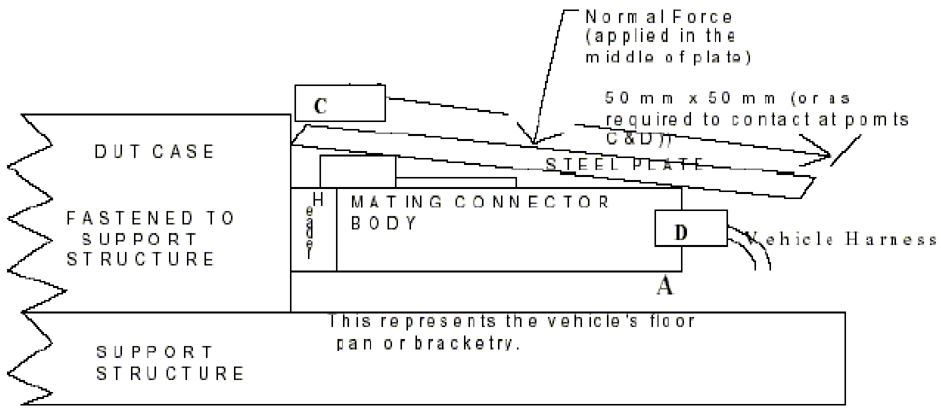
Method B. Operating Type 1.2.

The DUT connector and header shall withstand, without electrical degradation or permanent physical damage, a simulated *foot load* of 890 N of a distributed force applied normally through a 50 mm x 50 mm (or appropriately sized) rigid steel plate for 1 min as shown in the Connector Integrity sketch. Apply this force to connector and DUT header. An alternative is the DUT shall be designed to prevent imposing such load.

Determine if the E/E device is able to meet specification requirements when subjected to the mechanical stresses imposed during vehicle assembly. Method A represents a load imposed by a person’s elbow while leaning forward on the DUT case. Method B represents loading imposed by a person standing on the DUT connector and header. Both conditions are representative of possible assembly plant abuse

.

Figure 34 Connector Integrity Test Setup



Note: The intent of the procedure is to not allow connector point A to strike the support structure allowing it to reduce the load on connector.

Criteria

The DUT shall be able to withstand the above mechanical stress without any shear, yield, and loss of function or loss of electrical isolation. The DUT shall pass the Functional/Parametric Test at the end of test.

6.6 Vibration Tests

6.6.1 Vibration (Sine Plus Random) – Mounting Location: Engine/Transmission

Purpose

This test evaluates the DUT for adequate design margin for fatigue resulting from vibrational inputs. Testing for wear requires special requirements that are not stated here. To determine if the E/E device is able to meet specification requirements when subjected to the appropriate vehicle vibration level. The specified profiles apply to direct mounting in the defined mounting location. Using a bracket in mounting can result in higher or lower loads.

Procedure

During vibration load testing the DUT shall be simultaneously subjected to vibration and temperature cycles according to the vibration test temperature cycle. The DUT shall be electrically operated and continuously monitored while on test.

Cars:

Test duration: 22 h for each X, Y, and Z coordinate axis of the DUT for a base requirement of 100,000 miles. The specified test profiles apply to both gasoline and diesel engines. Test durations apply to both the sinusoidal and random vibration tests.

Trucks:

Test duration: 22 h per each of the three axes *for every 100,000 miles of requirement* as noted in the CTS. Example: A 200,000-mile requirement would require 44 hours of vibration per axis. The specified test profiles apply to both gasoline and diesel engines. Test durations apply to both the sinusoidal and random vibration tests.

Sinusoidal followed by random vibration tests are to be performed on the same DUT. Combined sine on random testing may be performed in one test run if there is a desire to reduce the time on test.

Sinusoidal Vibration.

Perform the test according to IEC 60068-2-6.

Operating Type 3.2.

Figure 35 Sinusoidal Vibration For Engine Or Transmission

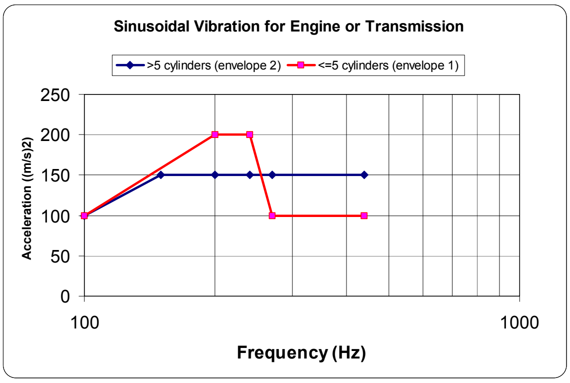


Table 17 Engine/Transmission Sinusoidal Vibration Severity

Envelope 1		Envelope 2	
Freq (Hz)	Maximum Acceleration (m/s^2)	Freq (Hz)	Maximum Acceleration (m/s^2)
100	100	100	100
200	200	150	150
240	200	200	150
270	100	240	150
440	100	270	150
		440	150

Frequency sweep:	≤ 1 octave/min
Envelope 1:	For ≤ 5 cylinder engines
Envelope 2:	> 5 cylinder engines and 4 cylinder engines with a balance shaft.

Random Vibration:

Perform the test according to IEC 60068-2-64.

Operating Type 3.2.

Figure 36 Random Vibration Profile For Engine Mounted Devices

Grms acceleration value = **180.55 m/s^2 = 18.41 Grms**

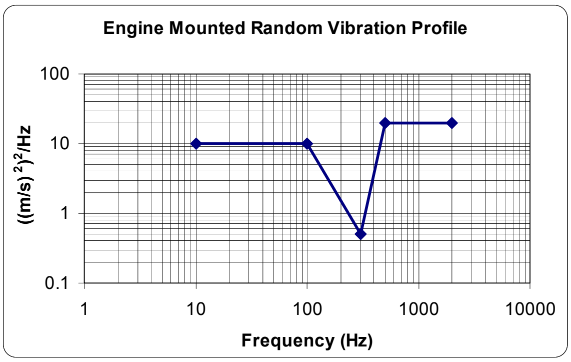


Table 18 Random Vibration Profile Engine Mounted (18.41 Grms)

FREQ (Hz)	Acceleration Power Density $(m/s^2)^2$ /Hz	Power Spectral Density g^2/Hz
10.00	10.0000	0.10
100.00	10.0000	0.10
300.00	0.5100	0.01
500.00	20.0000	0.21
2000.00	20.0000	0.21

Criteria:

Any inputs/outputs in an incorrect state or any incorrect on-vehicle communications messages shall be considered a nonconformance to specification requirements. Additionally, the DUT shall be able to withstand the above vibration levels without damage, degradation of performance, objectionable squeak or rattle, or inadvertent operation. Four parts should be tested-to-failure as explained in Appendix "B". The analytical method for quantifying the design margin for vibration should be performed using Weibull Analysis. The reliability level demonstrated for vibration shall be documented in the validation report.

6.6.2 Random Vibration – Mounting Location: Sprung Masses

Purpose:

This test evaluates the DUT for adequate design margin for fatigue resulting from vibrational inputs. Testing for wear requires special requirements that are not stated here. To determine if the E/E device is able to meet specification requirements when subjected to the appropriate vehicle vibration level. When the DUT will be attached to the body through an intermediate bracket, then the vibration test should include the bracket as intended. The actual vibration level on the DUT will be altered by the transmissibility of the intermediate bracket.

Procedure

During vibration load testing the DUT shall be simultaneously subjected to temperature cycles according to the vibration test temperature cycle. The DUT shall be electrically operated and continuously monitored while on test.

Cars:

The following profile with 2.84 Grms of energy needs to be run for **8** hrs. in each of the three axes to represent 100,000 miles of customer usage. This is representative of the damage accumulated in 95 hours on the Belgian Block Course at the GM Milford Proving Grounds and is representative of the 99.8% severe customer.

Trucks:

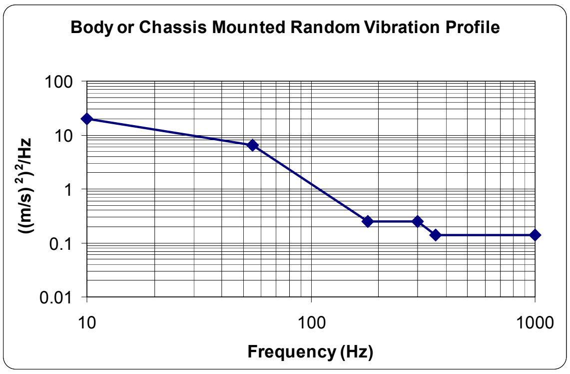
Data collected in preparation for GMW8289 provides a baseline of comparative usage between cars and trucks based on established GM Milford Proving Ground road tests. The data shows that trucks experience slightly less severe Grms values but significantly more hours of usage per 100,000 miles. Trucks require 380 hours of rough road usage compared to the 95 hours for cars within a representative 100,000 miles. Applying the equation in figure-31 allows for a common energy level test (2.84 Grms) but with different durations to account for the conditions explained above. Truck-based electronic devices should be run for 2.23 X the 8 hour baseline value for every 100,000 miles as required in the CTS. Thus truck-based electronics should be run for 17.84 hours in each axis for every 100,000 miles of requirement.

Test according to IEC 60068-2-64, random vibration.

Operating Type 3.2

Test duration is from 8 to 17.84 hours per axis as explained above for each X, Y, Z co-ordinate axis of the DUT. (Exception: Saab, use 16 h per axis for cars).

Figure 37 Cars And Trucks – Random Vibration Profile For Sprung Mass



RMS Acceleration Value

27.8 $(m/s)^2$ = <u>2.84 Grms</u>

Table 19 Random Vibration Profile For Sprung Mass

Frequency [Hz]	Acceleration Power Density $(m/s^2)^2/Hz$	Power Spectral Density (g^2/Hz)
10	20	.208
55	6.5	.0677
180	.25	.0026
300	.25	.0026
360	.14	.00146
1000	.14	.00146

Criteria:

Any inputs/outputs in an incorrect state or any incorrect on-vehicle communications messages shall be considered a nonconformance to specification requirements. Additionally, the DUT shall be able to withstand the above vibration levels without damage, degradation of performance, objectionable squeak or rattle, or inadvertent operation. Four parts should be tested to failure as explained in Appendix "B". The analytical method for quantifying the design margin for vibration should be performed using Weibull Analysis. The reliability level demonstrated for vibration shall be documented in the validation report.

6.6.3 Random Vibration – Mounting Location: Unsprung Masses

Purpose:

This test evaluates the DUT for adequate design margin for fatigue resulting from vibrational inputs. Testing for wear requires special requirements that are not stated here. To determine if the part is able to meet specification requirements when subjected to the appropriate vehicle vibration level. Using a bracket in mounting can result in higher or lower loads.

Procedure:

During vibration load testing the DUT shall be simultaneously subjected to temperature cycles according to the vibration test temperature cycle. The device shall be electrically operated and continuously monitored while on test.

Test according to IEC 60068-2-64, random vibration.

Operating Type 3.2

Test duration.

Cars:

The following profile with **10.95** Grms of energy needs to be run for **8** hours in each of the three axis to represent 100,000 miles of customer usage.

Trucks:

The following profile with **10.95** Grms of energy should be run for **8** hours for every 100,000 miles of requirement. Example: a 200,000 mile requirement would require 16 hours of 10.95 Grms per axis.

Loads below 20 Hz are not covered by the test profile stated here. In practice, high amplitudes can occur below 20 Hz; therefore, loads acting on the component in this frequency range shall be considered separately. The loads between 10 Hz and 20 Hz shall be covered in the CTS. Frequencies above 1000 Hz can be ignored with the approval of GM Engineering.

Criteria

Any inputs/outputs in an incorrect state or any incorrect on-vehicle communications messages shall be considered a nonconformance to specification requirements. Additionally, the DUT shall be able to withstand the above vibration levels without damage, degradation of performance, objectionable squeak or rattle, or inadvertent operation. Four parts should be tested-to-failure as explained in Appendix "B". The analytical method for quantifying the design margin for vibration should be performed using Weibull Analysis. The reliability level demonstrated for vibration shall be documented in the validation report.

Figure 38 Random Vibration Profile Unsprung Mass

Grms acceleration = 107.3 m/s^2 = 10.95 Grms

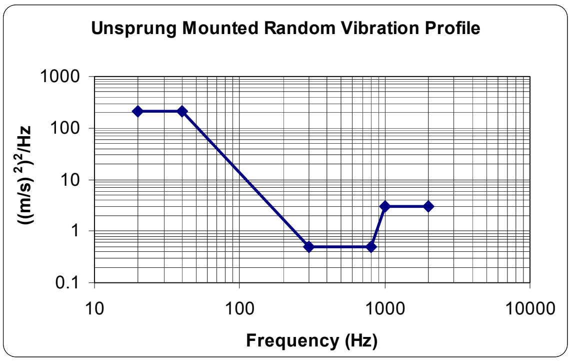


Table 20 Random Vibration Profile Unsprung Mass

Frequency – Hz	Acceleration Power Density – $(m/s^2)^2/Hz$	Power Spectral Density – g^2/Hz
20	208	2.08
40	208	2.08
300	0.5	0.005
800	0.5	0.005
1000	3	0.031
2000	3	0.031

6.7 Temperature Cycle Applied During Vibration

Purpose:

Evaluate the DUT, with vibration, at all temperatures between T_{min} and T_{max}.

Procedure:

Operating Type 3.2

The temperature cycle shall be conducted according to IEC 60068-2-14 Nb (TC). The DUT shall be continuously monitored (Operating Type 3.2) at T_{min} during the heating period starting from 20 °C, and during hold time at T_{max}. The temperature changes shall correspond to the temperature cycle table specification.

The functional test time shall be minimal, and only last long enough to verify proper performance to ensure that self-heating is as low as possible. Details are subject to agreement.

Additional drying of test chamber air is not permissible.

The post heating portion of the temperature cycles are not to be run with vibration.

Test Procedure:

Execute the 22 h vibration test specified in 4.3.3.3 with three temperature cycles per axis.

Execute the appropriate 8 h vibration test specified in 4.3.3.3 with one temperature cycle per axis.

Figure 39 Eight Hour Thermal Cycle During Vibration

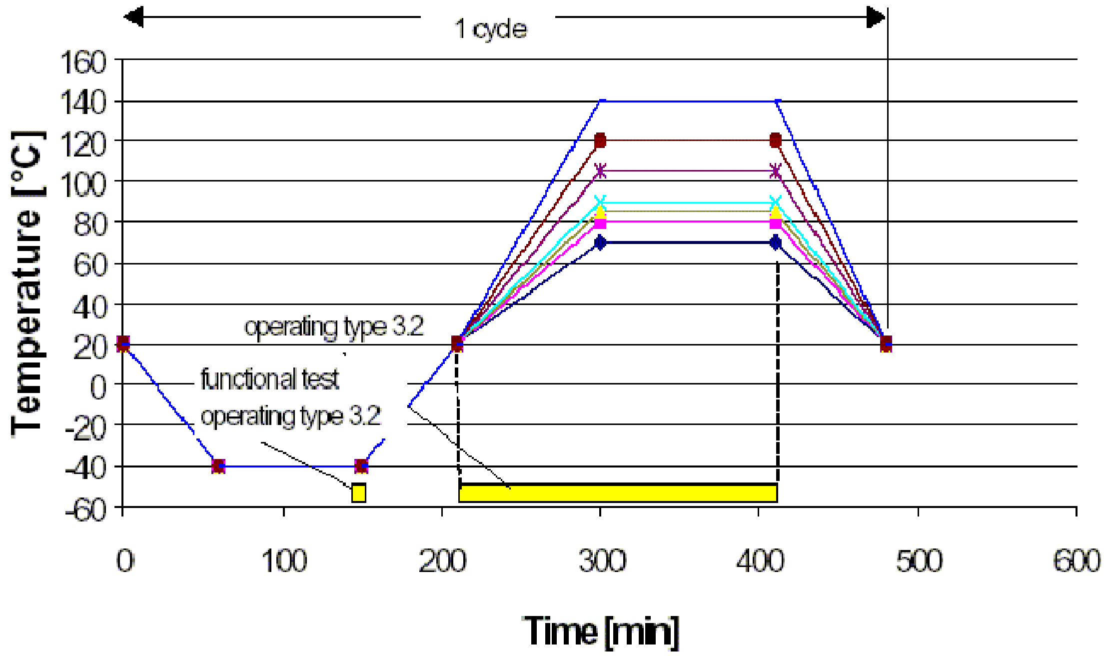
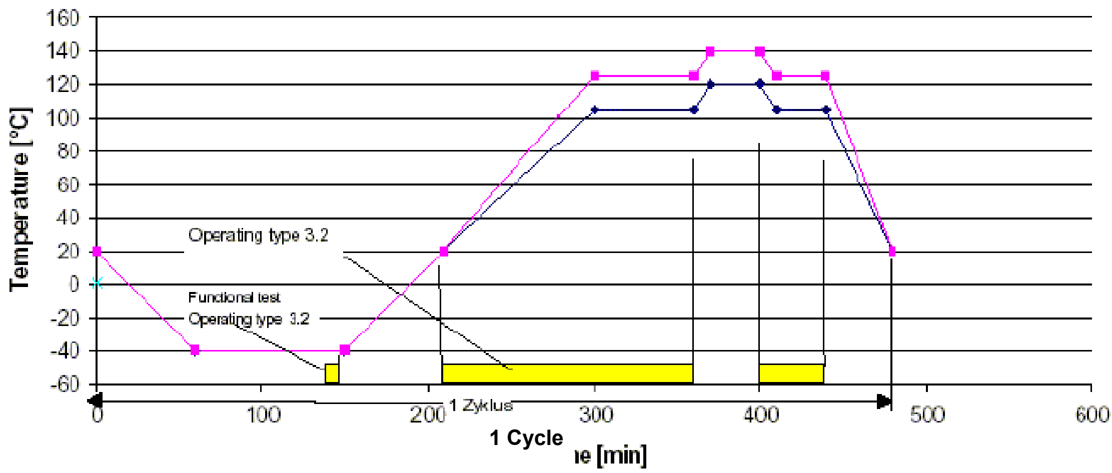


Table 21 Operating Temperature Range Code Letter

Cumulative Duration in minutes	A	B	C	D	E	F	G	H	I
0	+20	+20	+20	+20	+20	+20	+20	+20	+20
60	-40	-40	-40	-40	-40	-40	-40	-40	-40
150	-40	-40	-40	-40	-40	-40	-40	-40	-40
210	+20	+20	+20	+20	+20	+20	+20	+20	+20
300	+70	+80	+85	+90	+105	+105	+120	+125	+140
360	+70	+80	+85	+90	+105	+105	+120	+125	+140
370	+70	+80	+85	+90	+105	+120	+120	+140	+140
400	+70	+80	+85	+90	+105	+120	+120	+140	+140
410	+70	+80	+85	+90	+105	+105	+120	+125	+140
440	-	-	-	-	-	+105	-	+125	-
480	+20	+20	+20	+20	+20	+20	+20	+20	+20

Note: Identify the column for your code letter and read the chronology of temperature settings going downward in the column. All values are in degrees Celsius.

Figure 40 Temperature Cycle With Post Heating



6.8 Mechanical Shock

Purpose:

The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to the mechanical stresses defined below. Tests 1 is for pothole impacts for 100000 miles (160935 km) and test 2 is for shock loads imposed by minor 16 miles per hour collisions. The collision test assumes that the vehicle is drivable and the concern is for safety and function as the vehicle is driven away from the collision site.

Procedure:

Two shock tests have to be performed with different shock parameters. These tests have to be met by any component, independent of the installation position. The tests are conducted according to IEC 60068-2-27 Ea. Perform test 1 followed by test 2 on the same DUT. The 100 G. tests should be run in all axes if the orientation of the device in the vehicle may change or be different on other or future applications. Products that cannot be mounted in different orientations for practical reasons (like a gauge cluster) do not require the 100 G. test in the vertical direction.

Operating Type 1.2 during the test and 3.2 following the test. However, devices that include relays, such as wiper electronics and window modules, should be evaluated for proper function during the mechanical shock event to ensure unwanted activation does not occur.

Table 22 Mechanical shock (Potholes Plus Minor Collisions)

Description	Test # 1 The Default for Any Vehicle	Test #2 15.3 MPH Collision For Any Vehicle
Acceleration (A)	25 g_n	100 g_n
Nominal shock duration (D)	15 ms	11 ms
Nominal shock shape	Half sine	Half sine
Total Number of shocks (shock times each direction in each axis)	132 X 6 = 792	3 X 6 = 18

The equation for converting test #2 into a comparable velocity change is as follow:

Figure 41 Acceleration to Velocity Change Equation

$$\Delta Velocity\,(m/s) = \frac{\frac{2}{\pi} \times A \times 9.8 \times D}{1000}$$

Criteria:

The DUT shall pass the Functional/Parametric Test after the shock test and be able to withstand the above shock levels without damage or degradation of performance.

6.8.1 Door/Trunk/Hood Slam Test

Purpose:

Special requirements for components mounted in closures (door, trunk lid, hatchback, and hood). The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to the mechanical stresses defined below.

Procedure Operating Type 3.2

Shock test according to IEC 60068-2-29 Eb.

Table 23 Slam Based Mechanical Shocks

Acceleration	40 X g_n
Nominal shock duration	6 ms
Nominal shock shape	half sine

Closure	Number of shocks (in the main direction)
Driver's Door	100 000
Passenger Door/Hatch Lid	50 000
Trunk Lid	30 000
Rear Doors	20 000
Hood	1500

Criteria:

Any discrepancies during the slam test, inadvertent operations, including intermittent operation or non-operation, shall be considered a failure. The DUT shall not have any mechanical degradation (breakage, cracks, squeaks, rattles, etc.) including all mounting hardware. All production intent connectors shall also demonstrate mechanical integrity.

6.9 Crush Test for Device Housing

Purpose:

At least one pre-prototype unit shall be used to evaluate/verify that the device will meet the crush requirements.

To determine if the E/E device is able to meet specification requirements when subjected to the mechanical stresses imposed during vehicle assembly. Method "A" represents a load imposed by a person's elbow while leaning forward on the DUT case. Method "B" represents loading imposed by a person standing on the DUT and/or its connector and header. Both conditions are representative of possible assembly plant abuse. The application of these forces should not generate damaging forces on the circuit board or on components mounted on the circuit board.

Procedure:

Method A. Operating Type 1.1

The DUT shall withstand, without electrical degradation or permanent physical damage, a simulated *elbow load* of 110 N. The DUT shall be set up to allow testing on all external surfaces with a 13.0 mm or larger diameter area. Subject the DUT to an evenly distributed 110 N force about any 13.0 mm diameter area for 1.0 s (this represents the force applied by a person's elbow). A Functional/Parametric Test shall be performed at the end of test.

Method B. Operating Type 1.2

The DUT shall withstand, without electrical degradation or permanent physical damage, a simulated *foot load* of 890 N of a distributed force applied normally through a 50 mm x 50 mm (or appropriately sized) rigid steel plate for 1 min as shown in the Connector Integrity sketch. Apply this force to the top of the device and/or the connector and header.

6.10 Free Fall (Drop Test)

Purpose:

To determine if the DUT is able to meet specification requirements when subjected to the mechanical stresses encountered by being dropped from a one-meter height onto a concrete surface.

Procedure Operating Type 1.1

Test according to IEC 60068-2-32, Ed, with a height of 1 m. The DUT is to be dropped in each direction of each axis. A different dimensional axis shall be chosen for the first fall of each device under test. The second fall shall be performed on the given device under tests with the same dimensional axis as in the first fall, but on the opposite side of the housing. There are 2 falls per DUT with one axis tested per part. Thus there are a total of 6 drops spread across 3 parts.

Criteria:

- If there is *no visible* external damage to the DUT, then the DUT shall have no internal damage and shall pass the Functional/Parametric Test at the end of test.
- If there is *visible* external damage to the DUT and the damage is judged by GM Engineering to be:
  - *Insignificant*, then the DUT shall have no internal damage and shall pass the Functional/Parametric Test at the end of test.
  - *Significant*, then the DUT does not have to meet the performance requirements.

6.11 Low Temperature Wakeup Test

Purpose:

This test verifies DUT functionality after prolonged exposure to low temperature extremes.

Procedure Operating Type 3.2.

Testing shall be performed according to IEC 60068-2-1 Test Ab. T_{min} of the operating temperature range table (4) is the low temperature that is to be used. At the start of a 24 h cycle, the test parts shall be energized at room temperature for 2 minutes and evaluated for proper function at V_{nom}. The DUT shall then experience a cold soak condition for 24 hours with 12.8 V (test part drawing parasitic current only) and the device in an off or sleep state. At the end of 24 hours, and while still in the cold environment, the product is to be turned on, or awakened from its sleep state, and evaluated for proper function for 1 hour.

All DUT inputs/outputs (including communications) shall be continuously cycled and monitored for proper functional operation over all battery voltage ranges during the post-cold 1-hour functional check.

Note: This test is used in combination with a functional check at T_{max} as the first task in the test flows.

Criteria:

Any inputs/outputs in an incorrect state or any incorrect communication messages shall be considered a nonconformance to specification requirements. Special attention should be given for proper wake up and function of the circuit after being inactive for long periods of time.

6.12 High Temperature Test

Purpose:

To submit the DUT to a sustained high temperature to evaluate material degradation and diffusion based failure mechanisms.

Procedure Operating Type 3.2

The test operating voltage shall be nominal for 80 %, low for 10 % and high for 10 % of the functional tests and/or cycles.

Testing shall be performed according to IEC 60068-2-2, Dry Heat Test Ba. T_{max} of the operating temperature range table (4) is the temperature load.

Duration of load is 500 h, 2000 h, or per the CTS.

The functional cycling scheme shall exercise the DUT and allow for detection of degradation or failure.

Criteria

All functional requirements shall be met during and after the test. Any inputs/outputs in an incorrect state or any incorrect communication messages shall be considered a nonconformance to specification requirements.

6.13 Power Temperature Cycle Test With Monitoring (PTC)

Purpose:

The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to the power and temperature cycling stresses that cause failures related to mechanical attachments, integrated circuit dies, electromigration and solder creep.

Procedure:

The temperature cycle testing shall be performed according to IEC 60068-2-14 Nb. The input/output cycling shall be scheduled such that the required minimum number of 1 life cycles, as shown in the following table, for each function is evenly distributed and achieved during the total PTC test. The test parts shall be power moded 100 s on and 20 s off unless requirements in the CTS dictate otherwise.

The control instrumentation must be capable of synchronizing the DUT on/off time with the chamber temperature transitions.

Table 24 Worksheet – Cycles Of Function During Power-Temperature-Cycling

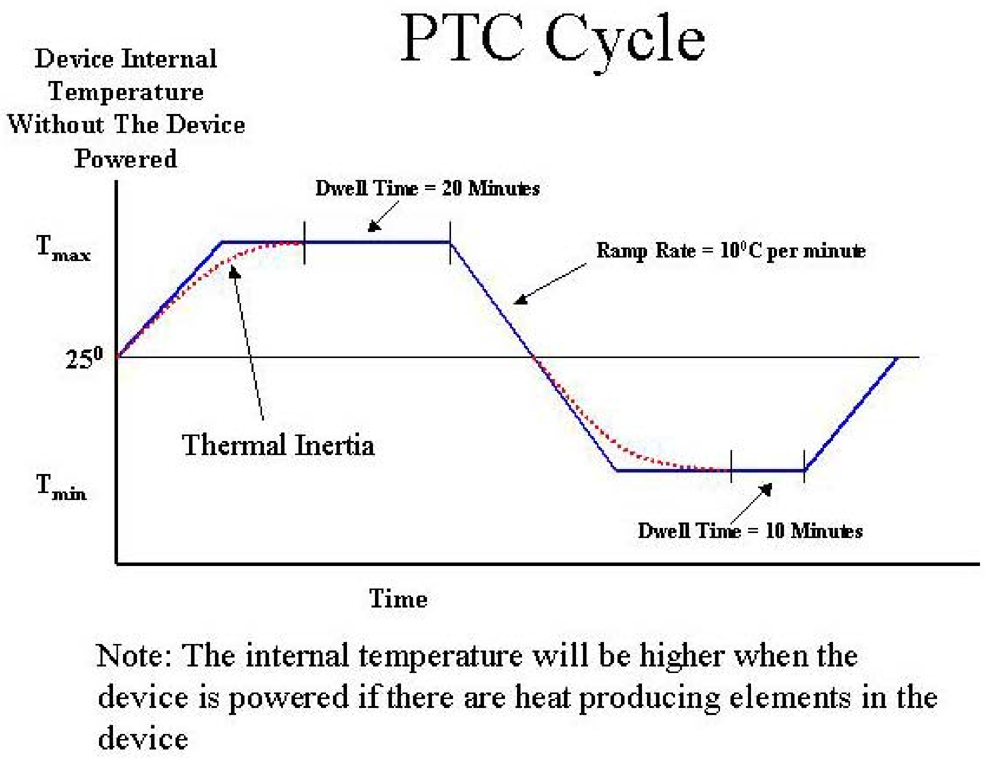
Minimum Number of 1 Life Cycles	
(This table is to be filled out by GM Engineering)	
Function	Number of Cycles
1	
2	
3	
4	

Table 25 Power-Temperature-Cycling Requirements

Temperature Range	T_{min} to T_{max}
Operating type	3.2
Temperature transition rate	(10 ± 1) °C/min or modified with the approval of GM Engineering
Dwell time *after temperature stability in the DUT has been reached*	A 20 minute hot dwell and a 10 minute cold dwell is required after the product has reached the designated temperature. The thermal mass of the DUT will require more time to reach the set temperature than is shown by the straight lines in the symbolic temperature cycle graph shown below. The curved lines shown are more representative of the actual temperature profile. The dwell periods at T_{min} and T_{max} are needed for solder to creep, leading to failure
Minimum number of thermal cycles	Generally, 200 should be used. However, in special circumstances with approval of GM, 50 may be used with the correspondingly larger number of thermal shock cycles. One life of electric function is expected to occur during the PTC process and this may increase the number of PTC cycles required.

Power moded on 100 s and off 20 s and cycling loads	Low to high temperature transitions. During high temperature dwell. During second half of low temperature dwell.
Power off	High to low temperature transitions. During first half of low temperature dwell.
Supply Voltage	% of Operational Cycles V_{low} 10% $V_{nominal}$ 80% V_{high} 10%

Figure 42 Power Temperature Cycle Profile



Criteria:

Any inputs/outputs in an incorrect state or any incorrect on vehicle messages shall be considered a nonconformance to specification requirements.

6.14 Thermal Shock In Air (TS)

Purpose:

This is an accelerated test to evaluate failure mechanisms, which may be driven by mismatches in coefficients of thermal expansion. This test is used on combination with the power-temperature-cycling test to exercise thermal cycling based failure mechanisms. Trade-offs between the number of thermal shock cycles and the number of power-temperature-cycles can be used to minimize test time.

Procedure:

The temperature cycle testing shall be performed according to IEC 60068-2-14 Na. Devices that produce significant self-heating should experience a higher temperature in thermal shock than identified in Table 4. The amount of high temperature extension should be quantified from measurements taken on functioning products.

Table 26 Air To Air Thermal Shock

Temperature rise:	T_{min} to T_{max}
Operating type:	1.1 or 1.2
Transfer duration:	≤ 30 s
Total time for a complete hot and cold temperature cycle	30 min, 40 min, 60 min, or 90 min depending on DUT thermal mass.
Time at cold	The time at T_{min} should be just long enough for the DUT to stabilize (10 minutes minimum is expected).
Time at hot	The time at T_{max} should allow stabilization and creep (10 minutes minimum to reach Tmax and 10 min minimum creep time is expected).
Minimum number of thermal cycles:	100 for interior and exterior, (C through I)
	300 for engine compartment, (A, B)

Upon agreement, this test can be performed without a case, or with a modified case, to increase the rate of temperature change. The DUT is expected to experience the Power Temperature Cycle Test following thermal shock. If this cannot happen for special reasons then a Tri-Temperature Functional Test shall be run after the thermal shock tests.

Criteria:

All functional requirements shall be met after this test.

6.15 Extended Thermal Shock For Design Margin Assessment

Purpose:

The optional extended thermal shock testing is designed to detect weaknesses hovering close to design-life and not detected with the prior success-run test process. Thermal fatigue is most prominent in large-scale surface mount designs and is one of the more difficult failures to detect; hence the need for this extended evaluation. Thermal shock is the most effective way to accelerate this failure mechanism, and detailed dissection and analysis is an effective way to identify the onset of failure.

Procedure:

Three parts, out of the original twelve, are removed on a periodic basis and evaluated for proper performance. These three parts are then dissected with special attention given to observing degraded solder joints and other connection points. These parts will not go back on test after dissection. The probability of detecting degradation will increase as the test-remove-evaluate sequence progresses.

Criteria:

Evidence of impending failures early in this test sequence should signal concern, even though the official validation sequence is complete. Failures near the end of this test sequence are to be expected, however the location of failure should be provided to manufacturing. These failure location points should be used by manufacturing to evaluate soldering process control (height of solder pad and quality of fill).

6.16 Thermal Shock/Water Splash

Purpose:

This test will verify the DUT functionality after exposure to sudden changes in temperature after a water splash of arbitrary length. The aim is to simulate driving through water in the wintertime. This applies to E/E devices that lie in the splash area, (i.e. fog lamps, trumpet horns, etc.).

Procedure Operating Type 3.2

The DUT is to be electrically connected as in the vehicle in the normal driving mode.

Test cycle: Heat the DUT to T_{max} and hold this temperature for 30 min. Splash the hot DUT with cold water. The DUT is splashed with water from one direction while being in as-installed position. If the equipment is splashed from various directions in the vehicle, then these directions shall be taken into account. Provided that this is the case, a new DUT shall be used for each splash direction. The width of the splash directed at the DUT shall always be greater than the width of the DUT. If DUTs of considerable size are splashed that prove too big for one jet, several jets shall be arranged in a row to produce a line of splash impact on the DUT.

Repeat the cycle. If the test is conducted with several DUTs at the same time, a jet for splashing shall be provided for each DUT.

Table 27 Water Splash

Number of cycles:	100
Holding time at T_{max}:	30 min
Transition duration:	< 20 s
	(For manual transition of DUT between temperature storage and splashing)
Test fluid:	de-ionized water
Water temperature:	0°C to +4°C
Splashing duration:	3 s
Jet specification:	Slot jet, see Figure 13.
Width of jet slot:	1.2 mm
Length of jet	220 mm
Water flow:	(3..4) l/3 s [(1.00..1.33) l/s]
Distance between jet and DUT surface:	(325 ± 25) mm (water shall be applied over the complete width of the DUT)
Operating type:	Operating type 3.2 during the entire test. Special attention should be paid during the last 15 min at T_{max} for possible intermittent behavior.

Criteria:

The requirements of the functional status A shall be met during and after the test.

Figure 43 Splash Cycle

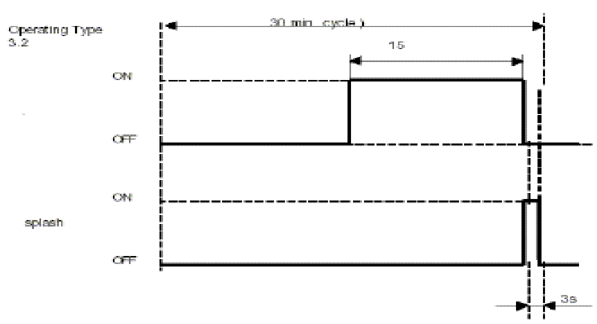
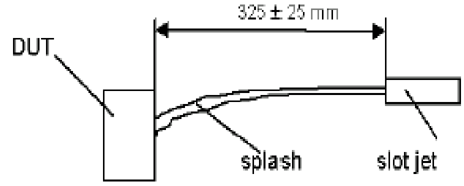


Figure 44 DUT Location With Respect To Slot Jet



DUT mounting according to as-installed condition in vehicle.

6.17 The Corrosion Salt Mist Test And Salt Spray Test

Figure 45 Corrosion Tests

Location	Days of Repeating The Test Cycle	Total Test Hours	Salt Mist Applications per Test Cycle
Passenger Compartment	**6**	**144**	Mist for 8 of 24 hrs.
Door Interior	**10**	**240**	Spray for 3 hours within each 24 hrs.
Engine Compartment High Mount or Exterior High Mount – Salt Spray	**10**	**240**	Spray for 3 hours within each 24 hrs.
Underbody – Salt Spray (duration may be extended to 40 days)	**20**	**480**	Spray for 3 hours within each 24 hrs.
Engine Compartment Low Mount – Salt Spray (duration may be extended to 40 days)	**20**	**480**	Spray for 3 hours within each 24 hrs.

Purpose:

To verify DUT functionality after exposure to salt spray as experienced in coastal regions and road salt environments.

Procedure:

Care shall be taken to mount the DUTs in the “On Vehicle Position”. The vehicle interface connector and associated harness shall be connected to the parts at all times during this test with the opposite end of the harness kept outside the chamber or sealed off at the end.

Operating Type 3.2 (Salt Mist and Salt Spray).

Salt Mist Test

Location: Standard Interior And Trunk Mounted Devices

Procedure:

Use ISO16750-4 Salt Fog Test (Described as a Salt Spray Test using a salt mist) for a period of 6 days. The test is composed of misting the DUT for 8 hours and then drying for 16 hours. The DUT is operated between the 4^{th} and 5^{th} hour of the 8-hour mist period. Operating type 3.2 is to apply during this one hour operating evaluation period with a Functional Status Classification of “A”. This 24-hour test cycle and evaluation process (8+16) is to be carried out each day over a 6-day period. Perform the test according to IEC 60068-2-11 Ka.

Criteria:

Samples must function properly during the one hour of electrical operation during each cycle, and must also complete a final functional test after a one-hour drying period at the end of the 6-day test.

Salt Spray Test

Location: Engine Compartment, Door Interior, Vehicle Exterior And Underbody Devices

Electrical devices located in those areas where salt spray rather than just salt mist may be encountered, will be tested according to the following Salt Spray Test.

Procedure:

The following 24-hour sequence is repeated as many times as necessary per the requirement for the mounting location:

- The following sequence is repeated three times for a total of 9 hours:
    1. 1 hour at 70^0C. with the power off.
    2. 1 hour in salt spray with the power on. The spray booth is 35^0C. with the spray solution at room temperature. The pH of the solution should be from (6.5) to (7.2). Operating type 3.2 is to be applied during this one hour operating evaluation period with a Functional Status Classification of “A”.
    3. 1 hour at 25^0C. as a drying period with the power off. Humidity is uncontrolled and is expected to be high.
- A drying period of 15 hours at 25^0C. with the power off. Humidity is uncontrolled but is expected to be high.

This 24-hour test sequence shall be repeated for multiple days as shown in the table:

After the final cycle perform a Functional/Parametric Test within 1 hour. The DUTs shall also be inspected for signs of corrosion. An external and connector cavity inspection is required at this time; an internal inspection is optional. Internal inspection is required during the “Internal and External Inspection” process at the end of the test sequence. The DUTs shall not be cleaned prior to proceeding onto other tests in the test sequence.

Criteria:

The acceptance criteria for corrosion is not limited to conditions as observed at the end of the Salt-Spray Test. Corrosion can start and continue at different times of the test sequence, thus the corrosion acceptance criteria applies to the entire sequence.

1. Failure of any Functional/Parametric Test item is not acceptable.
2. Structural corrosion damage that reduces any structural physical properties of a material by 25 % or more at the corrosion site is not acceptable. Structural corrosion damage is defined as corrosion related material loss or degradation that weakens the physical properties related to the structural integrity and strength of the device/assembly/packaging. These properties include, but are not limited to, yield strength, hardness, pierce strength, mass, buckling or flex resistance, etc.
3. Cosmetic appearance external corrosion is not allowed on surfaces exposed to vehicle occupants.
4. Cosmetic appearance external corrosion on unexposed surfaces that do not penetrate deeper than 5% of a surface or panel thickness or that do not cover more than 10% of the unexposed surface area is acceptable.
5. Corrosion related degradation that results in electrical parameter performance shifts that exceed the allowable drift/variation margins of the parameters analyzed for the start-to-end

6. Comparison analysis of the Functional/Parametric Tests is not acceptable.

6.18 Humidity Tests.

For the HHC, HHCO, and DEW humidity tests the DUT shall be powered with a system test voltage of 11.0 V, (to minimize excessive localized heating of DUT components that could cause localized drying). The DUT shall be functionally active but continuously locked in a steady or holding state of inputs and outputs (I/O) and circuit activity (i.e. statically active rather than dynamically I/O exercising active).

The I/O states shall be chosen to maximize voltage differential bias conditions, up to the 11.0 V system voltage, among physically adjacent circuit traces and terminals across the largest area practical on the circuit board or substrate. Example: one circuit trace is at a voltage high state, the next adjacent circuit trace is at ground or a low voltage potential (note: not open circuited), the next at a voltage high again and so forth. This arrangement should be optimized, to a practical maximum, dependent upon the specific board layout.

6.18.1 Humid Heat, Cyclic – (HCC).

Purpose:

The cyclic temperature/humidity test is designed to reveal defects in test specimens caused by humid air being forced to circulate in and around components by the breathing action that occurs from changes in temperature. The breathing effect is not only applicable to a sealed case unit but is also applicable to cavities in a normal assembled module (not sealed), with or without conformal coating. The accelerated breathing and the effect of the freezing of trapped water in cracks and fissures are the essential features of this composite test.

Procedure:

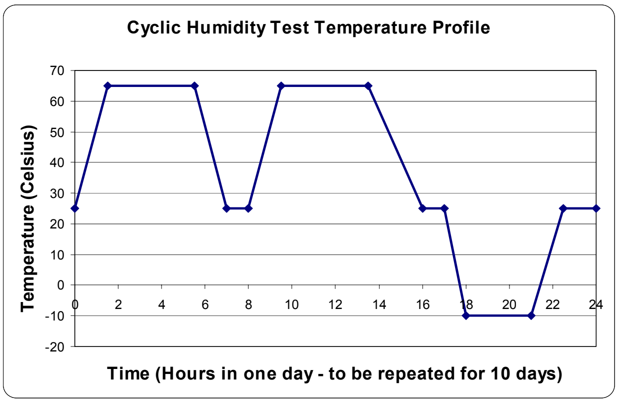
Test according to IEC 60068-2-38-Z/AD.

High Temperature	+65 °C
Low Temperature	-10 °C
Duration	10 days

Special Concern For Fuses Within The Bused Electrical Center: The zinc material used inside fuses becomes maximally reactive with high humidity and a temperature of 85^0 C. The Cyclic Humidity Test, when applied to Bused Electrical Centers can be conducted as described above, however, fuse integrity should receive special attention.

Operating Type 3.2.

The supply voltage for the DUT is to be cycled every 2 h with 1 h on and 1 h off during exposure to the cyclic humidity environment. The following graph shows the cyclic humidity cycle with the cold cycle included. Five of the first nine 24 hour cycles are to include the cold cycle.



Note: The humidity is controlled at a high level during higher temperatures per IEC-60068-2-38

Criteria:

The requirements of functional status A shall be met throughout the test.

6.18.2 Humid Heat - Constant (HHCO)

Purpose:

Evaluate the functionality of DUTs during exposure to extreme humidity and temperature.

Procedure:

Test according to IEC 60068-2-56 Cb.

Temperature	(+65 ± 3)°C
Duration	7 days
Relative Humidity	(95..100) %

Optional: If fungus growth is a concern, this test should be run at 42°C for 21 days.

Operating Type 3.2.

Criteria:

The requirements of functional status A shall be met throughout the test.

Special Note: This test can be accelerated through the use of the Arrhenius-Peck equation with the temperature not to exceed the service temperature of plastic components. This can represent a significant reduction in test time.

6.18.3 Frost Test

Purpose:

The purpose of this test is to determine if the DUT is able to meet specification requirements when subjected to condensed moisture. This is a qualitative test for detecting weakness or degradation in a device's moisture resistance capability. The use of this test prior to vibration and thermal fatigue in the test flow is intended to detect excessive levels of ionic contamination. The use of this test following vibration and thermal fatigue is intended to detect cracks in seals or loss of assembly integrity.

Procedure:

One cycle of this procedure shall be performed. The test parts shall be soaked in a chamber at (–20°C) for a minimum of 2 h.

The test parts shall then be transferred to a second chamber maintained at (+45°C) and (95%) relative humidity within one minute. The vehicle interface connector and associated harness shall be connected to the parts to allow for the Functional/Parametric Test to be performed.

Perform the Functional/Parametric Test after 5 min, 30 min, and 2 h at (+45°C) and a relative humidity of (95 to 100)%. Alternately, constant monitoring could be required during the entire test duration.

Criteria:

The part shall pass the Functional/Parametric Test at all three test intervals. The Frost Test is run at the beginning of the test flow to detect dendritic growth problems resulting from contamination on the circuit board. The Frost Test is also run at the end of the test flow to detect degradation in sealing resulting in changes in circuit board performance.

6.18.4 DEW Test

Purpose:

This test covers requirements for E/E devices that are exposed to extreme humidity levels, due to their installation position in humid locations (e.g. doors, wiper systems in plenums, and sunroof systems).

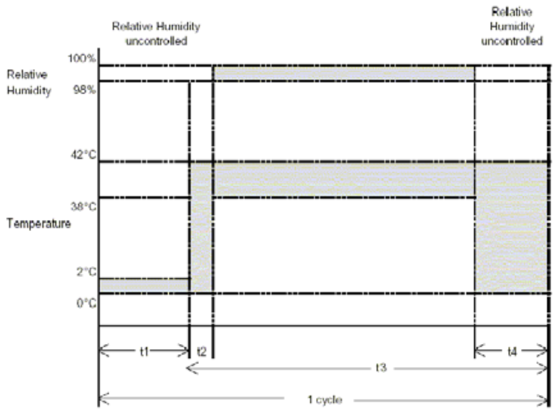
Procedure:

Operating Type 1.1 and 3.2

Conditioning:

Ensure that the surrounding air has free access to internal devices (printed circuit board) by the appropriate method (e.g. opening of the component, removing of covers). This requirement ensures meaningful results within 10 cycles (10 days). If free access to internal devices cannot be guaranteed, the test parameters have to be changed in the relevant specification.

The test consists of 10 cycles as follows:



Description of one 24 h cycle:

T_1	Time
1	2 h
2	3 min max.
3	22 h
4	1 h

Operating Type	Time	
1.1	2 h	Exposure (0 + 2)°C relative humidity uncontrolled.
		The component is transferred to the high humidity chamber within 3 min.
3.2	22 h	Exposure to (+40 ± 3)°C and (98 + 2) % relative humidity.

It is recommended to use two separate environmental chambers when performing this test.

Functional Cycling: The component shall be functionally cycled during the 40°C portion of the test sequence. The functional cycle and the number of cycles shall be individually specified in the relevant component specification or on the component drawing. Requirements of functional status A shall be met. If functional cycling while exposure to the high humidity is not possible, it shall be done during the 1 h transfer period at the end of every 24 h cycle. This shall be stated in the relevant specification or on the component drawing.

Criteria:

The requirements of functional status A shall be met throughout the test.

6.19 Altitude Test Or Analysis

Purpose:

This test has two purposes. The first test (Test 1) is used to determine if the DUT will suffer permanent damage from being shipped in an un-pressurized aircraft up to an altitude of 15240 meters (50,000 feet above sea level). The second test (Test 2) is used to determine if the DUT will suffer from overheating when operating the vehicle at a high altitude up to 4267 m (14,000 feet above sea level). High altitude results in a reduction in convective heat transfer from reduced air density.

Test 1 – if the E/E device has pressure sensitive technology, a sustained low-pressure environment may affect its performance. Hermetically sealed devices would be typical items of concern. Marginal heat dissipating E/E devices may overheat during Test 1.

Test 2 – High altitude *operation* is to be performed on all E/E devices that contain significant heat generating elements on their circuit board. The reduced air density at high altitude will reduce convective heat transfer and may cause marginal designs to overheat while in operation within the vehicle.

Procedure:

Test according to IEC 60068-2-13. The DUT shall be mated to the vehicle interface connector and associated harness at all times during Test 1. The DUT requires no connection during Test 2.

Test 1: Low Pressure (Operating Type 1.1) Place the DUT in a pressure chamber and lower the absolute pressure to 11 kPa. This test shall be 16 h in duration. A Functional/Parametric Test shall be performed at the end of test.

Test 2: Low Pressure (Operating Type 3.1) Place the DUT in a pressure chamber and lower the absolute pressure to 55 kPa. This test shall be 16 h in duration. Perform a Functional Check every 15 min.

Alternative[7] to Test 2: Analytical methods can be used to account for the effect of reduced air density and the resulting reduced convective cooling at increased altitude. The following methods and equations should be used:

The effect of convective cooling is reduced as the air density decreases. Air density is reduced as altitude is increased. The appropriate multiplier as shown in table 29 can account for this phenomenon. The assumptions used to produce the multipliers are as follows:

- The heat transfer coefficient in a naturally cooled system can be expressed as a function of the Gashoff and Prandtl numbers. The temperature and density dependence of the Grashoff number dictates the increase in case-to-ambient-resistance and thus the increase in operating temperatures.
- Energy balance is used in a forced air system and the air temperature rise is inversely proportional to the density of air.
- Power dissipation dominates the temperature rise in a high power fan cooling system. The effect of air density variation on the Reynolds number accounts for the increase in case to ambient resistance, which thus accounts for an increase in operating temperatures.

Table 28 Temperature Rise Multipliers For High Altitudes

Altitude	Multiplier		
Meter (Feet)	Fan Cooled (General)	Fan Cooled (High Power)	Naturally Cooled
0	1	1	1
1500 (5000)	1.2	1.16	1.1
3000 (10,000)	1.45	1.35	1.21
4500 (15,000)	1.77	1.58	1.33
6000 (20,000)	2.18	1.86	1.48

The multipliers as noted in table 29 are used to adjust the temperature rise for high altitude effects with the use of the following equation:

$$T_{altitude} - T_{ambient} = \left(T_{sea\ level} - T_{sea\ level,\ ambient}\right) \times Multiplier_{altitude}$$

Where:

"$T_{altitude} - T_{ambient}$" is the surface or air temperature minus the ambient temperature at altitude and…

"$T_{sea\ level} - T_{sea\ level,ambient}$" is the surface or air temperature minus ambient temperature at sea level

The multiplier to calculate temperature rise requires that one knows the temperature while operating at full power at sea level. Once the surface temperatures are scaled for high altitude, the other critical temperatures, such as junction temperatures can be calculated using a traditional thermal resistance network.

Criteria:

The DUT shall pass the Functional Check during Test 1 and the Functional/Parametric Test after Test 2.

6.20 Corrosion With Flow Of Mixed Gas (Optional)

Purpose:

This test is to be performed *only if required by the CTS*. This test is relevant for; plug contacts, open switching contacts, conformal coating (silicone based coatings will accumulate and transport the contaminates to the underlying components), and surface mounted chip components with high silver content and protective paint coats. This test is only conducted on new materials or coatings.

Procedure:

Test according to "Corrosion Test with Flow of Mixed Gas" procedure in GMW3431.

Criteria:

The DUT shall pass the Functional/Parametric Test and shall be visually examined and approved by GM Engineering.

6.21 Colorfastness Test (Weatherometer Xenon-Arc)

Purpose:

A Xenon Weatherometer test is provided to evaluate the appearance of decorative first or second surface finishes on plastic parts exposed to sunlight in the interior of the vehicle. Only show-surface components of the assembly are required to be tested. Testing is to be performed on materials after production intent processing. These tests shall be conducted on separate samples from those previously identified for environmental tests. Results for previously tested products may be referenced in the test report provided that the materials, colors, and processes are identical. This test should be performed on visible E/E devices.

Procedure Operating Type 1.1

Method A (GM Europe):

Color-fastness to artificial light:

- GME 60292-1-Rating 6 min. (no other changes) for areas with direct sunlight in exposed positions
- GME 60292-2-X-2-Grade 4 min. (no other changes) for areas with direct sunlight.
- GME 60292-2-Rating 6 min. (no other changes) for areas without direct sunlight.

Method B (GM North America):

Samples from the finished assembly or samples representing each production intent component shall be exposed in a Xenon Arc apparatus per SAE J1885. The exposure requirements shall be per the covering material specification.

- ABS plastic is typically exposed to 263.2 kJ/m^2 for 7 days
- Nylons are exposed to 601.6 kJ/m^2 for 16 days
- Paints are exposed to 1240.8 kJ/m^2 for 33 days

Reference the component drawing or component technical specification for the exact material requirements.

Criteria:

Method A:

Grade 7 min.

Method B:

Appearance Requirements:

1. The exposed samples must not show any surface deterioration, staining, objectionable color or gloss change, or any other undesirable effects.
2. The exposed samples of different material types from each of the component parts shall be assembled or combined and evaluated to determine if there is a shift in hue or a mismatch in color.
3. If sample geometry allows, after exposure the color change (ΔE) reading shall be taken and must be no greater that 3.3. Measure sample in same area before and after exposure.

Exposed samples may be wiped with a solution of water and mild detergent and blotted dry with a clean white cloth before the color reading is taken. Report ΔE values and visual inspection results. If sample geometry does not allow for a ΔE reading, then only visual inspection results should be reported.

4. Any visual color change, which is considered objectionable or unacceptable by the GM Design Responsible Engineer and Materials Engineer, can override the ΔE value.

6.22 Tests For Enclosures

Dust and water tests are to be performed when the CTS specifies an IP Code (International Protection Code). The IP Code determines the degree of protection and the required test procedures. For a complete description of the IP Codes, see 3.5.3.

Operating Type 1.2

6.22.1 Dust Tests

Purpose:

To determine if the enclosure provides sufficient protection from dust intrusion from windblown sand and road dust to allow the DUT to continue to meet the performance requirements specified in the CTS.

Procedure:

(When specified by first characteristic IP code numeral to be protected against dust; 5K or 6K). Test according to IEC 60529, 13.4 (pulsed dust injection using Talcum Powder) or the SAE procedure (constant dust dispersal). This test shall be conducted using SAE J726 Fine Grade Dust and should occur for a period of 8 hours.

Criteria:

The DUT shall experience no damage or degradation of performance. The DUT shall pass the Functional/Parametric Test at the end of test.

6.22.2 Water Tests

Purpose:

To determine if the enclosure meets the International Protection Requirement specified in the CTS.

Procedure:

(When specified by second characteristic IP code numerals 1-8, 4K, 6K or 9K).

Test as specified by IEC 60529 Table VIII. Use DIN 40050, Part 9 for IP code 9K.

For IP Codes 4K and 6K the following additions to Table VIII apply:

Second characteristic numeral	Test Means	Water Flow Rate	Duration of Test
4K	As in item 3 IEC 60529, except with opening Ø 0.8 mm at ± 90 ° spray	0.5 l/min ± 5 % per opening (average)	10 min (5 min in one position, 5 min turned 90 °
6K	As in item 6 IEC 60529 except nozzle 6.3 mm Ø	75 l/min ± 5 %	Minimum 3 min

When the second IP code is 8, use the Seal Evaluation Test unless stated otherwise in the CTS.

When the second code is 9K (high pressure jet cleaning) use the DIN 40050, Part 9 procedure or the following procedure:

The DUT shall be attached to a rotary table revolving at (5 ± 5) rpm.

The DUT shall be subjected to jet spray from four flat spray nozzles operated one at a time or a single nozzle used once in each of the four required positions.

The nozzles shall be positioned at a distance between 100 mm and 150 mm from the surface of the DUT. The nozzle(s) shall be positioned in a 90° arc around the DUT.

The nozzle(s) shall be located at the 0°, 30°, 60°, and 90° positions with respect to the three dimensional center of the DUT. The 0° position shall be directly horizontal with respect to the three dimensional center of the DUT and the 90° position shall be directly vertical above the three dimensional center of the DUT.

The nozzle(s) shall all be pointing directly at the three dimensional center of the DUT and the flat portion of the spray from each nozzle shall be aligned with the arc formed by the four nozzle positions (the flat portion of the spray shall be positioned vertically).

The nozzles shall be flat spray nozzles with a spray angle of 30° ± 6°. The width of the flat portion of the spray shall be (8 ± 2) mm at 100 mm from the nozzle and (10 ± 2) mm at 150 mm from the nozzle. The flow rate for each nozzle shall be (14..16) l/min at a pressure of approximately (8000..10 000) kPa. Each DUT shall be subjected to the spray for 30 s with the water temperature of (80 ± 5) °C or as agreed upon.

Criteria

The DUT shall experience no damage or degradation of performance. The part shall pass the Functional/Parametric Test at the end of test.

6.22.3 Seal Evaluation

Purpose:

To verify the DUT functionality after exposure to thermal shocks induced by heating in air and cooling in water. The test should be used for sealed electrical devices to evaluate the effectiveness of the seals. This test is the default test when the second IP code is 8.

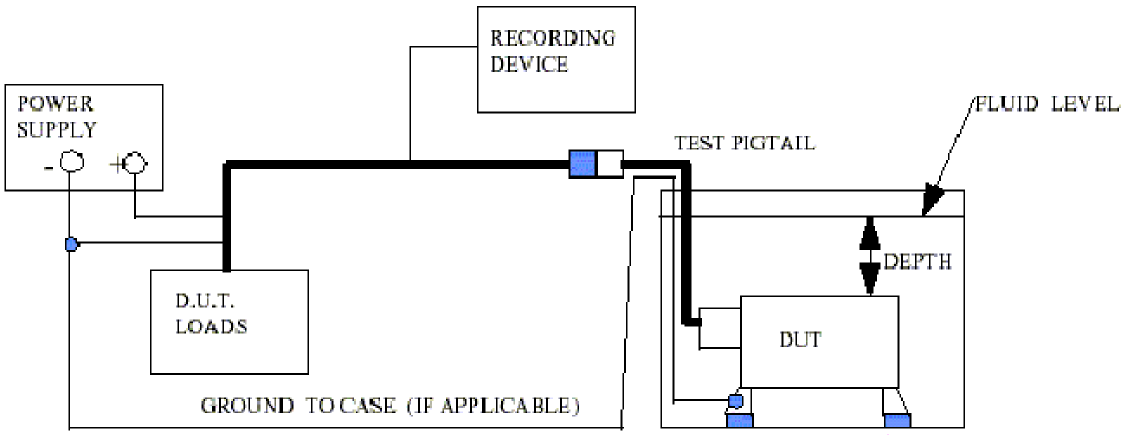
Procedure:

The test fluid shall consist of a 5% sodium chloride/de-ionized water solution with an inert visible dye added.

Operating Type 3.2.

Place the DUT in a temperature chamber at T_{max} for a total of 30 min. Remove the DUT and immediately immerse it in the test solution.

Figure 46 Water Submersion Test Setup



DUT Voltage	V_{max}
Fluid Temperature	0°C
DUT Temperature Above Fluid	T_{max}
Depth	(76 ± 5.0) mm

Connect the power and cycling/monitoring equipment and function the DUT. Check all functions at least once during the submergence period. The DUT shall remain submerged for a total of 30 min. Repeat this procedure four times for a total of five cycles. Special note: The ground wire is to be placed under water along with the DUT during the test for all sealed controllers when the ground wire will be located low on the vehicle.

Criteria:

At the end of the test, the DUT shall be opened and inspected for signs of leakage. The DUT shall pass all functional testing and shall show no evidence of leakage.

6.23 Flammability Test

Purpose:

The purpose of this test is to determine if the E/E device is constructed using materials that meet the specification requirements for flammability as defined in GMW3232 “Test Method for Determining the Flammability of Interior Trim Materials” *Waivers may be given for a specific material formulation upon proof of past test compliance*. This requirement applies to all EE devices located anywhere in the vehicle.

Effect on Performance:

No effect. Not an electrical performance issue.

Procedure Operating Type 1.1.

Reference GMW3232 “Test Method for Determining the Flammability of Interior Trim Materials”.

Criteria:

The burn rate must not exceed 100 mm/min.

7 Product Validation

7.1 General

Changes in location of manufacturing, major process changes, or product design changes should dictate what kind and amount of testing in necessary for product validation. Additionally, weaknesses in the design margins of the product during Design Validation should be considered in developing the product validation plan. The supplier and General Motors shall jointly determine exactly what testing is necessary for process validation.

If there are any Category 1 changes, the Qualification Test Plan should itemize the Design Validation tasks that need to be repeated for Product Validation. Category 1 changes are defined in the General Motors “Supplier Hardware Change Management Process” document.

7.2 Minimum Test Requirements For Product Validation

- Tests that have not fully passed DV should be completed with success in PV
- The test-to-failure Vibration Test shall be run in PV
- The Humidity Tests that were specified in DV are to be run in PV
- The Shipping Vibration Test is to be run in PV Electrical.

Review the results of the DV tests and any relevant changes to the product to determine if any of the tests should be repeated for PV.

7.2.1 Mechanical

Review the results of the DV tests and any relevant changes to the product to determine if any of the tests should be repeated for PV.

The vibration with temperature test is to be re-run to detect possible loss of design margin. This test is to be conducted on 4 parts and the resulting failures plotted on Weibull paper as explained in Appendix “B”. Alternately, a sample size of 23 can be run as a success-run test. The resulting reliability, as demonstrated is to be documented in the validation report.

7.2.2 Vibration Shipping Test

This test augments all previous vibration testing. The shipping vibration test is intended to evaluate shipping container effectiveness in preventing damage during shipping by all forms of transportation. The vibration profile in this specification is a modified composite worst-case profile that was derived from the truck, rail, and air profiles specified in ASTM D4728. The modification uses only those frequencies above 10 hertz to prevent damage to the shaker device. The vibration profile is shown below:

Figure 47 Shipping Vibration Profile

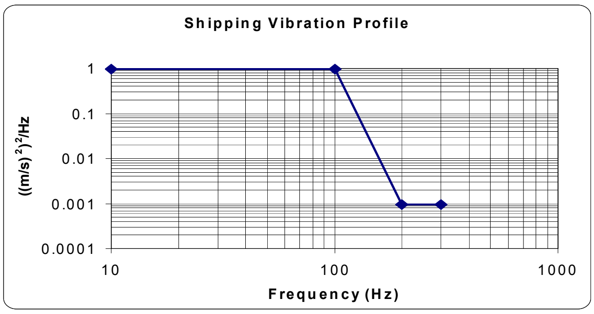


Table 29 Shipping Vibration PSD

Frequency (Hz.)	Acceleration Power Density $(m/s^2)^2$/Hz	Amplitude (g^2/Hz.)
10	.96	.01
100	.96	.01
200	.00096	.00001
300	.00096	.00001

Procedure:

Vibrate the shipping container for 24 hours in each of the three axes using the methods outlined in ASTM D4728. This test is to be conducted on one box of product in its final shipping container. All interior packing material must be in place as intended for production. The vibration test fixture must allow one box of product to move freely in the vertical axis of the vibration table. One effective design for retaining the box of product is a base plate with four upright posts that are taller then the box of product and spaced such that the box of product cannot fall off of the shaker table. A vibration profile as shown in the table above is to be used for a total duration of 72 hours (24 x 3).

Criteria:

The box of product is to be opened and thoroughly inspected for possible damage following the total 72-hour vibration test. Additionally, the product must meet the functional and parametric requirements specified in the CTS. The GM design release engineer may allow a selected evaluation of a statistical sample of parts as opposed to all parts contained in the shipping container. Parts should be randomly chosen from all quadrants of the shipping container if only a sample is taken.

7.2.3 Chemical Loads

Review the results of the DV tests and any relevant changes to the product to determine if any of the tests should be repeated for PV.

8 Evaluation Of Engineering Changes After Production

Engineering changes occurring to the product after validation is complete may detract from the reliability acquired during the ADV process. Testing for the effect of change should begin by identifying the failure mechanisms that may be affected by the engineering change.

Detecting potential weakening in the affected failure mechanisms as a result of the engineering change should be addressed with a Paired Comparison Test using qualitative methods. Product that incorporates the engineering change should be compared to product manufactured prior to the change. The comparison should use a simple but accelerated test strategy.

A paired comparison test plan based on “Three vs. Three” is suggested, and provides 95% confidence in evaluating change. This concept uses a non-parametric approach to variability and is explained as follows:

- If three samples of design “B” perform better than three samples of design “A”, then one is 95% sure that design “B” is better than design “A”. The difference in the medians of the two groups of three represents the amount that design “B” is better than design “A”. It is important that the type of stress used in this comparison be one of importance to field performance for this engineering change. The exact correlation to the field is not needed because both designs will be evaluated on the same test.

Engineering changes can affect vibration fatigue life, thermal fatigue life, and immunity to moisture. Paired Comparison Testing using HALT is very effective in addressing vibration and thermal fatigue. HALT can be augmented with pretreatments of 85%/85^{0}C for 72 hours to detect moisture related problems. Paired Comparison Testing using HAST or Cyclic Humidity is effective in evaluating degradation in resistance to the ingress of water vapor by diffusion. Paired Comparison Testing using the Frost Test is effective in evaluating conformal coating alternatives.

Alternately, the Vibration test-to-failure as described in Appendix “B” could be used as a replacement for the vibration contained in the HALT test, and thermal shock combined with a short Power Temperature Cycle could be used to replace the rapid temperature change contained in the HALT test.

9 Production Screening To Prevent Quality Spills

A mature and reliable product should be the result of the efforts explained in this document. Maintaining this level of reliability may require periodic screening activities during production. Degradation in processing or changes in components can lead to unexpected outcomes with negative consequences in warranty costs. The screening methods explained in GMW8287 can effectively prevent quality spills from reaching the field. The screening process can take the form of HASA when HALT equipment is available, or can be executed as ESS when conventional equipment is available. The HASA approach allows for the screened samples to be sold, where the ESS approach will require that the screened samples not be sold. The frequency of sampling for the purpose of screening can very depending upon the expected level of risk. A higher frequency of screening should occur during production startup.

10 Abbreviations and Symbols

Table 30 Abbreviations

ABS	Acrylonitrile Butadiene-Styrene Plastic
A/D/V	Analysis/Development/Validation
AFD	Anticipatory Failure Determination™
ASNT	American Society of Nondestructive Testing
C	Statistical Confidence
CAE	Computer Aided Engineering
CSST	Calibrated Stepped-Stress Test
CAN	Controller Area Network
CD	Continuous Duty
CTS	Component Technical Specification
DMA	Dynamic Mechanical Analysis
DRBFM	Design Review By Failure Mode
DRBTR	Design Review By Test Results
D-SMC	Discrete Surface Mounted Component
DUT	Device Under Test
DV	Design Validation
E/E	Electrical/Electronic
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
FSC	Functional Status Classification
GM	General Motors
GMI	General Motors International
GMIO	General Motors International Operations
g_n	Standard acceleration of free fall (Gravitational Constant), 9.80665 m/s^2
HALT	Highly Accelerated Life Test
IEC	International Electrotechnical Commission
IP	International Protection
I/O	Input/Output
IR	Incident Report
I_{RP}	Rate current of protection
L	Number of lives to be tested
m	Fatigue exponent (slope of the S-N line)
n	Number of samples to be tested
NAO	North American Operations
PCB	Printed Circuit Board
PDT	Product Development Team
PWM	Pulse Width Modulated
PTC	Power Temperature Cycles
PV	Product Validation
PWA	Printed Wiring Assembly (Printed Circuit Board as assembled with all components)
R	Reliability
RFA	Remote Function Actuation
RKE	Remote Keyless Entry
SAGT	Simulation Aided/Guided Testing
SD	Short Duration
SDM	Sensing diagnostic module (airbag controller)
SOR	Statement of Requirements
SS	Steady State
SW	Thermal Shock (Splash Water) Test
TS	Thermal Shock in Air Test
T_{max}	Typical high steady state temperature
T_{min}	Typical low steady state temperature
T_{maxRP}	Repaint temperature
T_{maxPH}	Post Heating (soak back) temperature
V_{low}	Low Voltage
$V_{nominal}$	Nominal Voltage
V_{high}	High Voltage
β	Weibull Slope
ΔE	Color Change

11 Coding System

Detailed explanation for coding and inclusion into CTS documents appears in section (1.4).

12 Releases and Revisions

12.1 Release

This specification was first approved and published in December 2000 to replace GM9123P and GMI12558.

12.2 Revisions

Rev.	Approval Date	Description (Organization.)
B	DEC 2001	Complete Rework (GMNA)
C	AUG 2004	Completely Reworked (GMNA)

Appendix A – Plastic Snapfit Design Worksheet

1. **The Primary Objective Of The Design Should Be To Develop An Interlocking Integral Attachment, Using Engaging Lugs, In The Direction Of Primary Forces**

   The snapfit feature should retain the engagement of the lugs and should operate in a direction different from the primary direction of forces. Example: a sphere is made in two halves. The primary direction of force, when the sphere is used, is to pull the two halves apart. One could plan to snap the two halves together directly, but that would oppose the objective noted above. The optimum strategy is for the two halves to engage interlocking lugs with a small twisting motion. Radial snapfits would be designed to keep the lugs "screwed" together. The snapfits must only resist an "unscrewing" motion, the least likely direction of usage force.

   - When an interlocking lug approach is not feasible because of motion constraints, a "hook and snapfit" should be considered. The hook is a very strong and robust retention feature that is also easy to mold. The hook acts as a retention feature, a locator, and controls the motion to better align the snapfit. The single snapfit completes the assembly.
   - When a hook-and-snapfit is not feasible because of motion constraints or geometry interferences, an over designed, minimum quantity snapfit system should be used. The "all snapfit approach" should be the last resort in the design strategy.

2. **Ultimately, Two Different Design Forces Will Surface That Must Be Specifically Addressed In The Design Process. These Two Forces Must Be Defined And Understood Before The Design Process Can Proceed**

   - The force that works to "disconnect" the attachment.
   - The force needed by a human being to assemble the attachment.

     a. The snapfit will, most probably, be required to retain a dynamically functioning force. This is certainly true in automotive applications. Vibration, usage forces, and the accidental "drop" must be comprehended by the retention requirement. First calculate the actual weight that the snapfit must hold and then calculate the "effective weight" that must be retained resulting from the dynamic effect of impact operating on that weight.

     Example:

     - Retention force required under dynamic conditions
       - Our attachment must retain a 1 lb weight
       - 10 Gs are expected to operate on the 1 lb weight as a result of extreme pothole encounters.
       - The retention force should be at least 10 times the weight of the part being retained (greater than 10 lbs retention force is required)
     - My retention force requirement is:________________________ lbs.

     b. Snapfits are generally designed to utilize a human assembly process. The forces required to repetitively make the assembly must be low enough to prevent human injury. The following forces have been established as upper limits by experts in the world of human factors for the following methods of assembly. The requirements are:

     - Allowable installation forces are not to exceed:
       - 27 Newtons (6 pounds) per hand
       - 11 Newtons (2.5 pounds) for a thumb

- 9 Newtons (2 pounds) for a single finger
- I expect that my assembly will be made using (one hand, two hands, finger, etc.) ____________________________
- My maximum assembly force requirement is: _____________lbs.

3. Your Assembly Should Not Be Allowed To Move In Any Unwanted Direction, And This Includes Rotation. You Must Document How You Are Controlling The Motion Of Three Axes Of Translation, And Three Axes Of Rotation

Show how you have constrained three translations and three rotations. Also show that you have not double constrained any rotation or translation. Multiple constraints in any one direction can create interference problems.

4. Establish Whether This Assembly Will Be Designed For Disassembly Without Damage

When disassembly is necessary, the snapfit geometries must allow for disassembly either through an applied force or by providing an access opening for a release tool. When the assembly is expected to come apart by applying force then the ramp angle that is used for retention must not exceed the “critical angle”. The critical angle is a value less than 90 degrees, but will act as if it was 90 degrees. If any value greater than the critical angle is used, the assembly will not come apart as desired. When a tool will be used to release the hook attachment, access must be provided and the use of a “limiter” is very important to ensure that the tool does not permanently damage the snapfit cantilever (see section 12 for explanation of “limiter”).

- This assembly will be designed to be disassembled (yes or no?) _____________

5. Identify The Engineering Parameters For The Materials Being Used In This Design

a. Identify the “permissible short term strain” for the plastic elements that will be experiencing strain during the flexing that occurs during assembly. The following are reasonable approximations the basic types of plastic:

- 1% for glass filled plastic
- 2% for “ABS”
- 2.5% for “ABS-Polycarbonate blend”
- 3% for Polycarbonate
- 4% for Acetyl and Nylon
- 5% for “TPO” and polypropylene
- The material that will be flexing in this design is:_________________
- The maximum permissible strain for this material is:_______________%. (Between 1 and 5 percent).

b. Friction

- Friction will be a critical factor in the forces necessary for assembly and for retention of serviceable designs. The “coefficient of friction” is a unit-less parameter (μ) with a value between .2 and .8, with .5 a good average.
- The expected coefficient of friction for the two materials that will be sliding against each other in this design is: ___________________

6. Engagement Of The Snapfit Hook

- Adequate engagement of the snapfit hook is necessary to ensure robustness under conditions of dynamic loading, dirt, flash and dimensional variation.

A Good Rule of Thumb for automotive applications: no less than two millimeters of engagement. Three to six millimeters is preferred for larger assemblies.

- The larger engagements are necessary when there are strong dynamic forces working to disengage the parts.
  - The engagement that I believe is necessary for this design is:_________________mm.

7. Effect Of Engagement Variation On Variation In Force

- Situations that require "extra" control of variation in force to assemble should perform the following analysis:
  - Variation in the degree of engagement will translate into variation in force needed to snap the assembly together. This translation between engagement variation and force variation can be calculated as follows:
    - ✷ Assume "k" is the spring constant that relates force of assembly to displacement of engagement feature as in $force = k \times displacement$
    - ✷ Assume "4 times sigma $_{displacement}$" is the range of variation expected 95% of the time in the engagement feature displacement and "sigma $_{displacement}$" is the value we will use in our equation.
    - ✷ Assume 4 times sigma $_{force}$" will be the range of variation expected 95% of the time in the assembly force
    - ✷ $4\ times\ sigma_{force} = 4 \times \sqrt{k^2 \times sigma_{displacement}{}^2}$
    - ✷ This variation (4 times sigma $_{force}$) will be centered about the nominal value calculated for the force to assemble
  - Smaller values of "k" will result in less variation. Smaller "k" values are often achieved through longer cantilevers. Many times, longer cantilevers are difficult to package due to space limitations and thus a compromise is established.

8. Environmental Conditions

- The service temperature for the stressed plastic must be greater than the worst-case high temperature environmental conditions.
- The high temperature condition is detrimental because it accelerates the creep phenomenon that may occur in continuously strained plastic. An automotive application will experience a maximum temperature either with the car running (underhood application), or parked in the Arizona sun (interior application).
- The design margin for temperature is the service temperature minus the worst-case high temperature environmental temperature. The design margin should be a positive number, if not, either the material should be changed, the location changed to an area of a lower temperature, or the continuous stresses on cantilevers reduced to near zero.
  - The service temperature for the plastic that will be stressed in this design is ________ degrees C.
  - The worst-case temperature for the snapfit elements of this design is:______degrees C.
  - The temperature design margin is ________ degrees C.

9. A Compliant Mechanism That Absorbs Looseness Should Be Built Into This Design

This will prevent relative motion that creates squeaks and rattles while accommodating variation in parts. The compliant mechanism is usually accomplished in one of two ways. The angle of the locking ramp surface of the snap-fit feature provides the compliance, or a separate "spring like feature" is added to take up any looseness in the assembly. Examples of compliant mechanisms are shown in the reference sections.

- Show and explain the compliant mechanism that you have designed into this assembly to prevent squeaks and rattles. Quantify how much variation your compliant mechanism is capable of handling.

10. Design The Actual Flexing Snapfit Feature

The design strategy for the flexing cantilever should first address strain management and then forces. The following is a good process to follow:

- Review the equations for strain and force when a cantilever is flexed. Note how some dimensions have a greater effect than others because they are squared or cubed in the equation.
- Establish the amount of hook engagement desired for this application (explained in 5.)
- Establish the length of cantilever necessary for the amount engagement planned.
  - *A good Rule of Thumb: the length of the cantilever should be 8 to 10 times the length of the hook engagement for plastics similar to ABS.*
- The thickness of the cantilever is often predetermined from wall thickness. When necessary (walls thicker than two millimeters), modifications to reduce the cantilever thickness should be considered to assist in controlling the strain in the cantilever.
- Calculate the width of the cantilever to develop the forces desired.
  - Altering the width generally does not affect the strain in the cantilever, but does affect the forces. Increasing the width will increase the force proportionally, and vice versa.
- Use thickness tapering and width tapering to make your design more efficient. See the tapering section in the references for the suggested ratio of the taper (usually 2 to 1). Tapering can be helpful when attempting to obtain the greatest degree of flexure from a short cantilever.
- The forces that the flexing cantilever will exert depend on the plastic material being used. The Secant Modulus is a characteristic of the plastic and is used to determine how much force a particular type of plastic will exert in a flexing situation. Secant Modulus values for various plastics can be found in the reference material.
- The equations necessary to perform the following are available from the GM Material and Fastening Center Analysis Guidelines described in “Fundamentals of Snap fit Design” (Version 2.0). Commercial software is also available to improve the accuracy and speed of this analytical process.
  - Show the math that predicts the forces to assemble and disassemble.
  - Show the math that allows for disassembly, if disassembly is a requirement.
  - Show the math that predicts that the strain in the plastic will be less than the maximum permissible strain. This strain generally occurs during the time of maximum deflection during assembly.
  - Show the math that dictates the ramp angles for engagement and disengagement of the snapfit feature. Detail the profile of the ramps on the snapfits.
  - Show the math that dictates the dimensions and all proportions of the flexed snapfit feature.
  - Engineering is always a compromise. Write down what you believe are the two most prominent weaknesses of this snapfit attachment design, even though you have rigorously engineered this assembly. This information will assist the design team in understanding what key dimensions or handling/packaging considerations should receive special attention during manufacturing.

11. “Guides” Should Be Employed To Act As Alignment Tools Outside Of The Snapfit Process

The guide system should provide the effect of “fitting a shaft into a large cone”. Guides should provide full control of motion *prior* to the engagement of any snapfits. Guides are often used in a cumulative manner as explained in the following “Good Example”.

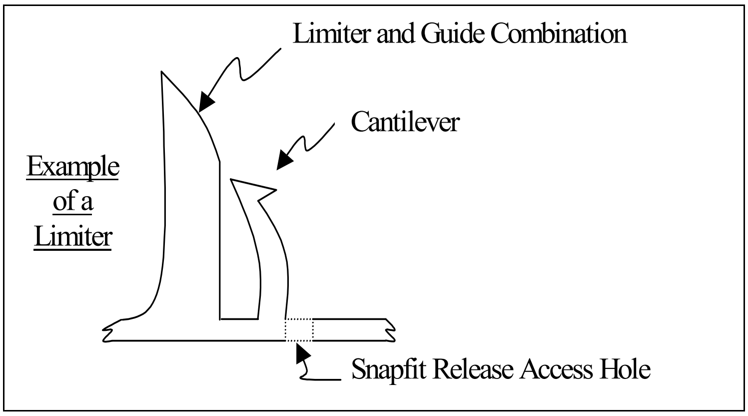
- Good Example: The first guide is easily seen by the operator, and positions the engagement process in one axis. A second guide is engaged following the first, and begins to control rotation. No remaining attention must be given to alignment, and the operator has only to concentrate on insuring complete snapfit engagement through tactile/audible feedback.
- Bad Example: A speaker grille is to be snapfit attached to a door inner panel. No guides are employed, and there are 12 snapfits around the perimeter that must be engaged, all at the same time. Placing the grille against the door obscures all vision of the snapfit engagements and the operator is left wondering if all 12 attachments were completed.
  - Identify the guide system you are employing and explain how it fully aligns the snapfits prior to their engagement.

12. Snapfits Often Lack Structural Robustness As A Result Of The Requirement To Flex During Assembly. An Additional Feature Can Be Added, Known As A "Limiter", Which Protects The Snapfit Feature From Overextension Or Damage

Damage can occur from the use of pry tools, shipping forces, or warpage occurring from the stacking of hot parts right out of the mold. See the figure below for an example of a "limiter". The "limiter" can also become a "guide" (explained in number 10.), thus serving two functions.

Identify and explain your use of limiters. If you will not be using a limiter then you must explain why not!

Figure 48 Limiter Example Used In Snapfit Design



Appendix B – Vibration Test To Failure Methodology

The basic specification requires the product to be tested at 2.84 Grms with a specified Power Spectral Density (PSD) for 8 hours in each axis. The product should be tested for 8 hours in the "X" and then tested for 8 hours in the "Y" direction. The "X" and "Y" direction are defined as being in the plane of the circuit board. The "Z" direction is to be tested last. The "Z" direction is defined as being perpendicular to the plane of the circuit board. All vibration testing is performed with superimposed thermal cycling occurring simultaneously, and with the product fully monitored. Testing in the "Z" direction will occur at 2.84 Grms *until all four products fail*. Product failure is essential in providing the data necessary for performing a Weibull Analysis. The analysis process that follows requires that all failure modes be similar. The Weibull Analysis approach allows for the use of a small sample size to demonstrate the required level of reliability.

If testing does not produce failures within 20 hours of vibration at 2.84 Grms in the "Z" direction, then the test may be suspended with a conclusion of passing the requirement.

Weibull analysis shall be performed on the four "time to failure" values. These values shall be plotted on Weibull paper and the reliability at the life requirement identified and documented using proper Weibull analysis methodology.

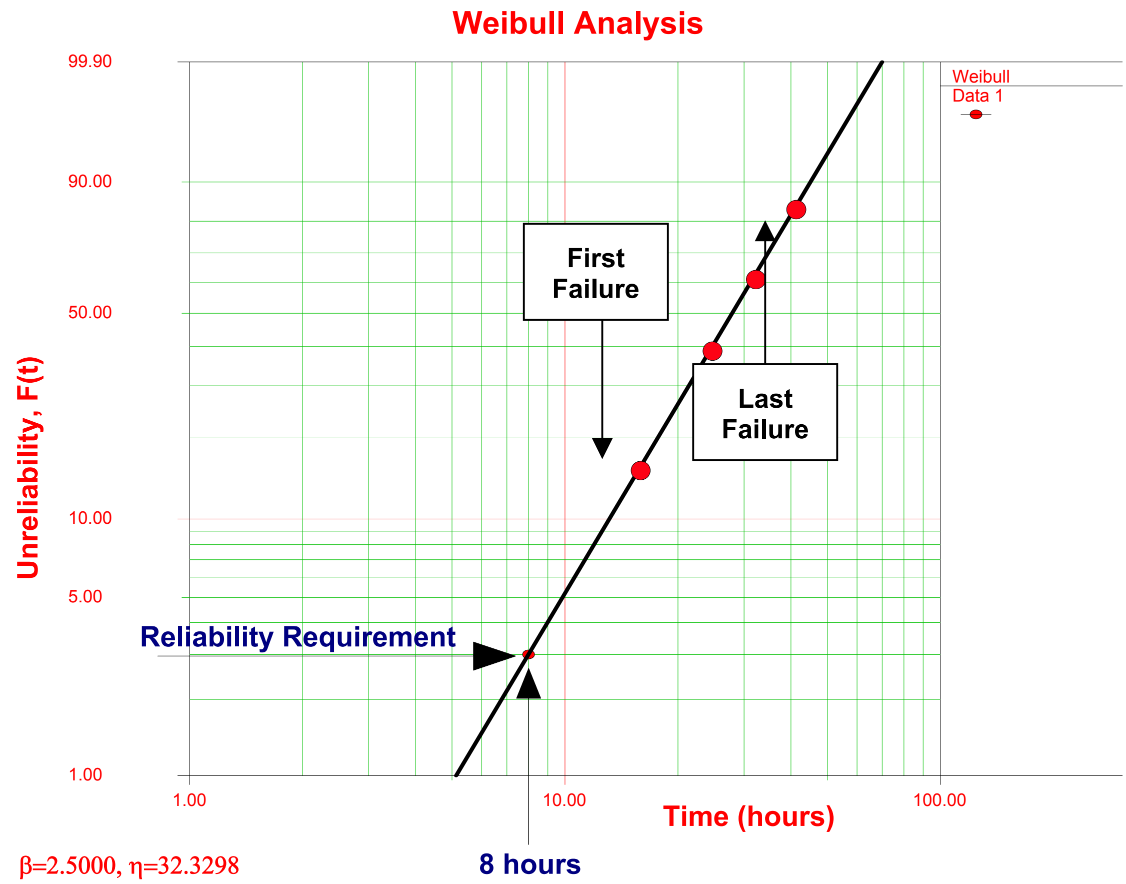
An example of four parts tested to failure and plotted on Weibull paper is shown on the following page. The failure values are organized in increasing value and their corresponding median rank value assigned. The median rank values will always be the same for the same sample size, however the times to failure that will form the plotting pair will be a product of the device under test. Different sample sizes will have different median rank values.

The paired plotting points using the median rank values for a sample of 4 are as follows:

- [(the earliest failure in your data), **15.9%**]
- [(the second failure in your data), **38.6%**]
- [(the third failure in your data), **61.4%**]
- [(the last failure in your data), **84.1%**]

The product in this example meets the reliability requirement exactly because the best-fit Weibull line passes through the intersection of 8 hours and 97% reliability requirement (3% failure). Any line passing to the left of this point will not meet the requirement, and any point passing to the right of this point will more than meet the requirement. The slope of this line will vary as a function of the variability of the test data.

Figure 49 Weibull Plot Example



Special Note: When the product is mounted on rubber isolators or grommets, the above test may generate excessive heat within the rubber causing abnormal failure of the rubber isolators. The following process is suggested to prevent this problem:

- Apply the standard specification level vibration to the rubber mounted device and measure the Grms value ($Grms_2$) and PSD (PSD_2) on the device downstream from the rubber isolator.
- Test as explained in section (15) using the new Grms value ($Grms_2$) and the new PSD (PSD_2) as the requirement with the rubber isolators removed from the system.

Deviations

Random Vibration - Mounting Location: Sprung Masses (Body)

Saab: Test duration is 16 h for each X, Y, Z co-ordinate axis of the DUT.

b pin18 my07 benchtest malibu view 4pins

2005-2007MY Body Control Module Intermittent Brake Light Issue

Facts:

- Intermittent BCM brake light warranty has shown <u>peak</u> reports for 2005 MY January month built for Pontiac G6.
- 2005 January 36 MIS = 37 IPTV
- 2005 January 36 MIS with Unique VIN = <u>28 IPTV</u>
- 2006 January 34 MIS = 13 IPTV
- 2006 January 34 MIS with Unique VIN = <u>11 IPTV</u>

- 2005 MY 36 MIS Overall = 8.0 IPTV
- 2006 MY 36 MIS Overall = 4.6 IPTV
- 2007 MY 24 MIS Overall = 2.0 IPTV

Root Cause:

- Fretting corrosion in BCM terminal interface to the brake position sensor.
- Cause of surged warranty report for the vehicles built in January 2005 is undetermined.
    - Red-X study showed higher nickel content of the pins for non-January vehicle builds.

Corrective Actions:

<u>Production</u>

- Dielectric lubricant is applied in Orion plant. **COMPLETE 11/8/08**

<u>Service</u>

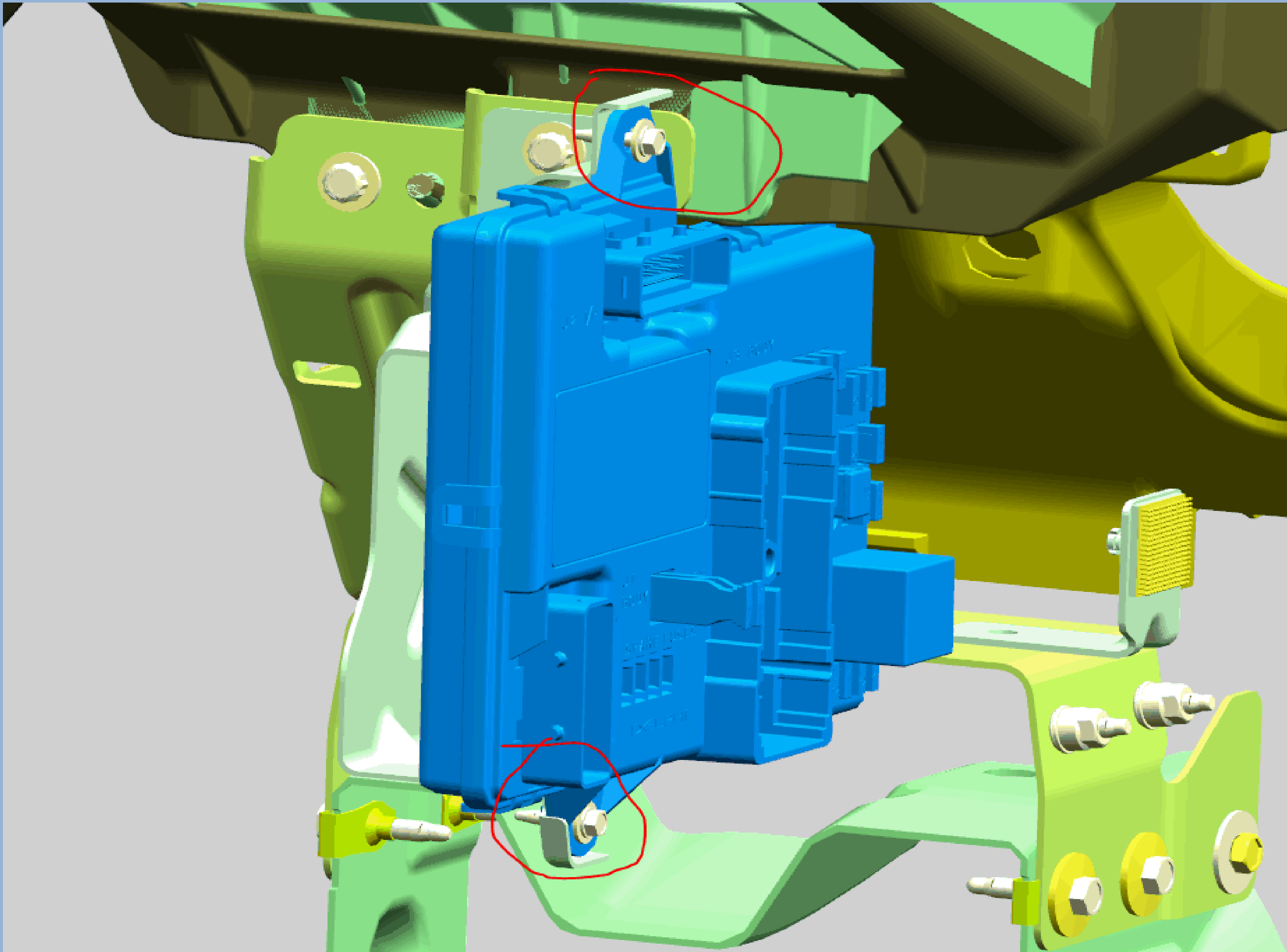
- Technical Service Bulletin 08-05-22-009 issued to apply the lubricant. **COMPLETE 12/4/08**

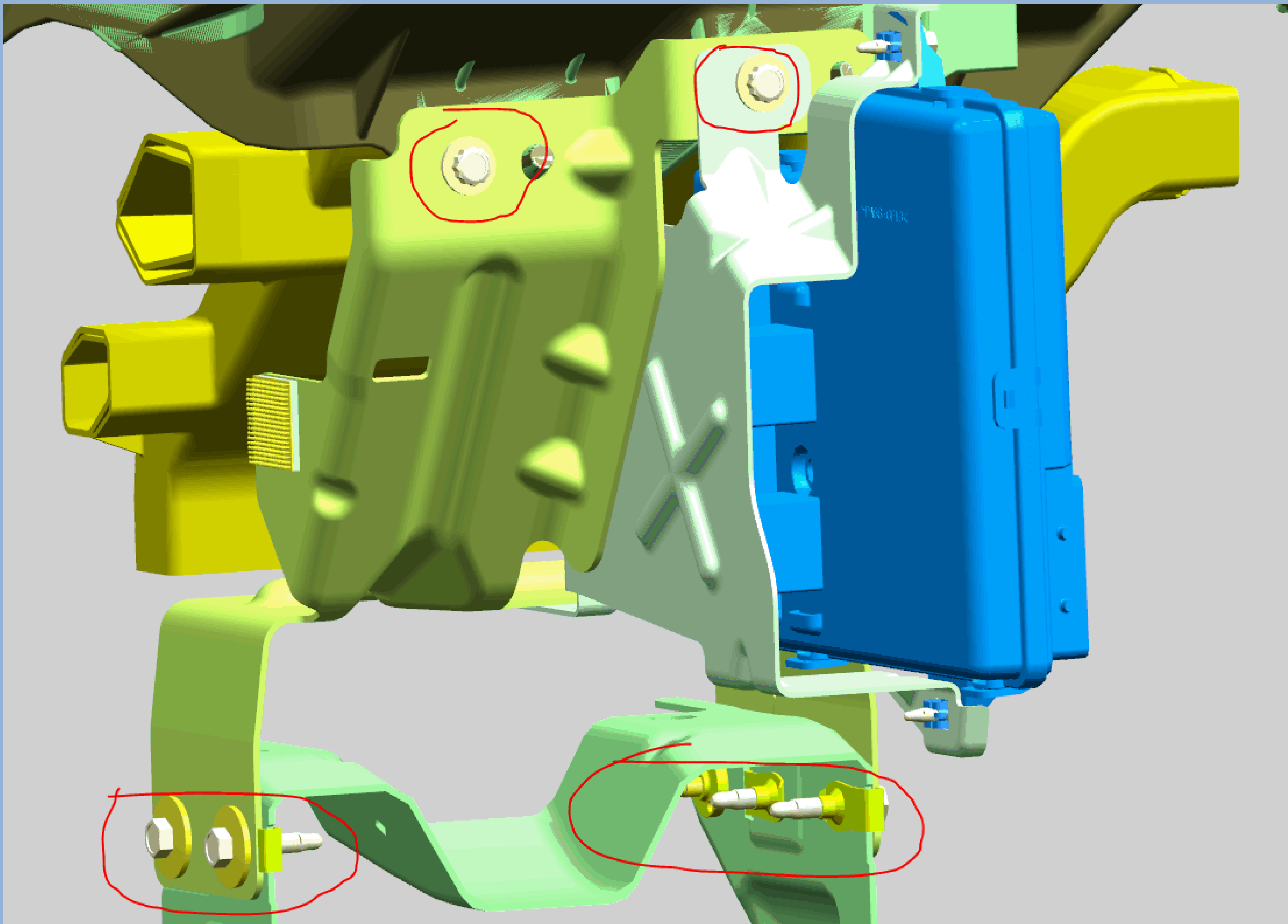
Proposed Next Steps:

- Run more tests to confirm the difference of the nickel content for WOW vs. BOB. **TO BE COMPLETED 1/22/09**

- Review records of terminal build for changes in maintenance, machine calibration, or material composition. **TO BE COMPLETED 1/22/09**

- Monitor the warranty monthly since January 2005 built had the highest peak and showed 28 IPTV (36 MIS) with unique VINs





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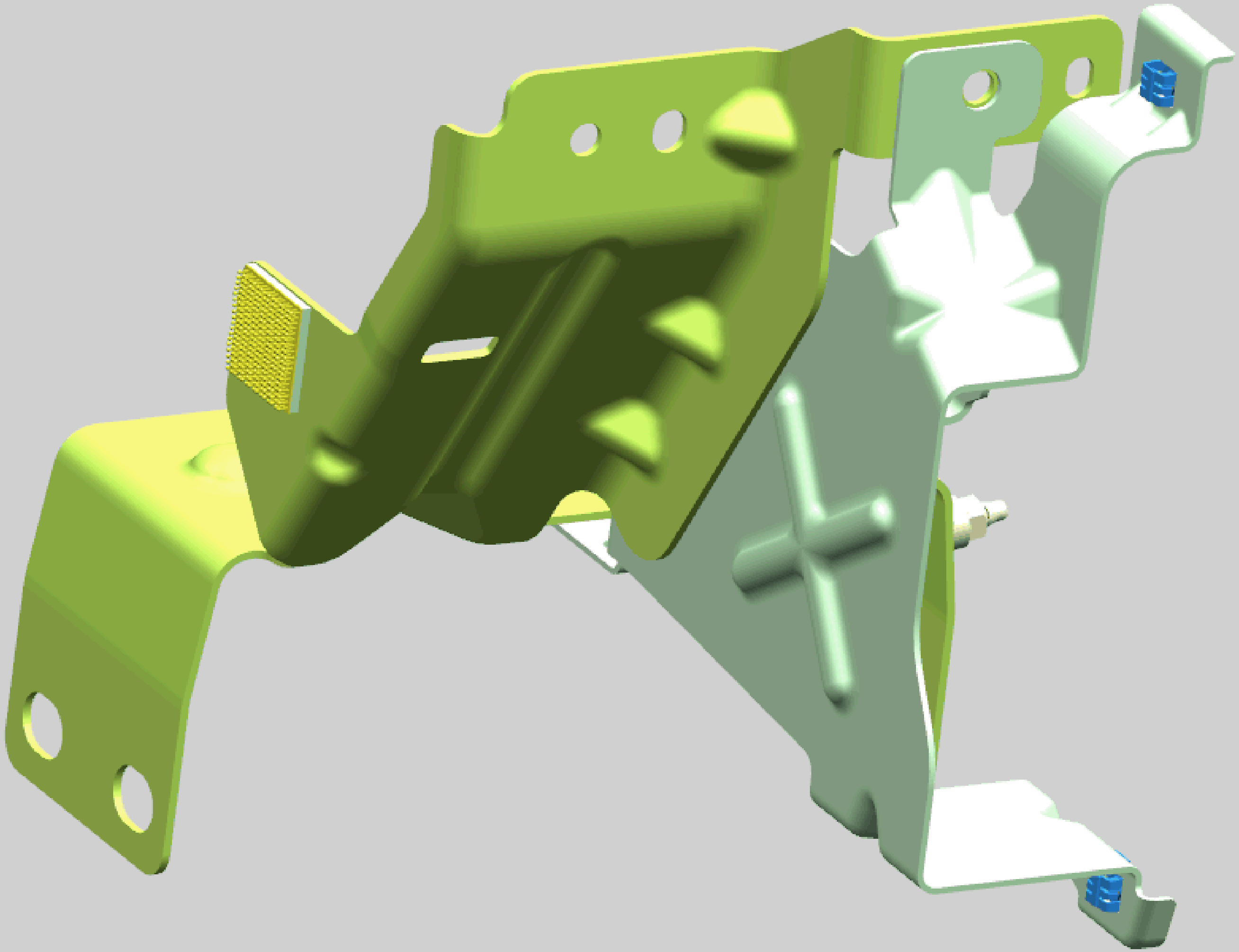
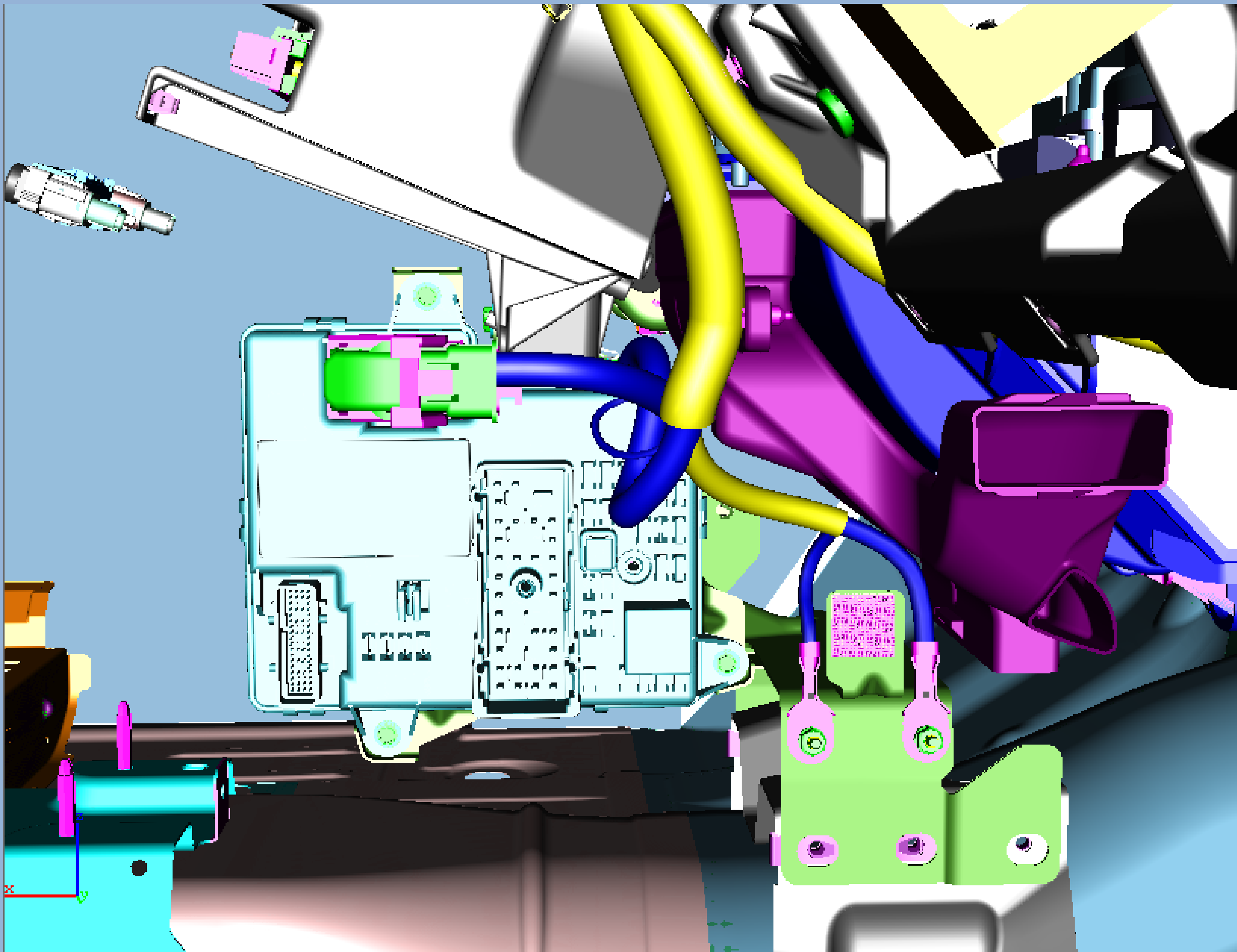
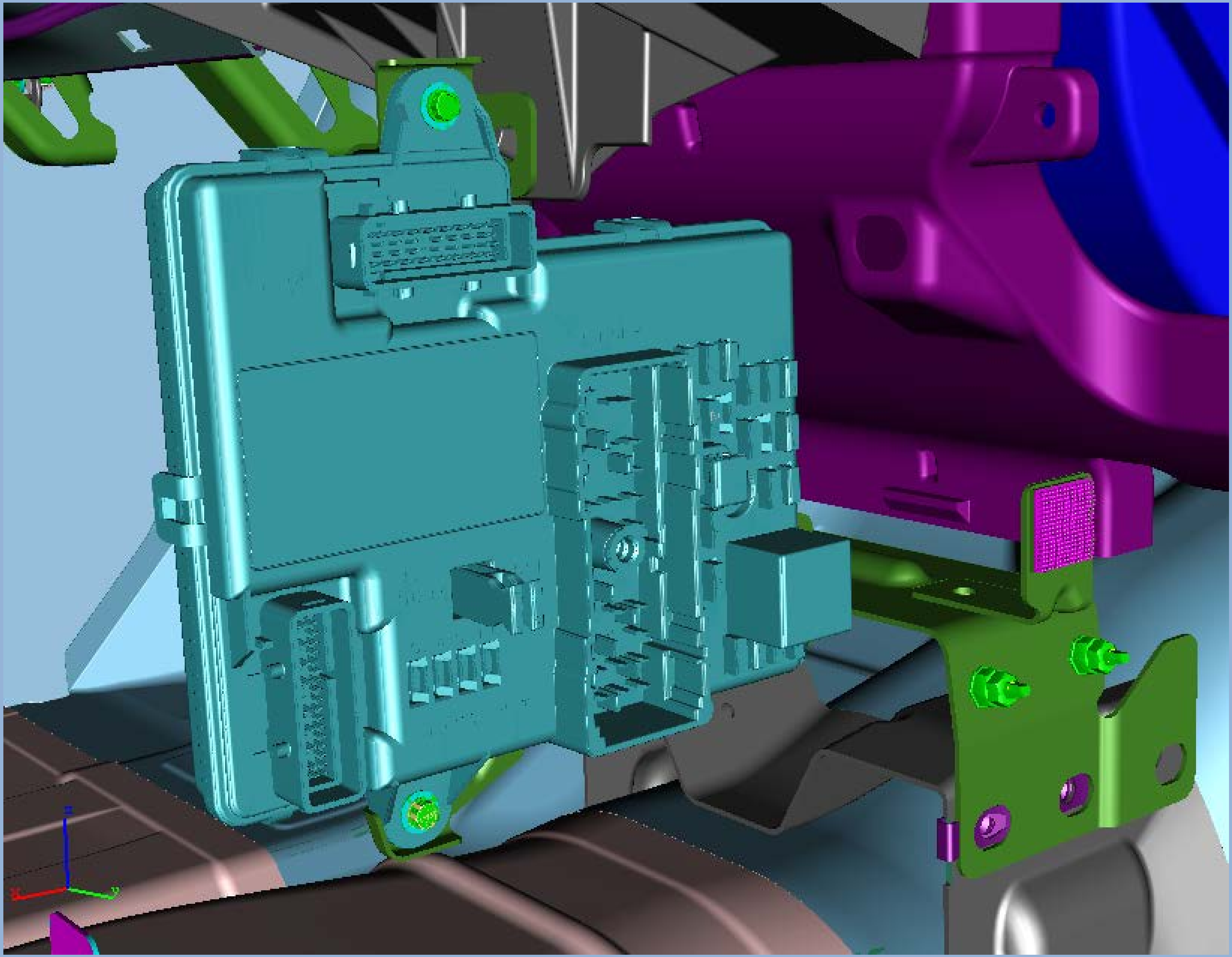
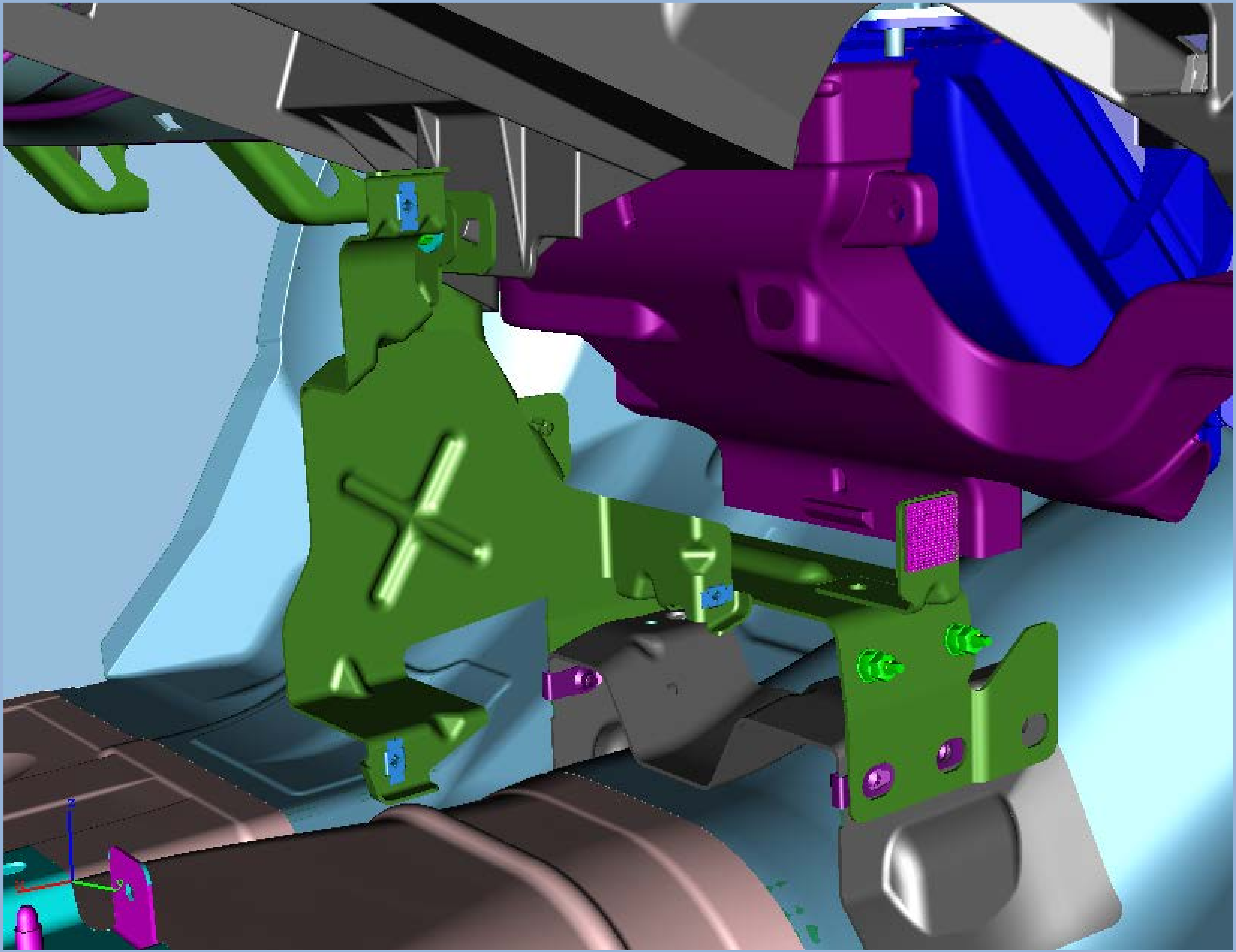
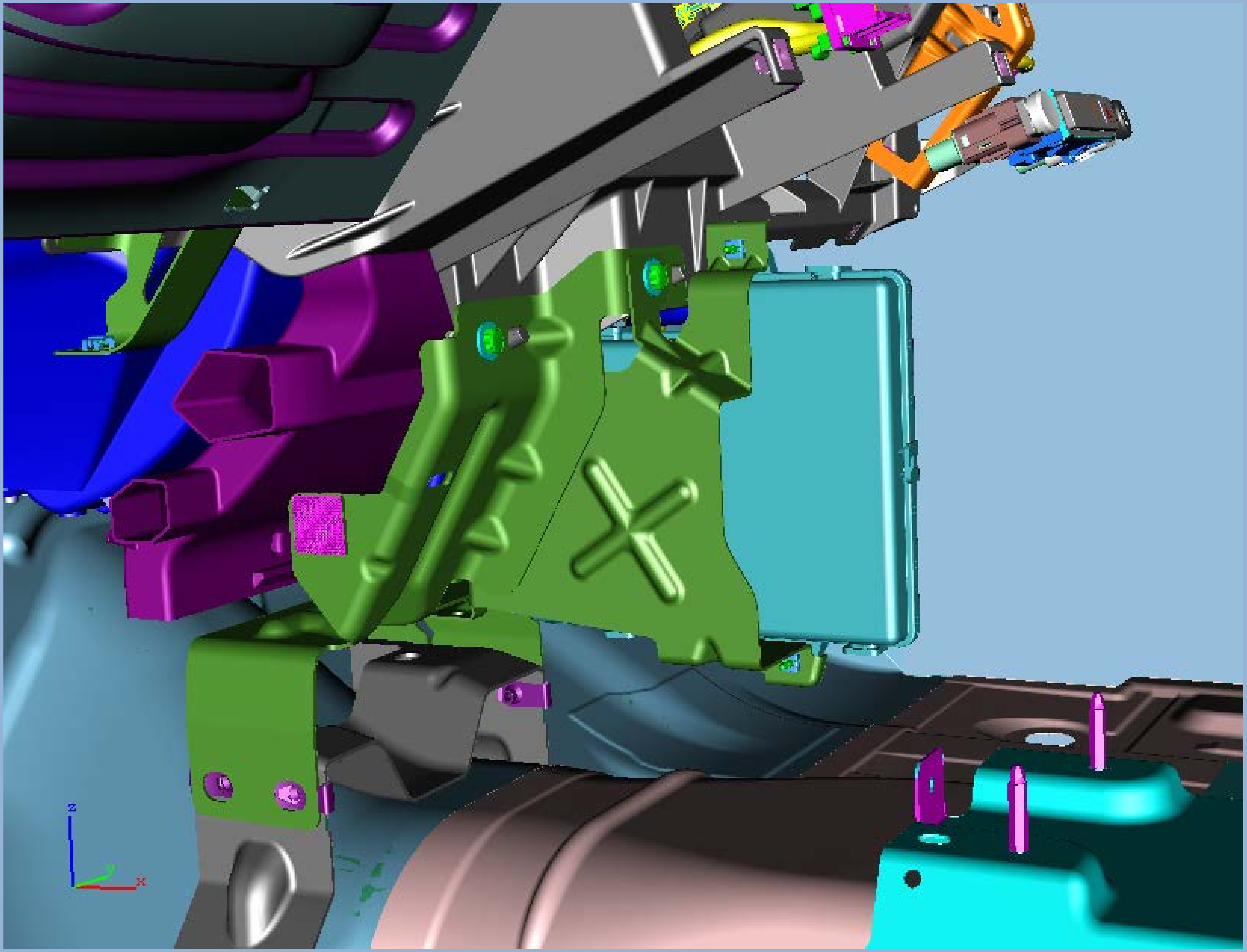
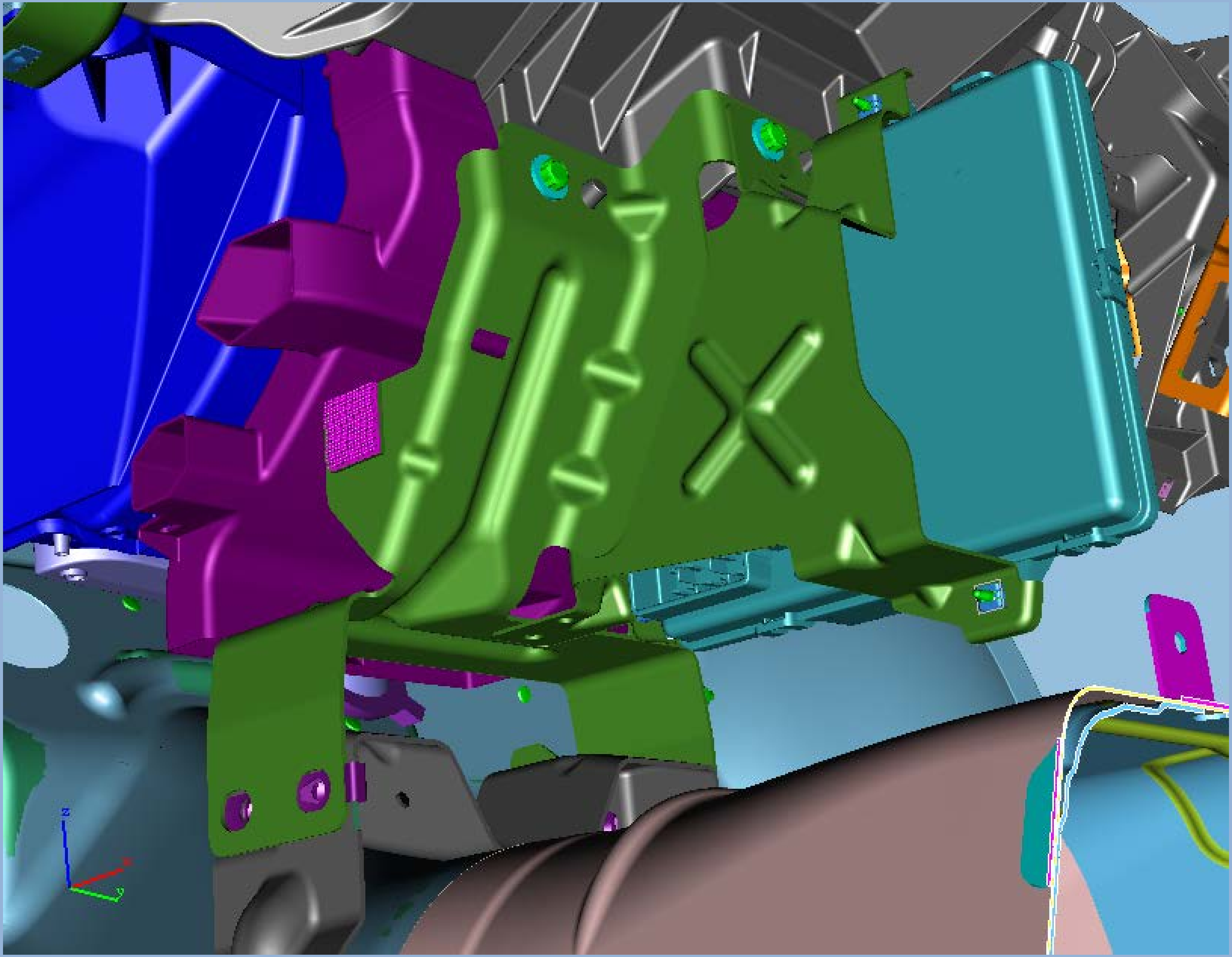


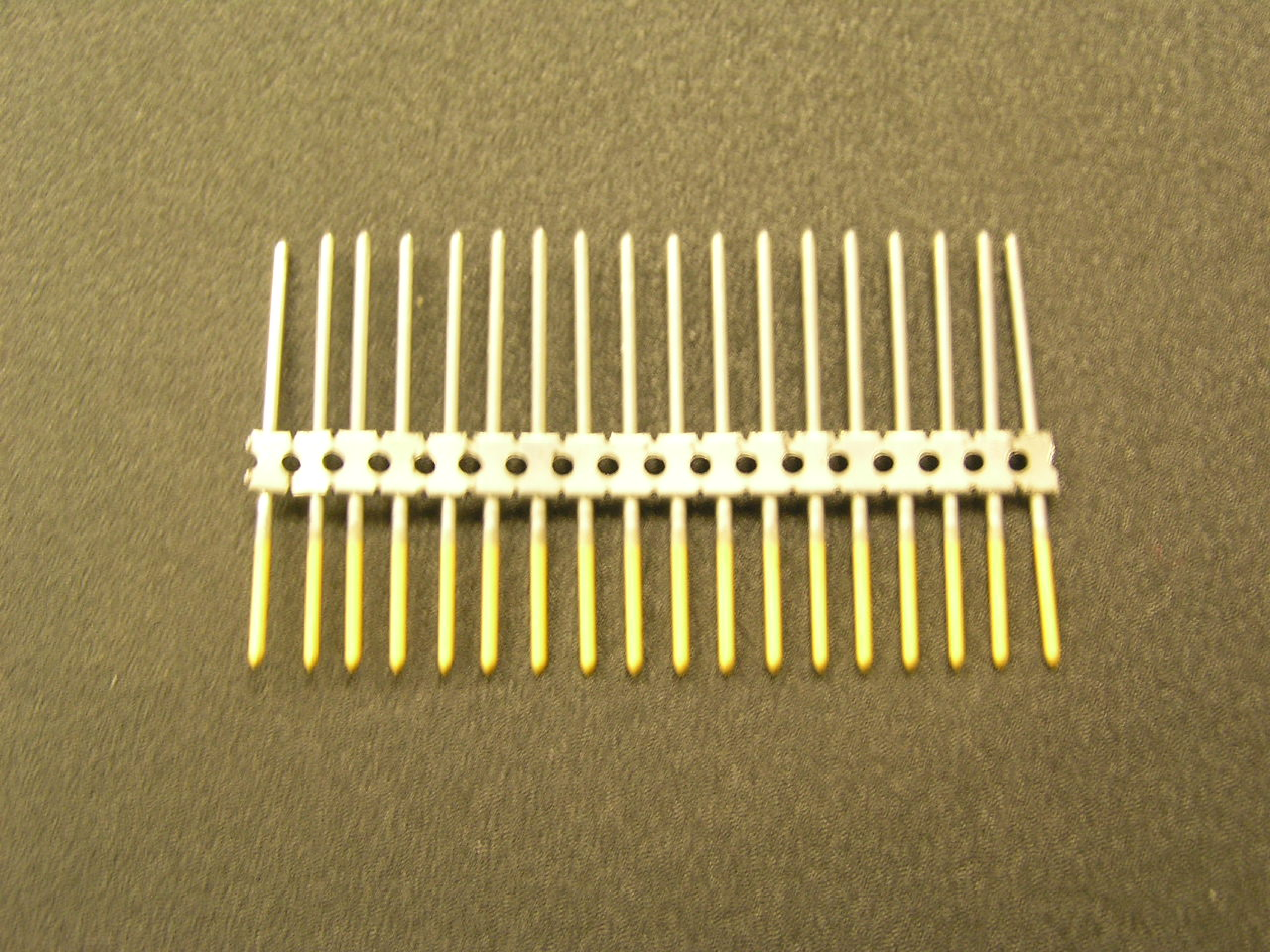







Z
X





Re: Request for 2005-2009MY Pontiac G6 Warranty on Stop Lamps
William J. Kremer to: Kimberly Desotell 02/11/2013 02:29 PM
Cc: Jay H. Sim

From: William J. Kremer/US/GM/GMC
To: Kimberly Desotell/US/GM/GMC@GM
Cc: Jay H. Sim/US/GM/GMC@GM

Kim,

Per our conversation this morning between Jay, you and I. I ran the file in GART AA with the labor codes only (no date). I have also attached the VOP file I ran previously. Let me know if you need me to pull anything else for Jay's analysis. Thanks.

039 2005-09 G6 V2044 & V2045.xlsx 042 2005-09 G6 11-LCs (36,118).xlsx

Regards,
Bill Kremer
GM Product Investigations
(586) 907-0437
Vehicle Engineering Center, (VEC)
MC: 480-210-2V1 (Dock 2)
30001 Van Dyke
Warren, MI 48090-9020
william.j.kremer@gm.com

Jay H. Sim Bill, Thank you for the Vop warranty information. 02/08/2013 03:23:56 PM

From: Jay H. Sim/US/GM/GMC
To: William J. Kremer/US/GM/GMC@GM
Date: 02/08/2013 03:23 PM
Subject: Request for 2005-2009MY Pontiac G6 Warranty on Stop Lamps

Bill,

Thank you for the Vop warranty information.

Please pull the GMNA warranty claims after February 10, 2009 for the following Labor Codes.

Model: Pontiac G6
Model Year: 2005 - 2009
Labor Codes: N9595
N9613
N4800
N2700
H2642

H2643
H2640
H9991
Z1241
Z1242
Z1243

Thanks.

Jay H. Sim
586-907-0329

Re: Request for 2005-2009MY Pontiac G6 Warranty on Stop Lamps
Kimberly Desotell to: Jay H. Sim 02/12/2013 05:11 AM
Cc: William J. Kremer
This message is digitally signed.

From:	Kimberly Desotell/US/GM/GMC
To:	Jay H. Sim/US/GM/GMC@GM
Cc:	William J. Kremer/US/GM/GMC@GM
History:	This message has been replied to.

Here is a report of vehicles that had a repair after the v op was performed. The first three columns are about the v op itself, followed by the detail of the second repair. Note that there can be multiple lines for one vin.

Kim

lamp secondary repair.xlsx

William J. Kremer	Kim, Per our conversation this morning between Jay,...	02/11/2013 02:29:09 PM

From:	William J. Kremer/US/GM/GMC
To:	Kimberly Desotell/US/GM/GMC@GM
Cc:	Jay H. Sim/US/GM/GMC@GM
Date:	02/11/2013 02:29 PM
Subject:	Re: Request for 2005-2009MY Pontiac G6 Warranty on Stop Lamps

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[attachment "039 2005-09 G6 V2044 & V2045.xlsx" deleted by Kimberly Desotell/US/GM/GMC]
[attachment "042 2005-09 G6 11-LCs (36,118).xlsx" deleted by Kimberly Desotell/US/GM/GMC]

Regards,
Bill Kremer
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william.j.kremer@gm.com

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N9613
N4800
N2700
H2642
H2643
H2640
H9991
Z1241
Z1242
Z1243

Thanks.

Jay H. Sim
586-907-0329

Re: Fw: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

Brian Pedersen to: John C Lyons 03/18/2013 09:31 AM

Cc: James L Duffy, Jay H. Sim, Juvenal Zavala, Thomas J. Wang, Jae L. Loman

From: Brian Pedersen/US/GM/GMC

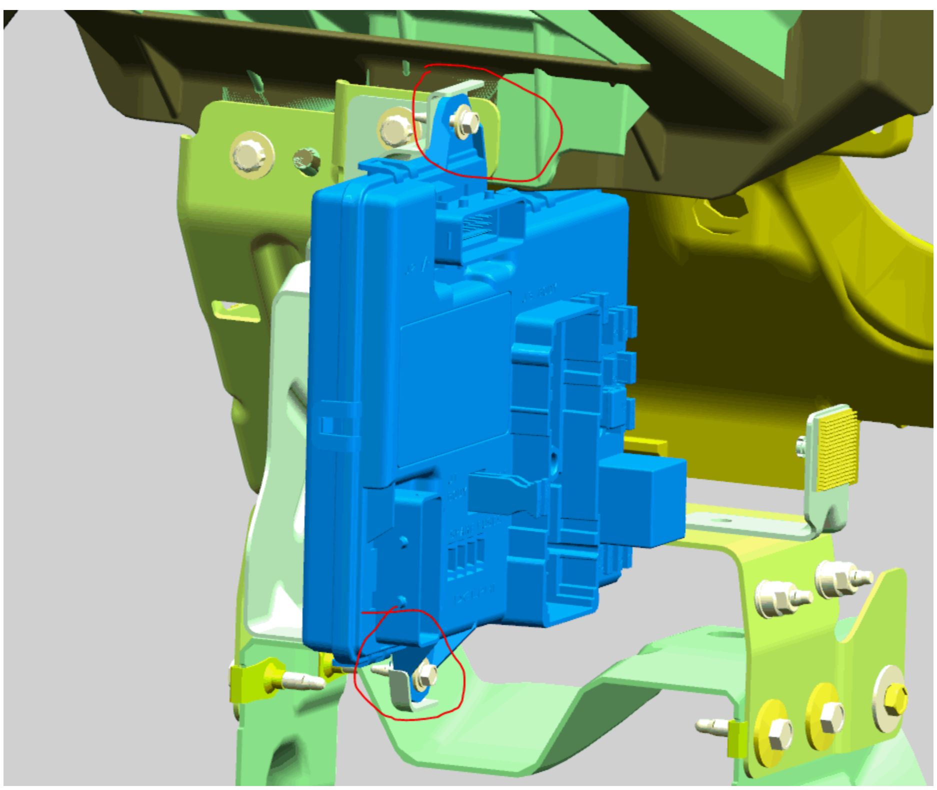
To: John C Lyons/US/GM/GMC@GM

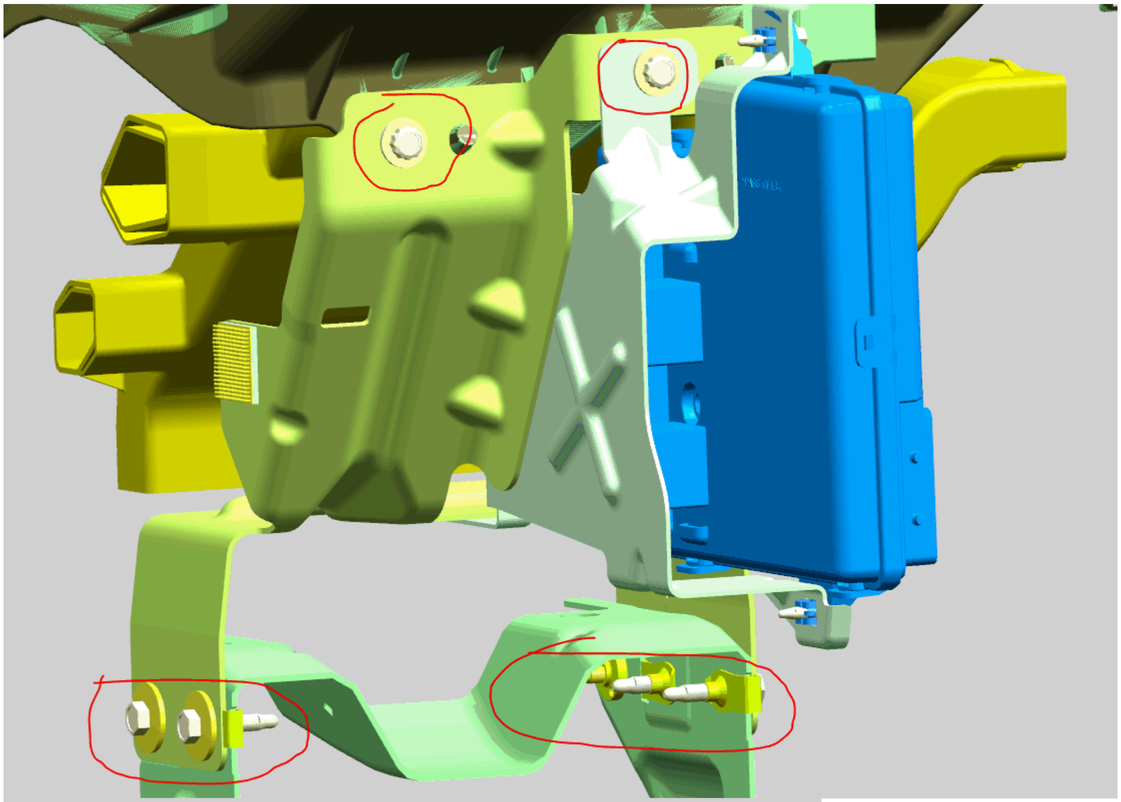
Cc: James L Duffy/US/GM/GMC@GM, Jay H. Sim/US/GM/GMC@GM, Juvenal Zavala/US/GM/GMC@GM, Thomas J. Wang/US/GM/GMC@GM, Jae L. Loman/US/GM/GMC@GM

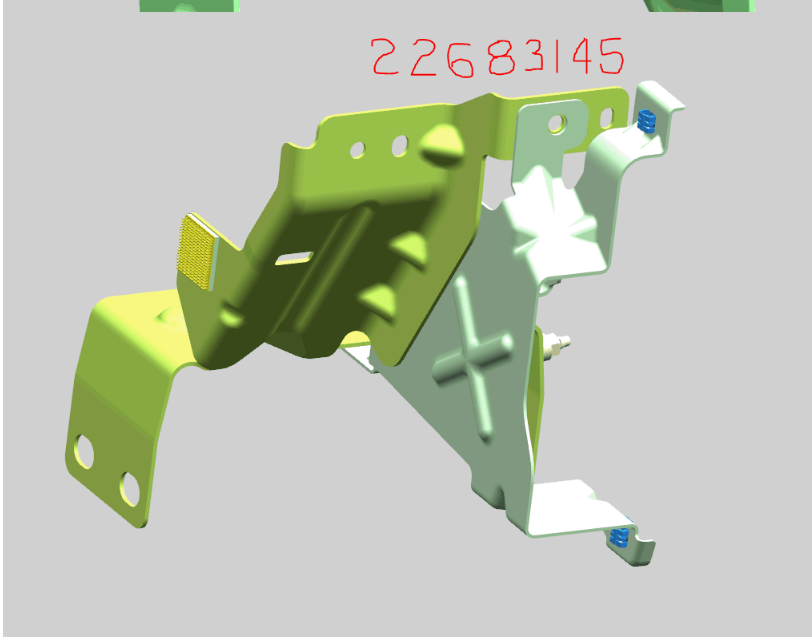
John,

The module attaches to bracket pn 22683145 with two screws. The bracket attaches to a floor pan bracket with five screws.
The bracket pn 22683145 is made up from two stamped pieces welded together. I will get confirmation regarding the welds.
I added the floor pan bracket and fasteners to file AMS43450/001.0002.

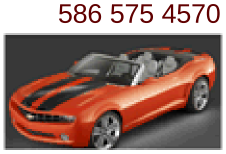
GPDS lists the mass for pn 22683145 as 1.16Kg







Brian Pedersen
Electrical Design
586 575 4570



John C Lyons	Hi all,	03/15/2013 06:22:09 PM

From: John C Lyons/US/GM/GMC
To: Jay H. Sim/US/GM/GMC@GM
Cc: Brian Pedersen/US/GM/GMC@GM, James L Duffy/US/GM/GMC@GM, Juvenal Zavala/US/GM/GMC@GM, Thomas J. Wang/US/GM/GMC@GM
Date: 03/15/2013 06:22 PM
Subject: Re: Fw: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

Hi all,

Brian provided me with an IA for the components so I have sent them to our team at GM TCI for meshing and FRF analysis.

Please confirm that mass of the module is 7.77kg and that there are only two mounting points as seen in the attachment.

Best Regards,
John

-----Jay H. Sim/US/GM/GMC wrote: -----
To: John C Lyons/US/GM/GMC@GM
From: Jay H. Sim/US/GM/GMC
Date: 03/15/2013 10:51AM
Cc: Brian Pedersen/US/GM/GMC@GM, James L Duffy/US/GM/GMC@GM, Juvenal Zavala/US/GM/GMC@GM, Thomas J. Wang/US/GM/GMC@GM
Subject: Re: Fw: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

John,

Brian Pedersen has the math data.

Jim Duffy is the DRE for the BCM.

Jay H. Sim
586-907-0329

John C Lyons---03/15/2013 10:32:40 AM---Hi Jim, Jay mentioned that you could provide me with the CAD data for the BCM bracket and module. D

From: John C Lyons/US/GM/GMC
To: James L Duffy/US/GM/GMC@GM
Cc: Thomas J. Wang/US/GM/GMC@GM, Brian Pedersen/US/GM/GMC@GM, Jay H. Sim/US/GM/GMC@GM, Juvenal Zavala/US/GM/GMC@GM
Date: 03/15/2013 10:32 AM
Subject: Fw: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

Hi Jim,

Jay mentioned that you could provide me with the CAD data for the BCM bracket and module. Do you have an IA number that will place it in vehicle?

Best Regards,
John
----- Forwarded by John C Lyons/US/GM/GMC on 03/15/2013 10:31 AM -----

From: Jay H. Sim/US/GM/GMC
To: John C Lyons/US/GM/GMC@GM
Cc: Mark Klein/US/GM/GMC@GM, James L Duffy/US/GM/GMC@GM, Juvenal Zavala/US/GM/GMC@GM, Wendy S. Keem/US/GM/GMC@GM
Date: 03/15/2013 08:26 AM
Subject: Fw: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

John,

Here is more info from Delphi. Do you have some time to talk about this and your analysis?

Jay H. Sim
586-907-0329

----- Forwarded by Jay H. Sim/US/GM/GMC on 03/15/2013 08:23 AM -----

From: Jay H. Sim/US/GM/GMC
To: Linda Matusz/US/GM/GMC@GM, Mark Klein/US/GM/GMC@GM, Juvenal Zavala/US/GM/GMC@GM, Gary Taraski/US/GM/GMC@GM, Robert A. Johncox/US/GM/GMC@GM, Bernie Slovan/US/GM/GMC@GM, James L Duffy/US/GM/GMC@GM, John A. Carriere/US/GM/GMC@GM, Timothy J. Roggenkamp/US/GM/GMC@GM, Brian Pedersen/US/GM/GMC@GM, Dale A. Furney/US/GM/GMC@GM
Date: 03/14/2013 02:53 PM
Subject: Fw: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

Jay H. Sim
586-907-0329

----- Forwarded by Jay H. Sim/US/GM/GMC on 03/14/2013 02:50 PM -----

From: "Phifer, Michael L" <michael.phifer@delphi.com>
To: "jay.h.sim@gm.com" <jay.h.sim@gm.com>
Cc: "Greib, Gary R" <gary.r.greib@delphi.com>, "Martin, Gary" <gary.martin@delphi.com>
Date: 03/14/2013 02:27 PM
Subject: Door and Hood Closure Data G6, Aura Malibu Cobalt for Chart in Slide 7

Jay, attached is the Data for the Door and, Hood closure that represents the Chart in Slide 7 of my PowerPoint.

Also included in the Excel file is GMW3172 Aug 2004 method for calculating the fretting damage (Figure 27 Page 54). (Full Spec is also attached for reference.)

Sorry, I do not have the VIN's for the vehicles.

Any questions or comments, please do not hesitate to ask.

Michael Phifer
Reliability Engineering, CRE, DFSS MBB
Delphi Corp.
Packard Electric Systems
4551 Research Parkway, MS: 97 B (CTC)
Warren, OH 44483 - 1973
Phone: 330.306.1128
(Sorry No Voice Mail)
Fax: 330.306.1096
E-Mail: Michael.Phifer@delphi.com

 [attachment "Door Hood Closure IBCM G6 Aura Malibu Cobalt (Phifer Mar 14 2013).xlsx" deleted by John C Lyons/US/GM/GMC] [attachment "GMW3172_Aug2004.pdf" deleted by John C Lyons/US/GM/GMC] [attachment "BCM_bracket.pptx" deleted by Brian Pedersen/US/GM/GMC]

Factors Influencing Fretting Corrosion of Tin Plated Contacts

Tetsuya ITO, Masato MATSUSHIMA, Kensaku TAKATA and Yasuhiro HATTORI

In recent years, there have been ever-increasing demands to miniaturize automotive connectors. However, because the contact force decreases as connectors are miniaturized further, fretting corrosion, which is a typical problem occurring with low-force electric contacts, is expected to become a more serious problem in the future. This time we developed a new experimental device capable of controlling the contact load, fretting amplitude, fretting frequency, contact part temperature and humidity. In this report, we used the design of experiments, and quantitatively evaluated the extent of the influence of the expected factor (in terms of load, amplitude, and plating thickness, etc.) on the fretting phenomenon, which occurs in the tin plating of the connector terminal. Moreover, based on SEM examination, we analyzed the surface and cross section of the contact parts when degradation occurs, and considered the mechanism of the degradation.

1. Introduction

In recent years, there has been increasing demand for wiring harness connectors in automobiles, due to the increasing volume of electronic equipment. On the other hand, for the comfort and improved convenience of the passengers, the installation space allocated for in-vehicle electronic equipment has tended to be reduced, hence the ever-increasing demand to miniaturize automotive connectors.

In addition, a decrease in terminal insertion force is desirable, for improvement in automobile assembly work. Based on these external factors, there will be ever increasing demands for reduced contact force in the future.

However, it is well known that fretting corrosion, which is a typical problem occurring with low-force electric contact, is influenced by contact force. [(1)–(5)]. Therefore, it will become a serious problem in the future, due to the decrease in contact force.

With this in mind, investigations have been carried out on the fretting corrosion of vehicle connectors [(2)–(5)], for example, the fretting corrosion of a high temperature environment, and so on.

In this report, we used the design of experiments, and quantitatively evaluated the factors influencing fretting corrosion of tin plated contacts exposed to low level contact force. Moreover, we considered the influence of tin thickness, which was one of the principal factors of our research. Based on the surface and cross section SEM observation and the contact resistance data of positional dependency, we discussed the difference in the contact resistance increase based on the tin thickness.

2. Experimental Procedure

2-1 Fretting apparatus

The fretting apparatus is schematically illustrated in **Fig. 1**, with fretting motion provided by a computer-controlled high precision motor. Amplitude, frequency, and the number of cycles were arbitrarily set. The apparatus provided a cyclic motion, with amplitude ranging from 1 to 1000μm.

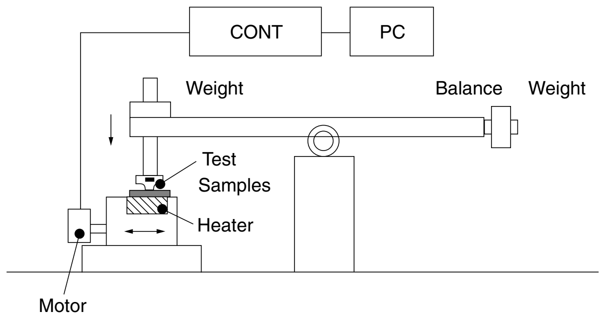


Fig. 1. Schematic Diagram of Fretting Apparatus

The contact load, which was vertical to the dimple, was applied by a dead weight set on one side of the scale bar. Test samples were maintained at the desired temperature via a heater set in the fretting stage. The setup humidity for the device was also maintained by way of a sealed case covering the device.

The test sample configuration (dimple-flat) and measuring method is schematically illustrated in **Fig. 2**.

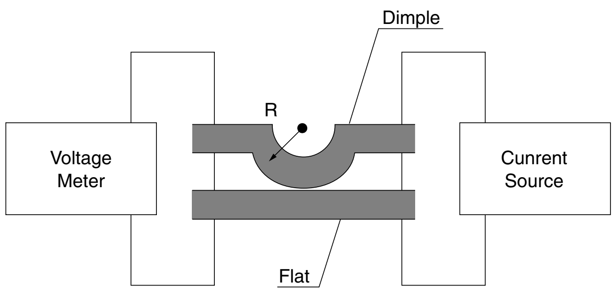


Fig. 2. Contact Configuration and Measuring Method

The test sample materials are 1μm, 5μm electroplated tin over Cu alloy (of thickness 0.25mm). The dimple radii are 1mm and 3mm, respectively.

Contact resistance was measured according to the 4 wire method (current 10mA, maximum voltage 1V). Contact resistance readings were taken at setup measurement points along the contact area, with bidirectional motion, and the readings were recorded on a computer.

2-2 Experimental Procedures

We used the design of experiments, and quantitatively evaluated the influence of the control factor on the fretting corrosion. The controlled factors and levels are listed in **Table 1**. The eight controlled factors thought to influence the fretting corrosion, were selected: tin thickness, temperature, humidity, load, amplitude, frequency, dimple diameter, and aged/brand-new, whereas an orthogonal array L12 (eleven controlled factors and 2 levels of each factor) was selected for the design of experiments. We selected only eight factors of eleven, so factors I~K were not in use.

Aged samples (factor H) were placed under accelerated test conditions, equivalent to 10 years of use: temperature 120deg C, humidity 34% RH, test time 300hours [6]. The twelve combinations of factors are listed in **Table 2** and they were carried out in random order. Based on the result, we conducted further examination of the main factors causing an increase in contact resistance.

Table 1. Control Factors and Levels

	Factor	Level 1	Level 2
A	Tin thickness (μm)	1	5
B	Temperature (deg C)	25	140
C	Humidity (%RH)	50	80
D	Load (N)	1	3
E	Amplitude (μm)	50	100
F	Frequency (Hz)	0.1	1
G	Dimple Diameter (mm)	1	3
H	Aged/Brand-new	Aged	Brand-New
I	Unused	–	–
J	Unused	–	–
K	Unused	–	–

Table 2. Experimental Design Layout-L12

No	A	B	C	D	E	F	G	H	I	J	K
1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	2	2	2	2	2	2
3	1	1	2	2	2	1	1	1	2	2	2
4	1	2	1	2	2	1	2	2	1	1	2
5	1	2	2	1	2	2	1	2	1	2	1
6	1	2	2	2	1	2	2	1	2	1	1
7	2	1	2	2	1	1	2	2	1	2	1
8	2	1	2	1	2	2	2	1	1	1	2
9	2	1	1	2	2	2	1	2	2	1	1
10	2	2	2	1	1	1	1	2	2	1	2
11	2	2	1	2	1	2	1	1	1	2	2
12	2	2	1	1	2	1	2	1	2	2	1

3. Results and Discussion

3-1 L12 examination

1000 cycle fretting motion experiments were carried out for each combination and the maximum contact resistance during the 1000 cycle motion was used as a characteristic parameter. The factor effect chart obtained from the examination result is shown in **Fig. 3**. In this figure, the X-axis indicates the examination factor and the Y-axis indicates sensitivity [dB] as a standard, via which the mean value is evaluated.

It is clear that tin thickness and load have a higher impact on contact resistance than the other control effect. No significant difference was found between other factors in this examination result. It is likely that they were influenced by factors such as tin thickness and load showing higher impact, and hence were buried in the difference. We think that the low sensitivity of the other factors is caused by the fretting rate at which an oxidation reaction proceeds.

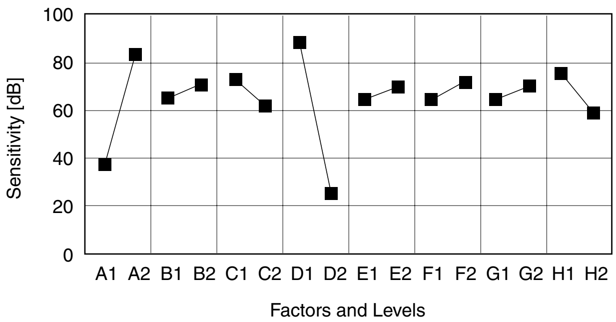


Fig. 3. Factor Effect Chart of L12

3-2 Detailed examination

Next, the parameters were limited to the load and tin thickness to clarify the effect of these two factors and extra examination was carried out.

The contact resistance was measured as a test condition by each of two levels in load (1N, 3N) and tin thickness (1μm, 5μm). Other factors were fixed to the condition shown in **Table 3**. The result is shown in **Fig. 4**.

Based on the results, we can observe the following tendencies:

(1) Tin thickness: Under the load 1N and 3N, there is considerable difference in the resistance based on the tin thickness.

(2) The load: The influence of the load on the increase in resistance is considerable, at thicknesses of either 1 or 5μm.

Table 3. Test Conditions

Factor	Level	Factor	Level
Load (N)	1,3	Humidity (%RH)	50
Plate thickness (µm)	1,5	Frequency (Hz)	1
Amplitude (µm)	50	Dimple Diameter (mm)	1
Temperature (deg C)	25	Aged/Brand-new	New

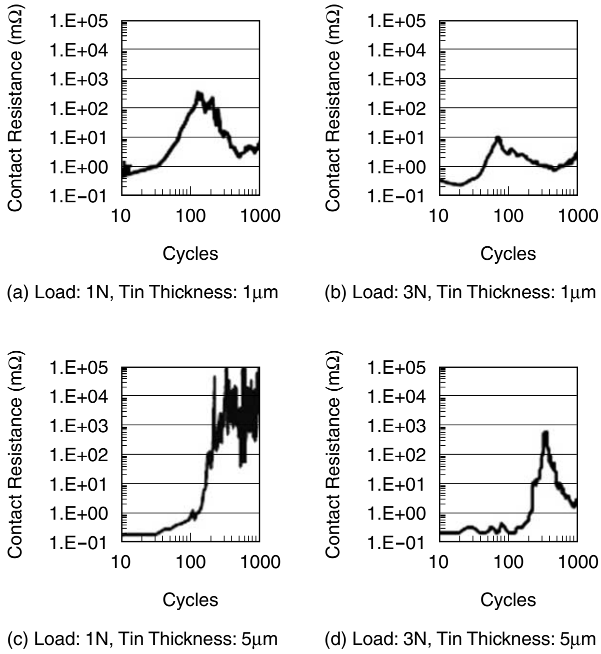


Fig. 4. Detailed Examination Results

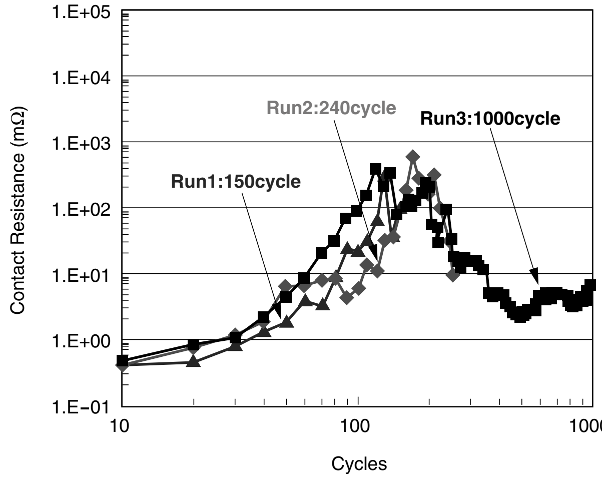


Fig. 5. Contact Resistance versus Cycles (Tin Thickness 1µm)

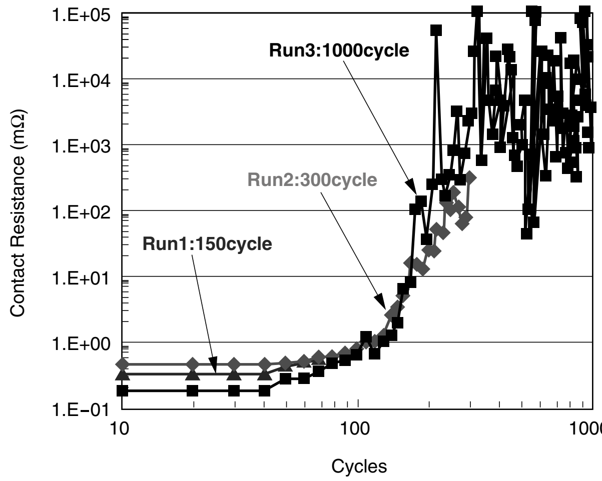


Fig. 6. Contact Resistance versus Cycles (Tin Thickness 5µm)

3-3 Influence of plating thickness on the fretting corrosion

The influence of the load on the fretting corrosion has been discussed [(1)–(5)], but the influence of the tin thickness on fretting corrosion, which showed a significant impact next to the load, remains unclear. Therefore, we would like to focus our attention on the influence of the tin thickness on the fretting corrosion.

(1) SEM observation

Based on SEM examination, we analyzed the surface and cross section of the 1 and 5 µm tin thickness contact parts of various cycles when the contact resistance increased. **Figs. 5 and 6** show the measured contact resistance (load 1N, other factors were fixed to the condition shown in **Table 3**, using cycles as a parameter) versus fretting cycles at tin thicknesses of 1 and 5µm. The measurement result in each cycle was approximately consistent, and reproducibility under each condition was confirmed.

The surface and cross-section SEM photographs of tin thicknesses of 1 and 5µm are shown in **Figs. 7 and 8**. The cross-section SEM photographs show that tin coatings consist of a soft layer of tin (white color) and uneven intermetallic compounds (light grey color) shown in **Figs. 7 (a) and 8 (a)**. As shown in **Figs. 7 (b) and 8 (b)**, the tin oxidation progresses from the contact surface of each tin thickness, as the fretting cycle and contact resistance increase.

We compared actual contact resistance measurement values to calculated values, which were calculated by the film resistance equation (1) using the values of the measured contact area and tin oxide film thickness obtained from **Figs. 7 and 8**. **Table 4** shows the result of the measurement value and the calculated value of each tin thickness. As a formula, we used the electrical resistivity of tin oxide (=6.7×10 (Ωm)) from ref [(7)]. As a result, the value of the actual measurement was 10^{-4} orders less than each plating thickness calculation.

$$R_f = \frac{\rho_f \times d}{\pi \times \alpha^2} \quad \cdots\cdots (1)$$

ρ_f : Film electrical resistivity
d : Film thickness
α : Contact area radius

The reason why the difference occurred is considered as follows.

Although we calculated the film contact resistance using the tin oxide value as an electrical resistivity of film, but since it is undergoing tin oxidation, tin, (which possesses low electrical resistivity (=11.4×10^{-6})), exists in parts of the contact area. As a result, the actual contact resistance was low.

(2) Positional dependency on the contact resistance

Based on the surface observation of **Figs. 7 and 8**, fretting debris could be seen piled up outside the contact area. Thus, we suspect that the external edge contact resistance may have exceeded the internal contact resistance.

Therefore we analyzed the contact resistance along the contact area, defining the measuring points as a positional phase, which is shown in **Fig. 9**. It means that the contact resistance measurement per cycle begins from the center of the contact area (= phase 0) via left (= phase $\pi/2$), center (= phase π), right (= phase $3\pi/2$), to center (= phase 2π).

To take some example, **Fig. 10 (a) and (b)** each show the positional dependency of the resistance at each cycle at tin thicknesses of 1and 5μm respectively.

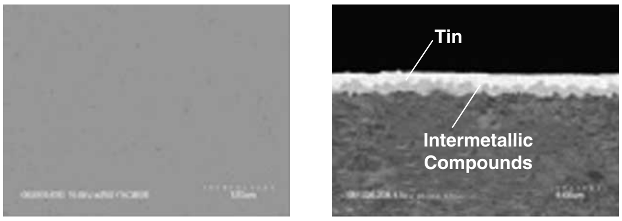
Based on these results, we found the following:

(1) When contact resistance is low, the positional dependency of the contact resistance is slight.

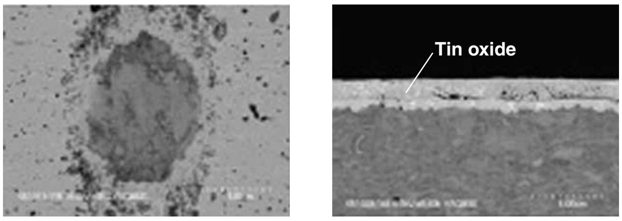
(2) When contact resistance is high, there is positional dependency of the contact resistance. However, although the contact resistance of the contact area tends to be slightly high on both sides, this is not a clear-cut tendency.

Furthermore, the results of the surface EPMA mapping analysis of oxide are shown in **Fig. 11** (tin thickness 1μm: 10 and 150cycle and tin thickness 5μm: 10 and 300cycle). Although from the results, there are some concentration differences of the oxygen density, we can observe that the whole contact area has oxidized.

Based on the cross-section observation, the contact resistance data of positional dependency and the surface EPMA mapping of oxide, contact resistance is likely to increase as a result of the fretting debris placed between the entire contact area, rather than the external fretting debris of the contact area. Therefore, it is concluded that the difference in the contact resistance increase based on the tin thickness is caused by the extent of the tin oxidation film thickness, as shown in **Fig. 12**.

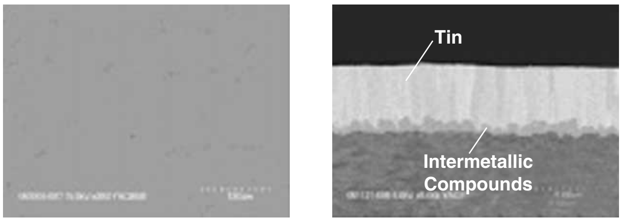


(a) 0cycle

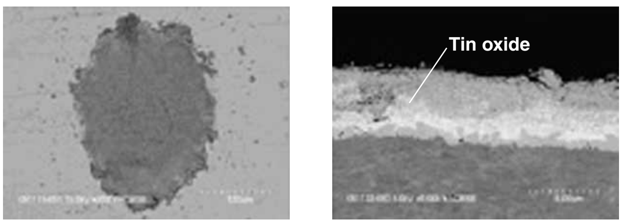


(b) 150cycle

Fig. 7. Surface (Left) and Cross Section (Right) of SEM (Tin Thickness 1μm)



(a) 0cycle



(b) 300cycle

Fig. 8. Surface (Left) and Cross Section (Right) of SEM (Tin Thickness 5μm)

Table 4. Actual and Calculated Value of Contact Resistance

Thickness (μm)		Contact Resistance (mΩ)	
Tin	Tin Oxide	Measurement	Calculation
1 + 1	1.8	1.1×10^{-1}	4.1×10^{3}
5 + 5	3.5	3.4×10^{-1}	5.2×10^{3}

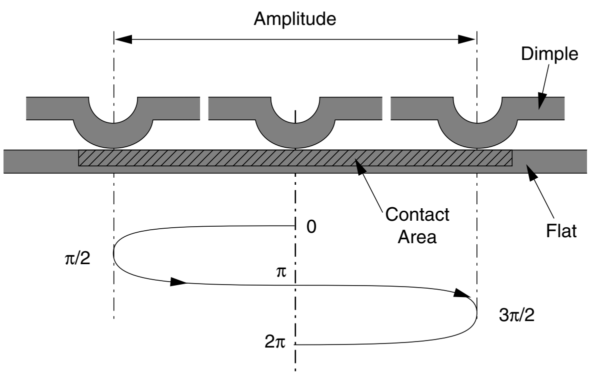
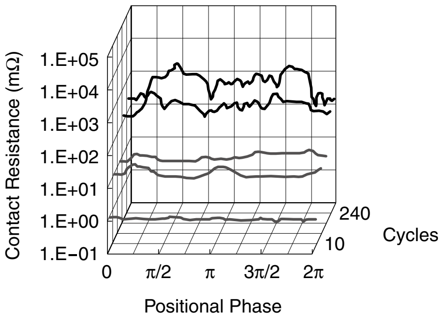
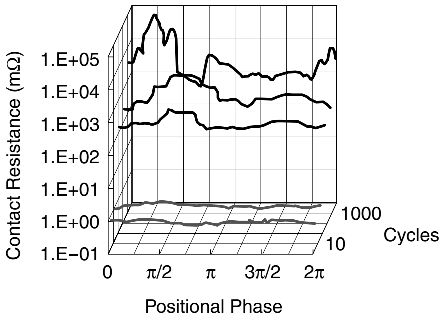


Fig. 9. Definition of Positional Phase

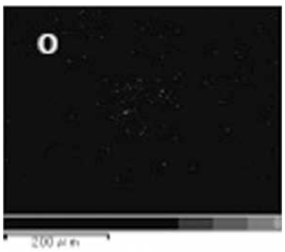


(a) Tin thickness: 1μm

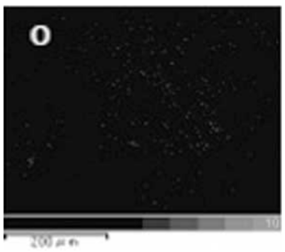


(b) Tin thickness: 5μm

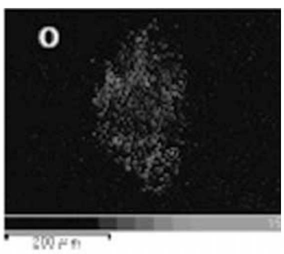
Fig. 10. Positional Dependency on the Contact Resistance



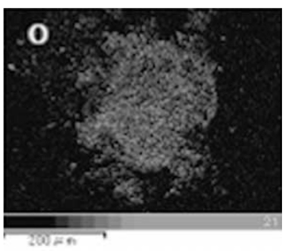
(a) 10cycle (Tin Thickness 1μm)



(b) 10cycle (Tin Thickness 5μm)

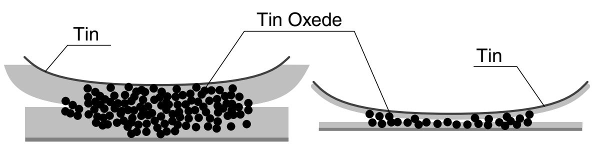


(c) 150cycle (Tin Thickness 1μm)



(c) 300cycle (Tin Thickness 5μm)

Fig. 11. Surface EPMA mapping of Oxide



(a) 5μm (b) 1μm

Fig. 12. Difference in the Oxidation Model of Tin Film Thickness 5μm/1μm

4. Conclusions

(1) Based on the experimental design and extra experiments, it was found that load and tin thickness have a high impact on the increase in contact resistance caused by fretting corrosion.

(2) We examined the surface and cross-section using SEM and positional dependency relative to contact resistance. Consequently, it seemed likely that the difference in the contact resistance increase by tin thickness was caused by the amount of tin oxidation film thickness.

References

(1) J. M. Hooyer, and K. Peekstok. "THE Influence of Practical Contact Parameters of Fretting Corrosion of Tin-Bass Low-Level Connector Contacts", Proc. Holm Conf on Electrical Contacts, 1987, p. 43.

(2) A. Lee, M. S. Mamrick, and A. Mao. "Fretting Corrosion of Tin at Elevated Temperatures", Proc. Holm Conf on Electrical Contacts, 1988, p. 87.

(3) A. Lee. "Thermal Cycling Induced Wiping Wear of Connector Contacts at 150 degrees C", Proc. Holm Conf on Electrical Contacts, 1997, p. 132.

(4) J. L. Queffelec, N. BEN Jemma, and D. Travers. "MATERIALS AND CONTACT SHAPE STUDIES FOR AUTOMOBILE CONNECTOR DEVELOPMENT", Proc. Holm Conf on Electrical Contacts, 1990, p. 225.

(5) J. Swingler, and J. W. McBride. "The Degradation of Road Tested Automotive Connectors", Proc. Holm Conf on Electrical Contacts, 1999, p. 146

(6) Y.Sugiyama, et al. "Research on Vehicle Connector Aging Accelerated Test", SAE INTERNATIONAL, 1999.

(7) Fukuda, Nakajima, and Isono. "Journal of the Japan Copper and Brass Research Association Vol. 26", 1987, p.174

Contributors (The lead author is indicated by an asterisk (*)).

T. ITO*

- Basic Technology R&D Department, Circuits and Connection R&D Division, AutoNetworks Technologies, Ltd.

M. MATSUSHIMA

- Basic Technology R&D Department, Circuits and Connection R&D Division, AutoNetworks Technologies, Ltd.

K. TAKATA

- Manager, Basic Technology R&D Department Circuits and Connection R&D Division, AutoNetworks Technologies, Ltd.

Y. HATTORI

- Senior Manager, Basic Technology R&D Department Circuits and Connection R&D Division, AutoNetworks Technologies, Ltd.

Safety Recall Statement

General Motors Corporation

GM Communications
Detroit, Mich., USA
media.gm.com

January 23, 2009

For use in response to media queries. Not for external distribution.

For additional information, contact:
Dan Flores – (cell) 313-418-2374, (work) 313-665-4629, daniel.flores@gm.com

Recall date: January 2009

Models involved: 2005-06 Pontiac G6

Number of vehicles involved: 9,416

Dates of manufacture: ~~TBD~~January 1, 2005 – January 31, 2005

Regions involved: GMNA

Description of condition: Fretting corrosion can occur in the body control module C2 wiring connector that can cause an increase in resistance, which results in a lower brake apply sensing signal voltage to the body control module. Vehicles with this BCM connector fretting corrosion may experience the following conditions:

- The brake lamps may illuminate when the brake pedal has not been depressed, or the lamps may not illuminate when the brake pedal is depressed,
- The cruise control may not engage,
- Additional brake pedal travel would be required to remove the gear shift mechanism from PARK

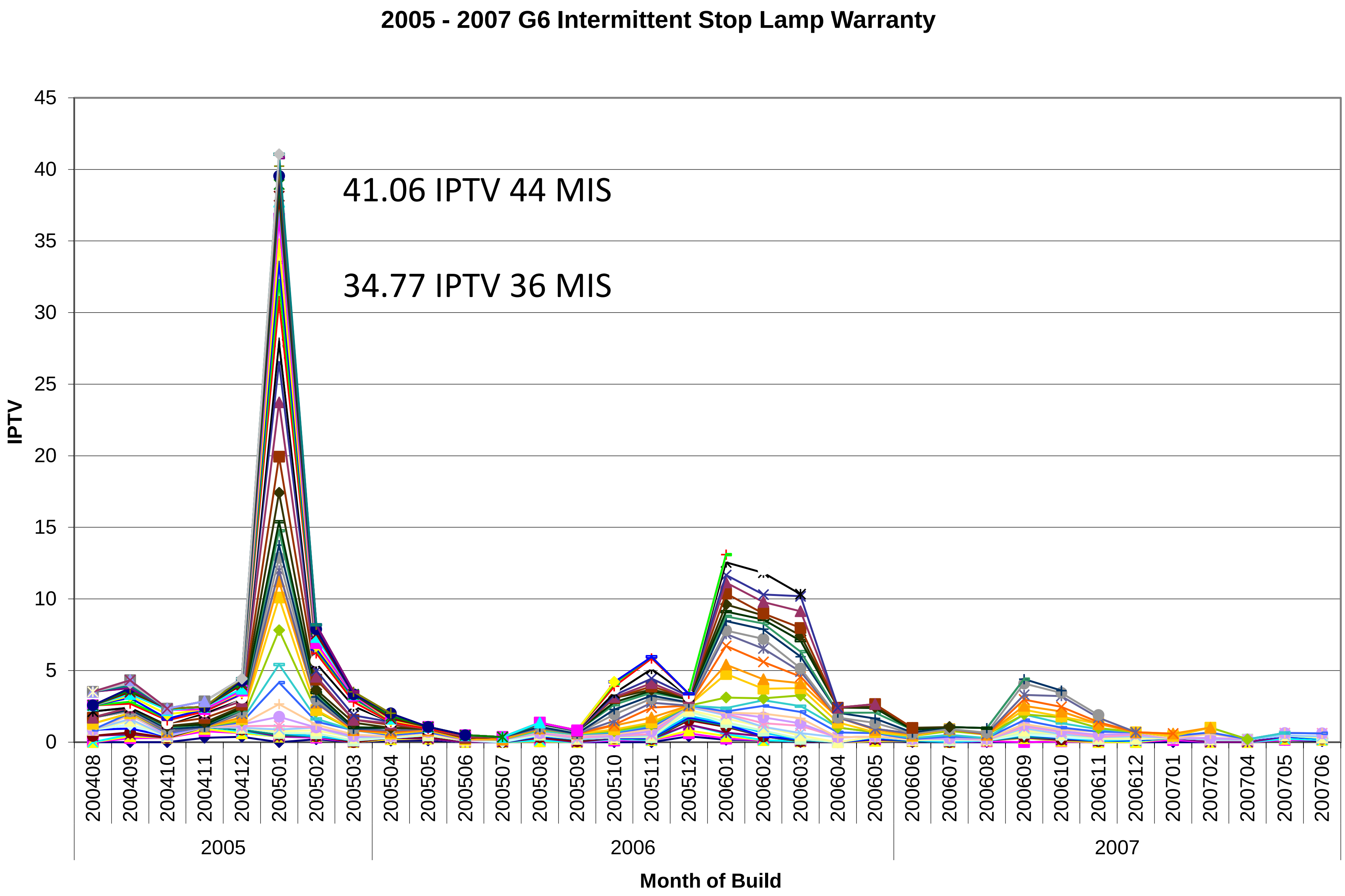
Remedy: Dealers are to apply a dielectric lubricant to the connector to repair and prevent fretting corrosion.

Dealer and customer contact dates: TBD

Accidents, injuries or deaths: N/A

Other relevant information:

GM does not discuss supplier involvement in recalls because the final product comes from General Motors.


2005 - 2007 G6 Intermittent Stop Lamp Warranty
41.06 IPTV 44 MIS
34.77 IPTV 36 MIS
IPTV
45
40
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25
20
15
10
5
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200408
200409
200410
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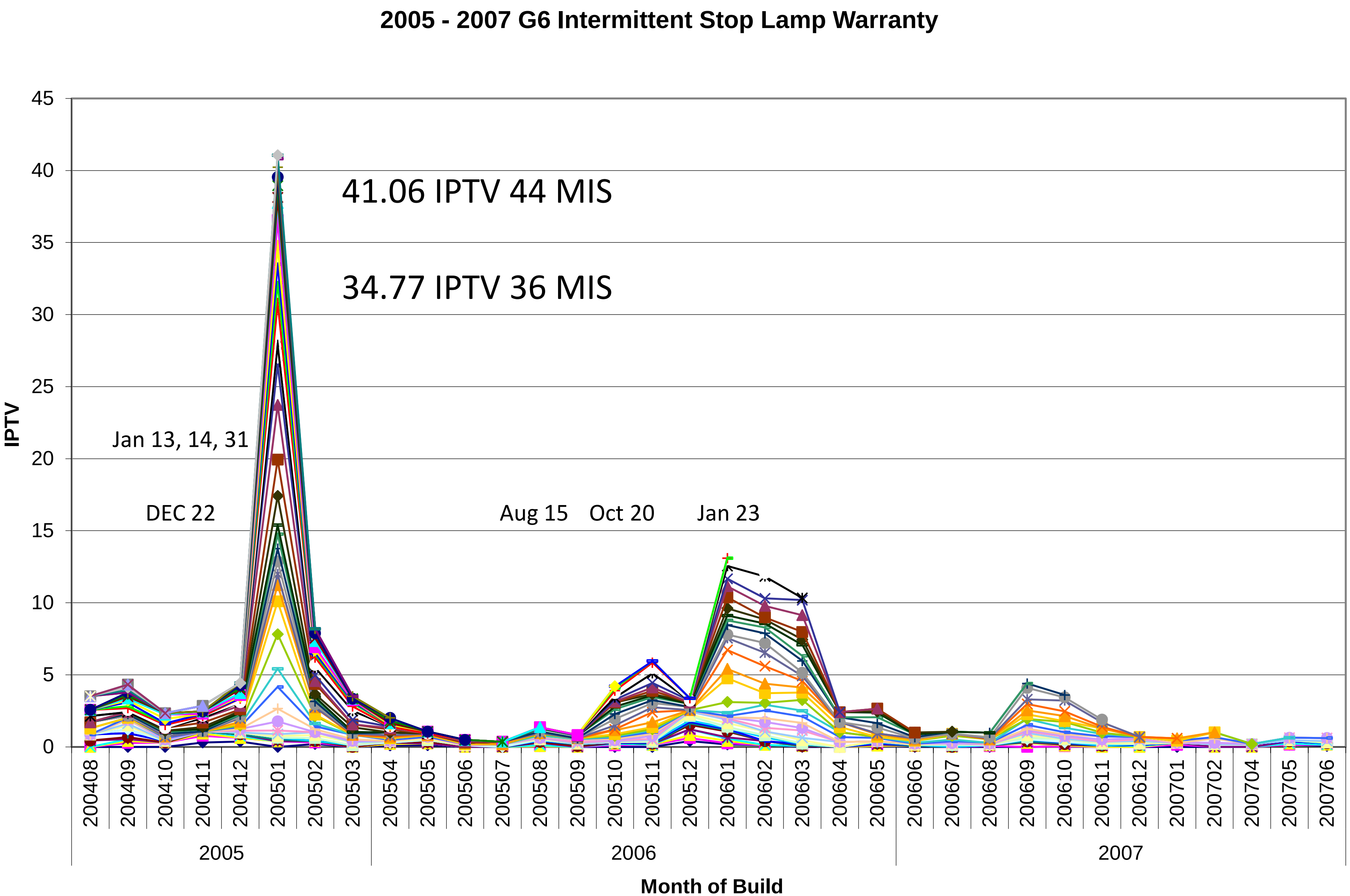
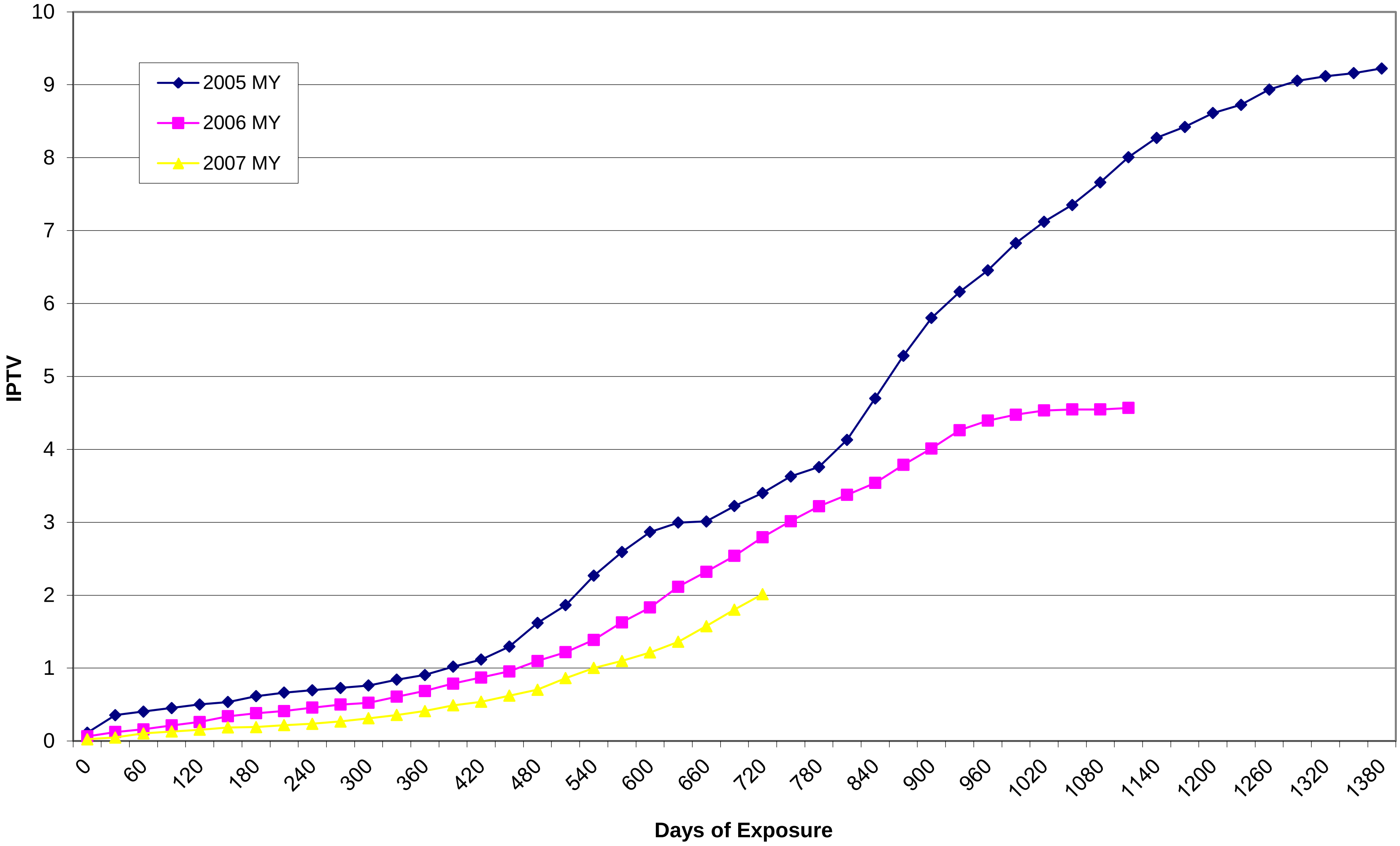
2006
2007
Month of Build



9 VOQs 2005MY: 4 2006MY: 4 2007MY: 1

20 VOQs 2005MY: 11 2006MY: 7 2007MY: 2

2005 - 2007 G6 Intermittent Stop Lamp Warranty



Back-up

Model Year Production Volume: U.S. Only

Make/ Model	2004MY	2005 MY	2006 MY	2007 MY	Total
Pontiac G6		62,481	170,394	164,307	397,182
Chevrolet Malibu	111,618	187,230	186,103	134,046	618,997
Total	111,618	249,711	356,497	298,353	1,016,179

Weekly Production Volume for the Month of January 2005: U.S. and Canada

Make/ Model	Week 03JAN05	Week 10JAN05	Week 17JAN05	Week 24JAN05	Day 31JAN05	Total
Pontiac G6	2,374	2,334	1,826	2,272	475	9,281
Chevrolet Malibu	3,673	3,843	2,988	4,282	854	15,640
Total	6,047	6,177	4,814	6,554	1,329	24,921

11. Furnish GM's assessment of the alleged defect in the subject vehicles, including:

- **a. The causal or contributory factor(s);**
- **b. The failure mechanism(s);**
- **c. The failure mode(s);**
- **d. The risk to motor vehicle safety that it poses;**
- **e. What warnings, if any, the operator and other persons both inside and outside the vehicle would have that the alleged defect was occurring or subject component was malfunctioning; and**
- **f. The reports included with this inquiry.**

General Motors is continuing its investigation of the alleged defect. GM has no reports of crashes, injuries or fatalities as a result of the alleged defect.

The suspected causal and/or contributory factor, failure mechanism and the associated failure modes are described in the
following summary:

The Body Control Module (BCM) receives a Brake Apply Sensor (BAS) signal voltage and uses that signal to activate or deactivate the brake lamps. The suspected failure mechanism is fretting corrosion at the terminal interface between the BCM and the instrument panel harness of the BAS circuits. Fretting corrosion causes an increase in resistance that result in a lower BAS signal voltage to the BCM.

Additionally, a door and hood closure shudder response clinical study determined that fretting corrosion was heightened for G6 model in comparison to Malibu and Aura models. Three accelerometers were placed on the BCM mounting bracket to measure the "g" force relative to two connectors and mounting hinge of the BCM. The relative "g' force vectors in three dimensions were measured and compared for all three models. The clinical study resulted that G6 model had 3.5 to 3.9 times of the g-force shudder reaction where Malibu model had 2.1 time and Aura model had 1.9 time of the g-force shudder reaction. Therefore, G6 model has heightened fretting corrosion in comparison to Malibu and Aura models.

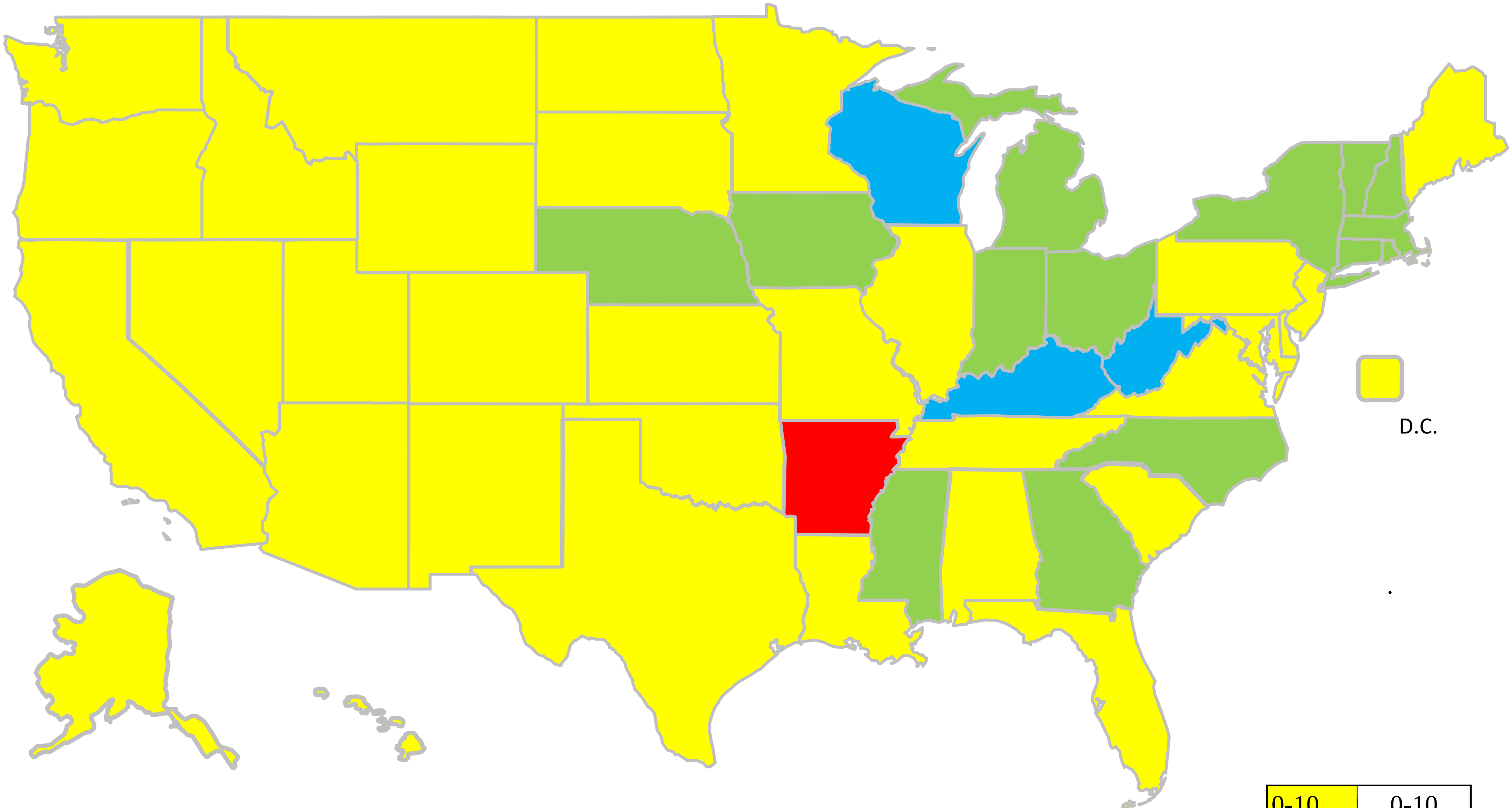
As shown in Figure 13-1, when the signal voltage drops into a range that is above 0.49 volts, but below 0.13 volts below the learned home position, the BCM activates the brake lamps after five seconds. They remain activated while the signal voltage is in this range. When the brake pedal is depressed, the brake lamps are deactivated once the signal voltage rises above 0.13 volts below the learned home position. Depressing the brake pedal farther will activate the brake lamps once the signal voltage rises above 0.25 volts past the learned home position. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

The BCM control of the brake lamps goes into a different mode if the signal voltage drops below 0.49 volts. This condition indicates an "open circuit" and the BCM sets a diagnostic trouble code. In this mode, the BCM activates the brake lamps once the vehicle is shifted from PARK. The brake lamps will be deactivated anytime the vehicle speed is above 2 kph, is accelerating, and the throttle is engaged at least 20%. In this mode, the transmission converter clutch will not engage and operators may notice that the cruise control will also not engage. While in PARK, with the key in the ACCESSORY or RUN positions and the shifter button depressed, the BCM energizes the Brake Transmission Shift Interlock solenoid so that the shift mechanism can be moved from the PARK position.

DIAGRAM REMOVED

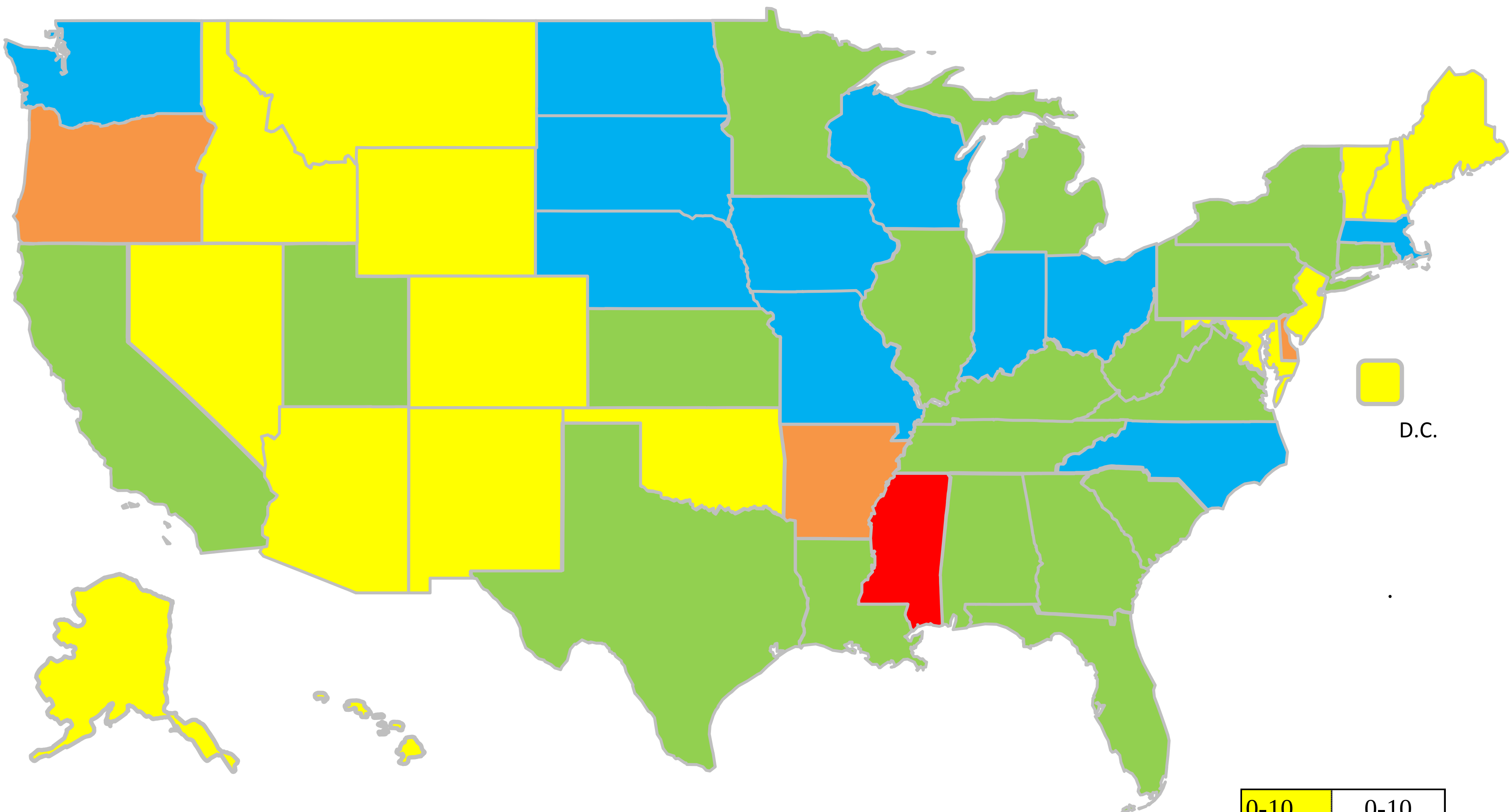
✷ ✷ ✷

2007MY Saturn Aura IPTV



0-10	0-10
11-20	11-20
21-30	21-30
31-40	31-40
41-50	41-50

2008MY Saturn Aura IPTV



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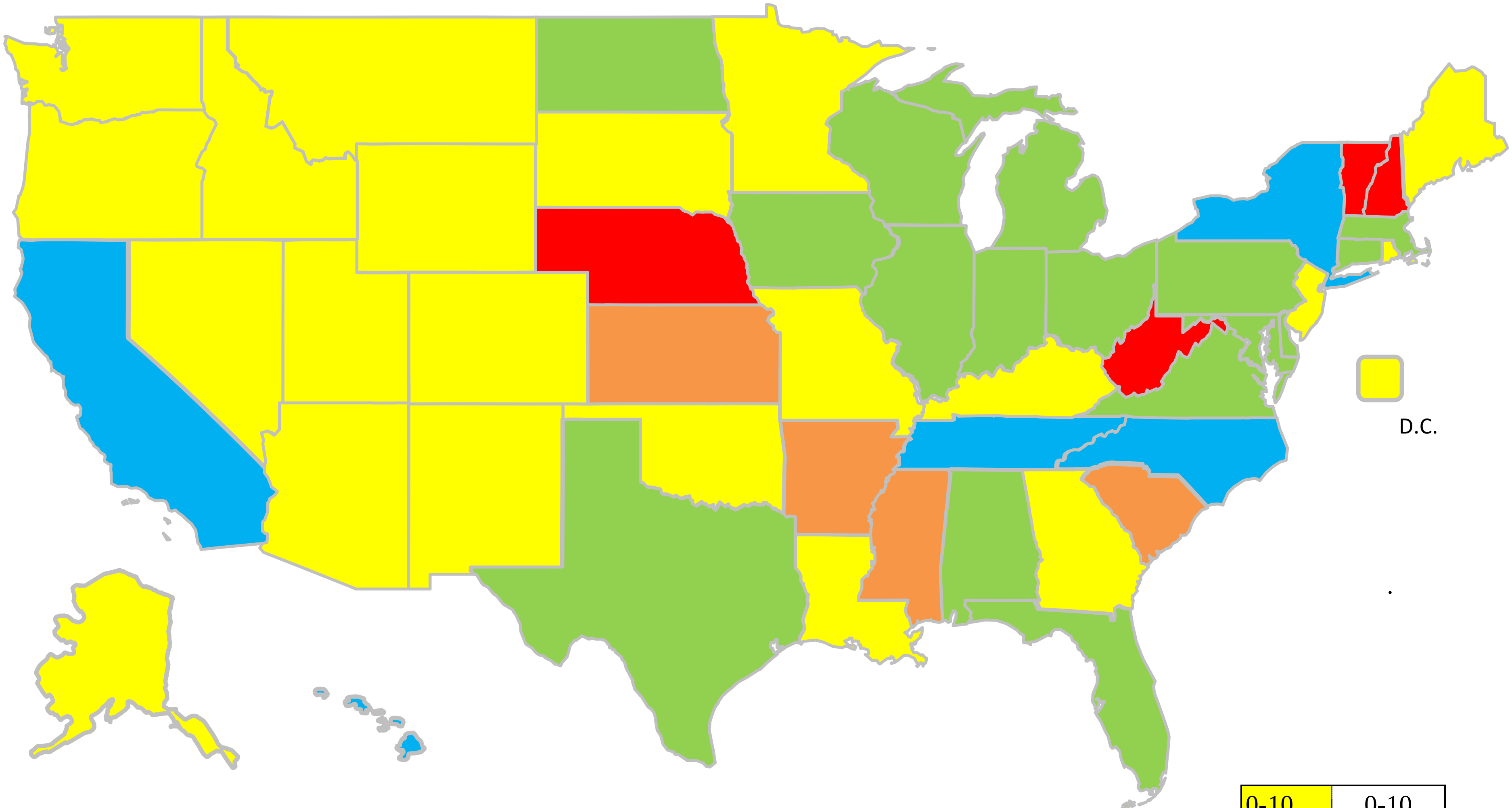
21-30	21-30
31-40	31-40
41-50	41-50

2009MY Saturn Aura IPTV



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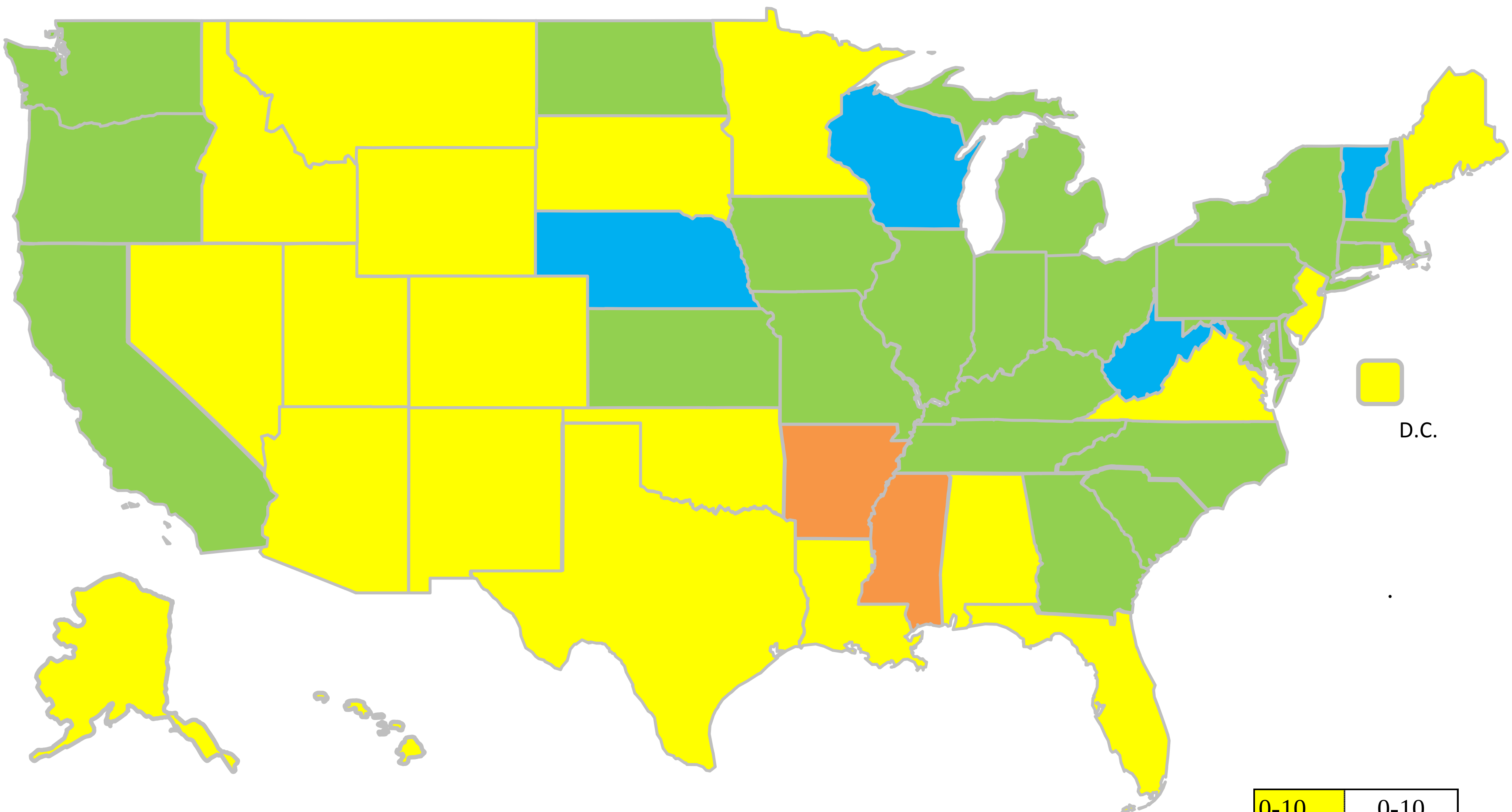
31-40	31-40
41-50	41-50

2007-2009MY Saturn Aura Average IPTV

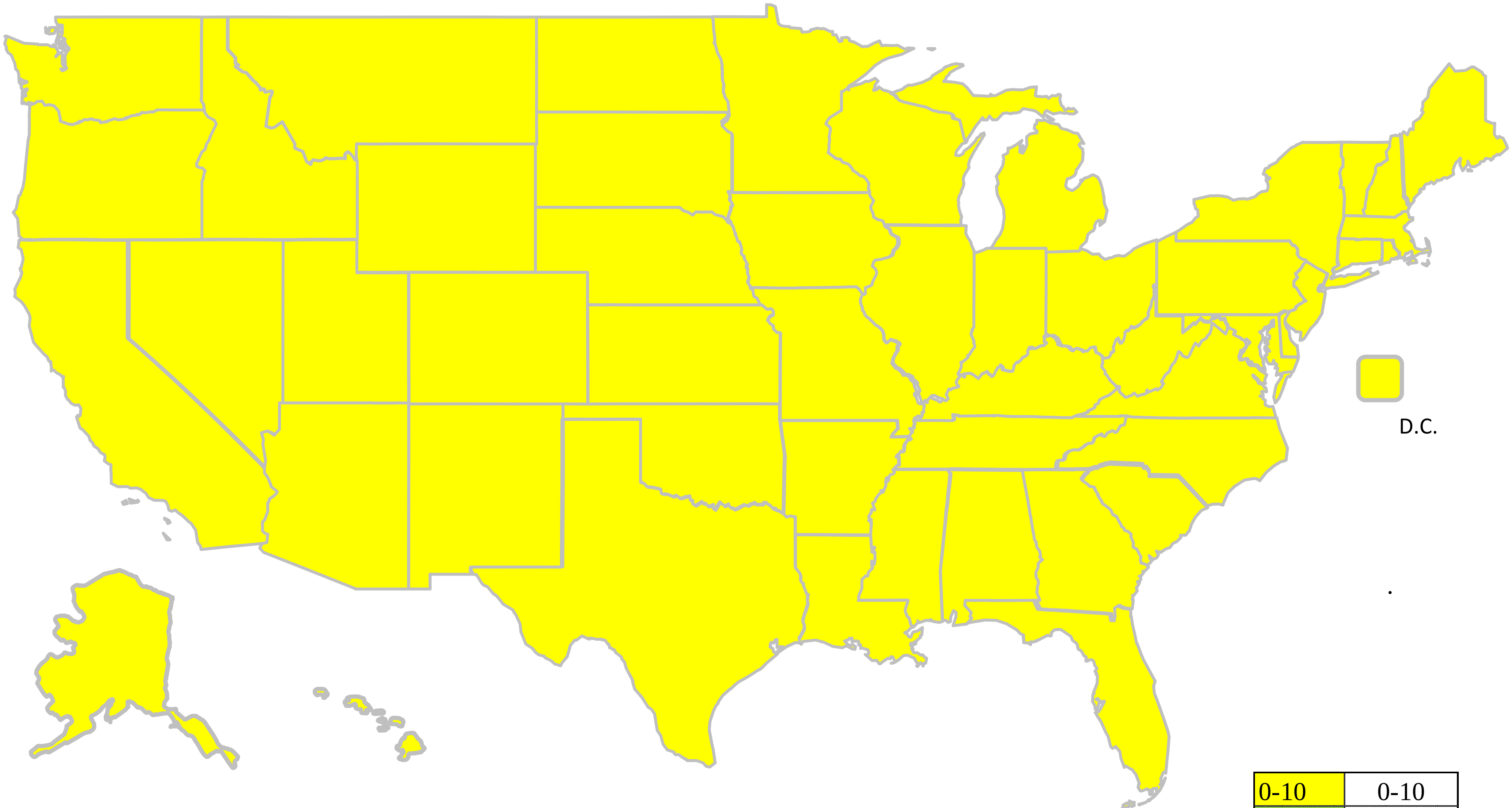


0-10	0-10
11-20	11-20
21-30	21-30
31-40	31-40
41-50	41-50

2007-2009MY Saturn Aura IPTV Table

	STATE	2007	2008	2009	2007-09MY Average
Alaska	AK	0.00	0.00	0.00	0.00
Alabama	AL	5.10	10.47	10.64	8.09
Arkansas	AR	43.17	37.97	30.77	38.87
Arizona	AZ	0.00	5.26	0.00	1.31
California	CA	5.33	15.81	22.10	10.44
Colorado	CO	6.85	5.18	4.13	5.73
Connecticut	CT	10.90	15.34	15.43	13.16
District_of_Columbia	DC				
Delaware	DE	0.00	33.33	13.33	12.12
Florida	FL	4.30	18.82	12.51	9.04
Georgia	GA	11.78	11.74	5.05	10.03
Hawaii	HI	0.00	0.00	29.41	3.76
Iowa	IA	12.82	21.82	13.57	15.56
Idaho	ID	9.71	0.00	0.00	6.49
Illinois	IL	6.89	12.09	17.27	11.15
Indiana	IN	12.36	25.50	17.52	16.98
Kansas	KS	9.12	14.44	31.09	14.73
Kentucky	KY	20.56	16.39	6.49	15.64
Louisiana	LA	9.79	11.93	7.59	9.81
Massachusetts	MA	10.81	21.96	19.74	15.48
Maryland	MD	9.83	9.72	15.47	11.15
Maine	ME	9.62	0.00	0.00	4.57
Michigan	MI	11.99	16.82	15.33	14.64
Minnesota	MN	6.35	10.54	6.93	8.09
Missouri	MO	9.10	26.32	4.88	12.55
Mississippi	MS	17.54	50.00	34.48	30.17
Montana					
North_Carolina	NC	10.30	26.49	27.07	17.85
North_Dakota	ND	7.19	21.74	18.87	14.08
Nebraska	NE	10.26	20.62	50.00	21.51
New_Hampshire	NH	14.93	0.00	46.30	19.09
New_Jersey	NJ	5.28	5.13	9.07	6.20
New_Mexico	NM	0.00	0.00	0.00	0.00
Nevada	NV	0.00	8.23	0.00	1.74
New_York	NY	14.03	14.78	21.60	15.61
Ohio	OH	14.69	26.40	15.99	18.18
Oklahoma	OK	0.00	1.16	0.70	0.63
Oregon	OR	6.64	38.46	9.43	15.99
Pennsylvania	PA	7.94	17.16	16.46	12.63
Rhode_Island	RI	10.58	16.13	0.00	8.80
South_Carolina	SC	7.35	11.56	31.25	14.12
South_Dakota	SD	0.00	21.51	0.00	7.81
Tennessee	TN	9.73	14.20	24.96	14.43
Texas	TX	6.31	11.16	11.54	8.62
Utah	UT	6.01	19.23	7.25	8.70
Virginia	VA	4.43	18.91	13.11	9.22
Vermont	VT	18.99	8.62	51.95	22.79
Washington	WA	7.45	25.27	9.66	11.64
Wisconsin	WI	20.93	22.09	16.87	20.38
West_Virginia	WV	21.62	12.99	57.14	27.11
Wyoming	WY	0.00	0.00	0.00	0.00

2004MY Chevrolet Malibu IPTV



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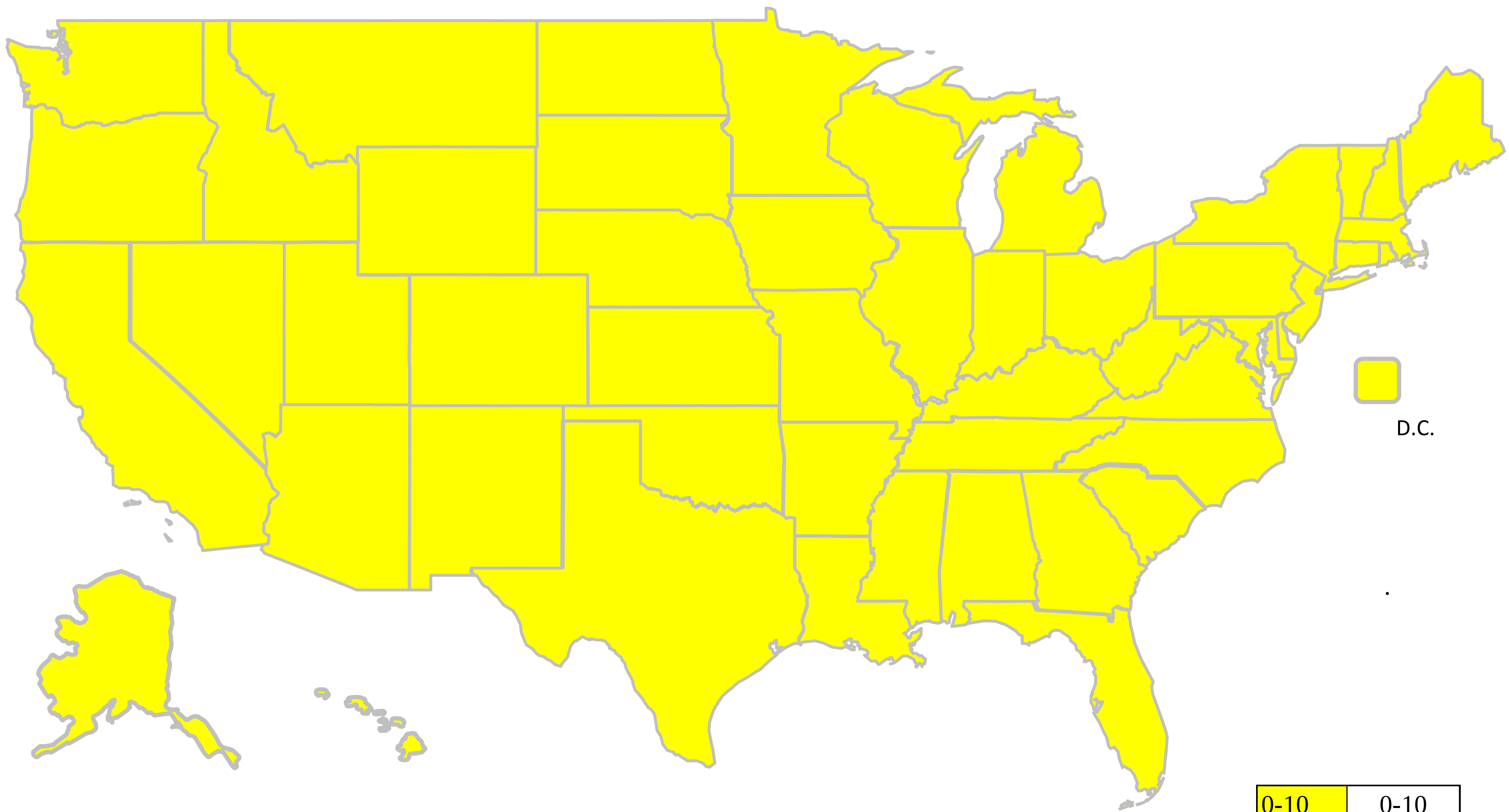
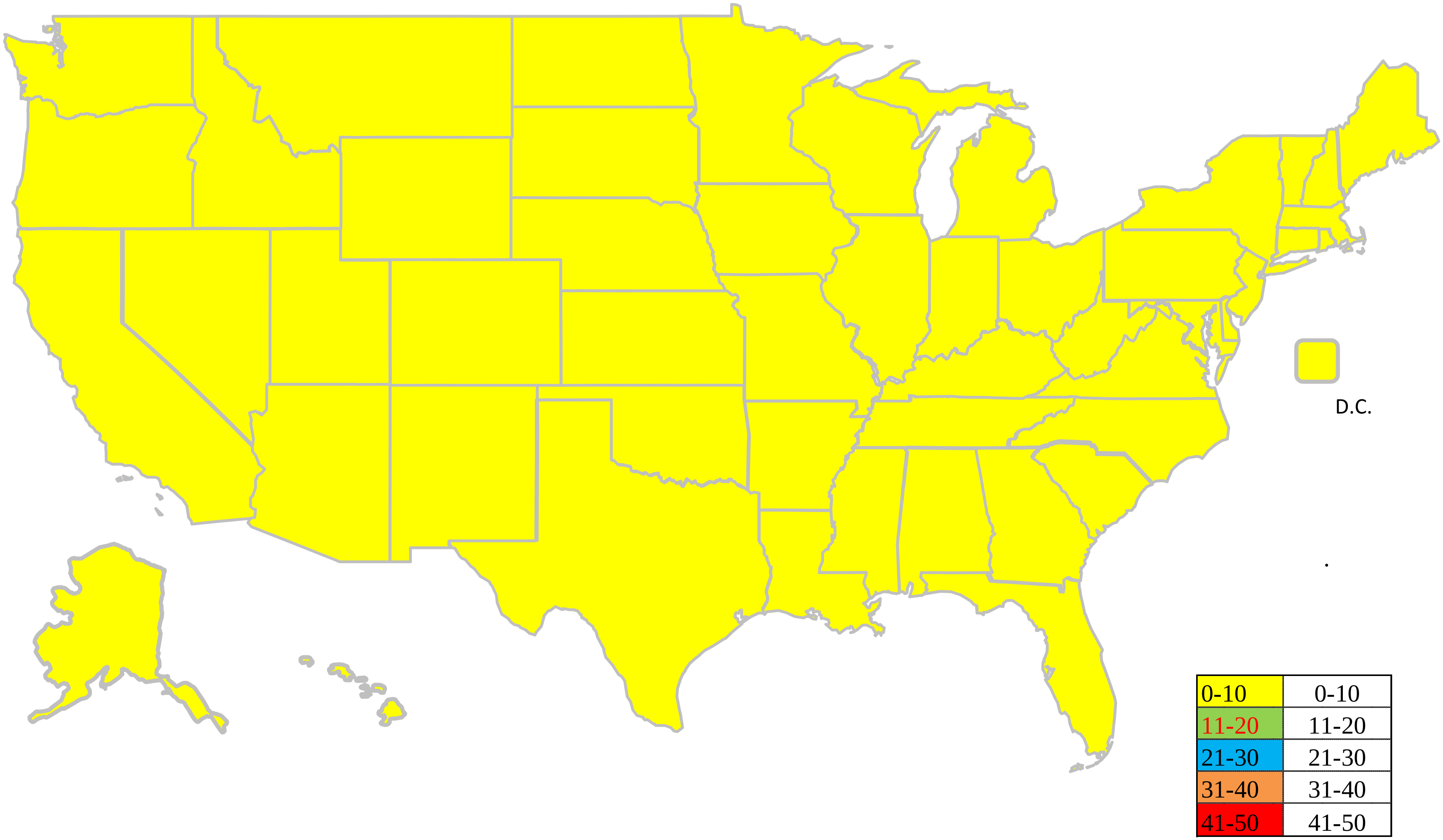
21-30	21-30
31-40	31-40
41-50	41-50

2005MY Chevrolet Malibu IPTV

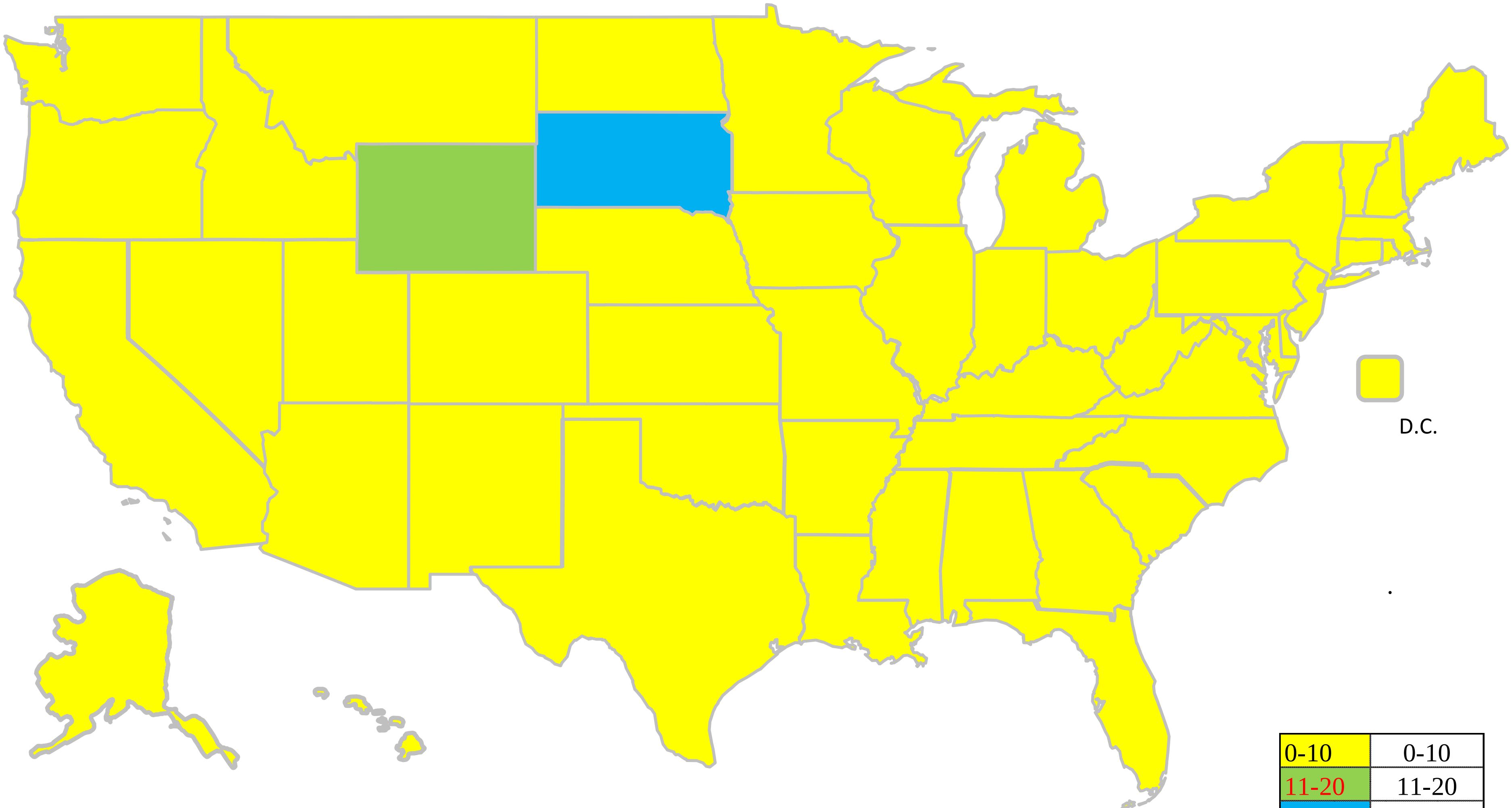


0-10	0-10
11-20	11-20
21-30	21-30
31-40	31-40
41-50	41-50

2006MY Chevrolet Malibu IPTV



2007MY Chevrolet Malibu IPTV



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21-30	21-30
31-40	31-40
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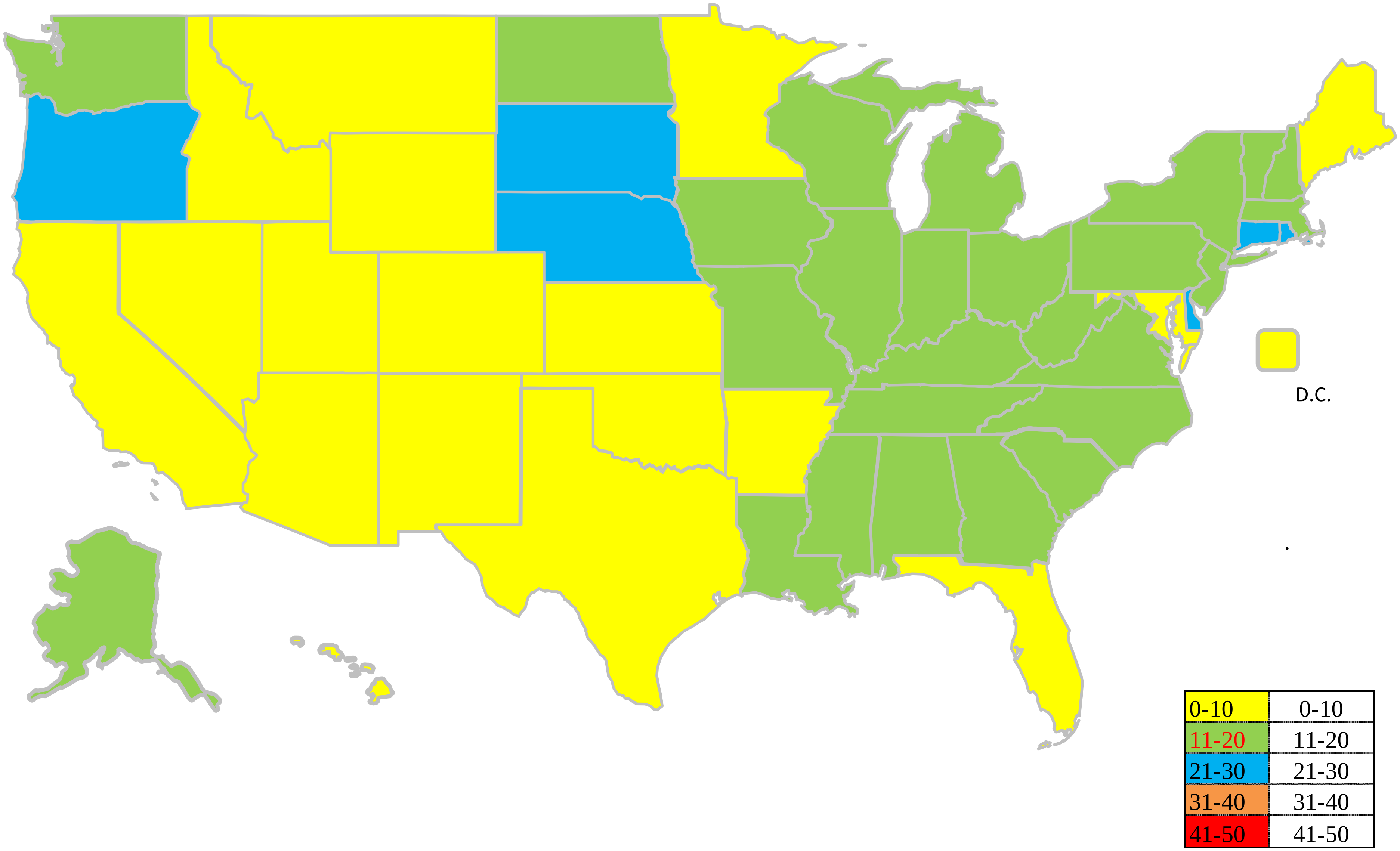
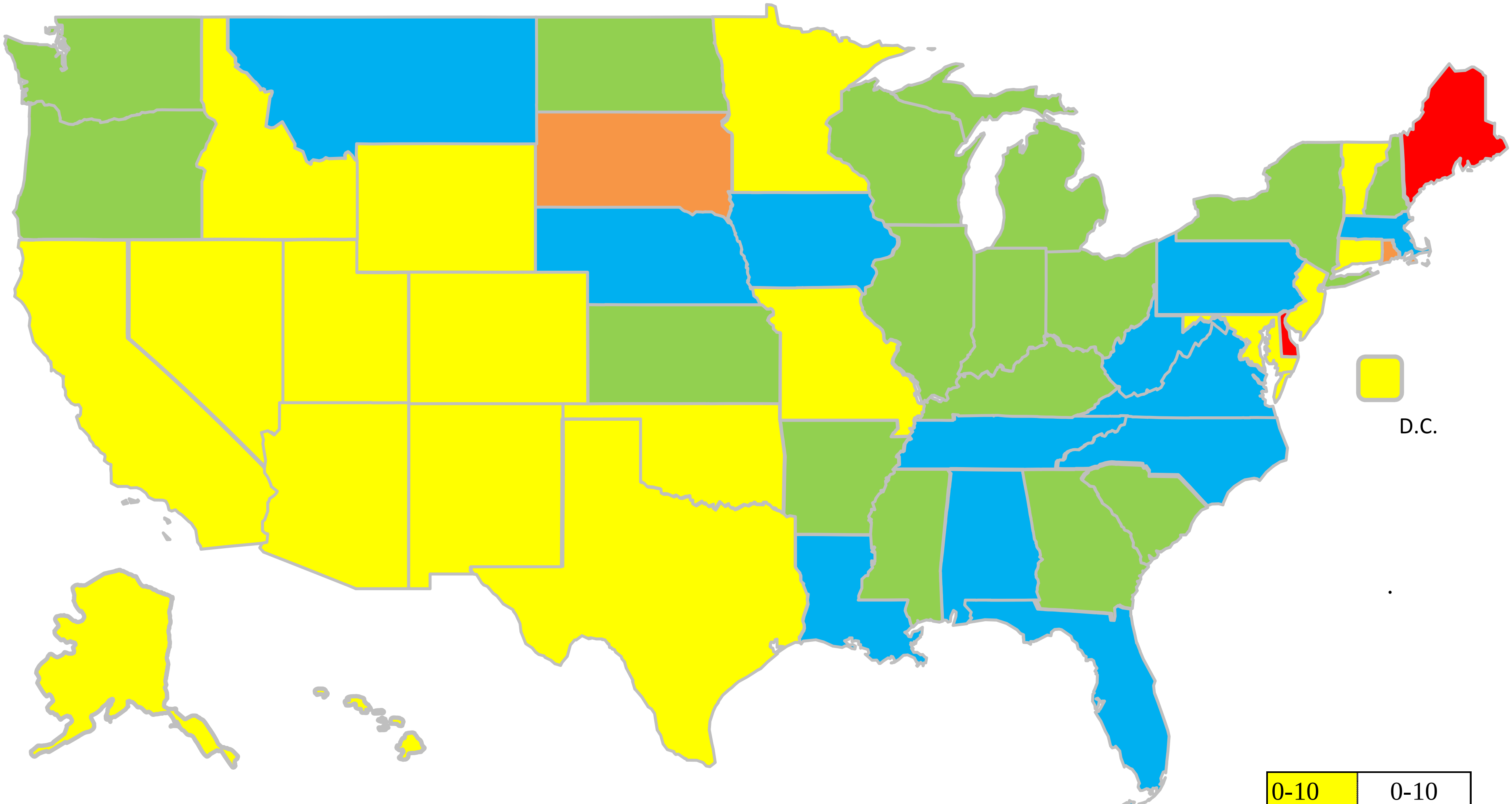
2008MY Chevrolet Malibu IPTV

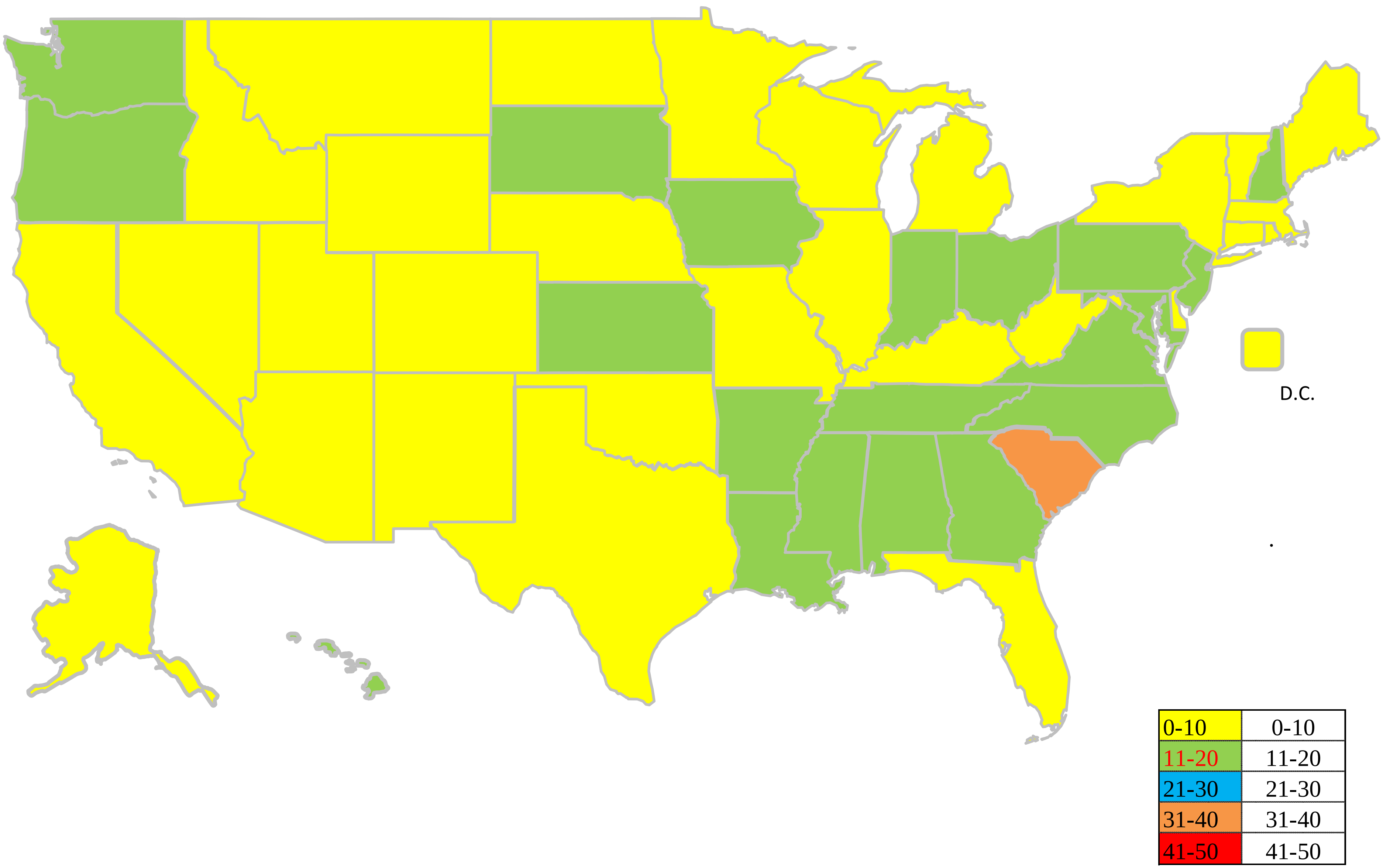


2009MY Chevrolet Malibu IPTV

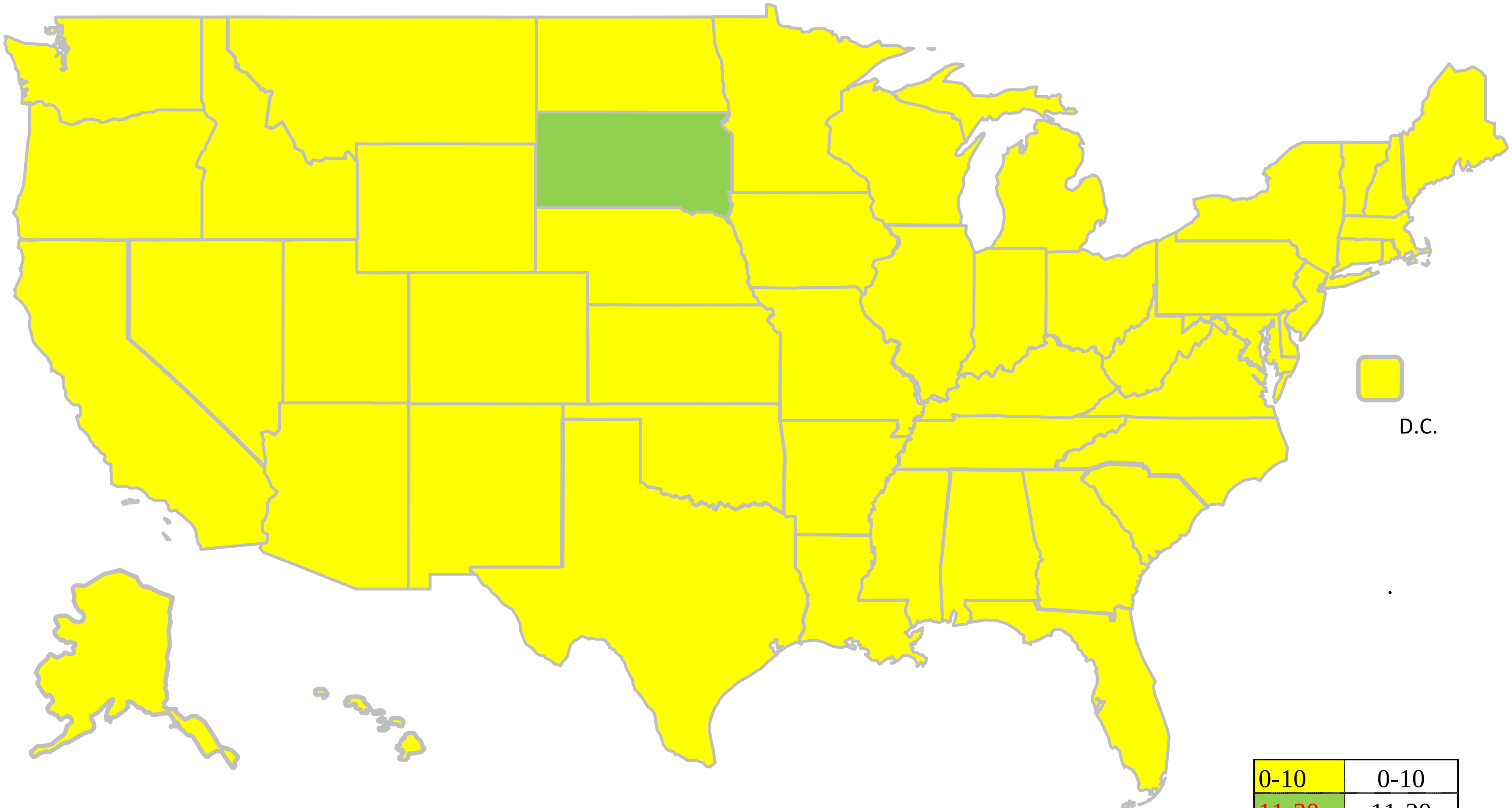


0-10	0-10
11-20	11-20
21-30	21-30
31-40	31-40
41-50	41-50

2010MY Chevrolet Malibu IPTV



2004-2010MY Chevrolet Malibu Average IPTV

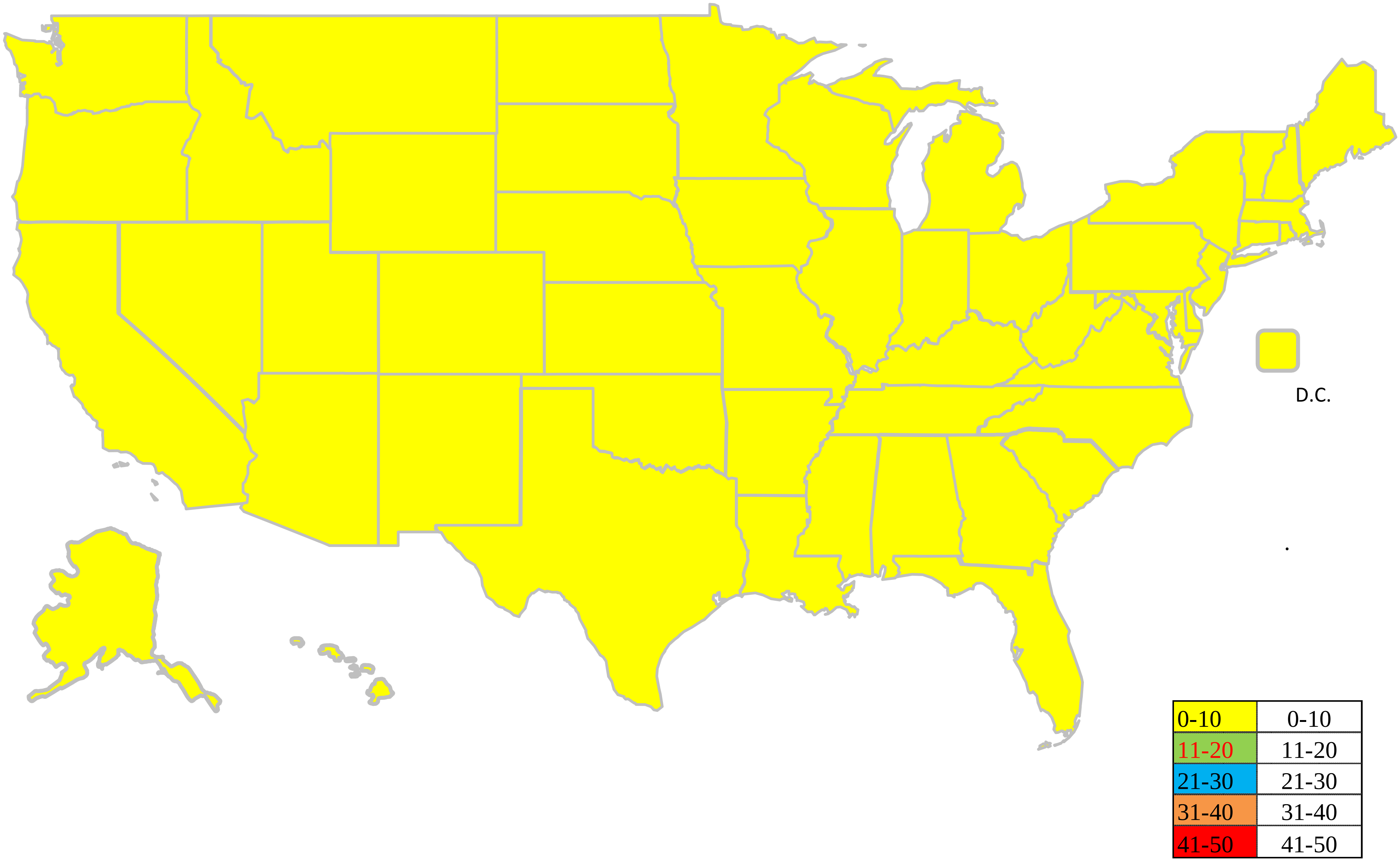


0-10	0-10
11-20	11-20
21-30	21-30
31-40	31-40
41-50	41-50

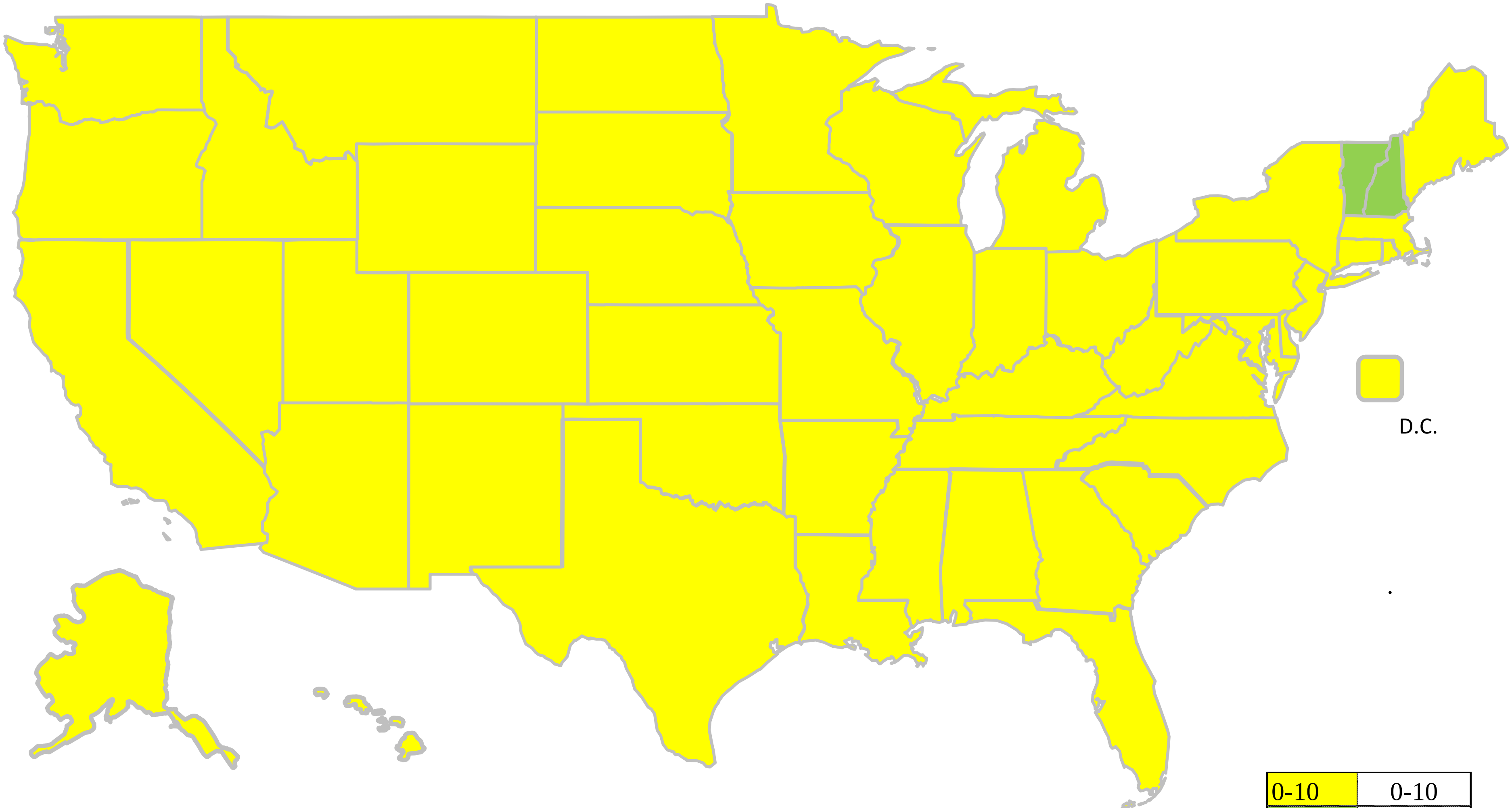
2004-2010MY Chevrolet Malibu IPTV Table

MODL_YR_NBR	2004	2005	2006	2007	2008	2009	2010	2011	2004-10 Average
AK	0.00	0.00	0.00	6.90	15.04	0.00	5.59	0.00	2.80
AL	0.00	0.72	1.46	2.79	13.88	23.00	19.28	1.44	7.58
AR	0.00	0.00	4.42	2.54	8.02	19.97	16.74	0.83	6.70
AZ	0.00	0.00	0.00	0.00	4.43	4.75	2.70	0.40	1.53
CA	0.00	0.00	0.60	0.71	4.32	2.94	5.06	0.07	1.60
CO	0.00	0.00	0.00	0.00	6.68	2.68	3.36	0.60	1.23
CT	0.00	1.05	7.97	1.78	20.04	9.45	7.02	2.06	5.78
DC	0.00	0.00	0.00	0.00					0.00
DE	0.00	0.00	0.00	9.43	20.16	41.78	7.36	1.55	8.93
FL	0.00	0.16	4.03	3.36	8.38	20.76	8.16	0.33	4.57
GA	0.00	0.52	1.55	3.30	14.98	19.94	14.76	2.19	6.66
HI	0.00	0.00	0.00	0.00	0.00	0.00	10.31	0.00	1.25
IA	0.00	1.81	7.54	7.29	11.06	20.28	10.62	0.00	6.69
ID	0.00	0.00	0.00	0.00	9.23	8.30	8.89	0.00	3.31
IL	0.12	0.30	1.99	2.65	15.40	11.38	7.78	0.18	4.82
IN	0.00	0.00	2.70	4.30	18.74	14.99	12.03	0.20	6.04
KS	0.00	0.00	7.14	4.20	7.28	14.47	16.08	0.00	6.02
KY	0.00	1.02	1.11	0.83	15.23	15.97	7.22	1.61	5.27
LA	0.00	0.50	1.20	2.97	11.02	26.03	12.85	1.31	6.43
MA	0.00	0.00	2.14	3.51	15.47	22.77	9.55	0.55	5.61
MD	0.00	0.34	1.10	0.72	6.78	7.20	10.42	0.71	3.90
ME	0.00	0.00	2.92	0.00	8.52	49.26	2.52	8.67	6.38
MI	0.08	0.43	3.05	4.07	14.36	14.31	8.41	0.55	4.93
MN	0.00	0.00	0.39	0.45	2.16	3.06	7.35	0.54	1.18
MO	0.00	0.34	1.66	2.77	10.19	4.04	1.11	0.00	1.36
MS	1.53	0.00	3.99	2.09	11.78	19.90	18.26	0.00	6.82
MT	0.00	0.00	2.79	7.09	9.17	25.36	3.26	0.00	6.01
NC	0.00	0.50	1.98	1.07	10.80	24.65	10.57	1.81	5.25
ND	0.00	0.00	5.46	2.62	11.83	17.86	5.95	0.00	5.12
NE	1.58	0.00	7.68	6.66	22.73	27.78	7.85	0.00	8.33
NH	0.00	0.00	6.30	8.75	10.27	10.55	12.46	1.75	5.79
NJ	0.00	0.00	2.48	0.61	16.19	9.75	11.48	0.43	4.33
NM	0.00	0.00	1.80	0.00	8.01	7.75	5.93	0.00	2.89
NV	0.00	0.00	0.00	0.00	3.80	0.00	1.45	0.00	0.89
NY	0.00	0.12	3.35	1.20	14.59	15.60	7.52	0.29	4.73
OH	0.00	0.61	4.22	5.02	18.39	17.64	10.76	1.03	6.03
OK	0.00	0.00	0.94	0.92	1.76	3.48	9.26	0.00	1.82
OR	0.00	0.00	7.14	9.49	29.75	13.16	19.69	0.00	9.36
PA	0.00	0.64	3.79	3.17	15.21	25.32	11.12	0.71	5.96
RI	0.00	0.00	0.00	0.00	20.41	38.46	9.40	1.92	8.83
SC	0.00	0.00	5.68	3.80	10.19	15.87	30.05	3.31	8.90
SD	0.00	0.00	6.41	25.42	24.00	30.15	15.63	0.00	10.70
TN	0.00	0.00	5.52	3.33	10.01	29.14	18.93	0.63	7.91
TX	0.00	0.06	0.84	0.46	4.40	8.71	7.62	0.66	2.51
UT	0.00	0.00	2.28	0.00	8.68	2.13	4.07	4.10	2.68
VA	0.00	0.35	3.66	5.84	14.15	27.78	15.01	1.08	7.58
VT	0.00	0.00	0.00	0.00	19.38	0.00	0.00	0.00	2.28
WA	0.70	0.00	2.43	6.24	16.77	19.02	13.73	1.08	6.67
WI	0.00	0.73	3.16	8.91	16.52	13.50	7.04	0.71	5.46
WV	0.00	0.00	3.56	5.56	11.48	24.19	8.22	2.47	6.04
WY	0.00	0.00	0.00	14.49	0.00	8.47	6.94	0.00	3.03

2005MY Pontiac G6 IPTV



2006MY Pontiac G6 IPTV



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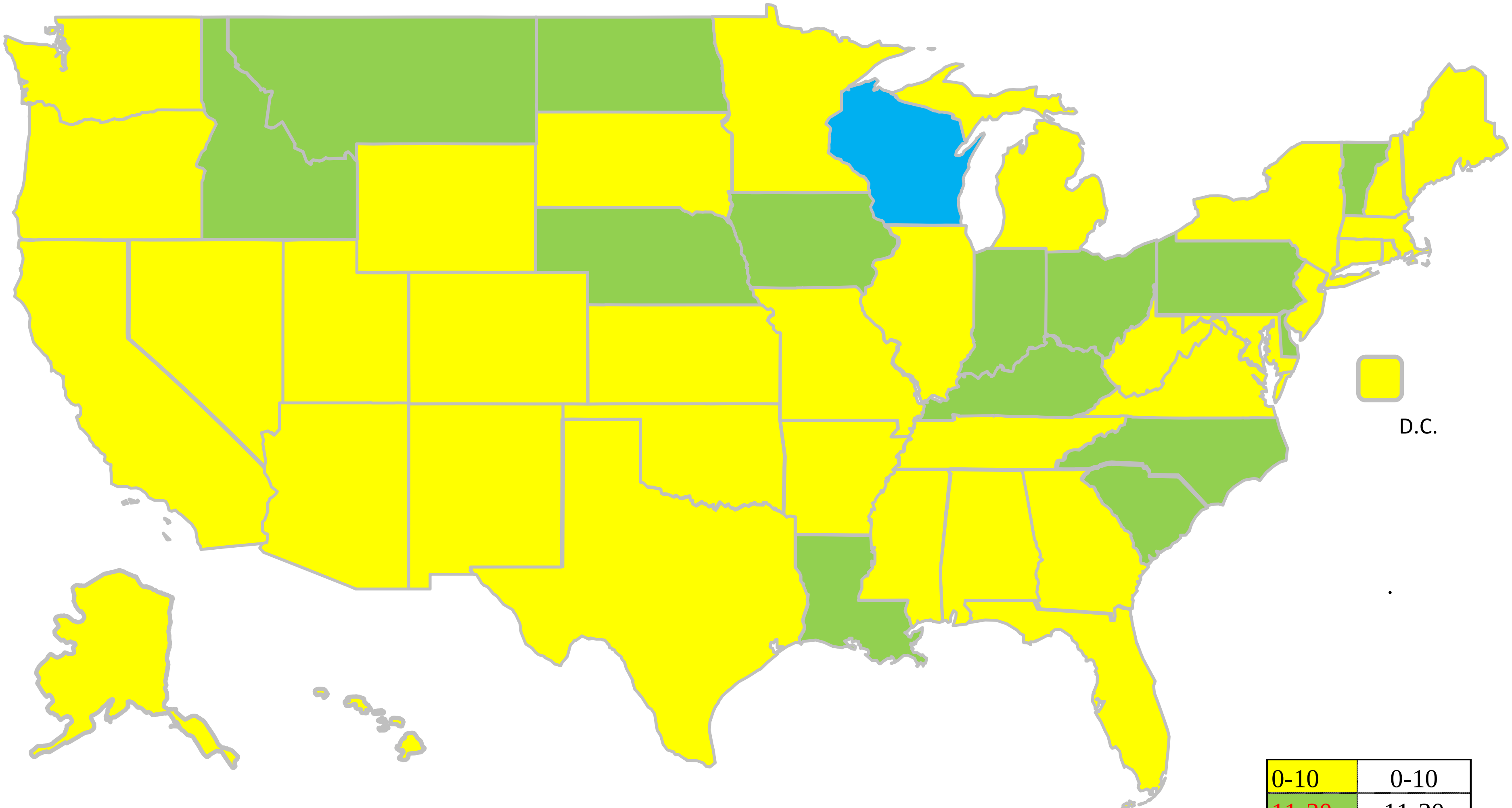
21-30	21-30
31-40	31-40
41-50	41-50

2007MY Pontiac G6 IPTV



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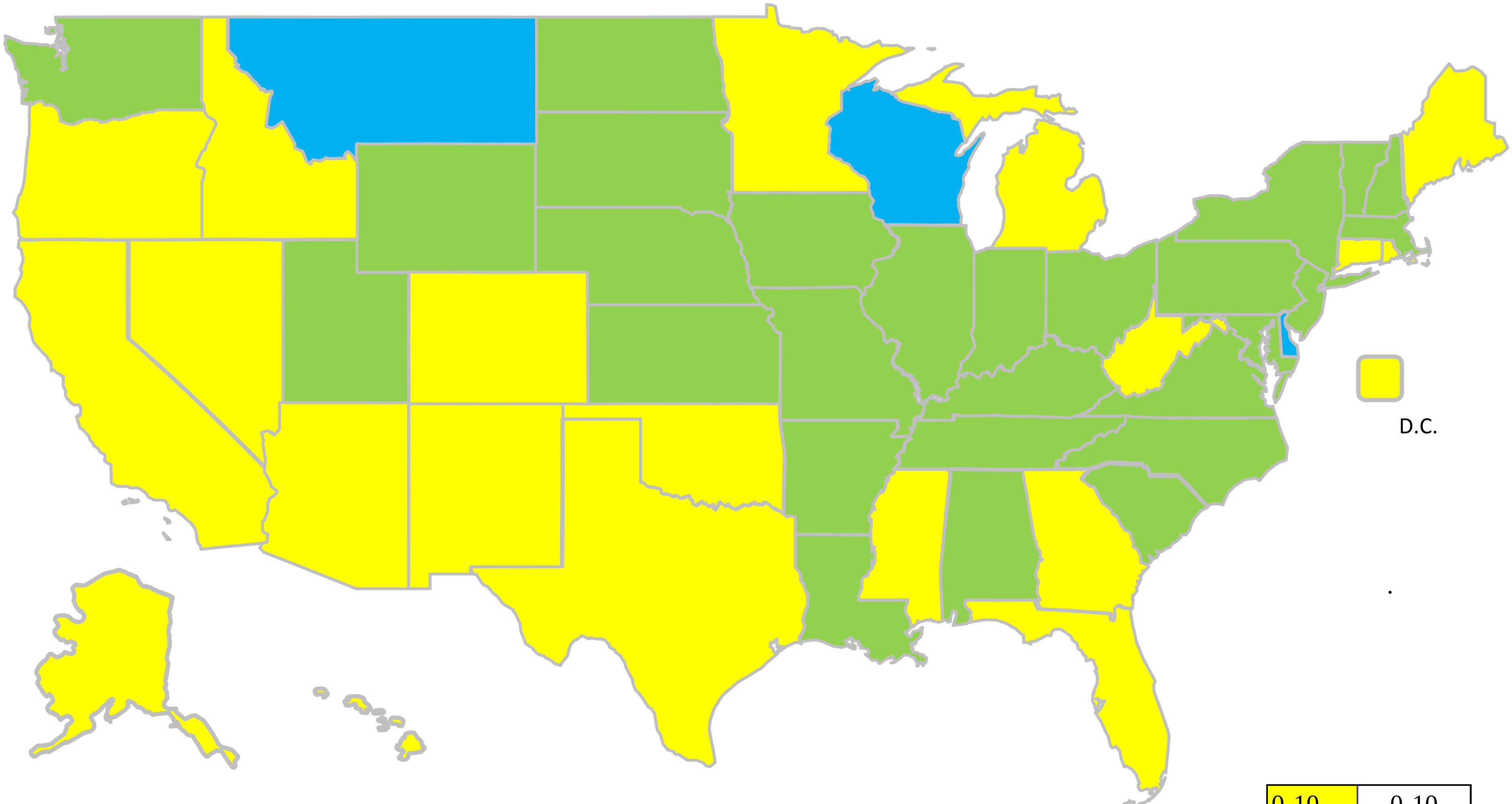
41-50	41-50

2008MY Pontiac G6 IPTV



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21-30	21-30
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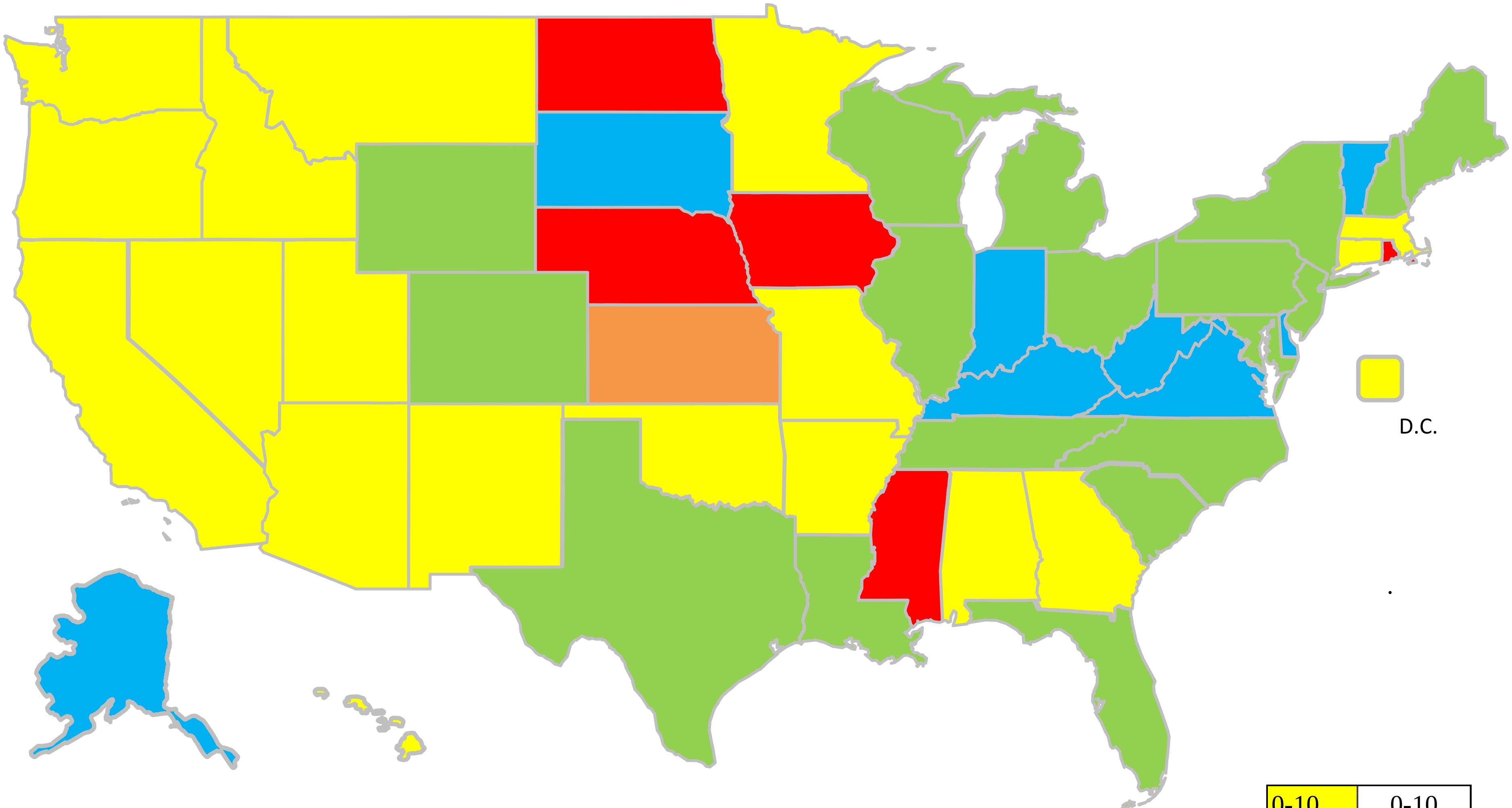
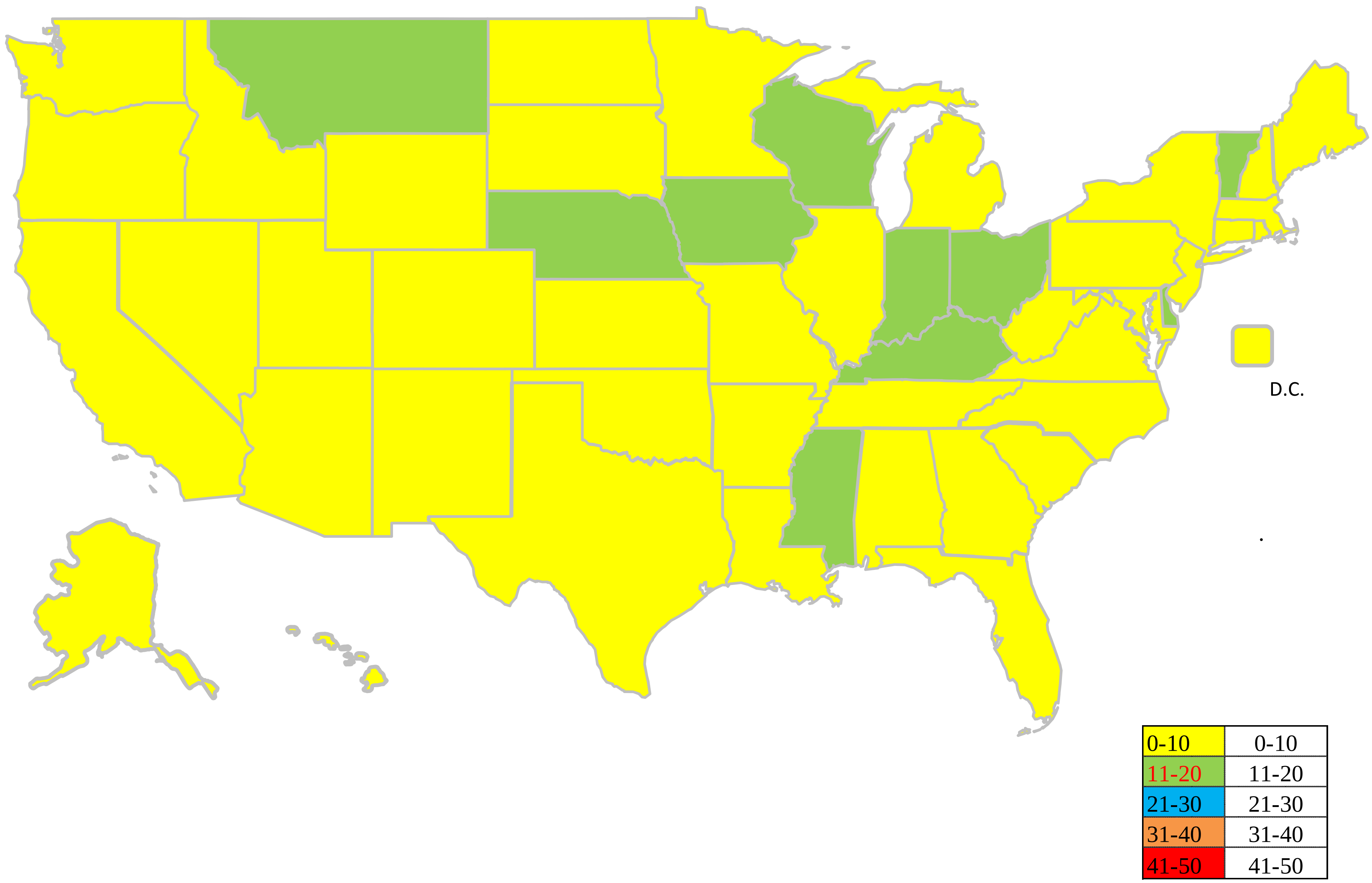
2009MY Pontiac G6 IPTV



0-10	0-10
11-20	11-20
21-30	21-30
31-40	31-40
41-50	41-50

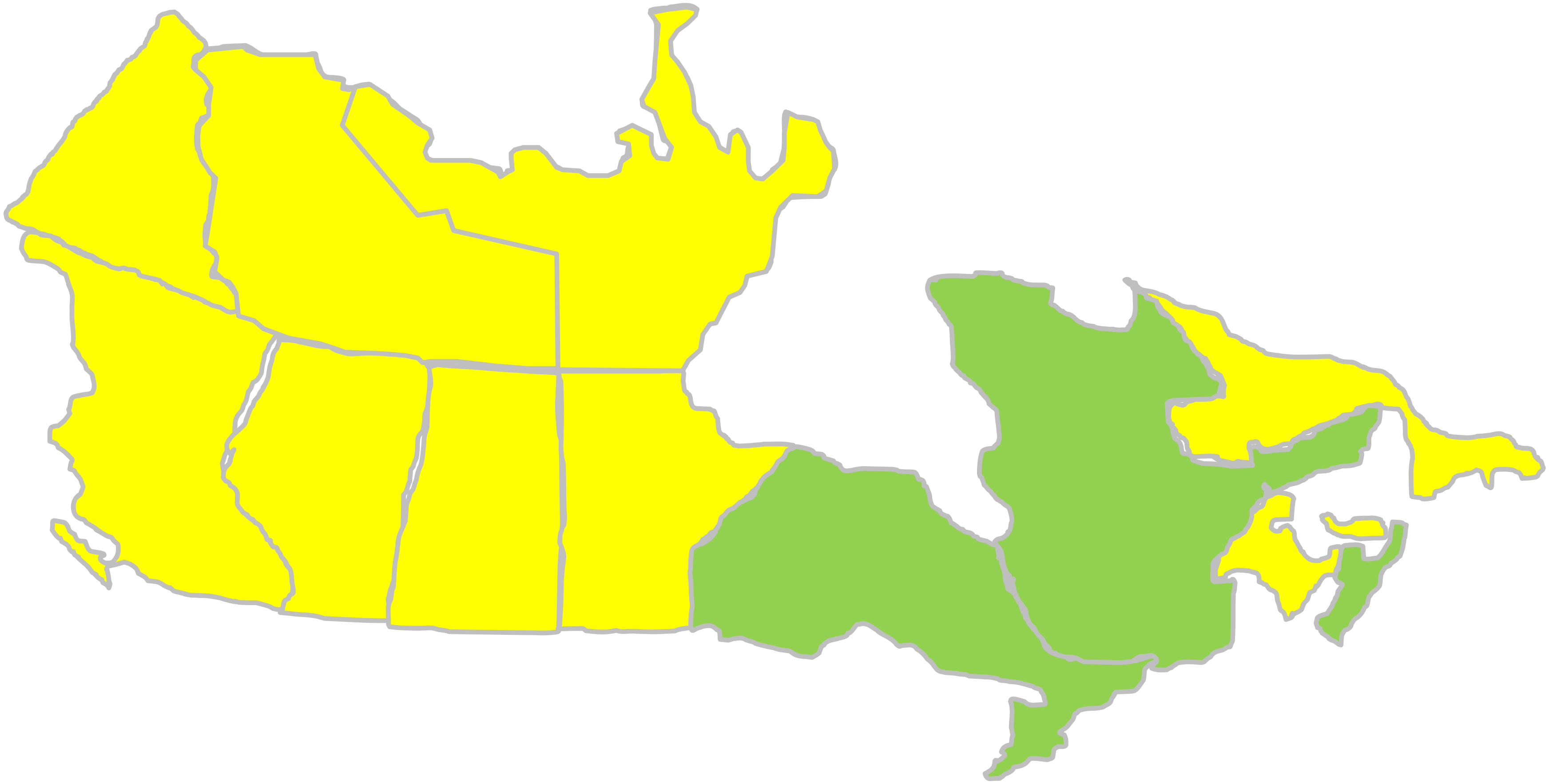
2005-09MY Pontiac G6 Average IPTV



2005-09MY Pontiac G6 IPTV Table

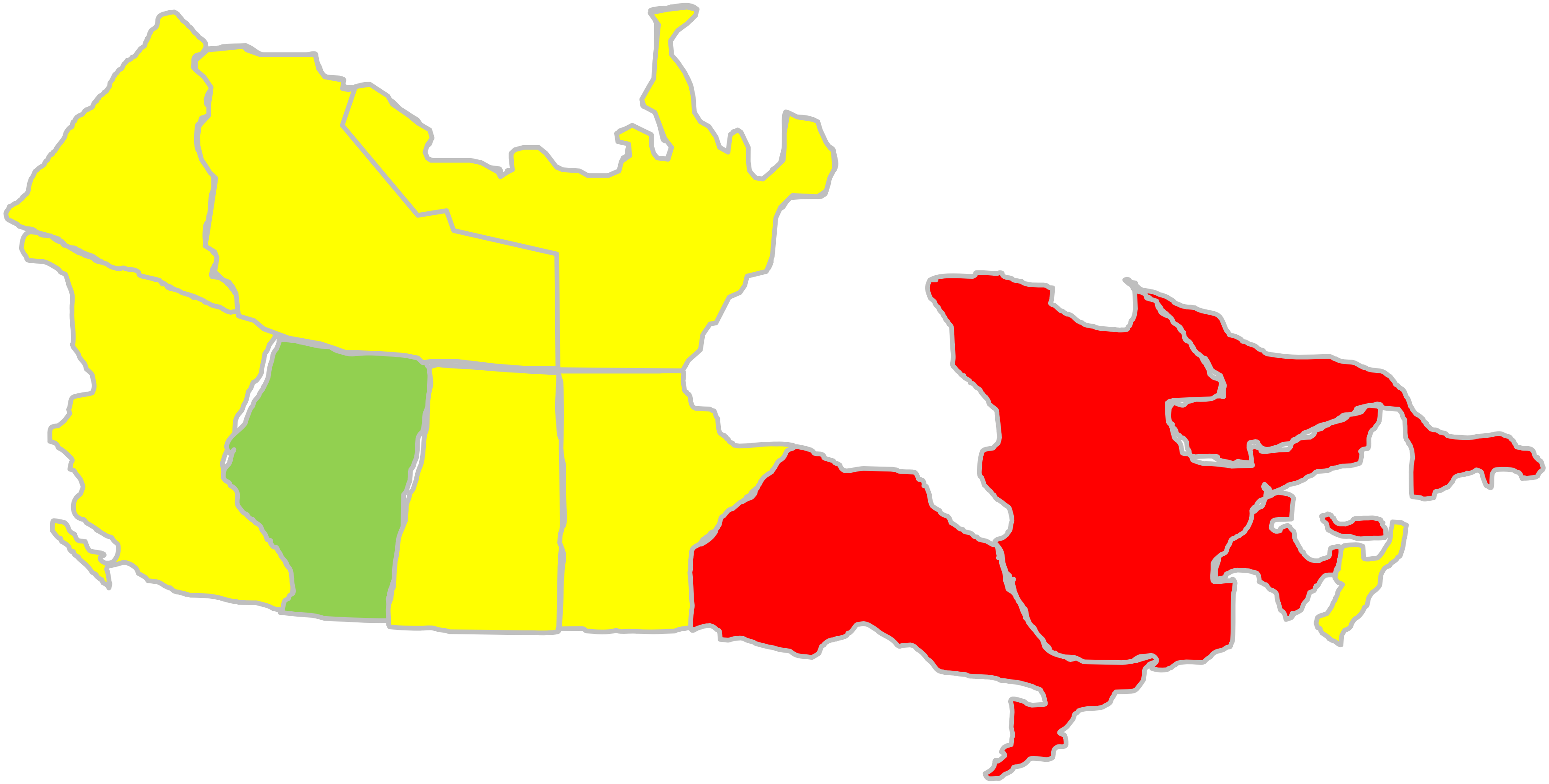
SALES DEALERSTATE	2005	2006	2007	2008	2009	2005-09 Average
AK	0.00	0.00	0.00	0.00	22.73	1.85
AL	0.00	0.64	8.96	13.63	6.58	6.18
AR	0.00	3.44	8.76	12.10	5.22	7.22
AZ	0.00	1.56	1.37	0.94	7.16	1.88
CA	0.86	1.10	1.14	0.87	0.29	0.80
CO	0.00	0.75	5.79	9.29	12.58	4.67
CT	0.00	3.59	6.10	2.09	0.00	3.20
DC						
DE	0.00	9.17	12.75	24.39	27.03	13.19
FL	0.00	5.60	7.11	9.61	12.46	7.34
GA	1.59	3.12	6.16	6.26	7.59	5.18
HI	0.00	0.00	0.00	0.00	0.00	0.00
IA	1.88	2.96	16.26	19.69	55.73	14.72
ID	0.00	0.00	10.27	6.71	0.00	4.72
IL	0.38	3.04	7.08	12.15	14.31	7.31
IN	0.98	3.81	14.07	11.16	21.76	10.01
KS	0.00	1.15	7.89	15.82	30.22	9.29
KY	0.00	2.37	10.86	16.26	20.30	10.08
LA	0.00	3.61	10.18	10.57	12.24	7.25
MA	2.72	2.50	5.62	10.47	8.51	5.90
MD	0.00	4.45	9.91	11.54	15.60	8.92
ME	0.00	0.00	7.35	4.85	19.42	5.59
MI	0.75	3.73	8.73	9.38	19.34	7.76
MN	0.00	1.20	1.93	3.32	4.12	2.29
MO	0.87	2.62	9.11	16.93	1.84	4.38
MS	4.48	9.35	6.68	7.26	45.25	11.95
MT	0.00	3.77	13.10	28.78	7.94	10.58
NC	0.00	4.06	11.47	10.24	13.73	8.23
ND	0.00	2.67	13.84	13.76	40.54	9.66
NE	0.00	3.46	15.90	16.13	44.78	12.88
NH	0.00	14.81	2.92	14.60	15.75	9.67
NJ	0.00	5.47	8.65	11.56	14.55	8.06
NM	0.00	1.16	1.18	1.96	0.00	1.04
NV	0.00	0.00	0.00	2.39	0.00	0.68
NY	1.10	3.09	8.42	14.92	18.92	9.19
OH	1.76	4.06	13.75	14.35	18.94	10.30
OK	0.00	0.19	1.30	0.86	0.00	0.79
OR	0.00	0.00	2.58	6.13	0.00	2.02
PA	1.75	3.84	11.98	11.62	15.37	8.85
RI	0.00	3.79	6.62	7.72	45.45	7.14
SC	0.00	0.00	12.99	17.71	19.35	9.86
SD	0.00	6.41	8.25	12.94	22.73	8.01
TN	0.00	0.57	6.30	10.23	11.97	5.58
TX	0.00	1.76	6.02	6.35	10.28	5.09
UT	0.00	2.30	2.25	12.05	0.00	3.82
VA	0.00	3.86	8.96	13.34	20.91	8.97
VT	0.00	12.35	11.41	16.67	28.57	14.20
WA	4.81	8.10	9.36	13.75	8.93	9.55
WI	4.31	7.15	21.71	20.70	13.58	14.68
WV	5.29	0.00	5.02	9.63	27.91	7.43
WY	0.00	0.00	5.52	11.11	16.95	4.98

2007MY Saturn Aura IPTV



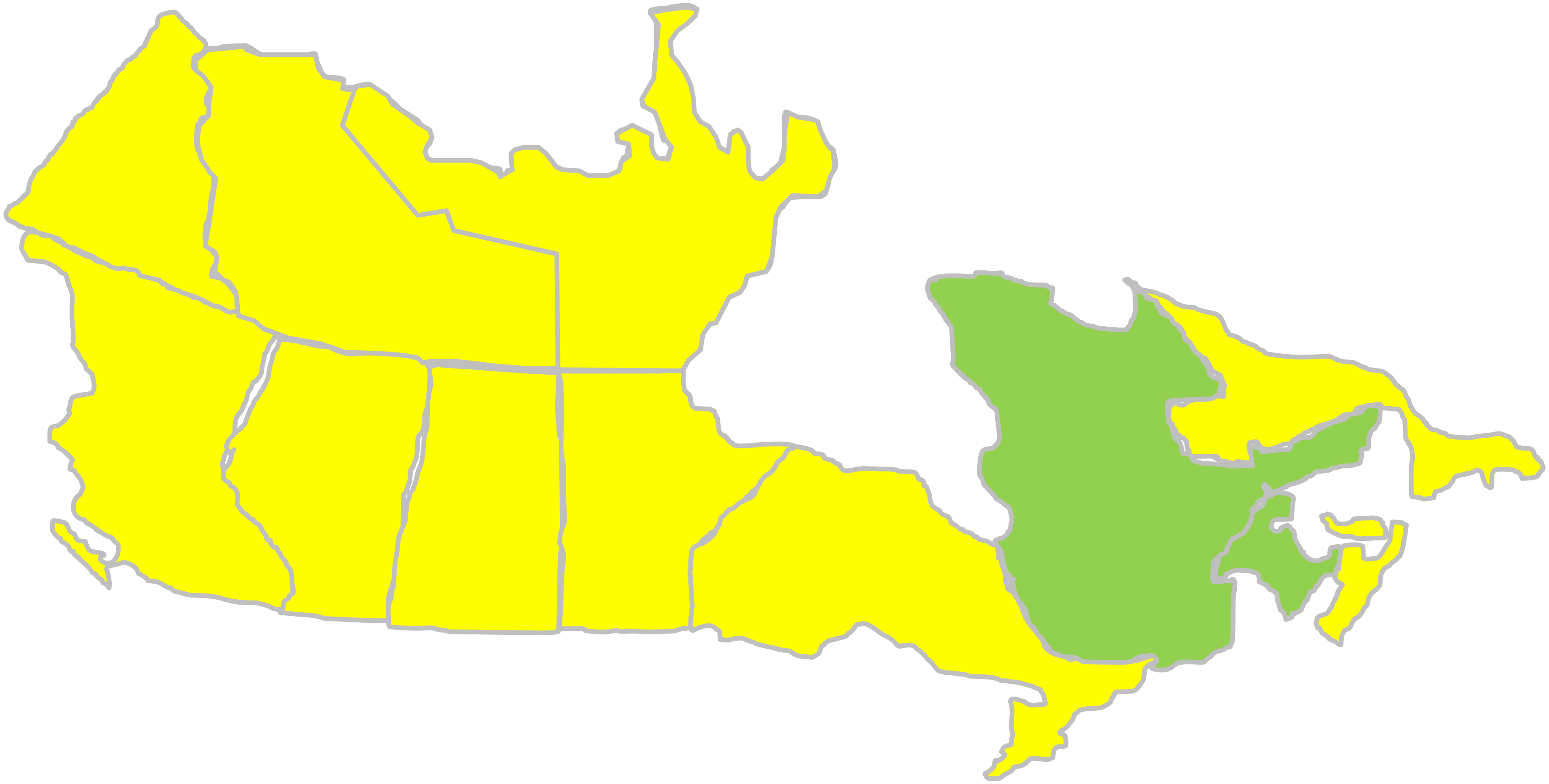
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2008MY Saturn Aura IPTV



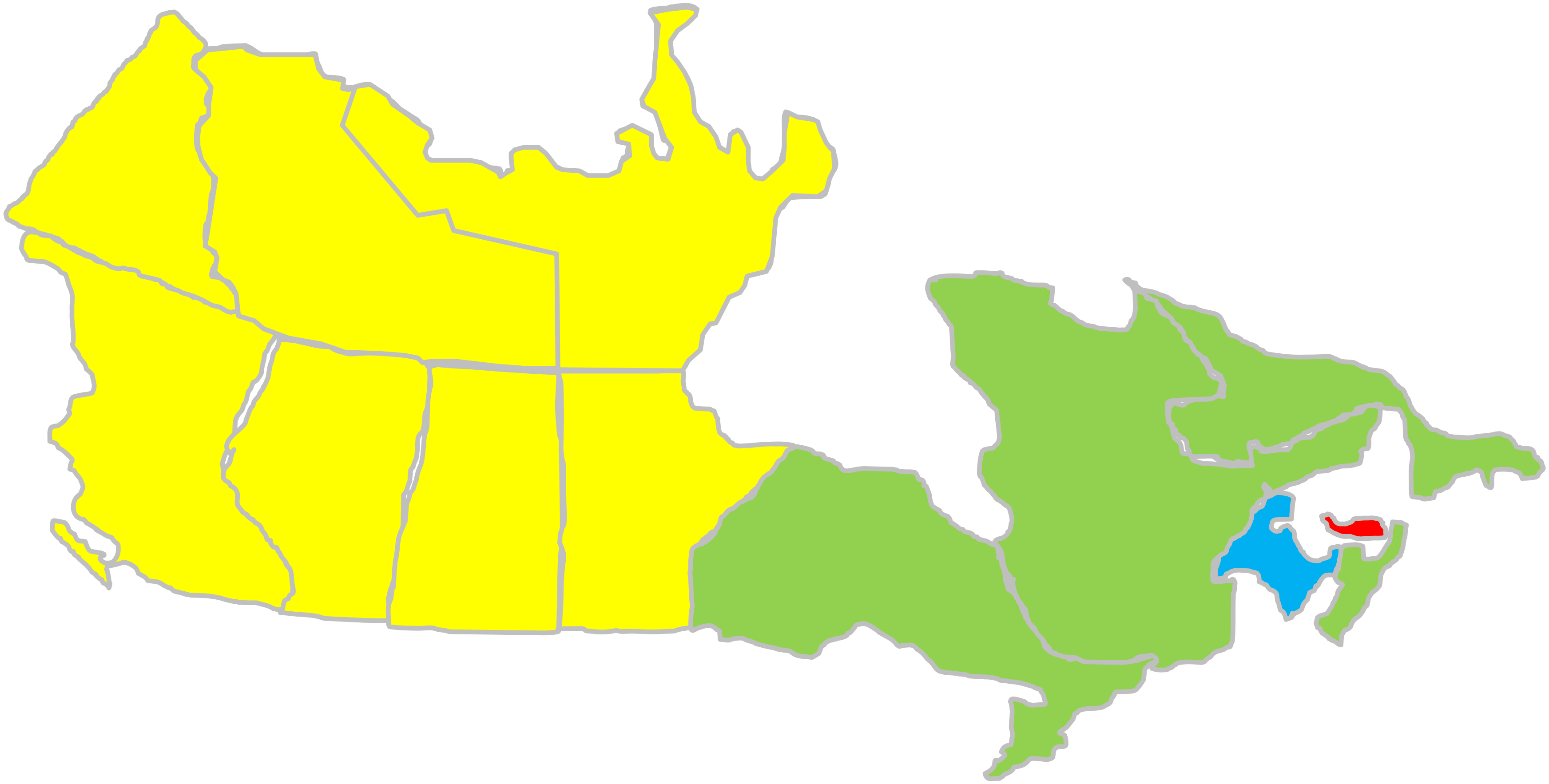
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2009MY Saturn Aura IPTV



0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2007-2009MY Saturn Aura IPTV

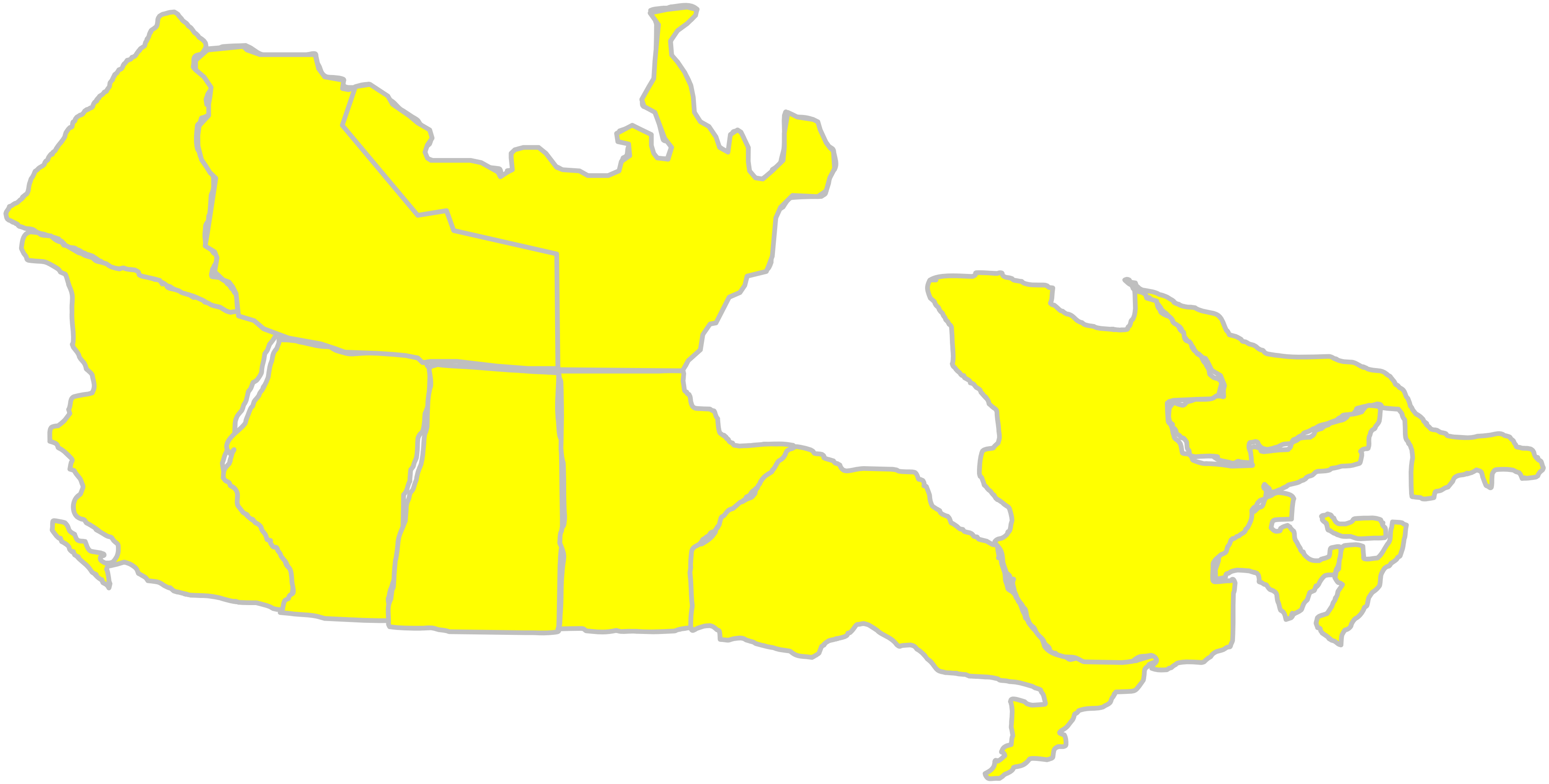


0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2007-2009MY Canada Saturn Aura IPTV Table

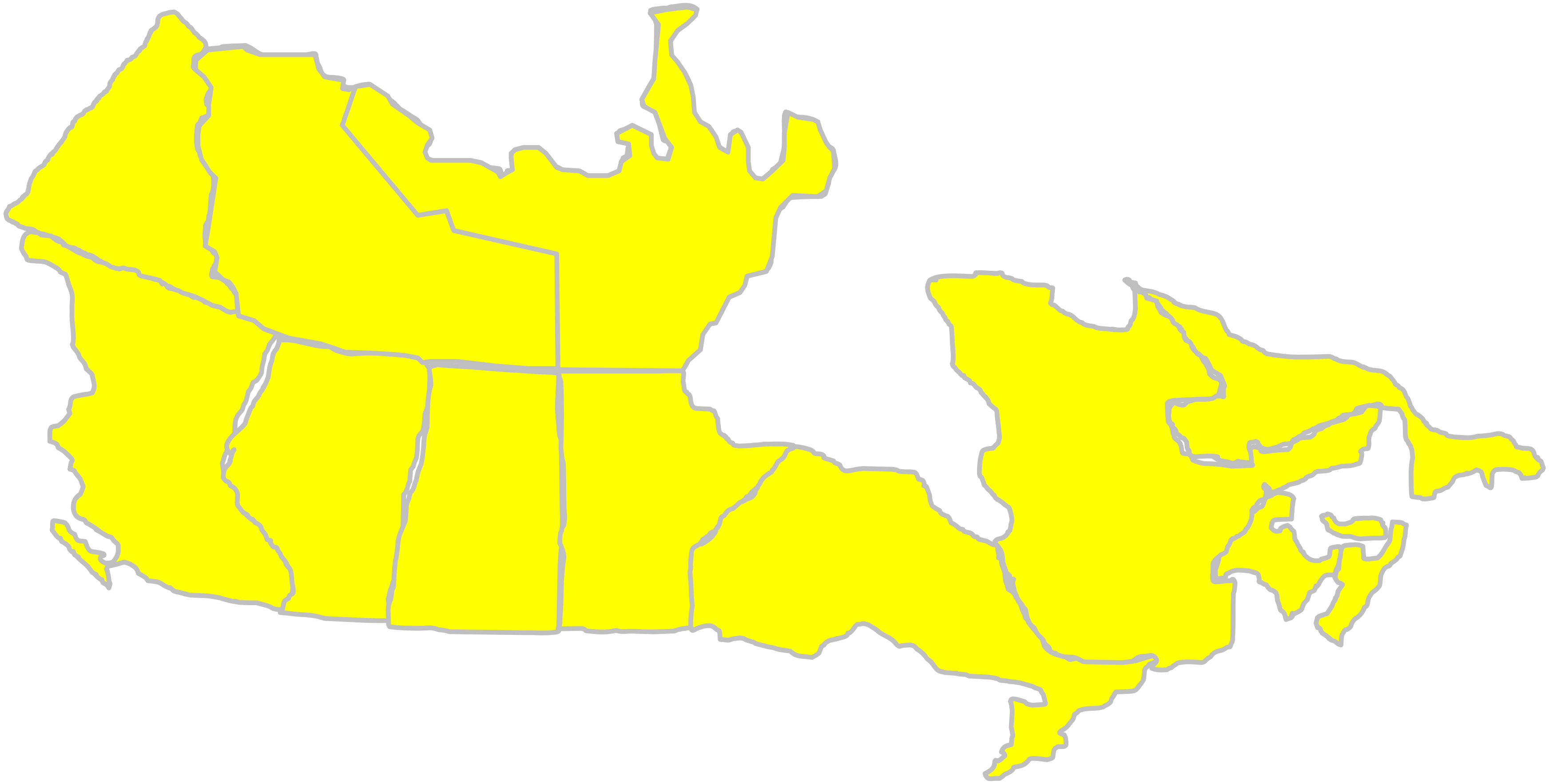
Province	2007	2008	2009	2007-09 Average
AB	2.13	12.58	8.77	5.39
BC	0.00	0.00	0.00	0.00
MB	0.00	0.00	0.00	0.00
NB	0.00	173.91	17.86	22.62
NF	0.00	60.61	0.00	10.81
NS	15.27	0.00	0.00	10.70
NT				
NU				
ON	12.93	46.23	9.59	17.79
PE	0.00	500.00	0.00	50.00
PQ	12.62	57.38	12.20	19.39
SK	8.62	0.00	0.00	5.05
YT				

2004MY Chevrolet Malibu IPTV



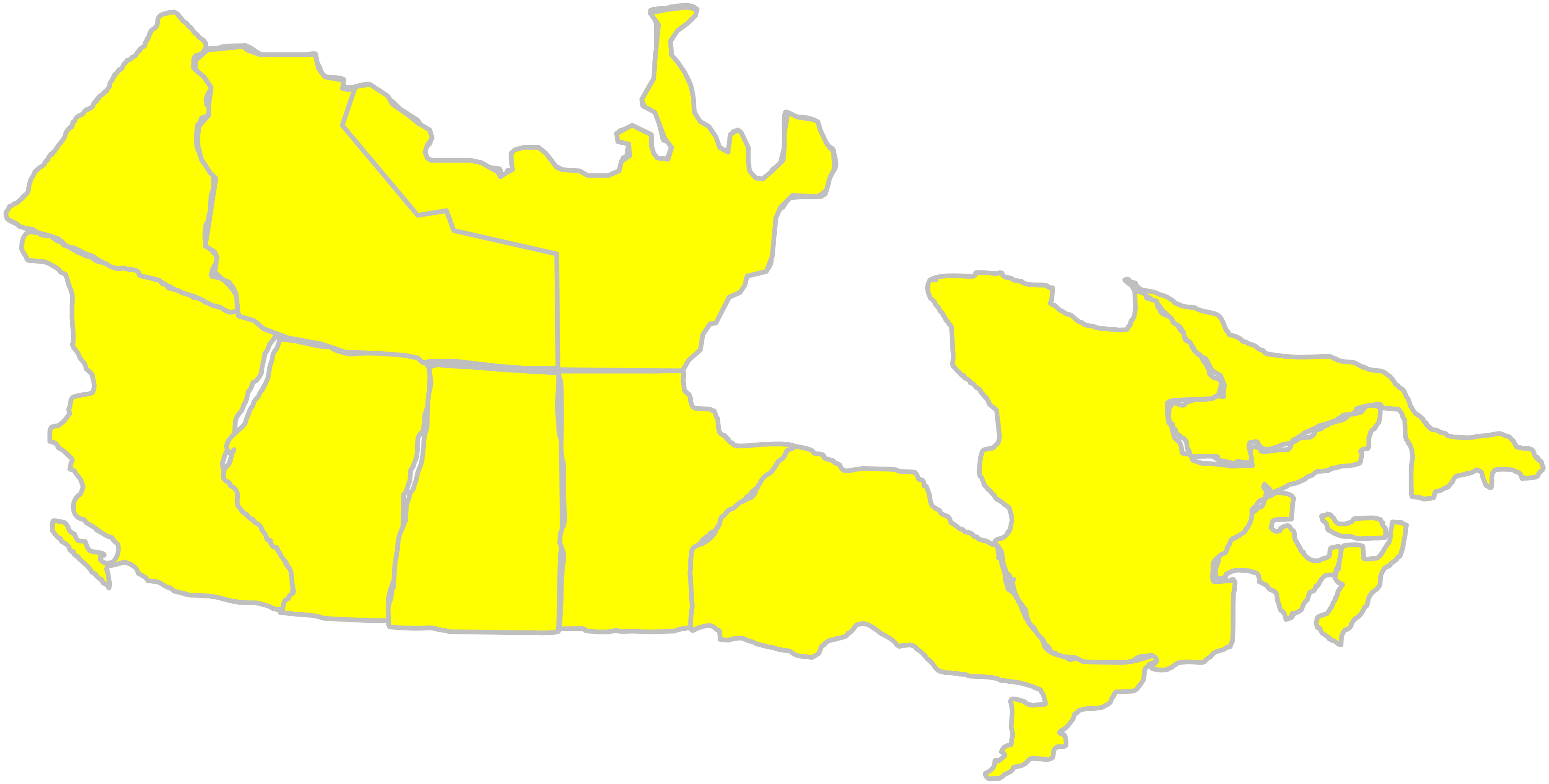
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2005MY Chevrolet Malibu IPTV



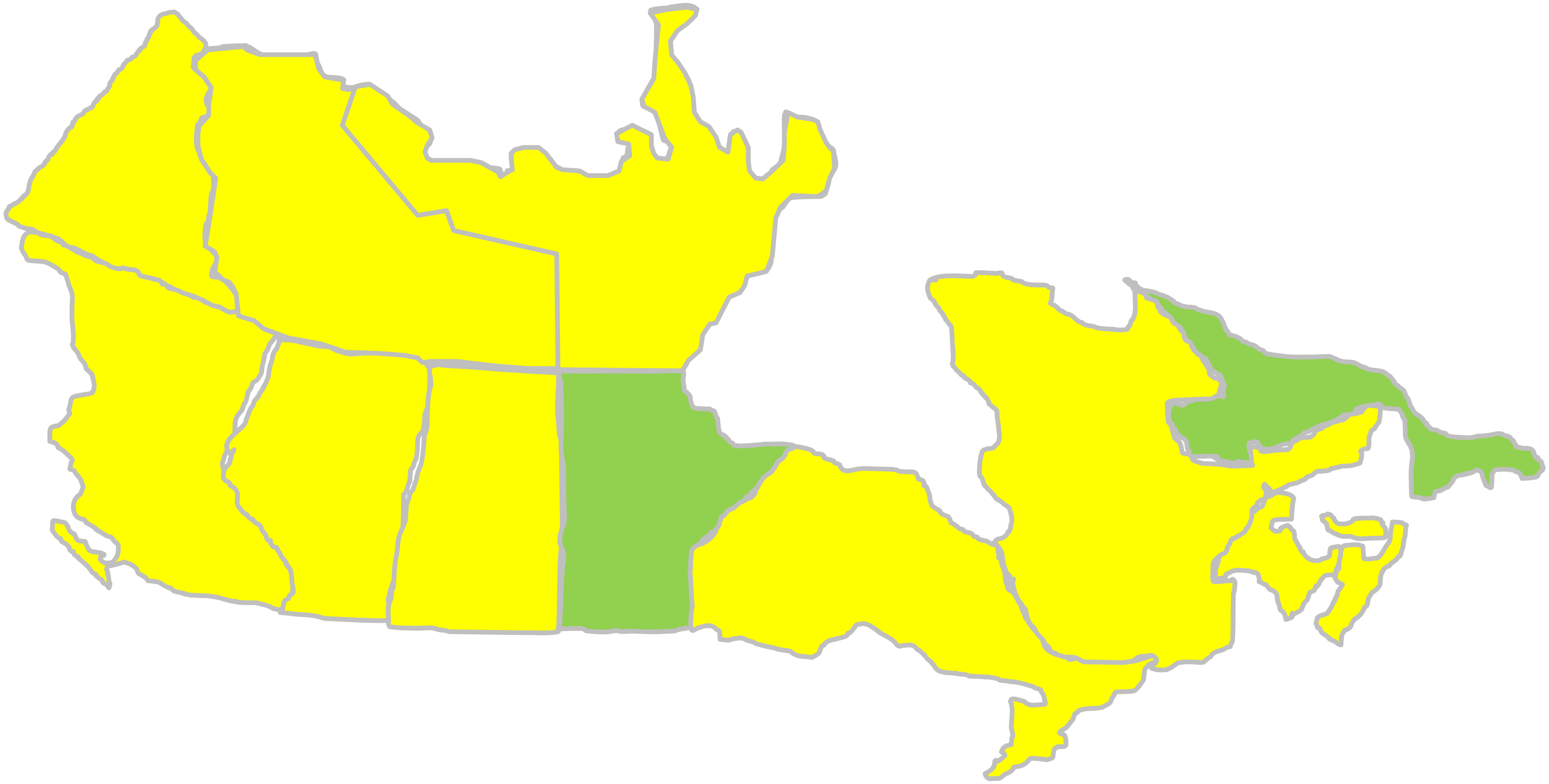
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2006MY Chevrolet Malibu IPTV



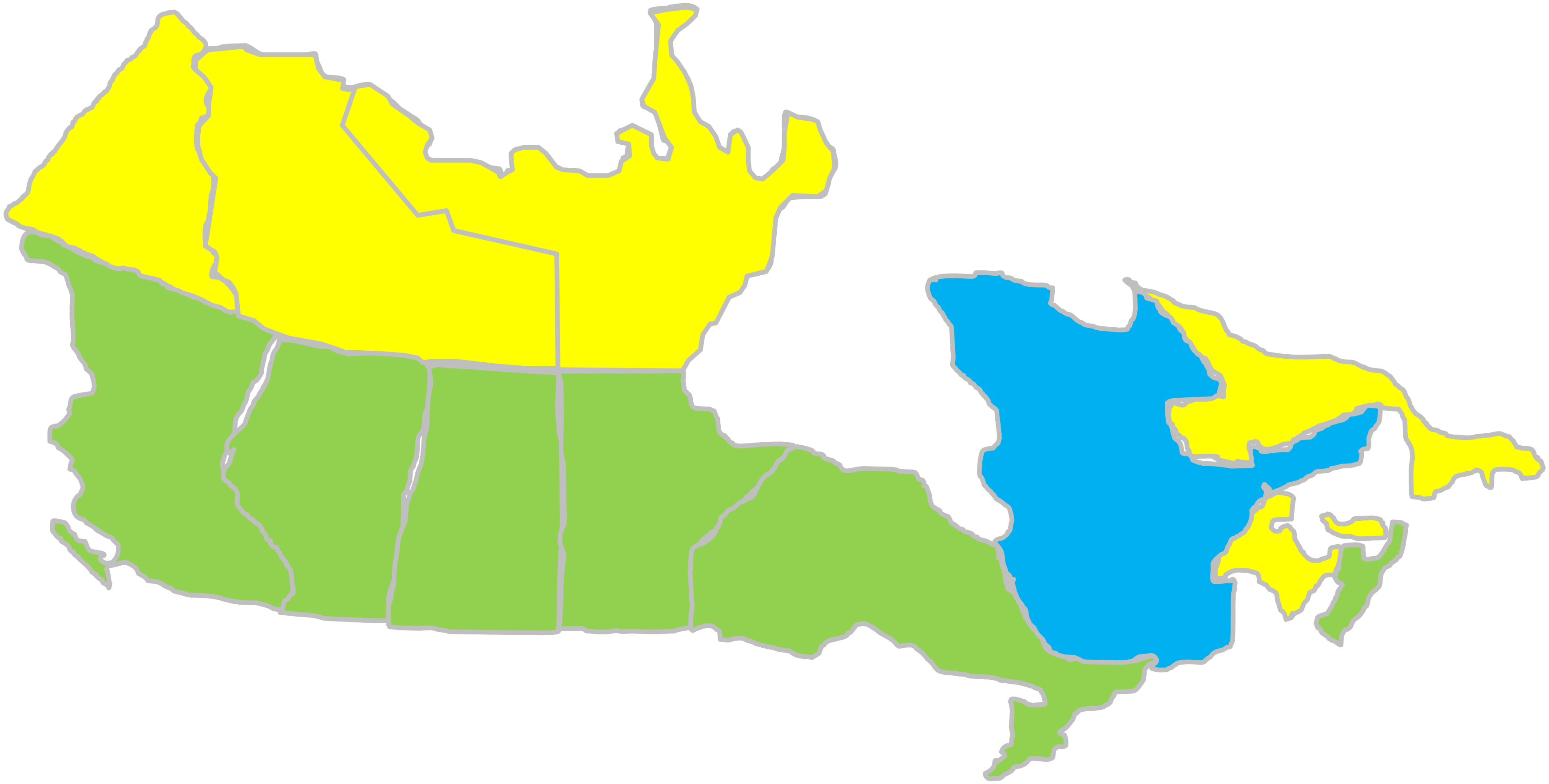
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2007MY Chevrolet Malibu IPTV



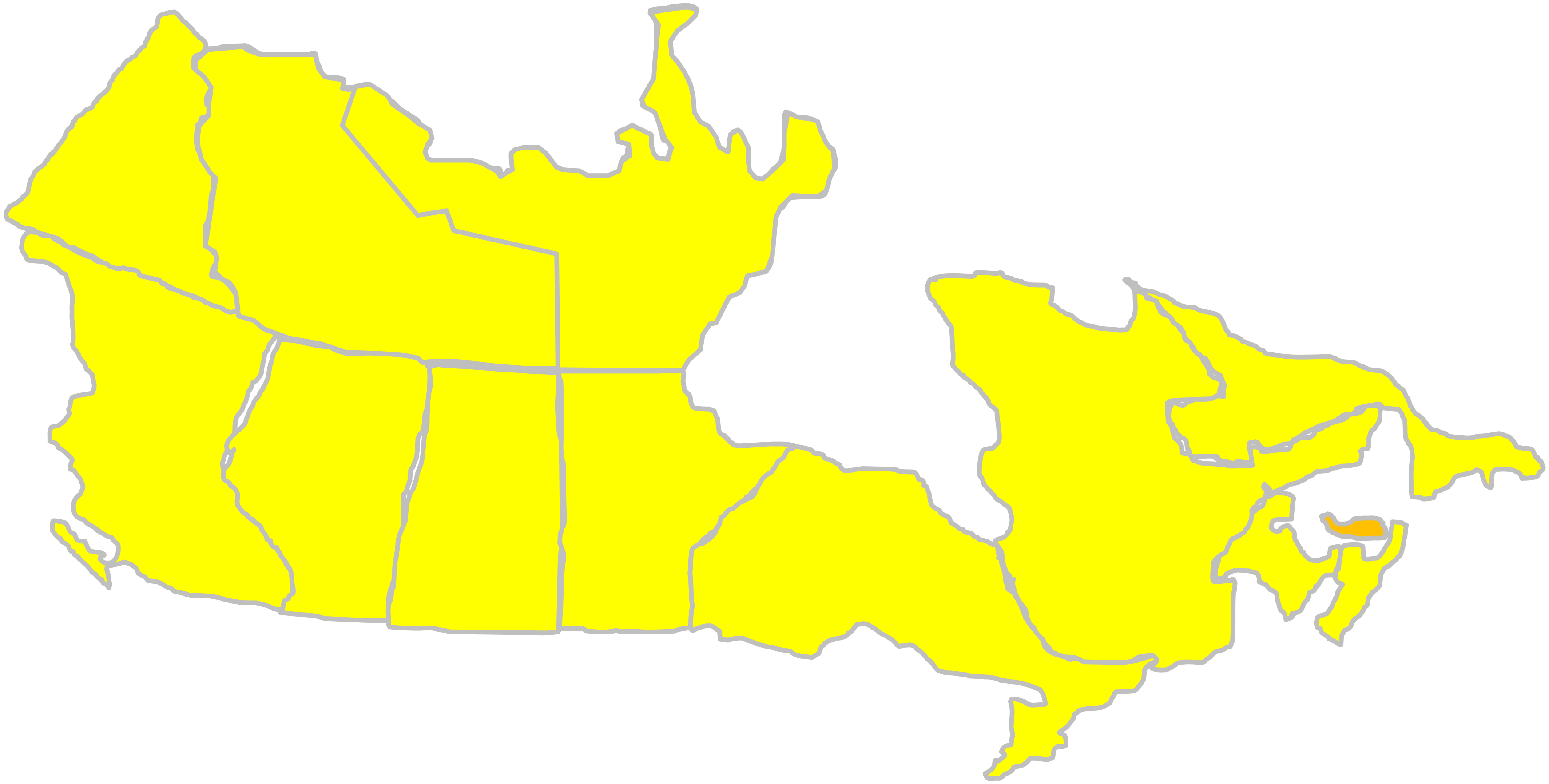
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2008MY Chevrolet Malibu IPTV



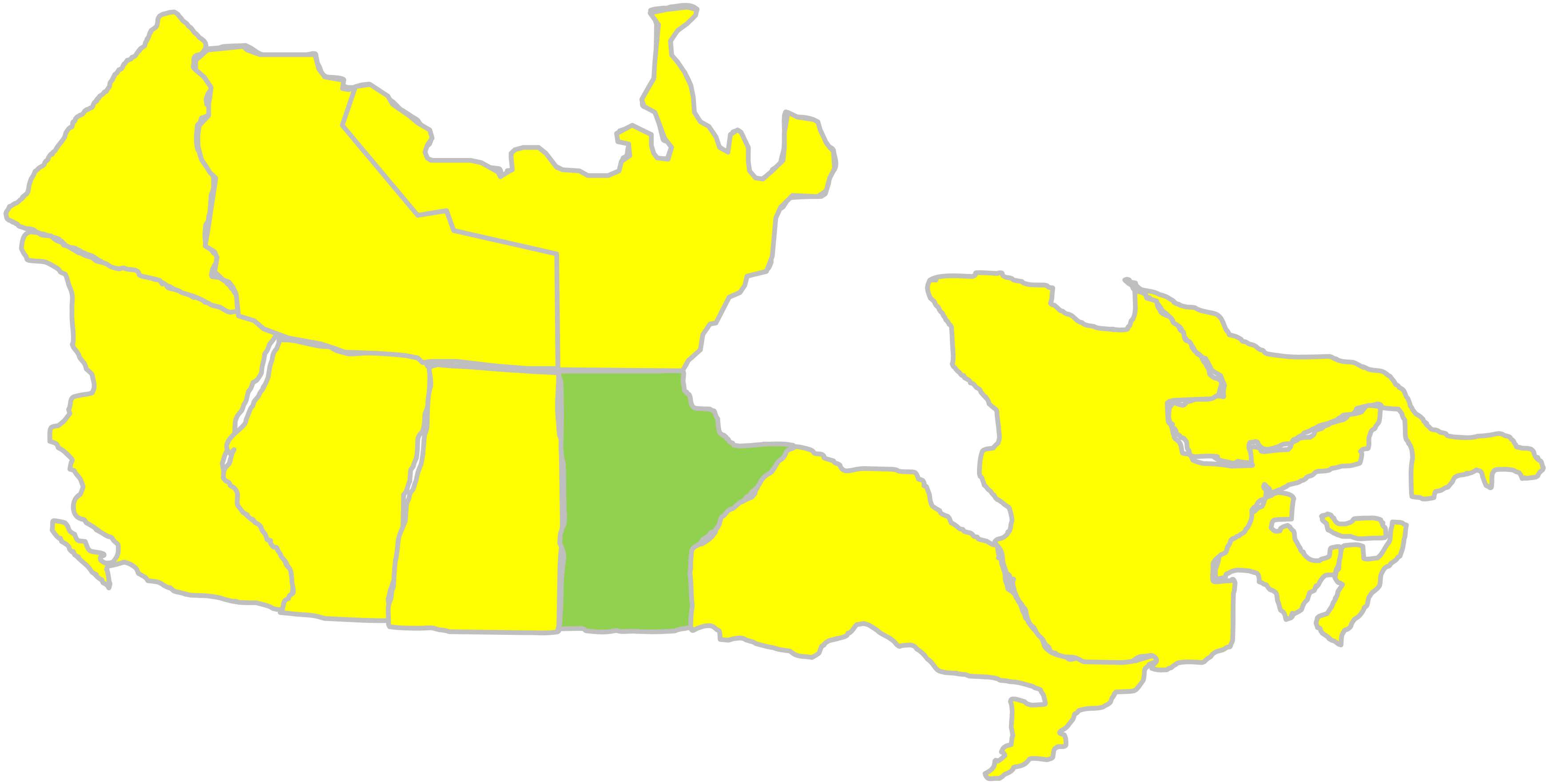
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2009MY Chevrolet Malibu IPTV



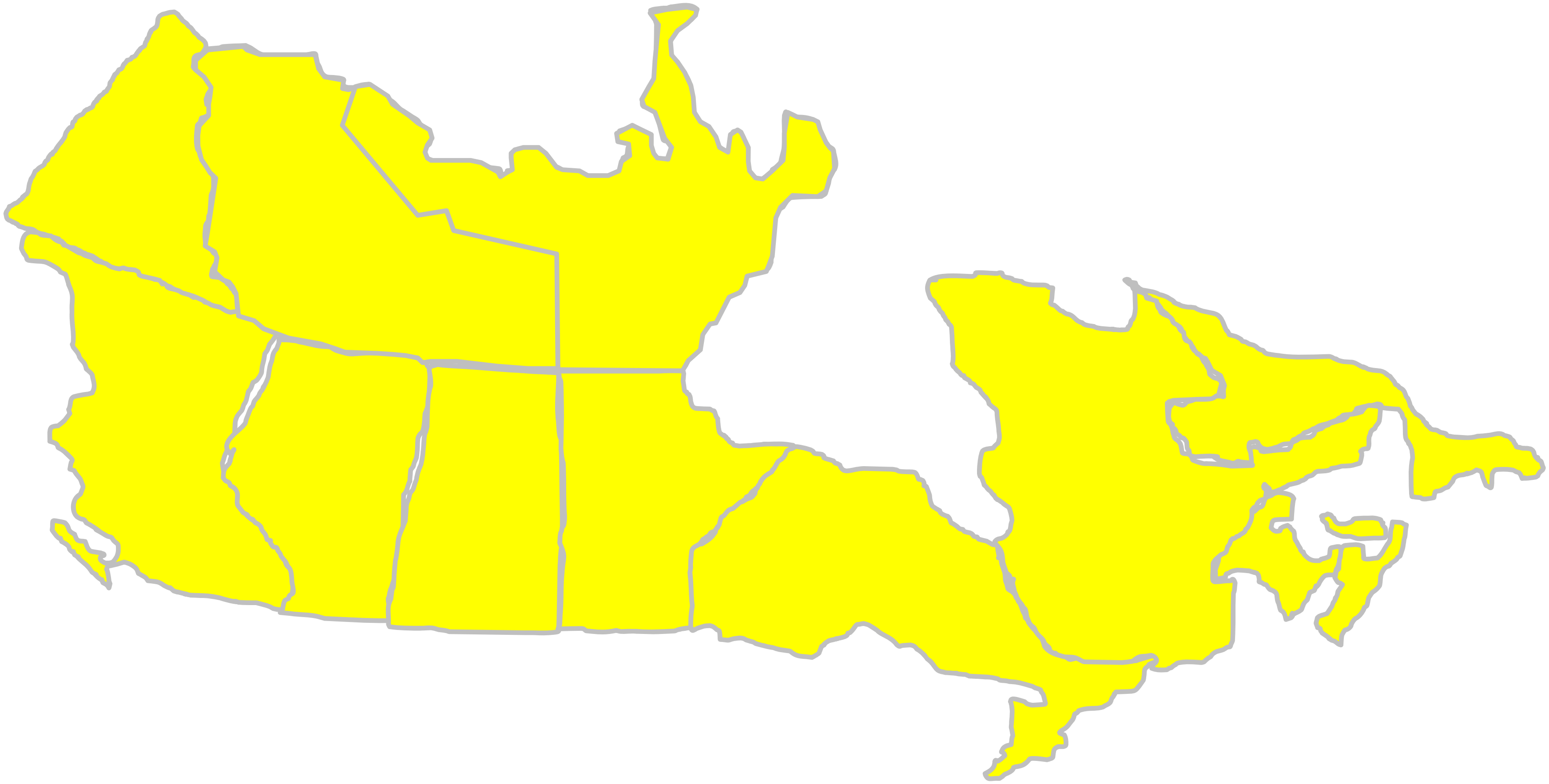
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2010MY Chevrolet Malibu IPTV



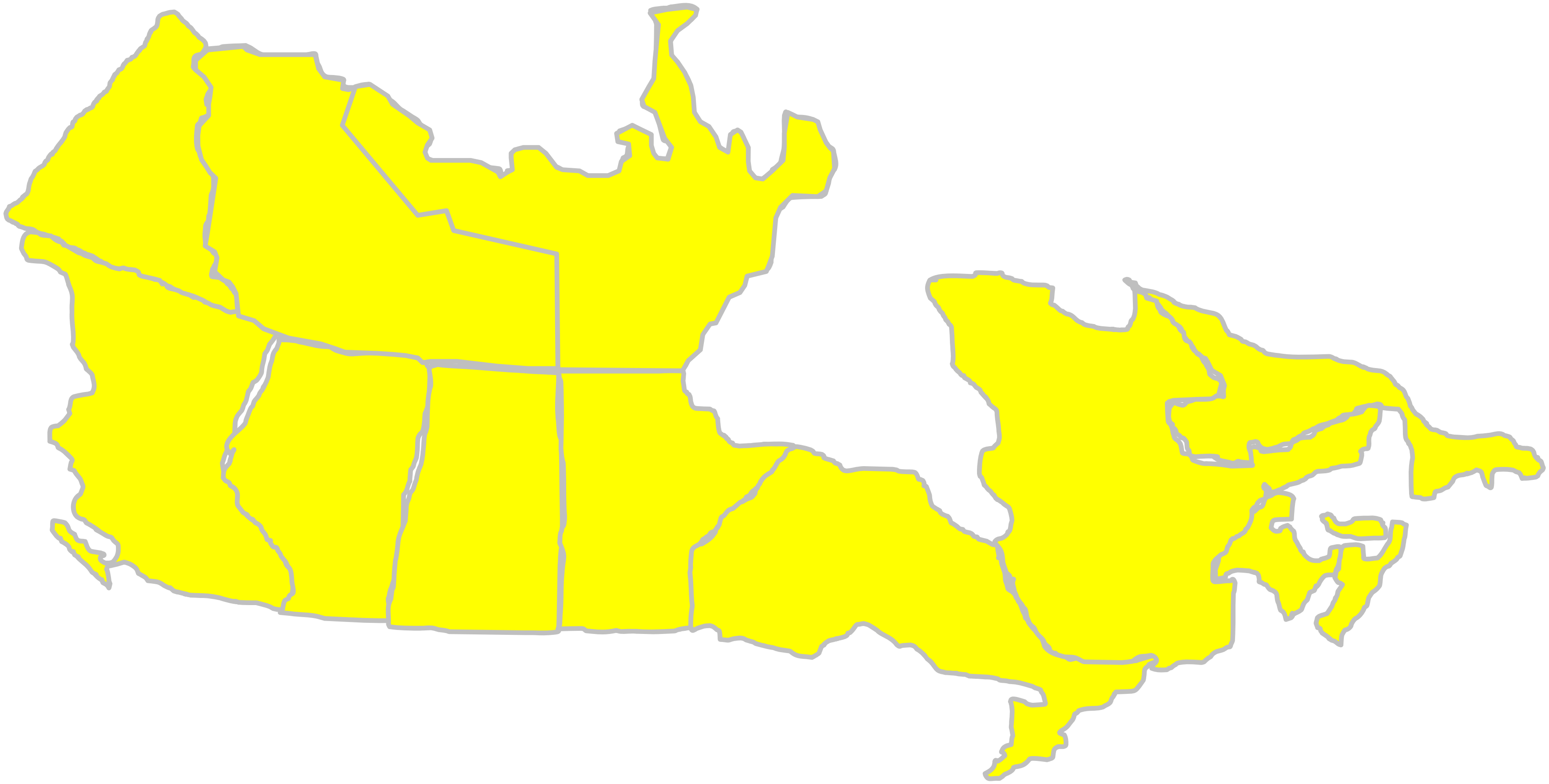
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2011MY Chevrolet Malibu IPTV



0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2004-2011MY Chevrolet Malibu Average IPTV

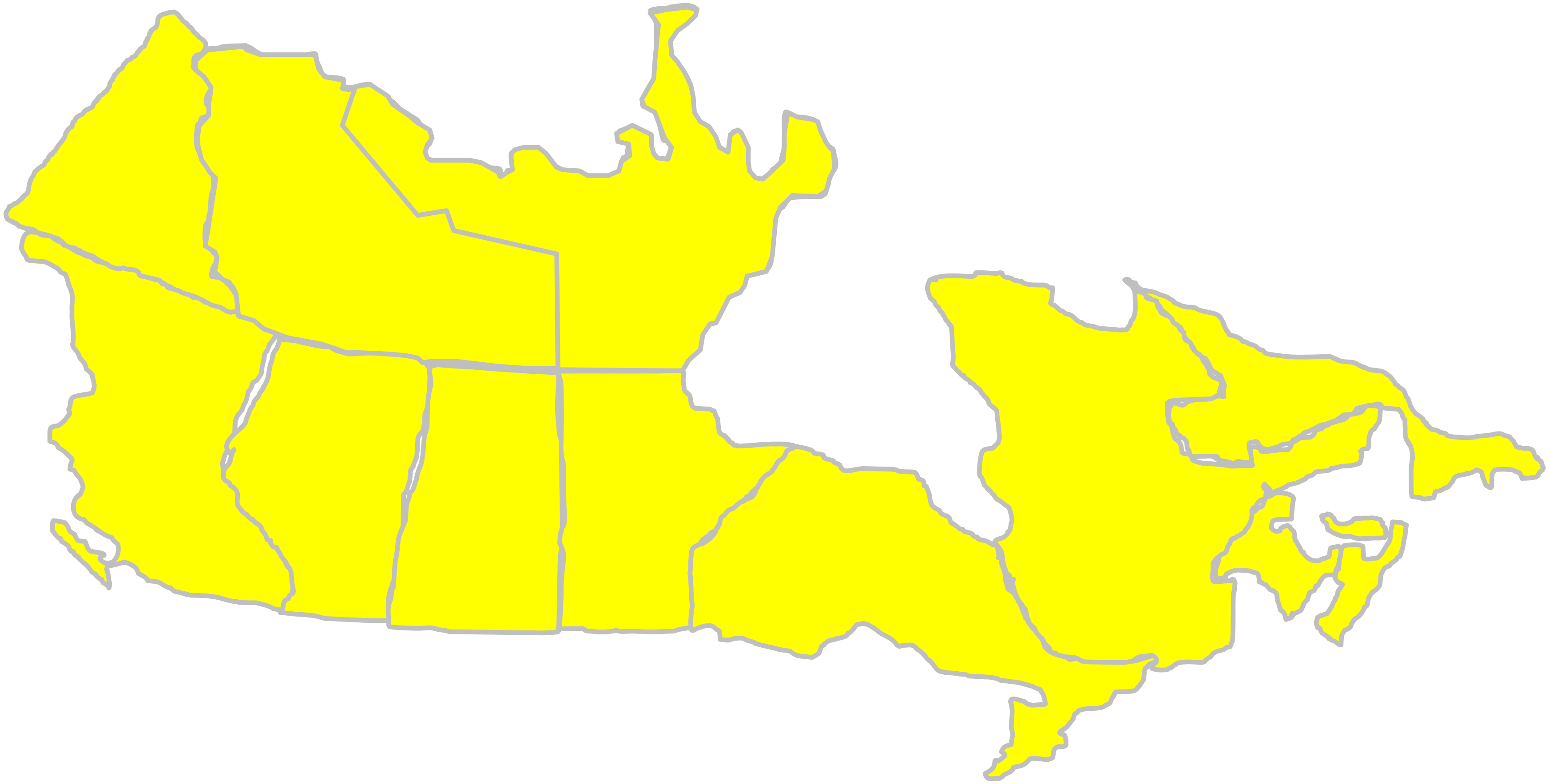


0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2004-2011MY Canada Chevrolet Malibu IPTV Table

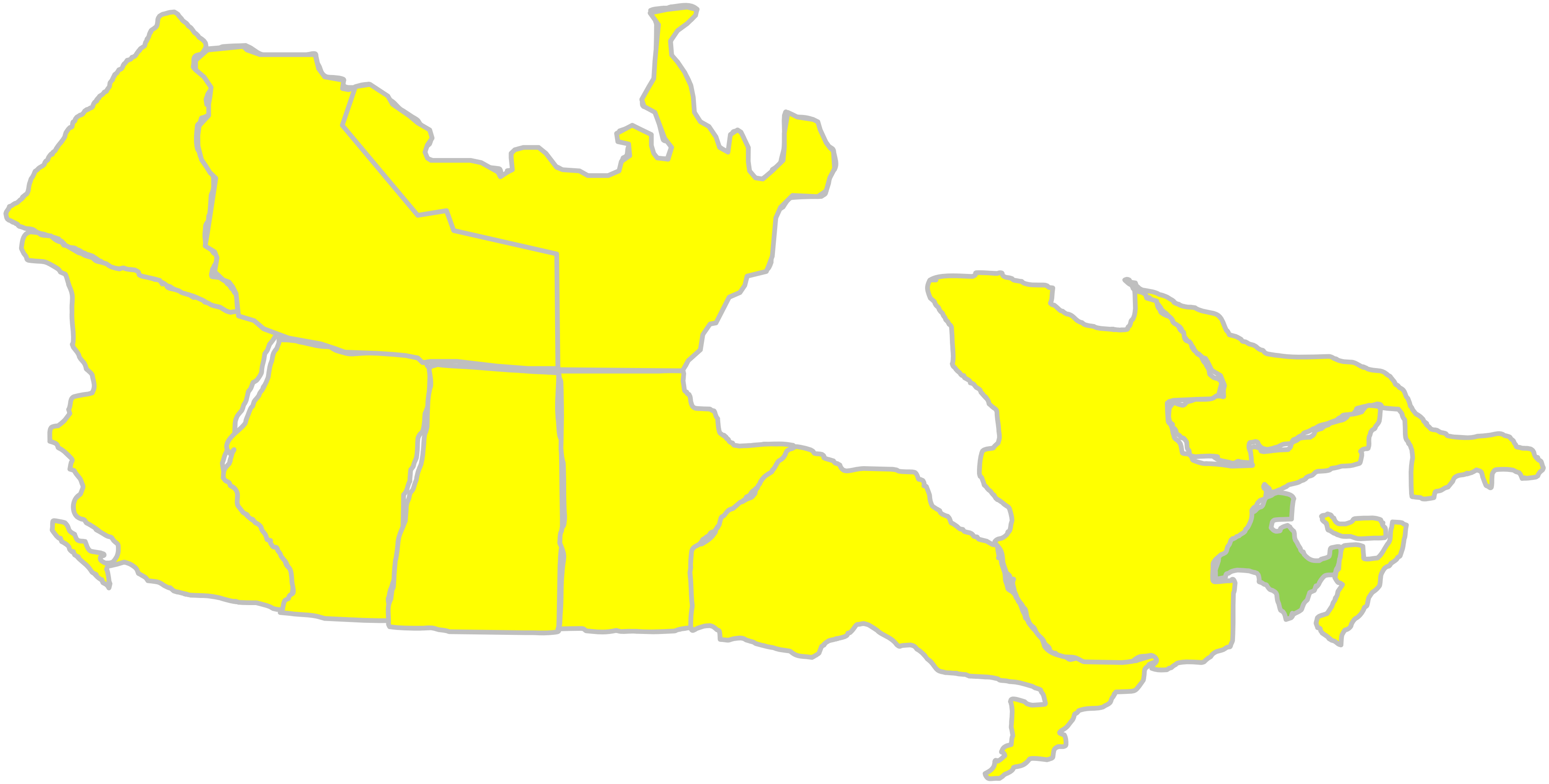
	Province	2004	2005	2006	2007	2008	2009	2010	2011	2004-11 Average
Alberta	AB	0.00	0.00	1.83	0.79	11.84	0.67	4.21	1.07	2.19
British_Columbia	BC	0.00	0.76	5.97	1.98	18.08	4.30	4.06	0.00	3.92
Manitoba	MB	0.00	0.00	3.45	11.64	18.06	3.13	16.13	2.35	6.67
New_Brunswick	NB	0.00	0.00	0.00	0.00	3.76	9.62	2.38	0.00	1.93
Newfoundland_and_Labrador	NF	0.00	0.00	7.23	11.63	2.86	7.58	3.51	0.00	4.43
Nova_Scotia	NS	0.00	0.00	2.17	5.26	19.34	2.35	5.63	0.00	4.12
Northwest_Territories	NT	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Nunavet										
Ontario	ON	0.00	0.16	3.25	4.05	16.14	9.55	7.10	0.23	5.07
Prince_Edward_Island	PE	0.00	0.00	0.00	0.00	0.00	37.04	0.00	0.00	3.66
Quebec	PQ	0.00	0.00	5.52	5.40	25.30	7.13	7.56	0.40	6.39
Saskatchewan	SK	0.00	0.00	5.95	8.73	12.44	3.16	9.96	0.00	5.37
Yukon	YT	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00

2005MY Pontiac G6 IPTV



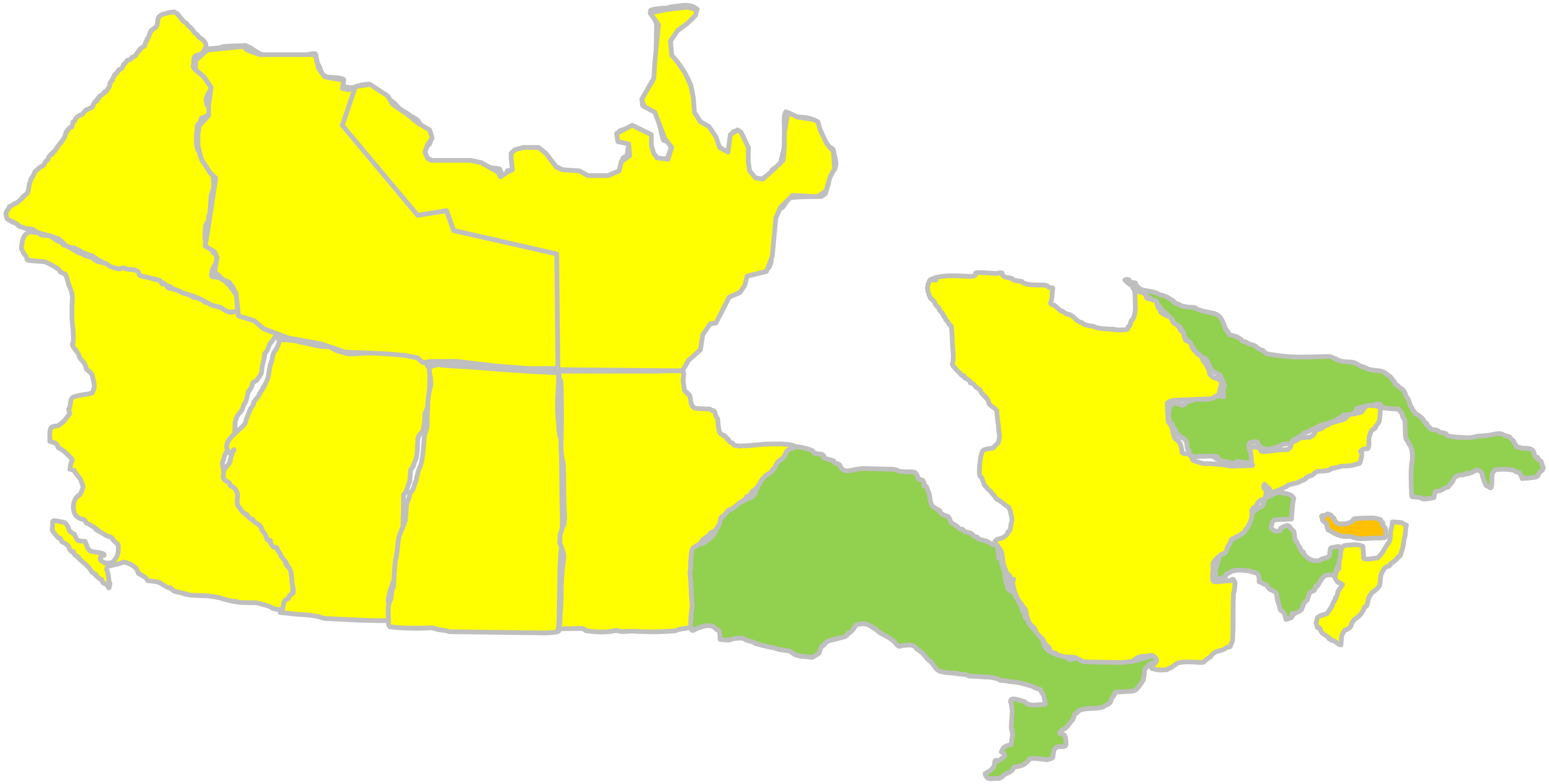
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2006MY Pontiac G6 IPTV



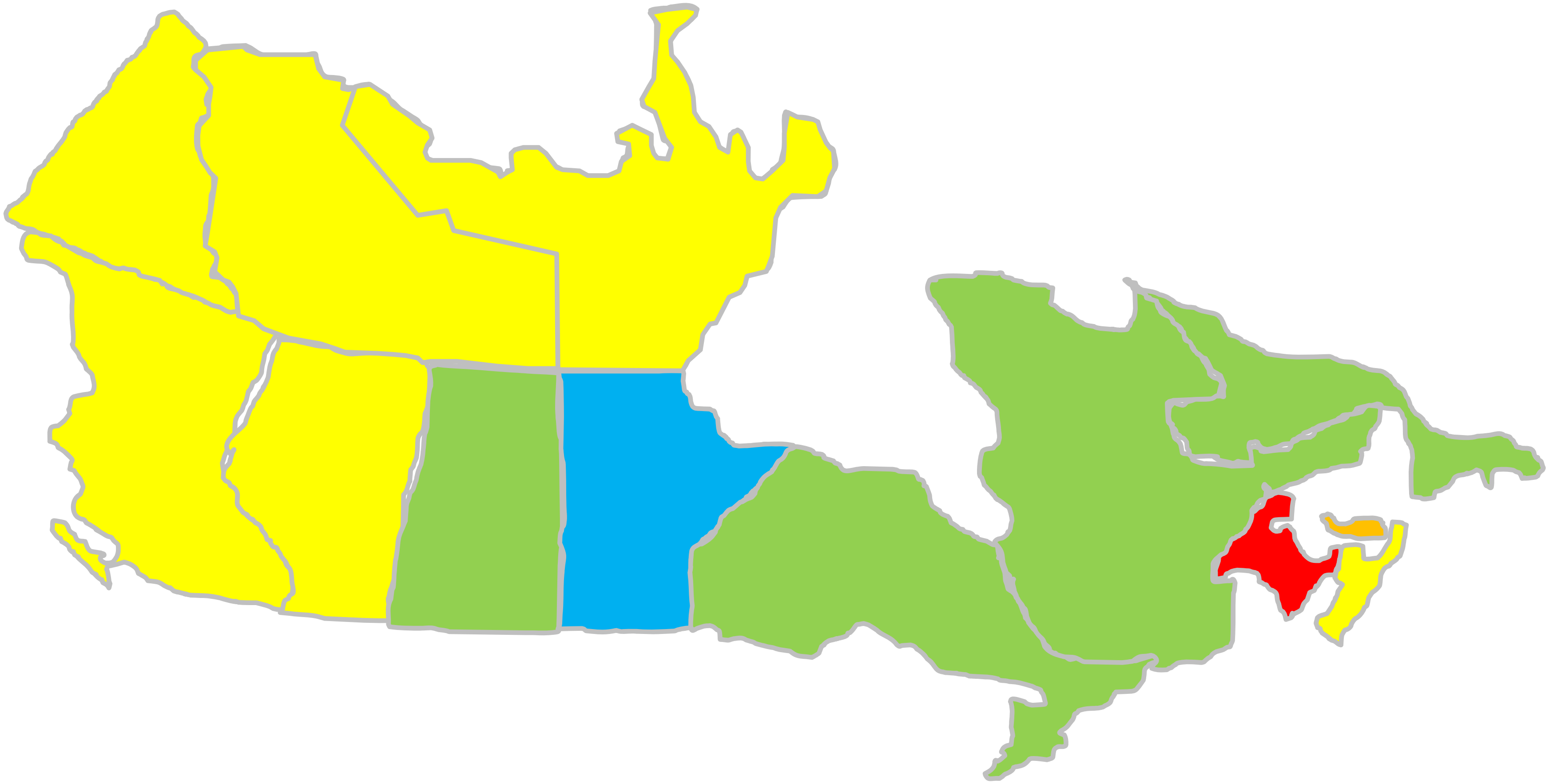
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2007MY Pontiac G6 IPTV



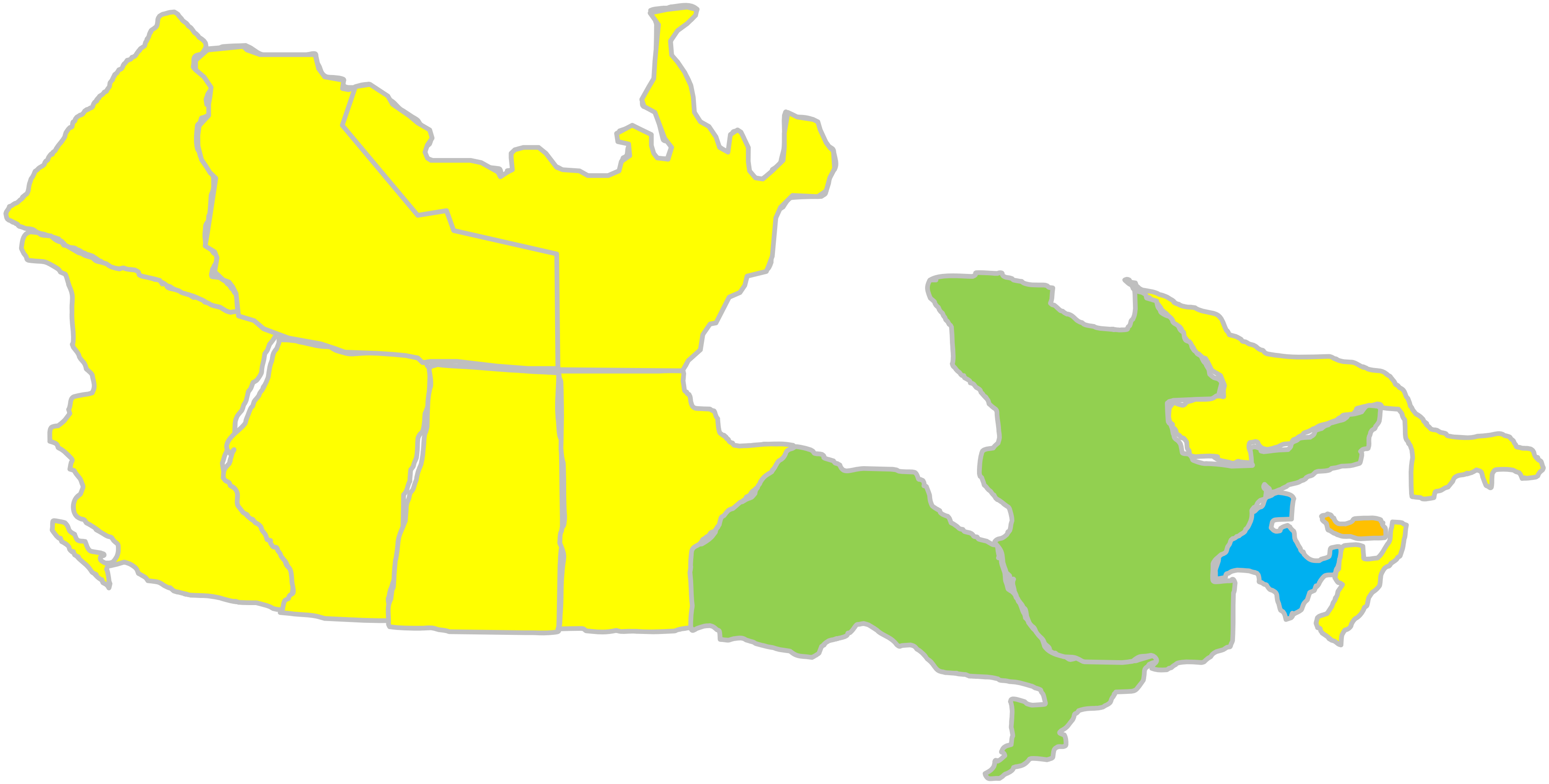
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2008MY Pontiac G6 IPTV



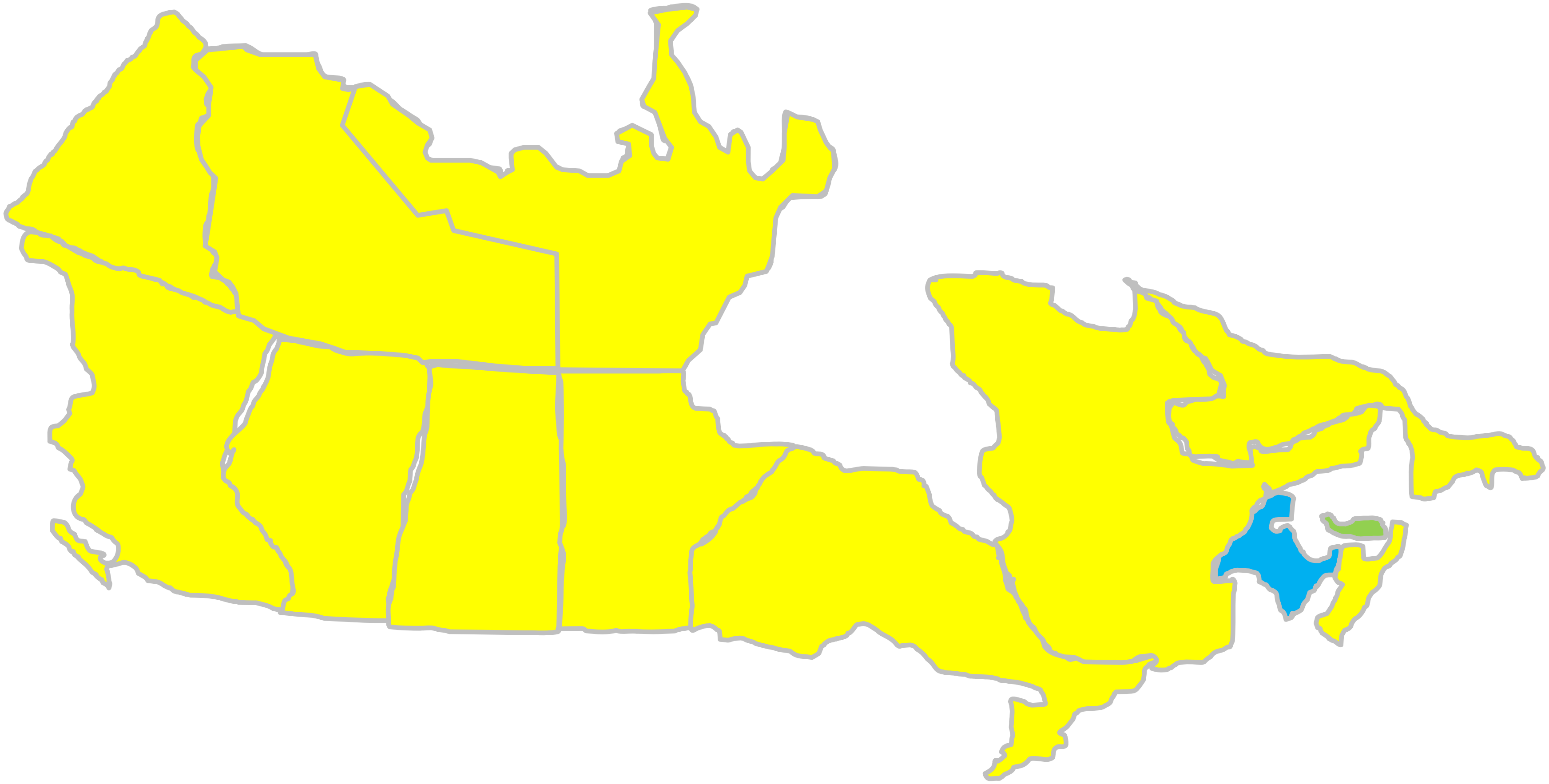
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2009MY Pontiac G6 IPTV



0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

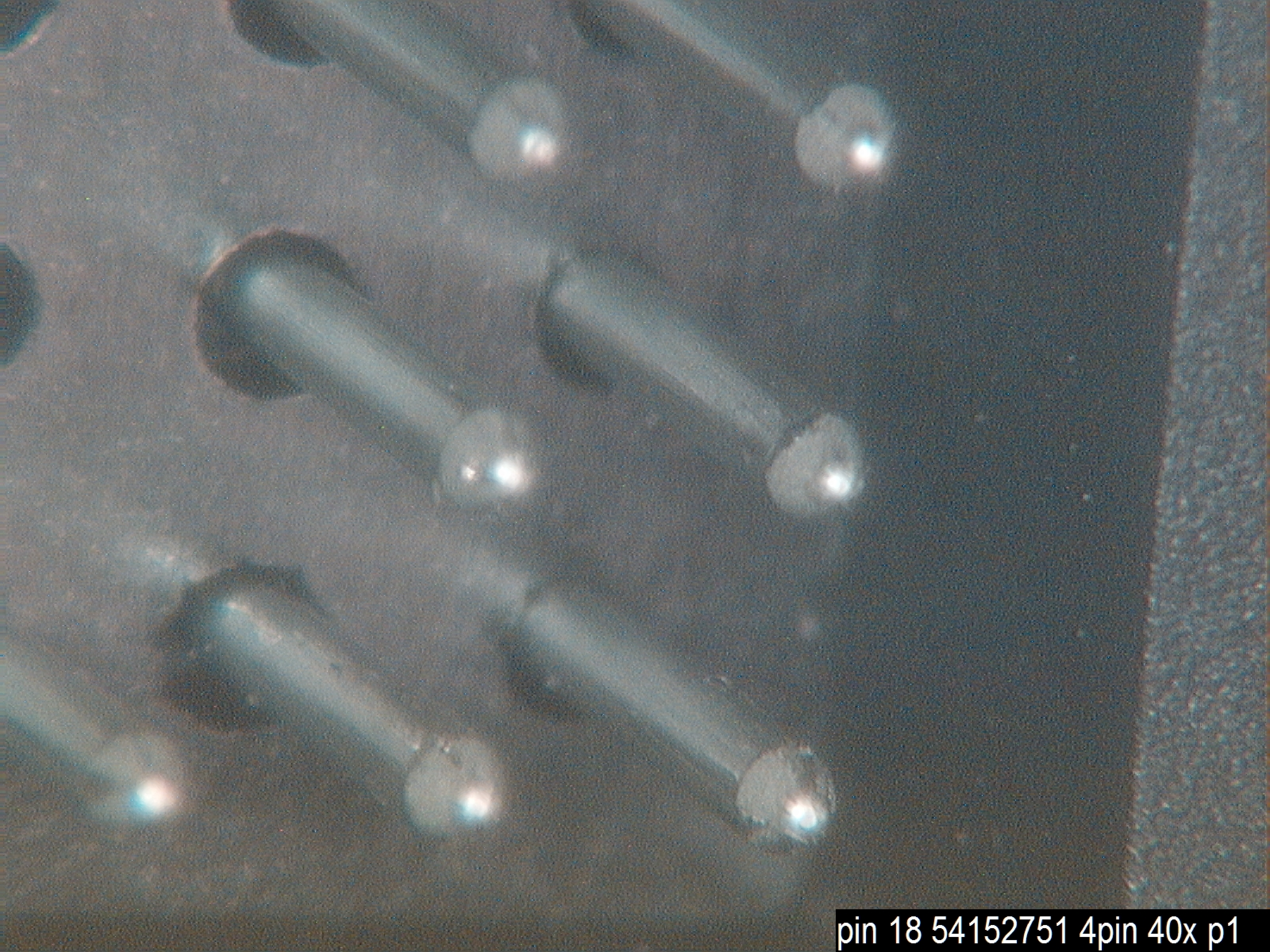
2005-09MY Pontiac G6 Average IPTV



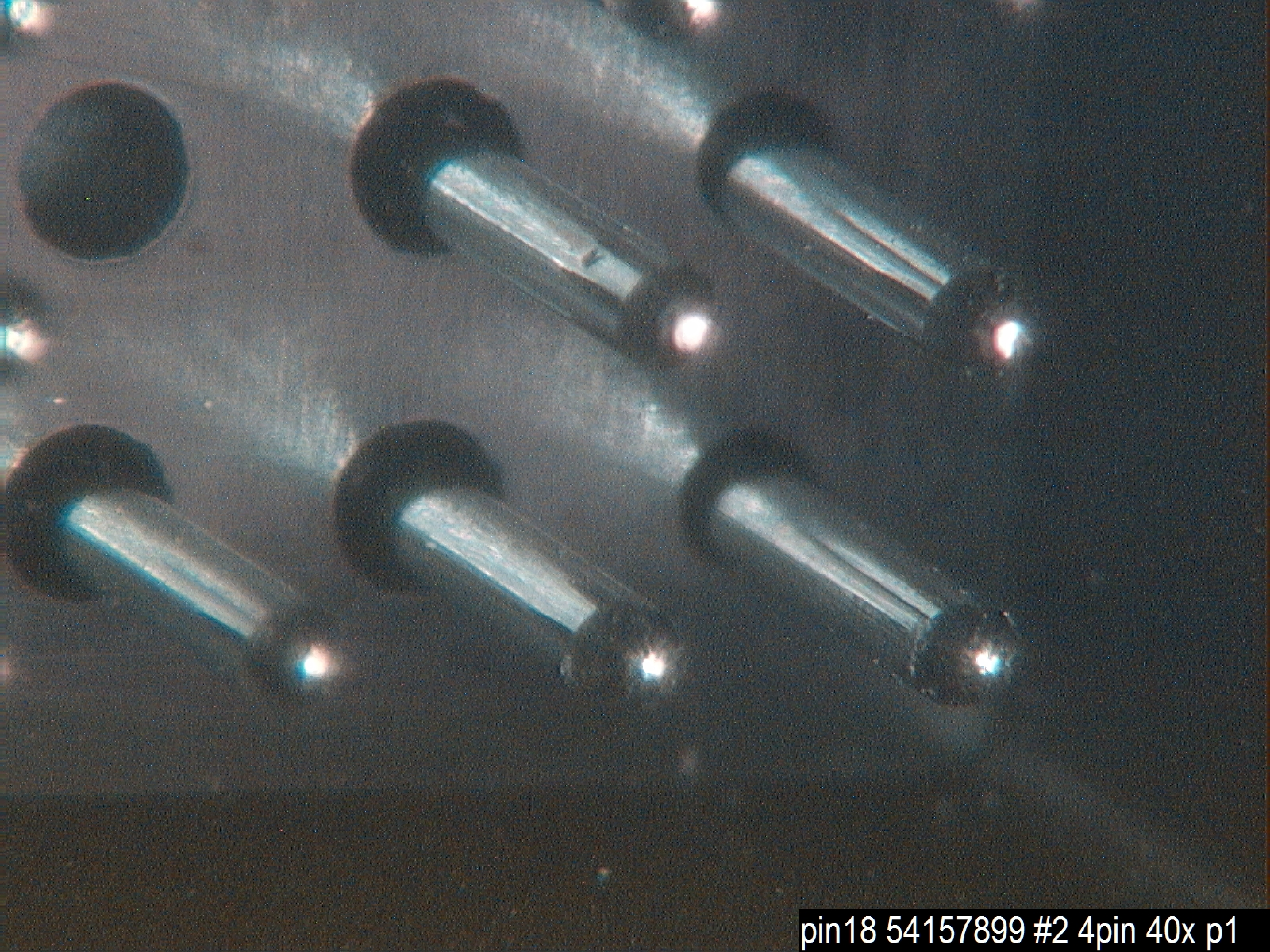
0-10	0-10
11-20	11 - 20
21-30	21 - 30
31-40	31 - 40
41+	41 +

2005-2009MY Canada Pontiac G6 IPTV Table

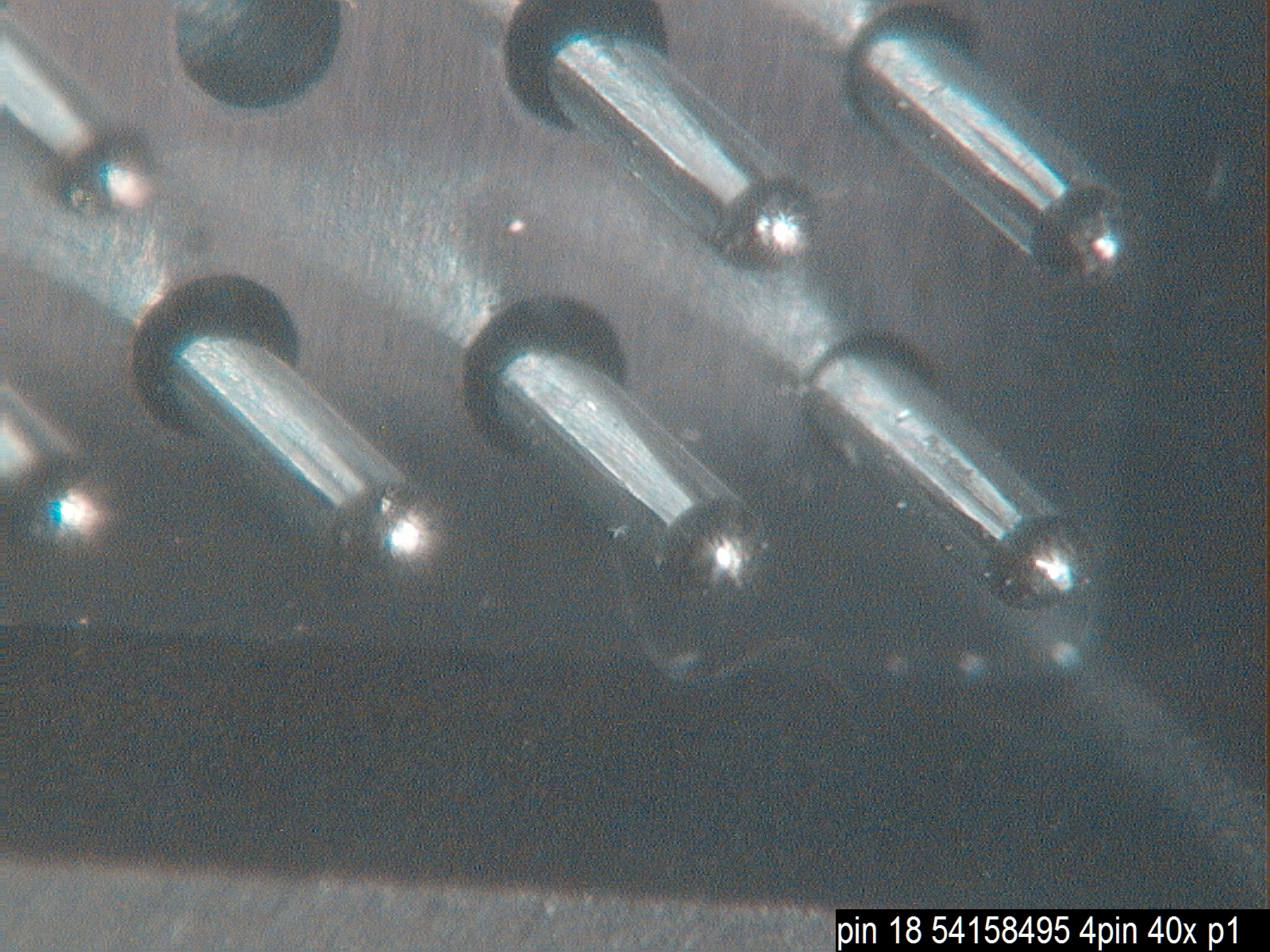
	Province	2005	2006	2007	2008	2009	2005-09 Average
Alberta	AB	0.00	1.12	5.87	1.85	7.13	2.91
British_Columbia	BC	0.00	1.75	2.32	5.93	2.76	2.83
Manitoba	MB	0.00	5.70	4.61	21.54	7.97	8.07
New_Brunswick	NB	5.68	10.58	13.25	49.69	20.13	21.10
Newfoundland_and_Labrador	NF	0.00	0.00	16.95	12.37	8.77	8.40
Nova_Scotia	NS	0.00	1.22	1.88	6.05	0.00	2.52
Northwest_Territories	NT	0.00	0.00	0.00	0.00	0.00	0.00
Nunavet							
Ontario	ON	0.40	4.83	13.51	15.99	10.83	9.70
Prince_Edward_Island	PE	0.00	0.00	33.33	32.26	34.48	18.87
Quebec	PQ	0.00	5.03	9.77	14.23	15.31	8.60
Saskatchewan	SK	0.00	0.00	7.12	17.39	0.00	5.33
Yukon	YT	0.00	0.00	0.00	0.00	0.00	0.00


pin 18 54152751 4pin 40x p1

pin18 54157899 #1 4pin 40x p1


pin18 54157899 #2 4pin 40x p1


pin 18 54158401 4pin 40x p1


pin 18 54158495 4pin 40x p1


pin18 54160380 4pin 40x p1


pin18 5F234657 4pin 40x p1

March 12, 2013

U.S. may order GM to expand recall over brake lights

Washington — The National Highway Traffic Safety Administration is investigating whether to add at least 550,000 additional vehicles to a 2009 General Motors recall for faulty brake lights.

Last month, NHTSA told GM it has opened a recall investigation into whether GM should expand its 2009 recall of the Pontiac G6 to address complaints that the brake lights do not operate properly.

NHTSA investigated the issue in 2008 but closed it when GM recalled 8,000 2005 and 2006 Pontiac G6 cars. Now, NHTSA is investigating whether GM should recall the entire population of 2005-08 G6 vehicles, estimated at 550,000 vehicles.

NHTSA has received 212 reports that the brake lights don't work properly on the 2005-08 G6 cars. The issue has been linked to rust in the wiring connector that could cause the brake lamps to turn on even when the brake pedal has not been pushed down — or not to work at all.

In October 2010, GM issued a technical service bulletin regarding brake light problems. The bulletin also included the 2004-11 Chevrolet Malibu, 2007-09 Saturn Aura and 2009-10 G6.

While not formally part of the investigation, NHTSA has asked for more information on complaints about those vehicles.

If the agency ordered a recall of those models as well, the total recall could be well more than 1 million vehicles.

NHTSA said it has received 12 complaints on 2009-10 G6 cars, 72 on the Malibu vehicles and 25 on the Saturn Aura cars for the same condition.

NHTSA asked GM a series of detailed questions in a Feb. 13 letter and requested the Detroit automaker to respond by March 29.

GM said in its 2009 recall that it attributed the problem to a "one month spike in claims for vehicles built in January 2005."

GM spokesman Alan Adler said the company is working with NHTSA and is looking at other possible spikes during production. "We are investigating it," Adler said.

GM's 2009 recall also disclosed one other problem: the cruise control may not engage or greater brake pedal force may be required to shift the vehicle out of park. Under the recall, GM dealers applied a dielectric lubricant to repair and prevent the rust.

dshepardson@detnews.com

Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.
March 2013	NHTSA opened a Recall Query Investigation for G6, Malibu, and Aura that is due on April 17, 2013.

Closing Resume

Intermittently Brake Lamps Do Not Function Correctly

2004-2011MY Epsilon (G6, Aura, Malibu)
Est. Population: 2.2M US Only
Est. Cost: $TBD

Condition: Fretting corrosion in the Body Control Module connector (C2 or X2) causes an increase in resistance that results in a reduction of Brake Apply Sensing (BAS) signal voltage to the BCM. Brake pedal status information affects the operation of brake lamps, cruise control, brake shifter interlock, and stability control systems.

Effect of the Condition: This results in erratic brake pedal status information. A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

{ * }

Potential Field Action Category: TBD

Discovery On September 15, 2008, NHTSA ODI opened PE investigation with 9 VOQs. On January 28, 2009, GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY. On February 13, 2013, NHTSA ODI opened RQ investigation initiated with 212 VOQs.

Intermittently Brake Lamps Do Not Function Correctly

Potential Field Remedy: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Frequency:
Month of Build January 2005 36 MIS = 34.8 IPTV Campaigned.
See updated IPTV vs. MOB graph for non-campaigned vehicles.

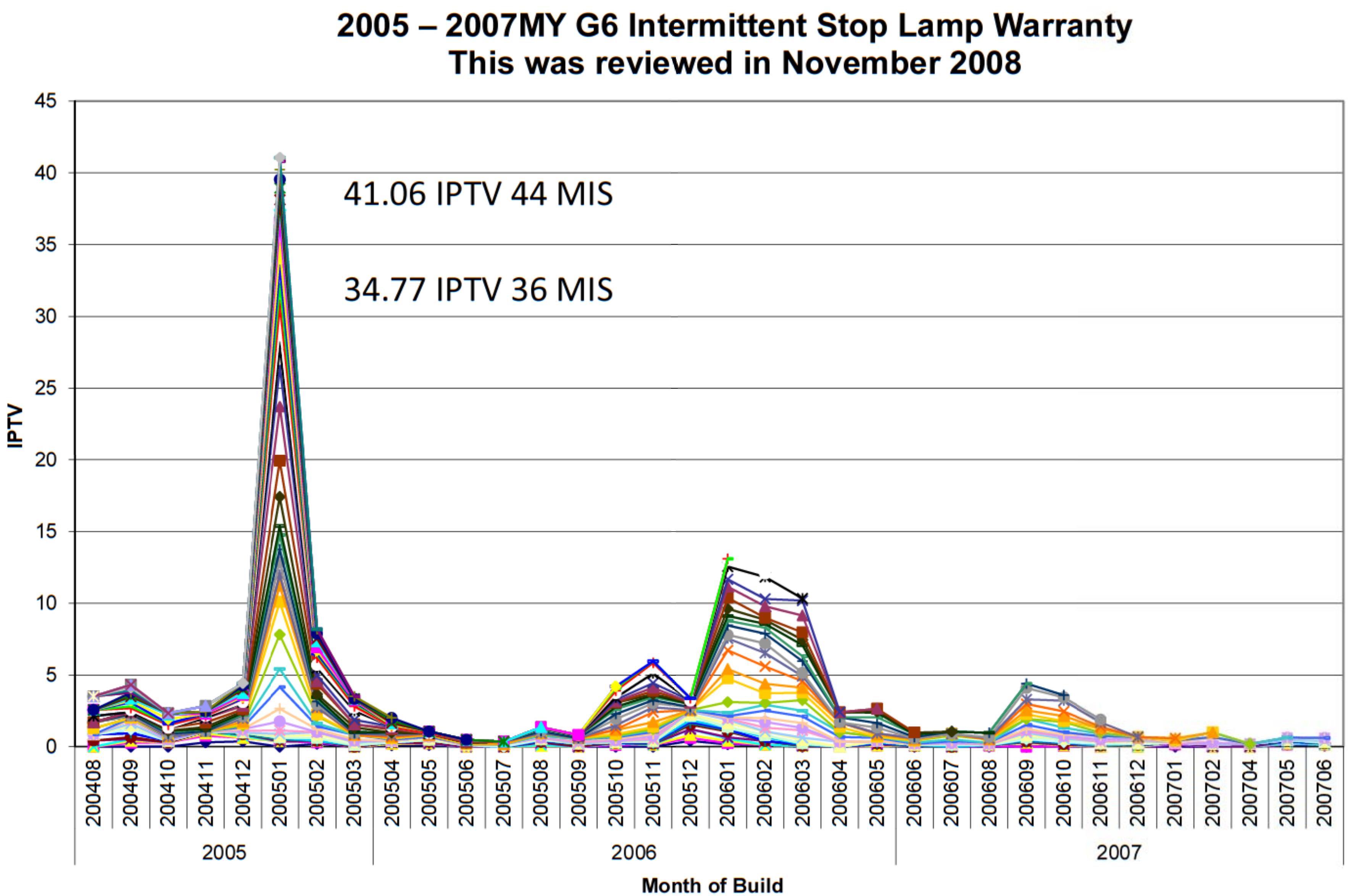
Immediate Improvement /Containment

On December 4, 2008, Technical Service Bulletin 08-05-22-009 was issued to apply the lubricant on the BCM terminal.

{ * }

Responsibility
GM and Delphi Engineering

Intermittently Brake Lamps Do Not Function Correctly

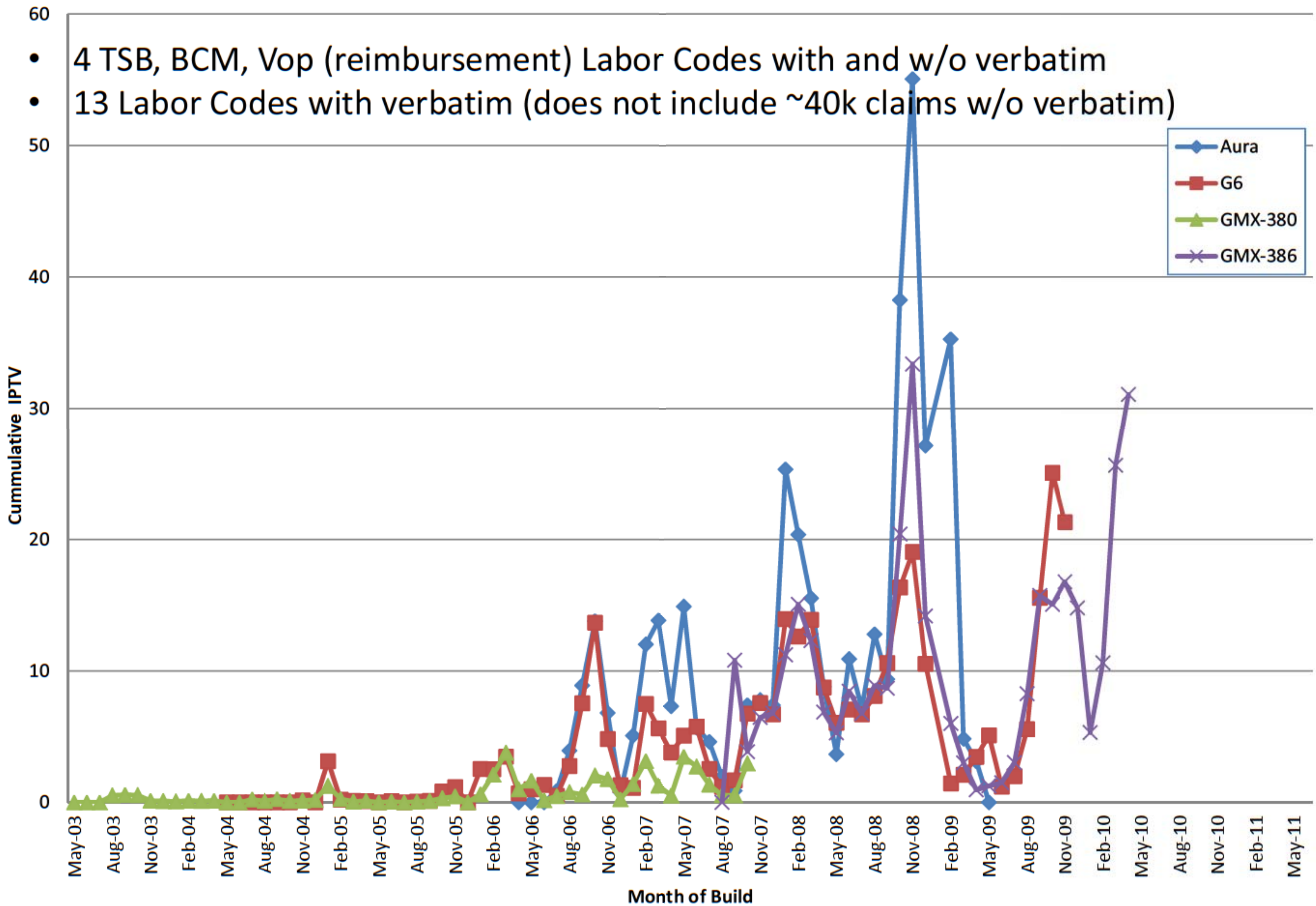


Subject component changed from BASS sensor (PE Date 9/08) to BCM connector (RQ Date2/13)

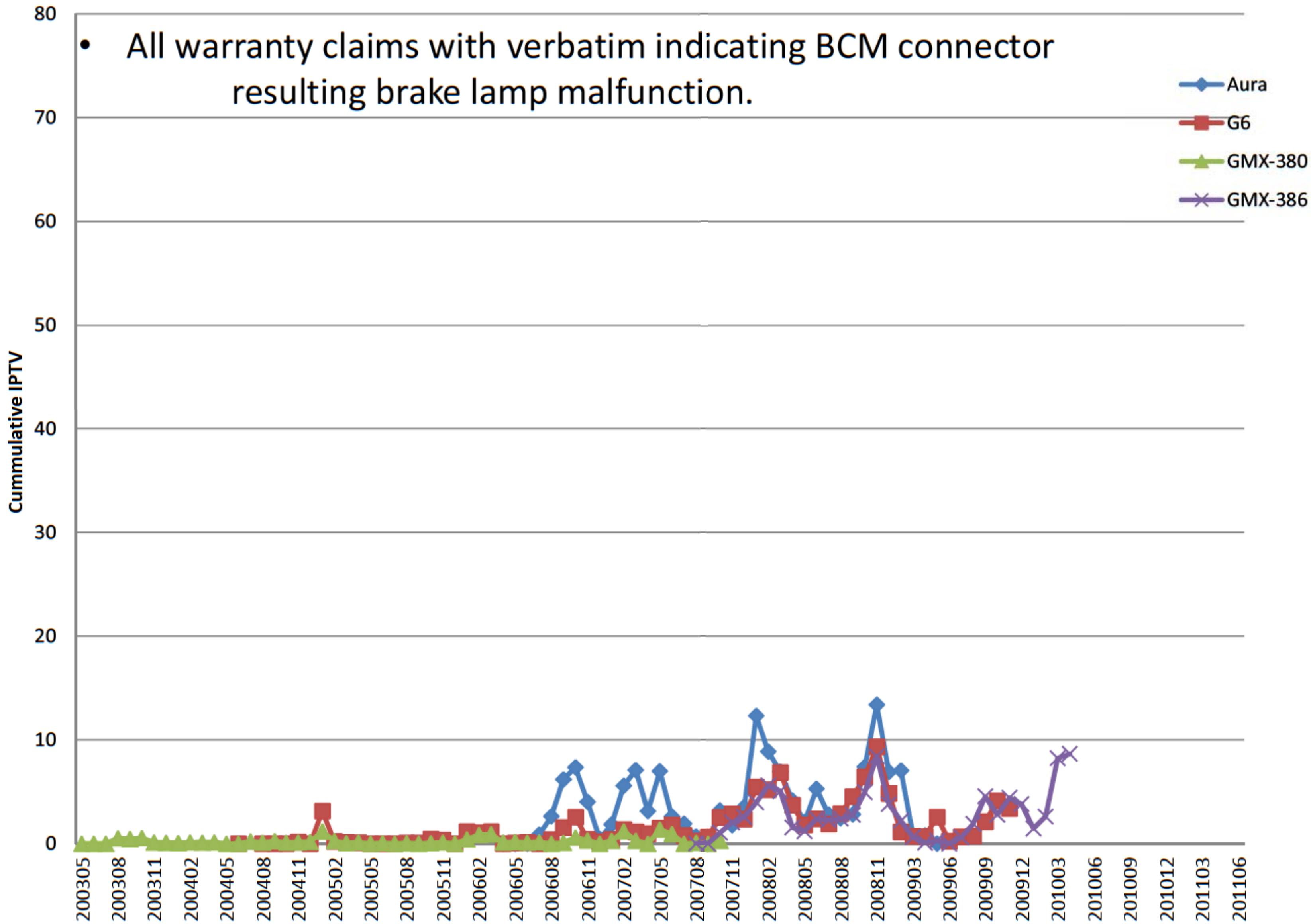
Labor Code	Description
N9595	BCM C2 or X2 Connector Repair
N9613	Lubricate Body Control Module (BCM) Connector with Dielectric Lubricant
N6612	Exterior Lighting Wiring and/or Connector Repair or Replace
N6616	Serial DATA/DLC/STAR Connect Wiring and/or Connector Repair or Replace
N6651	Connector Kit Repair
N6652	Connector with Leads Assembly Replace
N2700	Switch, Stop Lamp – Adjust
N4800	Body Control Module Replacement
H2640	Pedal and/or Bushing, Brake – R&R or Replace
H2642	Sensor, Brake Pedal Position – Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
H9991	Customer Concern Not Duplicated
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement – Product Allegation
Z1243	Inspection – Product Allegation Resolution
V2044	Apply Dielectric Lubricant to C2 Connector (08317)
V2045	Customer Reimbursement (08317)

Maroon color represents added RQ Labor Codes

Warranty Requested by NHTSA for RQ



March 2013 Warranty IPTV @ 36 MIS
Subset of NHTSA Warranty Claims Sorted by Verbatim 5,943



Back-up

5. State, by model and model year, a total count for all of the following categories of claims, collectively, that have been paid by GM to date that relate to, or may relate to, the subject component, regardless of why the claim was made, in the subject vehicles: warranty claims; extended warranty claims; claims for good will services that were provided; field, zone, or similar adjustments and reimbursements; and warranty claims or repairs made in accordance with a procedure specified in a technical service bulletin or customer satisfaction campaign. This specifically includes, but is not limited to, repairs made in accordance to TSB 09-05-22-009C.

Separately, for each such claim, state the following information:

a. GM's claim number;
b. Vehicle owner or fleet name (and fleet contact person) and telephone number;
c. VIN;
d. Repair or replacement date;
e. Vehicle mileage at time of repair;
f. Repairing dealer's or facility's name, telephone number, city and state or ZIP code;
g. Labor operation number;
h. Problem code;
i. Replacement part number(s) and description(s);
j. Whether glass fracture is alleged;
k. Concern stated by customer; and
l. Comment, if any, by dealer/technician relating to claim and/or repair or replacement.

Provide this information in Microsoft Access 2010, or a compatible format, entitled "WARRANTY DATA."

RQ Warranty Analysis Methodology 1
NHTSA Inquiry Response

<u>Many of the following warranty claims do not relate to the brake lamp malfunction condition</u>. The following process was used to sort the warranty claims:

All claims with labor code N9595 (TSB 08-05-22-009), N9613 (TSB 09-06-03-004), N4800 (Body Control Module Replacement) and V2045 (campaign 08317 reimbursements) were determined to be responsive to the alleged condition, even if no verbatim were provided.

All claims for V2044 were excluded as part of General Motors campaign 08317.

Each warranty record may have up to 6 verbatim fields. All available verbatim of the remaining claims were read and a claim was determined to be responsive if the verbatim indicated that the incident may have been caused by the BCM C2 or BCM X2 connector. In cases where it was specifically stated that a repair or replacement of the C2 or X2 did not correct the brake lamp problem and another component was repaired or replaced to correct the problem, those claims were not counted.

RQ Warranty Analysis Methodology 2
GM Warranty Estimate using Complaint & Causal Codes

139,689 VINs including duplicates

A. All claims with labor codes N9595 and N9613 were determined to be responsive to the alleged condition.
B. Total of 17 warranty labor codes with certain complaint codes and causal codes were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.
C. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.
D. All claims for vehicles covered by General Motors recall 08317 were excluded.
   6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%.

35,575

RQ Warranty Analysis Methodology 2
GM Warranty Estimate using Complaint & Causal Codes

139,689 VINs including duplicates for US Only

A. The verbatim of 17 warranty labor codes were read and counted if they stated that the claim was related to the loss/malfunction of the brake/stop lamps.
   5,943
B. The complaint codes and causal codes were selected from the overall claims including non-verbatim claims that are greater than 1.5% of the claims. These are representative of the overall claims and were determined to be responsive.
C. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.
D. Remove duplicate VINs including the VINs that were combined with dataset A and B.
E. All claims for vehicles covered by General Motors recall 08317 were excluded.
   6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%.

21,193

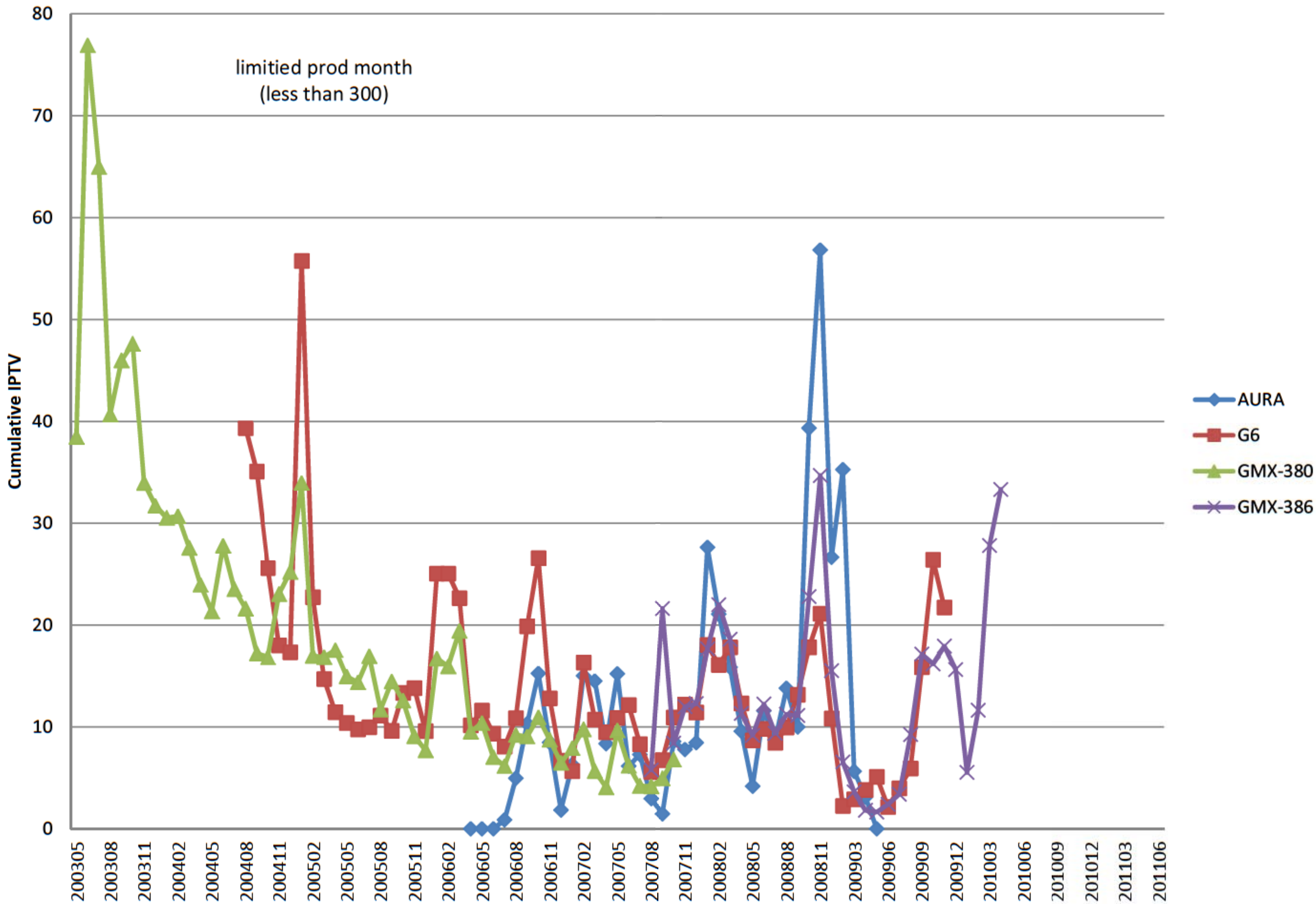
RQ Warranty Analysis Methodology 3
GM Warranty Estimate using Verbatim only

139,689 VINs including duplicates

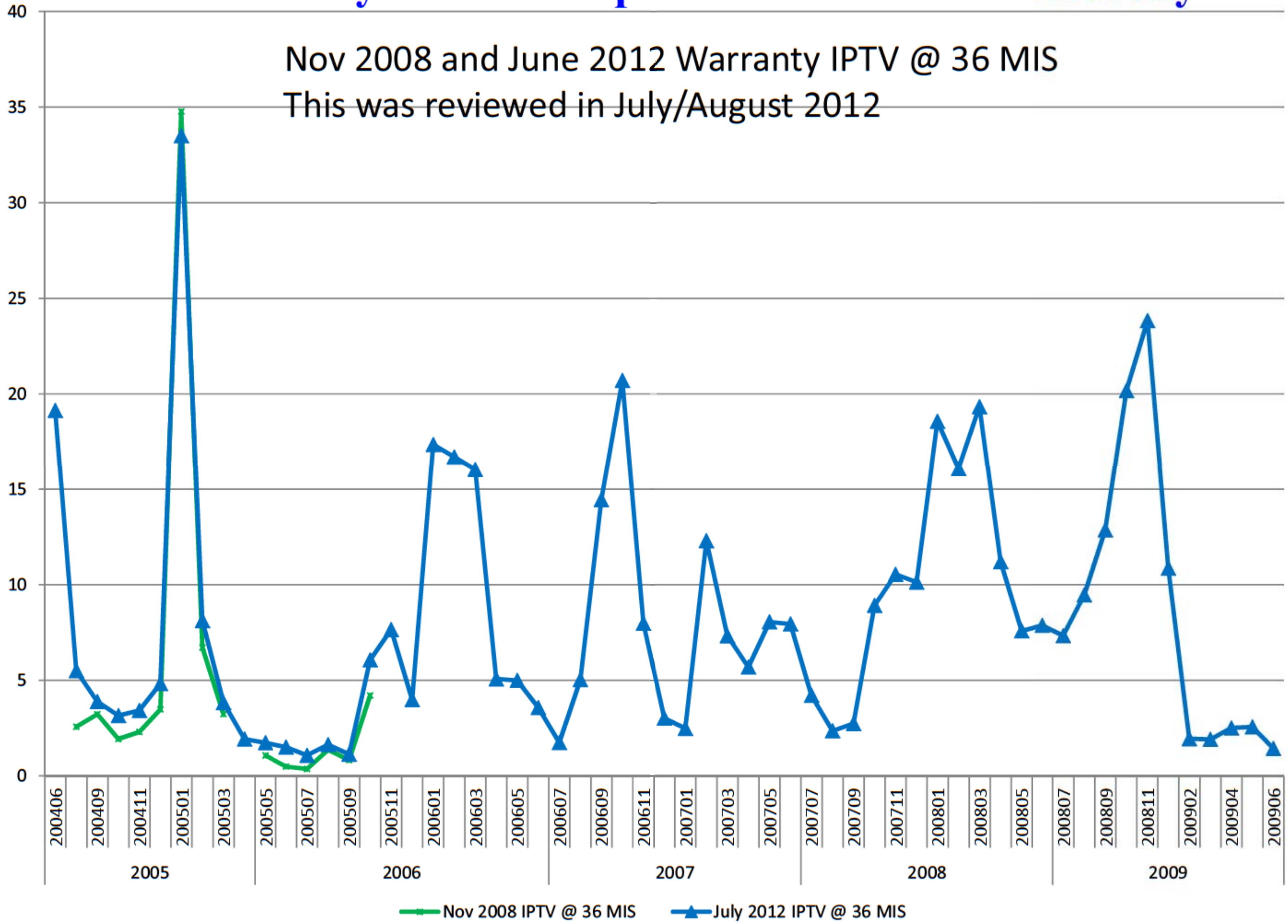
A. The verbatim of 17 warranty labor codes were read and counted if they stated that the claim was related to the loss/malfunction of the brake/stop lamps.

5,943

36 Months – 35,575 Complaint and Causal Claims



Intermittently Brake Lamps Do Not Function Correctly



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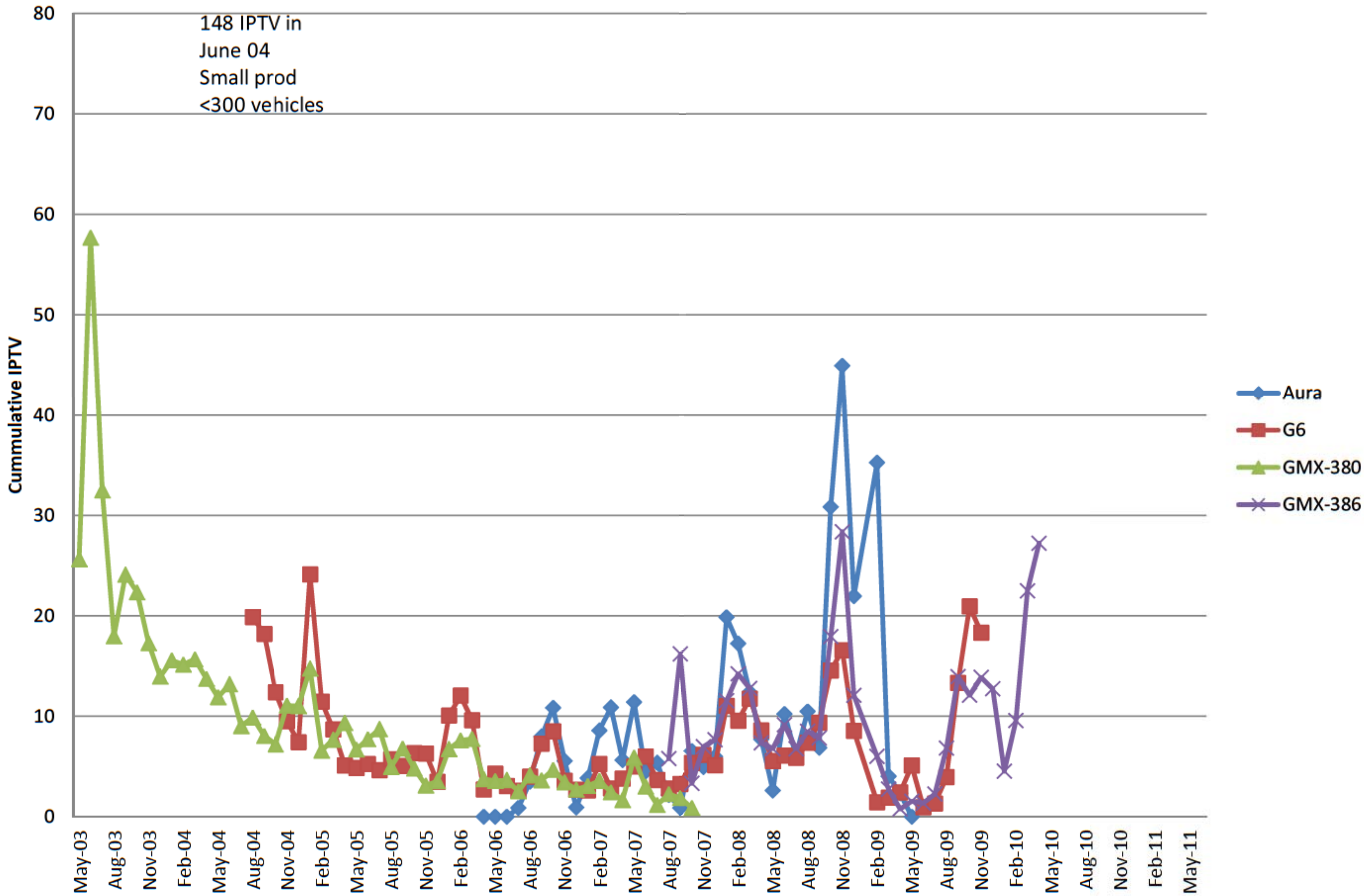
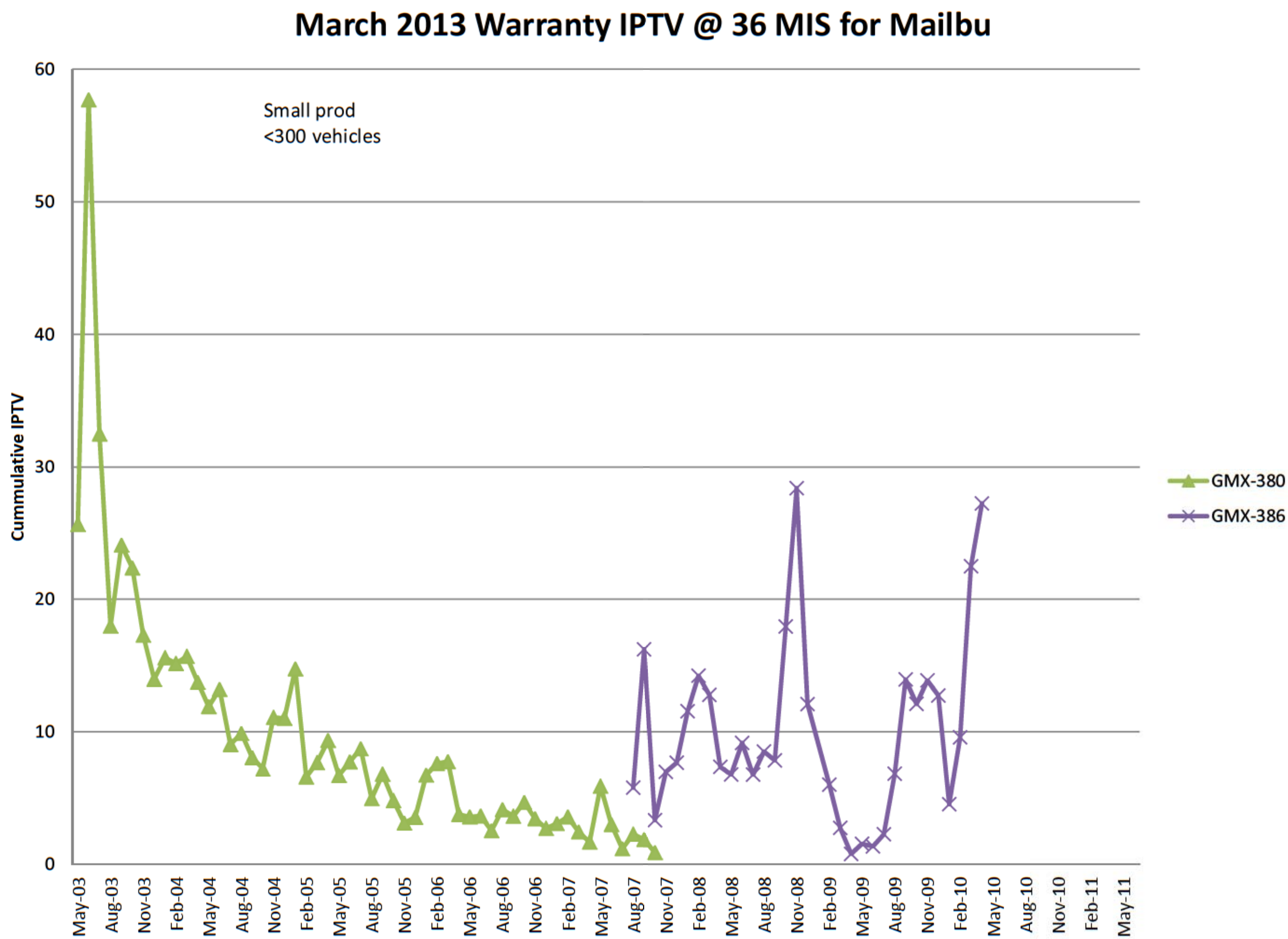
March 2013 Warranty IPTV @ 36 MIS
by Verbatim, Complaint and Causal Code Analysis




March 2013 Warranty IPTV @ 36 MIS for Mailbu
Small prod
<300 vehicles
Cummulative IPTV
60
50
40
30
20
10
0
May-03
Aug-03
Nov-03
Feb-04
May-04
Aug-04
Nov-04
Feb-05
May-05
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
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Feb-08
May-08
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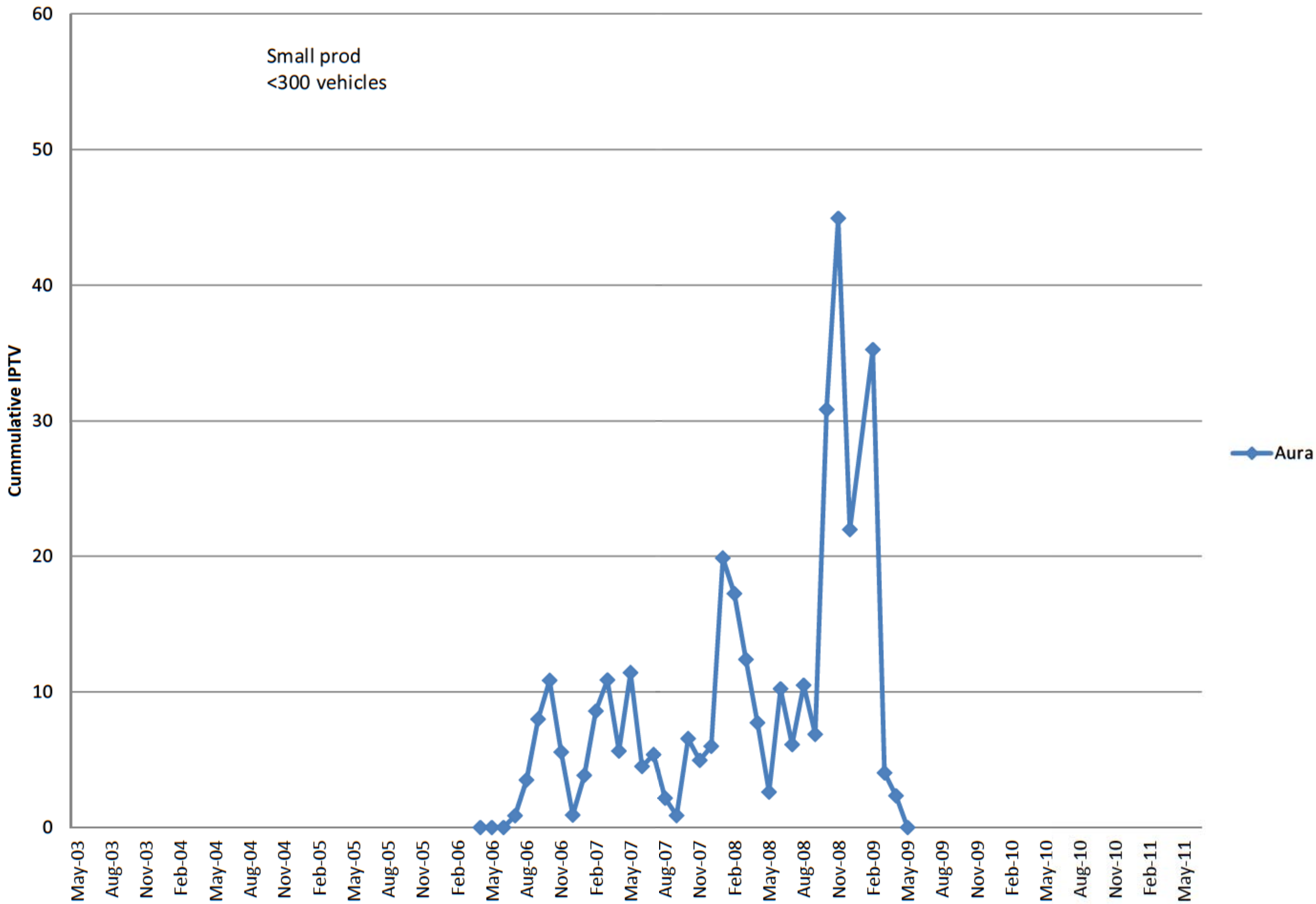
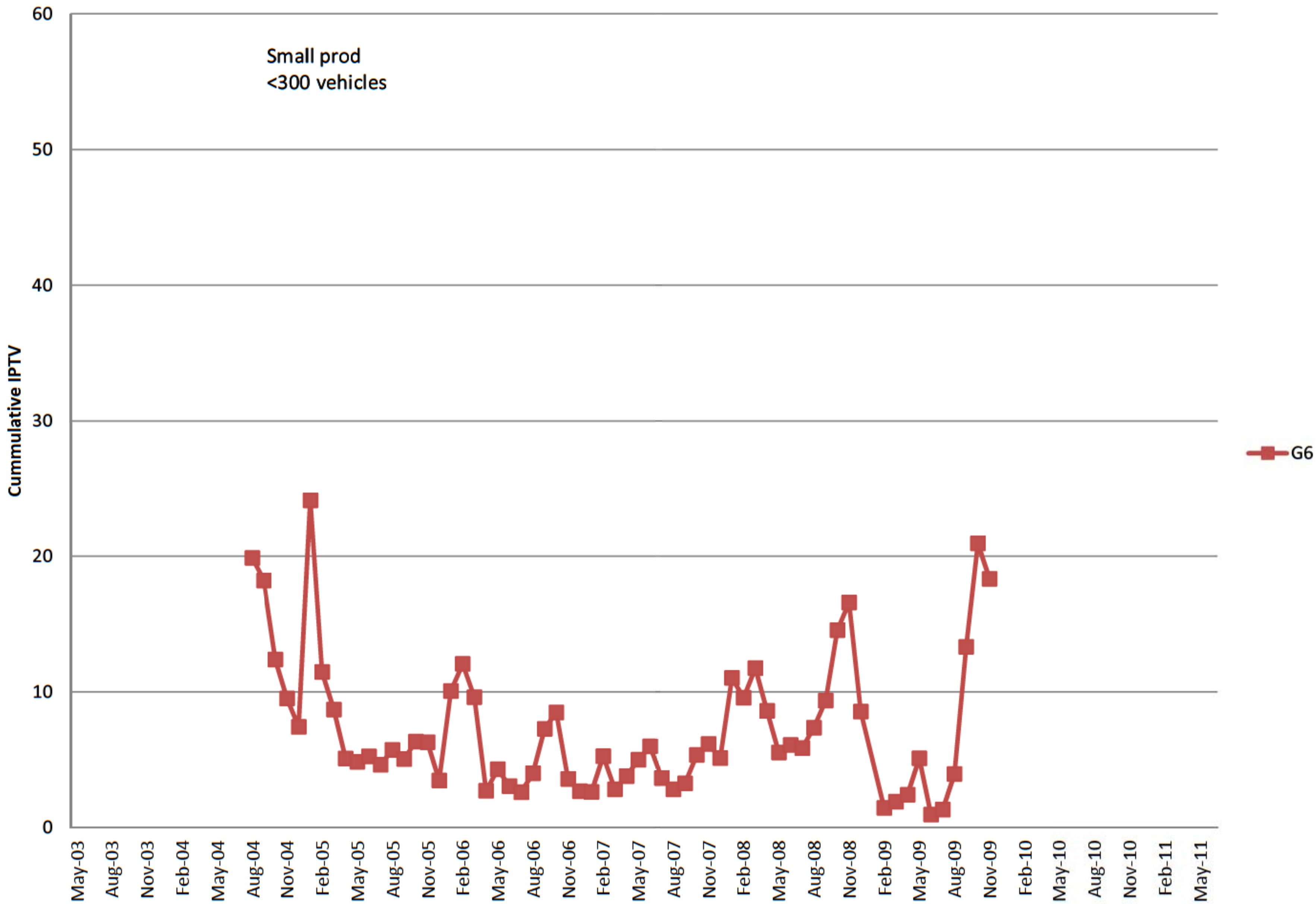
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
GMX-380
GMX-386

March 2013 Warranty IPTV @ 36 MIS for Aura



March 2013 Warranty IPTV @ 36 MIS for G6



March 2013 Warranty IPTV @ 48 MIS

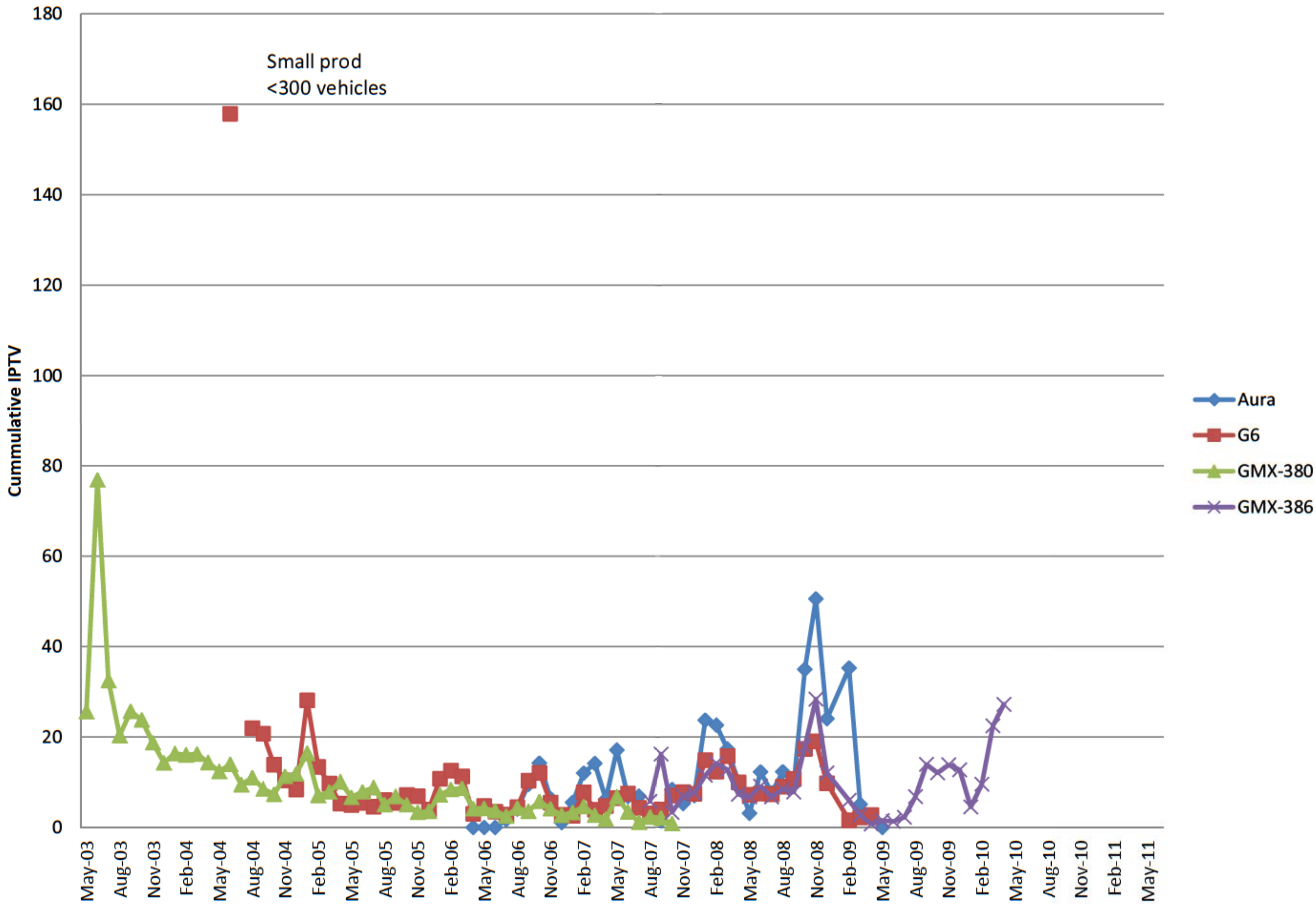


Table 1-1 Subject Vehicles Submitted to NHTSA

		Model Year								
Make	Model	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	183,783	211,055	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	N/A	N/A	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	N/A	N/A	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	25,586	N/A	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	N/A	N/A	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	209,369	211,055	2,214,173

Subject Vehicles For Discussion

		MODEL YEAR								
MAKE	MODEL	2004	2005	2006	2007	2008	2009	~~2010~~	~~2011~~	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	~~183,783~~	~~211,055~~	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	~~N/A~~	~~N/A~~	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	~~N/A~~	~~N/A~~	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	~~25,586~~	~~N/A~~	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	~~N/A~~	~~N/A~~	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	~~209,369~~	~~211,055~~	2,214,173

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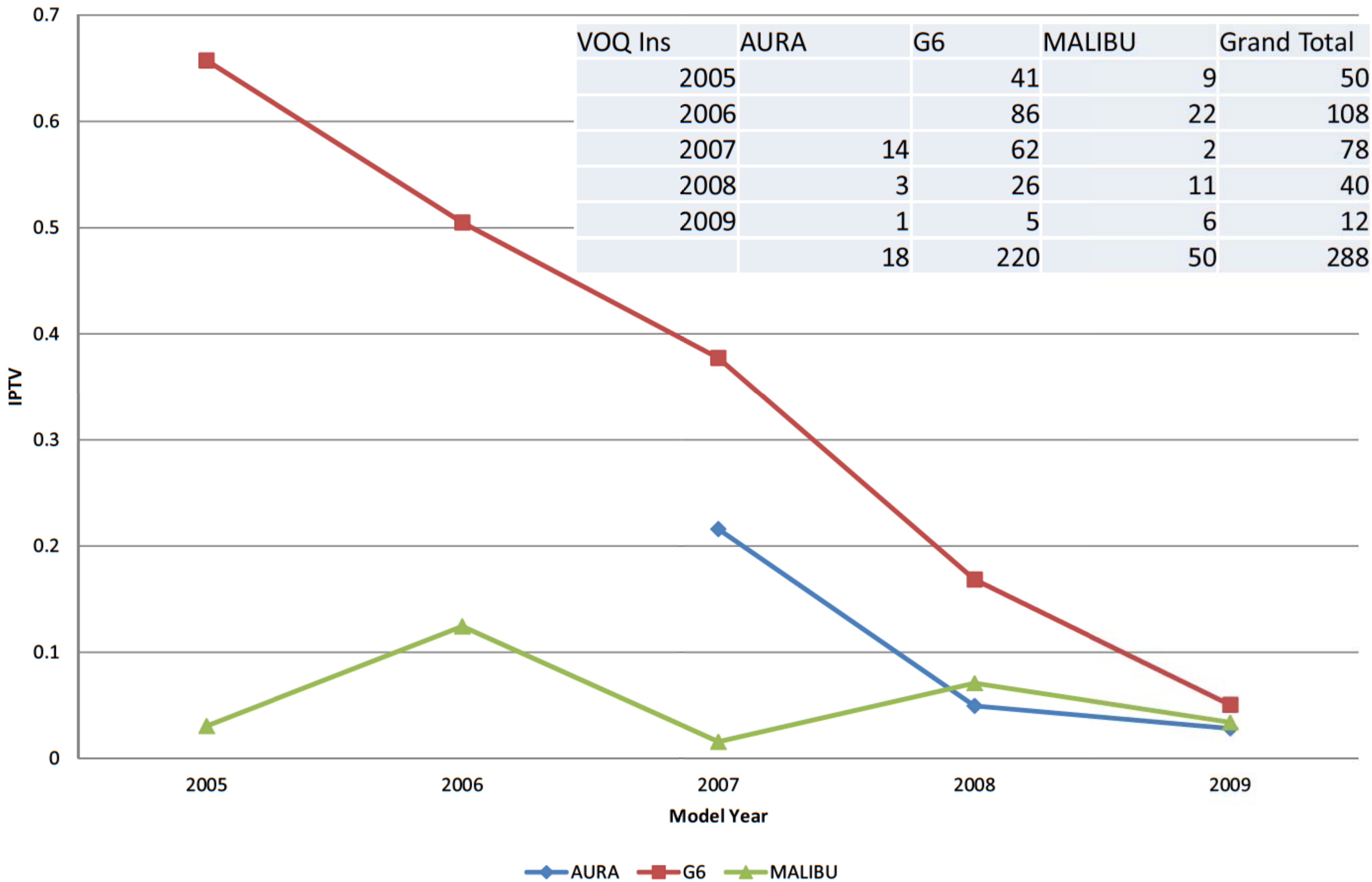
Intermittently Brake Lamps Do Not Function Correctly

2005-09MY G6, Mailbu and 2007-09MY Aura
Stop Lamp VOQ IPTV for US only

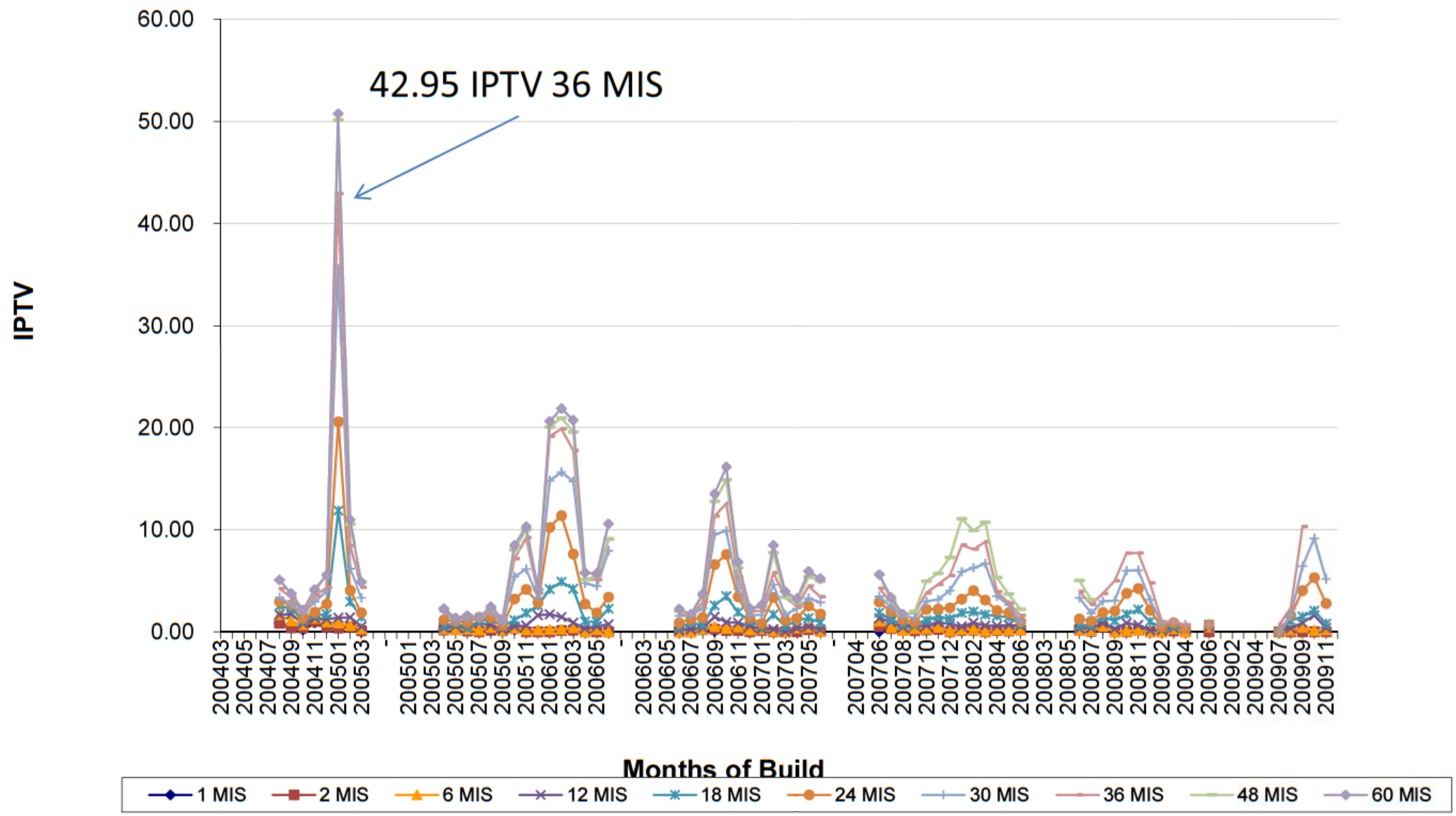


VOQ Ins	AURA	G6	MALIBU	Grand Total
2005		41	9	50
2006		86	22	108
2007	14	62	2	78
2008	3	26	11	40
2009	1	5	6	12
	18	220	50	288

Intermittently Brake Lamps Do Not Function Correctly

2005-2009MY Pontiac G6 Stop Lamp

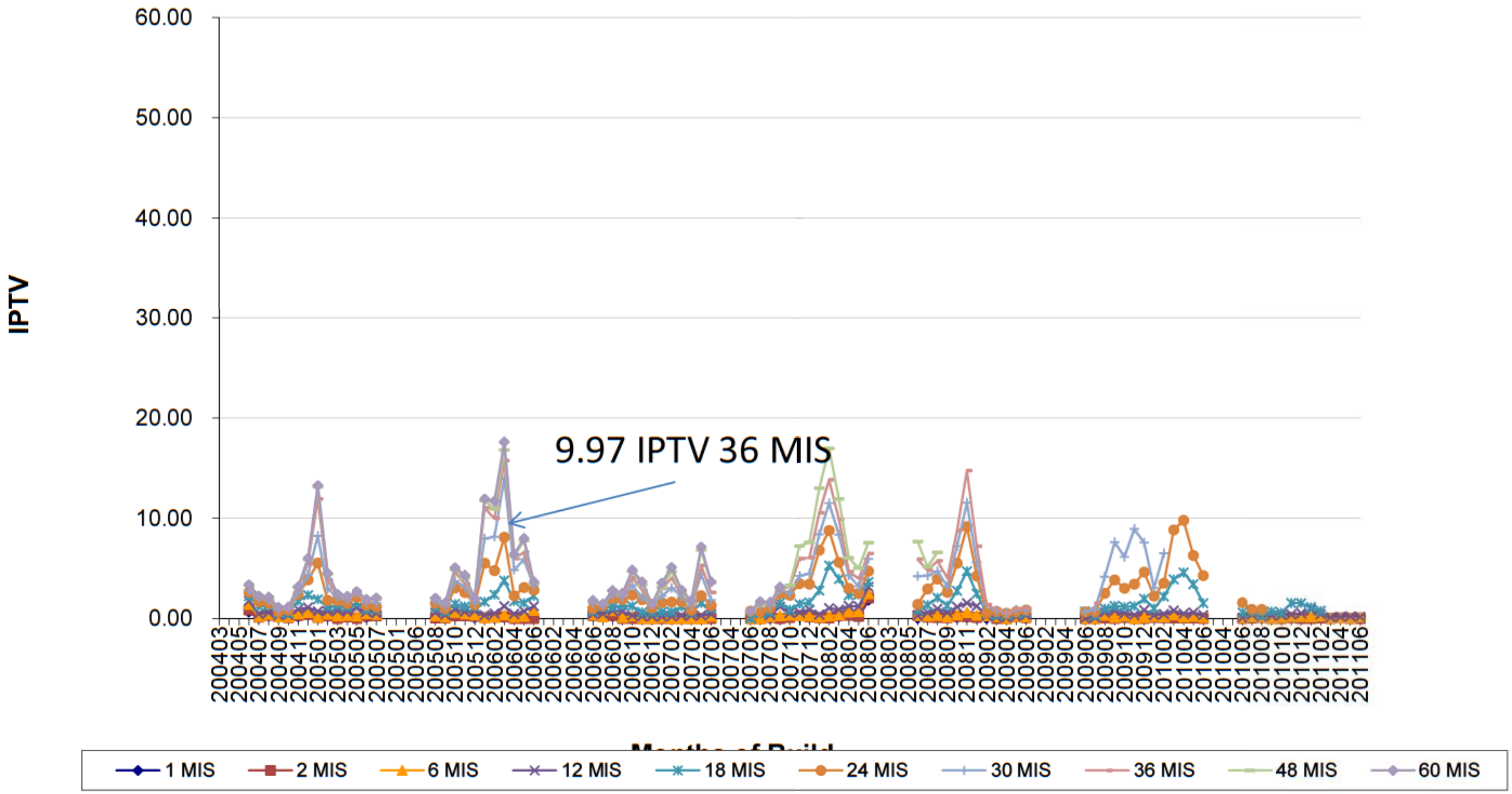
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

2005-2011MY Chevrolet Malibu Stop Lamp

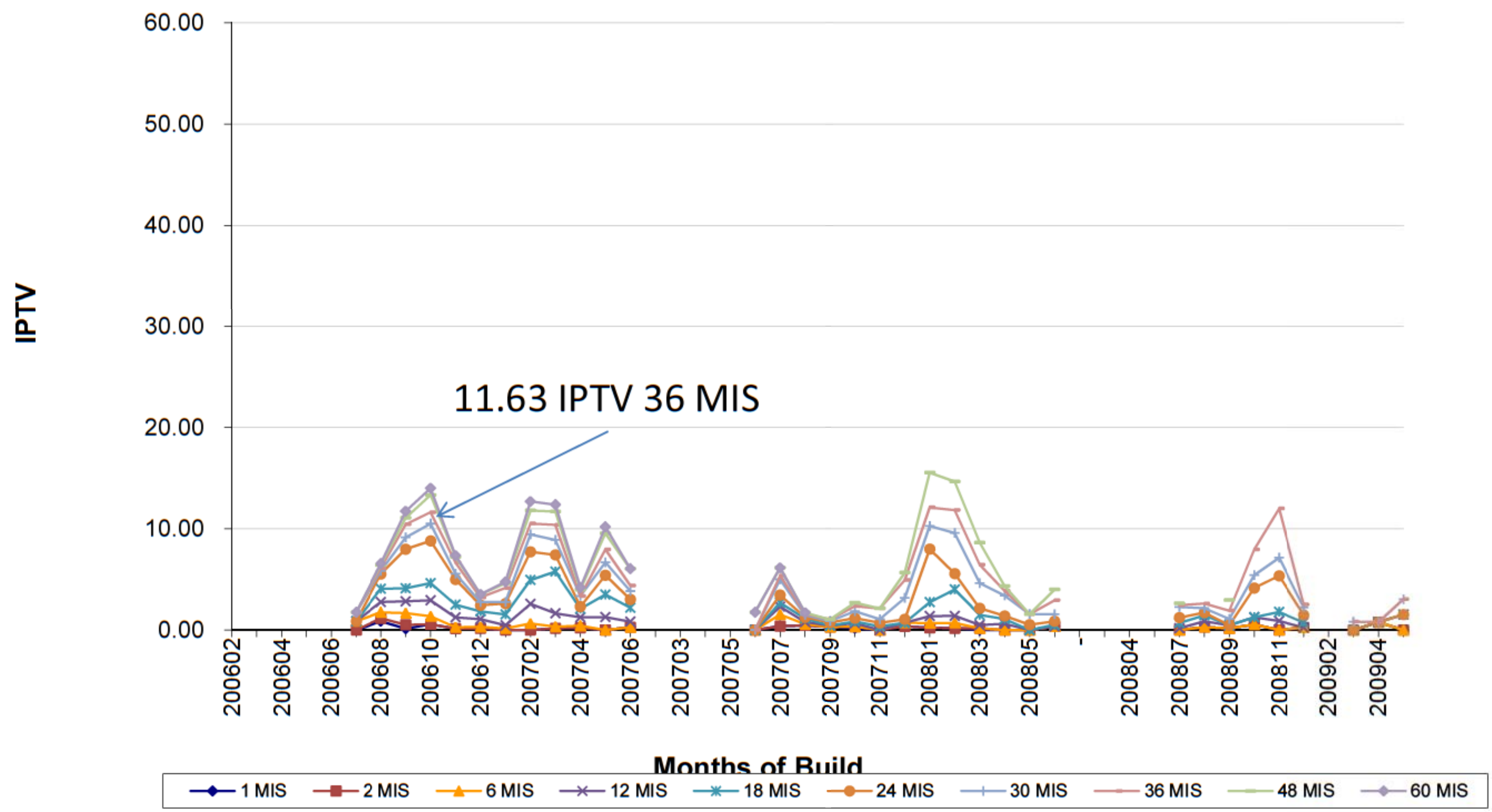
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

2007-2009MY Saturn Aura Stop Lamp

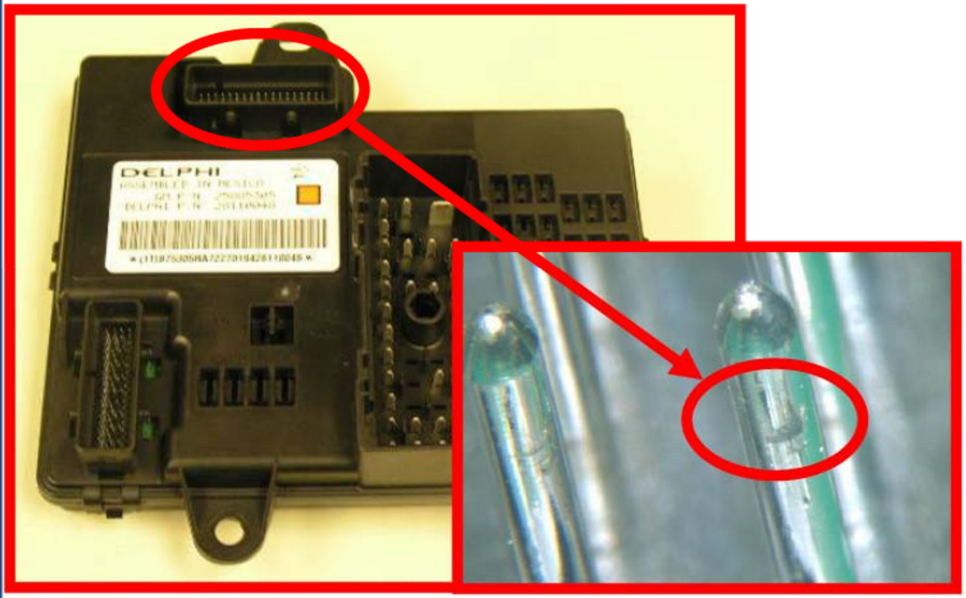
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Back-up

Intermittently Brake Lamps Do Not Function Correctly

Condition: Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.



Potential Field Action: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

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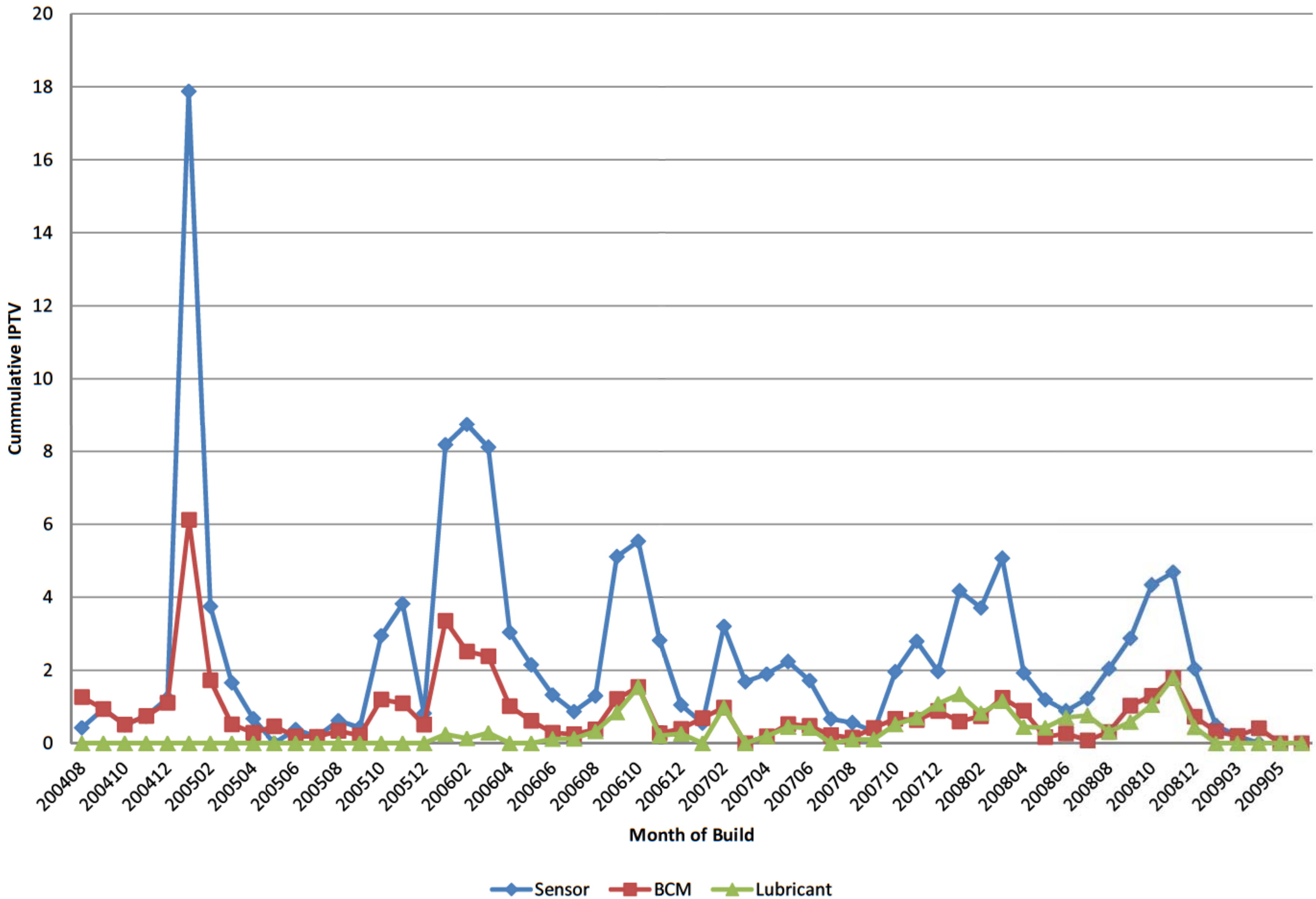
G6 claims by part number in 36 MIS



Intermittently Brake Lamps Do Not Function Correctly

Population

2005 – 2009MY Pontiac G6: 619,000

Excluding campaign population (Jan 2005) and vehicles built after February 2009 (grease applied).

2005	54,443
2006	170,255
2007	164,260
2008	154,323
2009	75,484
Grand Total	618,765

2005 – 2009MY Epsilon: 1.7M

Population	Aura	G6	Malibu	Grand Total
2005		62,360	294,833	357,193
2006		170,338	176,916	347,254
2007	64,847	164,260	127,660	356,767
2008	60,717	154,323	155,225	370,265
2009	35,472	99,216	176,689	311,377
	161,036	650,497	931,323	1,742,856

Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.

Closing Resume

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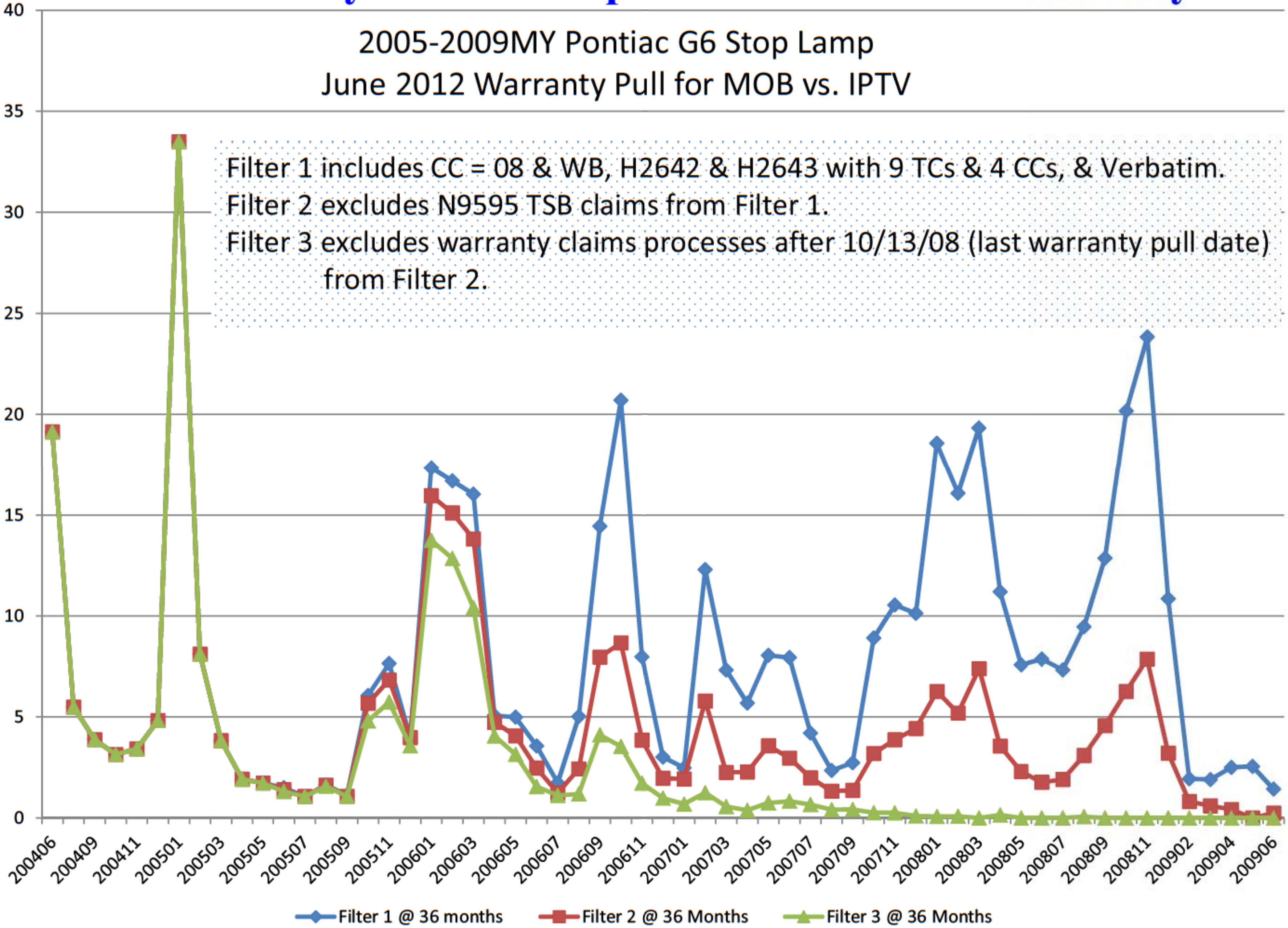
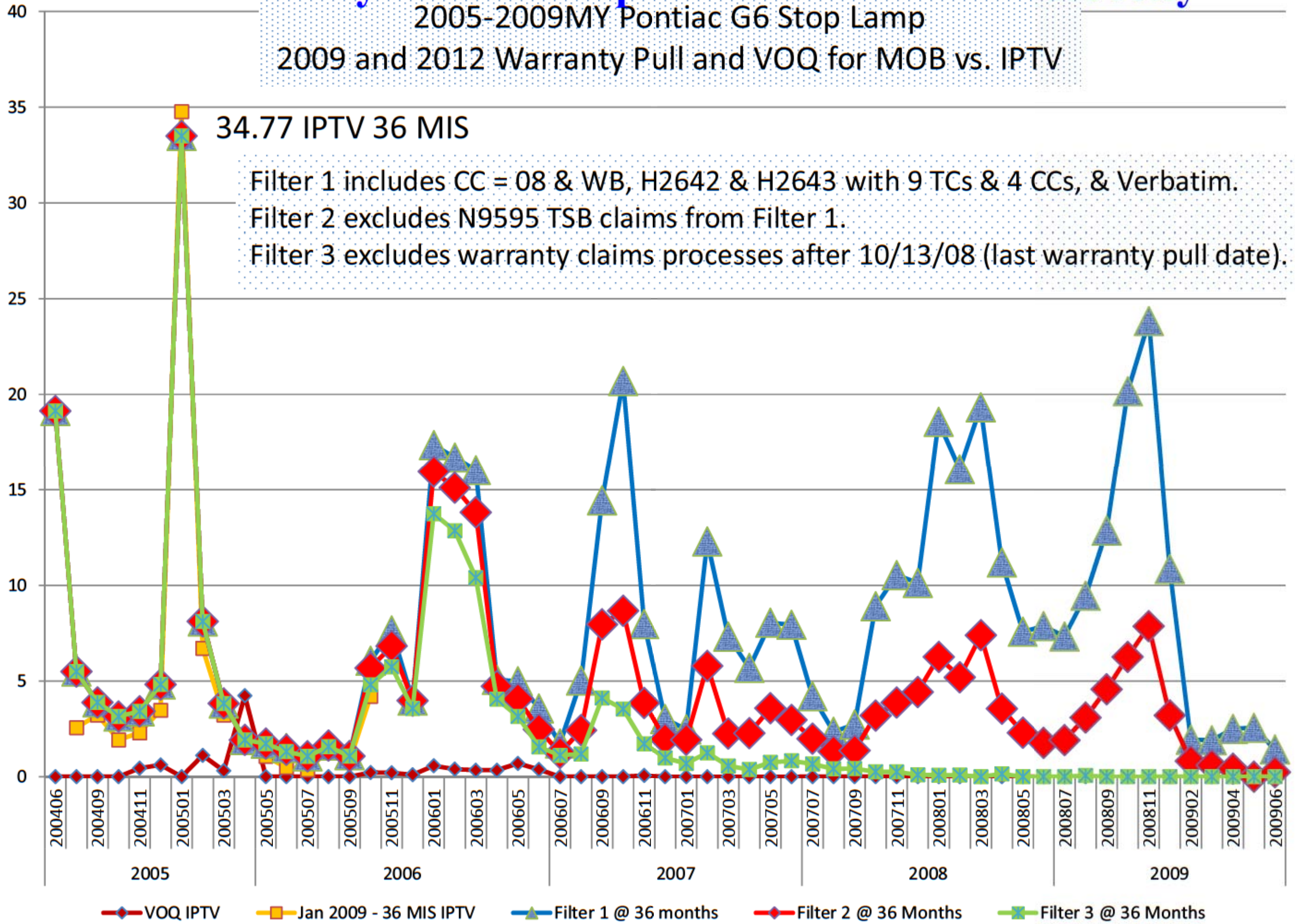
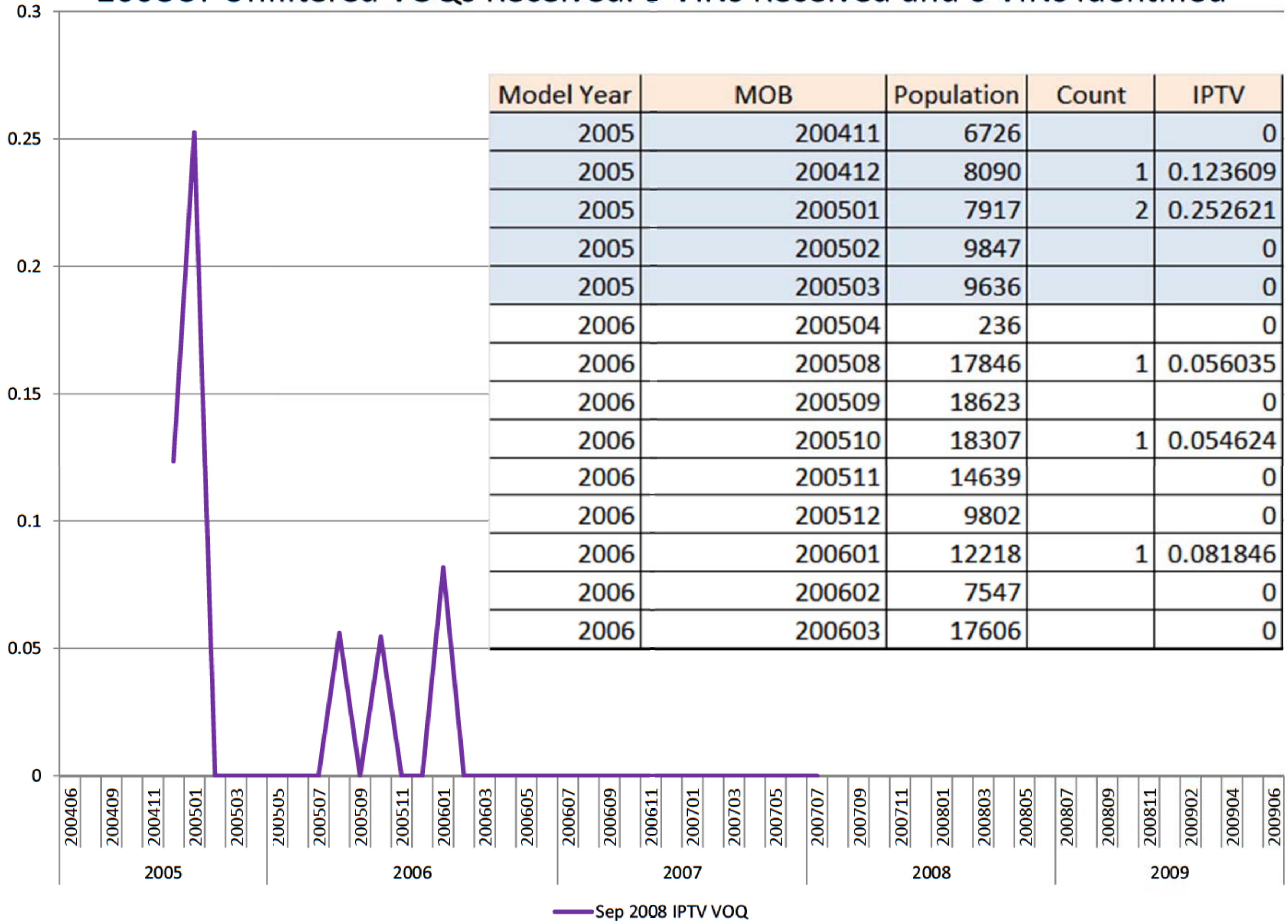
Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly



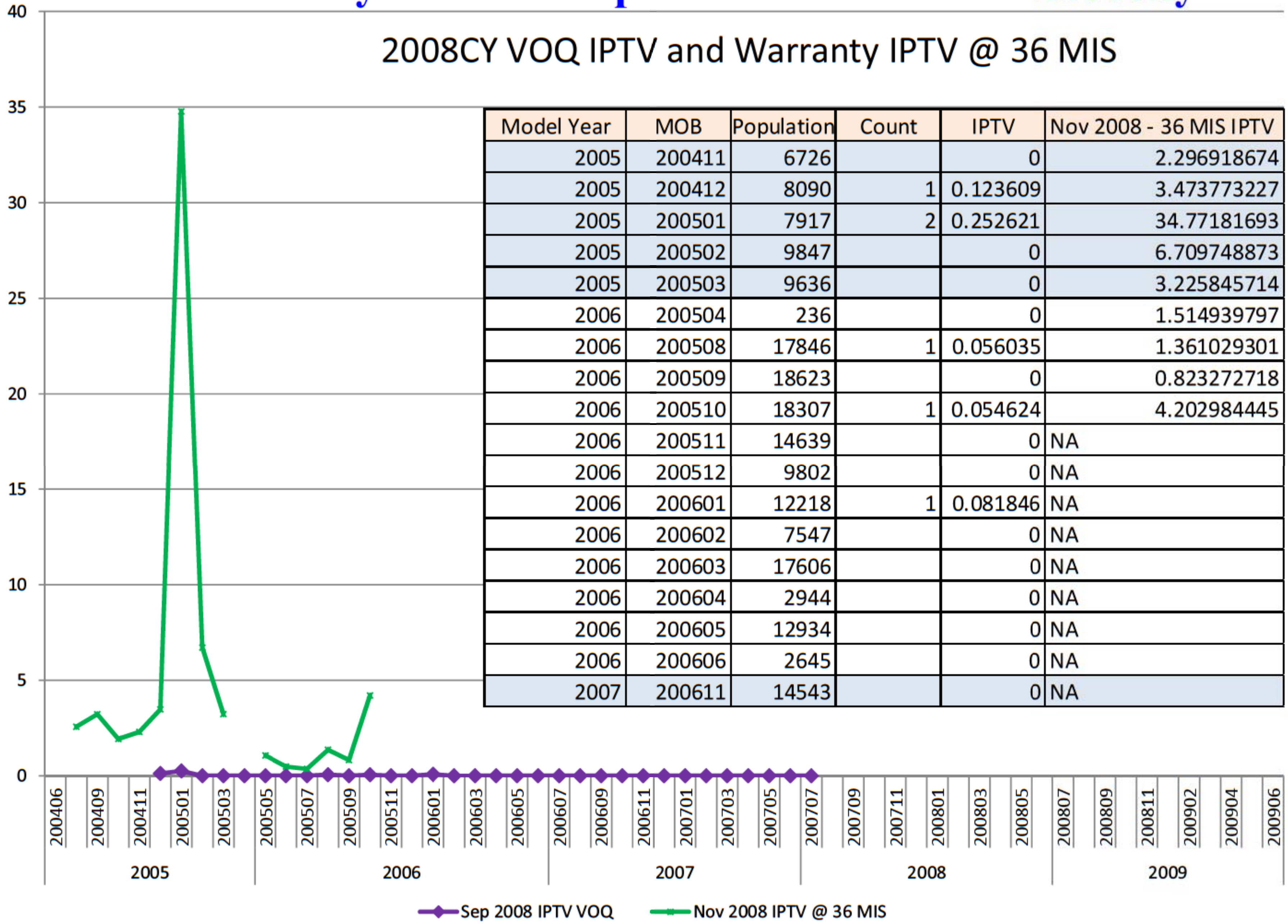
2008CY Unfiltered VOQs Received: 9 VINs Received and 6 VINs Identified



Model Year	MOB	Population	Count	IPTV
2005	200411	6726		0
2005	200412	8090	1	0.123609
2005	200501	7917	2	0.252621
2005	200502	9847		0
2005	200503	9636		0
2006	200504	236		0
2006	200508	17846	1	0.056035
2006	200509	18623		0
2006	200510	18307	1	0.054624
2006	200511	14639		0
2006	200512	9802		0
2006	200601	12218	1	0.081846
2006	200602	7547		0
2006	200603	17606		0

Intermittently Brake Lamps Do Not Function Correctly

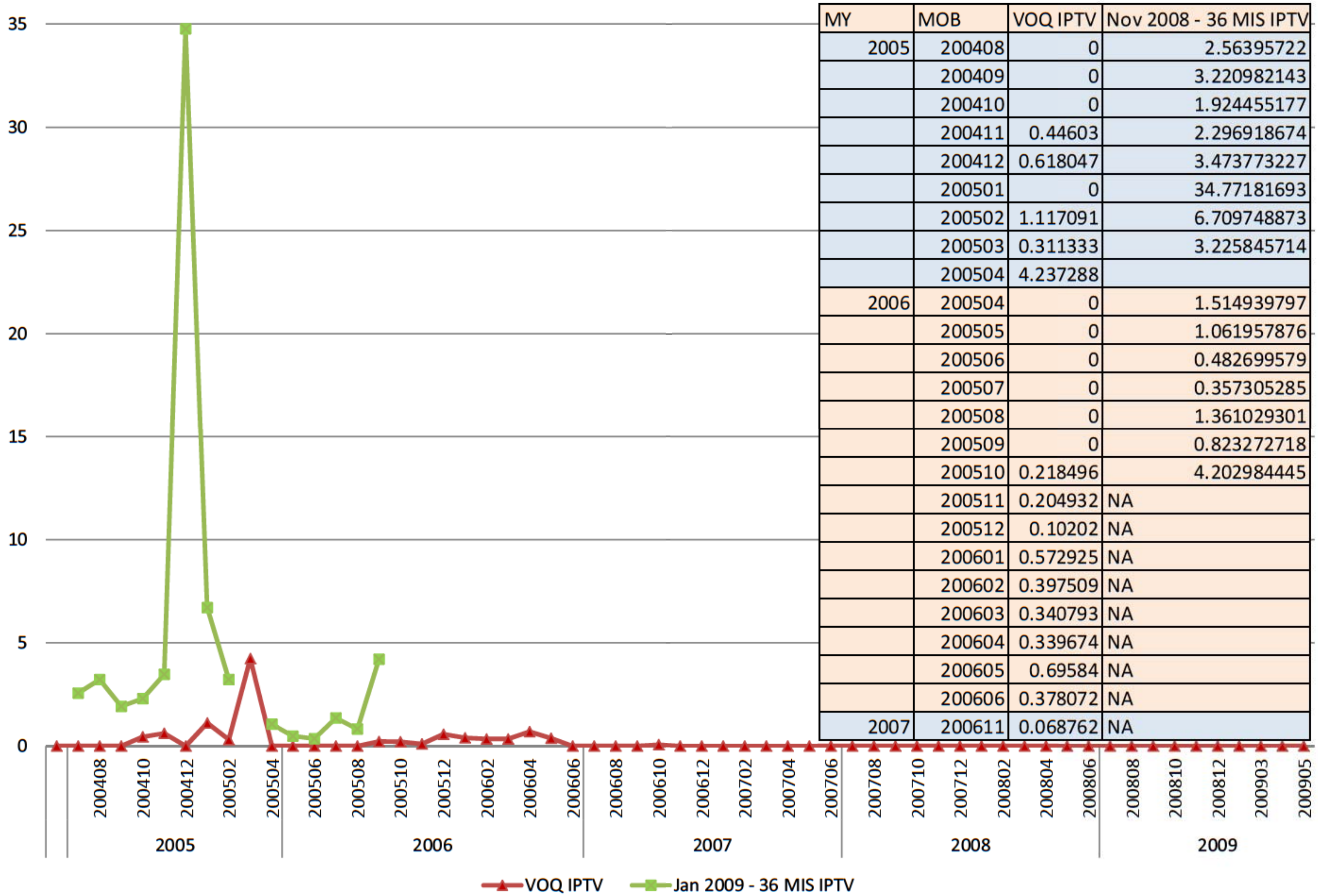
2008CY VOQ IPTV and Warranty IPTV @ 36 MIS



Model Year	MOB	Population	Count	IPTV	Nov 2008 - 36 MIS IPTV
2005	200411	6726		0	2.296918674
2005	200412	8090	1	0.123609	3.473773227
2005	200501	7917	2	0.252621	34.77181693
2005	200502	9847		0	6.709748873
2005	200503	9636		0	3.225845714
2006	200504	236		0	1.514939797
2006	200508	17846	1	0.056035	1.361029301
2006	200509	18623		0	0.823272718
2006	200510	18307	1	0.054624	4.202984445
2006	200511	14639		0	NA
2006	200512	9802		0	NA
2006	200601	12218	1	0.081846	NA
2006	200602	7547		0	NA
2006	200603	17606		0	NA
2006	200604	2944		0	NA
2006	200605	12934		0	NA
2006	200606	2645		0	NA
2007	200611	14543		0	NA

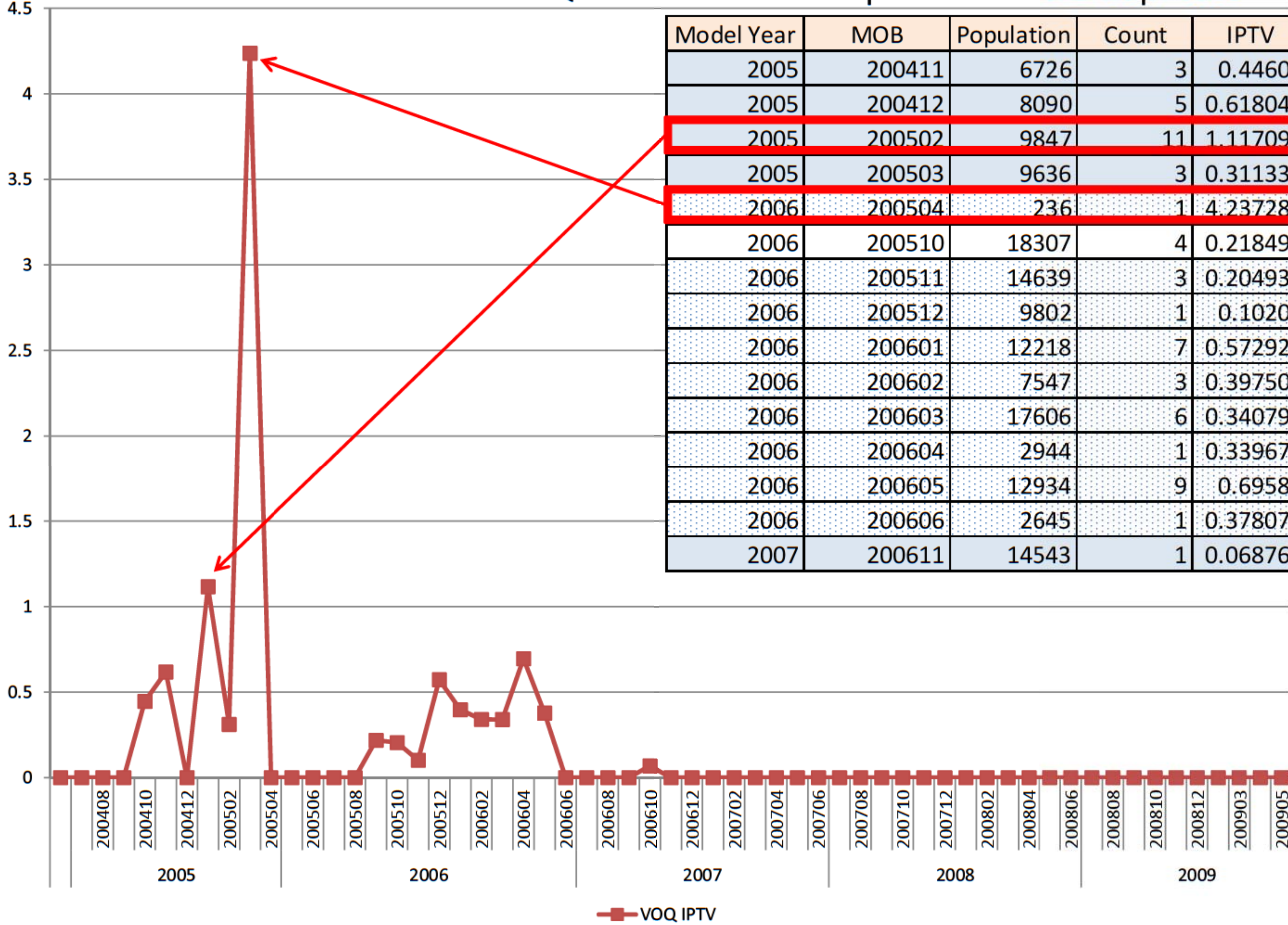
Intermittently Brake Lamps Do Not Function Correctly

2012 VOQ and Nov 08 Warranty IPTV @ 36MIS Trend line



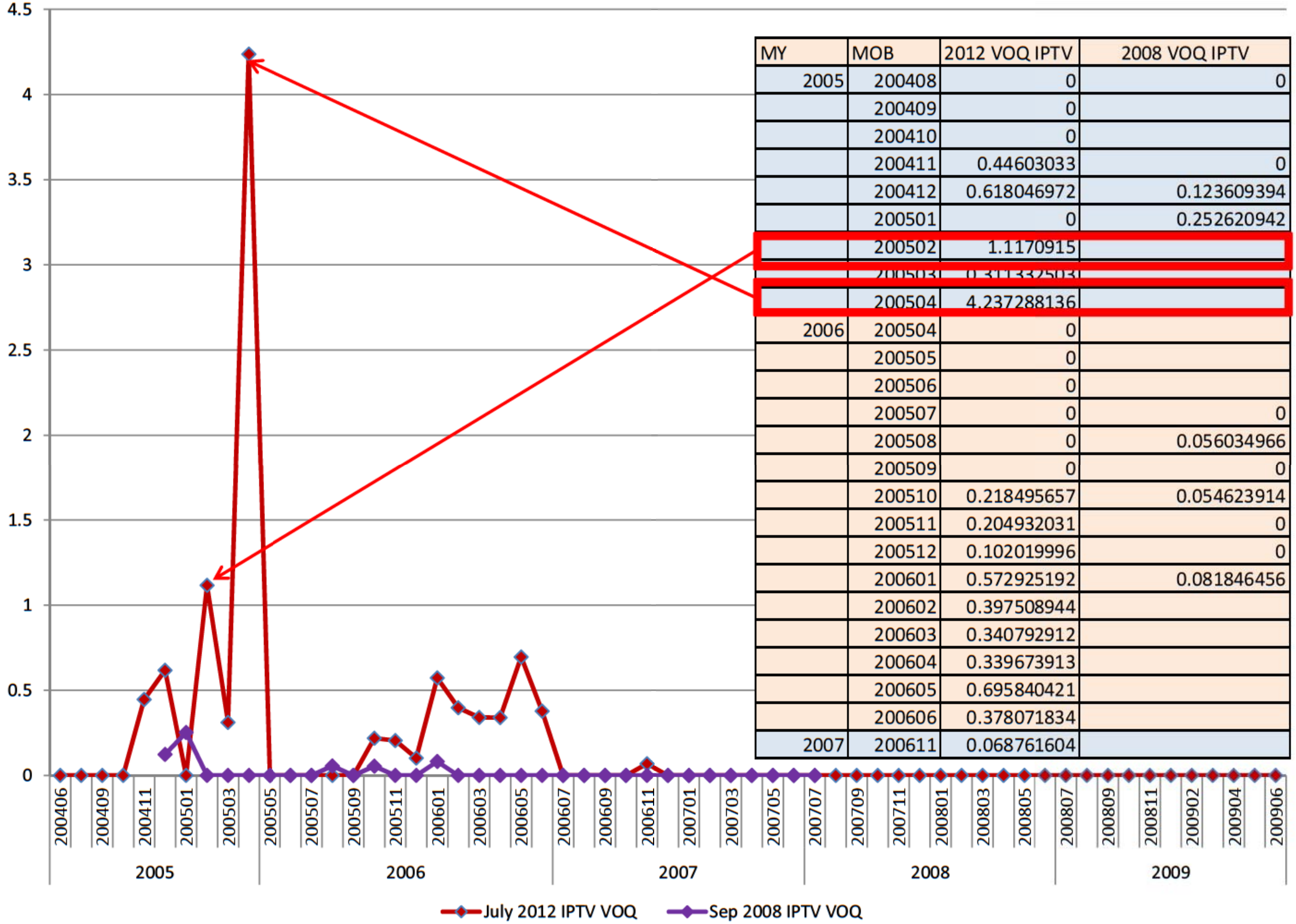
MY	MOB	VOQ IPTV	Nov 2008 - 36 MIS IPTV
2005	200408	0	2.56395722
	200409	0	3.220982143
	200410	0	1.924455177
	200411	0.44603	2.296918674
	200412	0.618047	3.473773227
	200501	0	34.77181693
	200502	1.117091	6.709748873
	200503	0.311333	3.225845714
	200504	4.237288	
2006	200504	0	1.514939797
	200505	0	1.061957876
	200506	0	0.482699579
	200507	0	0.357305285
	200508	0	1.361029301
	200509	0	0.823272718
	200510	0.218496	4.202984445
	200511	0.204932	NA
	200512	0.10202	NA
	200601	0.572925	NA
	200602	0.397509	NA
	200603	0.340793	NA
	200604	0.339674	NA
	200605	0.69584	NA
	200606	0.378072	NA
2007	200611	0.068762	NA

2012CY Unfiltered VOQs Received: 59 unique VINs and 1 duplicate



Model Year	MOB	Population	Count	IPTV
2005	200411	6726	3	0.44603
2005	200412	8090	5	0.618047
2005	200502	9847	11	1.117091
2005	200503	9636	3	0.311333
2006	200504	236	1	4.237288
2006	200510	18307	4	0.218496
2006	200511	14639	3	0.204932
2006	200512	9802	1	0.10202
2006	200601	12218	7	0.572925
2006	200602	7547	3	0.397509
2006	200603	17606	6	0.340793
2006	200604	2944	1	0.339674
2006	200605	12934	9	0.69584
2006	200606	2645	1	0.378072
2007	200611	14543	1	0.068762

Nov 2008 and June 2012 VOQ IPTV

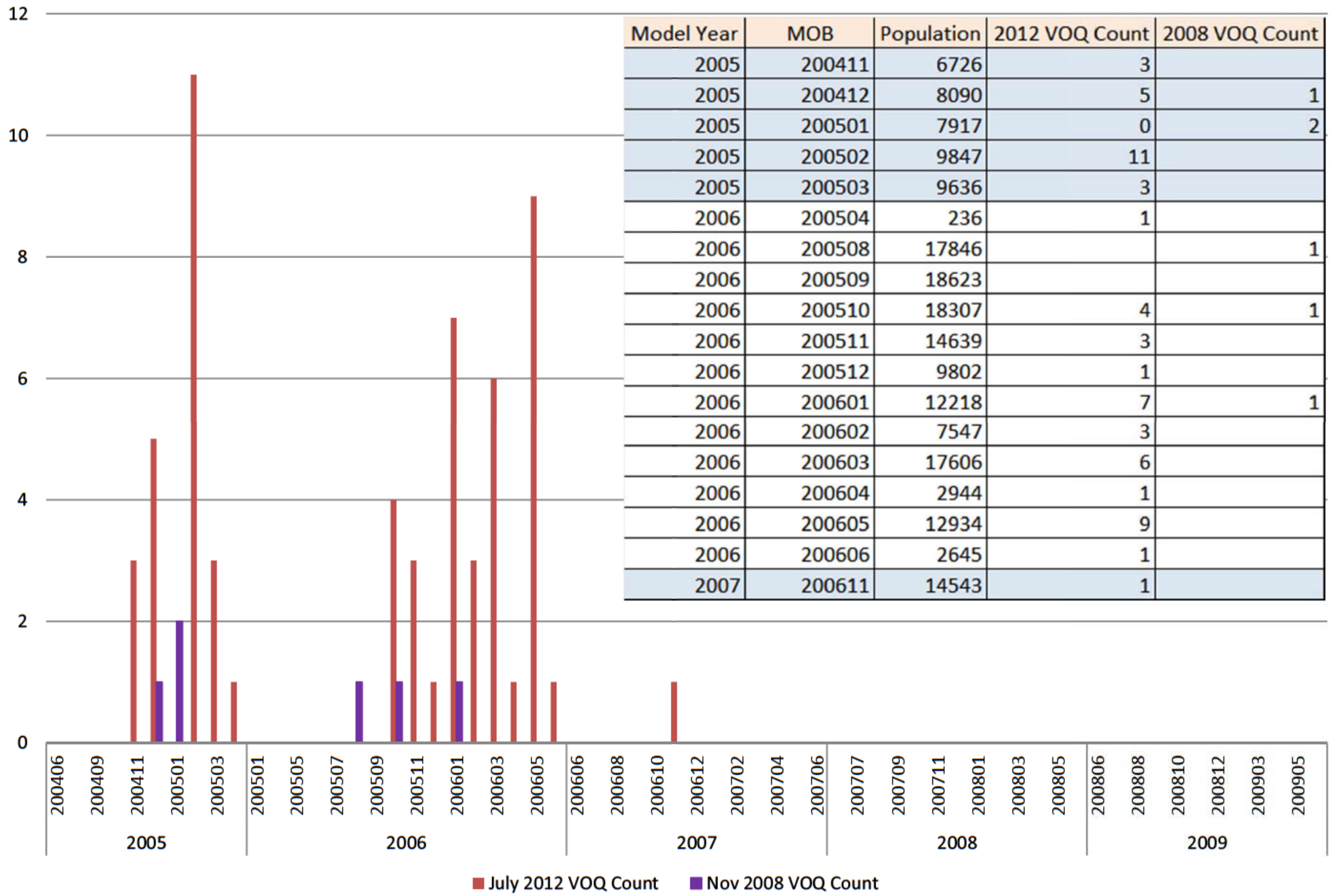


MY	MOB	2012 VOQ IPTV	2008 VOQ IPTV
2005	200408	0	0
	200409	0	
	200410	0	
	200411	0.44603033	0
	200412	0.618046972	0.123609394
	200501	0	0.252620942
	200502	1.1170915	
	200503	0.311332503	
	200504	4.237288136	
2006	200504	0	
	200505	0	
	200506	0	
	200507	0	0
	200508	0	0.056034966
	200509	0	0
	200510	0.218495657	0.054623914
	200511	0.204932031	0
	200512	0.102019996	0
	200601	0.572925192	0.081846456
	200602	0.397508944	
	200603	0.340792912	
	200604	0.339673913	
	200605	0.695840421	
	200606	0.378071834	
2007	200611	0.068761604	

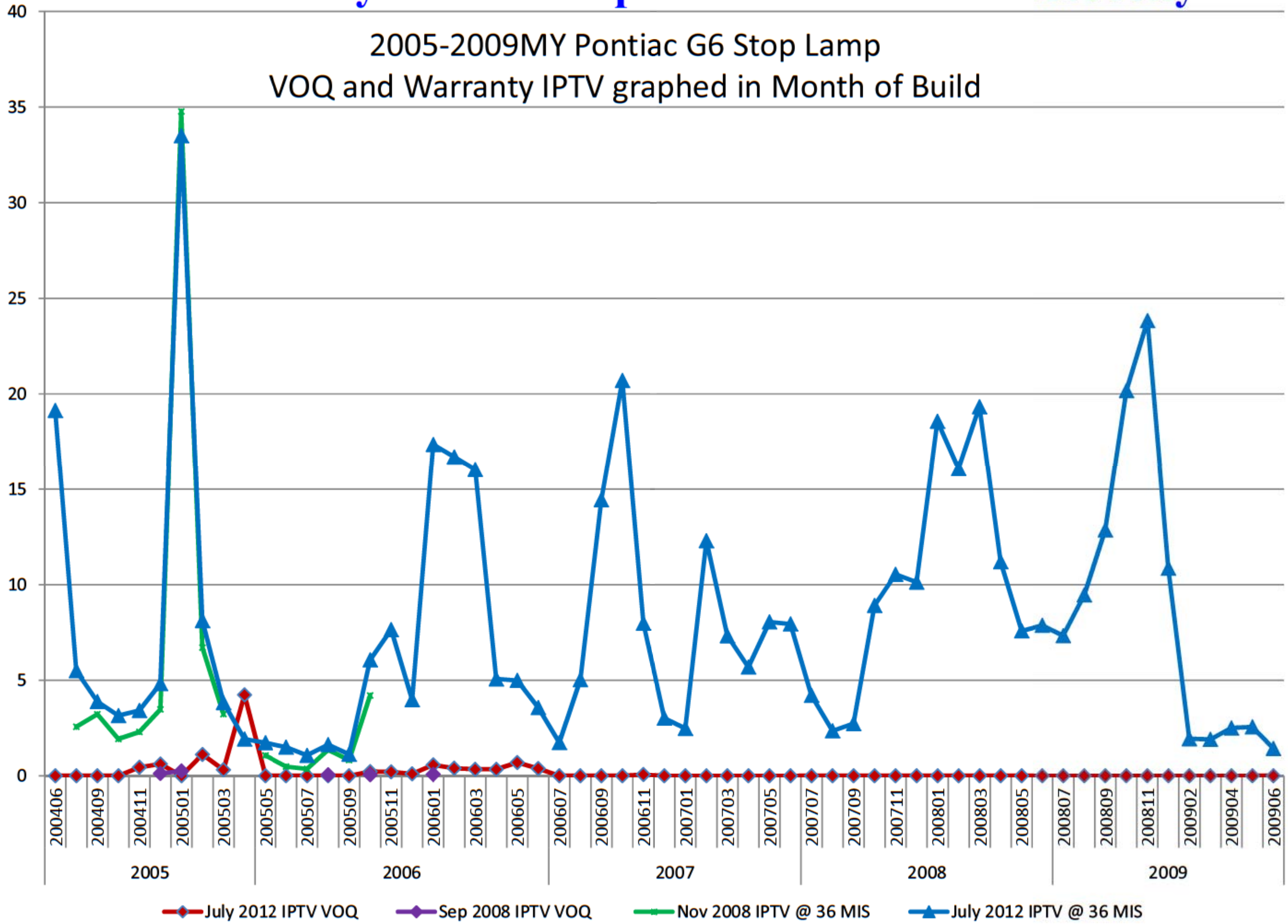
Intermittently Brake Lamps Do Not Function Correctly

VOQ Count Comparison: 2008 (6) vs 2012 (59)

Model Year	MOB	Population	2012 VOQ Count	2008 VOQ Count
2005	200411	6726	3	
2005	200412	8090	5	1
2005	200501	7917	0	2
2005	200502	9847	11	
2005	200503	9636	3	
2006	200504	236	1	
2006	200508	17846		1
2006	200509	18623		
2006	200510	18307	4	1
2006	200511	14639	3	
2006	200512	9802	1	
2006	200601	12218	7	1
2006	200602	7547	3	
2006	200603	17606	6	
2006	200604	2944	1	
2006	200605	12934	9	
2006	200606	2645	1	
2007	200611	14543	1	



Intermittently Brake Lamps Do Not Function Correctly



2012CY Update of G6 Stop Lamp Warranty Claims

2012CY Warranty Methodology

Started with 27,821	11,852 had correction-verbatim (42.6%)	
Labor Code	Started (%)	Filtered (%)
N4800 BCM	10,316 (37.1)	363 (20.7)
H2642 Sensor, Brake Pedal	4,643 (16.7)	1,203 (68.6)
H2643 Sonsor, Brake & Accel	420 (1.5)	144 (8.2)
H2640 Pedal / Bushing	418(1.5)	7 (0.4)
H9991 Cust Concern NTF	8,531(30.7)	36 (2.1)
N9595 TSB	3,493 (12.6)	0
Total	27,821	1,753 (6.3)

2012CY Warranty Methodology

27,821 including 243 same day repair duplicates

3,490 A. All claims with labor code N9595 were determined to be responsive to the alleged condition.

20,167 (B–D)

B. All claims with customer codes 08 (Operation: Won't Turn Off) and WB (Warning Lights-Brake Lights) were determined to be responsive to the alleged condition unless the verbatim text indicated that the claim was unrelated.

C. Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 2.7 and customer codes in Table 2.8 were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.

D. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.

2,168 E. The vehicle claims processed after 10/13/08 are excluded to compare with the original data.

F. All claims for vehicles covered by General Motors recall 08317 were excluded. 6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%

1,753

2009CY Update Methodology

Started with 8,978 | 2,362 had verbatim (26.3%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	6,758 (75.3)	274 (17.5)
H2642 Sensor, Brake Pedal	1,984 (22.1)	1,157 (74)
H2643 Sonsor, Brake & Accel	227 (2.5)	125 (8)
H2640 Pedal / Bushing	6 (0)	6 (0.4)
H9991 Cust Concern NTF	3 (0)	3 (0.2)
Total	8,978	1,565 (17.4)

2009CY Update Methodology

For the subject vehicles, the regular warranty, goodwill warranty, and MIC service contract claims with stop lamp malfunction are summarized by model and model year in Table 5-1. For the subject vehicles the UWC service contract claims with indication of stop lamp malfunction are summarized by model and model year in Table 5-2. A summary of the warranty claims, including the information requested in 5(a-k), is provided on the ATT_1_GM disk; folder labeled "Q_05:" refer to the Microsoft Access 2000 file labeled "Q_05_WARRANTY DATA." A list of the labor codes, customer complaint codes and trouble codes used to collect the warranty data is provided in response to item No. 6.

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	Regular	579	754	232	1,565
Pontiac G6	MIC	43	25	2	70

TABLE 5-1: REGULAR WARRANTY AND MIC SERVICE CONTRACT CLAIMS WITH STOP LAMP MALFUNCTION

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	UWC	0	3	0	3

TABLE 5-2: UWC SERVICE CONTRACT CLAIMS

SOURCE SYSTEM	LAST DATE GATHERED
GART - regular warranty	13 Oct 08
MIC - service contract claims	14 Oct 08
UWC - service contract claims	23 Sept 08

TABLE 5-3: DATES PULLED

2009CY Update Methodology

8,969

The GM Global Analysis and Reporting Tool (GART-regular warranty) regular warranty database and the Motors Insurance Corp (MIC) service contract claims database were searched using the labor codes that may be related to the alleged defect, listed in Table 6-1. Universal Warranty Corporation (UWC) does not use labor codes or trouble codes.

The following process was used to sort these claims:

544
- All claims with customer codes shown in Table 6-2 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

6,800
- Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 6-3 and customer codes in Table 6-4 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

60
- The verbatims of the remaining claims were then read and the claim was determined to be responsive if the verbatim related to the alleged defect.

1,565

2009CY Update Methodology

Labor Code	Description:
H2642	Sensor, Brake Pedal Position - Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
N4800	Body Control Module Replacement
H2640	Pedal And/Or Bushing, Brake - R&R Or Replace
H9991	Customer Concern Not Duplicated
N2700	Switch, Stop Lamp - Adjust
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement-Product Allegation
Z1243	Inspection-Product Allegation Resolution

Table 6-1 Labor Codes used in Warranty and MIC Search

Customer Code	Description:
O8	Operation: won't turn off
WB	Warning lights: brake light

Table 6-2 Customer Codes used in Warranty and MIC Sorting

Trouble Code	Description:
1D	Broken
6C	Component-inoperative
6D	Component -intermittent
6F	Component -Open
3A	Misadjusted
9Z	No Trouble Found
3L	Out of Calibration
3X	Registers Incorrectly
6N	Connector - Partial Connected

Table 6-3 Trouble Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

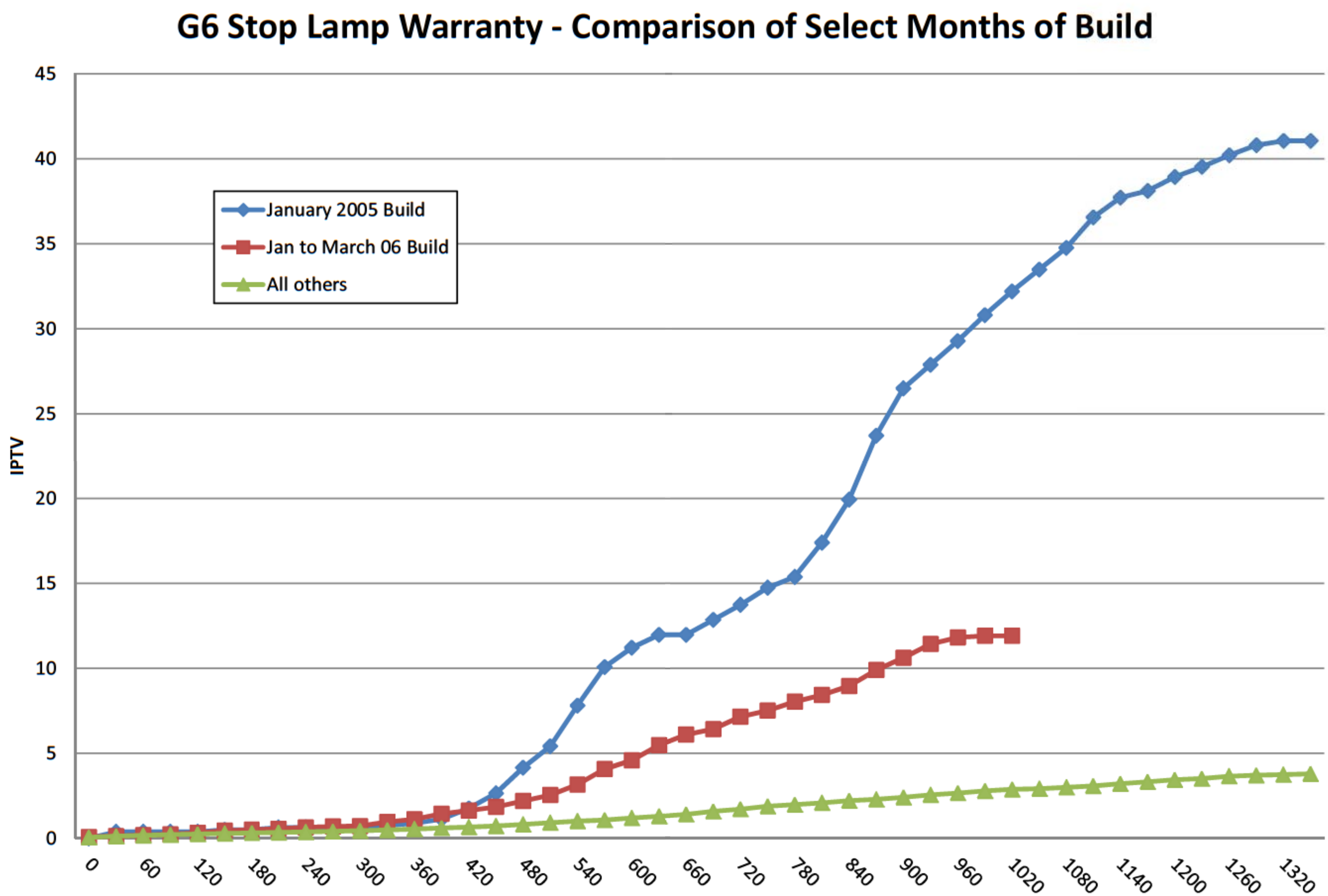
Customer Code	Description:
OG	Operation: Excess Eff (Excess Play)
OJ	Operation: Inoperative (Harsh)
OF	Operation: Engage/Dis(Excess Eff)
O7	Operation: No Maintain Adj

Table 6-4 Customer Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

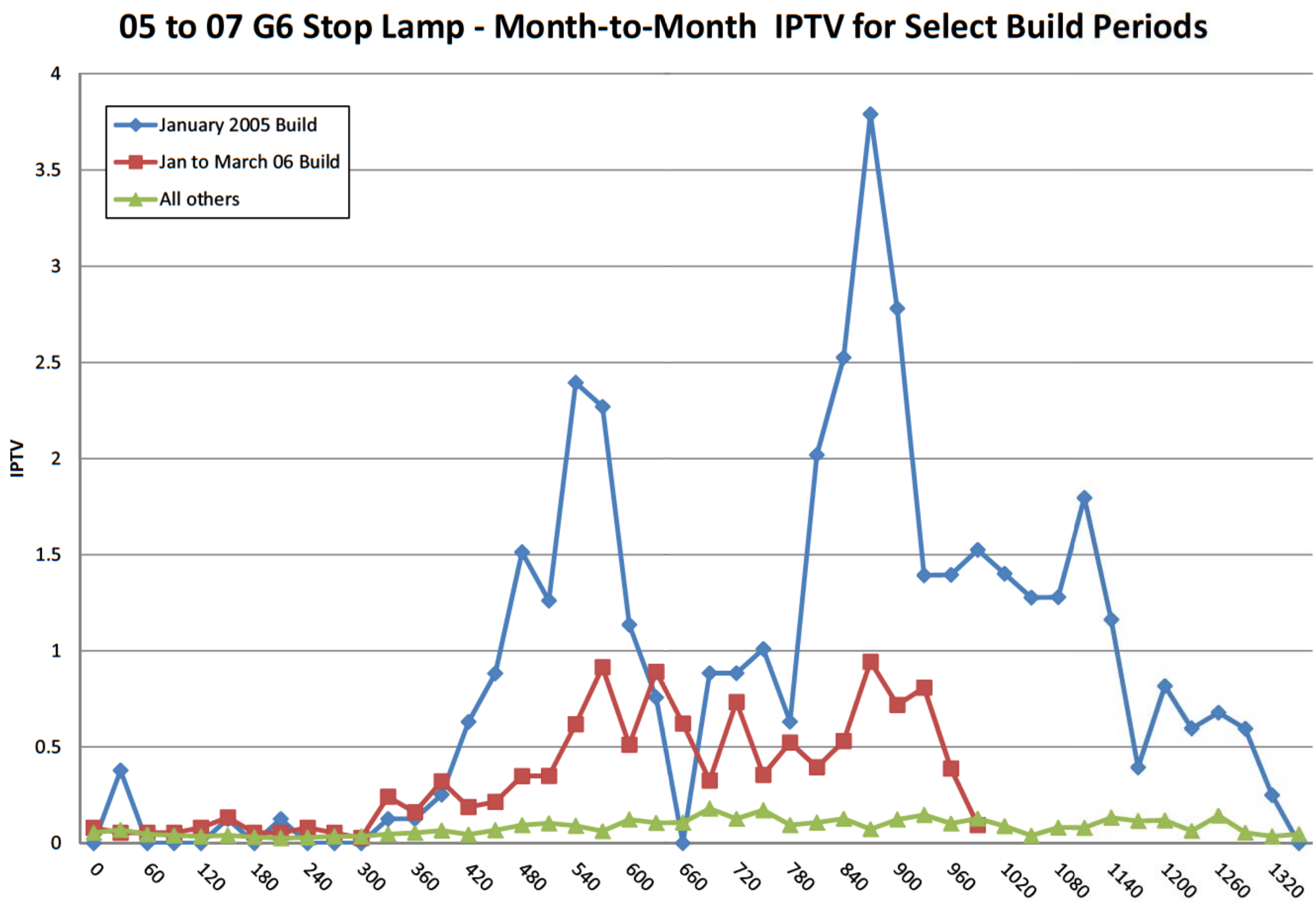
GM Confidential

Rationale for 2009 Decision

Intermittently Brake Lamps Do Not Function Correctly

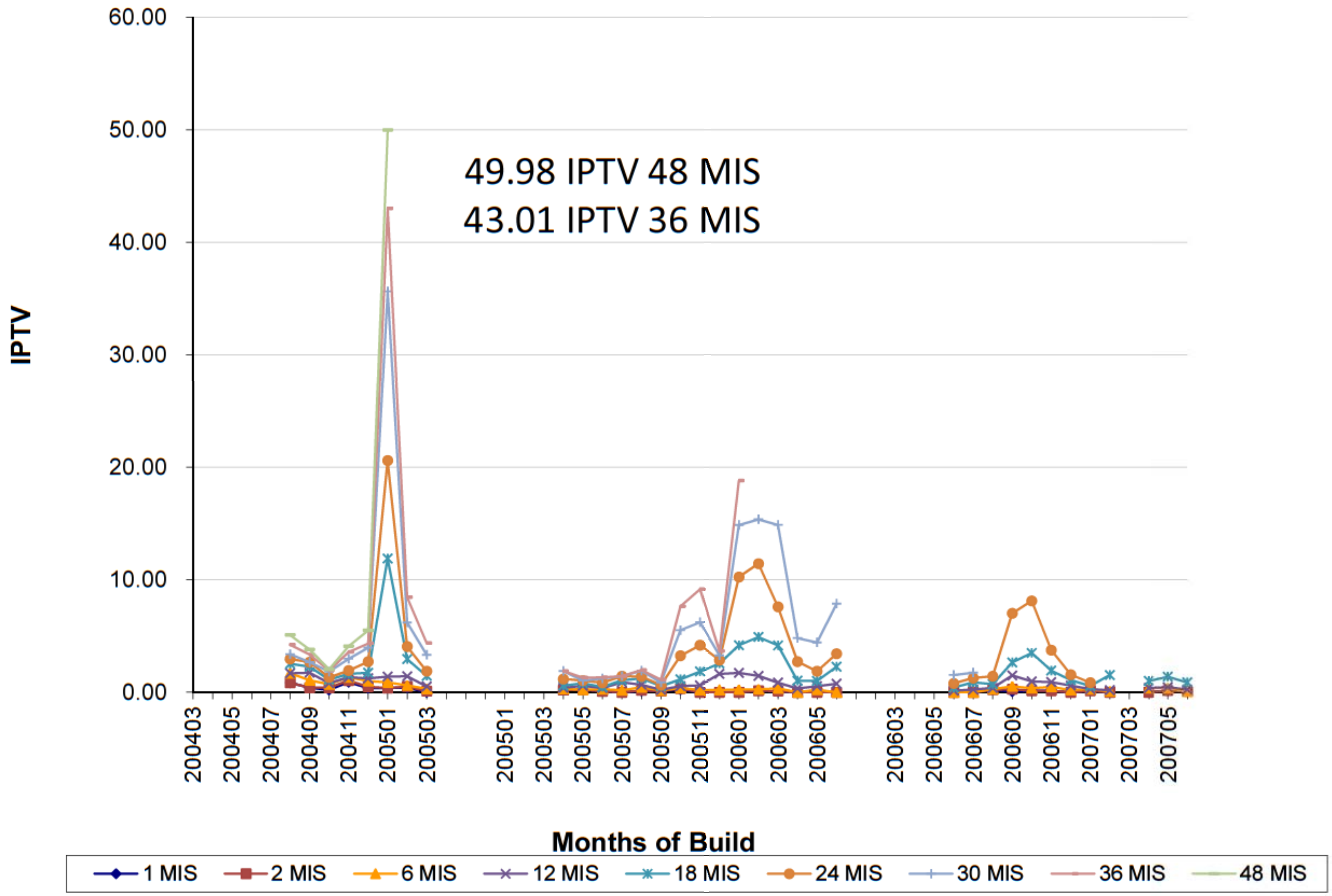


Intermittently Brake Lamps Do Not Function Correctly



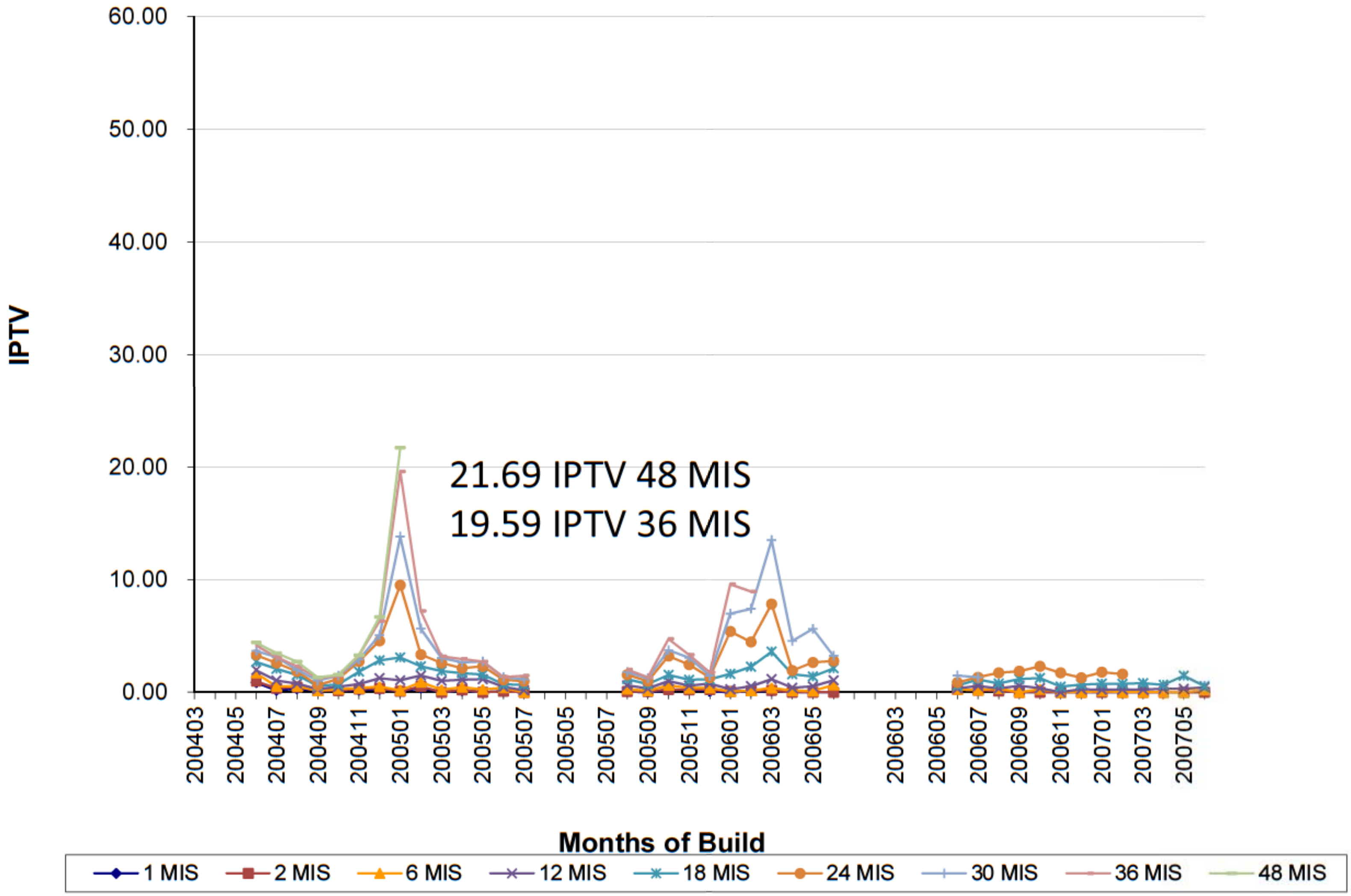
Intermittently Brake Lamps Do Not Function Correctly

Pontiac G6 Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



Intermittently Brake Lamps Do Not Function Correctly

Chevrolet Malibu Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



GM Confidential

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Intermittently Brake Lamps Do Not Function Correctly

The Body Control Module with different electrical harness architecture is used for the following platforms:

2004MY	Malibu, XLR	
2005MY	G6, Cobalt, Corvette	
2006MY	HHR, Solstice	
2007MY	Sky, Opel GT, Aura	- NEW MICROPROCESSOR
2008MY	New Malibu	

Intermittently Brake Lamps Do Not Function Correctly

Technical Service Bulletin

#08-05-22-009: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTC C0161/C0277 Set (Perform Repair as Outlined) - (Dec 4, 2008)

Subject: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTCs C0161/C0277 Set (Perform Repair as Outlined)

Apply dielectric lubricant (clear gel) GM P/N 12377900 (In Canada, use P/N 10953529) on the BCM C2 pins (apply with a one-inch nylon bristle brush) on all the C2 connector pins (this will treat the pins against fretting corrosion).

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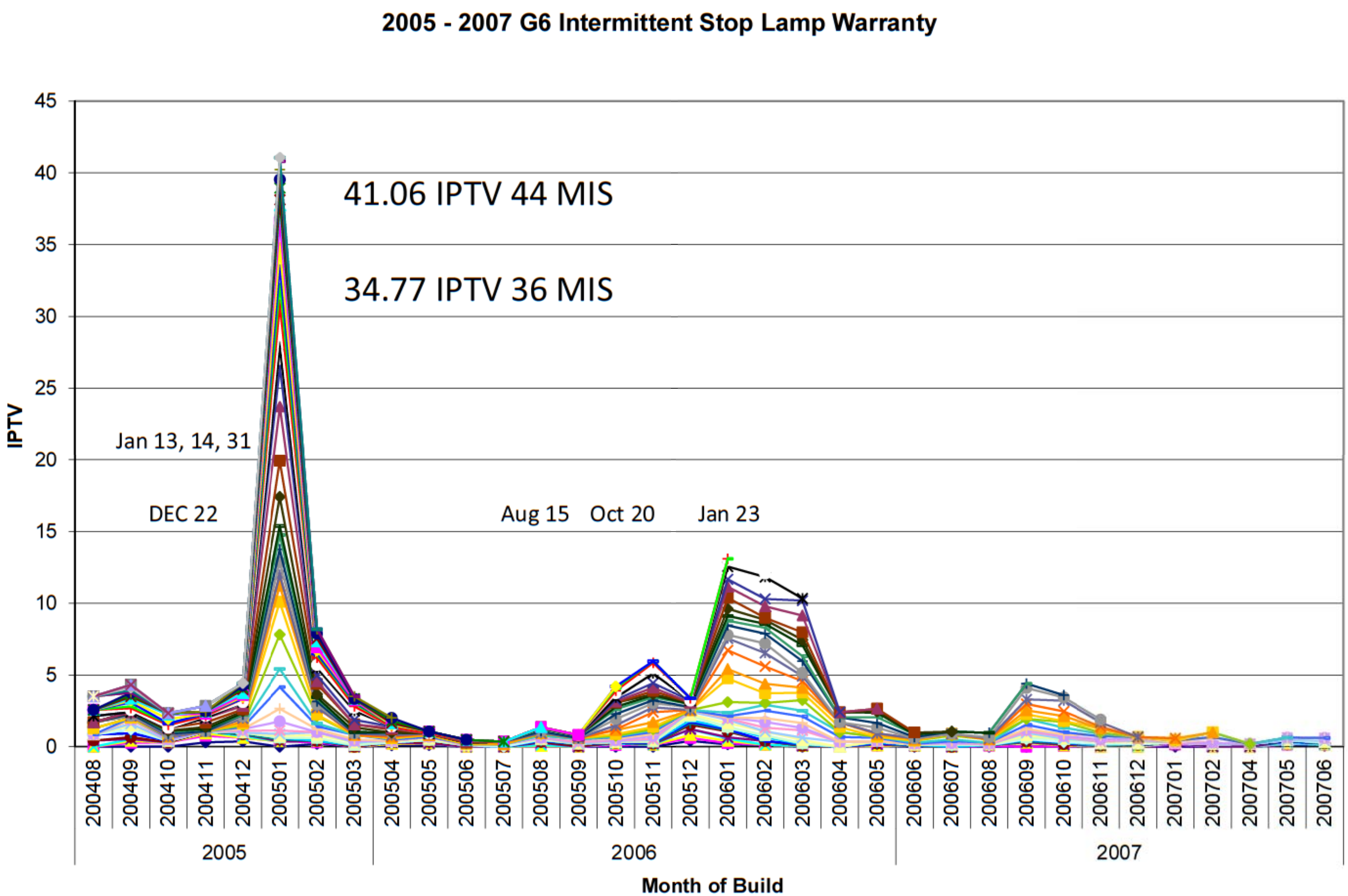
Intermittently Brake Lamps Do Not Function Correctly



9 VOQs 2005MY: 4 2006MY: 4 2007MY: 1

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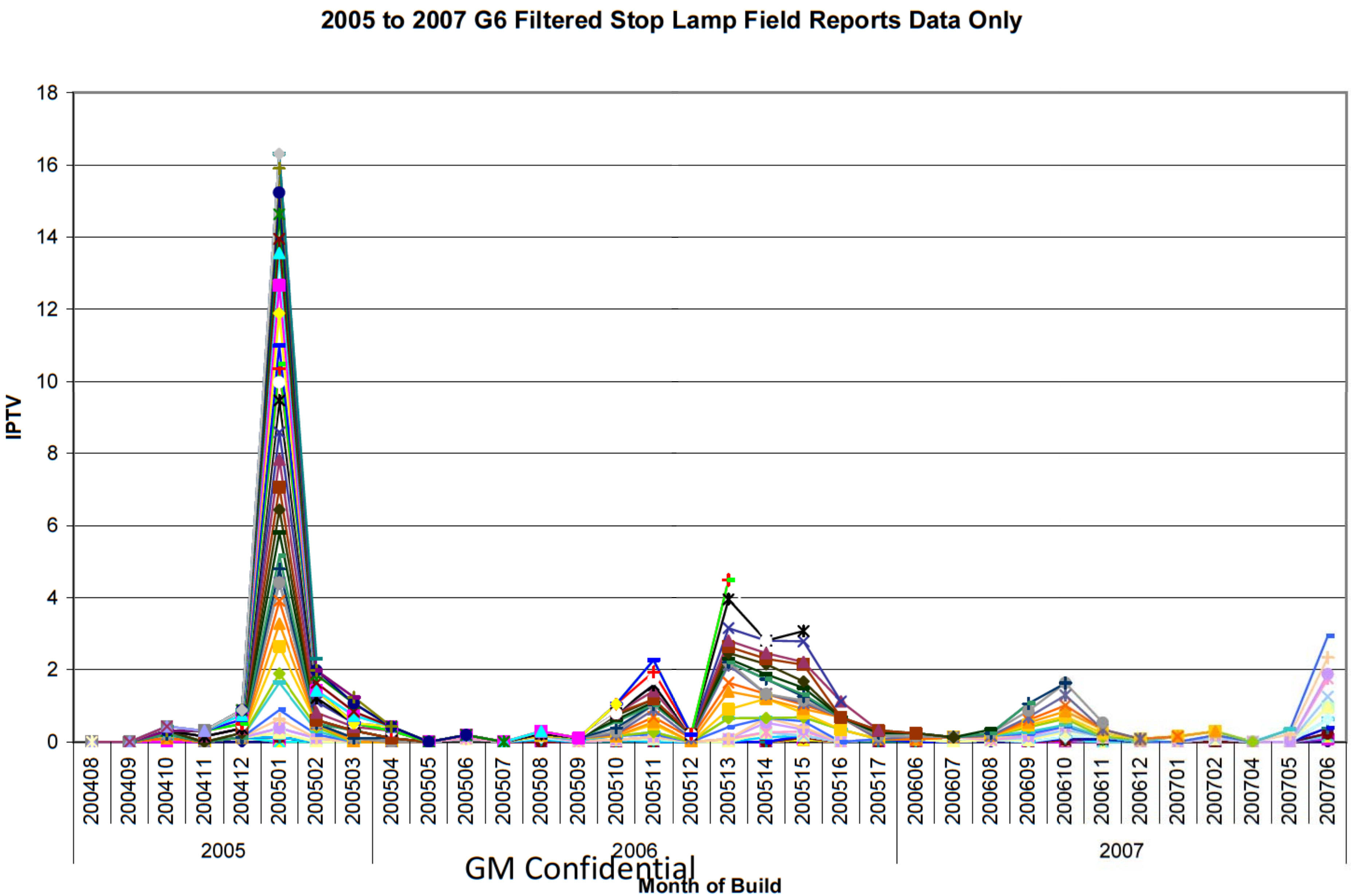
2005 - 2007 G6 BASS – TAC and CAC only



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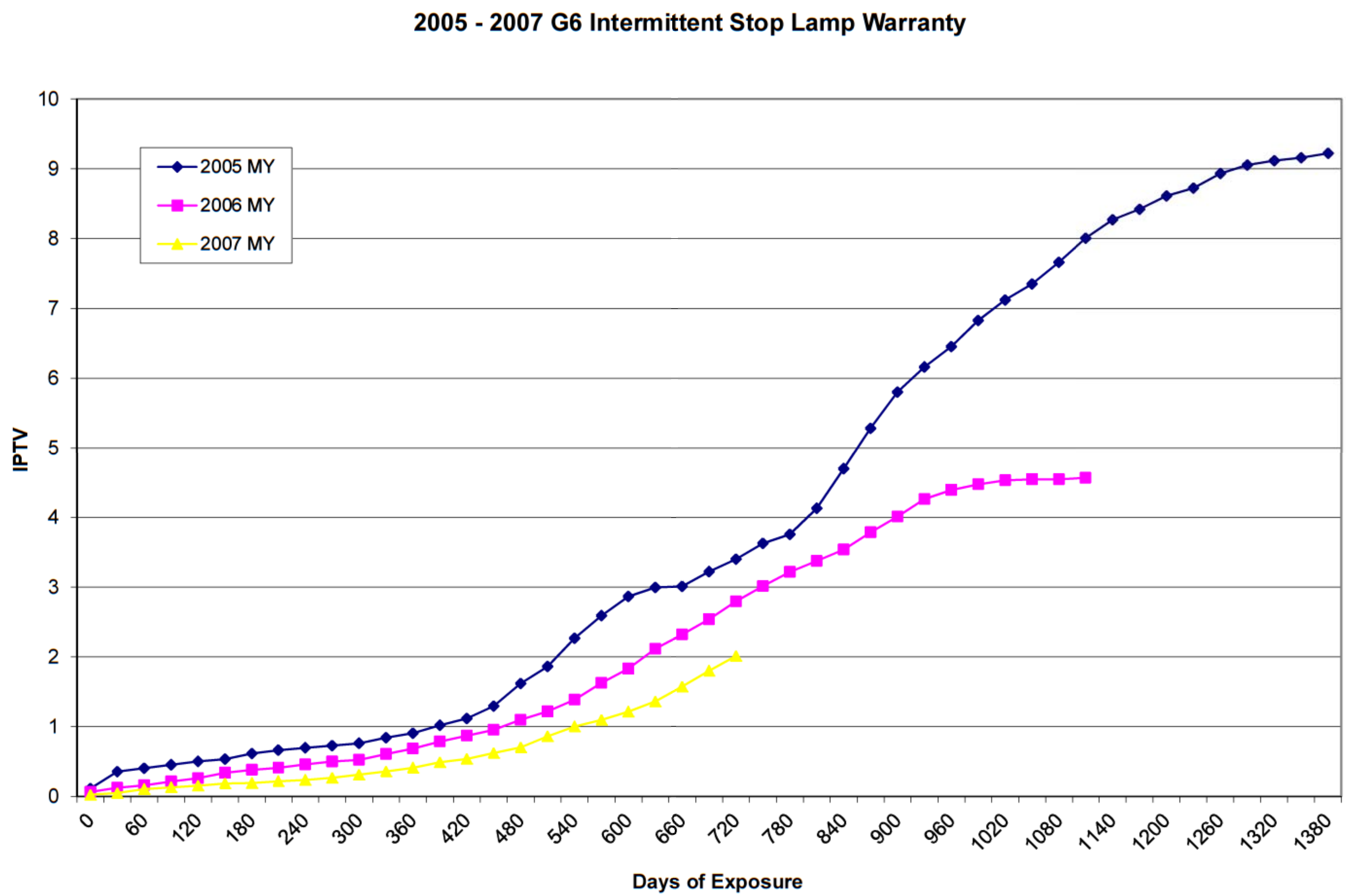
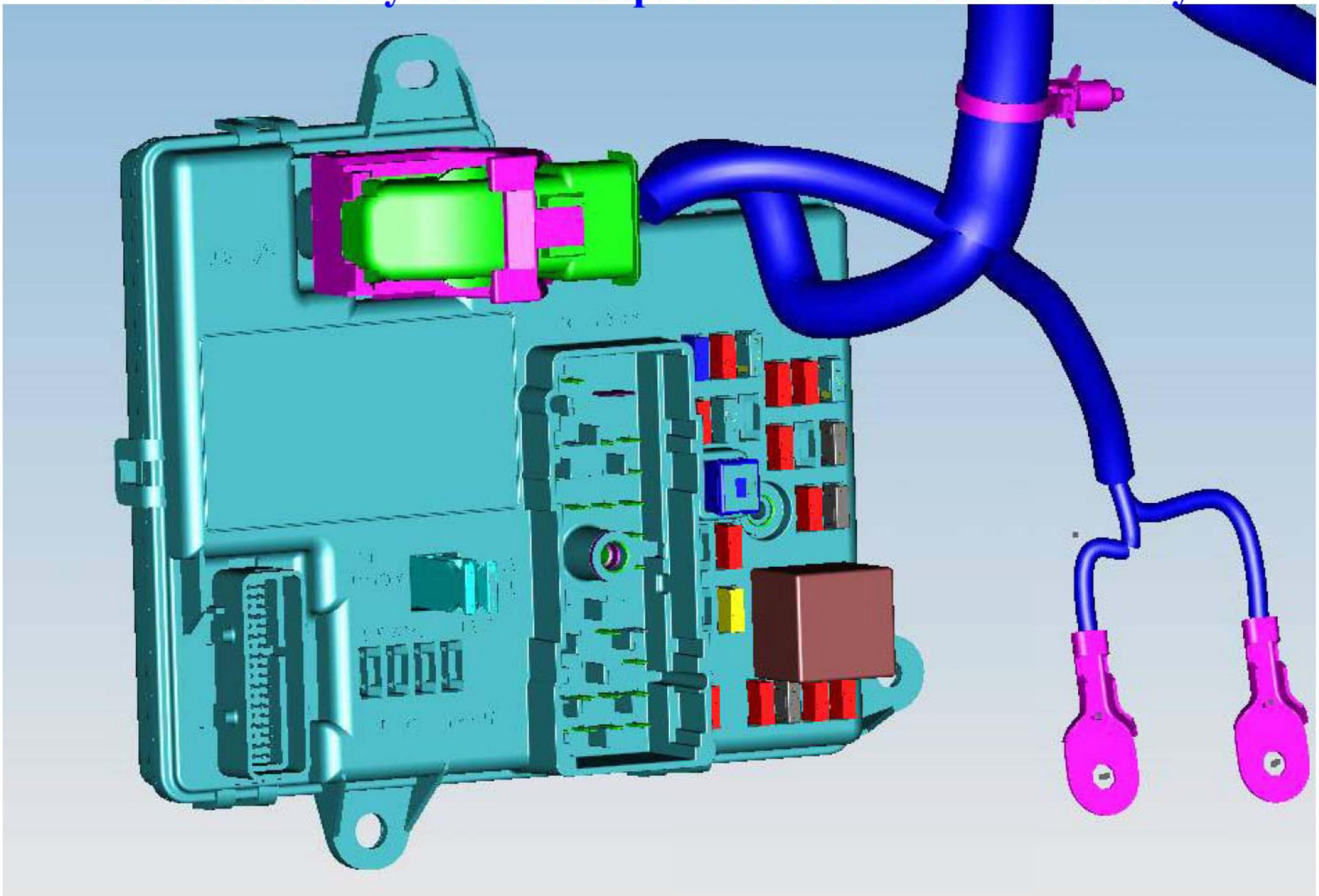
Intermittently Brake Lamps Do Not Function Correctly



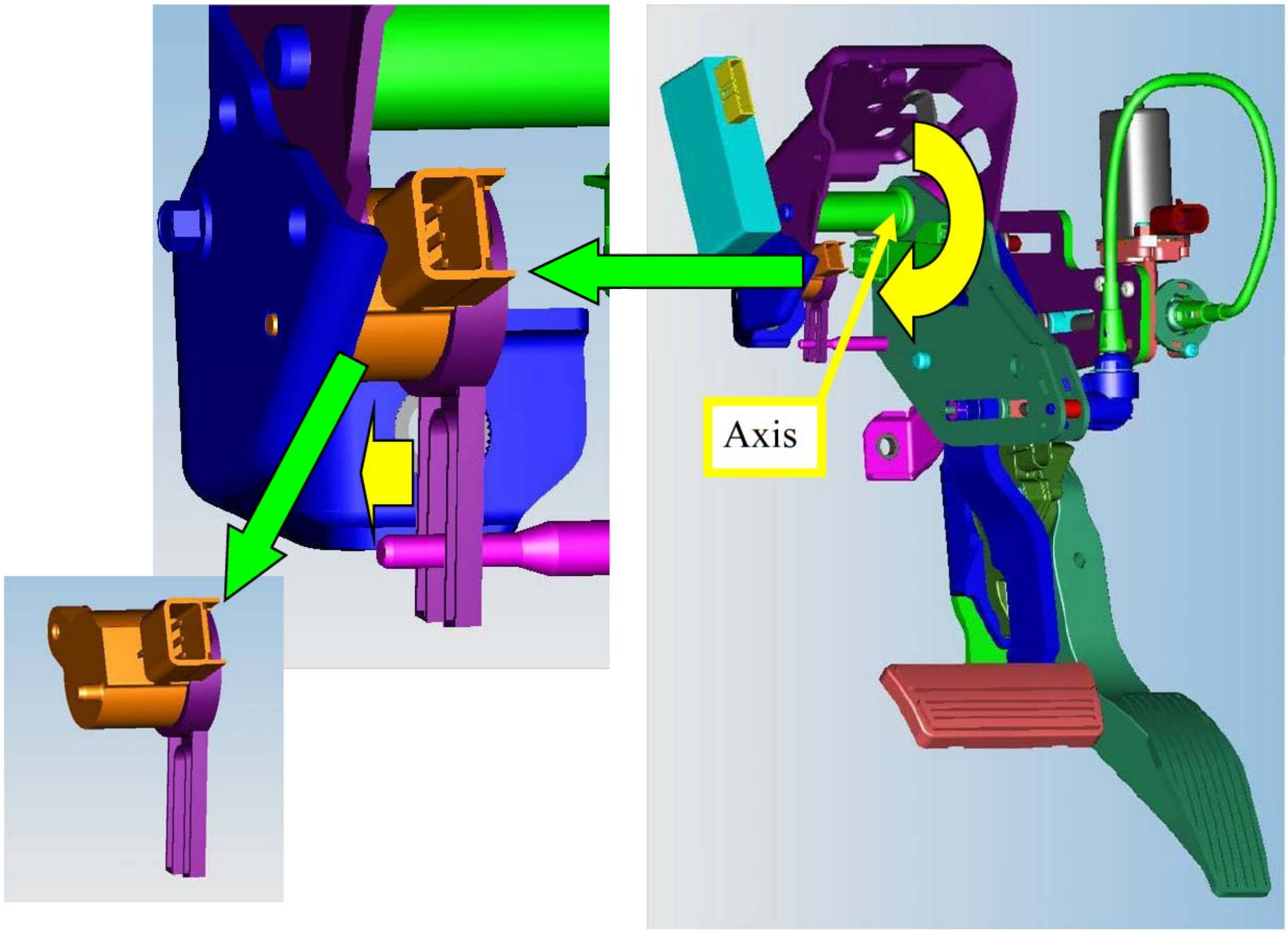
GM Confidential

Intermittently Brake Lamps Do Not Function Correctly



2005 - 2007 G6 Brake Apply Sensing System

Pedal/Sensor Movement



Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 or 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.
March 2013	NHTSA opened a Recall Query Investigation for G6, Malibu, and Aura that is due on April 17, 2013.

Closing Resume

Intermittently Brake Lamps Do Not Function Correctly

2004-2011MY Epsilon (G6, Aura, Malibu)
Est. Population: 2.2M US Only
Est. Cost: $TBD

Condition: Fretting corrosion in the Body Control Module connector (C2 or X2) causes an increase in resistance that results in a reduction of Brake Apply Sensing (BAS) signal voltage to the BCM. Brake pedal status information affects the operation of brake lamps, cruise control, brake shifter interlock, and stability control systems.

Effect of the Condition: This results in erratic brake pedal status information. A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

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Potential Field Action Category: TBD

Discovery On September 15, 2008, NHTSA ODI opened PE investigation with 9 VOQs. On January 28, 2009, GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY. On February 13, 2013, NHTSA ODI opened RQ investigation initiated with 212 VOQs.

Intermittently Brake Lamps Do Not Function Correctly

Potential Field Remedy: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Frequency:
Month of Build January 2005 36 MIS = 34.8 IPTV Campaigned.
See updated IPTV vs. MOB graph for non-campaigned vehicles.

Immediate Improvement /Containment

On December 4, 2008, Technical Service Bulletin 08-05-22-009 was issued to apply the lubricant on the BCM terminal.

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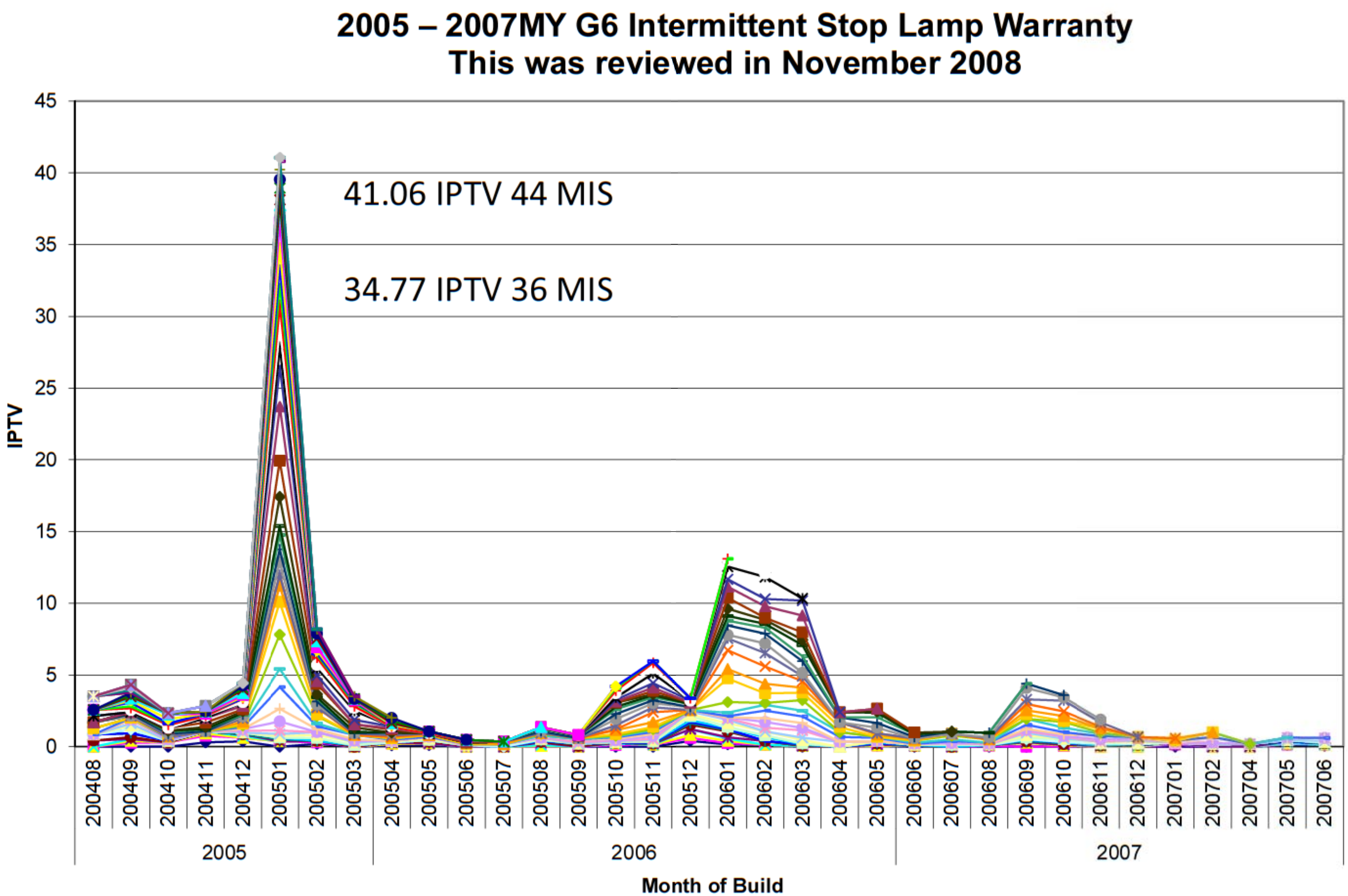
Responsibility
GM and Delphi Engineering

Intermittently Brake Lamps Do Not Function Correctly



Subject component changed from BASS sensor (PE Date 9/08) to BCM connector (RQ Date2/13)

Labor Code	Description
N9595	BCM C2 or X2 Connector Repair
N9613	Lubricate Body Control Module (BCM) Connector with Dielectric Lubricant
N6612	Exterior Lighting Wiring and/or Connector Repair or Replace
N6616	Serial DATA/DLC/STAR Connect Wiring and/or Connector Repair or Replace
N6651	Connector Kit Repair
N6652	Connector with Leads Assembly Replace
N2700	Switch, Stop Lamp – Adjust
N4800	Body Control Module Replacement
H2640	Pedal and/or Bushing, Brake – R&R or Replace
H2642	Sensor, Brake Pedal Position – Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
H9991	Customer Concern Not Duplicated
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement – Product Allegation
Z1243	Inspection – Product Allegation Resolution
V2044	Apply Dielectric Lubricant to C2 Connector (08317)
V2045	Customer Reimbursement (08317)

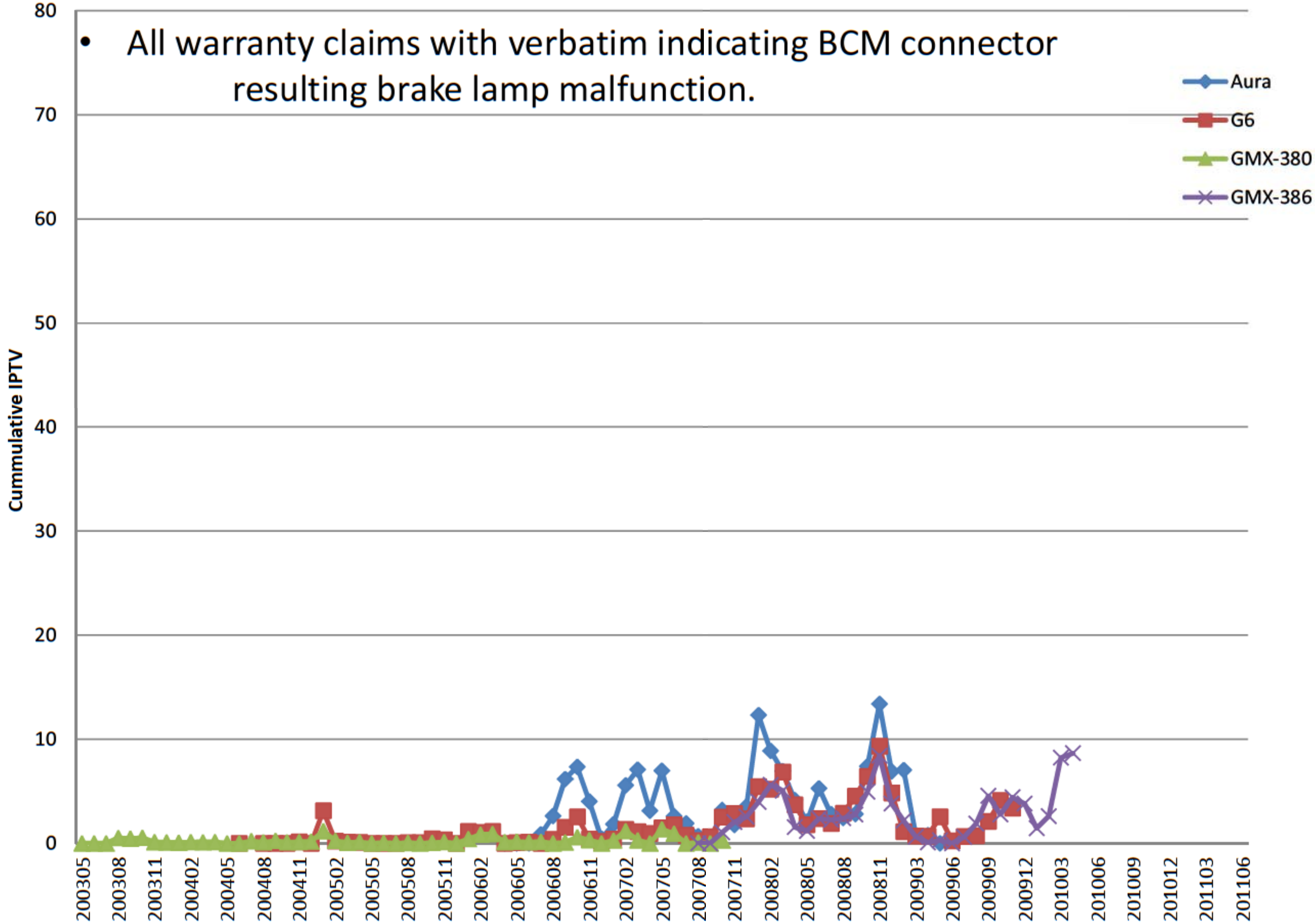
Maroon color represents added RQ Labor Codes

All Warranty Requested by NHTSA for RQ – 56,075 VINs

- Labor Codes of TSB, BCM, Vop (reimbursement) with and w/o verbatim - 54,929 VINs
- 13 Labor Codes with verbatim reading – 1,146 VINs
- Sub total of 56,075 VINs.

- For 13 Labor Codes, this does not include ~40k claims w/o verbatim.

March 2013 Warranty IPTV @ 36 MIS
Subset of NHTSA Warranty Claims Sorted by Verbatim - 5,943 VINs



11. Furnish GM's assessment of the alleged defect in the subject vehicles, including:
The causal or contributory factor(s);
The failure mechanism(s);
The failure mode(s);
The risk to motor vehicle safety that it poses;
What warnings, if any, the operator and other persons both inside and outside the vehicle would have that the alleged defect was occurring or subject component was malfunctioning; and the reports included with this inquiry.

The suspected causal or contributing factor(s), failure mechanism(s) and the associated failure mode(s) are described in the following summary:

The Body Control Module (BCM) receives a Brake Apply Sensor (BAS) signal voltage and uses that signal to activate or deactivate the brake lamps. The suspected failure mechanism is fretting corrosion at the terminal interface between the BCM and the instrument panel harness of the BAS circuits. Fretting corrosion causes an increase in resistance resulting in a lower BAS signal voltage to the BCM.

Indications that fretting corrosion may be affecting the signal voltage may include: 1) the transmission converter clutch may not engage, 2) the cruise control may not engage and 2) the driver may have difficulty shifting out of PARK. According to GM's supplier, vibration and thermal expansion/contraction are the primary sources of fretting motion.

In the GM reports, there were 3 crashes and no injuries.

GM is continuing its investigation in to this issue.

Back-up

5. State, by model and model year, a total count for all of the following categories of claims, collectively, that have been paid by GM to date that relate to, or may relate to, the subject component, regardless of why the claim was made, in the subject vehicles: warranty claims; extended warranty claims; claims for good will services that were provided; field, zone, or similar adjustments and reimbursements; and warranty claims or repairs made in accordance with a procedure specified in a technical service bulletin or customer satisfaction campaign. This specifically includes, but is not limited to, repairs made in accordance to TSB 09-05-22-009C.

Separately, for each such claim, state the following information:

a. GM's claim number;
b. Vehicle owner or fleet name (and fleet contact person) and telephone number;
c. VIN;
d. Repair or replacement date;
e. Vehicle mileage at time of repair;
f. Repairing dealer's or facility's name, telephone number, city and state or ZIP code;
g. Labor operation number;
h. Problem code;
i. Replacement part number(s) and description(s);
j. Whether glass fracture is alleged;
k. Concern stated by customer; and
l. Comment, if any, by dealer/technician relating to claim and/or repair or replacement.

Provide this information in Microsoft Access 2010, or a compatible format, entitled "WARRANTY DATA."

RQ Warranty Analysis for NHTSA Inquiry Response

Many of the following warranty claims do not relate to the brake lamp malfunction condition. The following process was used to sort the warranty claims:

All claims with labor code N9595 (TSB 08-05-22-009), N9613 (TSB 09-06-03-004), N4800 (Body Control Module Replacement) and V2045 (campaign 08317 reimbursements) were determined to be responsive to the alleged condition, even if no verbatim were provided.

All claims for V2044 were excluded as part of General Motors campaign 08317.

Each warranty record may have up to 6 verbatim fields. All available verbatim of the remaining claims were read and a claim was determined to be responsive if the verbatim indicated that the incident may have been caused by the BCM C2 or BCM X2 connector. In cases where it was specifically stated that a repair or replacement of the C2 or X2 did not correct the brake lamp problem and another component was repaired or replaced to correct the problem, those claims were not counted.

GM Warranty Analysis using Verbatim, Complaint & Causal Codes

139,689 VINs including duplicates for US Only

A. The verbatim of 17 warranty labor codes were read and counted if they stated that the claim was related to the loss/malfunction of the brake/stop lamps.
   5,943
B. The complaint codes and causal codes were selected from the overall claims including non-verbatim claims that are greater than 1.5% of the claims. These are representative of the overall claims and were determined to be responsive.
C. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.
D. Remove duplicate VINs including the VINs that were combined with dataset A and B.
E. All claims for vehicles covered by General Motors recall 08317 were excluded.
   6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%.

21,193

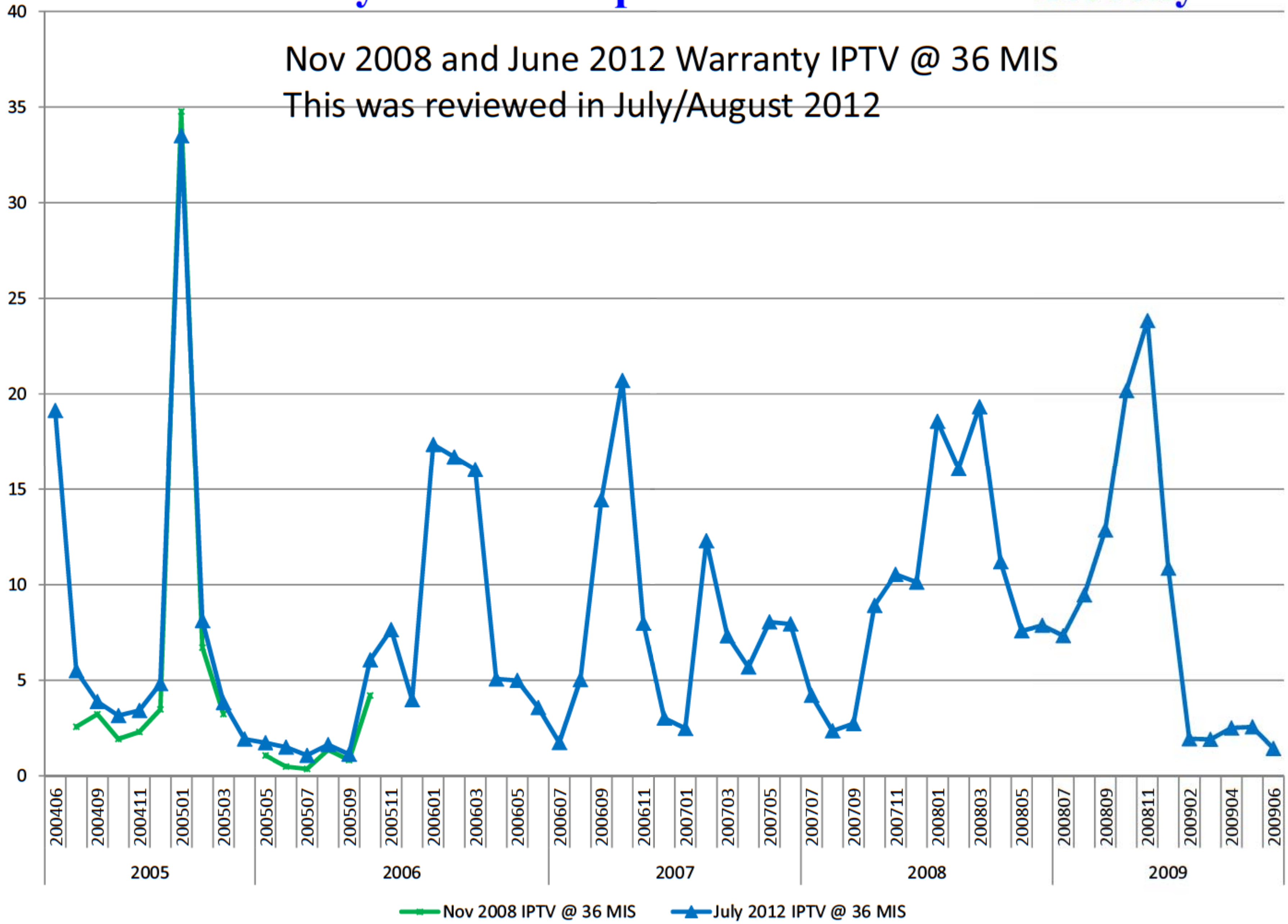
GM Warranty Analysis using Verbatim only

139,689 VINs including duplicates

A. The verbatim of 17 warranty labor codes were read and counted if they stated that the claim was related to the loss/malfunction of the brake/stop lamps.

5,943

Intermittently Brake Lamps Do Not Function Correctly



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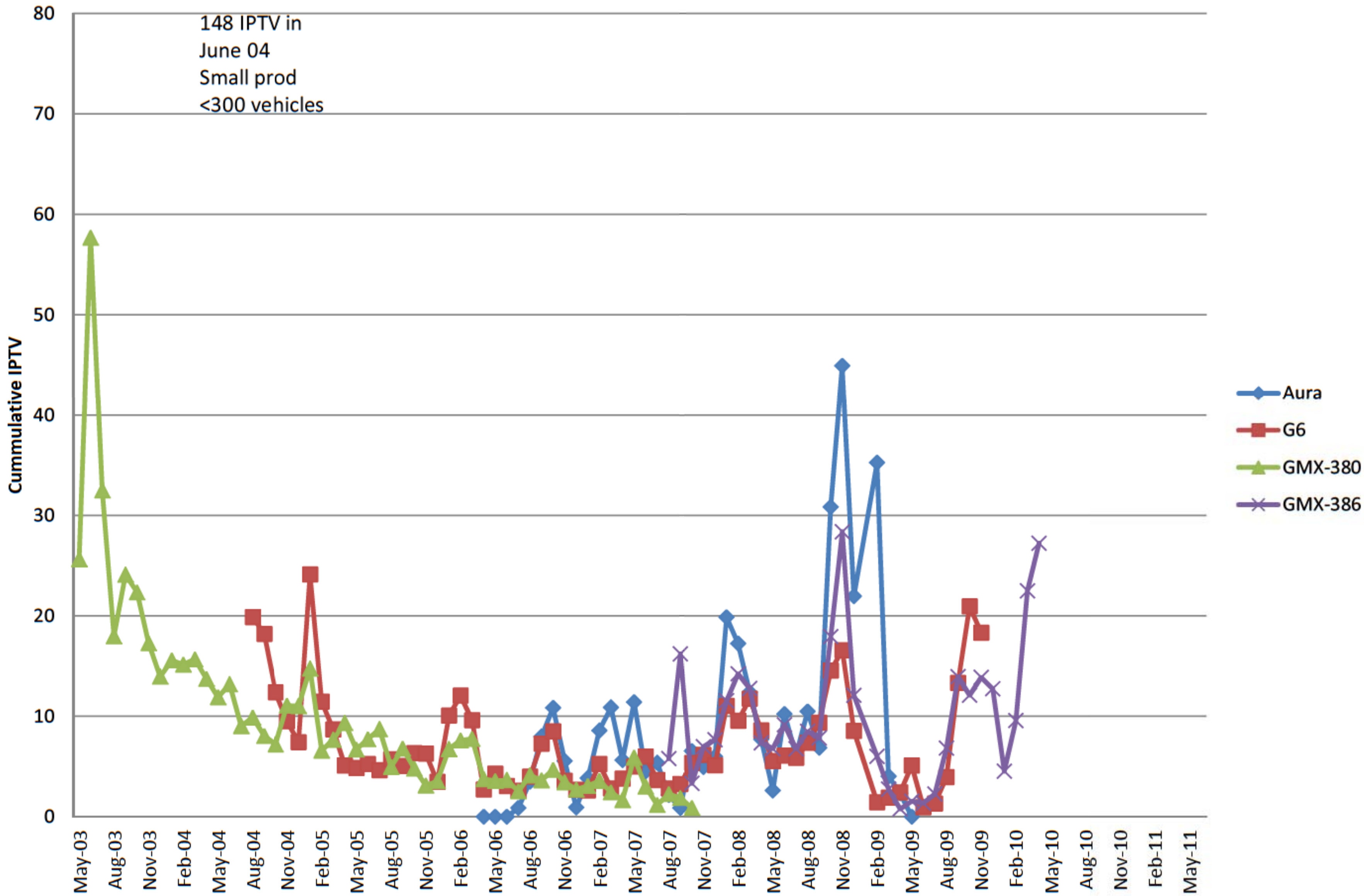
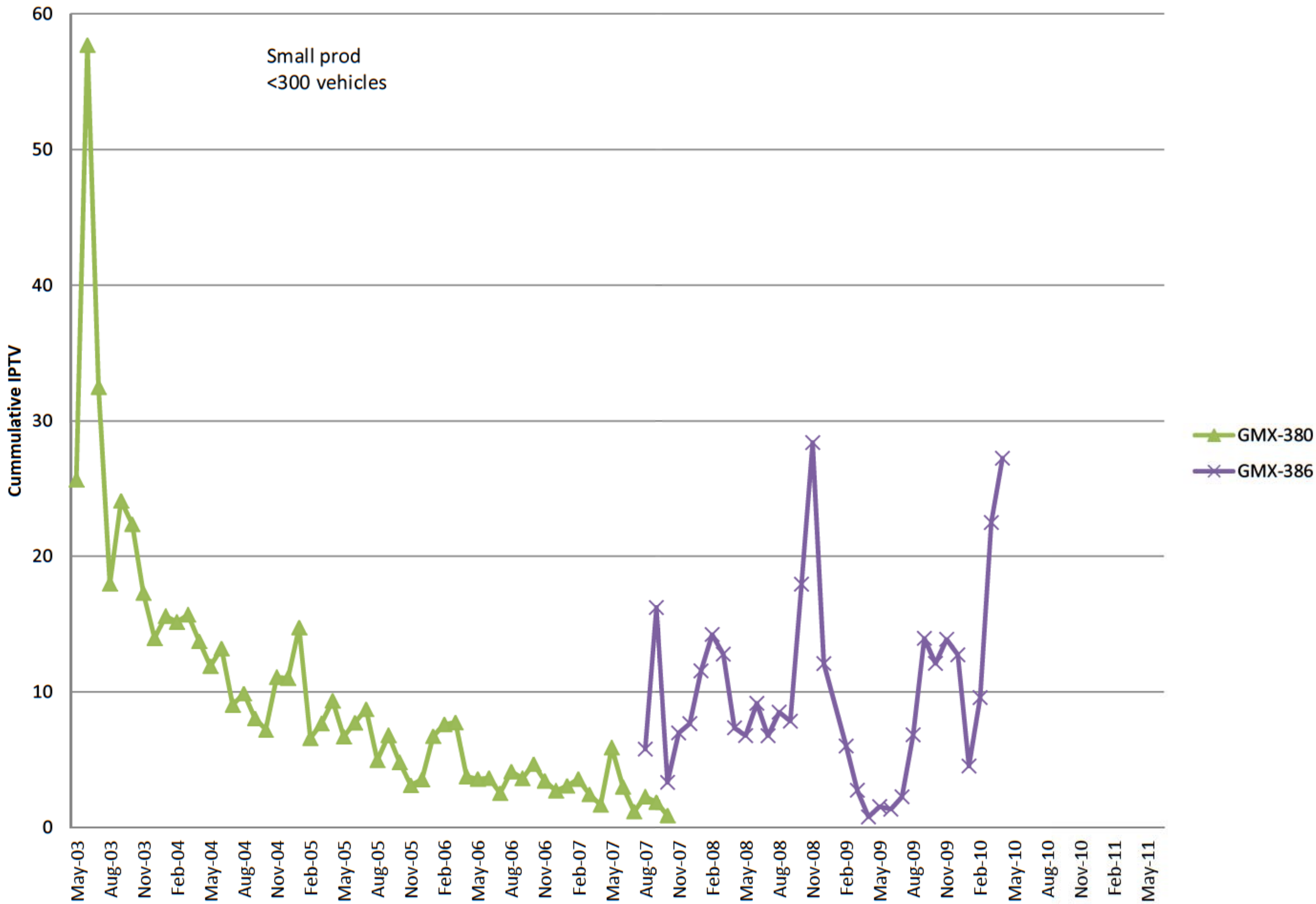
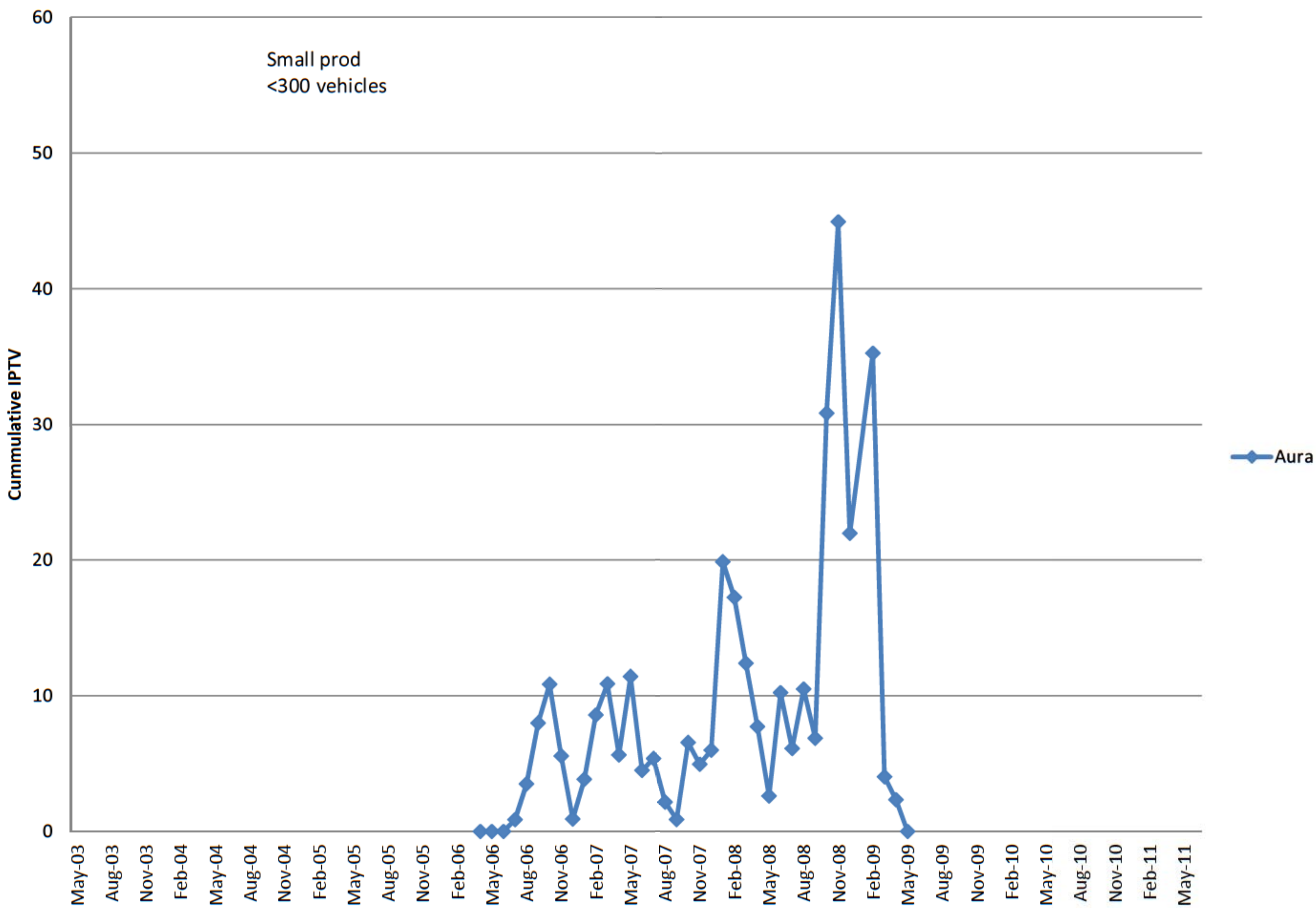
March 2013 Warranty IPTV @ 36 MIS
by Verbatim, Complaint and Causal Code Analysis

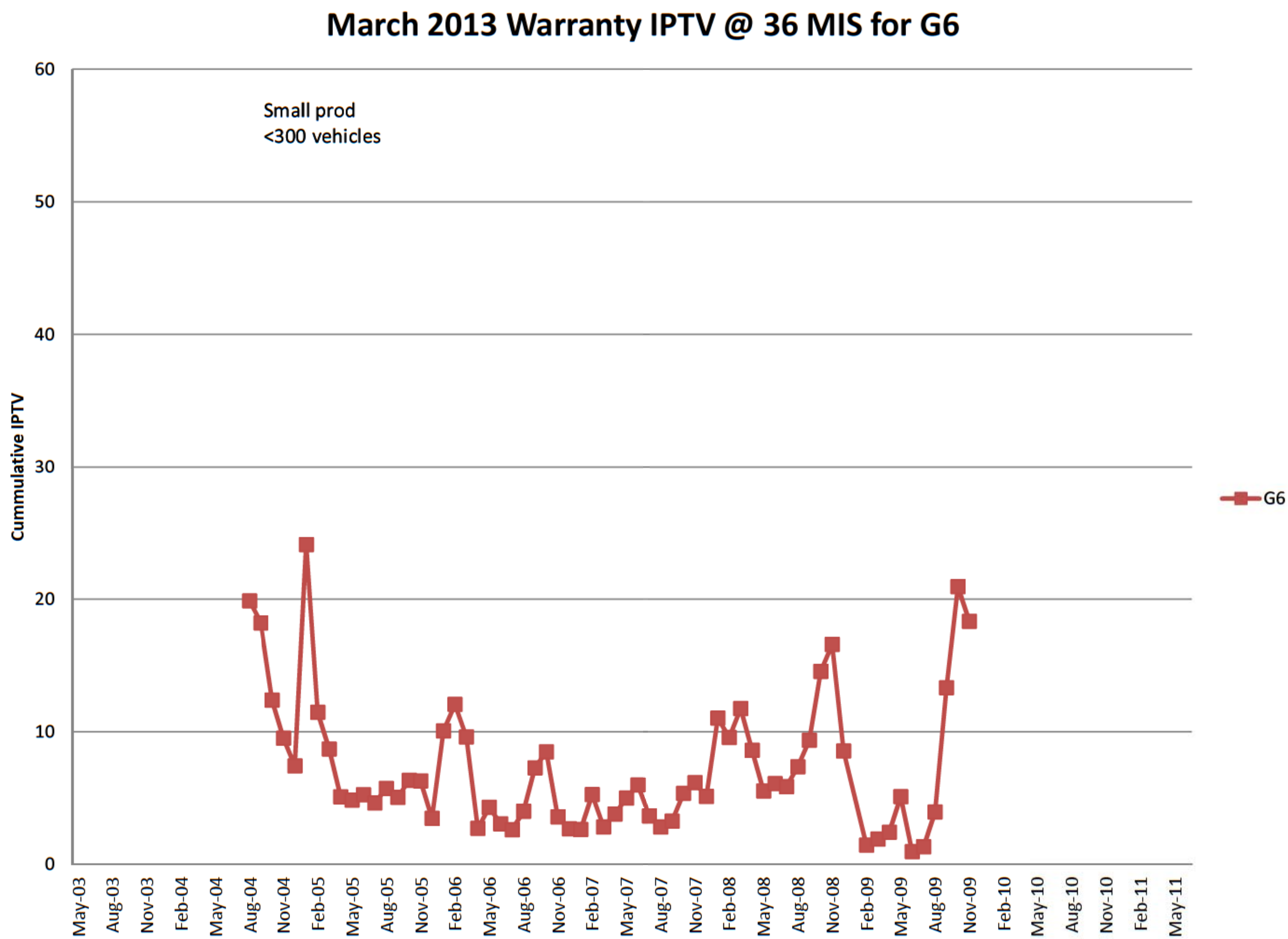


March 2013 Warranty IPTV @ 36 MIS for Mailbu



March 2013 Warranty IPTV @ 36 MIS for Aura




March 2013 Warranty IPTV @ 36 MIS for G6
Small prod
<300 vehicles
Cummulative IPTV
60
50
40
30
20
10
0
May-03
Aug-03
Nov-03
Feb-04
May-04
Aug-04
Nov-04
Feb-05
May-05
Aug-05
Nov-05
Feb-06
May-06
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May-10
Aug-10
Nov-10
Feb-11
May-11
G6

March 2013 Warranty IPTV @ 48 MIS

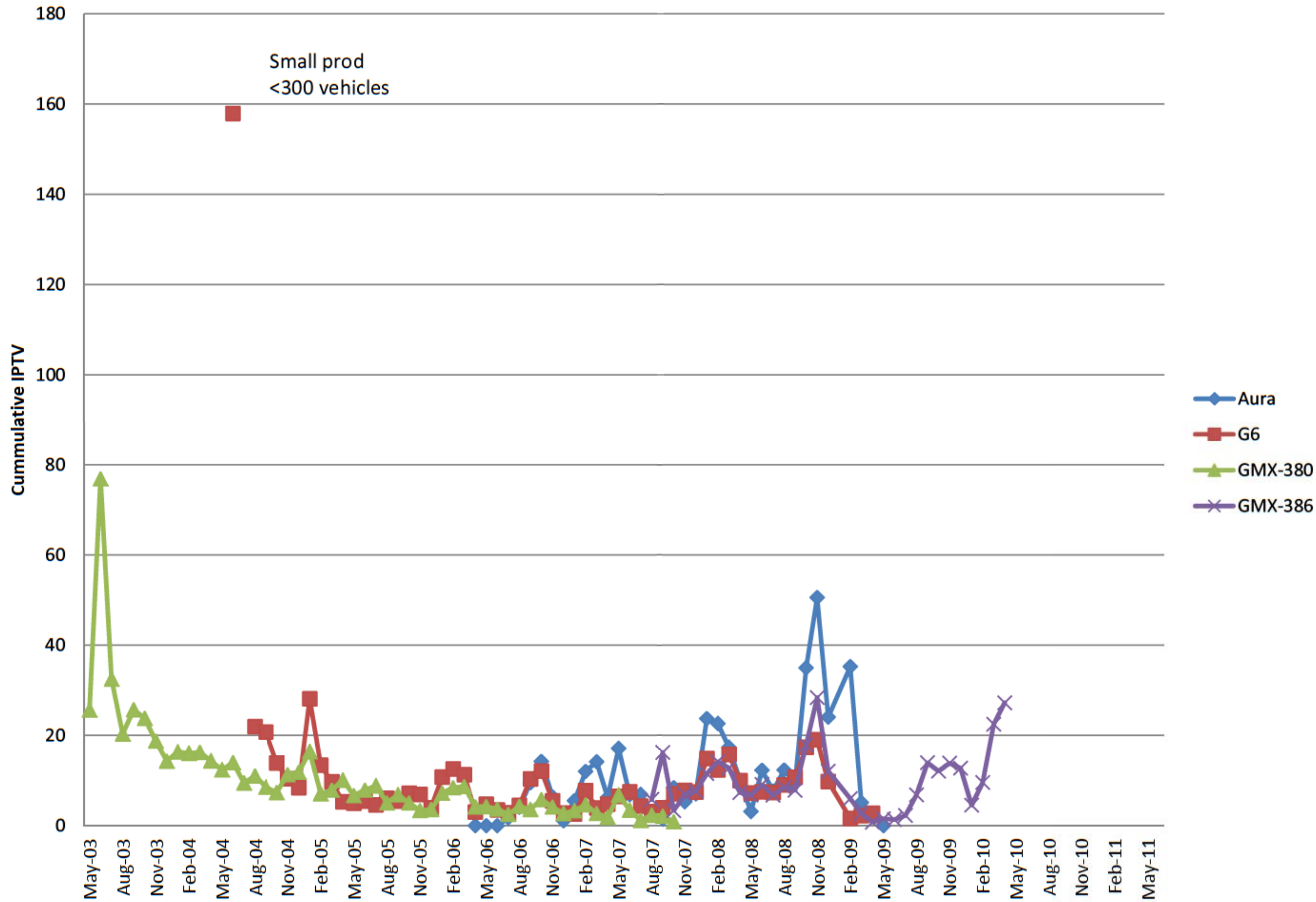

Table 1-1 Subject Vehicles Submitted to NHTSA

		Model Year								
Make	Model	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	183,783	211,055	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	N/A	N/A	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	N/A	N/A	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	25,586	N/A	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	N/A	N/A	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	209,369	211,055	2,214,173

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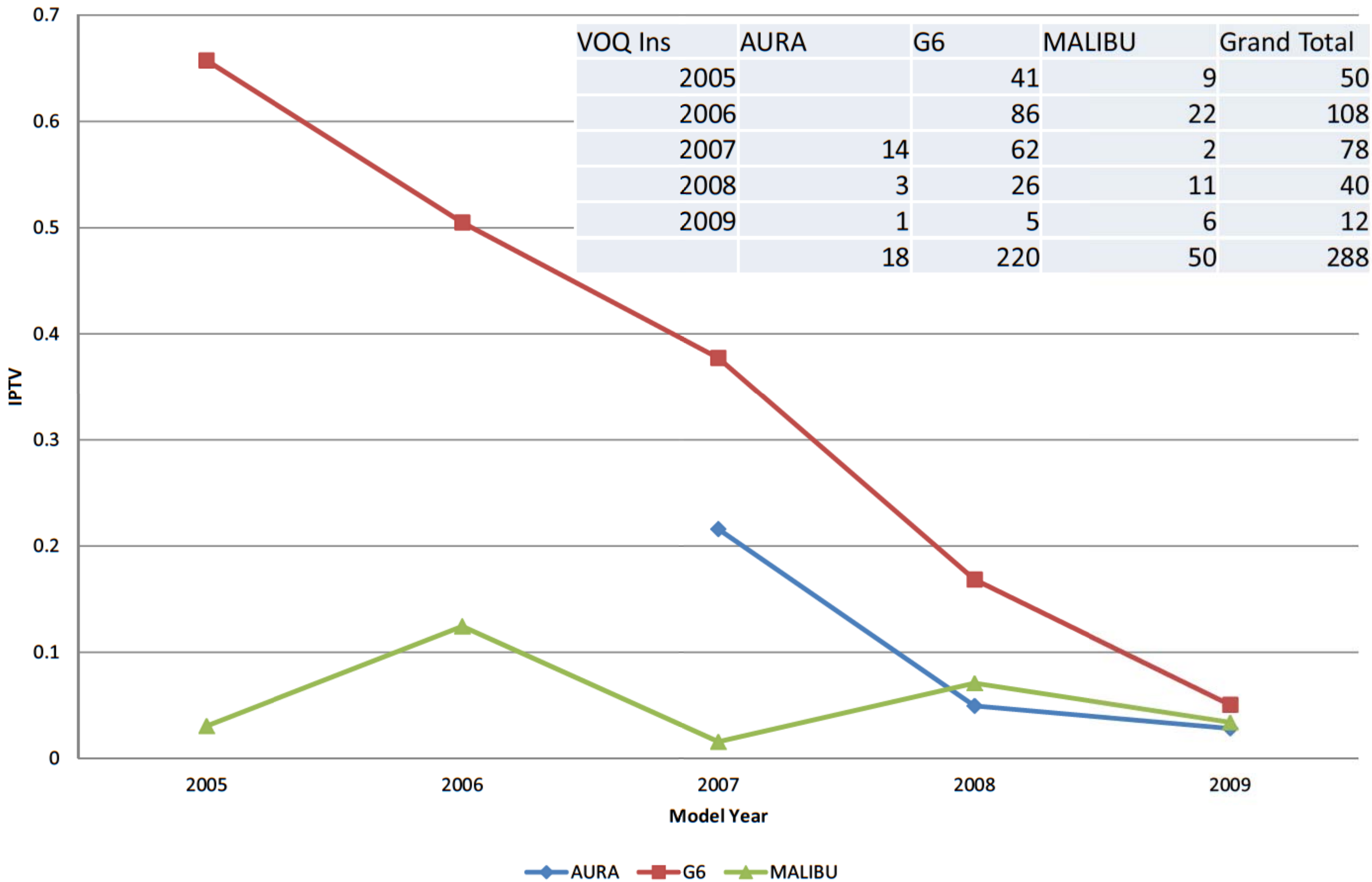
Intermittently Brake Lamps Do Not Function Correctly

2005-09MY G6, Mailbu and 2007-09MY Aura

Stop Lamp VOQ IPTV for US only

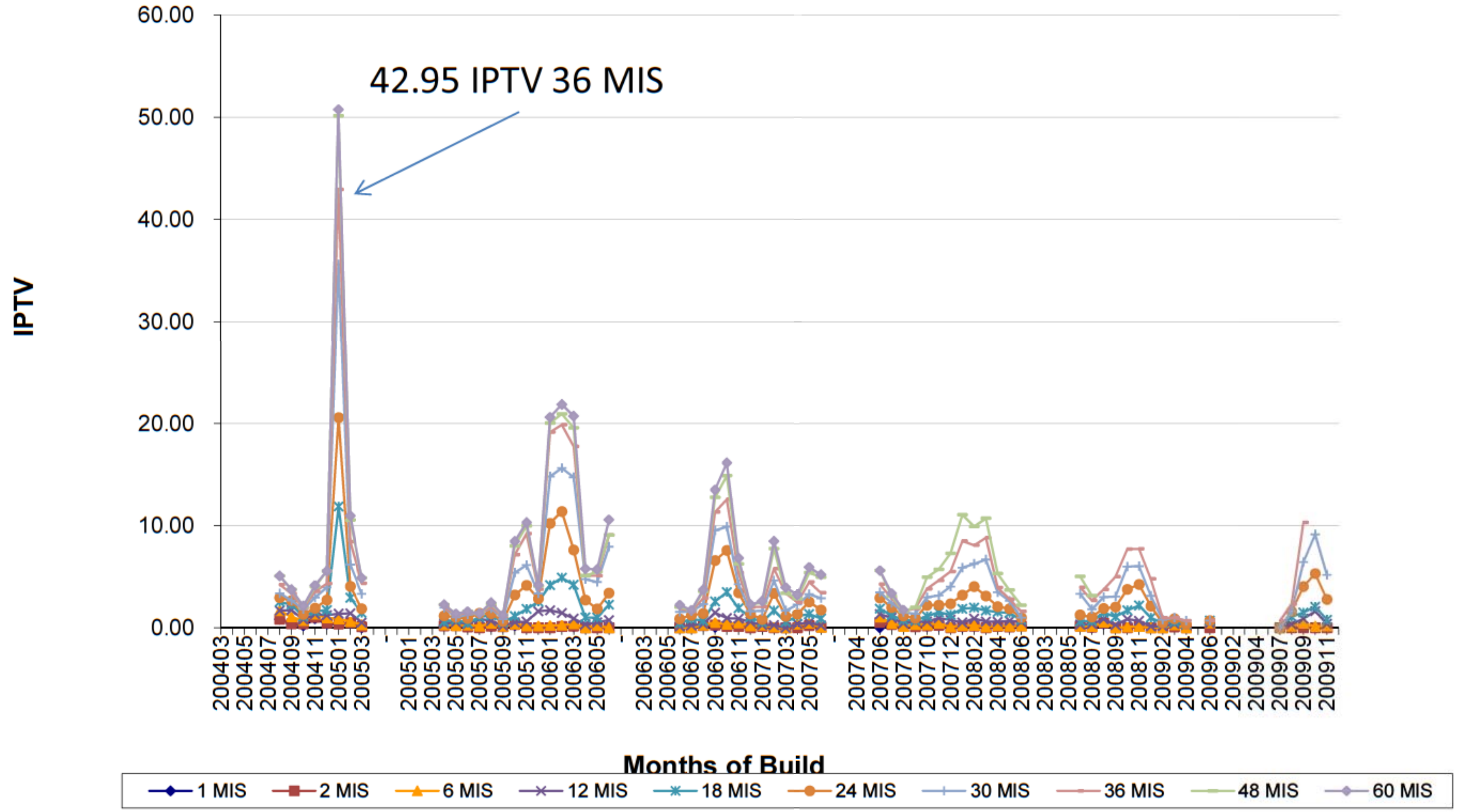


VOQ Ins	AURA	G6	MALIBU	Grand Total
2005		41	9	50
2006		86	22	108
2007	14	62	2	78
2008	3	26	11	40
2009	1	5	6	12
	18	220	50	288

Intermittently Brake Lamps Do Not Function Correctly

2005-2009MY Pontiac G6 Stop Lamp

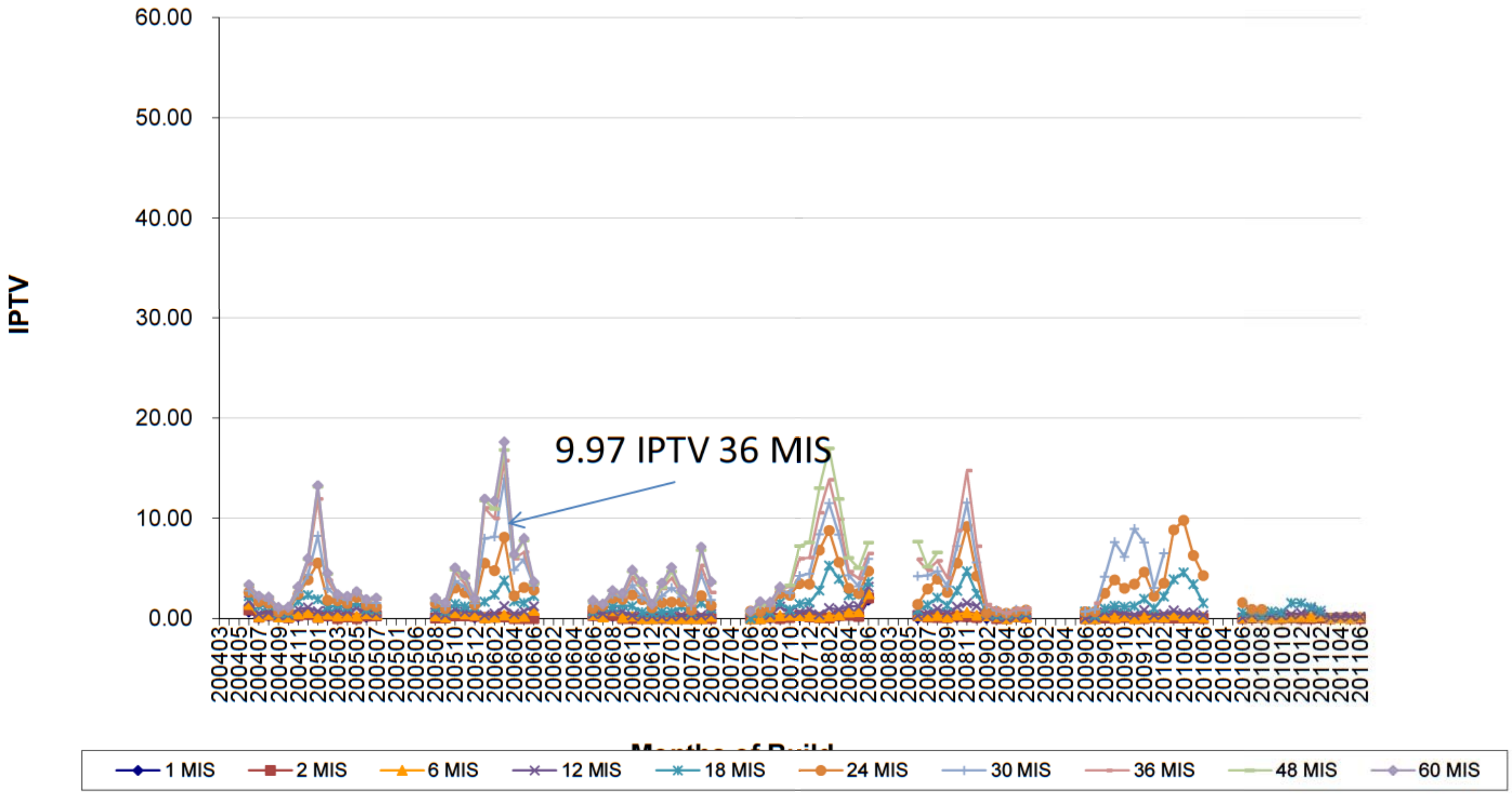
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

2005-2011MY Chevrolet Malibu Stop Lamp

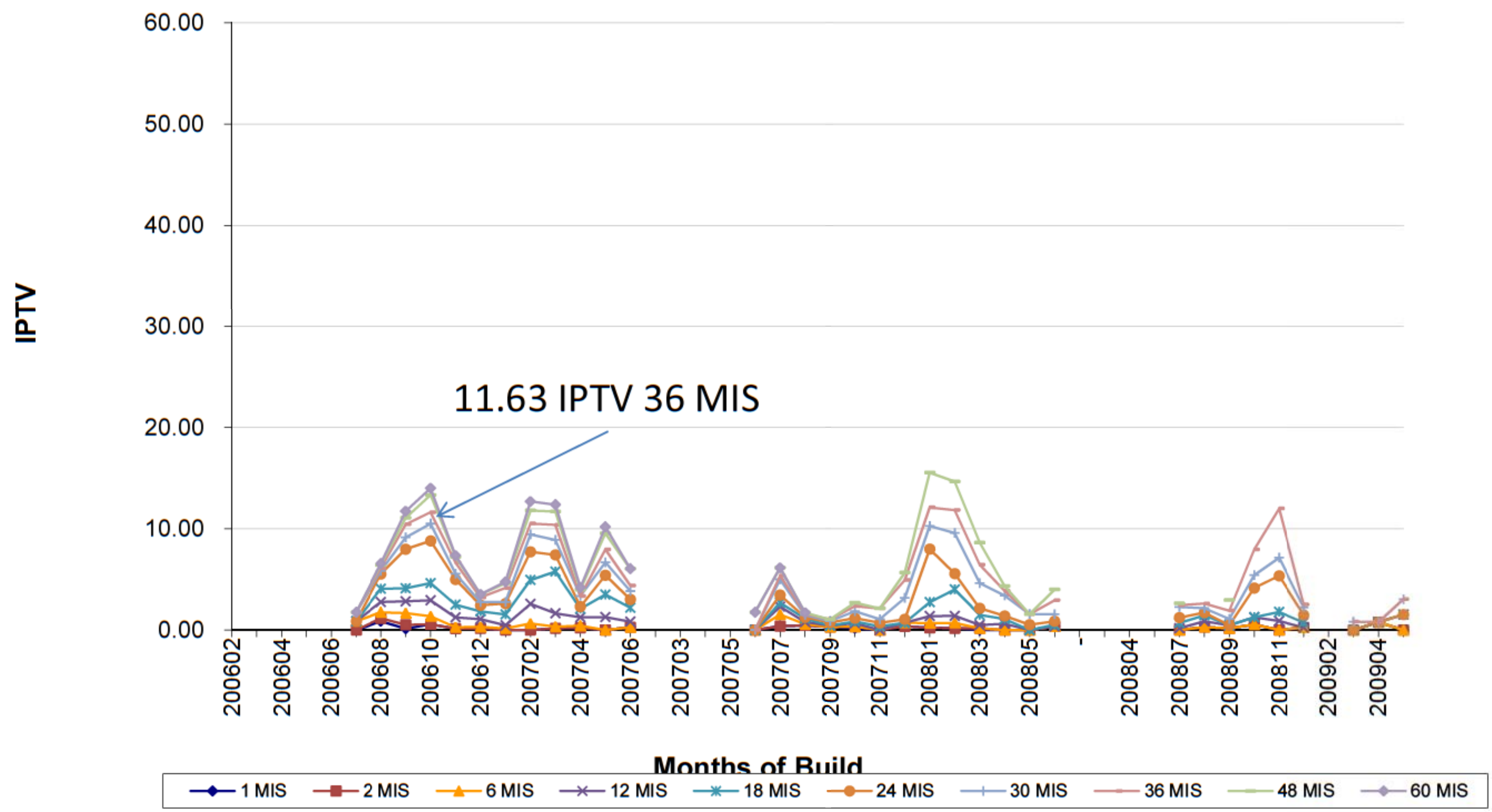
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

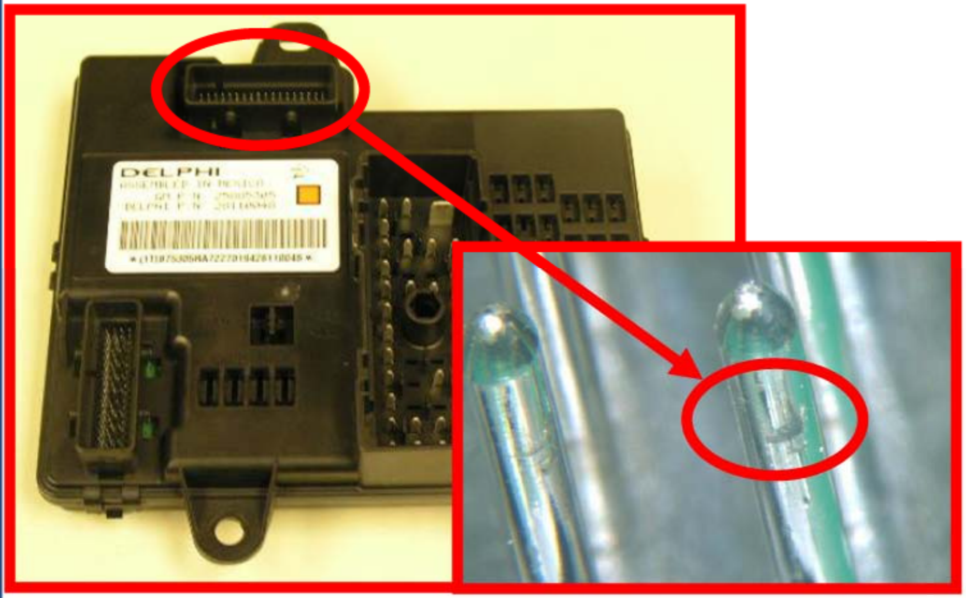
2007-2009MY Saturn Aura Stop Lamp

H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

Condition: Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.



Potential Field Action: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

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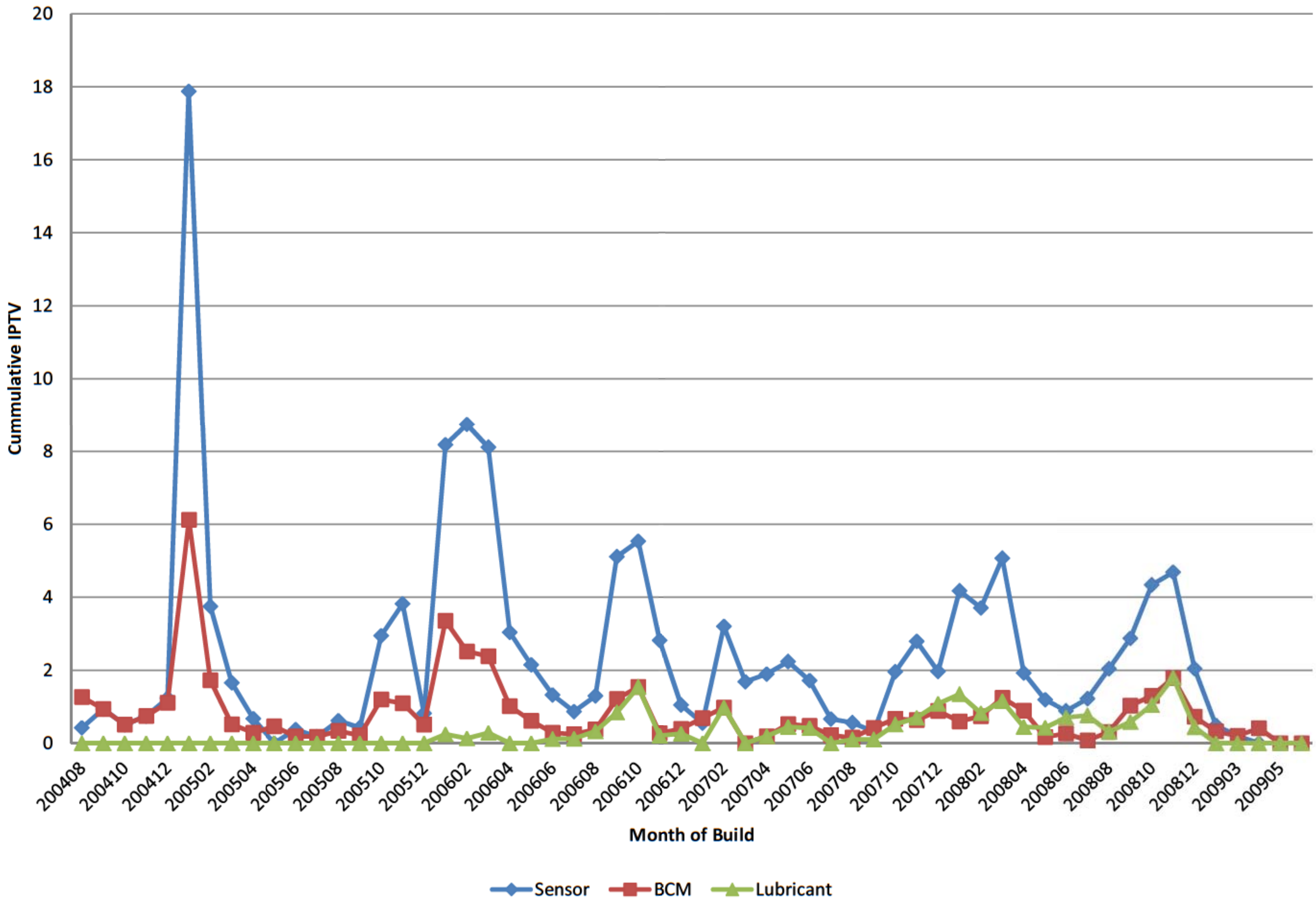
G6 claims by part number in 36 MIS



Intermittently Brake Lamps Do Not Function Correctly

Population

2005 – 2009MY Pontiac G6: 619,000

Excluding campaign population (Jan 2005) and vehicles built after February 2009 (grease applied).

2005	54,443
2006	170,255
2007	164,260
2008	154,323
2009	75,484
Grand Total	618,765

2005 – 2009MY Epsilon: 1.7M

Population	Aura	G6	Malibu	Grand Total
2005		62,360	294,833	357,193
2006		170,338	176,916	347,254
2007	64,847	164,260	127,660	356,767
2008	60,717	154,323	155,225	370,265
2009	35,472	99,216	176,689	311,377
	161,036	650,497	931,323	1,742,856

Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.

Closing Resume

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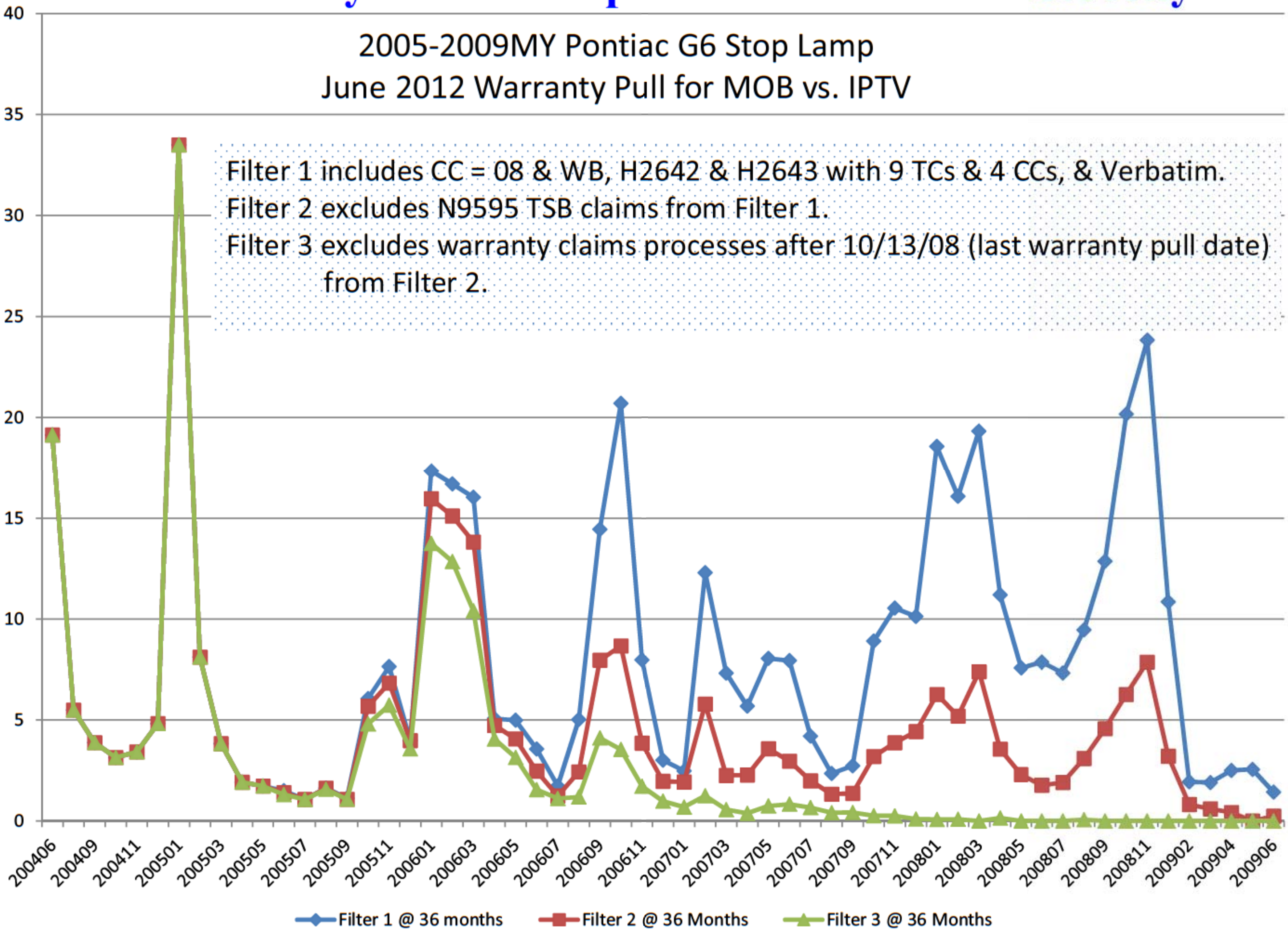
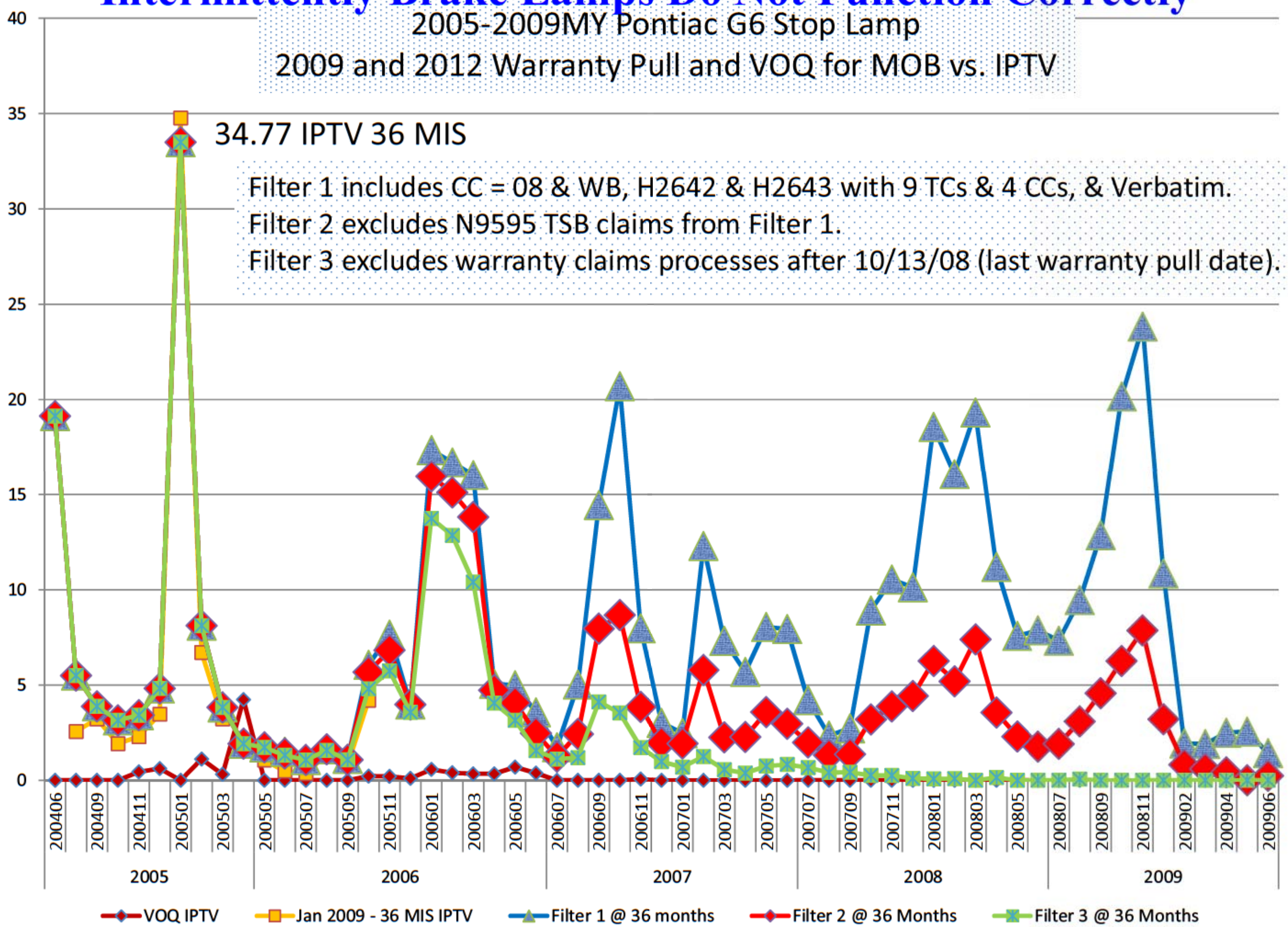
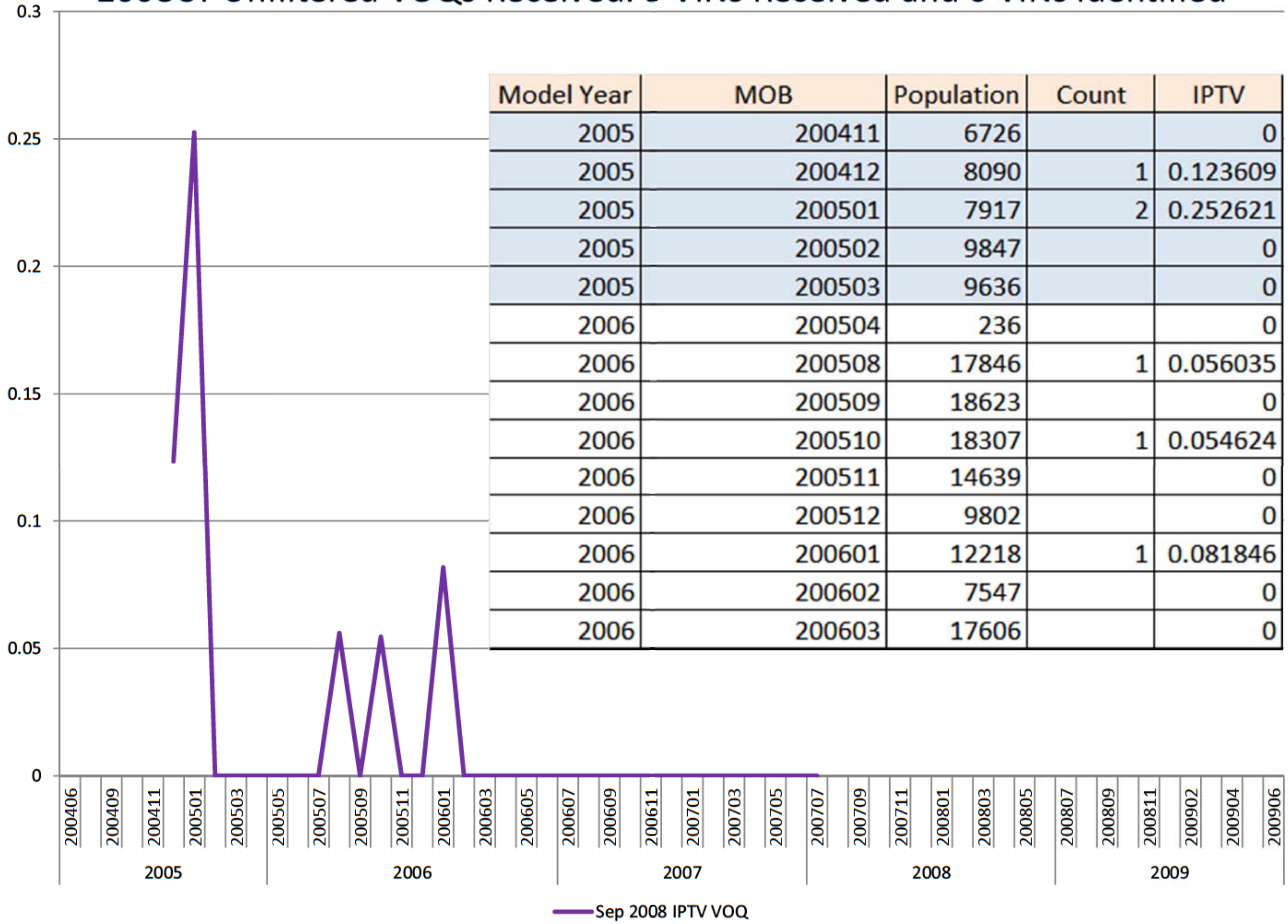
Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly

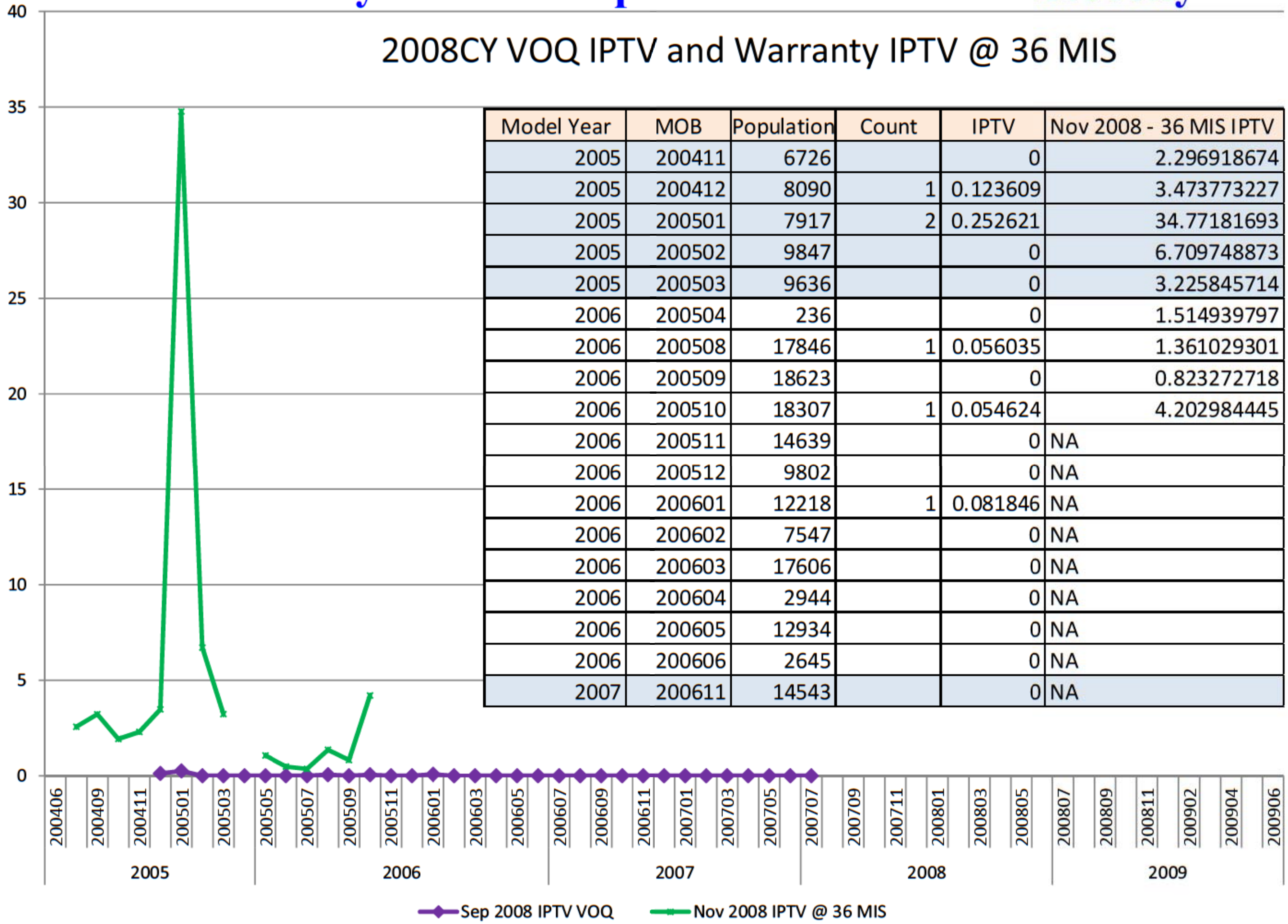


2008CY Unfiltered VOQs Received: 9 VINs Received and 6 VINs Identified



Model Year	MOB	Population	Count	IPTV
2005	200411	6726		0
2005	200412	8090	1	0.123609
2005	200501	7917	2	0.252621
2005	200502	9847		0
2005	200503	9636		0
2006	200504	236		0
2006	200508	17846	1	0.056035
2006	200509	18623		0
2006	200510	18307	1	0.054624
2006	200511	14639		0
2006	200512	9802		0
2006	200601	12218	1	0.081846
2006	200602	7547		0
2006	200603	17606		0

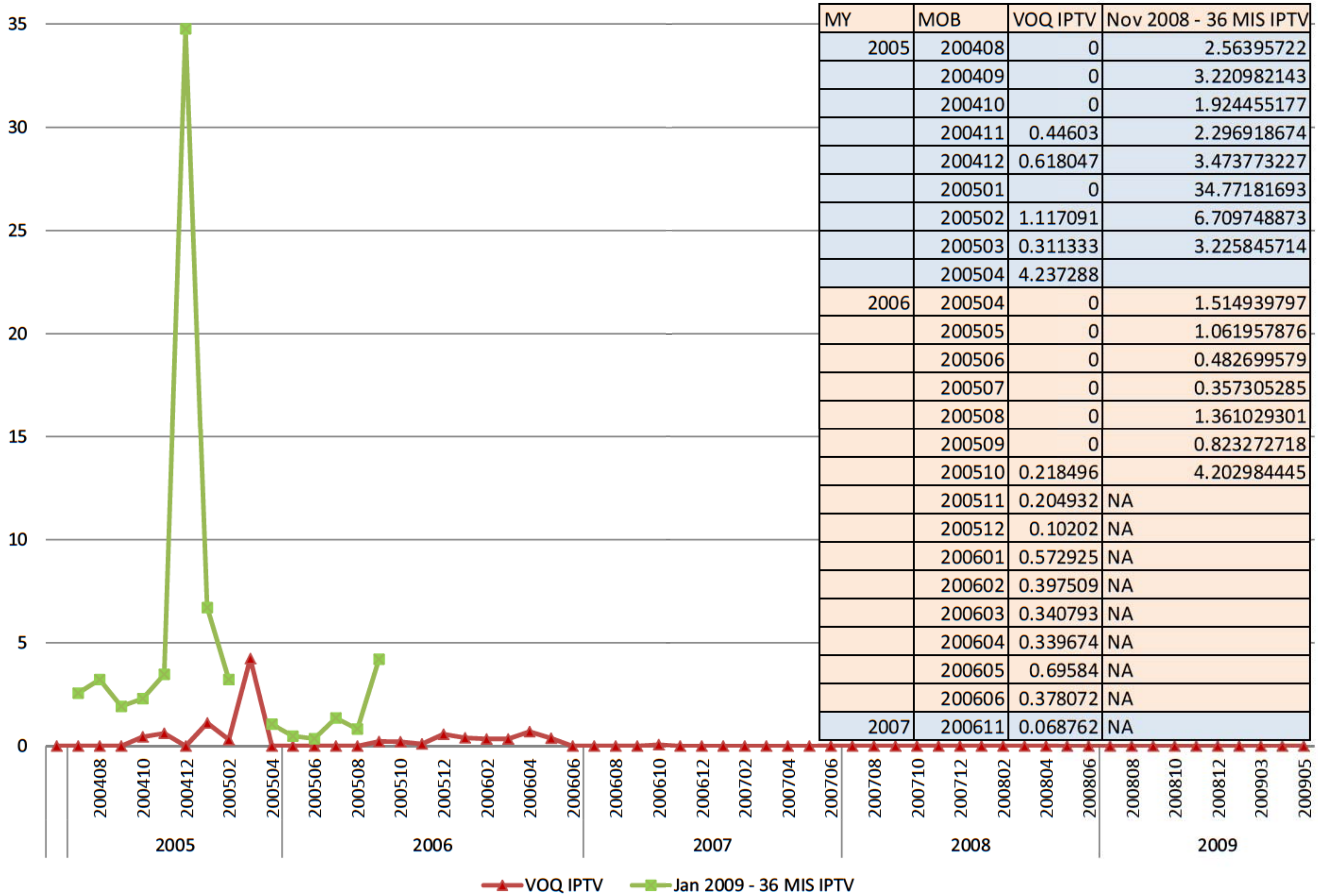
Intermittently Brake Lamps Do Not Function Correctly



Model Year	MOB	Population	Count	IPTV	Nov 2008 - 36 MIS IPTV
2005	200411	6726		0	2.296918674
2005	200412	8090	1	0.123609	3.473773227
2005	200501	7917	2	0.252621	34.77181693
2005	200502	9847		0	6.709748873
2005	200503	9636		0	3.225845714
2006	200504	236		0	1.514939797
2006	200508	17846	1	0.056035	1.361029301
2006	200509	18623		0	0.823272718
2006	200510	18307	1	0.054624	4.202984445
2006	200511	14639		0	NA
2006	200512	9802		0	NA
2006	200601	12218	1	0.081846	NA
2006	200602	7547		0	NA
2006	200603	17606		0	NA
2006	200604	2944		0	NA
2006	200605	12934		0	NA
2006	200606	2645		0	NA
2007	200611	14543		0	NA

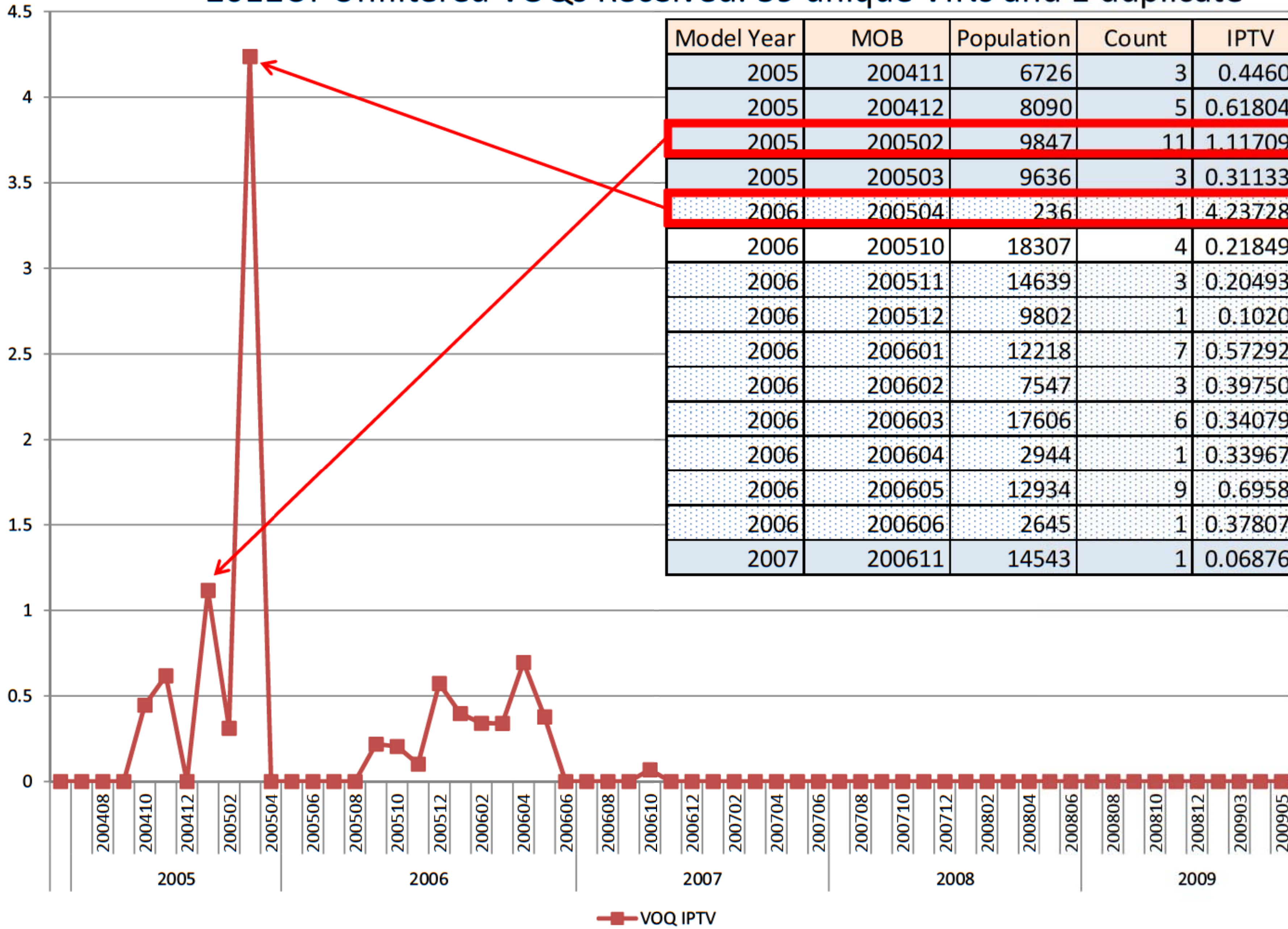
Intermittently Brake Lamps Do Not Function Correctly

2012 VOQ and Nov 08 Warranty IPTV @ 36MIS Trend line



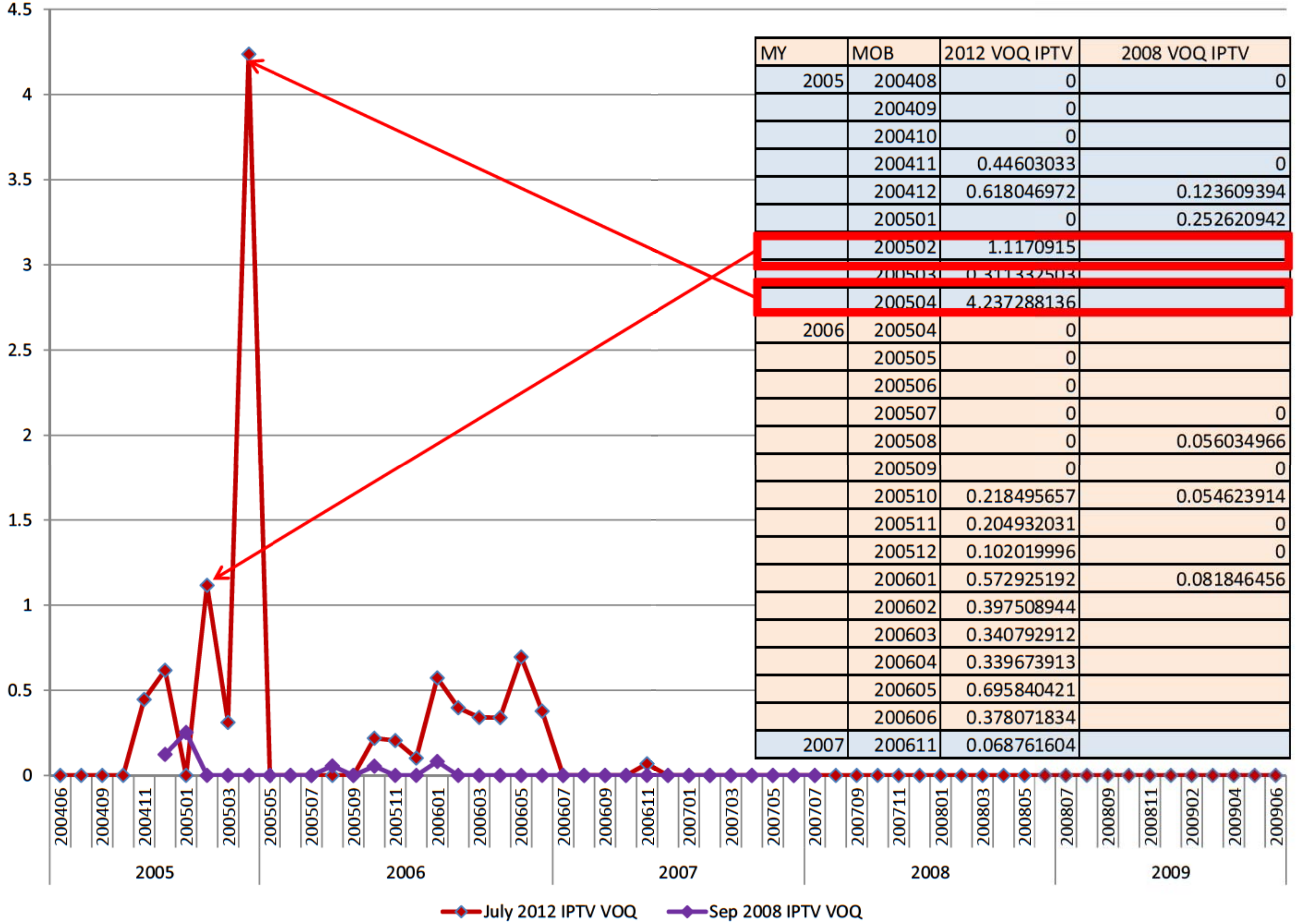
MY	MOB	VOQ IPTV	Nov 2008 - 36 MIS IPTV
2005	200408	0	2.56395722
	200409	0	3.220982143
	200410	0	1.924455177
	200411	0.44603	2.296918674
	200412	0.618047	3.473773227
	200501	0	34.77181693
	200502	1.117091	6.709748873
	200503	0.311333	3.225845714
	200504	4.237288	
2006	200504	0	1.514939797
	200505	0	1.061957876
	200506	0	0.482699579
	200507	0	0.357305285
	200508	0	1.361029301
	200509	0	0.823272718
	200510	0.218496	4.202984445
	200511	0.204932	NA
	200512	0.10202	NA
	200601	0.572925	NA
	200602	0.397509	NA
	200603	0.340793	NA
	200604	0.339674	NA
	200605	0.69584	NA
	200606	0.378072	NA
2007	200611	0.068762	NA

2012CY Unfiltered VOQs Received: 59 unique VINs and 1 duplicate



Model Year	MOB	Population	Count	IPTV
2005	200411	6726	3	0.44603
2005	200412	8090	5	0.618047
2005	200502	9847	11	1.117091
2005	200503	9636	3	0.311333
2006	200504	236	1	4.237288
2006	200510	18307	4	0.218496
2006	200511	14639	3	0.204932
2006	200512	9802	1	0.10202
2006	200601	12218	7	0.572925
2006	200602	7547	3	0.397509
2006	200603	17606	6	0.340793
2006	200604	2944	1	0.339674
2006	200605	12934	9	0.69584
2006	200606	2645	1	0.378072
2007	200611	14543	1	0.068762

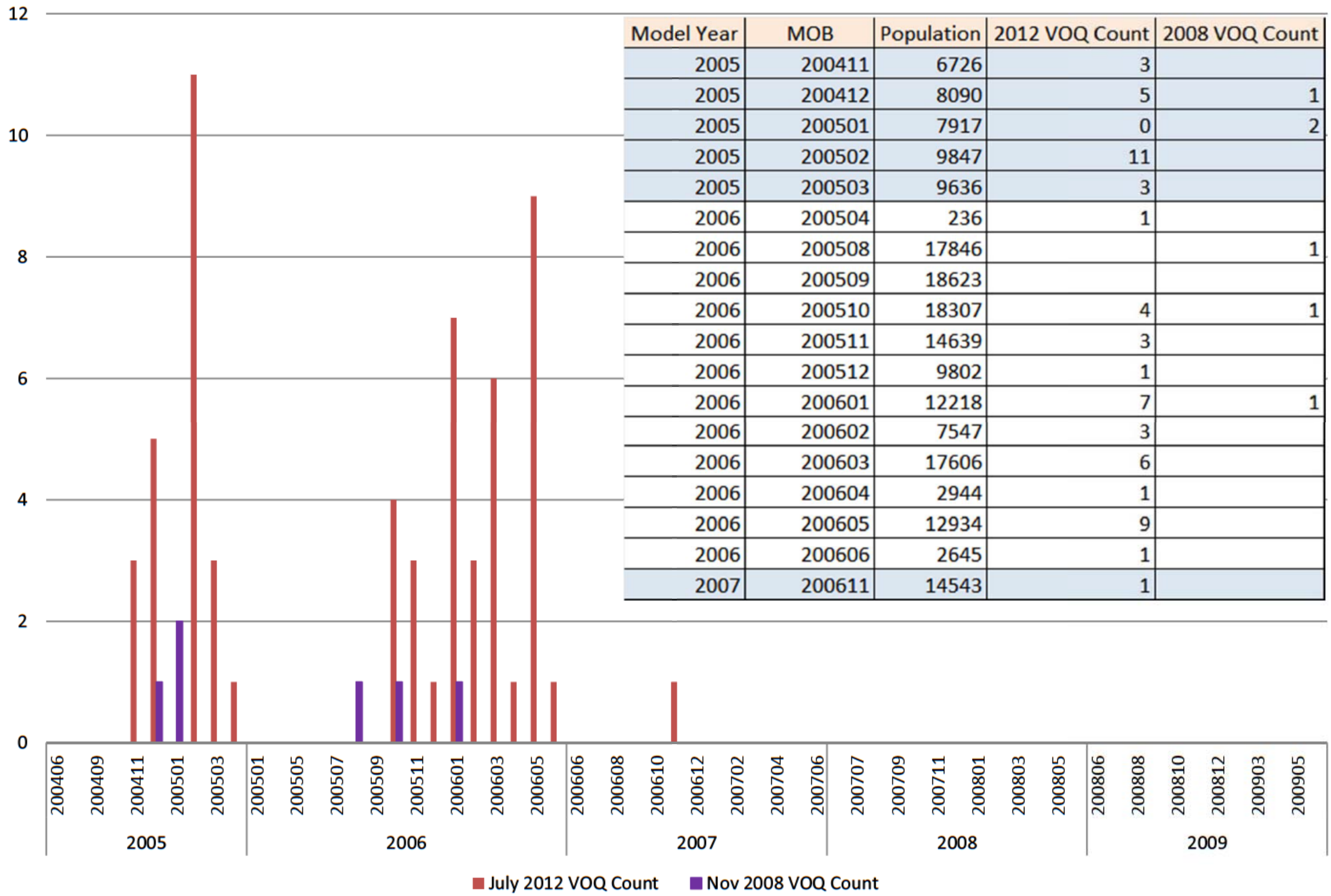
Nov 2008 and June 2012 VOQ IPTV



MY	MOB	2012 VOQ IPTV	2008 VOQ IPTV
2005	200408	0	0
	200409	0	
	200410	0	
	200411	0.44603033	0
	200412	0.618046972	0.123609394
	200501	0	0.252620942
	200502	1.1170915	
	200503	0.311332503	
	200504	4.237288136	
2006	200504	0	
	200505	0	
	200506	0	
	200507	0	0
	200508	0	0.056034966
	200509	0	0
	200510	0.218495657	0.054623914
	200511	0.204932031	0
	200512	0.102019996	0
	200601	0.572925192	0.081846456
	200602	0.397508944	
	200603	0.340792912	
	200604	0.339673913	
	200605	0.695840421	
	200606	0.378071834	
2007	200611	0.068761604	

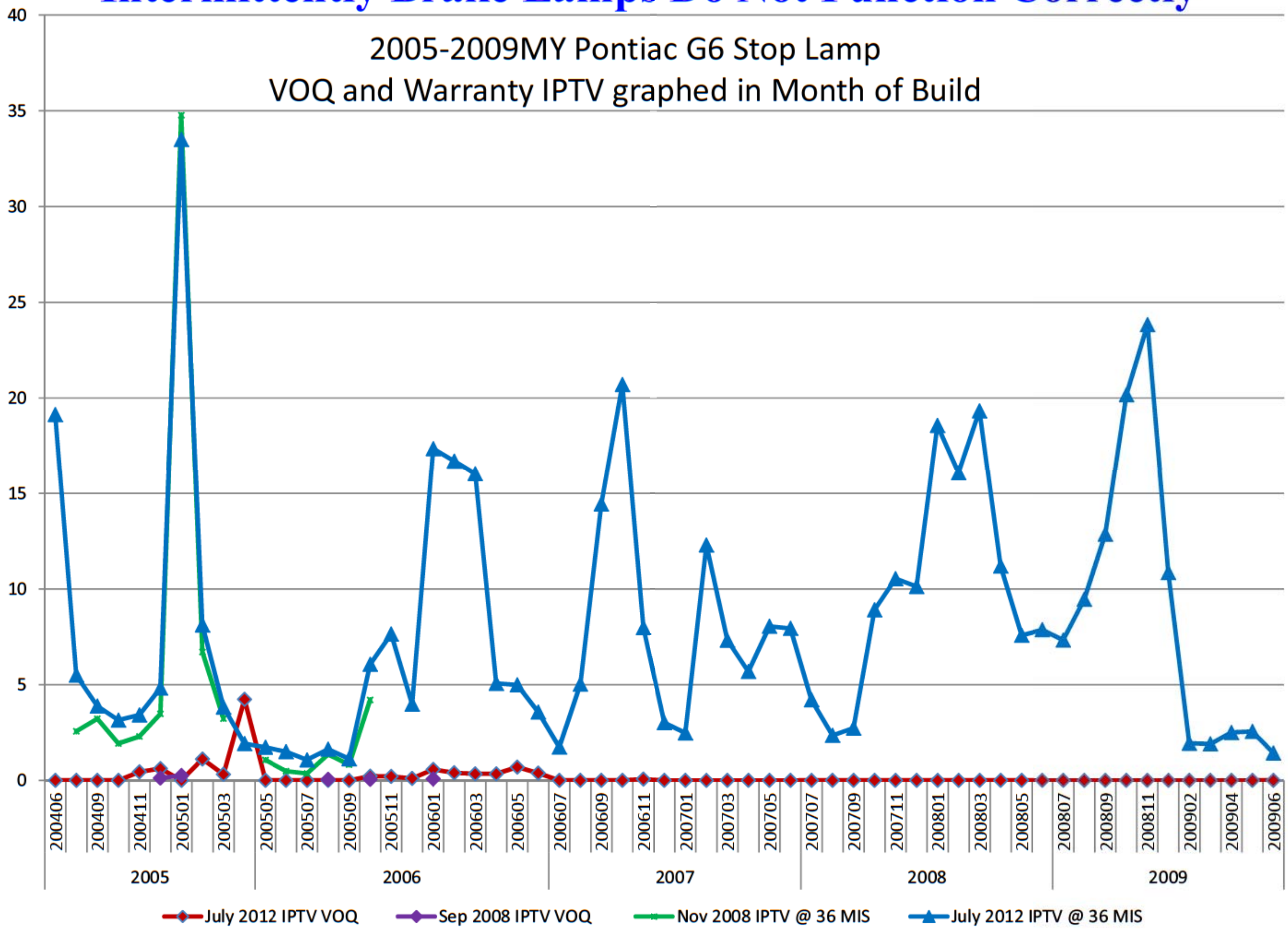
Intermittently Brake Lamps Do Not Function Correctly

VOQ Count Comparison: 2008 (6) vs 2012 (59)



Model Year	MOB	Population	2012 VOQ Count	2008 VOQ Count
2005	200411	6726	3	
2005	200412	8090	5	1
2005	200501	7917	0	2
2005	200502	9847	11	
2005	200503	9636	3	
2006	200504	236	1	
2006	200508	17846		1
2006	200509	18623		
2006	200510	18307	4	1
2006	200511	14639	3	
2006	200512	9802	1	
2006	200601	12218	7	1
2006	200602	7547	3	
2006	200603	17606	6	
2006	200604	2944	1	
2006	200605	12934	9	
2006	200606	2645	1	
2007	200611	14543	1	

Intermittently Brake Lamps Do Not Function Correctly



2012CY Update of G6 Stop Lamp Warranty Claims

2012CY Warranty Methodology

Started with 27,821 — 11,852 had correction-verbatim (42.6%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	10,316 (37.1)	363 (20.7)
H2642 Sensor, Brake Pedal	4,643 (16.7)	1,203 (68.6)
H2643 Sonsor, Brake & Accel	420 (1.5)	144 (8.2)
H2640 Pedal / Bushing	418(1.5)	7 (0.4)
H9991 Cust Concern NTF	8,531(30.7)	36 (2.1)
N9595 TSB	3,493 (12.6)	0
Total	27,821	1,753 (6.3)

2012CY Warranty Methodology

27,821 including 243 same day repair duplicates

A. All claims with labor code N9595 were determined to be responsive to the alleged condition.

3,490

B. All claims with customer codes 08 (Operation: Won't Turn Off) and WB (Warning Lights-Brake Lights) were determined to be responsive to the alleged condition unless the verbatim text indicated that the claim was unrelated.

C. Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 2.7 and customer codes in Table 2.8 were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.

D. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.

20,167 (B–D)

E. The vehicle claims processed after 10/13/08 are excluded to compare with the original data.

2,168

F. All claims for vehicles covered by General Motors recall 08317 were excluded. 6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%

1,753

2009CY Update Methodology

Started with 8,978 — 2,362 had verbatim (26.3%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	6,758 (75.3)	274 (17.5)
H2642 Sensor, Brake Pedal	1,984 (22.1)	1,157 (74)
H2643 Sonsor, Brake & Accel	227 (2.5)	125 (8)
H2640 Pedal / Bushing	6 (0)	6 (0.4)
H9991 Cust Concern NTF	3 (0)	3 (0.2)
Total	8,978	1,565 (17.4)

2009CY Update Methodology

For the subject vehicles, the regular warranty, goodwill warranty, and MIC service contract claims with stop lamp malfunction are summarized by model and model year in Table 5-1. For the subject vehicles the UWC service contract claims with indication of stop lamp malfunction are summarized by model and model year in Table 5-2. A summary of the warranty claims, including the information requested in 5(a-k), is provided on the ATT_1_GM disk; folder labeled "Q_05:" refer to the Microsoft Access 2000 file labeled "Q_05_WARRANTY DATA." A list of the labor codes, customer complaint codes and trouble codes used to collect the warranty data is provided in response to item No. 6.

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	Regular	579	754	232	1,565
Pontiac G6	MIC	43	25	2	70

TABLE 5-1: REGULAR WARRANTY AND MIC SERVICE CONTRACT CLAIMS WITH STOP LAMP MALFUNCTION

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	UWC	0	3	0	3

TABLE 5-2: UWC SERVICE CONTRACT CLAIMS

SOURCE SYSTEM	LAST DATE GATHERED
GART - regular warranty	13 Oct 08
MIC - service contract claims	14 Oct 08
UWC - service contract claims	23 Sept 08

TABLE 5-3: DATES PULLED

2009CY Update Methodology

8,969

The GM Global Analysis and Reporting Tool (GART-regular warranty) regular warranty database and the Motors Insurance Corp (MIC) service contract claims database were searched using the labor codes that may be related to the alleged defect, listed in Table 6-1. Universal Warranty Corporation (UWC) does not use labor codes or trouble codes.

The following process was used to sort these claims:

544
- All claims with customer codes shown in Table 6-2 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

6,800
- Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 6-3 and customer codes in Table 6-4 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

60
- The verbatims of the remaining claims were then read and the claim was determined to be responsive if the verbatim related to the alleged defect.

1,565

2009CY Update Methodology

Labor Code	Description:
H2642	Sensor, Brake Pedal Position - Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
N4800	Body Control Module Replacement
H2640	Pedal And/Or Bushing, Brake - R&R Or Replace
H9991	Customer Concern Not Duplicated
N2700	Switch, Stop Lamp - Adjust
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement-Product Allegation
Z1243	Inspection-Product Allegation Resolution

Table 6-1 Labor Codes used in Warranty and MIC Search

Customer Code	Description:
O8	Operation: won't turn off
WB	Warning lights: brake light

Table 6-2 Customer Codes used in Warranty and MIC Sorting

Trouble Code	Description:
1D	Broken
6C	Component-inoperative
6D	Component -intermittent
6F	Component -Open
3A	Misadjusted
9Z	No Trouble Found
3L	Out of Calibration
3X	Registers Incorrectly
6N	Connector - Partial Connected

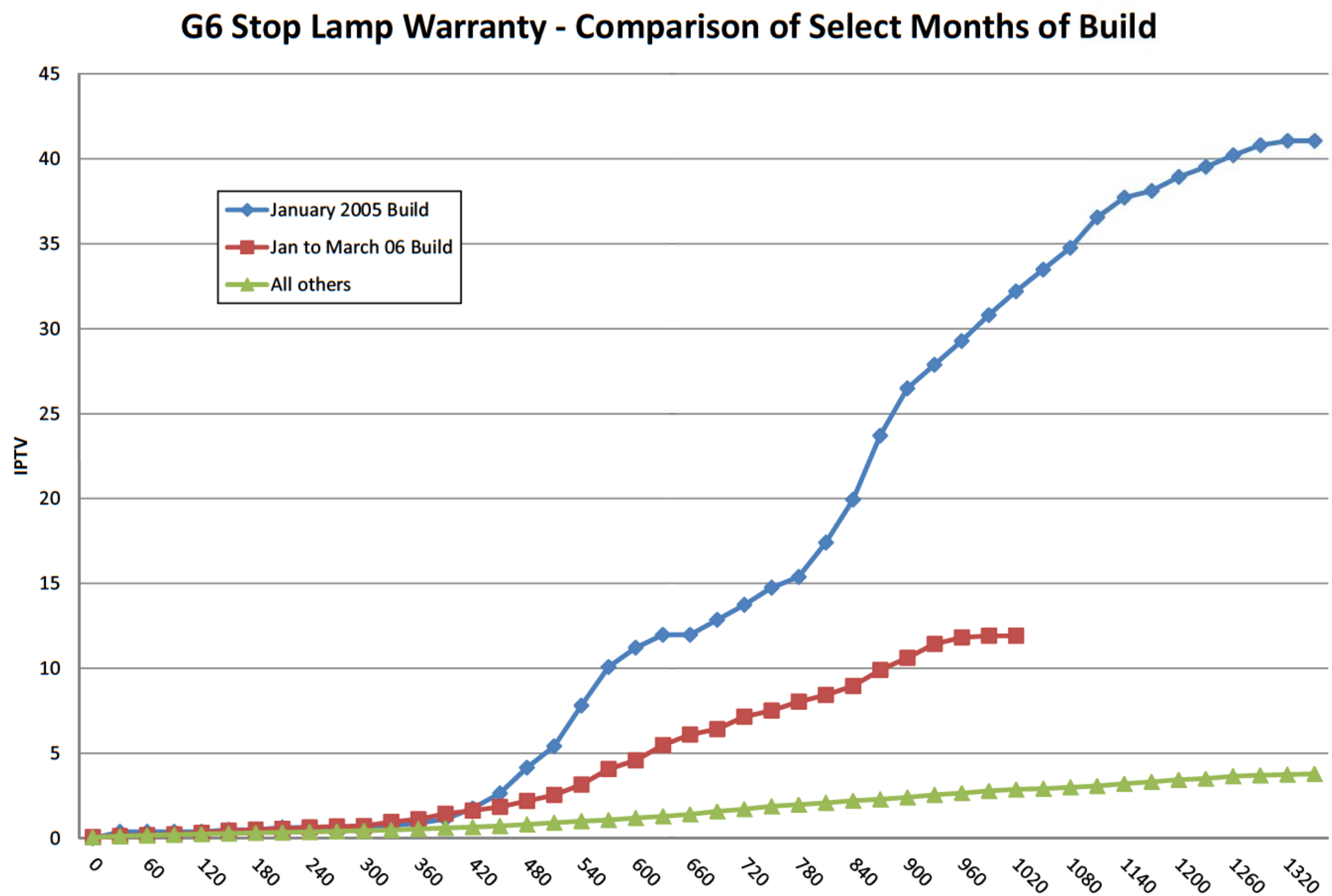
Table 6-3 Trouble Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Customer Code	Description:
OG	Operation: Excess Eff (Excess Play)
OJ	Operation: Inoperative (Harsh)
OF	Operation: Engage/Dis(Excess Eff)
O7	Operation: No Maintain Adj

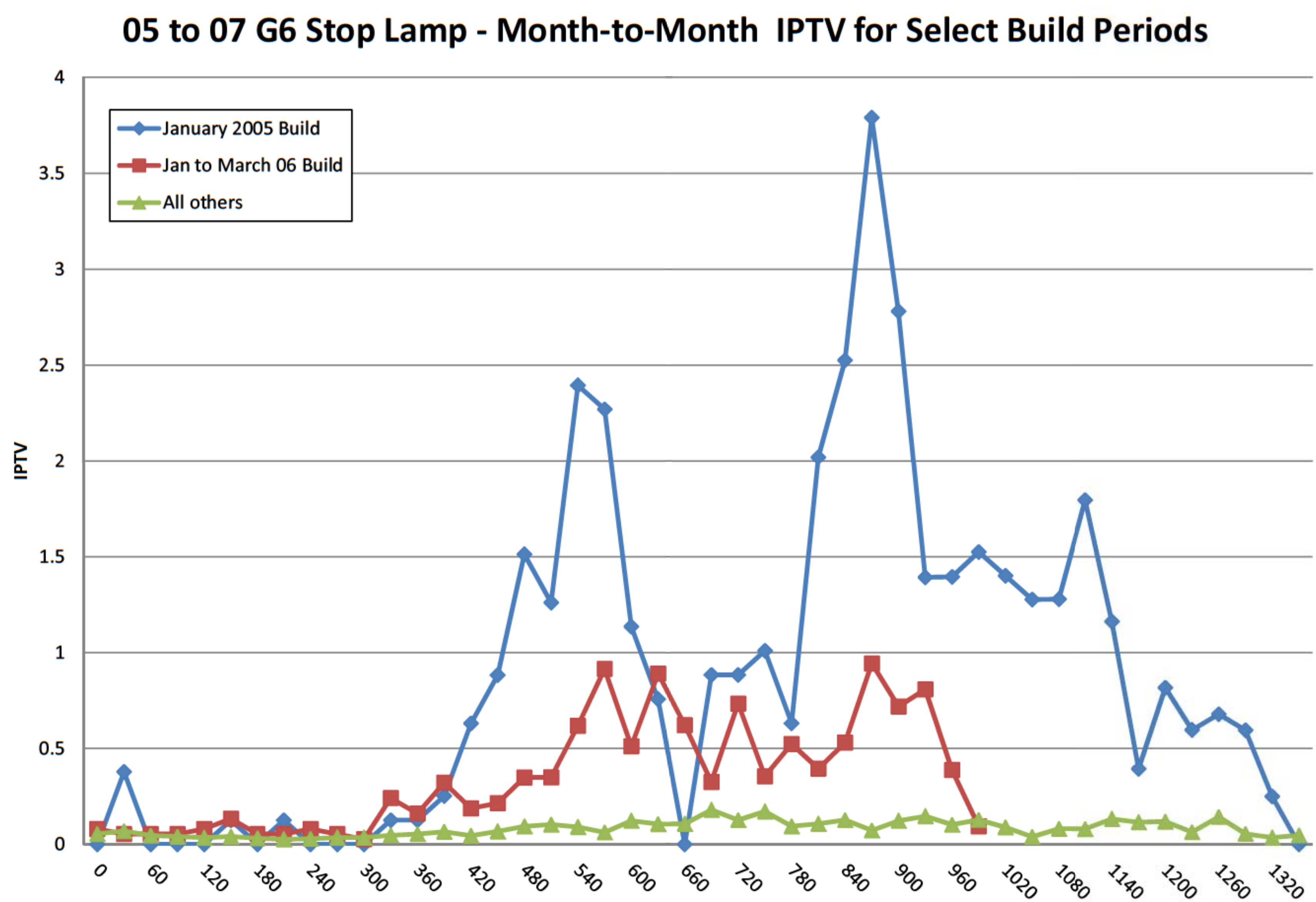
Table 6-4 Customer Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Rationale for 2009 Decision

Intermittently Brake Lamps Do Not Function Correctly

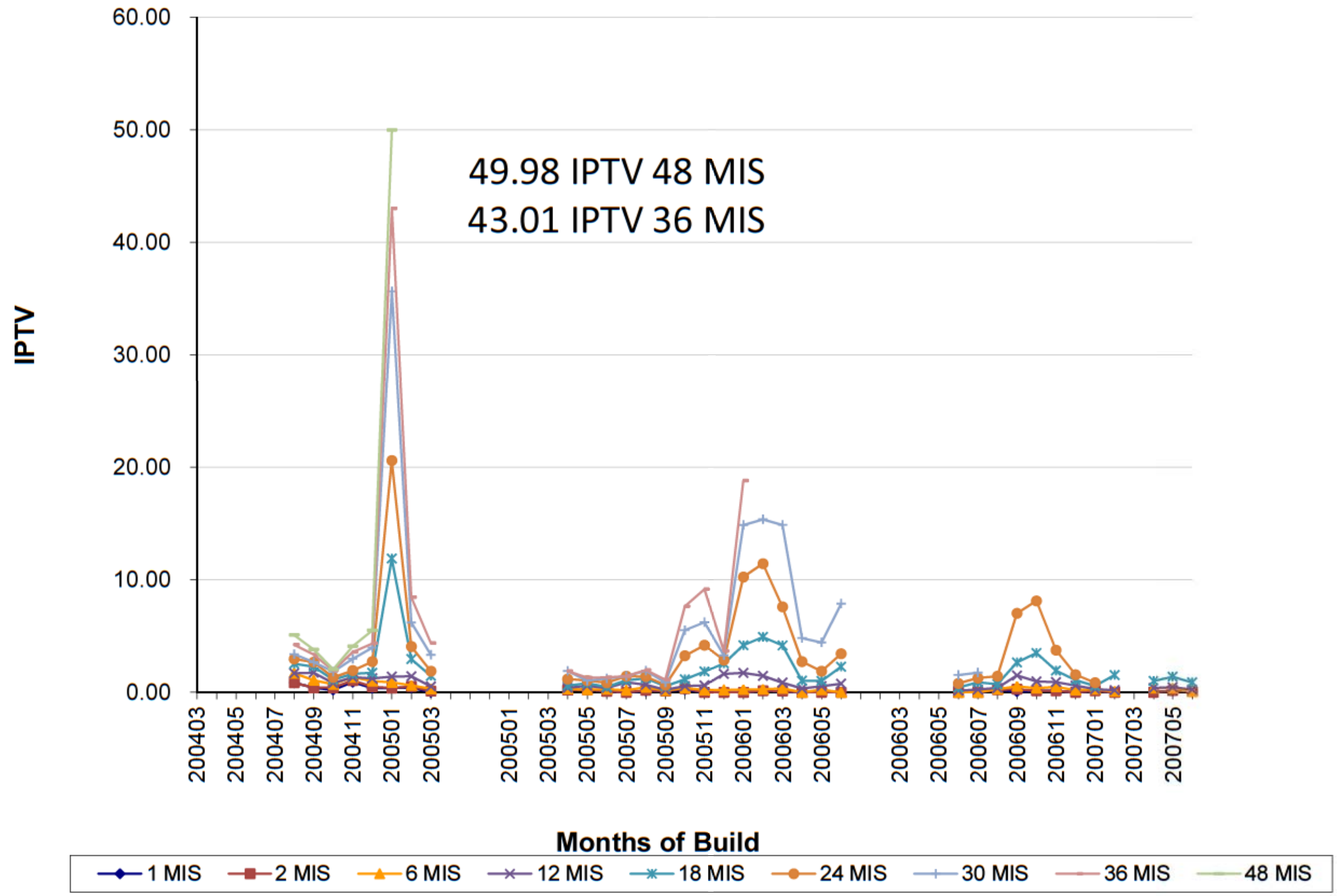


Intermittently Brake Lamps Do Not Function Correctly



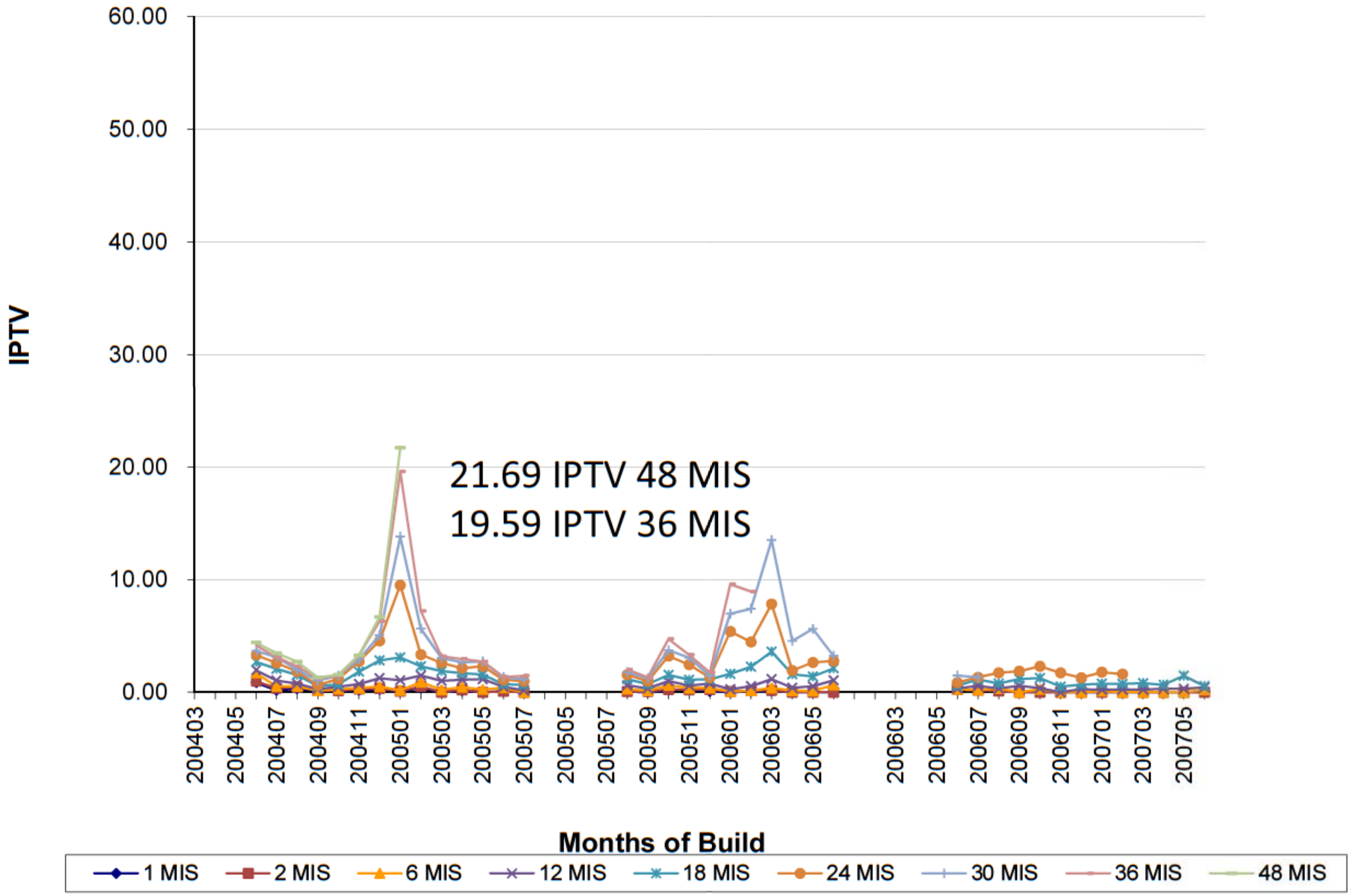
Intermittently Brake Lamps Do Not Function Correctly

Pontiac G6 Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



Intermittently Brake Lamps Do Not Function Correctly

Chevrolet Malibu Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



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Intermittently Brake Lamps Do Not Function Correctly

The Body Control Module with different electrical harness architecture is used for the following platforms:

2004MY	Malibu, XLR	
2005MY	G6, Cobalt, Corvette	
2006MY	HHR, Solstice	
2007MY	Sky, Opel GT, Aura	- NEW MICROPROCESSOR
2008MY	New Malibu	

Intermittently Brake Lamps Do Not Function Correctly

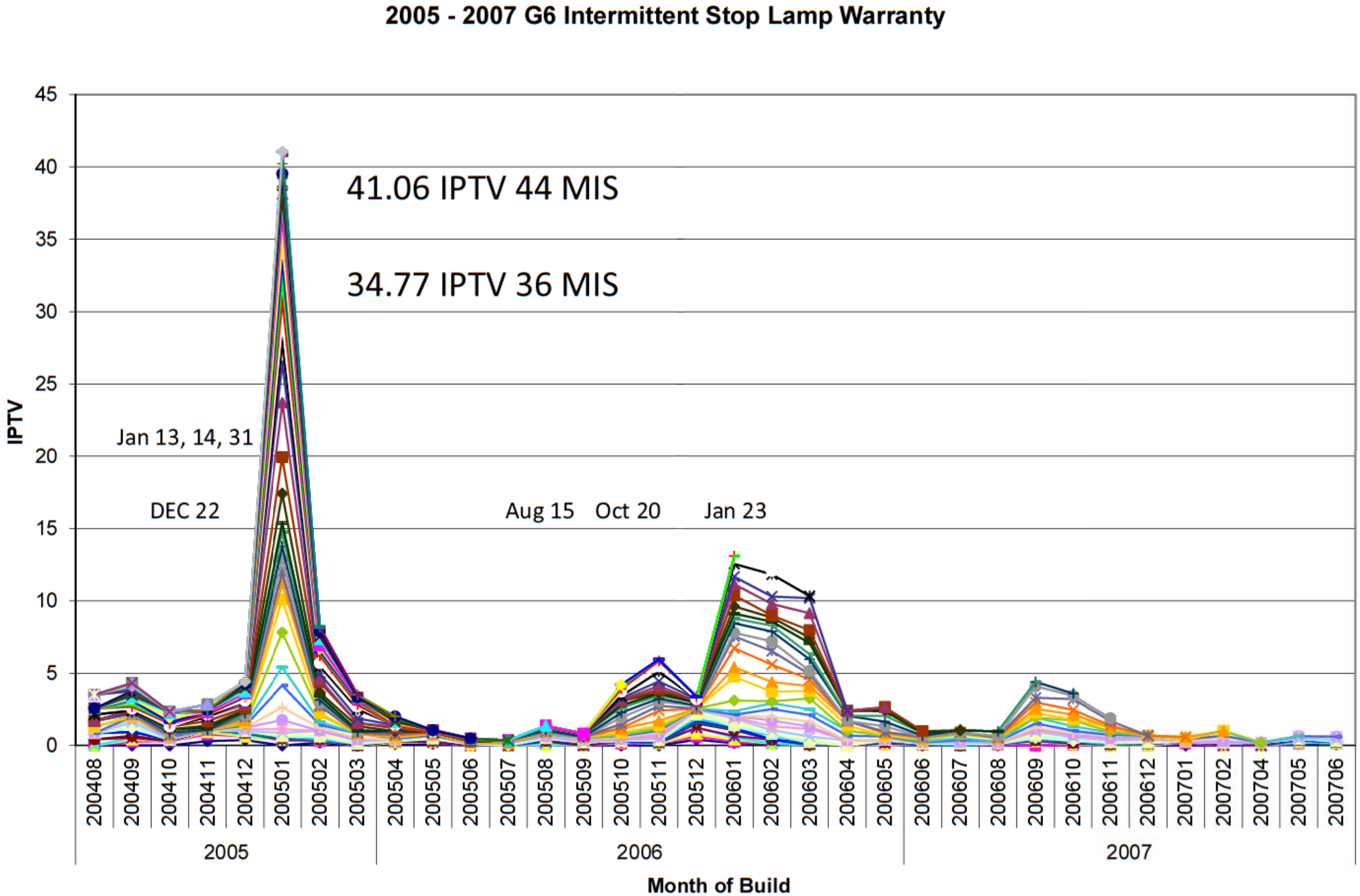
Technical Service Bulletin

#08-05-22-009: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTC C0161/C0277 Set (Perform Repair as Outlined) - (Dec 4, 2008)

Subject: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTCs C0161/C0277 Set (Perform Repair as Outlined)

Apply dielectric lubricant (clear gel) GM P/N 12377900 (In Canada, use P/N 10953529) on the BCM C2 pins (apply with a one-inch nylon bristle brush) on all the C2 connector pins (this will treat the pins against fretting corrosion).

Intermittently Brake Lamps Do Not Function Correctly



9 VOQs 2005MY: 4 2006MY: 4 2007MY: 1

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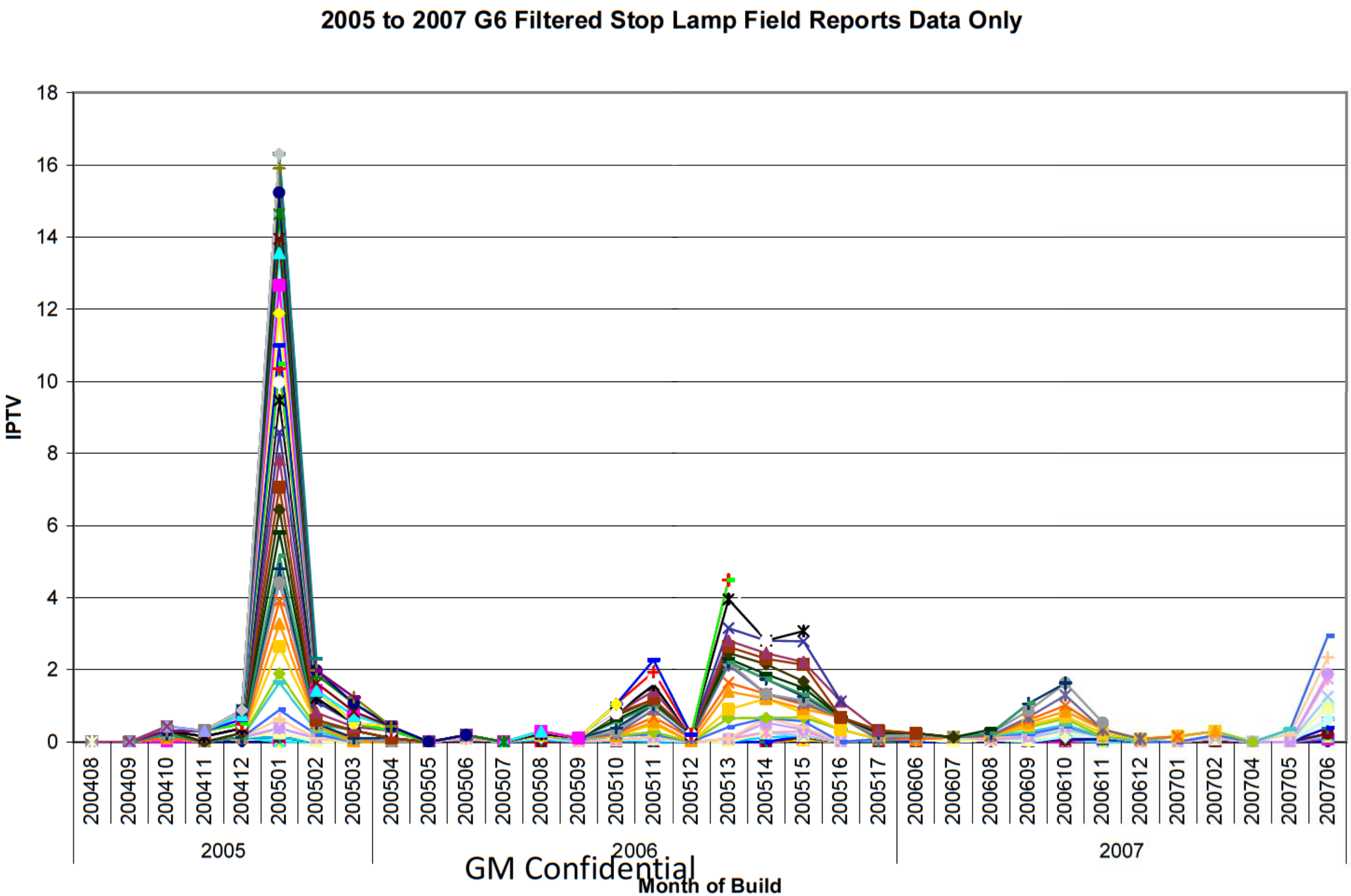
2005 - 2007 G6 BASS – TAC and CAC only



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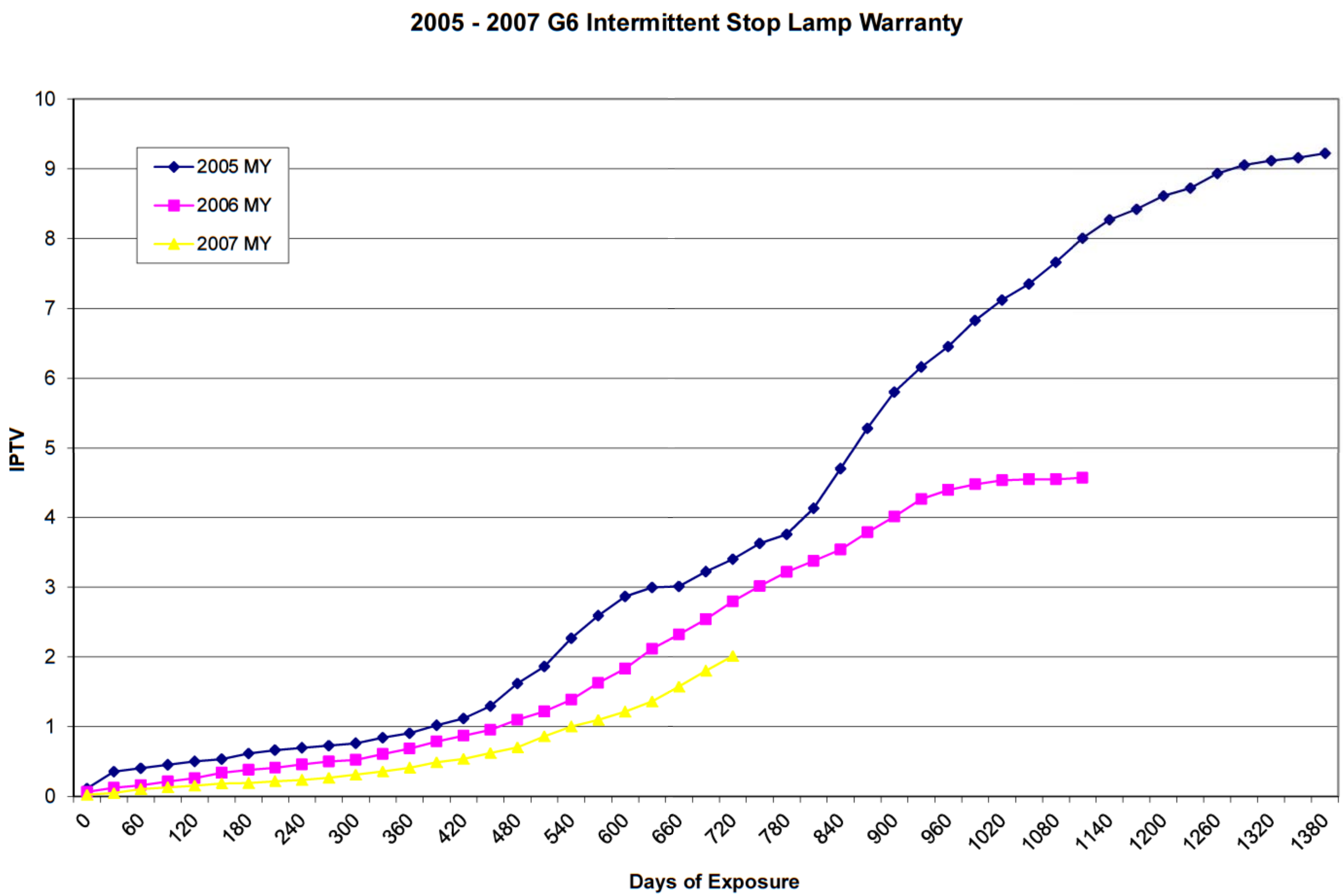
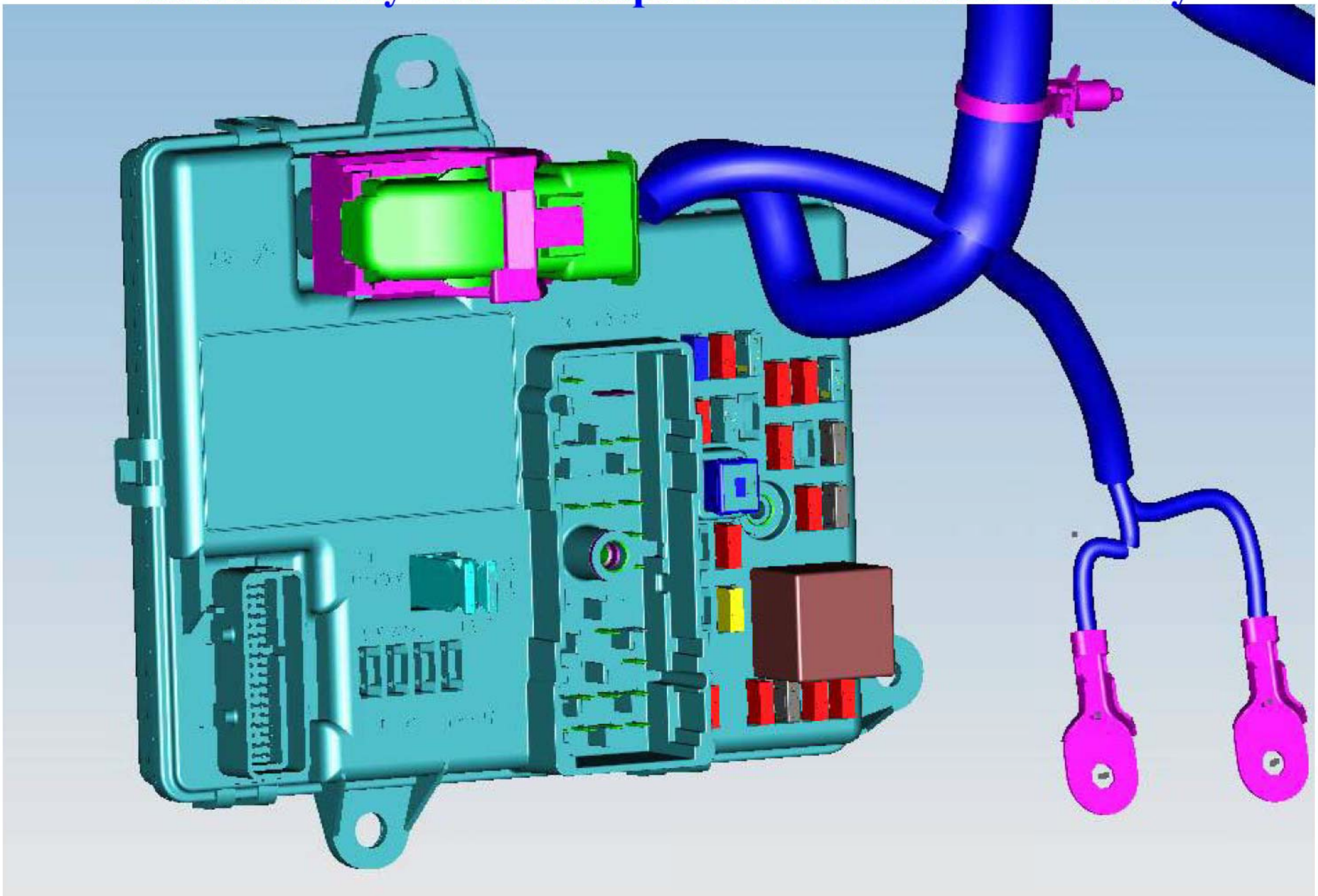
Intermittently Brake Lamps Do Not Function Correctly



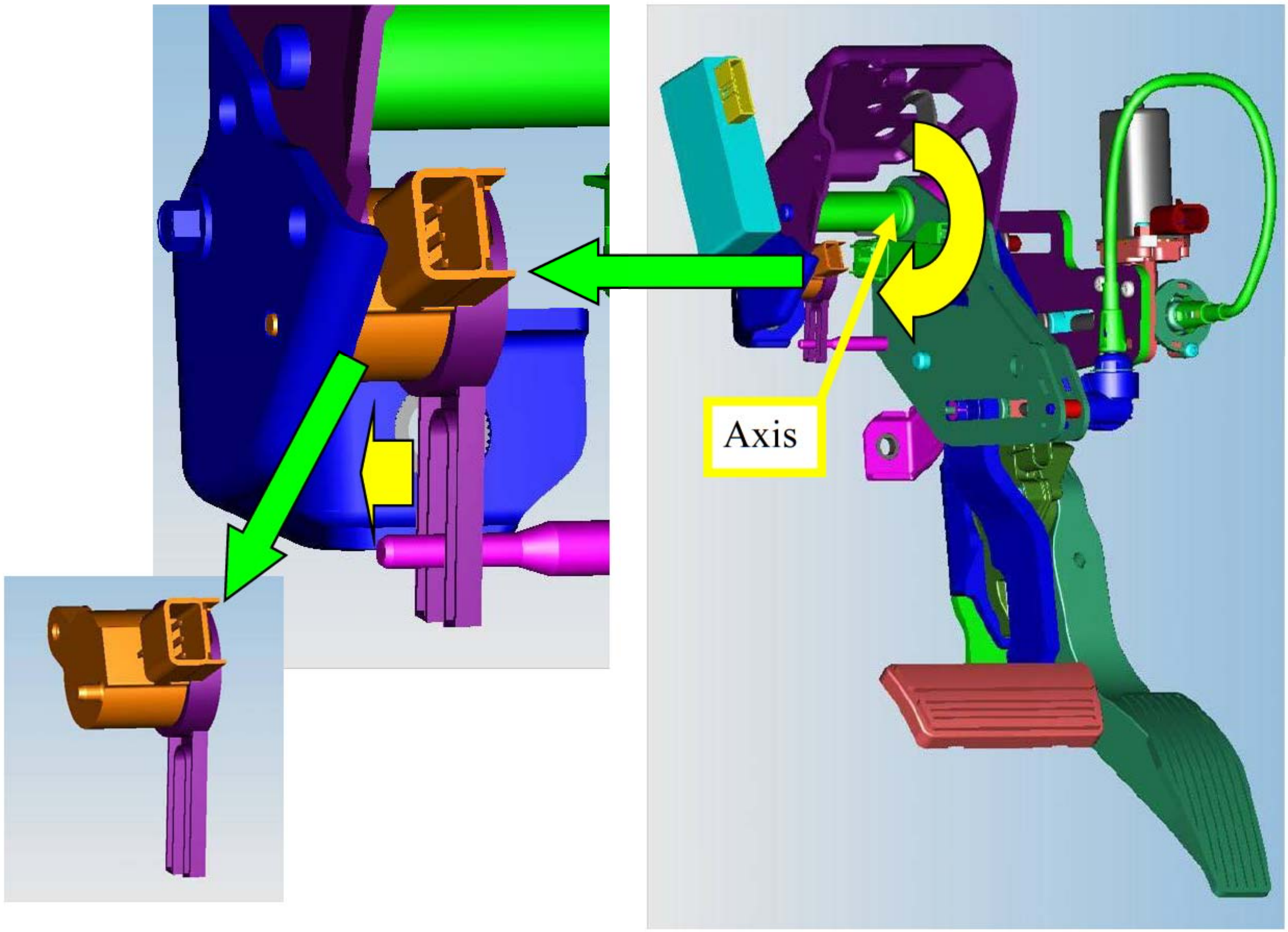
GM Confidential

Intermittently Brake Lamps Do Not Function Correctly



2005 - 2007 G6 Brake Apply Sensing System

Pedal/Sensor Movement



Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.
March 2013	NHTSA opened a Recall Query Investigation that is due on April 17, 2013.

Closing Resume

Intermittently Brake Lamps Do Not Function Correctly

2004-2009MY Epsilon (G6, Aura, Mailbu)
Est. Population: 1.8M – 2.2M
Est. Cost: $TBD

Condition: Fretting corrosion in the Body Control Module connector (C2 or X2) causes an increase in resistance that results in a reduction of Brake Apply Sensing (BAS) signal voltage to the BCM. Brake pedal status information affects the operation of brake lamps, cruise control, brake shifter interlock, and stability control systems.

Effect of the Condition: This results in erratic brake pedal status information. A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

{ * }

Potential Field Action Category: TBD

Discovery On September 15, 2008, NHTSA ODI opened PE investigation with 9 VOQs. On January 28, 2009, GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY. On February 13, 2013, NHTSA ODI opened RQ investigation initiated with 212 VOQs.

Intermittently Brake Lamps Do Not Function Correctly

Potential Field Remedy: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Frequency:
Month of Build January 2005 36 MIS = 34.8 IPTV Campaigned.
See updated IPTV vs. MOB graph for non-campaigned vehicles.

Immediate Improvement /Containment

On December 4, 2008, Technical Service Bulletin 08-05-22-009 was issued to apply the lubricant on the BCM terminal.

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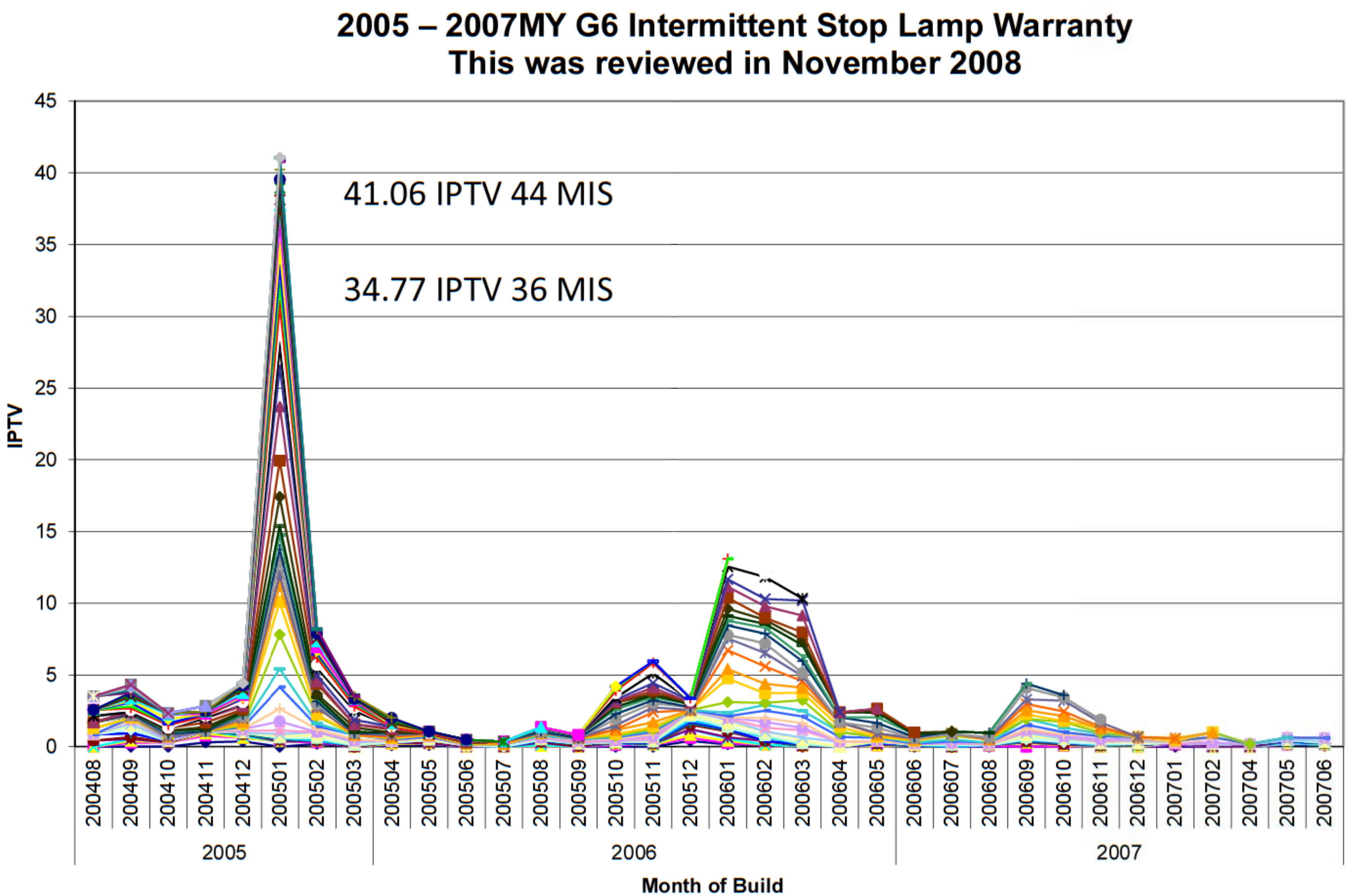
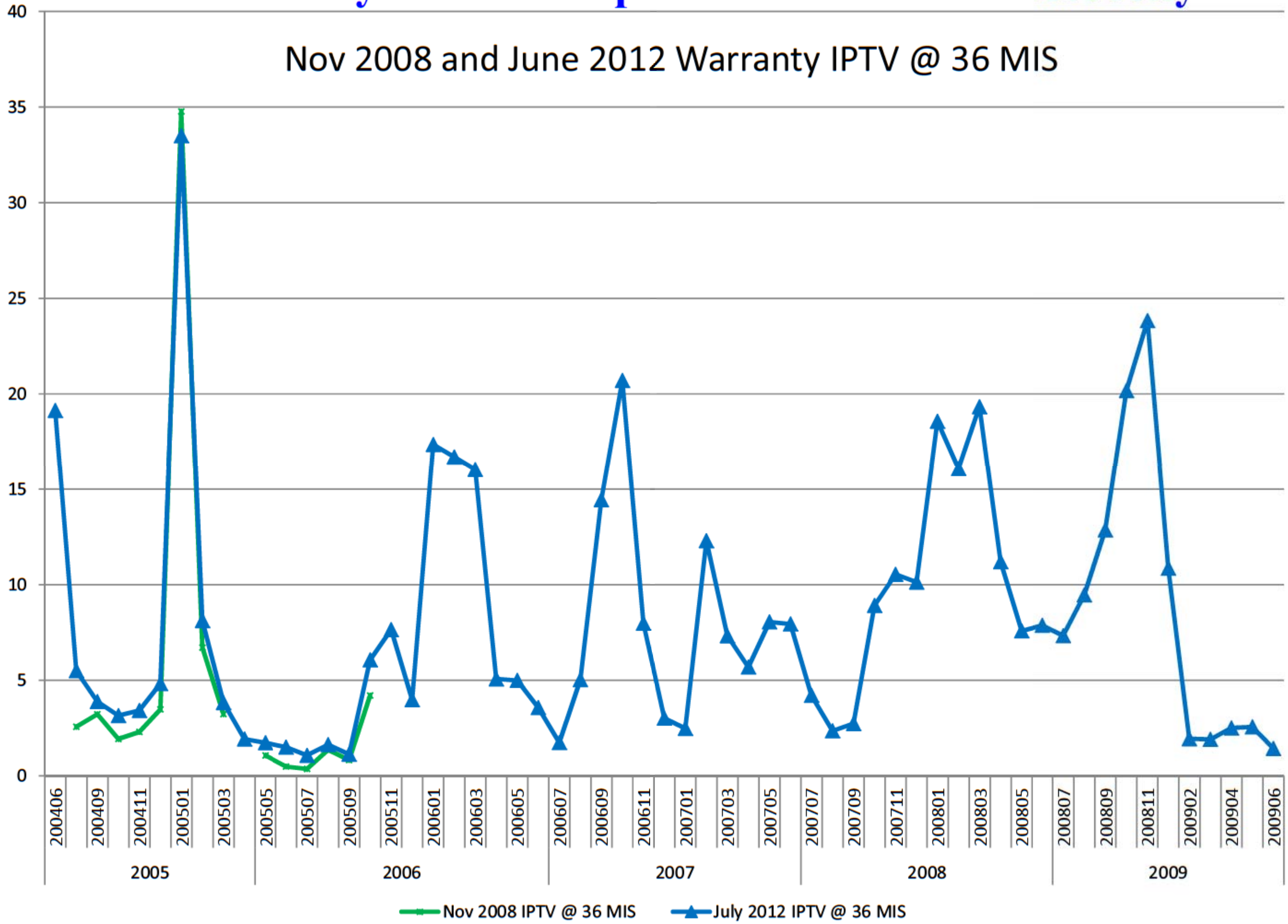
Responsibility
GM and Delphi Engineering

Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly



Updated Warranty Analysis will be provided at FPERC

Back-up

Labor Code	Description
N9595	BCM C2 or X2 Connector Repair
N9613	Lubricate Body Control Module (BCM) Connector with Dielectric Lubricant
N6612	Exterior Lighting Wiring and/or Connector Repair or Replace
N6616	Serial DATA/DLC/STAR Connect Wiring and/or Connector Repair or Replace
N6651	Connector Kit Repair
N6652	Connector with Leads Assembly Replace
N2700	Switch, Stop Lamp – Adjust
N4800	Body Control Module Replacement
H2640	Pedal and/or Bushing, Brake – R&R or Replace
H2642	Sensor, Brake Pedal Position – Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
H9991	Customer Concern Not Duplicated
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement – Product Allegation
Z1243	Inspection – Product Allegation Resolution
V2044	Apply Dielectric Lubricant to C2 Connector (08317)
V2045	Customer Reimbursement (08317)

Maroon color represents added RQ Labor Codes

RQ Warranty Analysis Methodology 1
NHTSA Inquiry Response

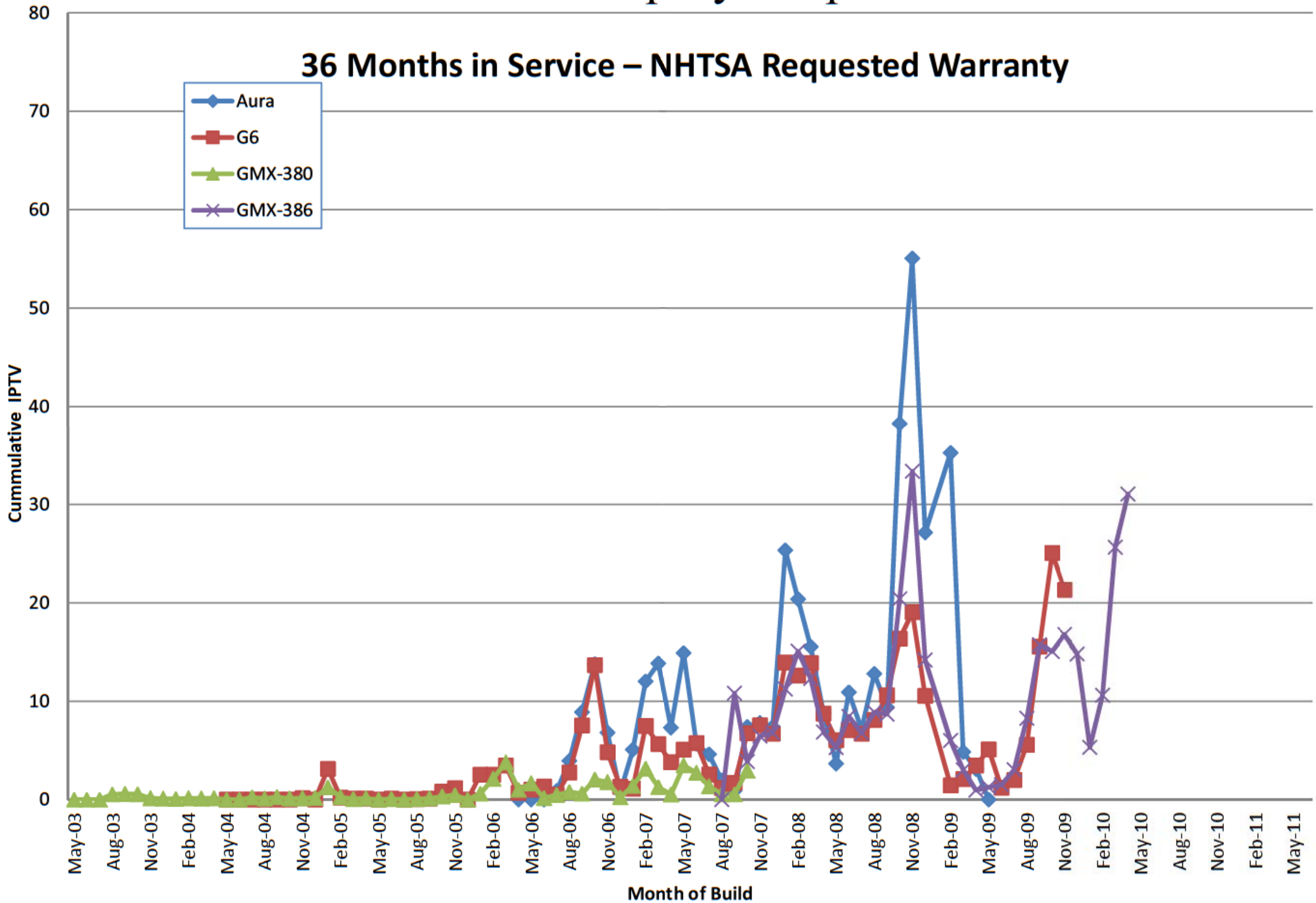
<u>Many of the following warranty claims do not relate to the brake lamp malfunction condition</u>. The following process was used to sort the warranty claims:

All claims with labor code N9595 (TSB 08-05-22-009), N9613 (TSB 09-06-03-004), N4800 (Body Control Module Replacement) and V2045 (campaign 08317 reimbursements) were determined to be responsive to the alleged condition, even if no verbatim were provided.

All claims for V2044 were excluded as part of General Motors campaign 08317.

Each warranty record may have up to 6 verbatim fields. All available verbatim of the remaining claims were read and a claim was determined to be responsive if the verbatim indicated that the incident may have been caused by the BCM C2 or BCM X2 connector. In cases where it was specifically stated that a repair or replacement of the C2 or X2 did not correct the brake lamp problem and another component was repaired or replaced to correct the problem, those claims were not counted.

RQ Warranty Analysis Methodology 1
NHTSA Inquiry Response



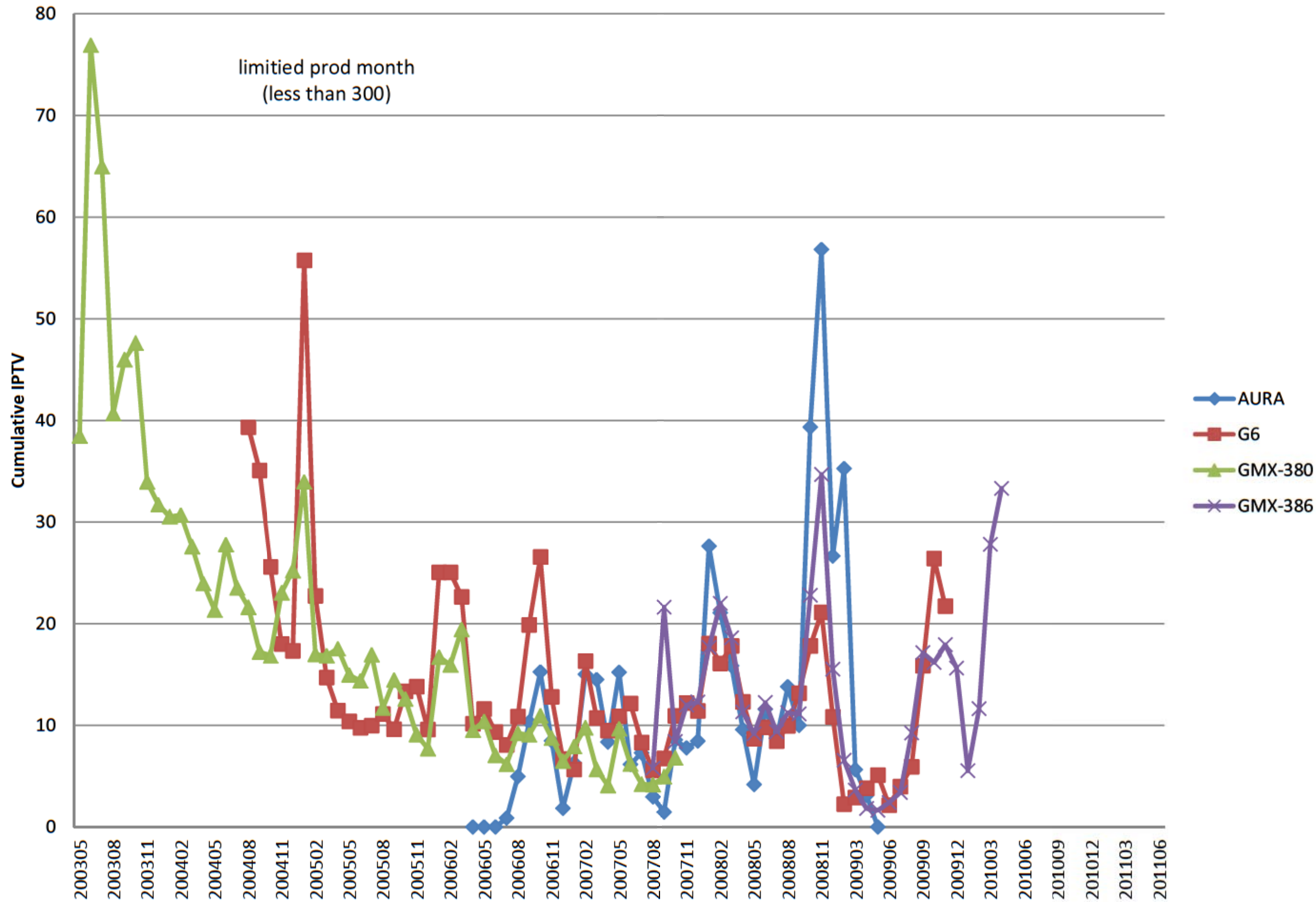
RQ Warranty Analysis Methodology 2
GM Warranty Estimate using Complaint & Causal Codes

139,689 VINs including duplicates

A. All claims with labor codes N9595 and N9613 were determined to be responsive to the alleged condition.
B. Total of 19 warranty labor codes with certain complaint codes and causal codes were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.
C. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.
D. All claims for vehicles covered by General Motors recall 08317 were excluded.
   6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%.

35,575

36 Months – 35,575 Complaint and Causal Claims



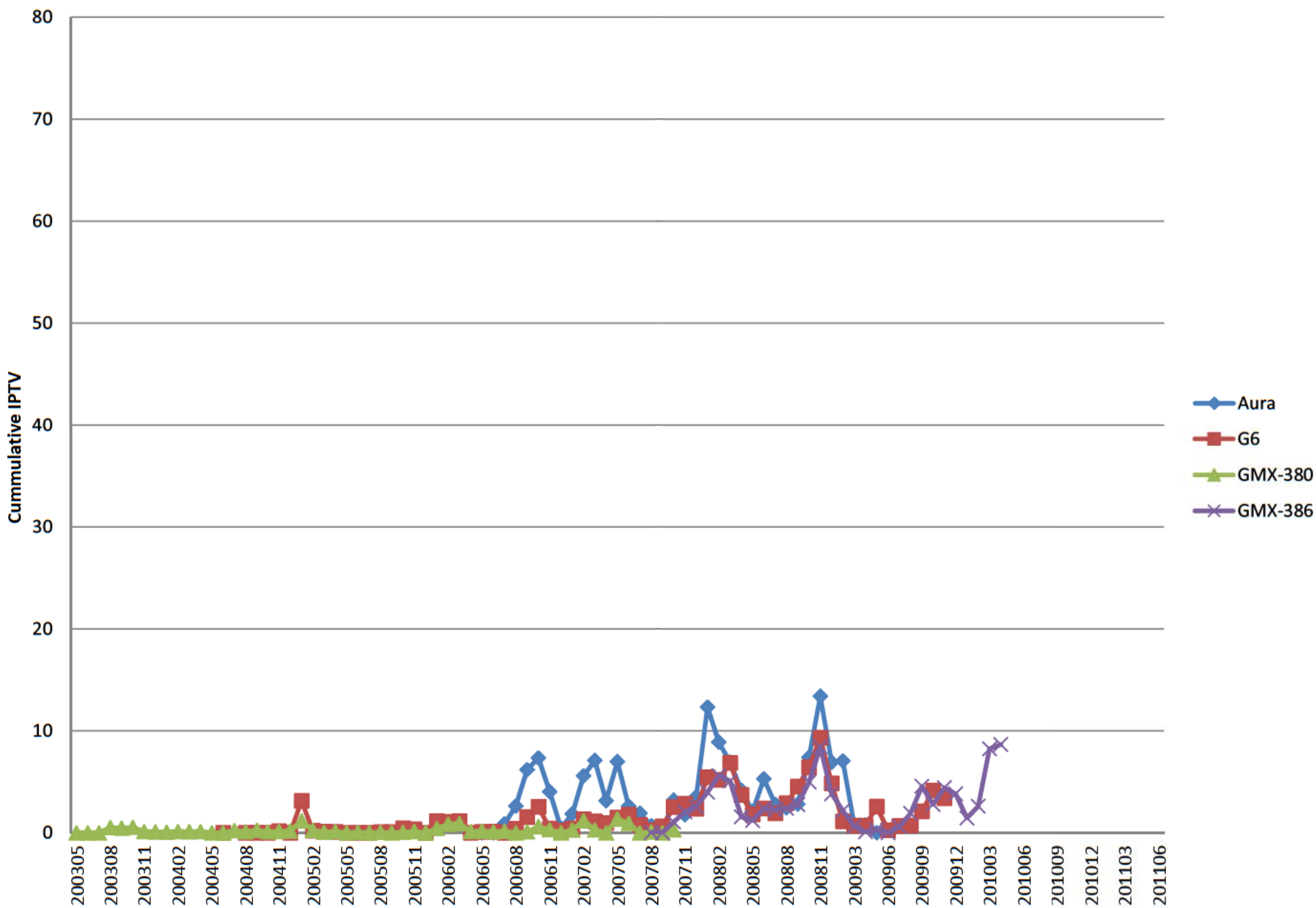
RQ Warranty Analysis Methodology 3
GM Warranty Estimate using Verbatim only

139,689 VINs including duplicates

A. The verbatim of 17 warranty labor codes were read and counted if they stated that the claim was related to the loss/malfunction of the brake/stop lamps.

5,943

36 Months – 5,943 Verbatim claims



Intermittently Brake Lamps Do Not Function Correctly

2004-2009MY Epsilon (G6, Aura, Mailbu)
Est. Population: 1.8M
Est. Cost: $TBD

Condition: Fretting corrosion in the Body Control Module connector (C2 or X2) causes an increase in resistance that results in a reduction of Brake Apply Sensing (BAS) signal voltage to the BCM. Brake pedal status information affects the operation of brake lamps, cruise control, brake shifter interlock, and stability control systems.

Effect of the Condition: This results in erratic brake pedal status information. A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

{ * }

Potential Field Action Category: TBD

Discovery On September 15, 2008, NHTSA ODI opened PE investigation with 9 VOQs. On January 28, 2009, GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY. On February 13, 2013, NHTSA ODI opened RQ investigation with 212 VOQs.

Intermittently Brake Lamps Do Not Function Correctly

Potential Field Remedy: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Frequency:

Month of Build January 2005 36 MIS = 34.8 IPTV Campaigned.
Other Months of Build for the subject population at 36 MIS = 5- 24 IPTV
See updated IPTV vs. MOB graph for non-campaigned vehicles.

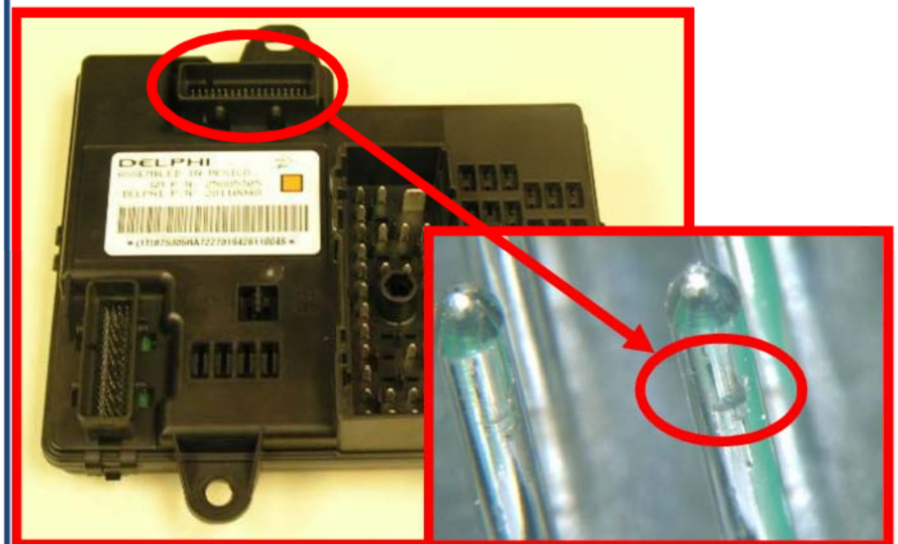
{ * }

Responsibility

GM and Delphi Engineering

Intermittently Brake Lamps Do Not Function Correctly

Condition: Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.



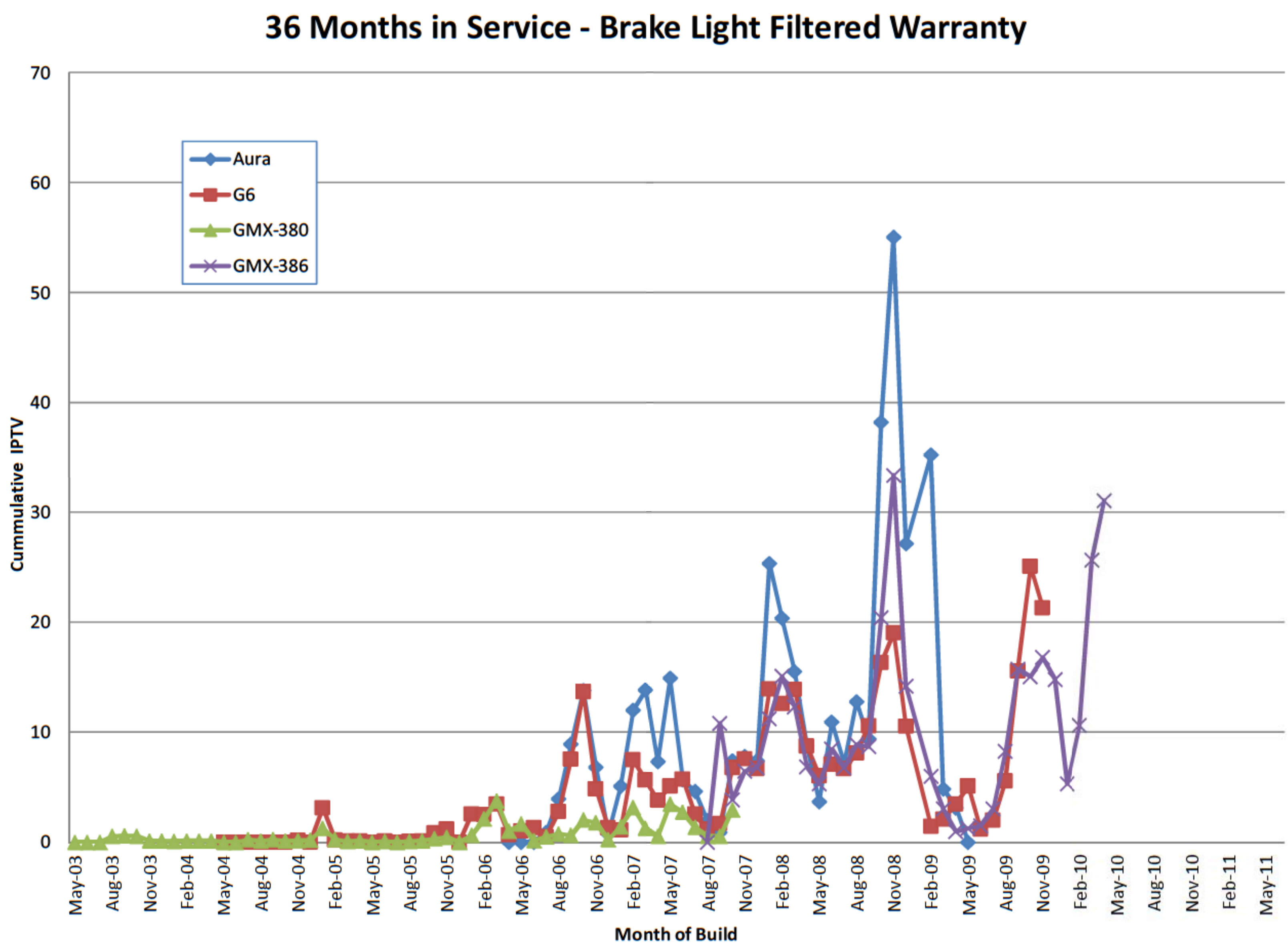
Potential Field Action: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Table 1-1 Subject Vehicles Submitted to NHTSA

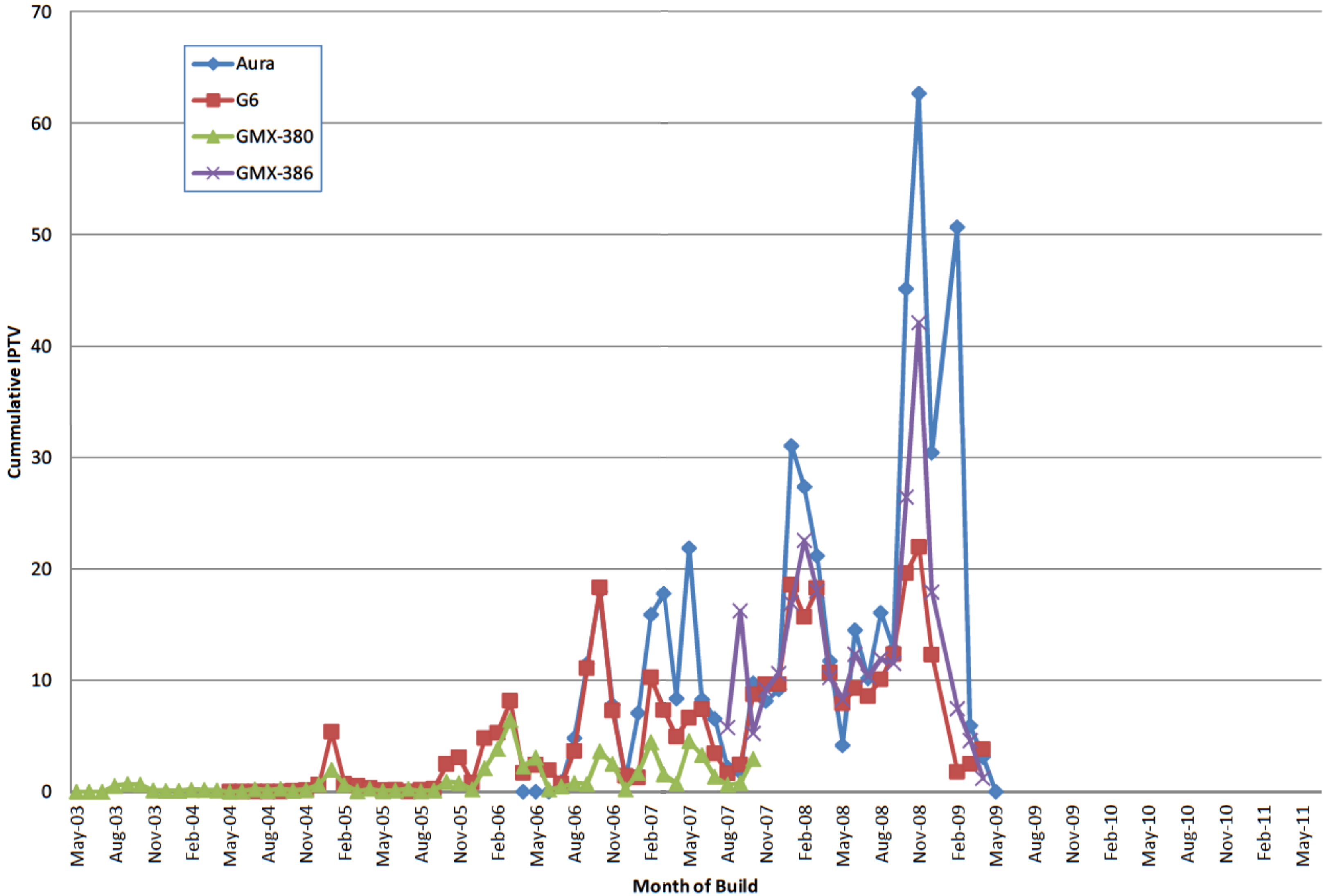
		Model Year								
Make	Model	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	183,783	211,055	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	N/A	N/A	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	N/A	N/A	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	25,586	N/A	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	N/A	N/A	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	209,369	211,055	2,214,173

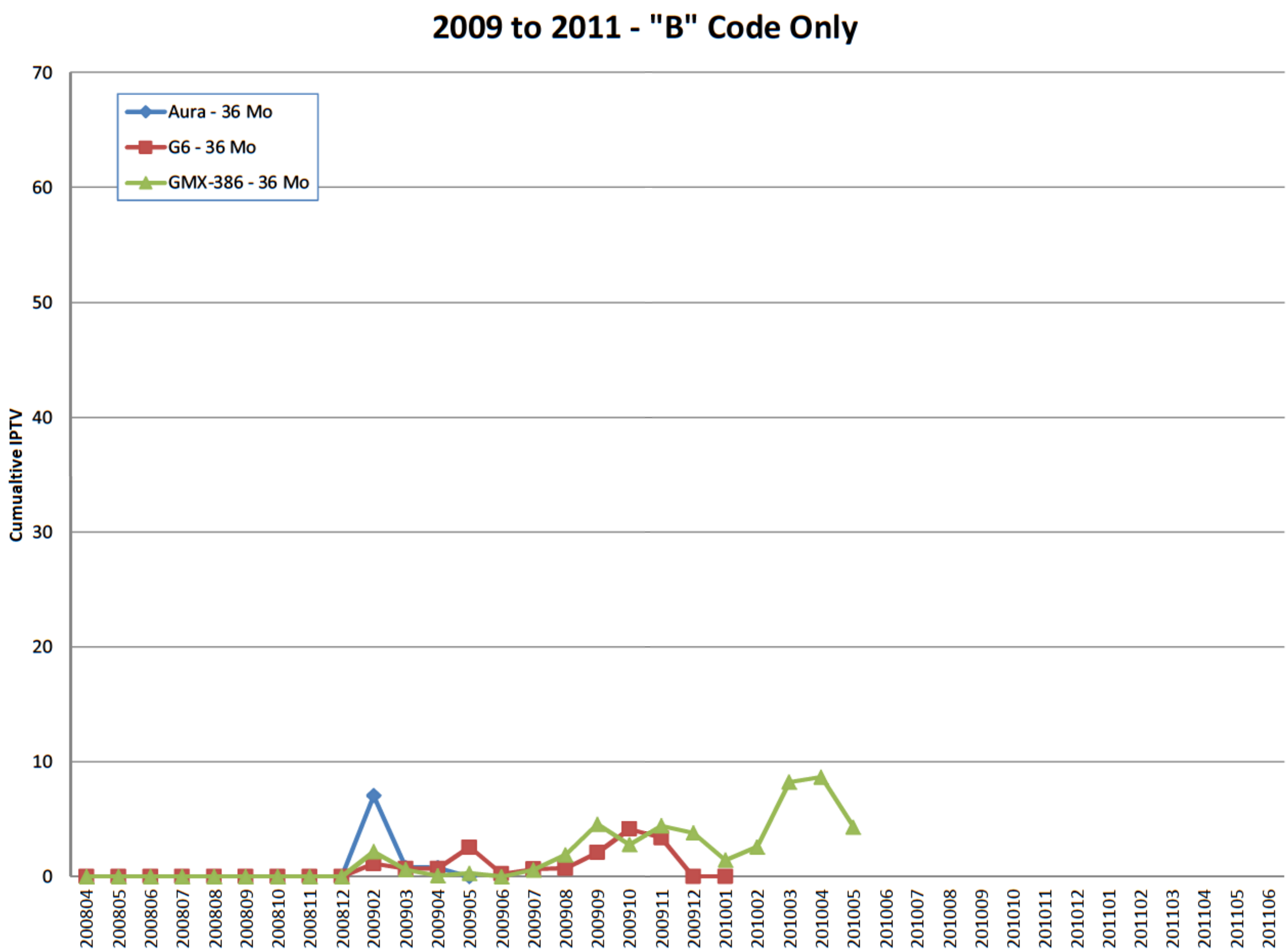
Subject Vehicles For Discussion

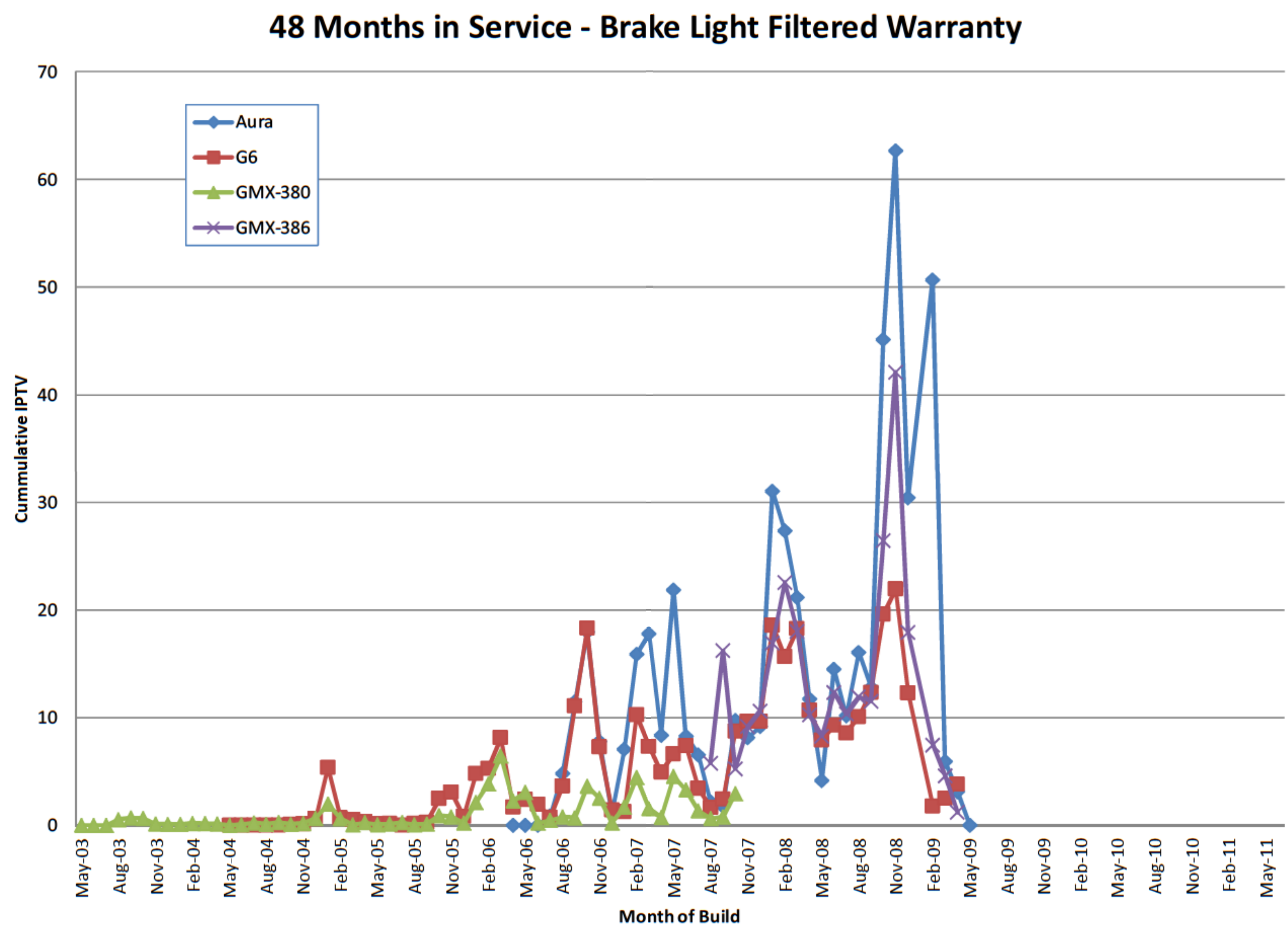
		Model Year								
Make	Model	2004	2005	2006	2007	2008	2009	~~2010~~	~~2011~~	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	~~183,783~~	~~211,055~~	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	~~N/A~~	~~N/A~~	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	~~N/A~~	~~N/A~~	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	~~25,586~~	~~N/A~~	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	~~N/A~~	~~N/A~~	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	~~209,369~~	~~211,055~~	2,214,173


36 Months in Service - Brake Light Filtered Warranty
Aura
G6
GMX-380
GMX-386
Cummulative IPTV
70
60
50
40
30
20
10
0
May-03
Aug-03
Nov-03
Feb-04
May-04
Aug-04
Nov-04
Feb-05
May-05
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Month of Build

48 Months in Service - Brake Light Filtered Warranty




2009 to 2011 - "B" Code Only
Aura - 36 Mo
G6 - 36 Mo
GMX-386 - 36 Mo
Cumualtive IPTV
70
60
50
40
30
20
10
0
200804
200805
200806
200807
200808
200809
200810
200811
200812
200902
200903
200904
200905
200906
200907
200908
200909
200910
200911
200912
201001
201002
201003
201004
201005
201006
201007
201008
201009
201010
201011
201012
201101
201102
201103
201104
201105
201106


48 Months in Service - Brake Light Filtered Warranty
Aura
G6
GMX-380
GMX-386
Cummulative IPTV
0
10
20
30
40
50
60
70
May-03
Aug-03
Nov-03
Feb-04
May-04
Aug-04
Nov-04
Feb-05
May-05
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Month of Build

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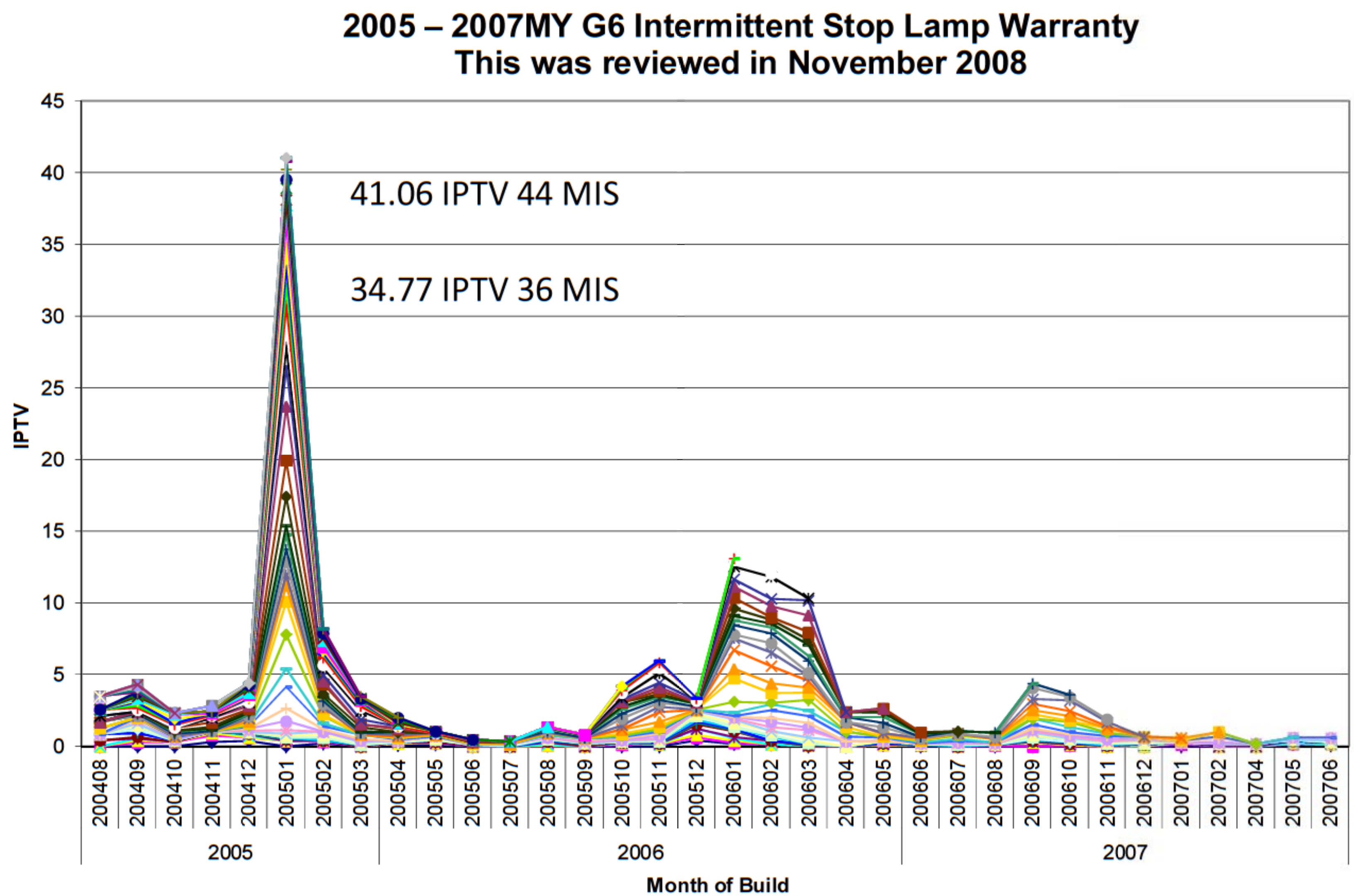
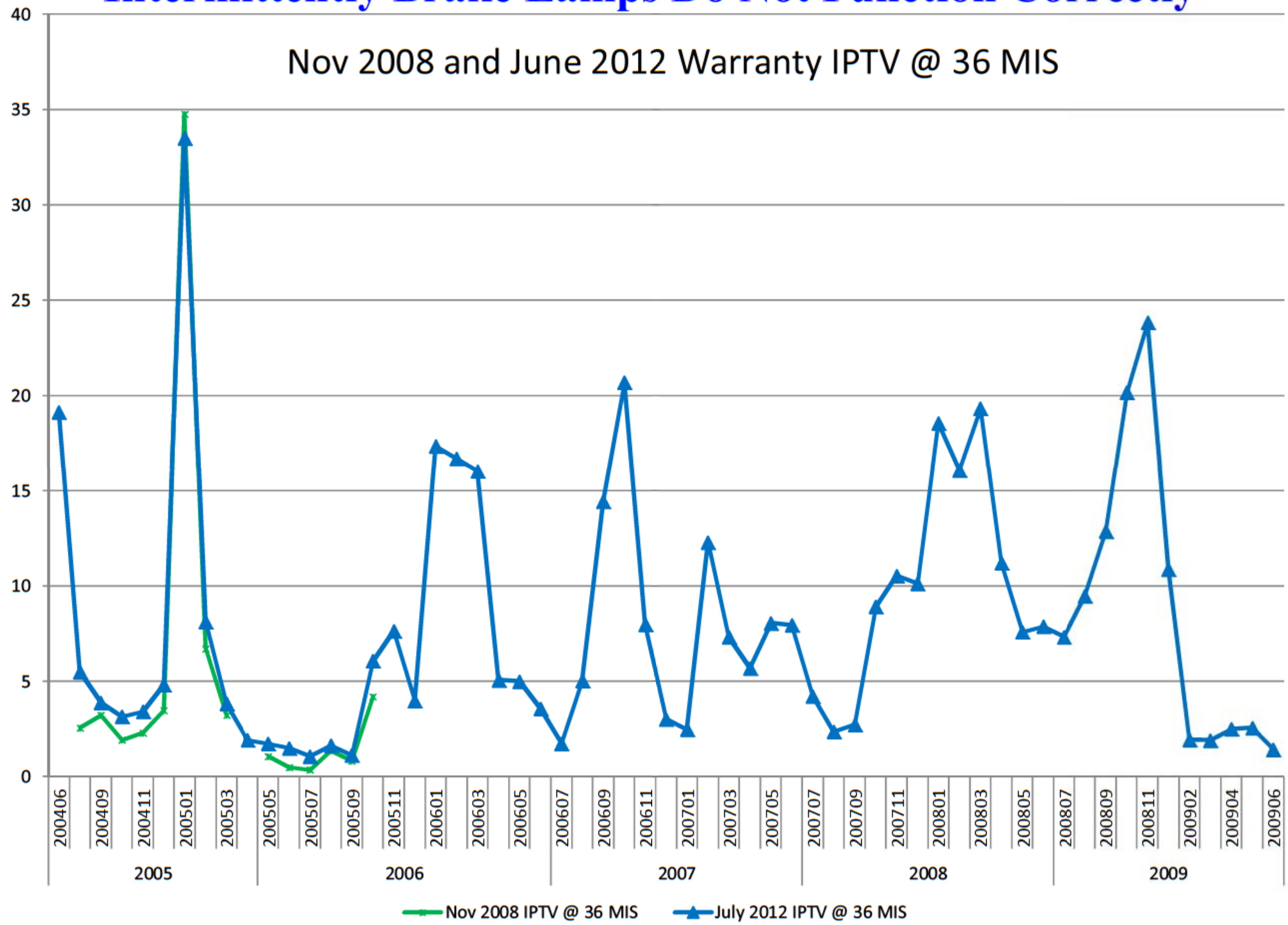
Intermittently Brake Lamps Do Not Function Correctly



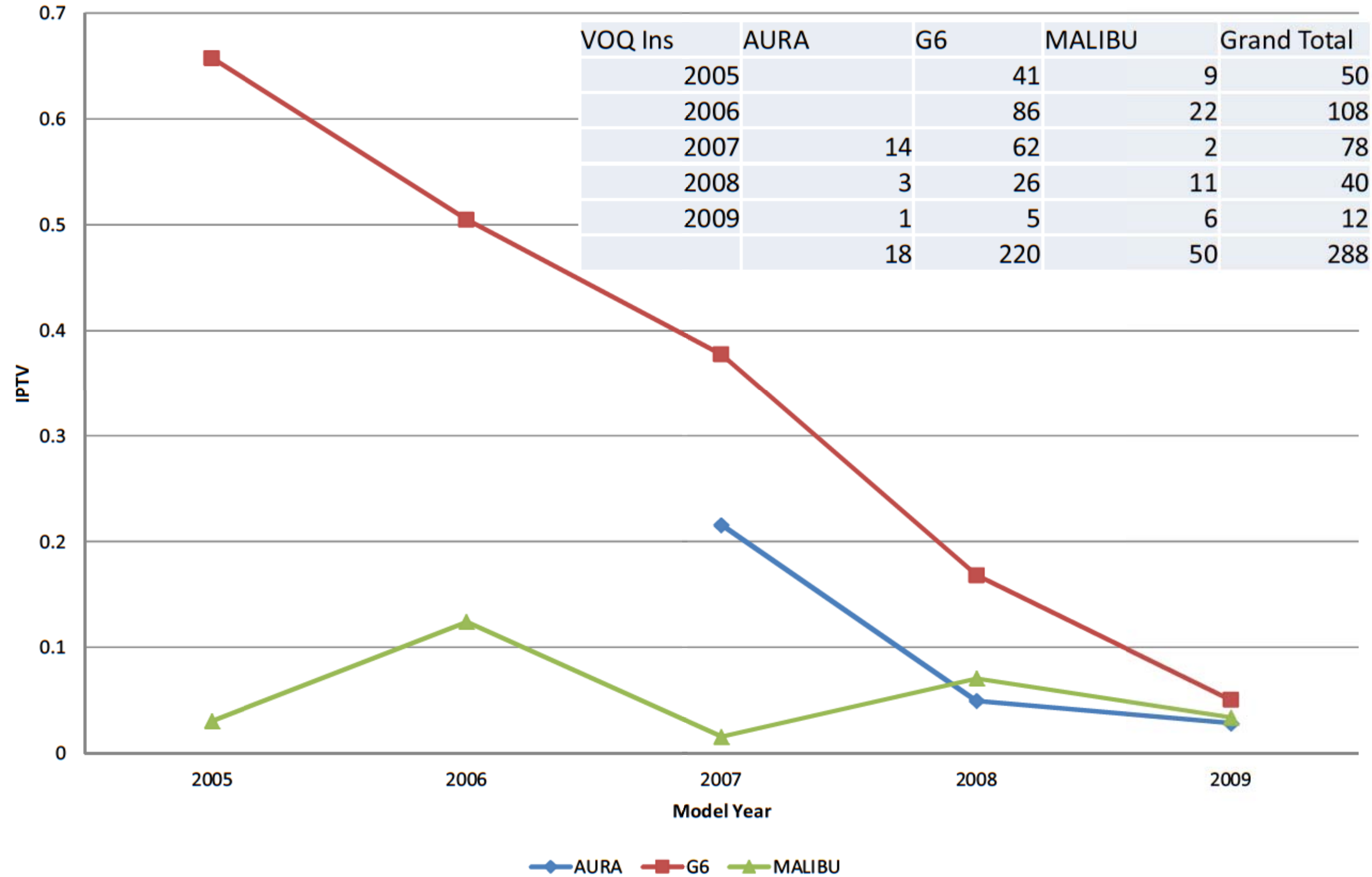
Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly

2005-09MY G6, Mailbu and 2007-09MY Aura

Stop Lamp VOQ IPTV for US only

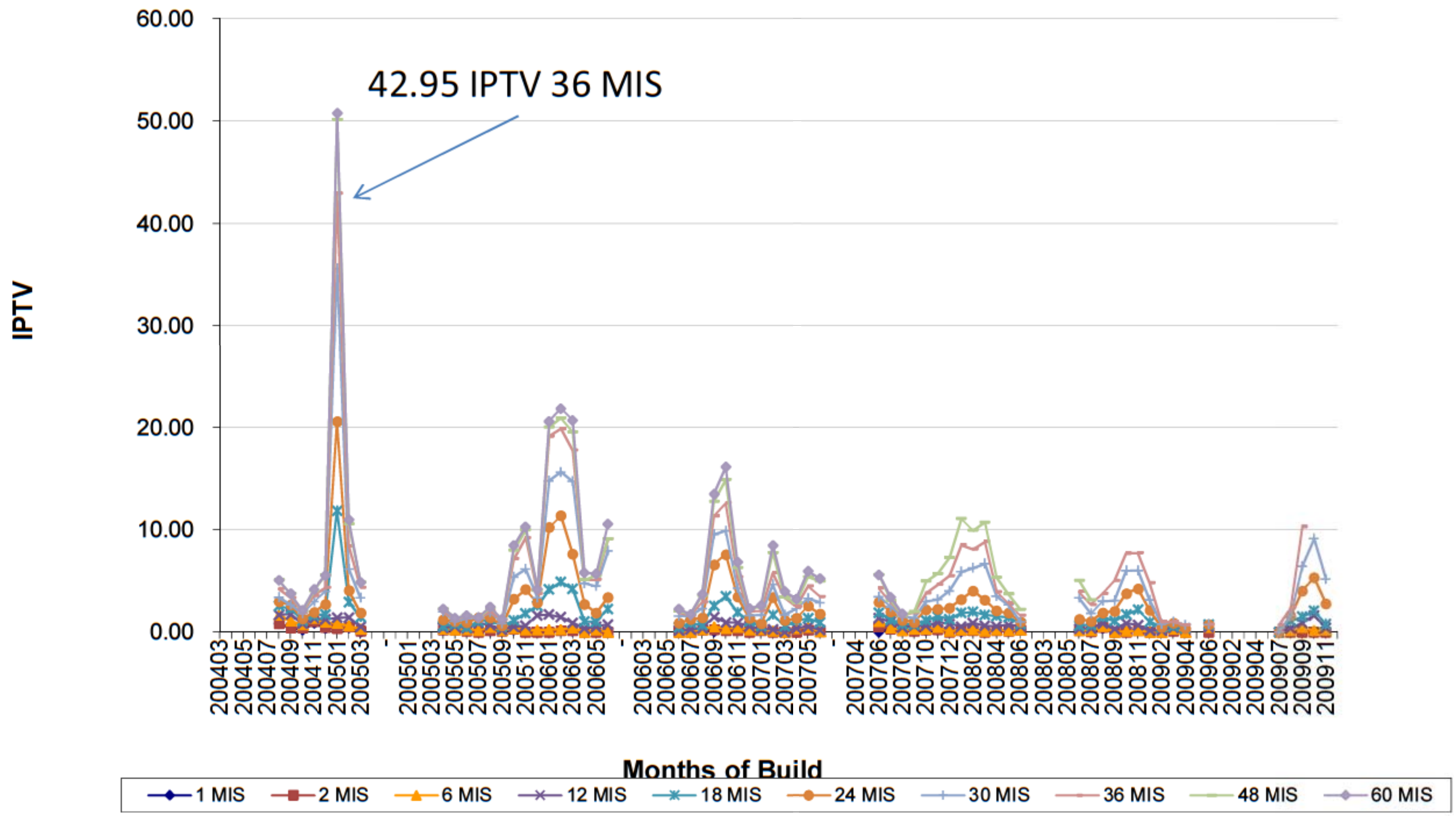


VOQ Ins	AURA	G6	MALIBU	Grand Total
2005		41	9	50
2006		86	22	108
2007	14	62	2	78
2008	3	26	11	40
2009	1	5	6	12
	18	220	50	288

Intermittently Brake Lamps Do Not Function Correctly

2005-2009MY Pontiac G6 Stop Lamp

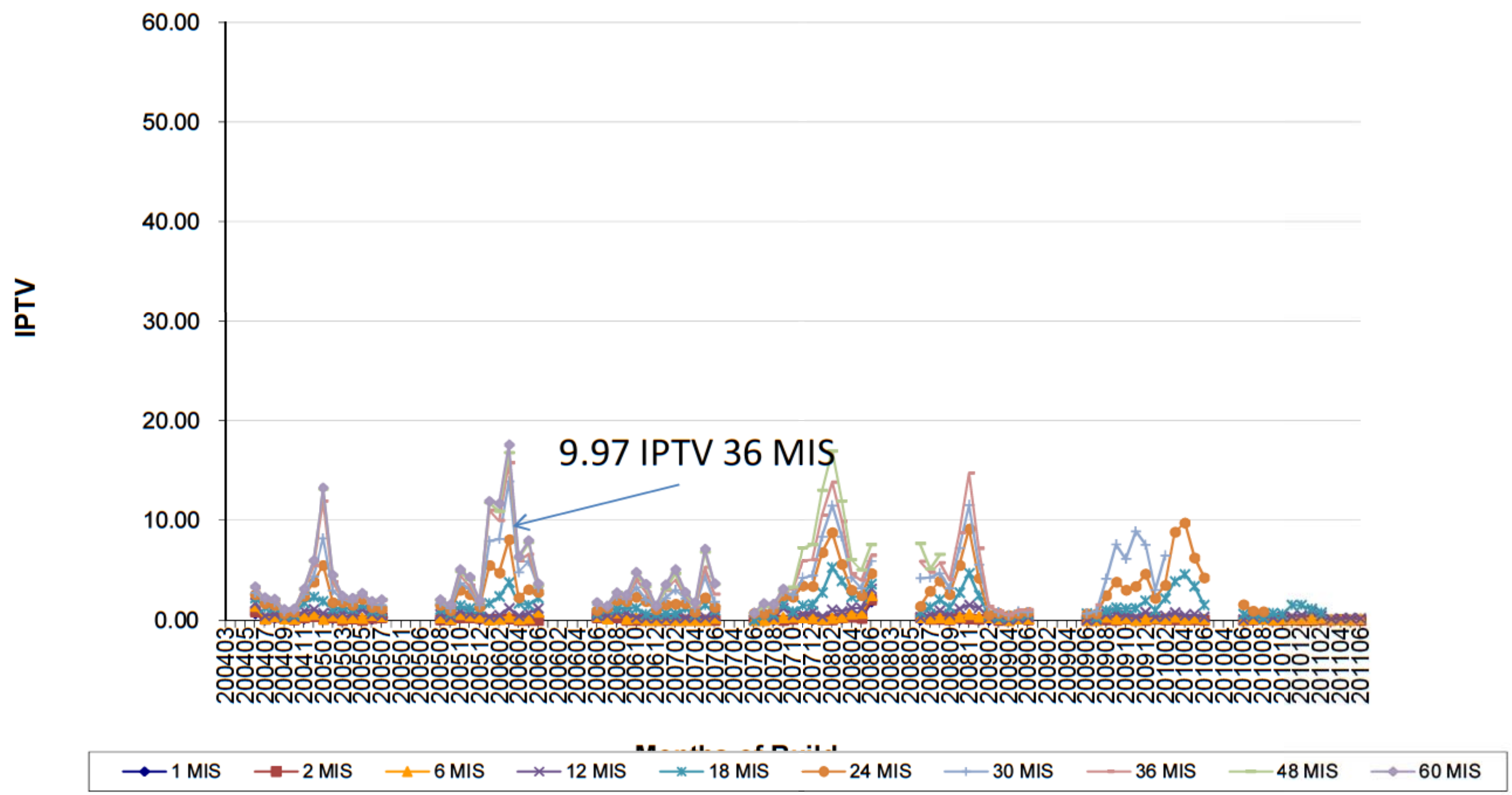
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

2005-2011MY Chevrolet Malibu Stop Lamp

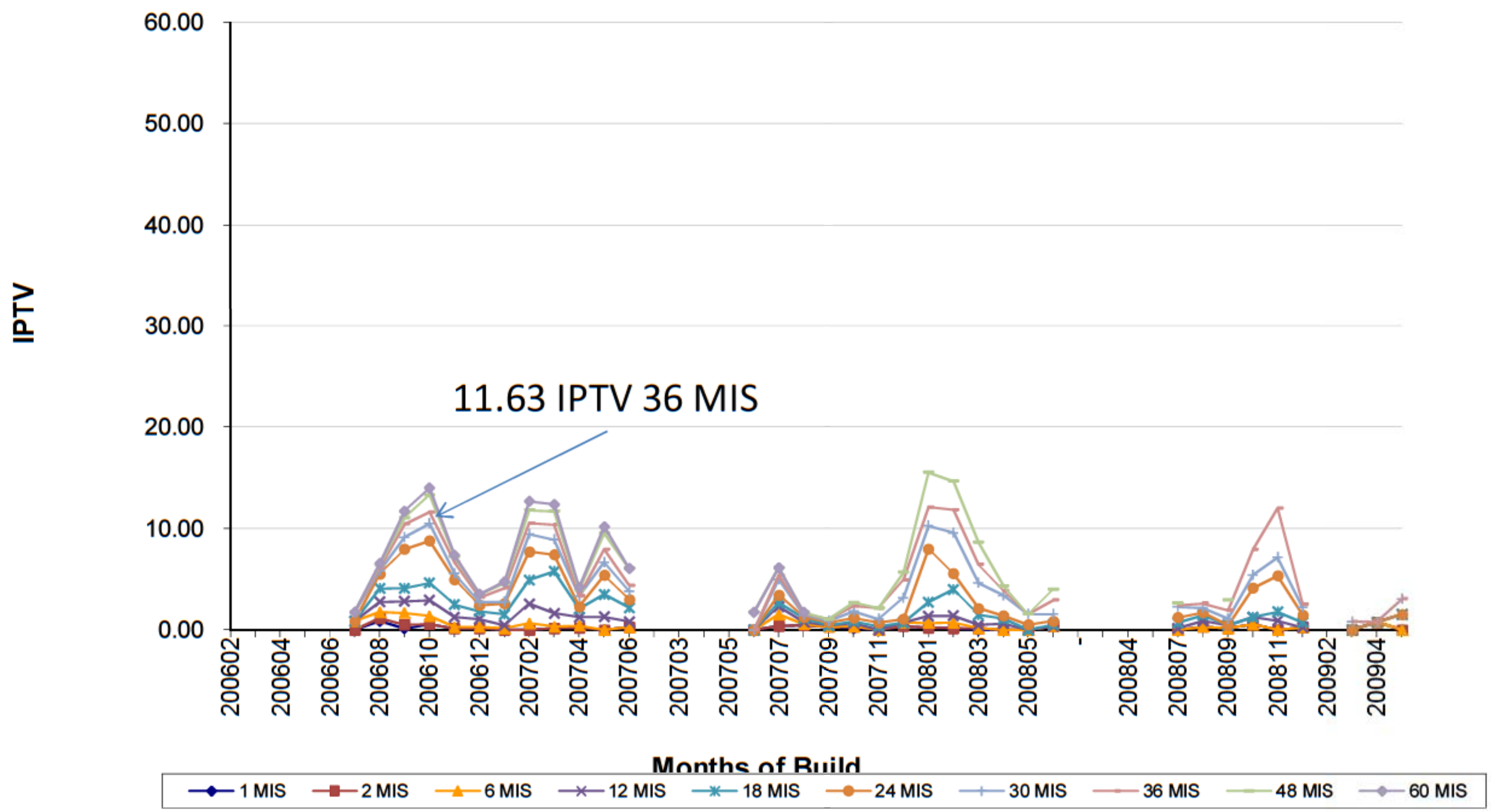
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

<u>2007-2009MY Saturn Aura </u>Stop Lamp

H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Back-up

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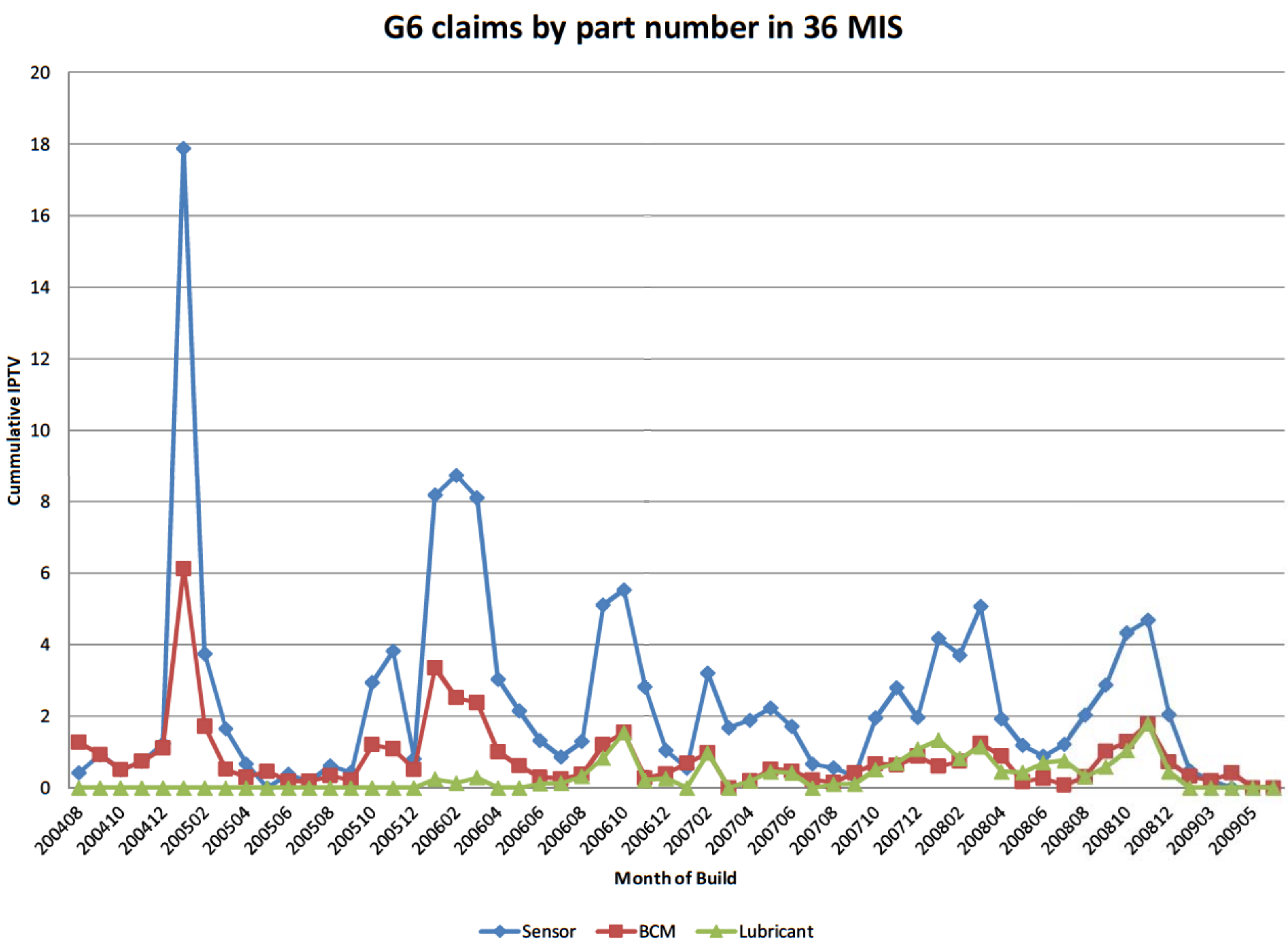
G6 claims by part number in 36 MIS
Cummulative IPTV
20
18
16
14
12
10
8
6
4
2
0
200408
200410
200412
200502
200504
200506
200508
200510
200512
200602
200604
200606
200608
200610
200612
200702
200704
200706
200708
200710
200712
200802
200804
200806
200808
200810
200812
200903
200905
Month of Build
Sensor
BCM
Lubricant

Population

2005 – 2009MY Pontiac G6: 619,000

Excluding campaign population (Jan 2005) and vehicles built after February 2009 (grease applied).

2005	54,443
2006	170,255
2007	164,260
2008	154,323
2009	75,484
Grand Total	618,765

2005 – 2009MY Epsilon: 1.7M

Population	Aura	G6	Malibu	Grand Total
2005		62,360	294,833	357,193
2006		170,338	176,916	347,254
2007	64,847	164,260	127,660	356,767
2008	60,717	154,323	155,225	370,265
2009	35,472	99,216	176,689	311,377
	161,036	650,497	931,323	1,742,856

Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.

Closing Resume

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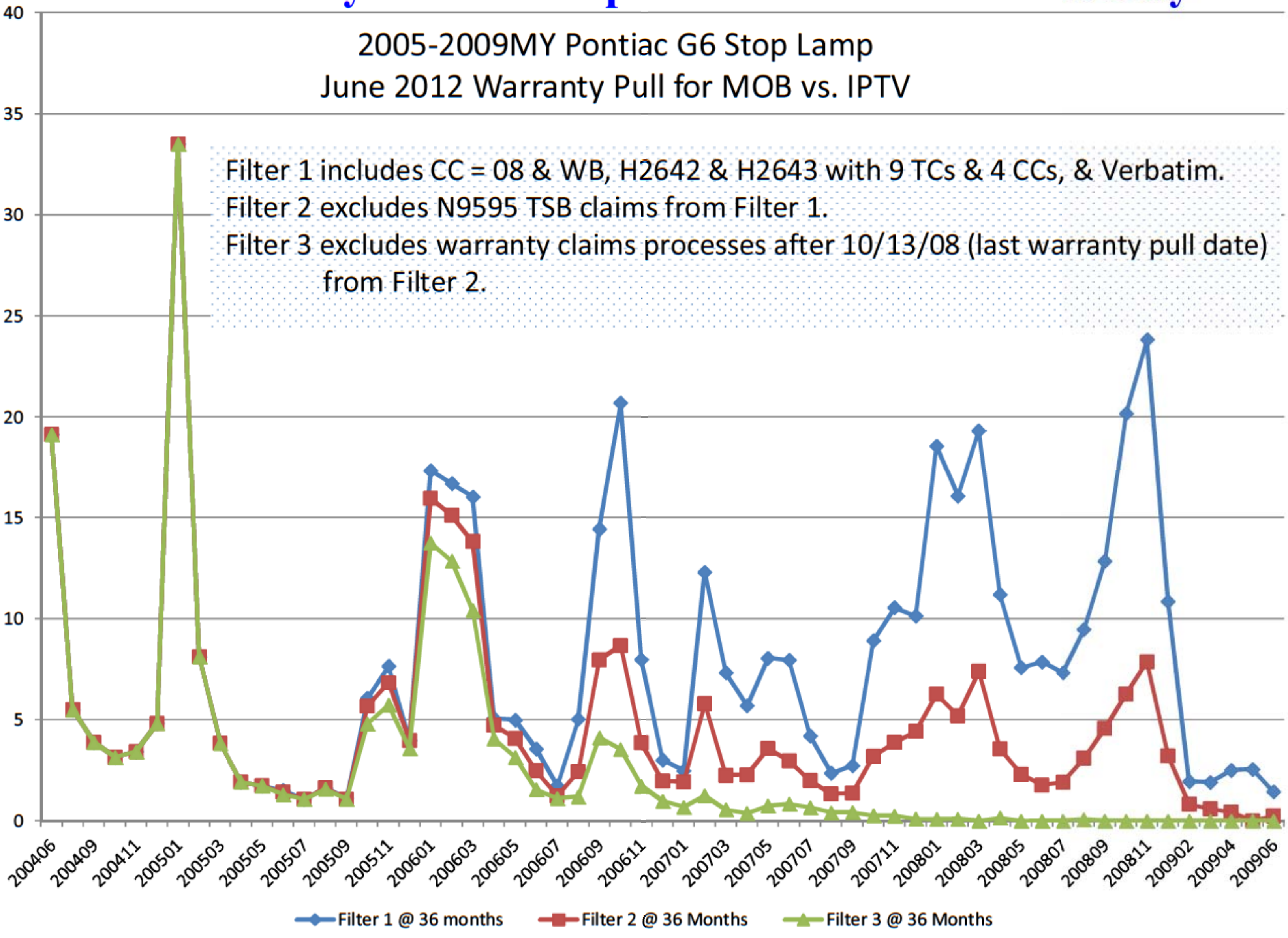
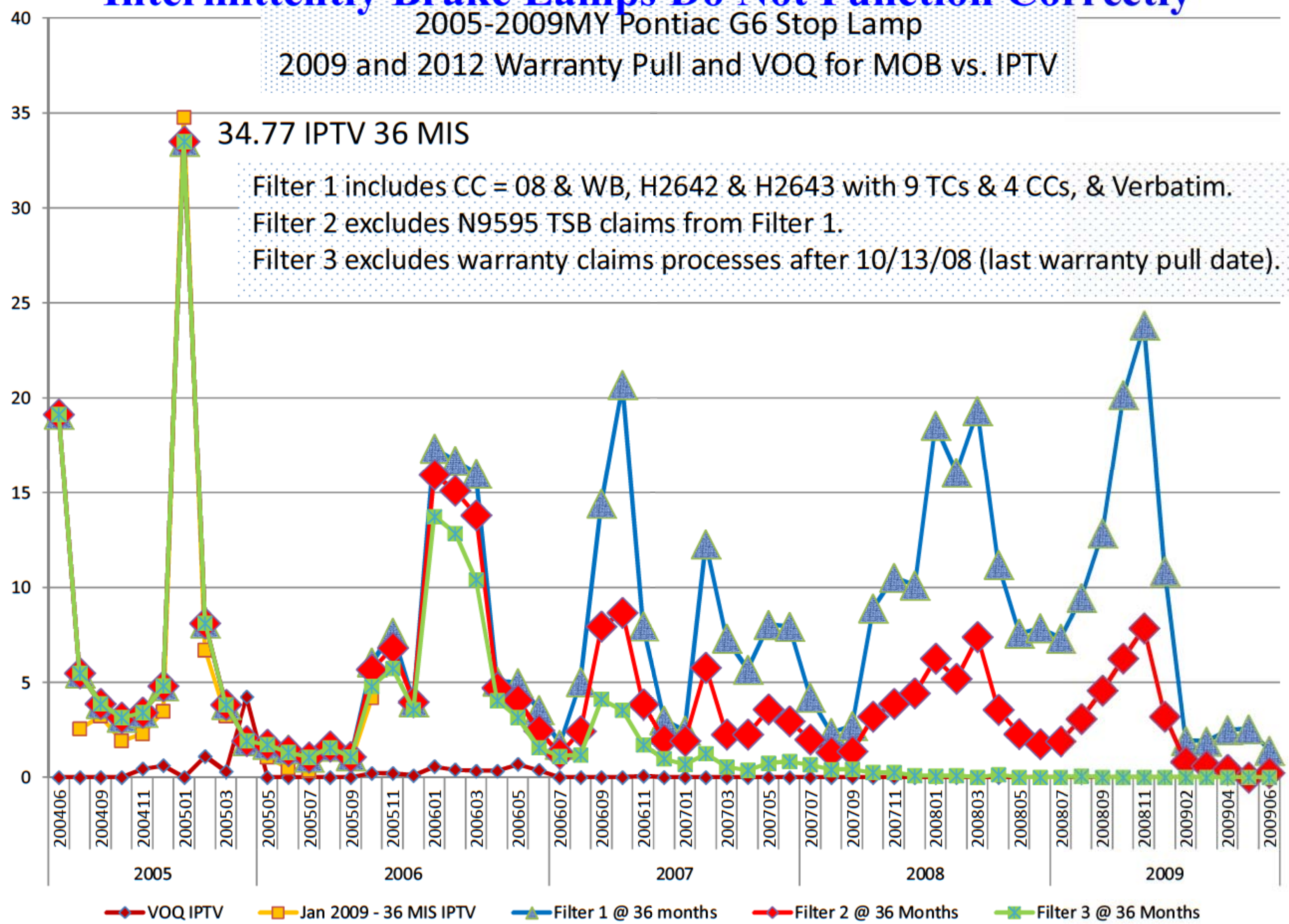
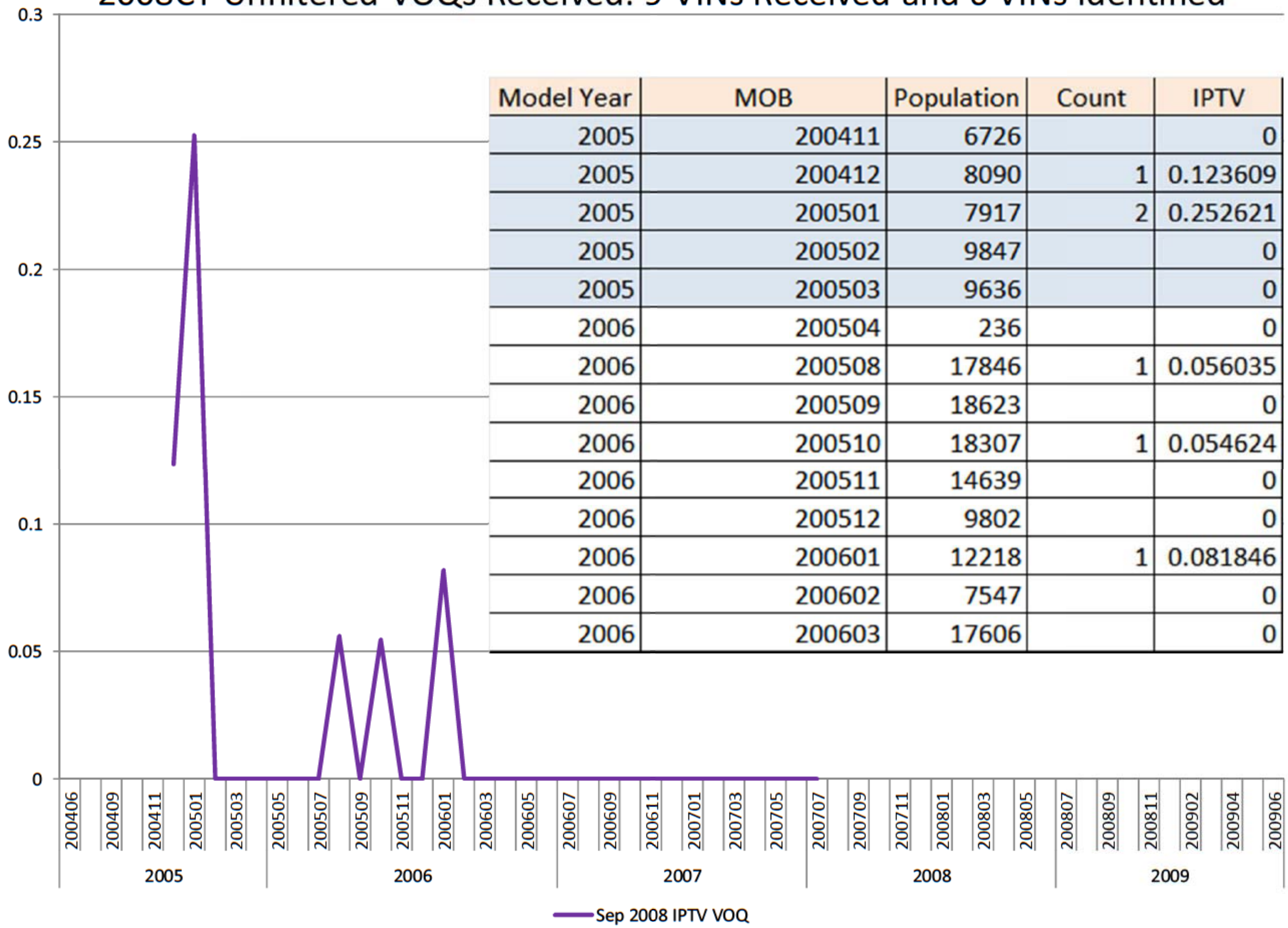
Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly

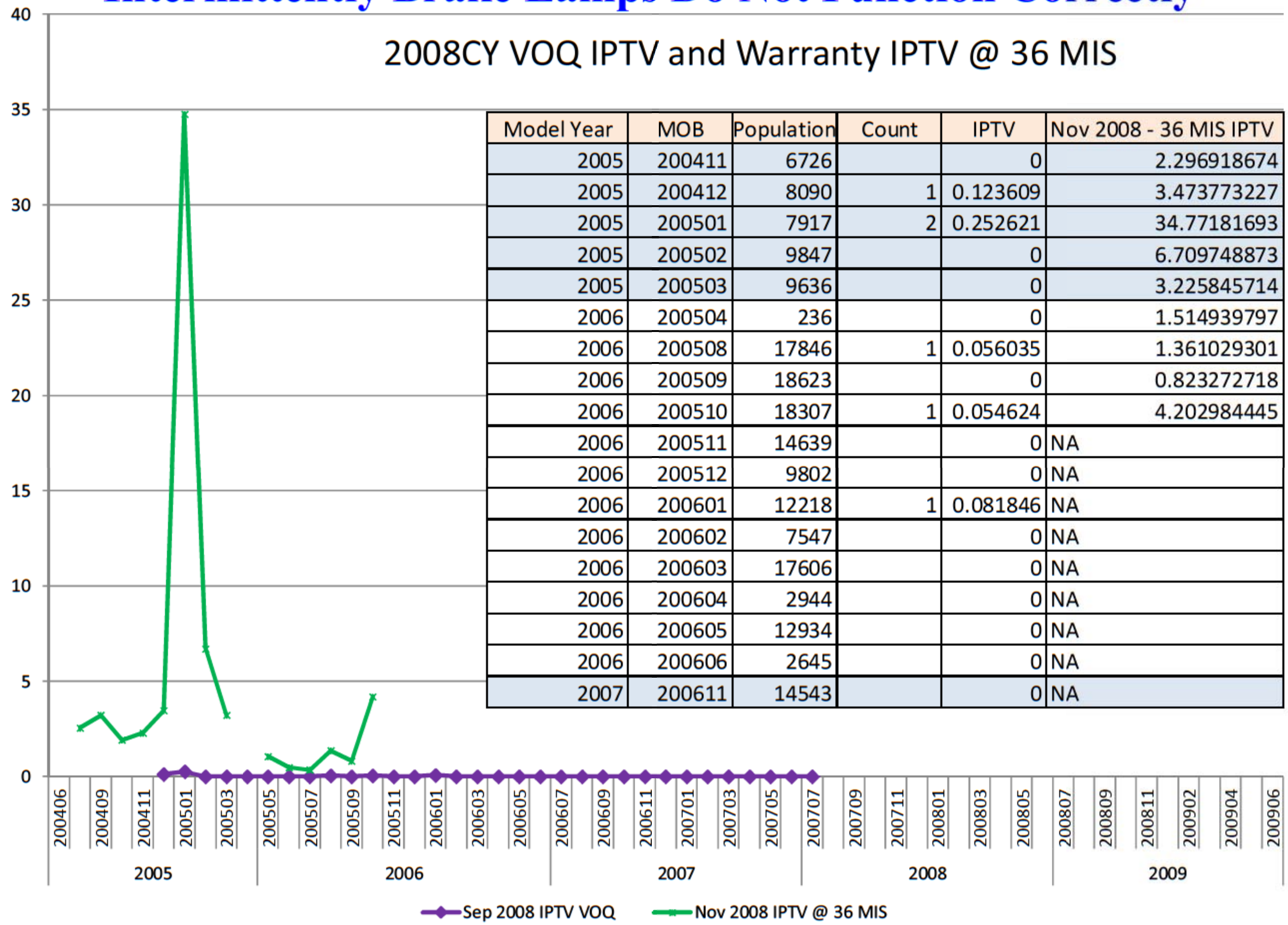


2008CY Unfiltered VOQs Received: 9 VINs Received and 6 VINs Identified



Model Year	MOB	Population	Count	IPTV
2005	200411	6726		0
2005	200412	8090	1	0.123609
2005	200501	7917	2	0.252621
2005	200502	9847		0
2005	200503	9636		0
2006	200504	236		0
2006	200508	17846	1	0.056035
2006	200509	18623		0
2006	200510	18307	1	0.054624
2006	200511	14639		0
2006	200512	9802		0
2006	200601	12218	1	0.081846
2006	200602	7547		0
2006	200603	17606		0

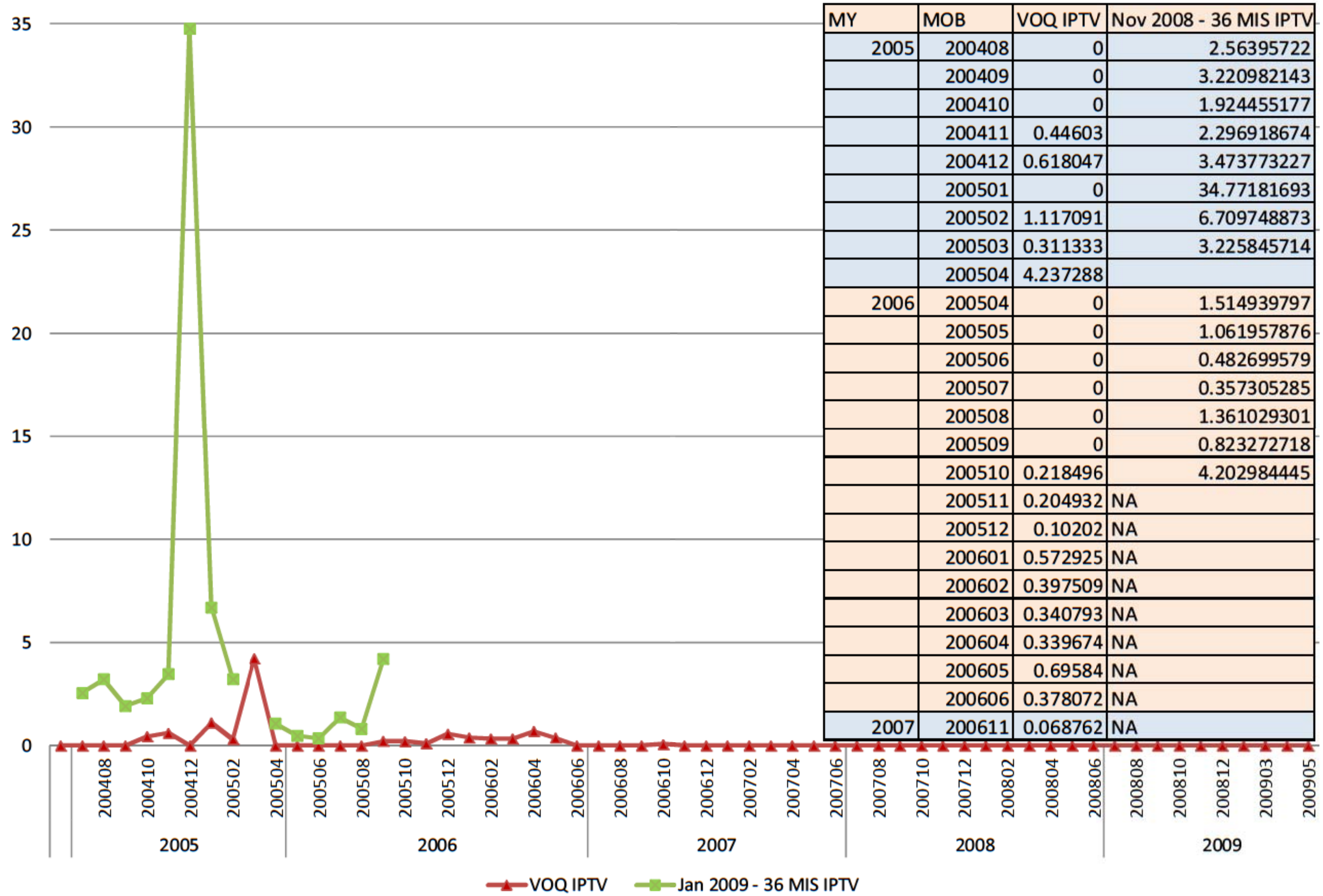
Intermittently Brake Lamps Do Not Function Correctly



Model Year	MOB	Population	Count	IPTV	Nov 2008 - 36 MIS IPTV
2005	200411	6726		0	2.296918674
2005	200412	8090	1	0.123609	3.473773227
2005	200501	7917	2	0.252621	34.77181693
2005	200502	9847		0	6.709748873
2005	200503	9636		0	3.225845714
2006	200504	236		0	1.514939797
2006	200508	17846	1	0.056035	1.361029301
2006	200509	18623		0	0.823272718
2006	200510	18307	1	0.054624	4.202984445
2006	200511	14639		0	NA
2006	200512	9802		0	NA
2006	200601	12218	1	0.081846	NA
2006	200602	7547		0	NA
2006	200603	17606		0	NA
2006	200604	2944		0	NA
2006	200605	12934		0	NA
2006	200606	2645		0	NA
2007	200611	14543		0	NA

Intermittently Brake Lamps Do Not Function Correctly

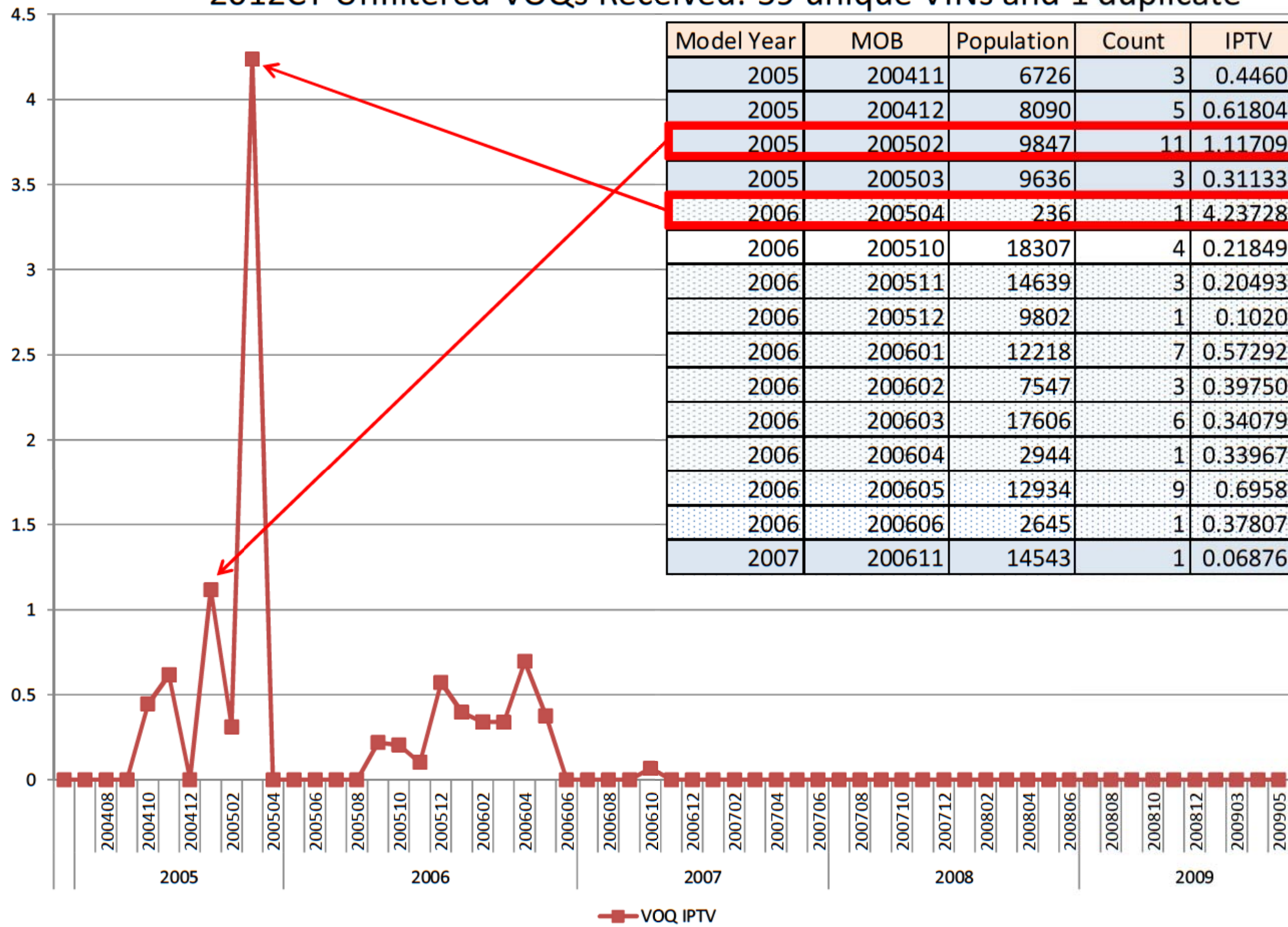
2012 VOQ and Nov 08 Warranty IPTV @ 36MIS Trend line



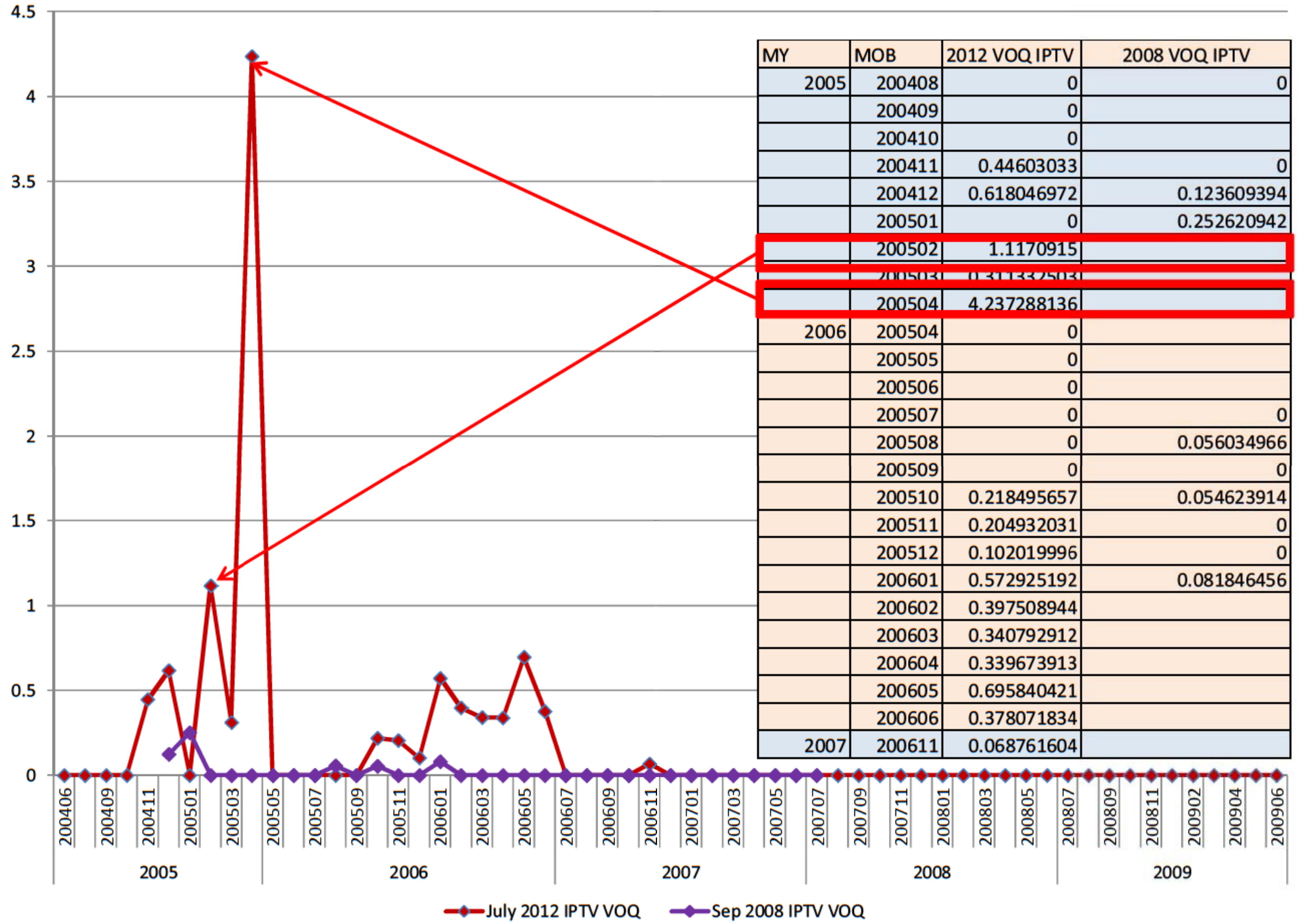
MY	MOB	VOQ IPTV	Nov 2008 - 36 MIS IPTV
2005	200408	0	2.56395722
	200409	0	3.220982143
	200410	0	1.924455177
	200411	0.44603	2.296918674
	200412	0.618047	3.473773227
	200501	0	34.77181693
	200502	1.117091	6.709748873
	200503	0.311333	3.225845714
	200504	4.237288	
2006	200504	0	1.514939797
	200505	0	1.061957876
	200506	0	0.482699579
	200507	0	0.357305285
	200508	0	1.361029301
	200509	0	0.823272718
	200510	0.218496	4.202984445
	200511	0.204932	NA
	200512	0.10202	NA
	200601	0.572925	NA
	200602	0.397509	NA
	200603	0.340793	NA
	200604	0.339674	NA
	200605	0.69584	NA
	200606	0.378072	NA
2007	200611	0.068762	NA

2012CY Unfiltered VOQs Received: 59 unique VINs and 1 duplicate

Model Year	MOB	Population	Count	IPTV
2005	200411	6726	3	0.44603
2005	200412	8090	5	0.618047
2005	200502	9847	11	1.117091
2005	200503	9636	3	0.311333
2006	200504	236	1	4.237288
2006	200510	18307	4	0.218496
2006	200511	14639	3	0.204932
2006	200512	9802	1	0.10202
2006	200601	12218	7	0.572925
2006	200602	7547	3	0.397509
2006	200603	17606	6	0.340793
2006	200604	2944	1	0.339674
2006	200605	12934	9	0.69584
2006	200606	2645	1	0.378072
2007	200611	14543	1	0.068762



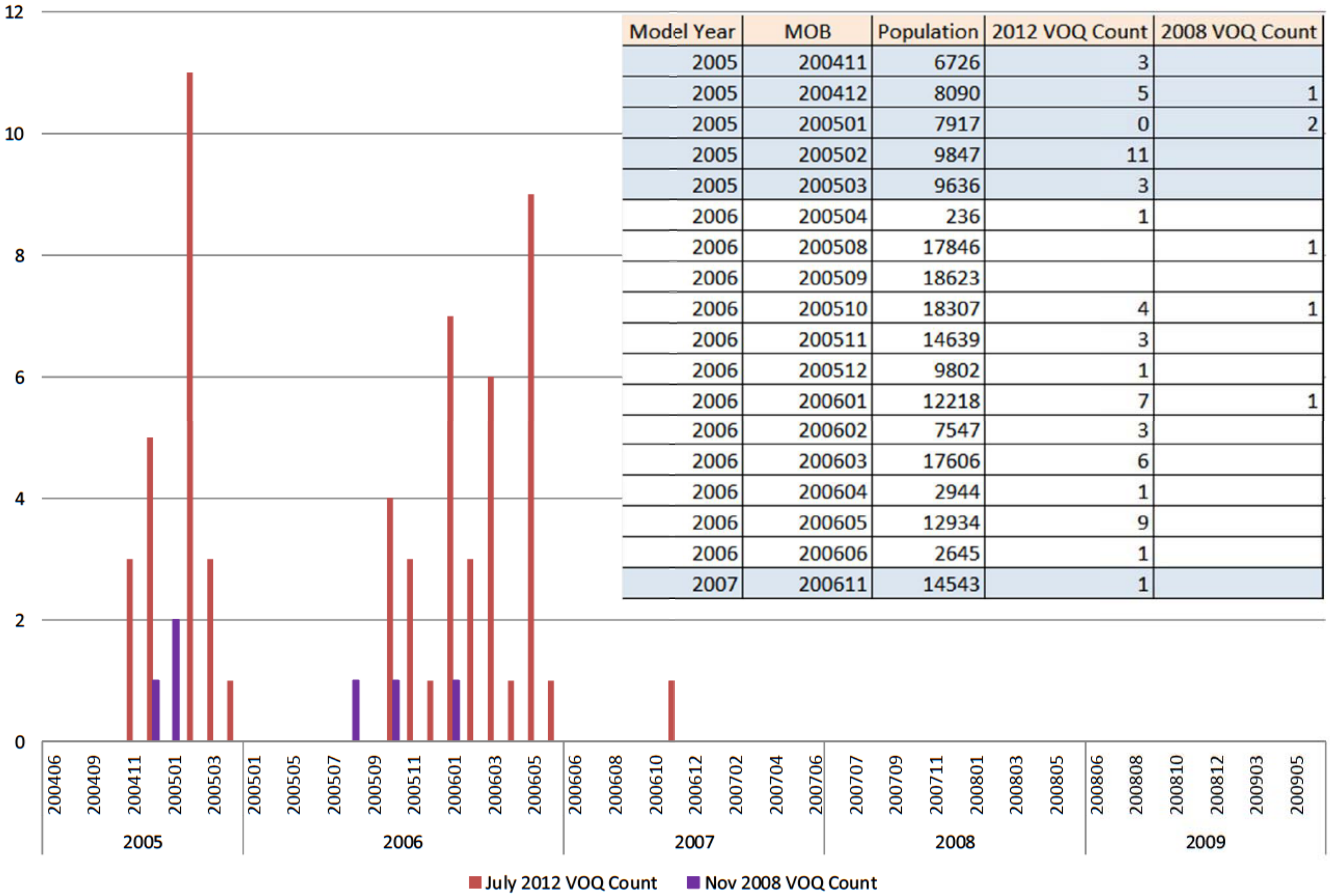
Nov 2008 and June 2012 VOQ IPTV



MY	MOB	2012 VOQ IPTV	2008 VOQ IPTV
2005	200408	0	0
	200409	0	
	200410	0	
	200411	0.44603033	0
	200412	0.618046972	0.123609394
	200501	0	0.252620942
	200502	1.1170915	
	200503	0.311332503	
	200504	4.237288136	
2006	200504	0	
	200505	0	
	200506	0	
	200507	0	0
	200508	0	0.056034966
	200509	0	0
	200510	0.218495657	0.054623914
	200511	0.204932031	0
	200512	0.102019996	0
	200601	0.572925192	0.081846456
	200602	0.397508944	
	200603	0.340792912	
	200604	0.339673913	
	200605	0.695840421	
	200606	0.378071834	
2007	200611	0.068761604	

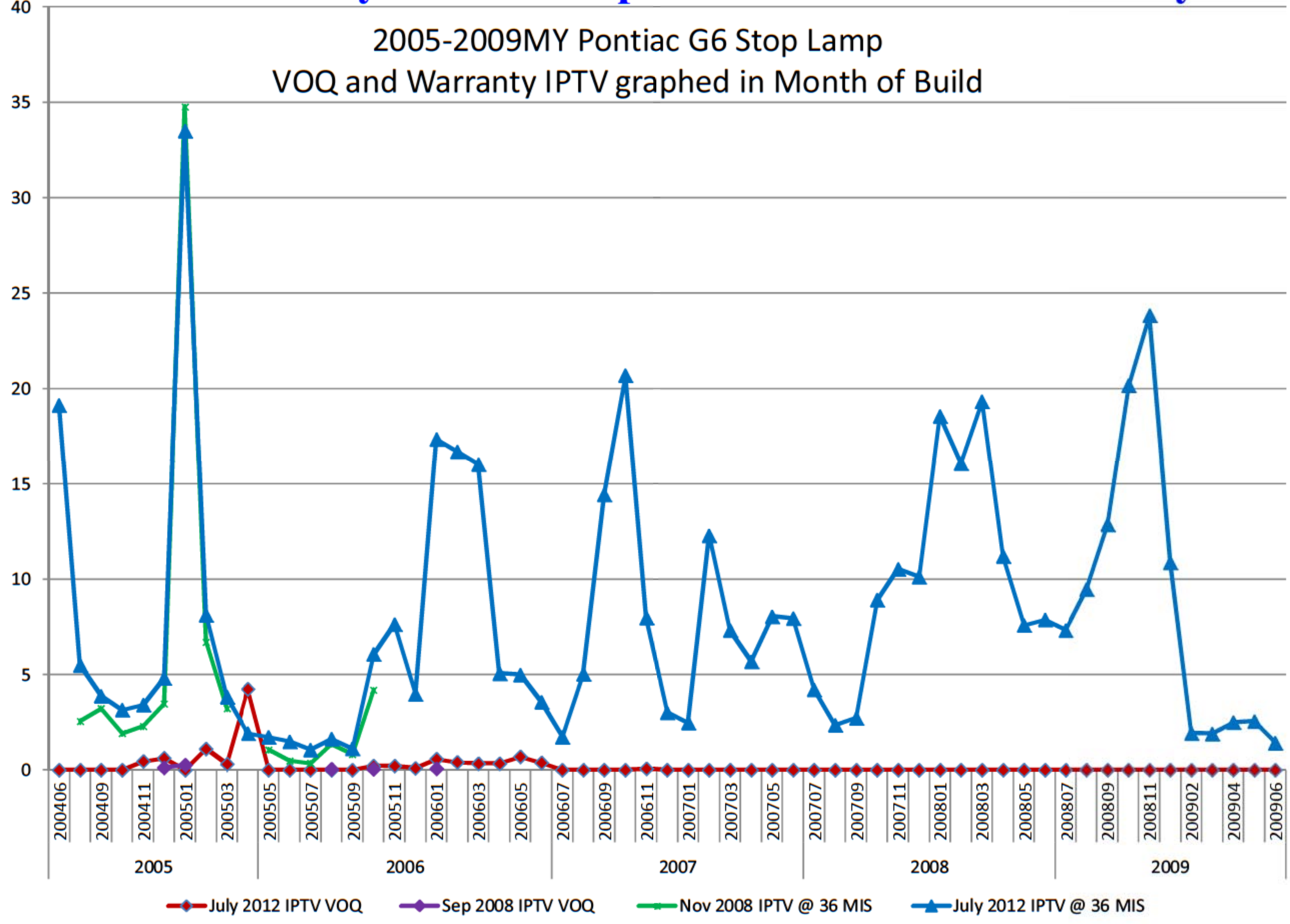
Intermittently Brake Lamps Do Not Function Correctly

VOQ Count Comparison: 2008 (6) vs 2012 (59)



Model Year	MOB	Population	2012 VOQ Count	2008 VOQ Count
2005	200411	6726	3	
2005	200412	8090	5	1
2005	200501	7917	0	2
2005	200502	9847	11	
2005	200503	9636	3	
2006	200504	236	1	
2006	200508	17846		1
2006	200509	18623		
2006	200510	18307	4	1
2006	200511	14639	3	
2006	200512	9802	1	
2006	200601	12218	7	1
2006	200602	7547	3	
2006	200603	17606	6	
2006	200604	2944	1	
2006	200605	12934	9	
2006	200606	2645	1	
2007	200611	14543	1	

Intermittently Brake Lamps Do Not Function Correctly



2012CY Update of G6 Stop Lamp Warranty Claims

2012CY Warranty Methodology

Started with 27,821 — 11,852 had correction-verbatim (42.6%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	10,316 (37.1)	363 (20.7)
H2642 Sensor, Brake Pedal	4,643 (16.7)	1,203 (68.6)
H2643 Sonsor, Brake & Accel	420 (1.5)	144 (8.2)
H2640 Pedal / Bushing	418(1.5)	7 (0.4)
H9991 Cust Concern NTF	8,531(30.7)	36 (2.1)
N9595 TSB	3,493 (12.6)	0
Total	27,821	1,753 (6.3)

2012CY Warranty Methodology

27,821 including 243 same day repair duplicates

A. All claims with labor code N9595 were determined to be responsive to the
3,490 alleged condition.

B. All claims with customer codes 08 (Operation: Won't Turn Off) and WB (Warning Lights-Brake Lights) were determined to be responsive to the alleged condition unless the verbatim text indicated that the claim was unrelated.

C. Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with
20,167 the trouble codes in Table 2.7 and customer codes in Table 2.8 were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.

D. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.

E. The vehicle claims processed after 10/13/08 are excluded to compare with
2,168 the original data.

F. All claims for vehicles covered by General Motors recall 08317 were excluded.
6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%

1,753

2009CY Update Methodology

Started with 8,978 — 2,362 had verbatim (26.3%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	6,758 (75.3)	274 (17.5)
H2642 Sensor, Brake Pedal	1,984 (22.1)	1,157 (74)
H2643 Sonsor, Brake & Accel	227 (2.5)	125 (8)
H2640 Pedal / Bushing	6 (0)	6 (0.4)
H9991 Cust Concern NTF	3 (0)	3 (0.2)
Total	8,978	1,565 (17.4)

2009CY Update Methodology

For the subject vehicles, the regular warranty, goodwill warranty, and MIC service contract claims with stop lamp malfunction are summarized by model and model year in Table 5-1. For the subject vehicles the UWC service contract claims with indication of stop lamp malfunction are summarized by model and model year in Table 5-2. A summary of the warranty claims, including the information requested in 5(a-k), is provided on the ATT_1_GM disk; folder labeled "Q_05:" refer to the Microsoft Access 2000 file labeled "Q_05_WARRANTY DATA." A list of the labor codes, customer complaint codes and trouble codes used to collect the warranty data is provided in response to item No. 6.

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	Regular	579	754	232	1,565
Pontiac G6	MIC	43	25	2	70

TABLE 5-1: REGULAR WARRANTY AND MIC SERVICE CONTRACT CLAIMS WITH STOP LAMP MALFUNCTION

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	UWC	0	3	0	3

TABLE 5-2: UWC SERVICE CONTRACT CLAIMS

SOURCE SYSTEM	LAST DATE GATHERED
GART - regular warranty	13 Oct 08
MIC - service contract claims	14 Oct 08
UWC - service contract claims	23 Sept 08

TABLE 5-3: DATES PULLED

2009CY Update Methodology

8,969

The GM Global Analysis and Reporting Tool (GART-regular warranty) regular warranty database and the Motors Insurance Corp (MIC) service contract claims database were searched using the labor codes that may be related to the alleged defect, listed in Table 6-1. Universal Warranty Corporation (UWC) does not use labor codes or trouble codes.

The following process was used to sort these claims:

544
- All claims with customer codes shown in Table 6-2 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

6,800
- Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 6-3 and customer codes in Table 6-4 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

60
- The verbatims of the remaining claims were then read and the claim was determined to be responsive if the verbatim related to the alleged defect.

1,565

2009CY Update Methodology

Labor Code	Description:
H2642	Sensor, Brake Pedal Position - Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
N4800	Body Control Module Replacement
H2640	Pedal And/Or Bushing, Brake - R&R Or Replace
H9991	Customer Concern Not Duplicated
N2700	Switch, Stop Lamp - Adjust
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement-Product Allegation
Z1243	Inspection-Product Allegation Resolution

Table 6-1 Labor Codes used in Warranty and MIC Search

Customer Code	Description:
O8	Operation: won't turn off
WB	Warning lights: brake light

Table 6-2 Customer Codes used in Warranty and MIC Sorting

Trouble Code	Description:
1D	Broken
6C	Component-inoperative
6D	Component -intermittent
6F	Component -Open
3A	Misadjusted
9Z	No Trouble Found
3L	Out of Calibration
3X	Registers Incorrectly
6N	Connector - Partial Connected

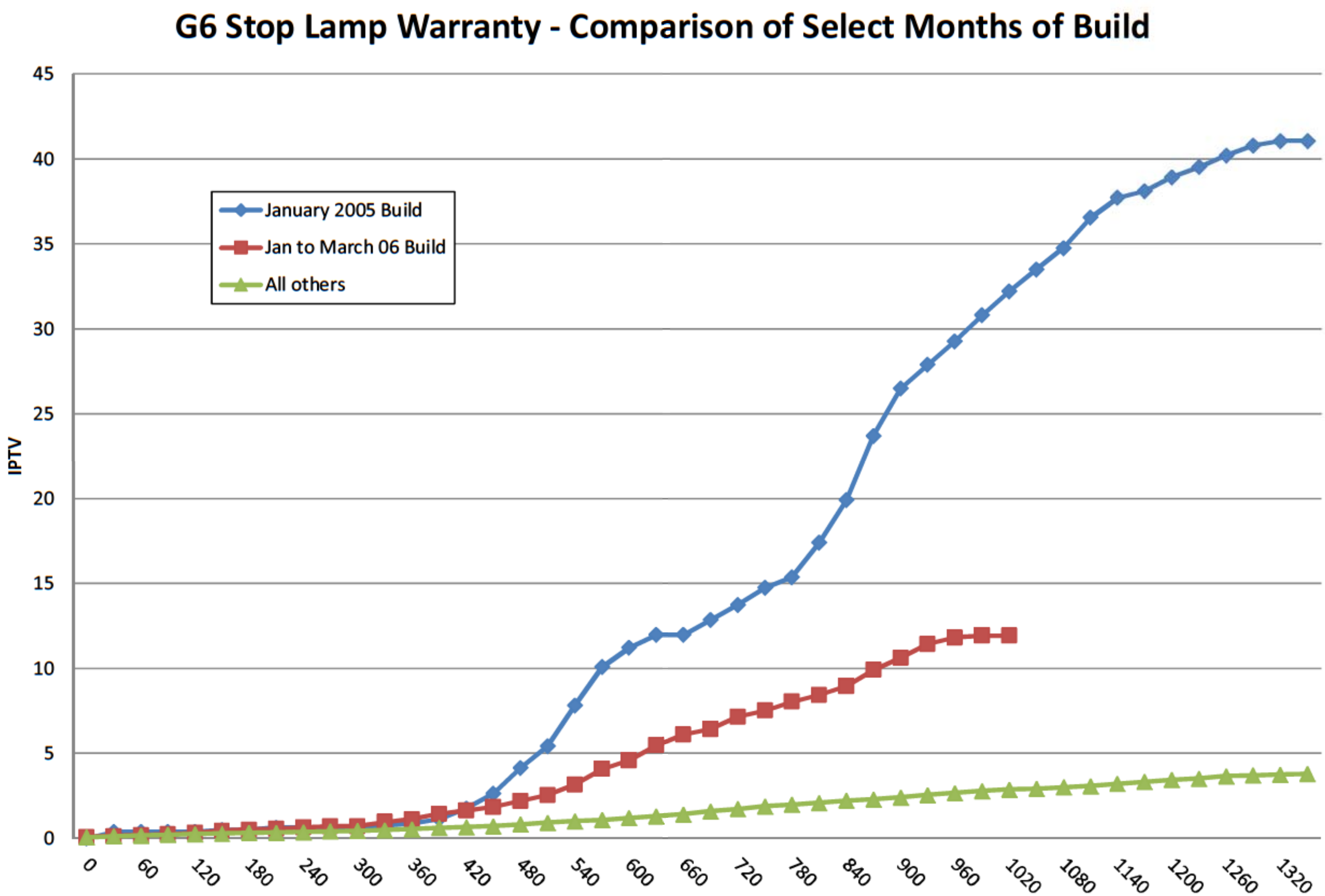
Table 6-3 Trouble Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Customer Code	Description:
OG	Operation: Excess Eff (Excess Play)
OJ	Operation: Inoperative (Harsh)
OF	Operation: Engage/Dis(Excess Eff)
O7	Operation: No Maintain Adj

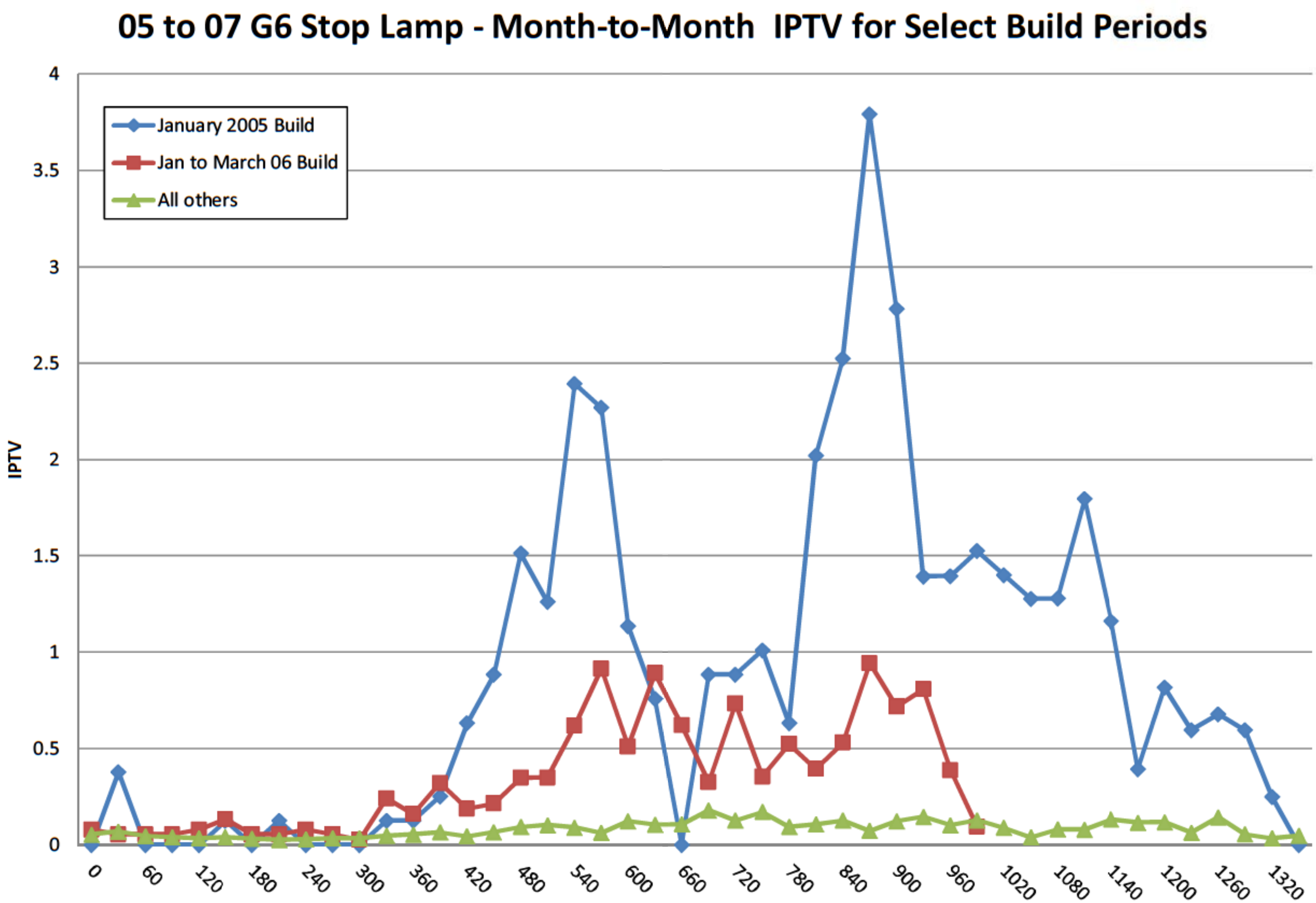
Table 6-4 Customer Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Rationale for 2009 Decision

Intermittently Brake Lamps Do Not Function Correctly

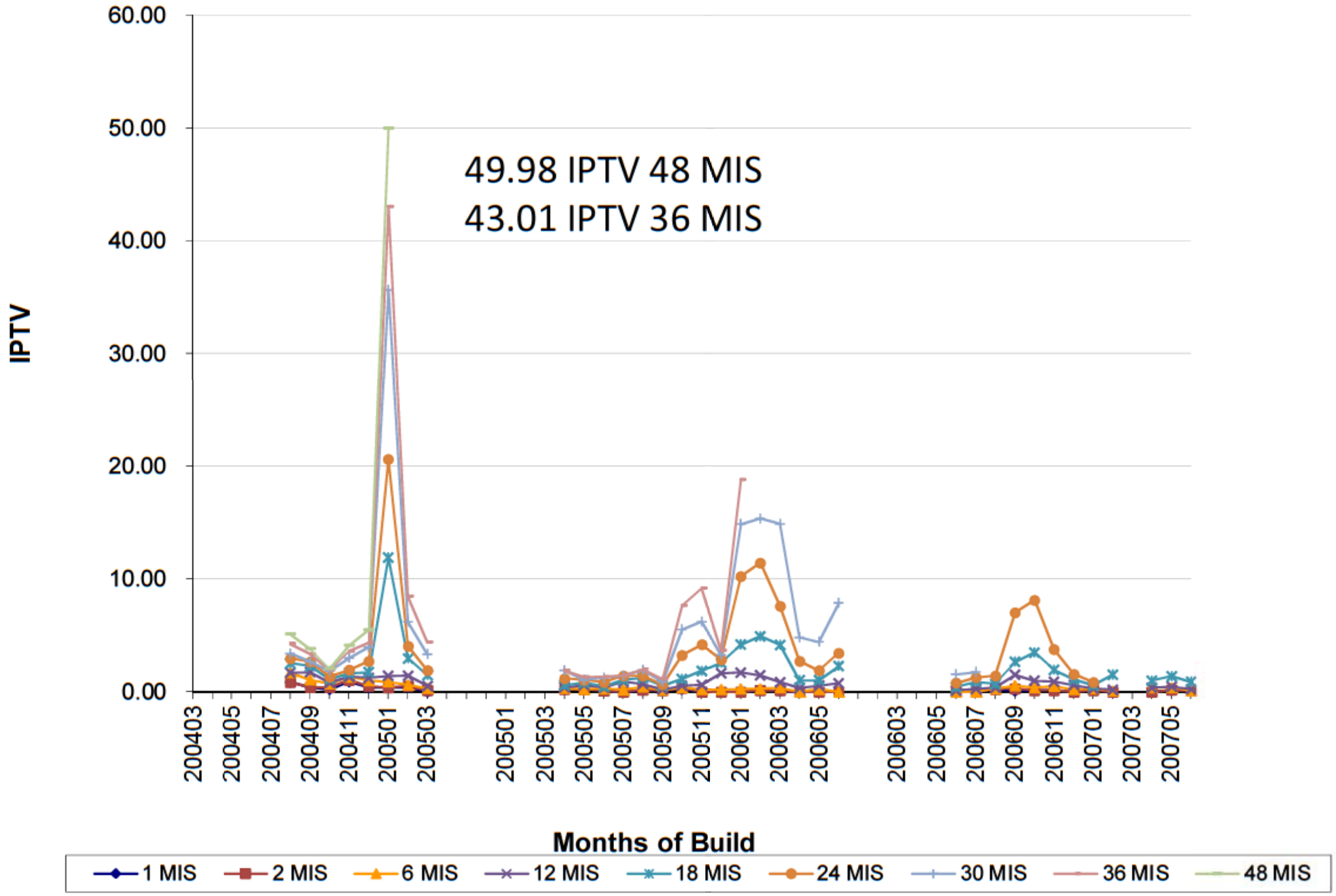


Intermittently Brake Lamps Do Not Function Correctly



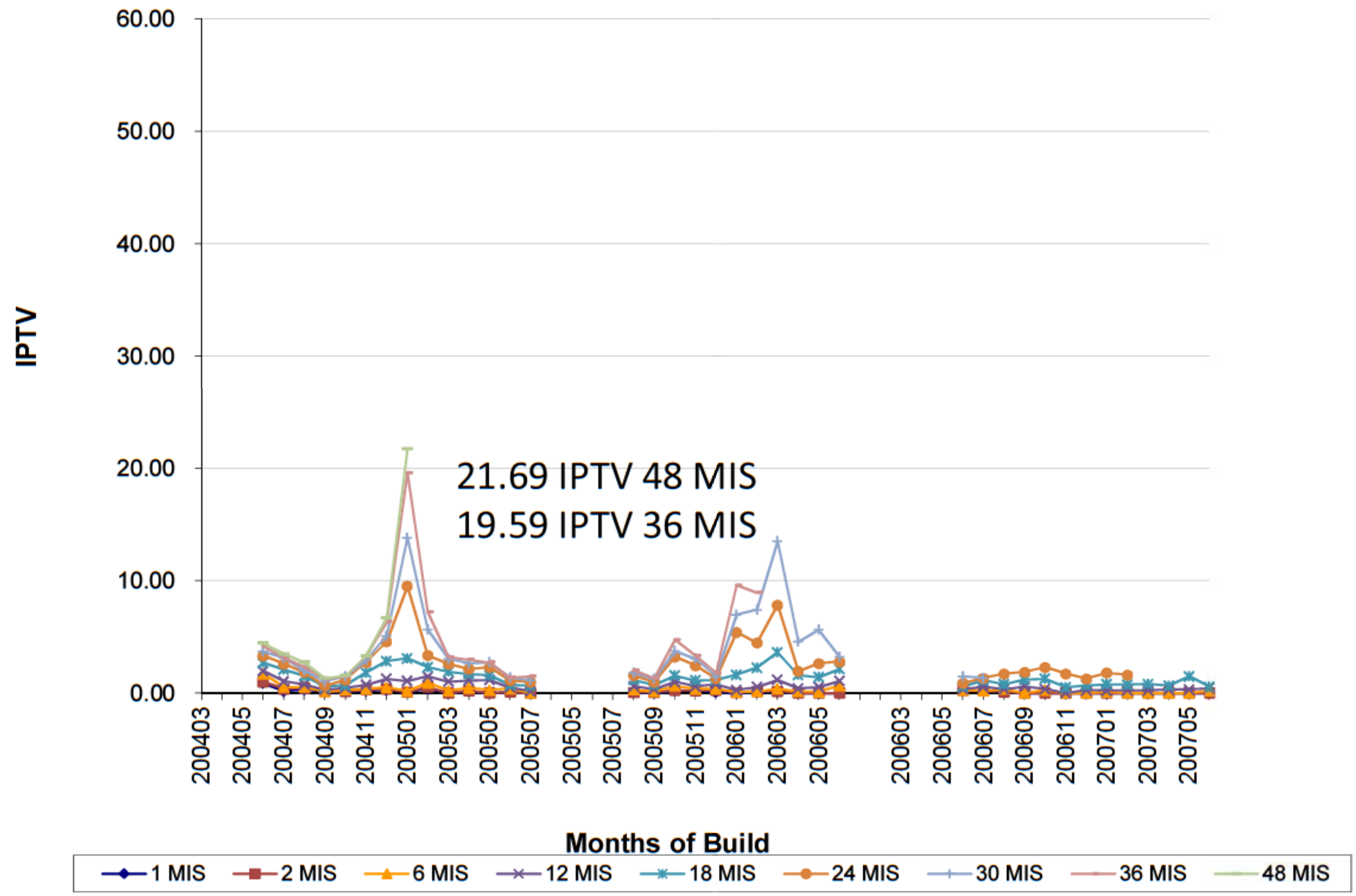
Intermittently Brake Lamps Do Not Function Correctly

Pontiac G6 Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



Intermittently Brake Lamps Do Not Function Correctly

Chevrolet Malibu Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



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Intermittently Brake Lamps Do Not Function Correctly

The Body Control Module with different electrical harness architecture is used for the following platforms:

2004MY	Malibu, XLR	
2005MY	G6, Cobalt, Corvette	
2006MY	HHR, Solstice	
2007MY	Sky, Opel GT, Aura	- NEW MICROPROCESSOR
2008MY	New Malibu	

Intermittently Brake Lamps Do Not Function Correctly

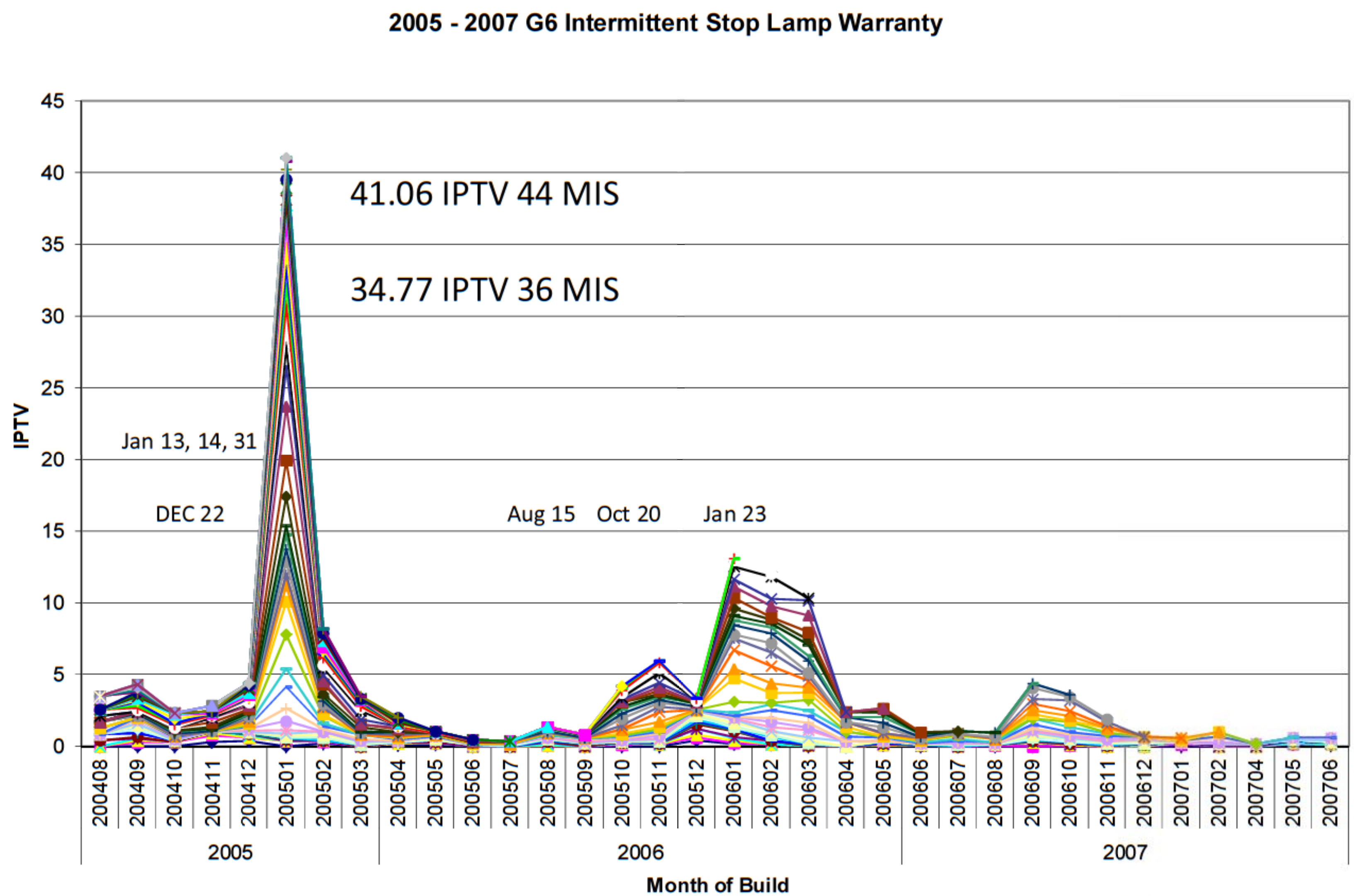
Technical Service Bulletin

#08-05-22-009: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTC C0161/C0277 Set (Perform Repair as Outlined) - (Dec 4, 2008)

Subject: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTCs C0161/C0277 Set (Perform Repair as Outlined)

Apply dielectric lubricant (clear gel) GM P/N 12377900 (In Canada, use P/N 10953529) on the BCM C2 pins (apply with a one-inch nylon bristle brush) on all the C2 connector pins (this will treat the pins against fretting corrosion).

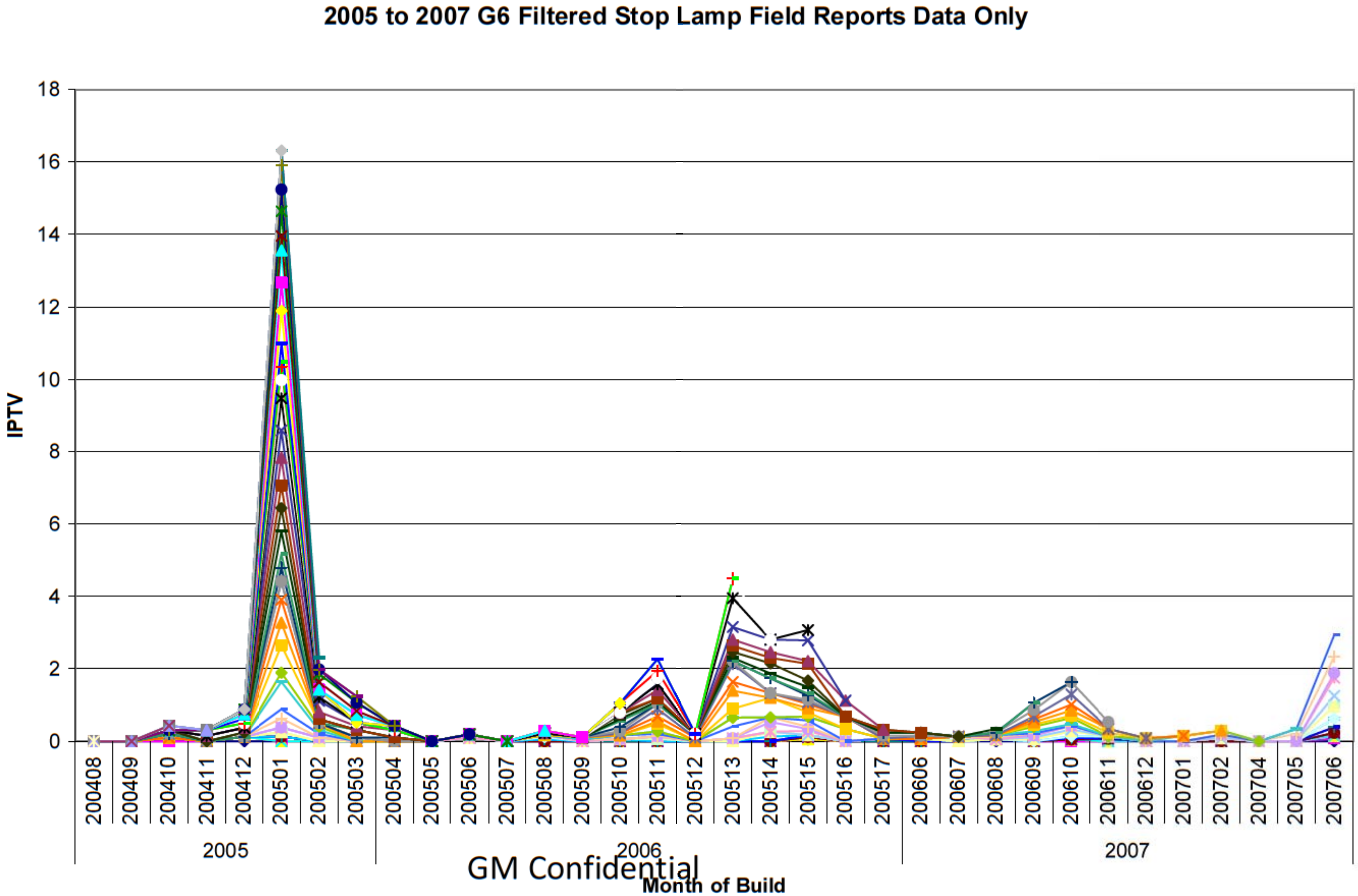
Intermittently Brake Lamps Do Not Function Correctly



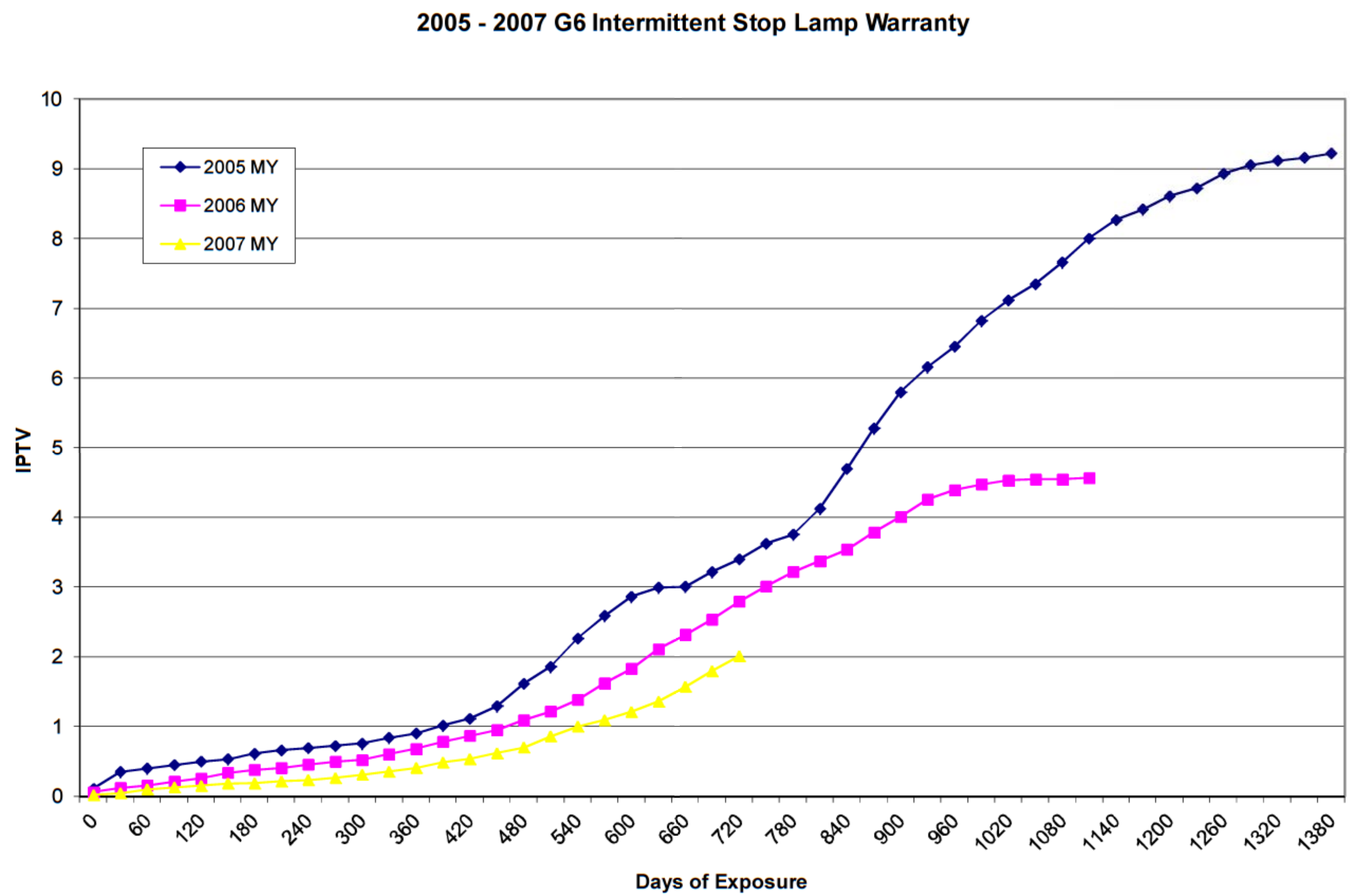
9 VOQs 2005MY: 4 2006MY: 4 2007MY: 1

GM Confidential

2005 - 2007 G6 BASS – TAC and CAC only

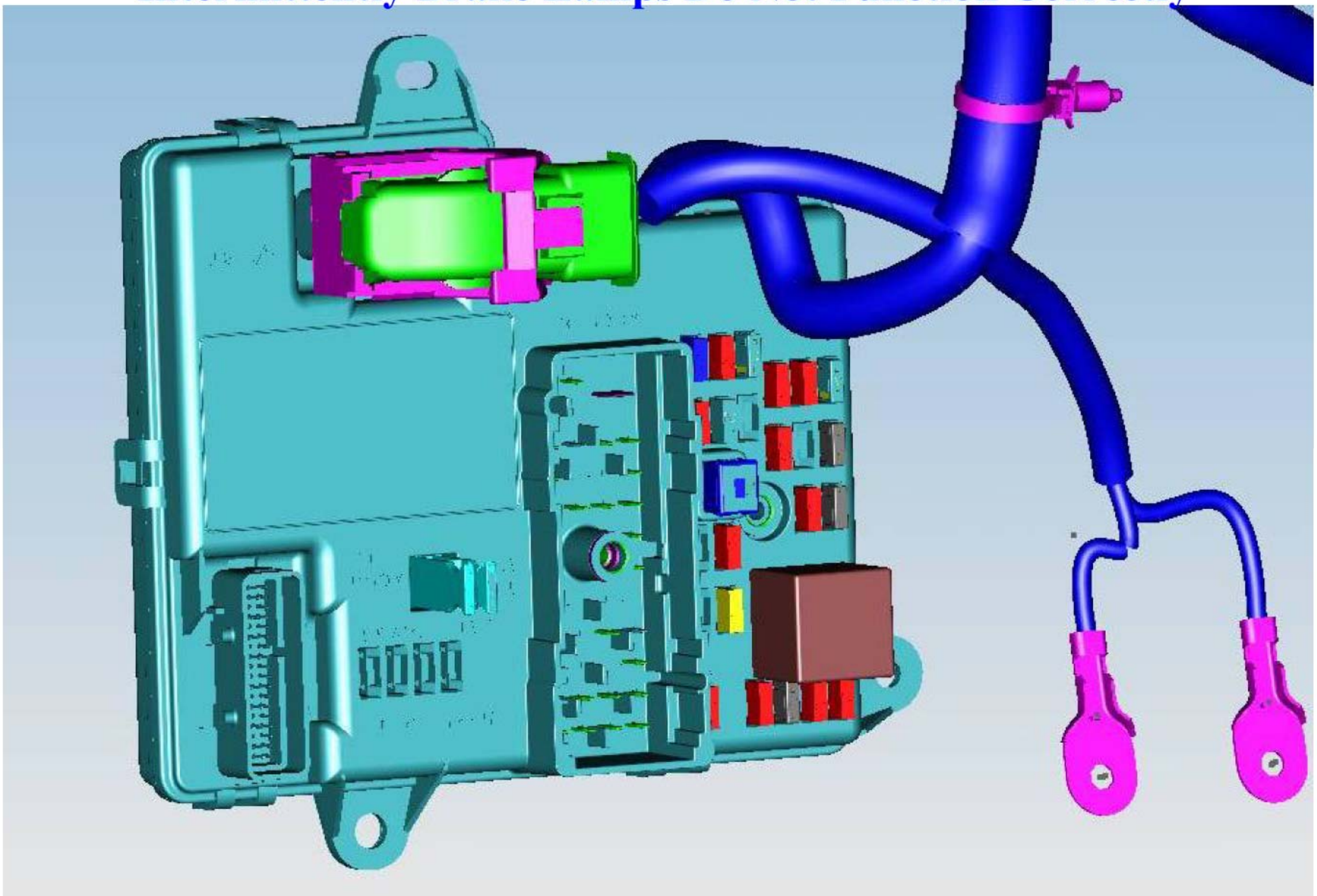


Intermittently Brake Lamps Do Not Function Correctly



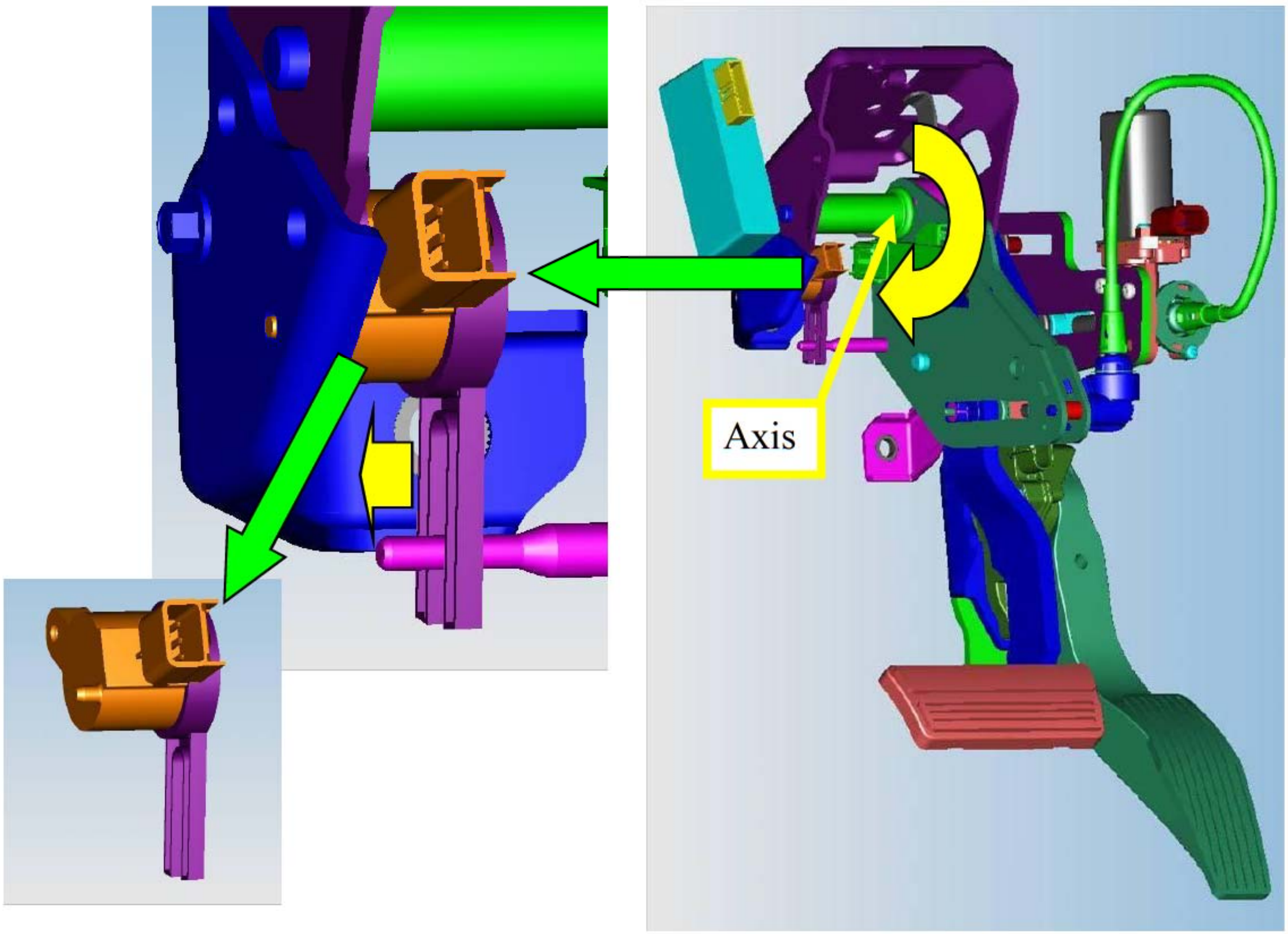
GM Confidential

Intermittently Brake Lamps Do Not Function Correctly



2005 - 2007 G6 Brake Apply Sensing System

Pedal/Sensor Movement



Intermittently Brake Lamps Do Not Function Correctly

2004-2009MY Epsilon (G6, Aura, Mailbu)
Est. Population: 1.8M – 2.2M
Est. Cost: $TBD

Condition: Fretting corrosion in the Body Control Module connector (C2 or X2) causes an increase in resistance that results in a reduction of Brake Apply Sensing (BAS) signal voltage to the BCM. Brake pedal status information affects the operation of brake lamps, cruise control, brake shifter interlock, and stability control systems.

Effect of the Condition: This results in erratic brake pedal status information. A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

{ * }

Potential Field Action Category: TBD

Discovery On September 15, 2008, NHTSA ODI opened PE investigation with 9 VOQs. On January 28, 2009, GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY. On February 13, 2013, NHTSA ODI opened RQ investigation with 212 VOQs.

Intermittently Brake Lamps Do Not Function Correctly

Potential Field Remedy: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Frequency:

Month of Build January 2005 36 MIS = 34.8 IPTV Campaigned.
Other Months of Build for the subject population at 36 MIS = 5- 24 IPTV
See updated IPTV vs. MOB graph for non-campaigned vehicles.

{ * }

Responsibility

GM and Delphi Engineering

Table 1-1 Subject Vehicles Submitted to NHTSA

		Model Year								
Make	Model	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	183,783	211,055	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	N/A	N/A	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	N/A	N/A	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	25,586	N/A	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	N/A	N/A	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	209,369	211,055	2,214,173

Subject Vehicles For Discussion

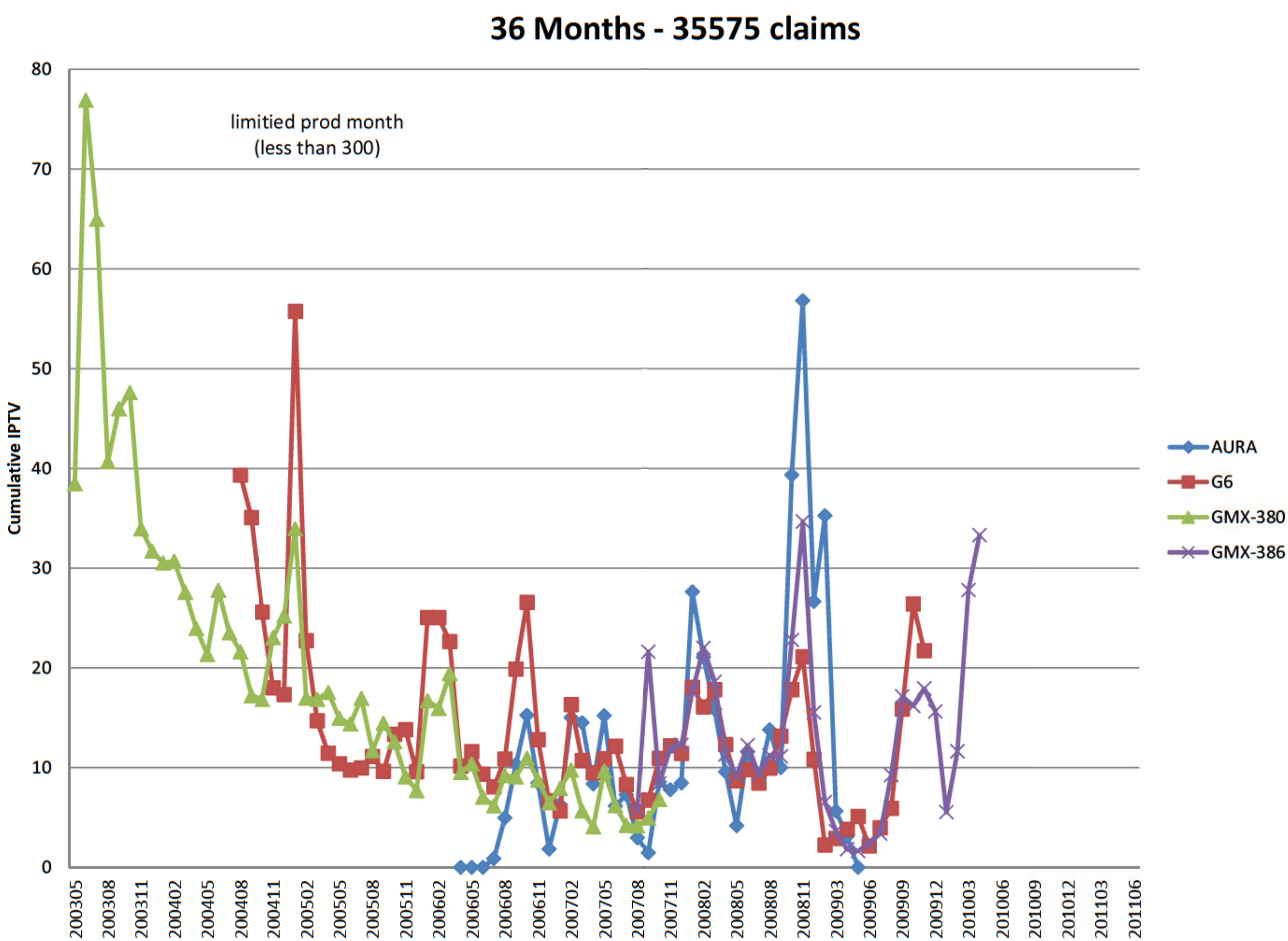
		Model Year								
Make	Model	2004	2005	2006	2007	2008	2009	~~2010~~	~~2011~~	TOTAL
Chevrolet	Malibu	96,597	163,822	141,677	113,944	126,208	176,815	~~183,783~~	~~211,055~~	1,213,901
Chevrolet	Malibu Maxx	35,756	48,578	35,585	13,774	N/A	N/A	~~N/A~~	~~N/A~~	133,693
Chevrolet	Malibu Classic	N/A	N/A	N/A	N/A	29,225	N/A	~~N/A~~	~~N/A~~	29,225
Pontiac	G6	N/A	62,481	170,386	164,302	154,337	99,226	~~25,586~~	~~N/A~~	676,318
Saturn	Aura	N/A	N/A	N/A	64,847	60,717	35,472	~~N/A~~	~~N/A~~	161,036
TOTAL	----	132,353	274,881	347,648	356,867	370,487	311,513	~~209,369~~	~~211,055~~	2,214,173

2013CY Warranty Methodology

139,689 VINs including duplicates

A. All claims with labor code N9595 and N9613 were determined to be responsive to the alleged condition.
B. Total of 19 warranty labor codes with certain complaint codes and causal codes were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.
C. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.
D. All claims for vehicles covered by General Motors recall 08317 were excluded. 6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%.

35,575

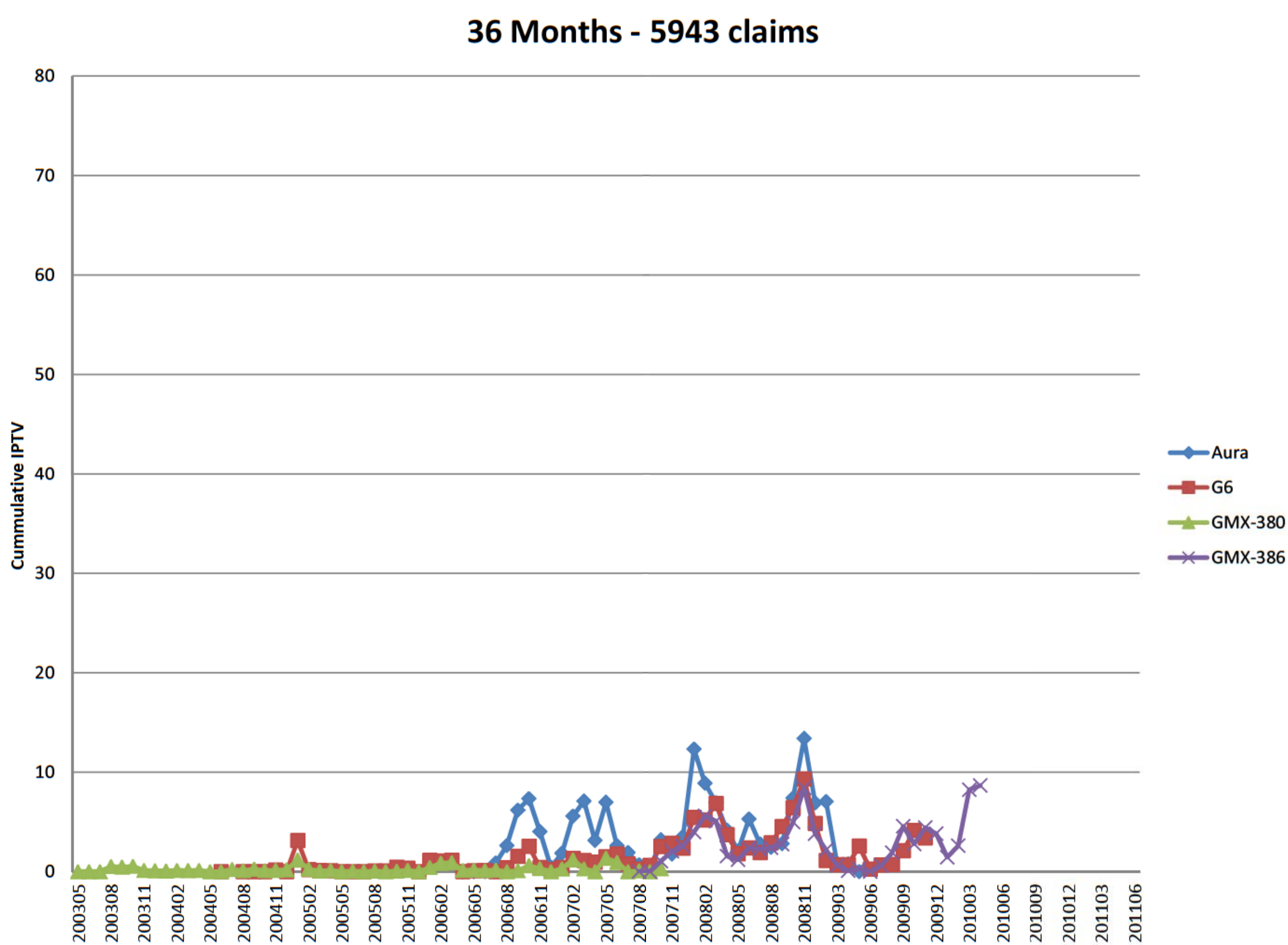

36 Months - 35575 claims
limitied prod month
(less than 300)
Cumulative IPTV
80
70
60
50
40
30
20
10
0
200305
200308
200311
200402
200405
200408
200411
200502
200505
200508
200511
200602
200605
200608
200611
200702
200705
200708
200711
200802
200805
200808
200811
200903
200906
200909
200912
201003
201006
201009
201012
201103
201106
AURA
G6
GMX-380
GMX-386

2013CY Warranty Methodology

139,689 VINs including duplicates

A. Total of 19 warranty labor codes verbatim were read that indicated that the claim was related to the loss/malfunction of the brake/stop lamps.

5,943


36 Months - 5943 claims
Cummulative IPTV
80
70
60
50
40
30
20
10
0
200305
200308
200311
200402
200405
200408
200411
200502
200505
200508
200511
200602
200605
200608
200611
200702
200705
200708
200711
200802
200805
200808
200811
200903
200906
200909
200912
201003
201006
201009
201012
201103
201106
Aura
G6
GMX-380
GMX-386

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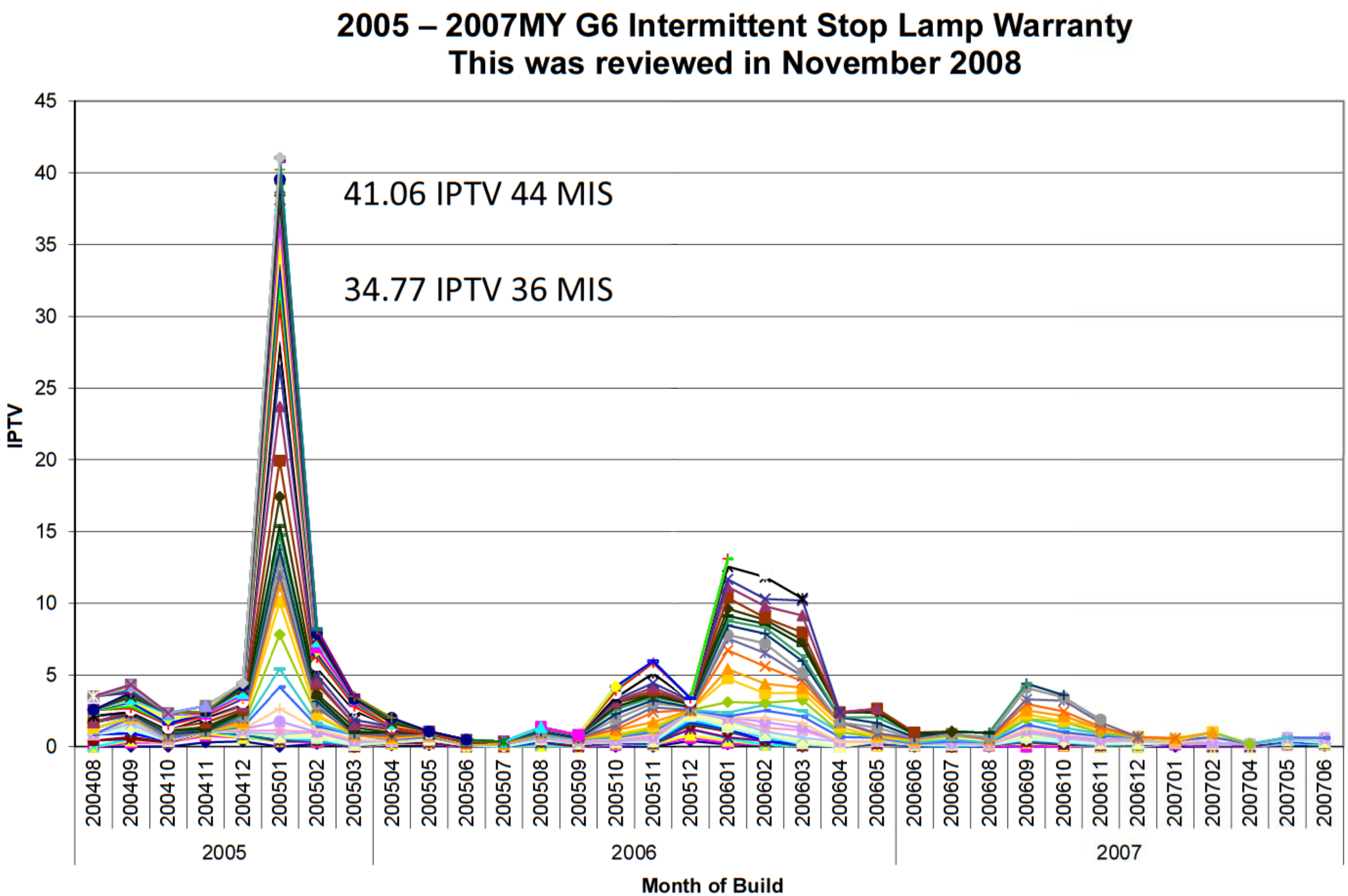
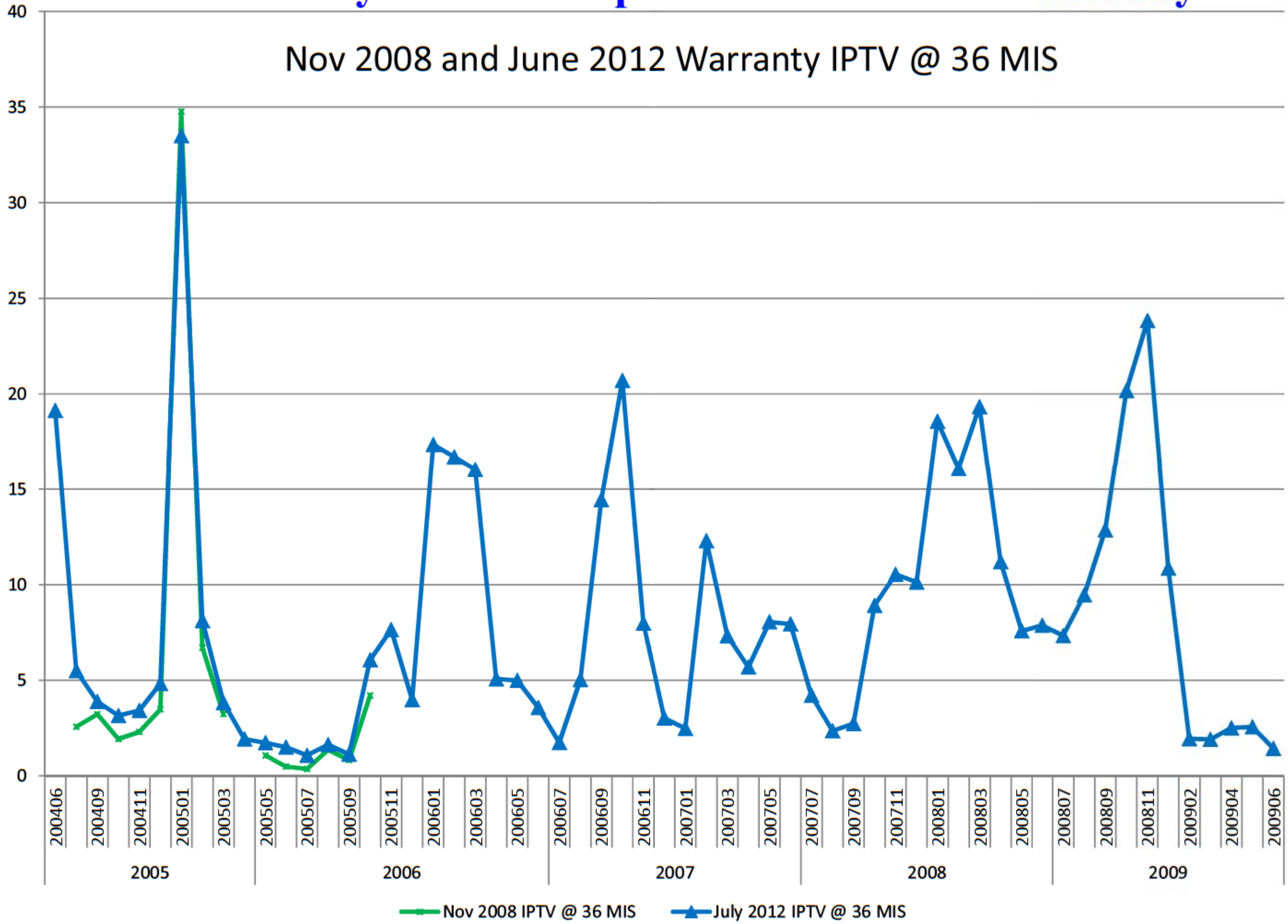
Intermittently Brake Lamps Do Not Function Correctly



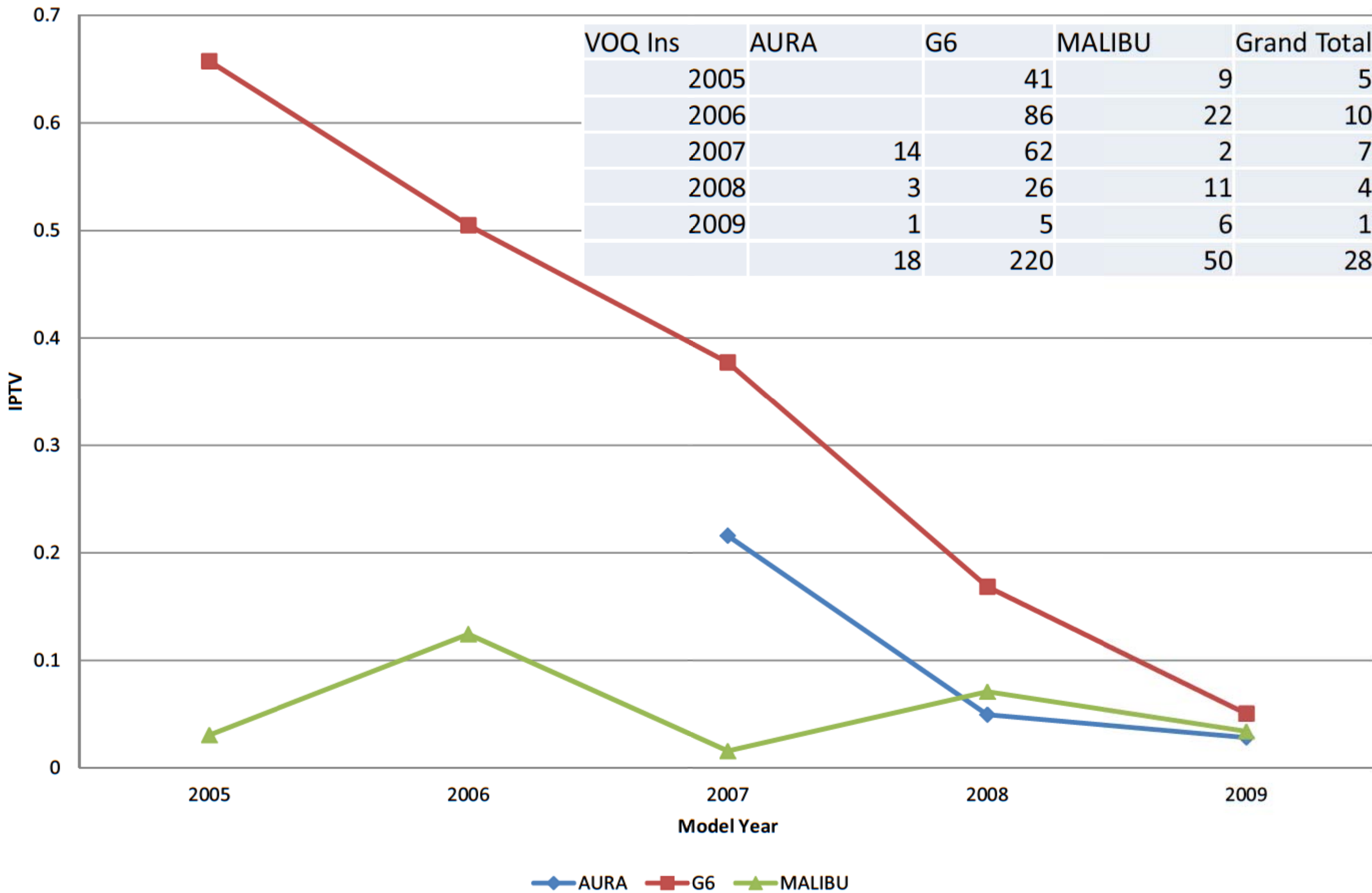
Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly

2005-09MY G6, Mailbu and 2007-09MY Aura
Stop Lamp VOQ IPTV for US only

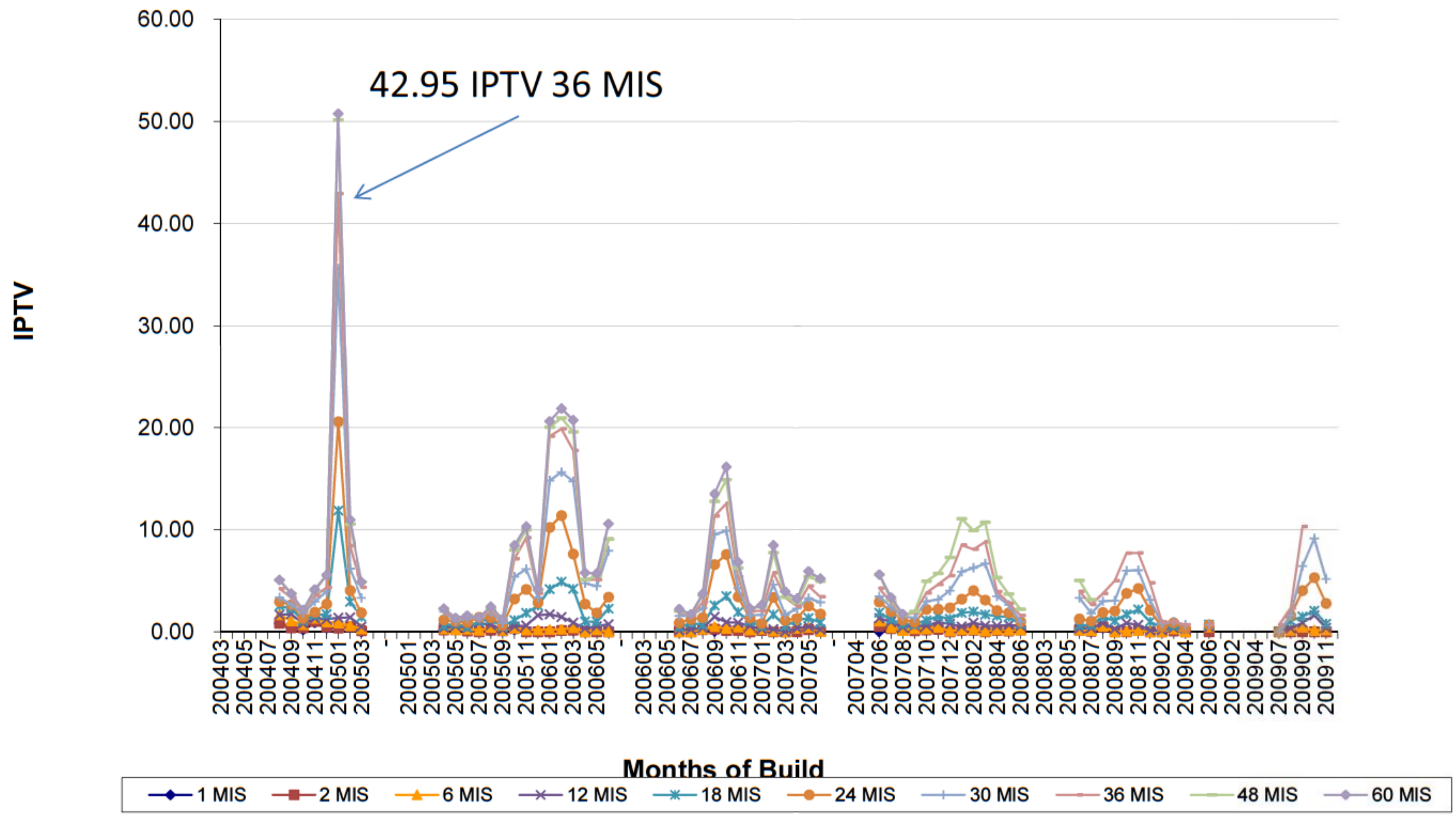
VOQ Ins	AURA	G6	MALIBU	Grand Total
2005		41	9	50
2006		86	22	108
2007	14	62	2	78
2008	3	26	11	40
2009	1	5	6	12
	18	220	50	288



Intermittently Brake Lamps Do Not Function Correctly

2005-2009MY Pontiac G6 Stop Lamp

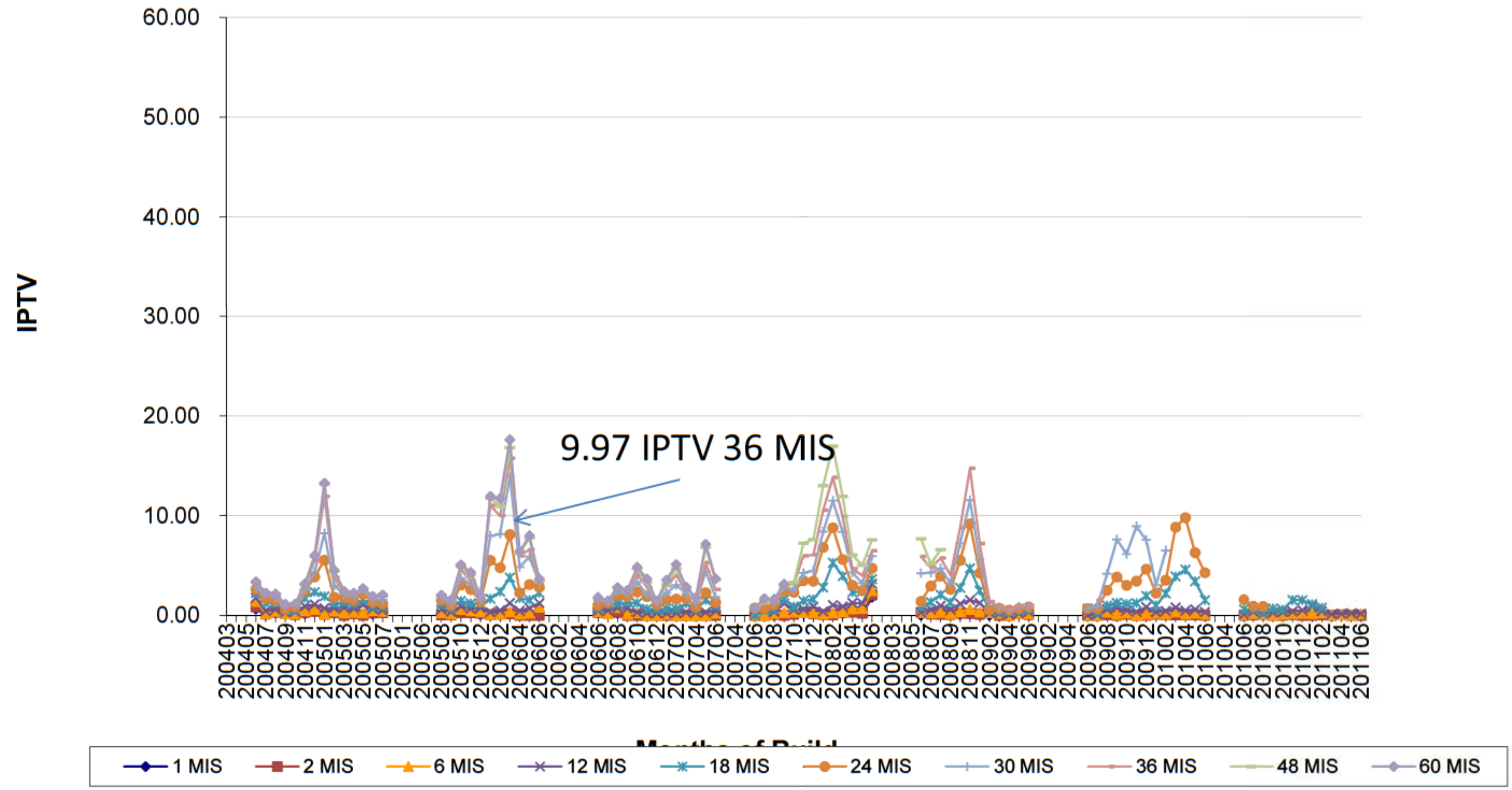
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

2005-2011MY Chevrolet Malibu Stop Lamp

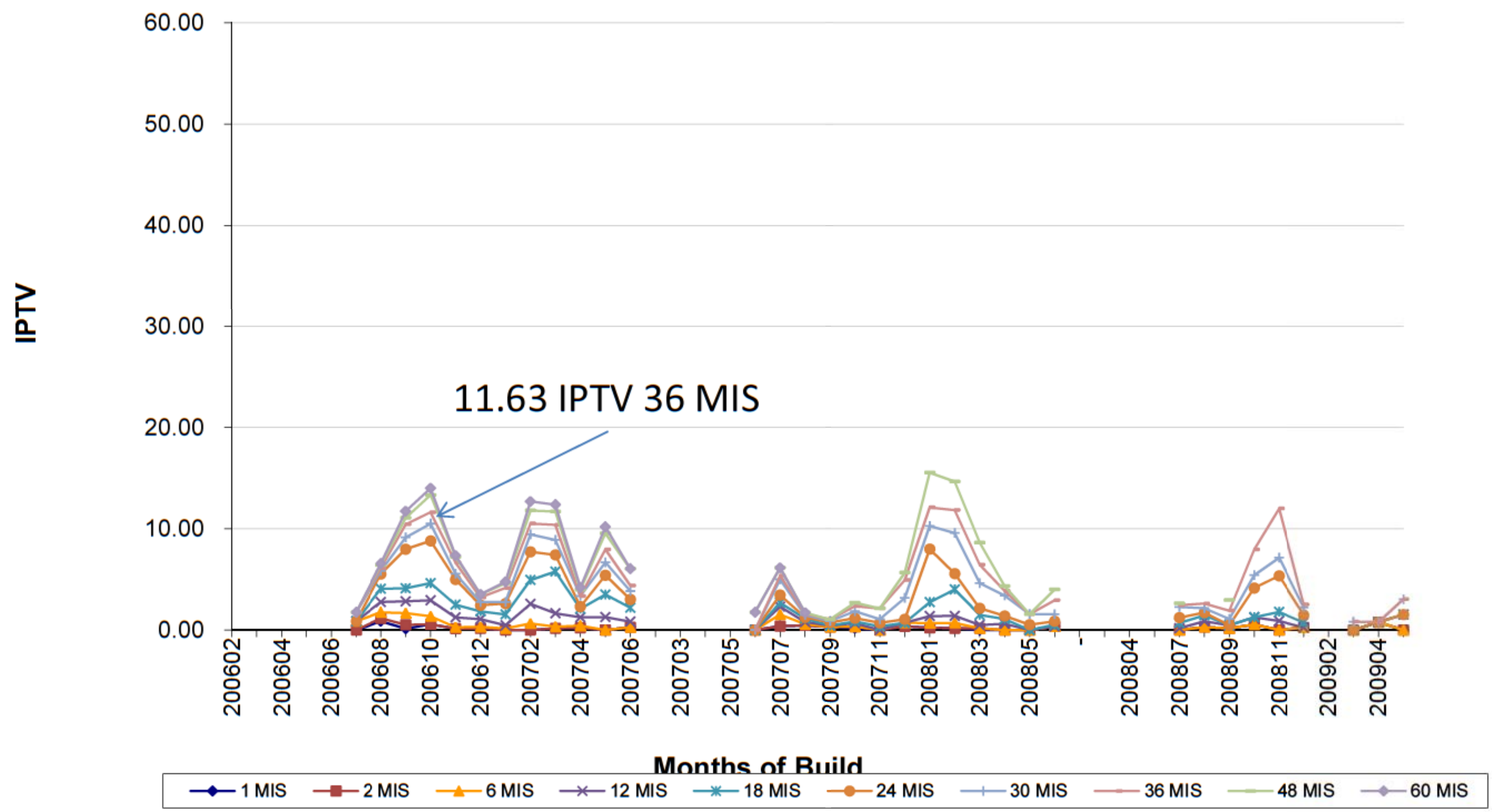
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Intermittently Brake Lamps Do Not Function Correctly

2007-2009MY Saturn Aura Stop Lamp

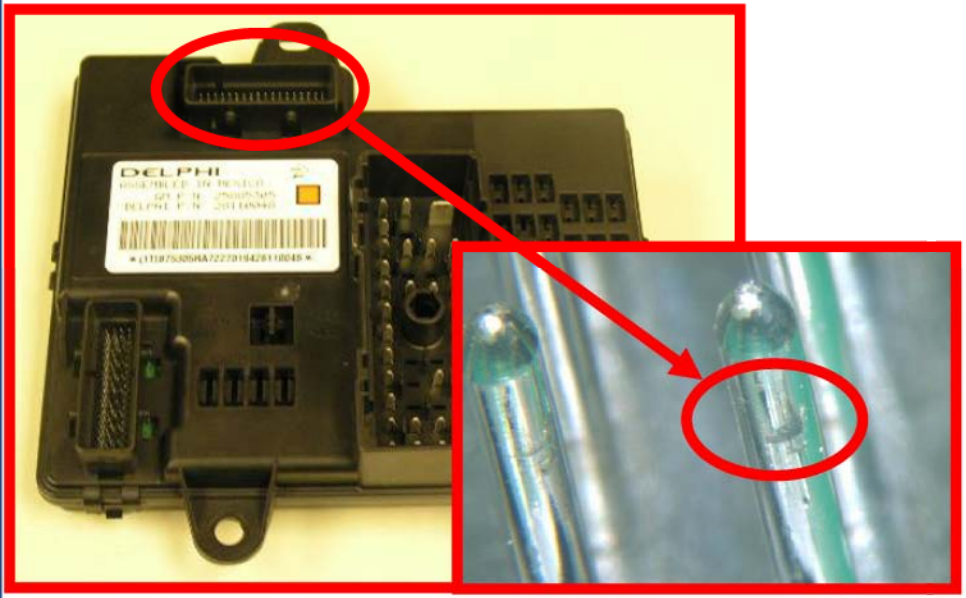
H2642 Brake Pedal Position Sensor Replacement Warranty IPTV in Month of Build



Back-up

Intermittently Brake Lamps Do Not Function Correctly

Condition: Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.



Potential Field Action: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

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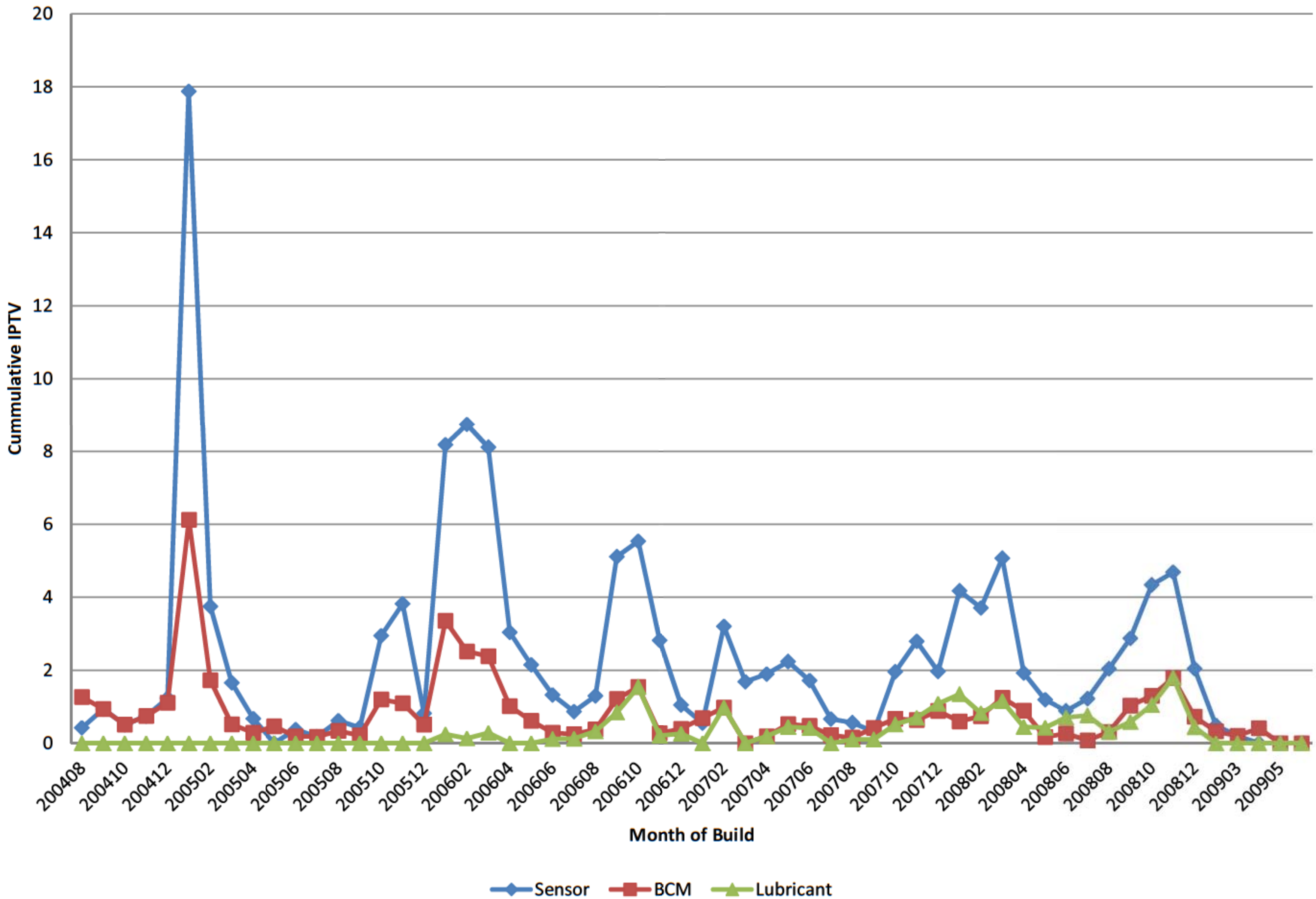
G6 claims by part number in 36 MIS



Population

2005 – 2009MY Pontiac G6: 619,000

Excluding campaign population (Jan 2005) and vehicles built after February 2009 (grease applied).

2005	54,443
2006	170,255
2007	164,260
2008	154,323
2009	75,484
Grand Total	618,765

2005 – 2009MY Epsilon: 1.7M

Population	Aura	G6	Malibu	Grand Total
2005		62,360	294,833	357,193
2006		170,338	176,916	347,254
2007	64,847	164,260	127,660	356,767
2008	60,717	154,323	155,225	370,265
2009	35,472	99,216	176,689	311,377
	161,036	650,497	931,323	1,742,856

Intermittently Brake Lamps Do Not Function Correctly

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.

Closing Resume

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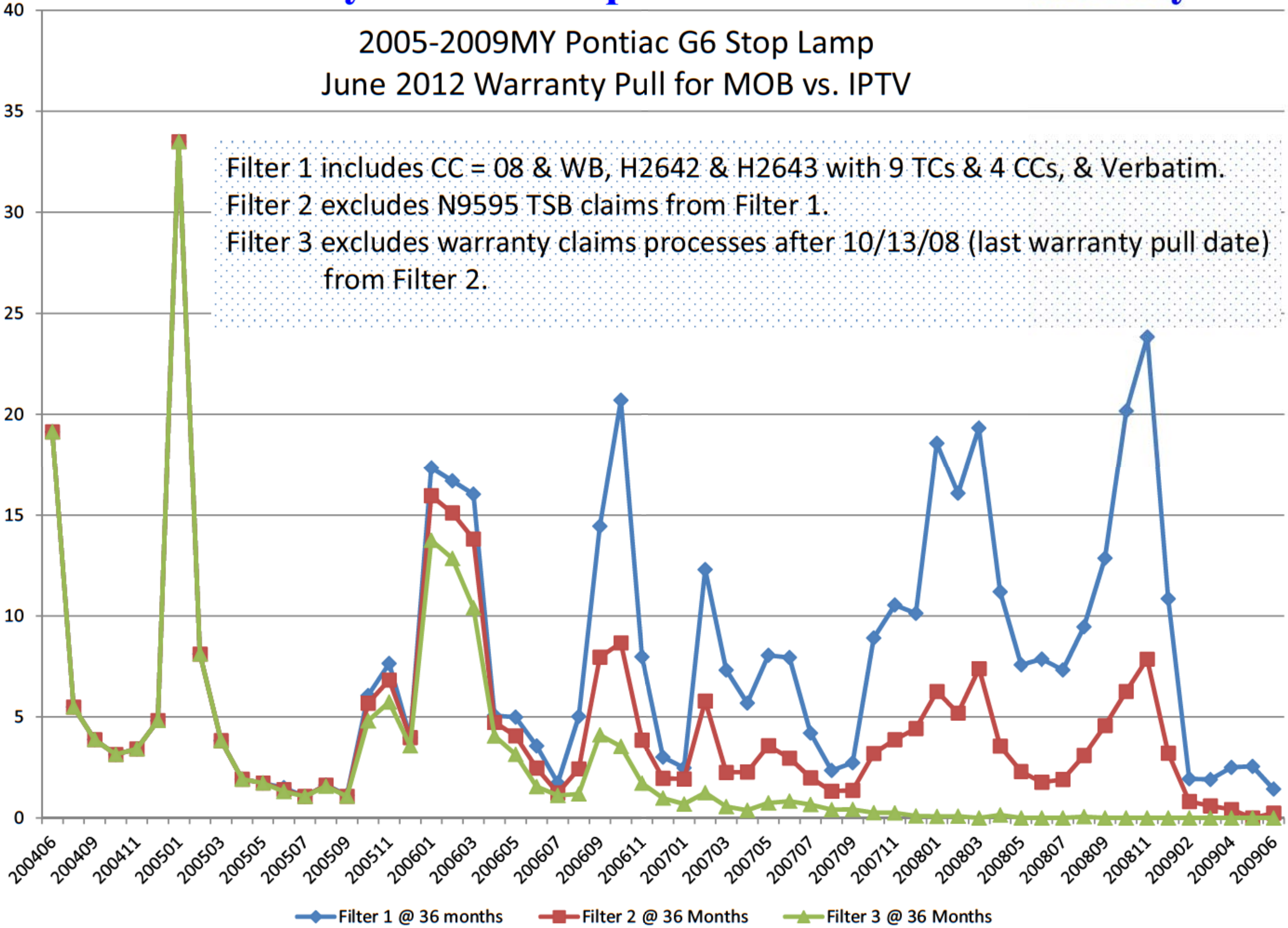
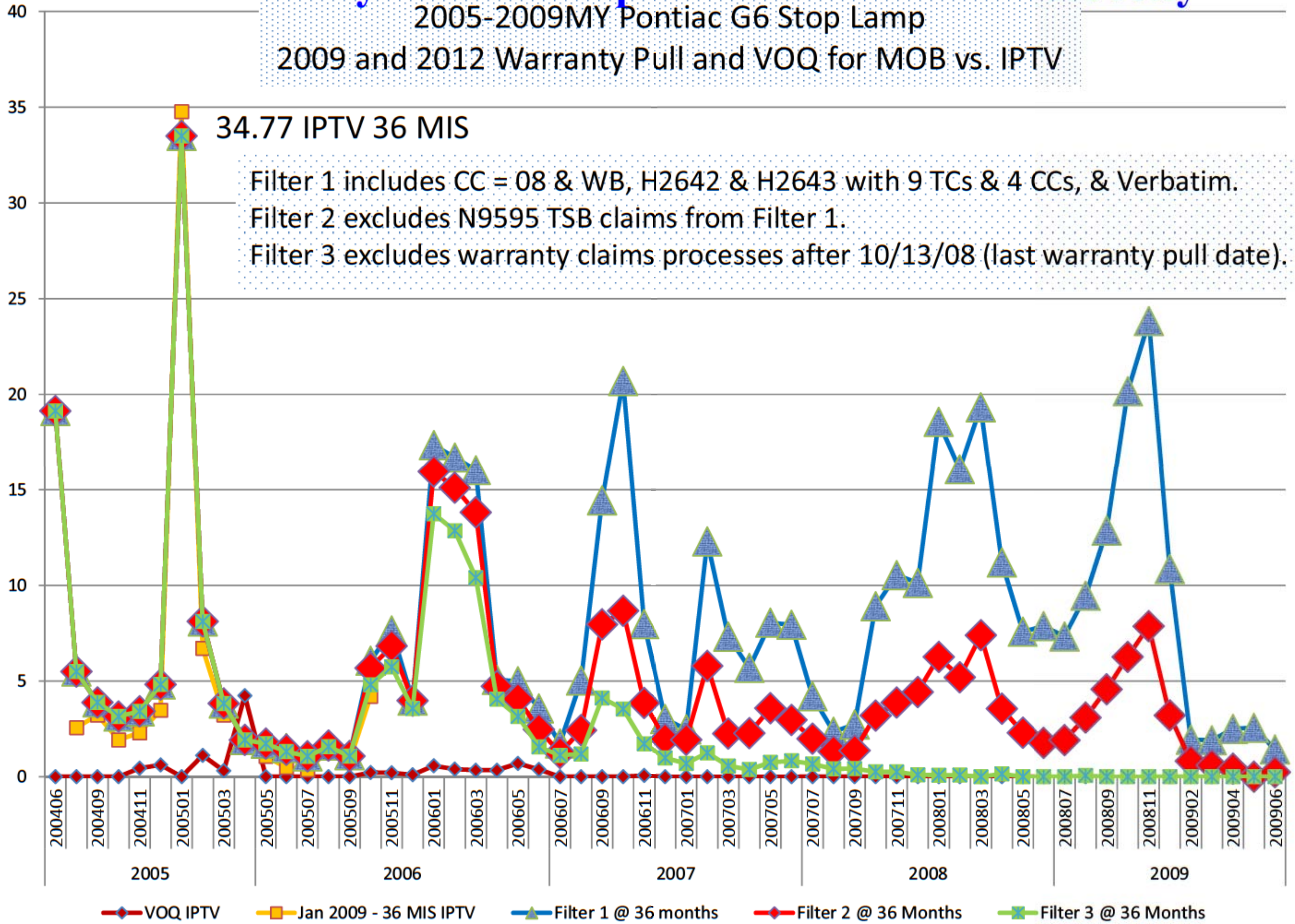
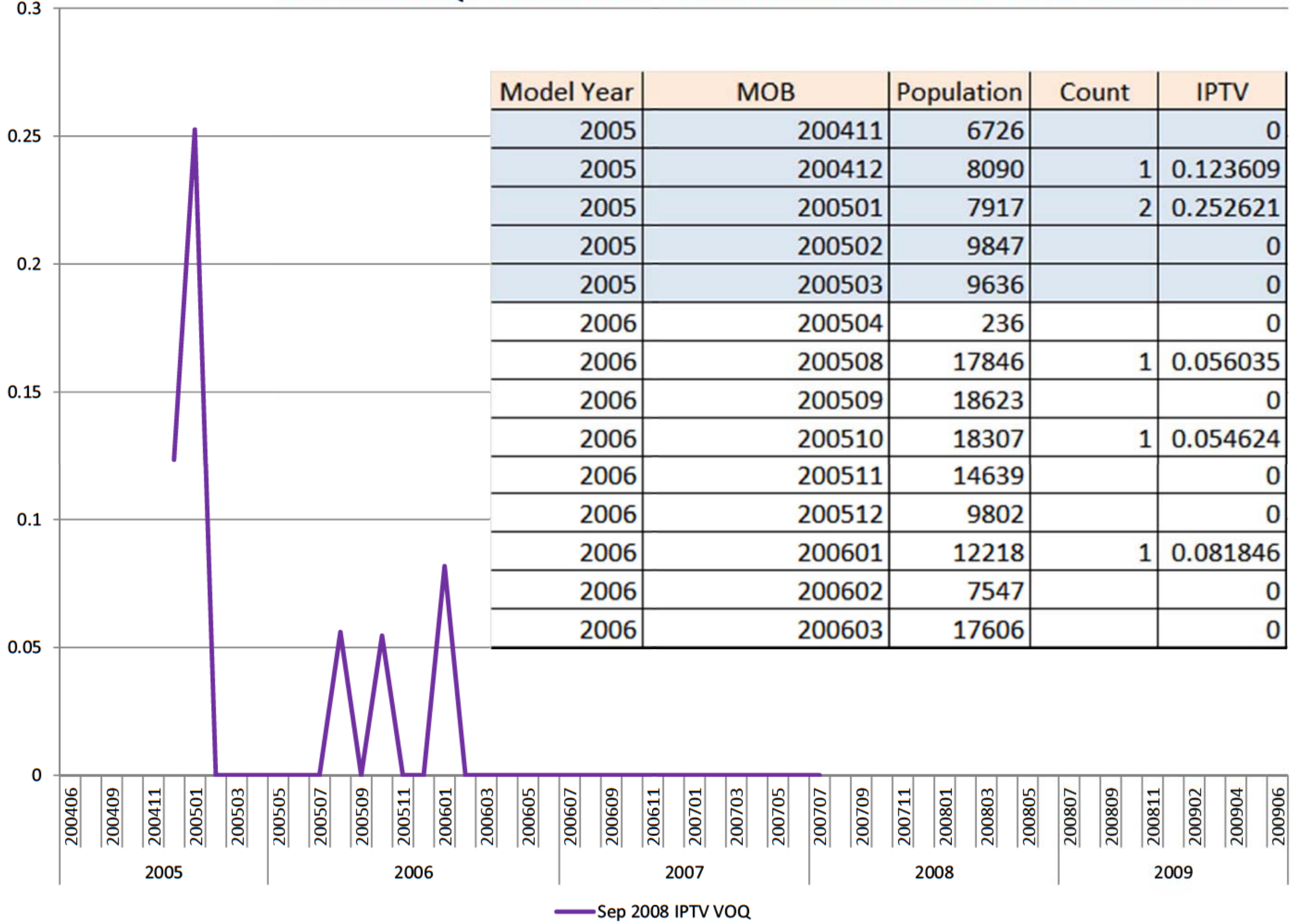
Intermittently Brake Lamps Do Not Function Correctly



Intermittently Brake Lamps Do Not Function Correctly



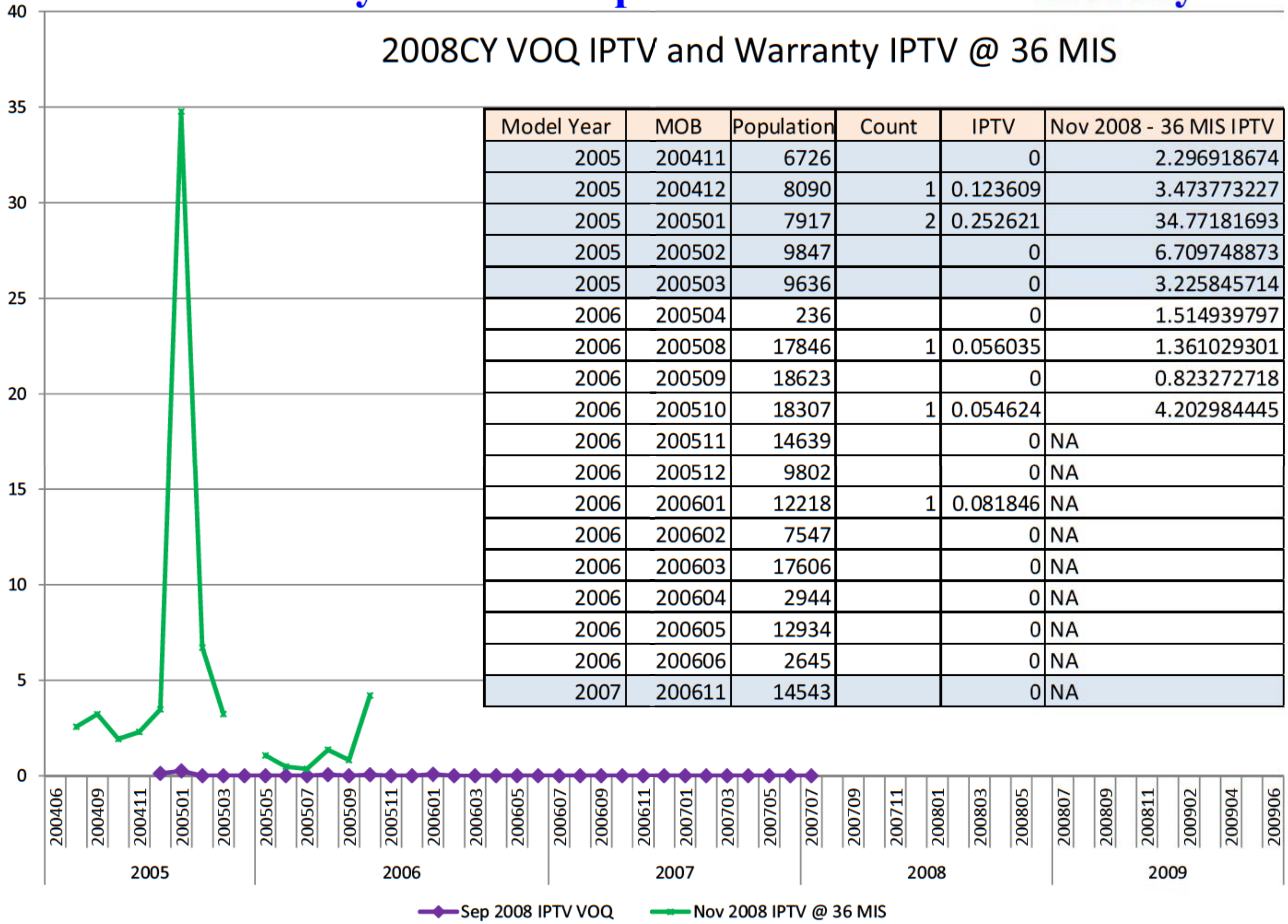
2008CY Unfiltered VOQs Received: 9 VINs Received and 6 VINs Identified



Model Year	MOB	Population	Count	IPTV
2005	200411	6726		0
2005	200412	8090	1	0.123609
2005	200501	7917	2	0.252621
2005	200502	9847		0
2005	200503	9636		0
2006	200504	236		0
2006	200508	17846	1	0.056035
2006	200509	18623		0
2006	200510	18307	1	0.054624
2006	200511	14639		0
2006	200512	9802		0
2006	200601	12218	1	0.081846
2006	200602	7547		0
2006	200603	17606		0

Intermittently Brake Lamps Do Not Function Correctly

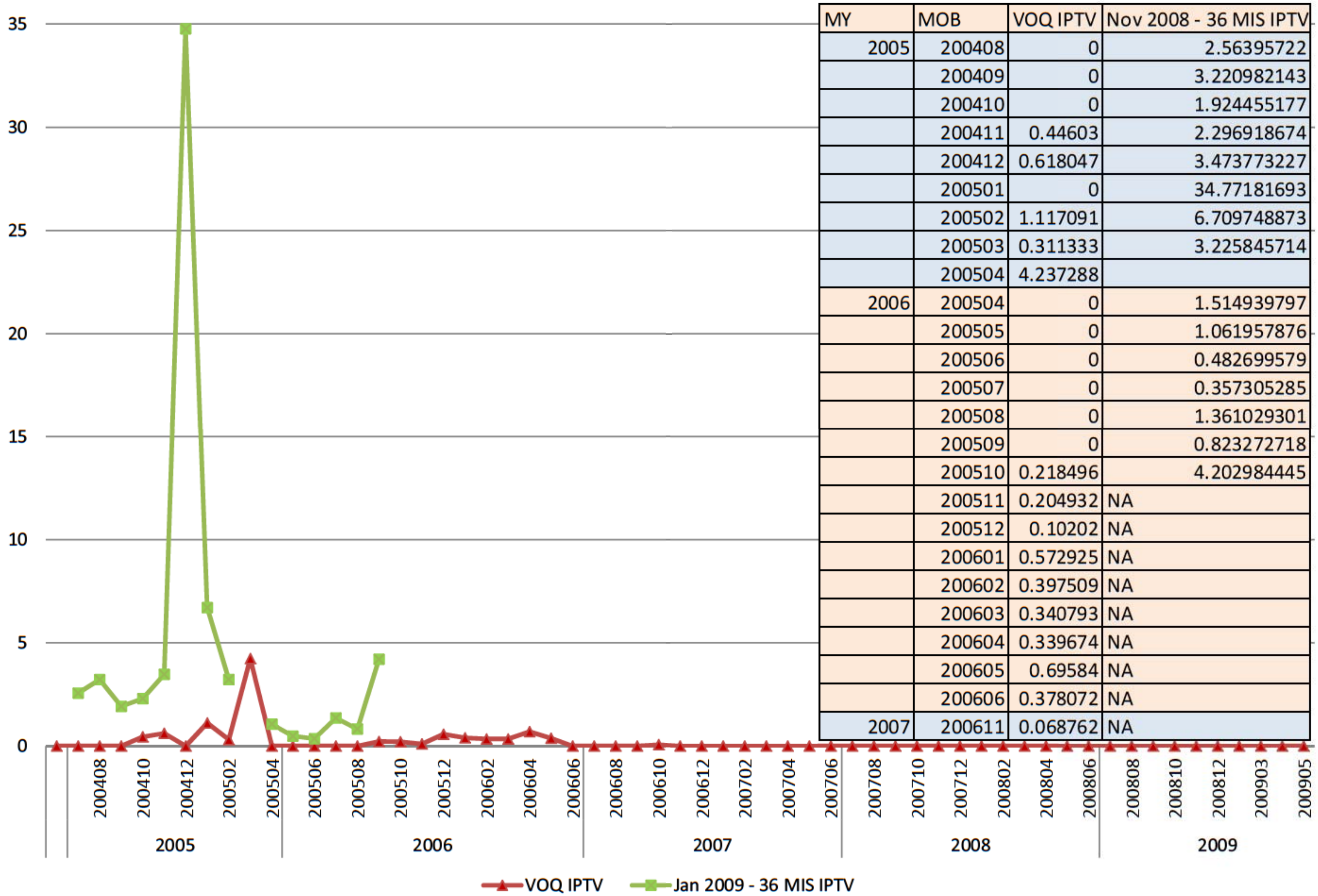
2008CY VOQ IPTV and Warranty IPTV @ 36 MIS



Model Year	MOB	Population	Count	IPTV	Nov 2008 - 36 MIS IPTV
2005	200411	6726		0	2.296918674
2005	200412	8090	1	0.123609	3.473773227
2005	200501	7917	2	0.252621	34.77181693
2005	200502	9847		0	6.709748873
2005	200503	9636		0	3.225845714
2006	200504	236		0	1.514939797
2006	200508	17846	1	0.056035	1.361029301
2006	200509	18623		0	0.823272718
2006	200510	18307	1	0.054624	4.202984445
2006	200511	14639		0	NA
2006	200512	9802		0	NA
2006	200601	12218	1	0.081846	NA
2006	200602	7547		0	NA
2006	200603	17606		0	NA
2006	200604	2944		0	NA
2006	200605	12934		0	NA
2006	200606	2645		0	NA
2007	200611	14543		0	NA

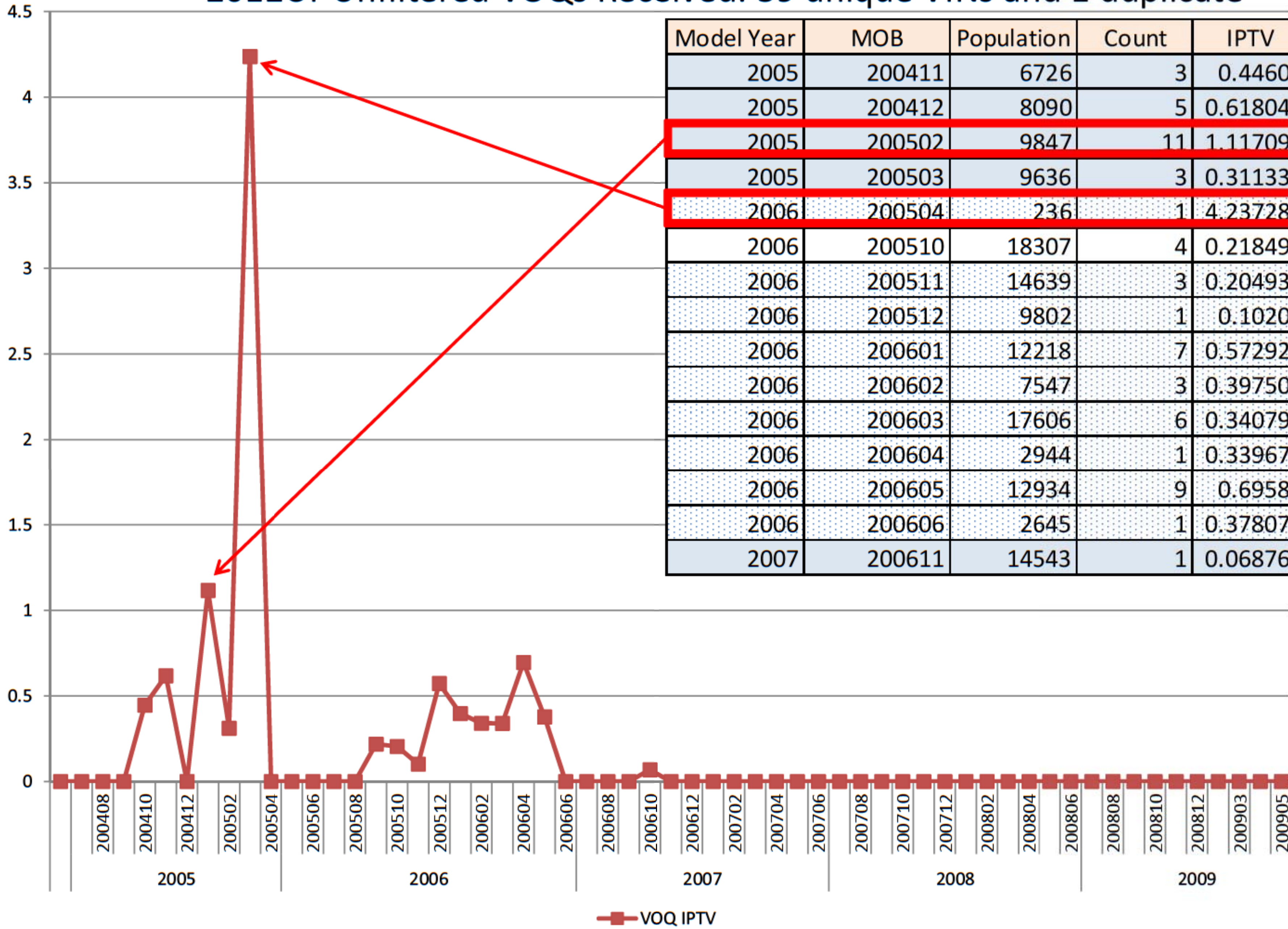
Intermittently Brake Lamps Do Not Function Correctly

2012 VOQ and Nov 08 Warranty IPTV @ 36MIS Trend line



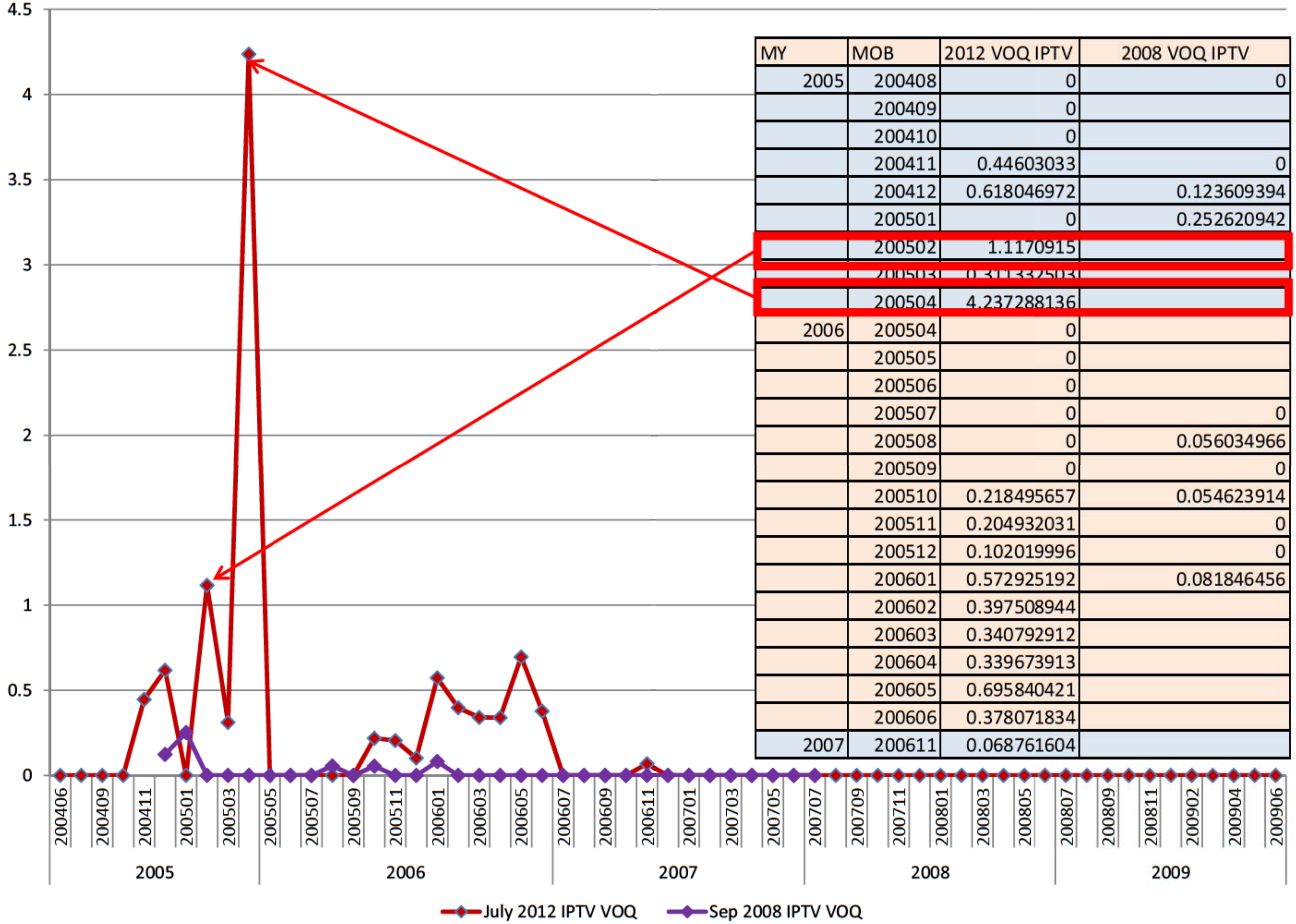
MY	MOB	VOQ IPTV	Nov 2008 - 36 MIS IPTV
2005	200408	0	2.56395722
	200409	0	3.220982143
	200410	0	1.924455177
	200411	0.44603	2.296918674
	200412	0.618047	3.473773227
	200501	0	34.77181693
	200502	1.117091	6.709748873
	200503	0.311333	3.225845714
	200504	4.237288	
2006	200504	0	1.514939797
	200505	0	1.061957876
	200506	0	0.482699579
	200507	0	0.357305285
	200508	0	1.361029301
	200509	0	0.823272718
	200510	0.218496	4.202984445
	200511	0.204932	NA
	200512	0.10202	NA
	200601	0.572925	NA
	200602	0.397509	NA
	200603	0.340793	NA
	200604	0.339674	NA
	200605	0.69584	NA
	200606	0.378072	NA
2007	200611	0.068762	NA

2012CY Unfiltered VOQs Received: 59 unique VINs and 1 duplicate



Model Year	MOB	Population	Count	IPTV
2005	200411	6726	3	0.44603
2005	200412	8090	5	0.618047
2005	200502	9847	11	1.117091
2005	200503	9636	3	0.311333
2006	200504	236	1	4.237288
2006	200510	18307	4	0.218496
2006	200511	14639	3	0.204932
2006	200512	9802	1	0.10202
2006	200601	12218	7	0.572925
2006	200602	7547	3	0.397509
2006	200603	17606	6	0.340793
2006	200604	2944	1	0.339674
2006	200605	12934	9	0.69584
2006	200606	2645	1	0.378072
2007	200611	14543	1	0.068762

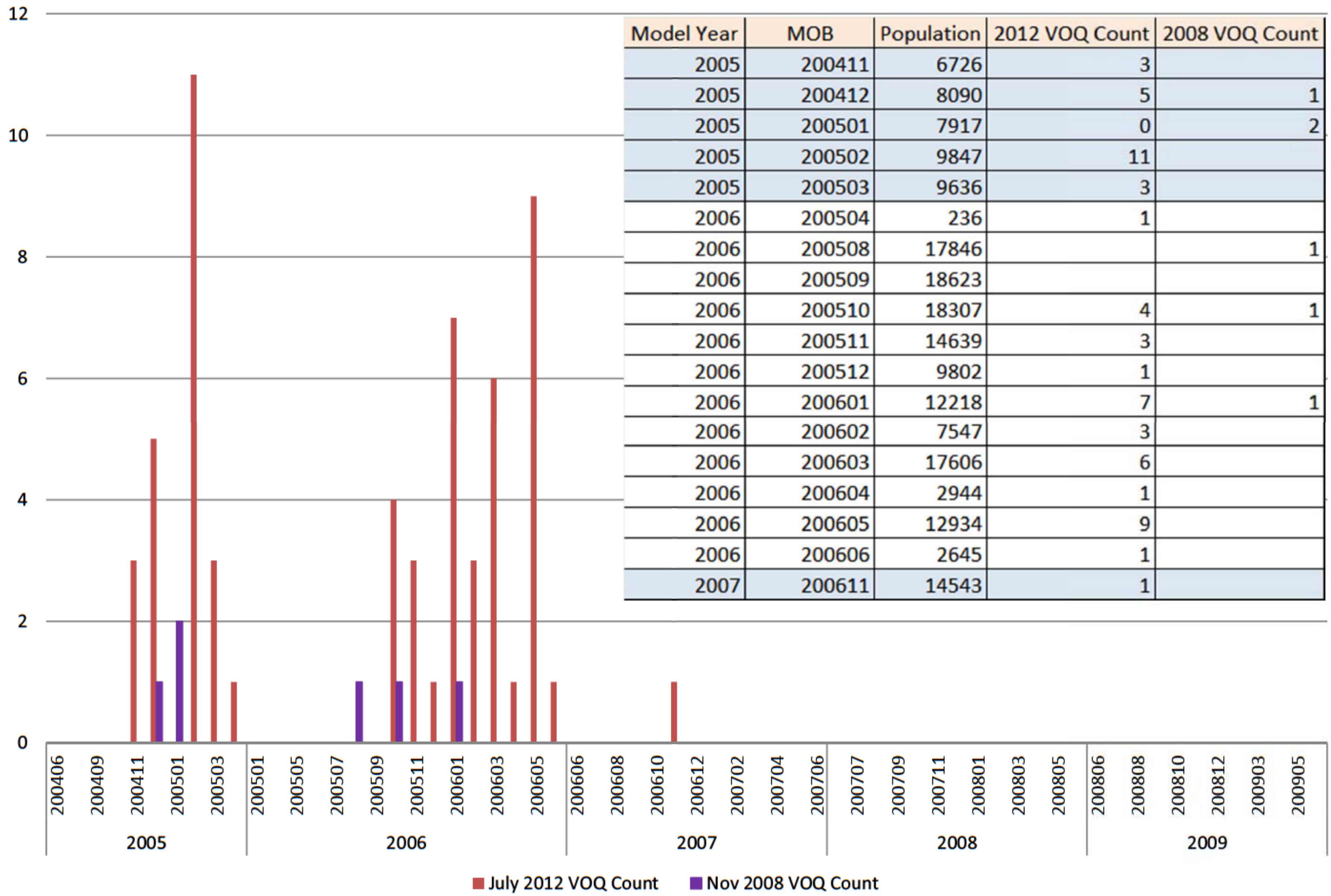
Nov 2008 and June 2012 VOQ IPTV



MY	MOB	2012 VOQ IPTV	2008 VOQ IPTV
2005	200408	0	0
	200409	0	
	200410	0	
	200411	0.44603033	0
	200412	0.618046972	0.123609394
	200501	0	0.252620942
	200502	1.1170915	
	200503	0.311332503	
	200504	4.237288136	
2006	200504	0	
	200505	0	
	200506	0	
	200507	0	0
	200508	0	0.056034966
	200509	0	0
	200510	0.218495657	0.054623914
	200511	0.204932031	0
	200512	0.102019996	0
	200601	0.572925192	0.081846456
	200602	0.397508944	
	200603	0.340792912	
	200604	0.339673913	
	200605	0.695840421	
	200606	0.378071834	
2007	200611	0.068761604	

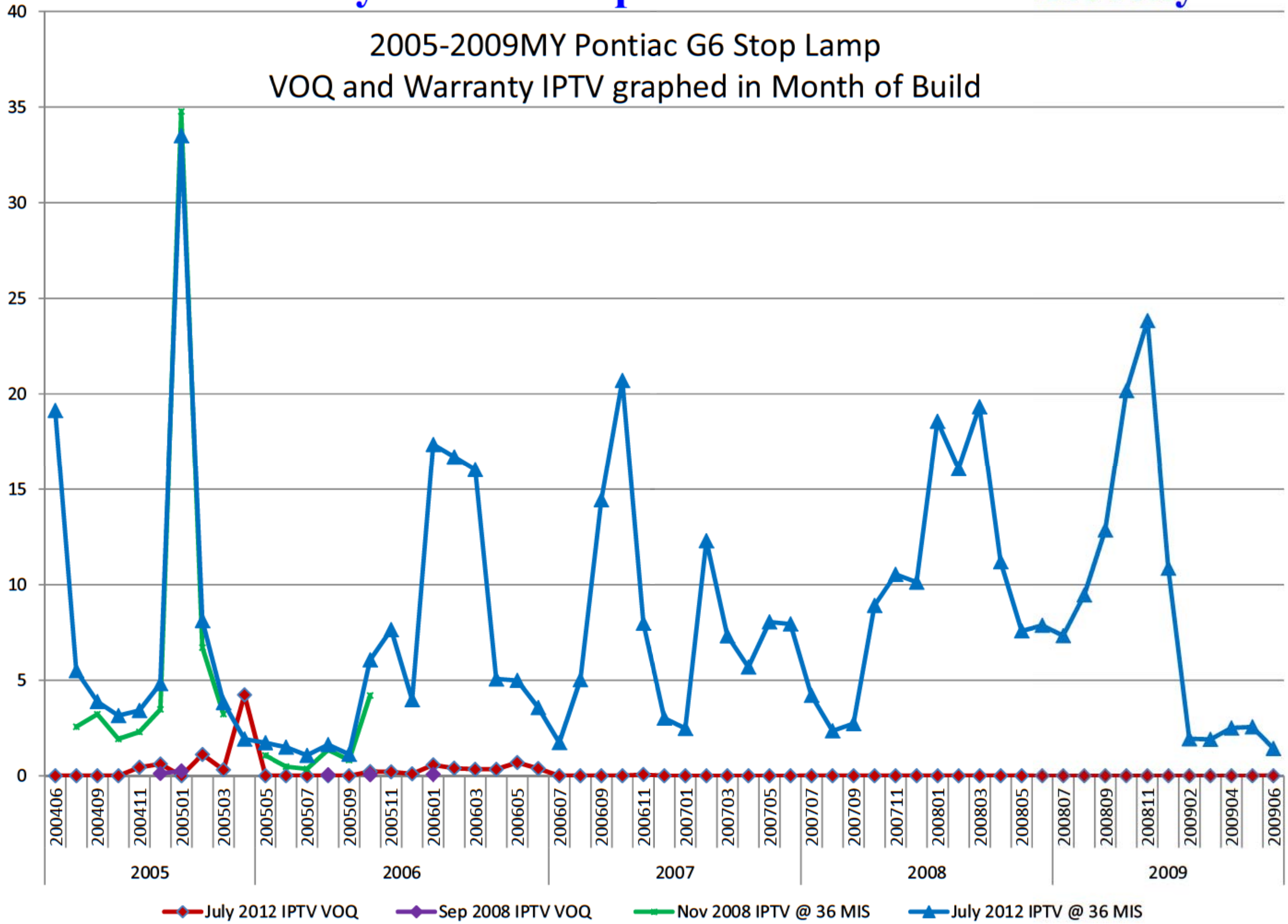
Intermittently Brake Lamps Do Not Function Correctly

VOQ Count Comparison: 2008 (6) vs 2012 (59)



Model Year	MOB	Population	2012 VOQ Count	2008 VOQ Count
2005	200411	6726	3	
2005	200412	8090	5	1
2005	200501	7917	0	2
2005	200502	9847	11	
2005	200503	9636	3	
2006	200504	236	1	
2006	200508	17846		1
2006	200509	18623		
2006	200510	18307	4	1
2006	200511	14639	3	
2006	200512	9802	1	
2006	200601	12218	7	1
2006	200602	7547	3	
2006	200603	17606	6	
2006	200604	2944	1	
2006	200605	12934	9	
2006	200606	2645	1	
2007	200611	14543	1	

Intermittently Brake Lamps Do Not Function Correctly



2012CY Update of G6 Stop Lamp Warranty Claims

2012CY Warranty Methodology

Started with 27,821 — 11,852 had correction-verbatim (42.6%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	10,316 (37.1)	363 (20.7)
H2642 Sensor, Brake Pedal	4,643 (16.7)	1,203 (68.6)
H2643 Sonsor, Brake & Accel	420 (1.5)	144 (8.2)
H2640 Pedal / Bushing	418(1.5)	7 (0.4)
H9991 Cust Concern NTF	8,531(30.7)	36 (2.1)
N9595 TSB	3,493 (12.6)	0
Total	27,821	1,753 (6.3)

2012CY Warranty Methodology

27,821 including 243 same day repair duplicates

A. All claims with labor code N9595 were determined to be responsive to the alleged condition.

3,490

B. All claims with customer codes 08 (Operation: Won't Turn Off) and WB (Warning Lights-Brake Lights) were determined to be responsive to the alleged condition unless the verbatim text indicated that the claim was unrelated.

C. Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 2.7 and customer codes in Table 2.8 were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.

D. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.

20,167 (B–D)

E. The vehicle claims processed after 10/13/08 are excluded to compare with the original data.

2,168

F. All claims for vehicles covered by General Motors recall 08317 were excluded. 6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%

1,753

2009CY Update Methodology

Started with 8,978 | 2,362 had verbatim (26.3%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	6,758 (75.3)	274 (17.5)
H2642 Sensor, Brake Pedal	1,984 (22.1)	1,157 (74)
H2643 Sonsor, Brake & Accel	227 (2.5)	125 (8)
H2640 Pedal / Bushing	6 (0)	6 (0.4)
H9991 Cust Concern NTF	3 (0)	3 (0.2)
Total	8,978	1,565 (17.4)

2009CY Update Methodology

For the subject vehicles, the regular warranty, goodwill warranty, and MIC service contract claims with stop lamp malfunction are summarized by model and model year in Table 5-1. For the subject vehicles the UWC service contract claims with indication of stop lamp malfunction are summarized by model and model year in Table 5-2. A summary of the warranty claims, including the information requested in 5(a-k), is provided on the ATT_1_GM disk; folder labeled "Q_05:" refer to the Microsoft Access 2000 file labeled "Q_05_WARRANTY DATA." A list of the labor codes, customer complaint codes and trouble codes used to collect the warranty data is provided in response to item No. 6.

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	Regular	579	754	232	1,565
Pontiac G6	MIC	43	25	2	70

TABLE 5-1: REGULAR WARRANTY AND MIC SERVICE CONTRACT CLAIMS WITH STOP LAMP MALFUNCTION

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	UWC	0	3	0	3

TABLE 5-2: UWC SERVICE CONTRACT CLAIMS

SOURCE SYSTEM	LAST DATE GATHERED
GART - regular warranty	13 Oct 08
MIC - service contract claims	14 Oct 08
UWC - service contract claims	23 Sept 08

TABLE 5-3: DATES PULLED

2009CY Update Methodology

8,969

The GM Global Analysis and Reporting Tool (GART-regular warranty) regular warranty database and the Motors Insurance Corp (MIC) service contract claims database were searched using the labor codes that may be related to the alleged defect, listed in Table 6-1. Universal Warranty Corporation (UWC) does not use labor codes or trouble codes.

The following process was used to sort these claims:

- 544 All claims with customer codes shown in Table 6-2 were determined to be responsive unless the verbatim indicated that the claim was unrelated.
- 6,800 Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 6-3 and customer codes in Table 6-4 were determined to be responsive unless the verbatim indicated that the claim was unrelated.
- 60 The verbatims of the remaining claims were then read and the claim was determined to be responsive if the verbatim related to the alleged defect.

1,565

2009CY Update Methodology

Labor Code	Description:
H2642	Sensor, Brake Pedal Position - Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
N4800	Body Control Module Replacement
H2640	Pedal And/Or Bushing, Brake - R&R Or Replace
H9991	Customer Concern Not Duplicated
N2700	Switch, Stop Lamp - Adjust
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement-Product Allegation
Z1243	Inspection-Product Allegation Resolution

Table 6-1 Labor Codes used in Warranty and MIC Search

Customer Code	Description:
O8	Operation: won't turn off
WB	Warning lights: brake light

Table 6-2 Customer Codes used in Warranty and MIC Sorting

Trouble Code	Description:
1D	Broken
6C	Component-inoperative
6D	Component -intermittent
6F	Component -Open
3A	Misadjusted
9Z	No Trouble Found
3L	Out of Calibration
3X	Registers Incorrectly
6N	Connector - Partial Connected

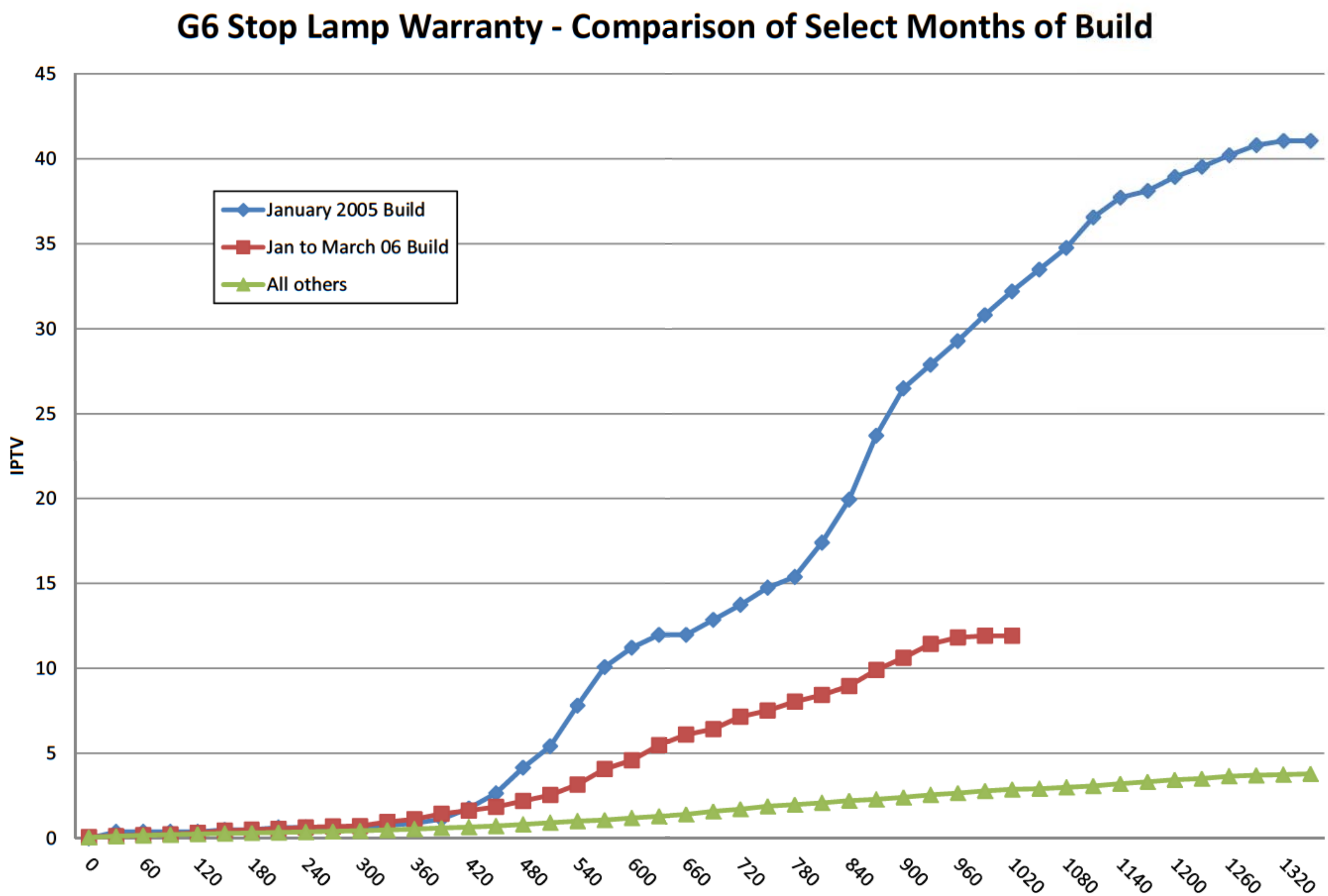
Table 6-3 Trouble Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Customer Code	Description:
OG	Operation: Excess Eff (Excess Play)
OJ	Operation: Inoperative (Harsh)
OF	Operation: Engage/Dis(Excess Eff)
O7	Operation: No Maintain Adj

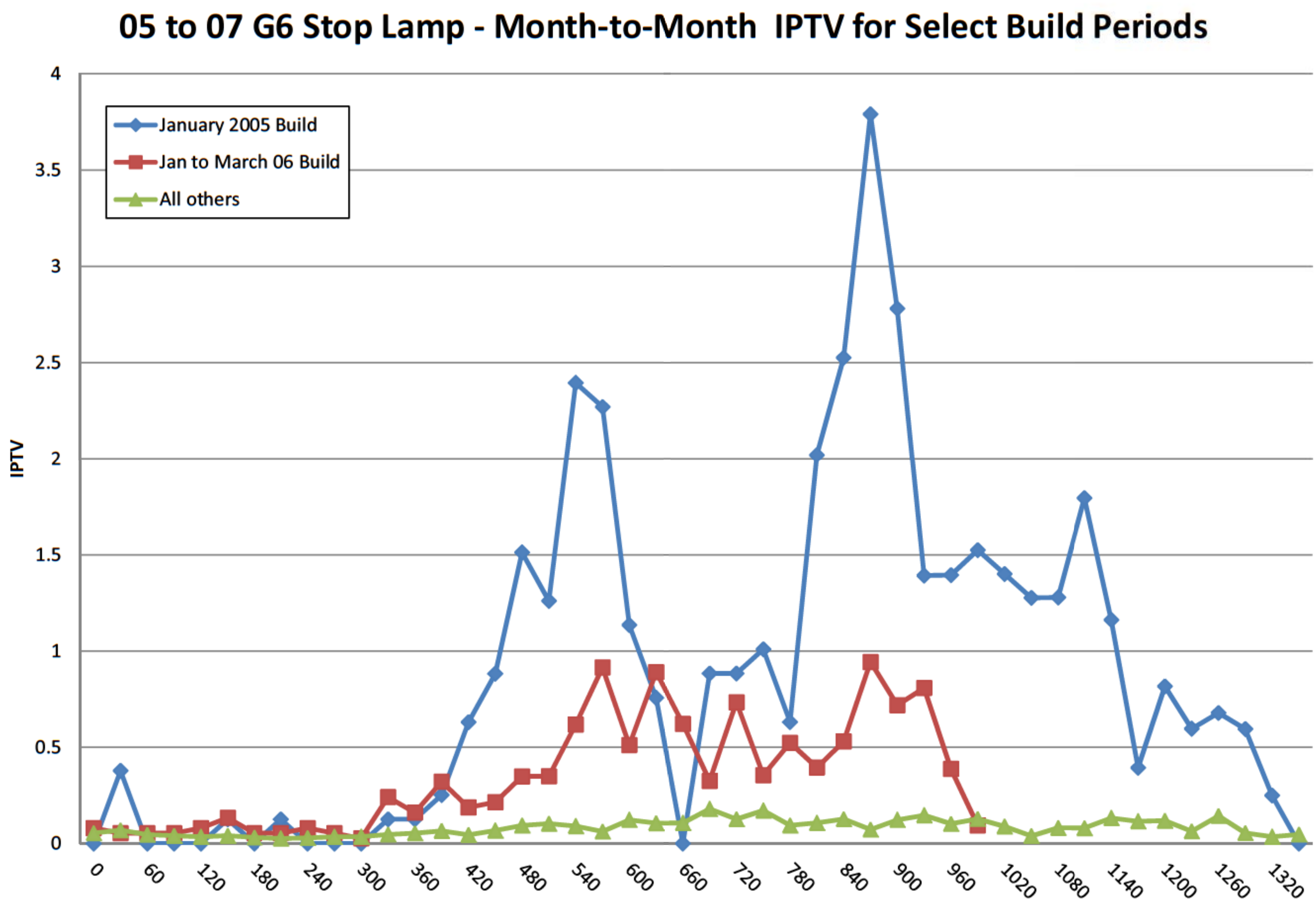
Table 6-4 Customer Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Rationale for 2009 Decision

Intermittently Brake Lamps Do Not Function Correctly

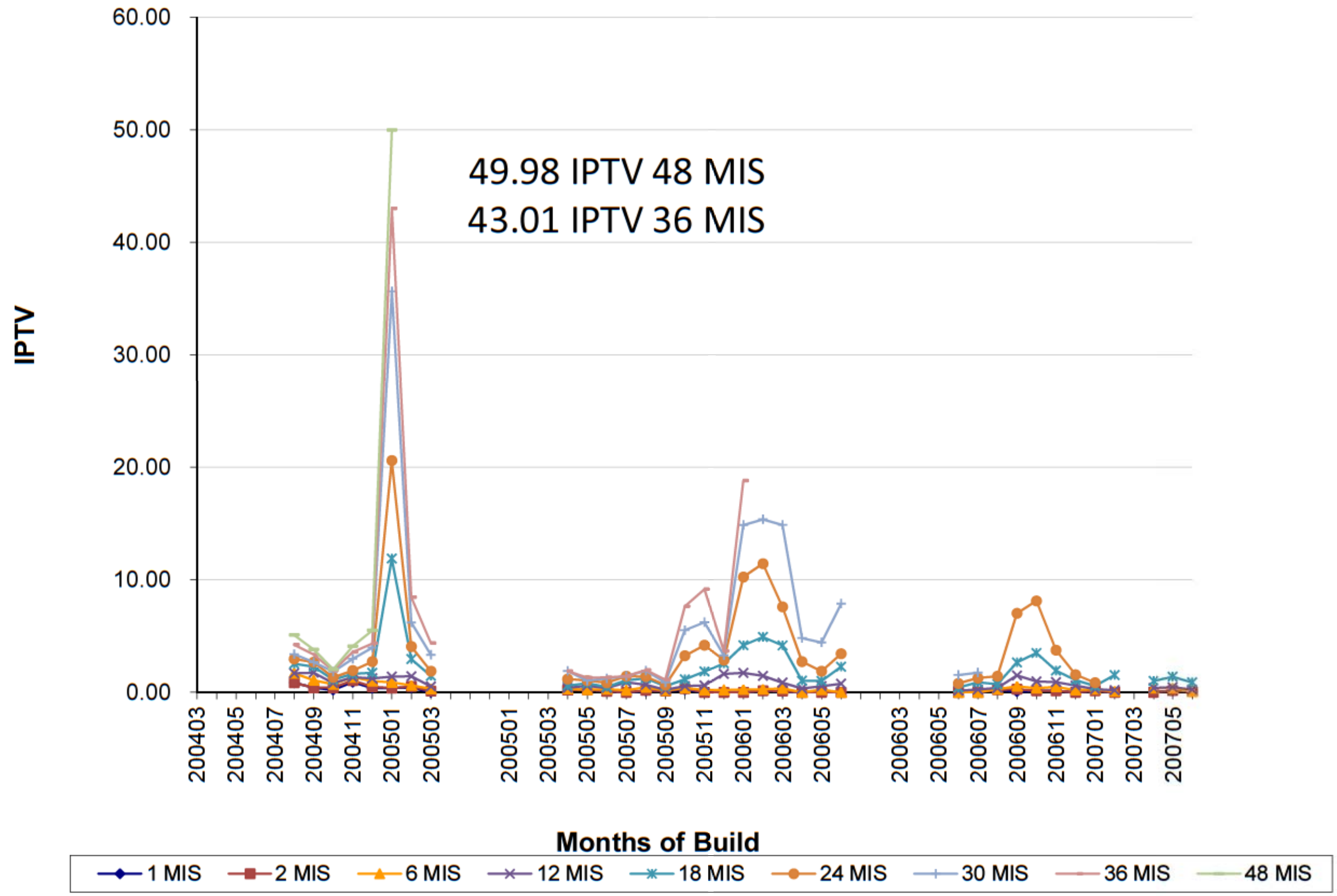


Intermittently Brake Lamps Do Not Function Correctly



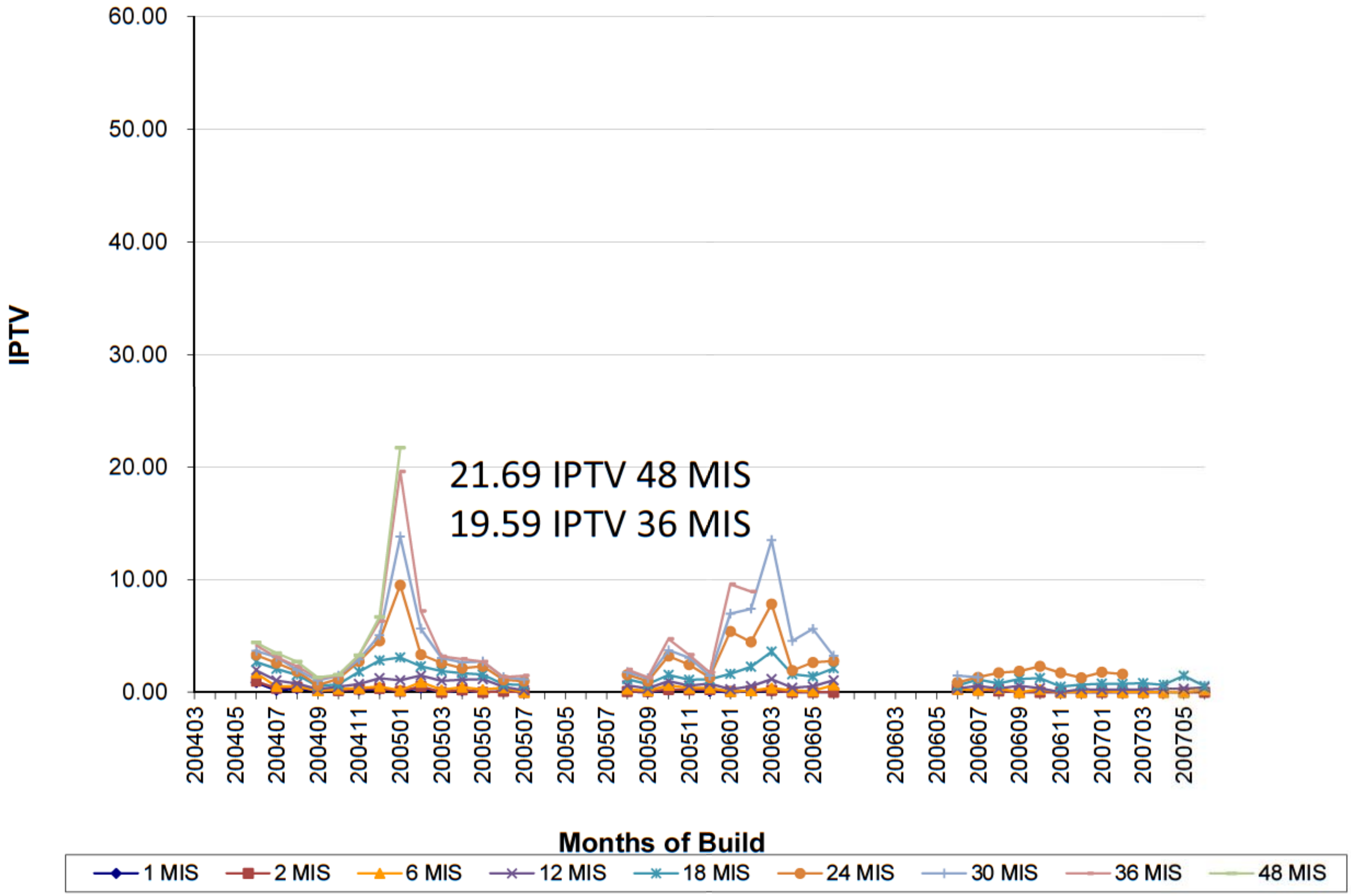
Intermittently Brake Lamps Do Not Function Correctly

Pontiac G6 Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



Intermittently Brake Lamps Do Not Function Correctly

Chevrolet Malibu Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



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Intermittently Brake Lamps Do Not Function Correctly

The Body Control Module with different electrical harness architecture is used for the following platforms:

2004MY	Malibu, XLR	
2005MY	G6, Cobalt, Corvette	
2006MY	HHR, Solstice	
2007MY	Sky, Opel GT, Aura	- NEW MICROPROCESSOR
2008MY	New Malibu	

Intermittently Brake Lamps Do Not Function Correctly

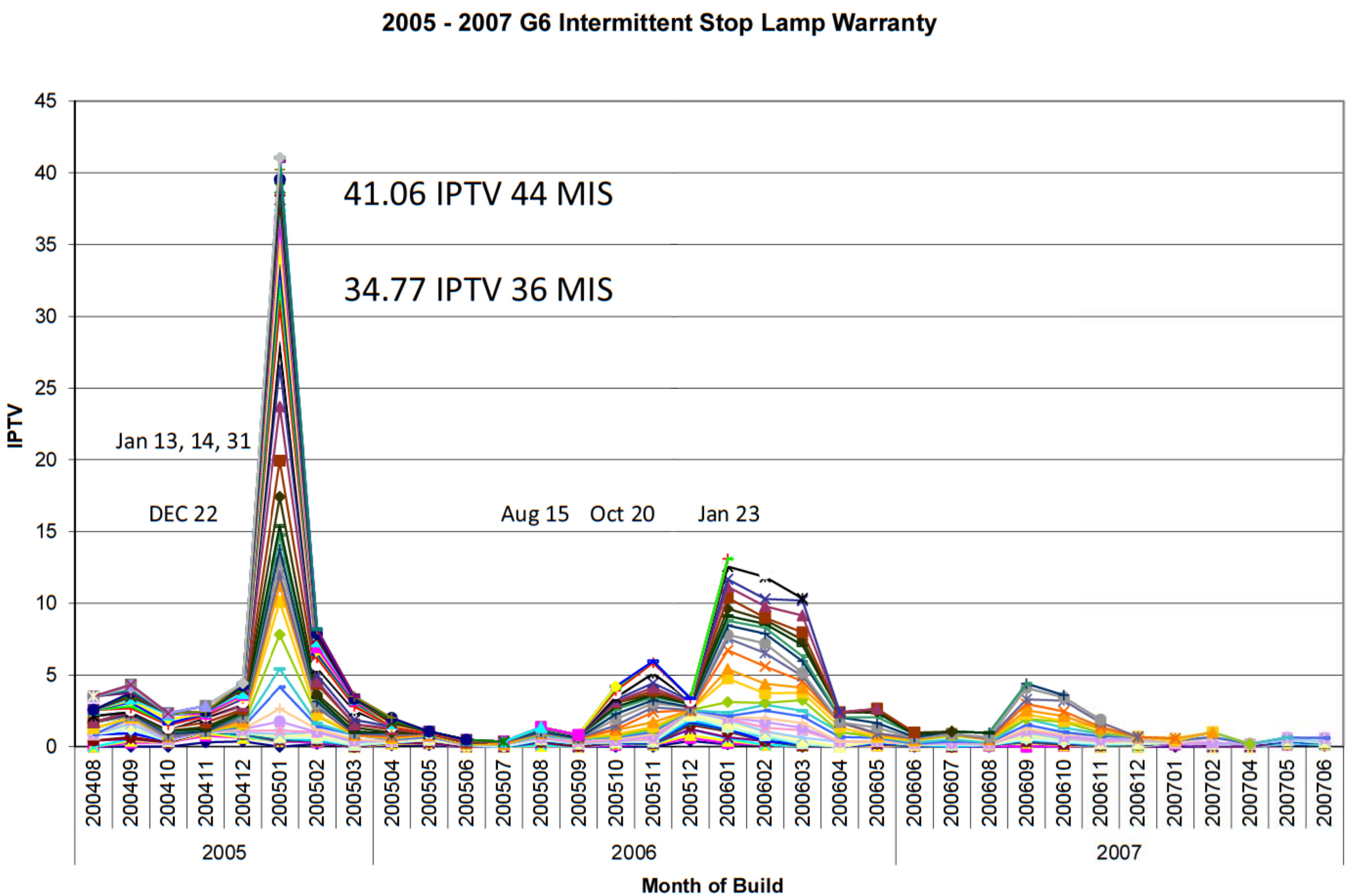
Technical Service Bulletin

#08-05-22-009: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTC C0161/C0277 Set (Perform Repair as Outlined) - (Dec 4, 2008)

Subject: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTCs C0161/C0277 Set (Perform Repair as Outlined)

Apply dielectric lubricant (clear gel) GM P/N 12377900 (In Canada, use P/N 10953529) on the BCM C2 pins (apply with a one-inch nylon bristle brush) on all the C2 connector pins (this will treat the pins against fretting corrosion).

Intermittently Brake Lamps Do Not Function Correctly



9 VOQs 2005MY: 4 2006MY: 4 2007MY: 1

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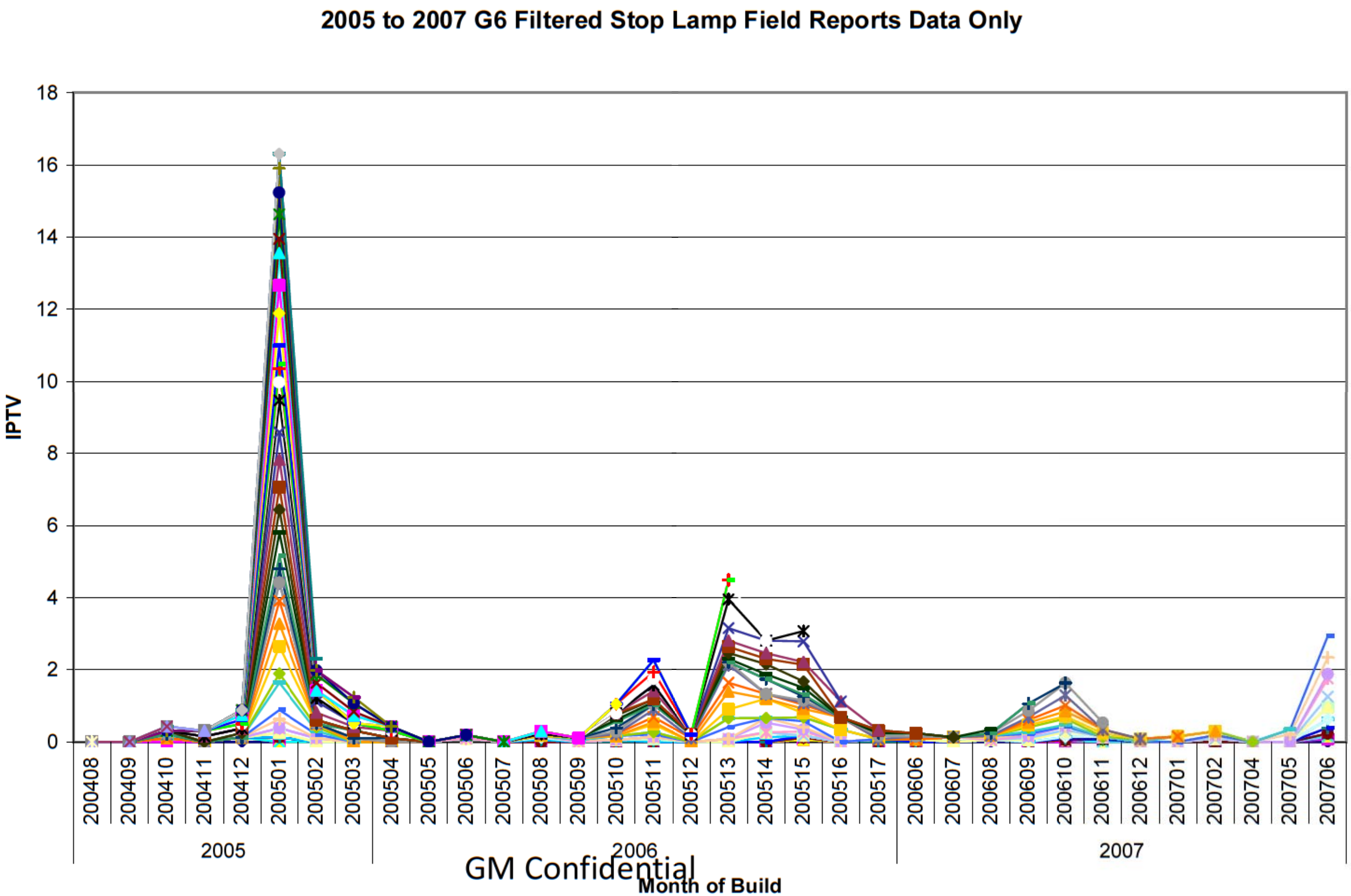
2005 - 2007 G6 BASS – TAC and CAC only



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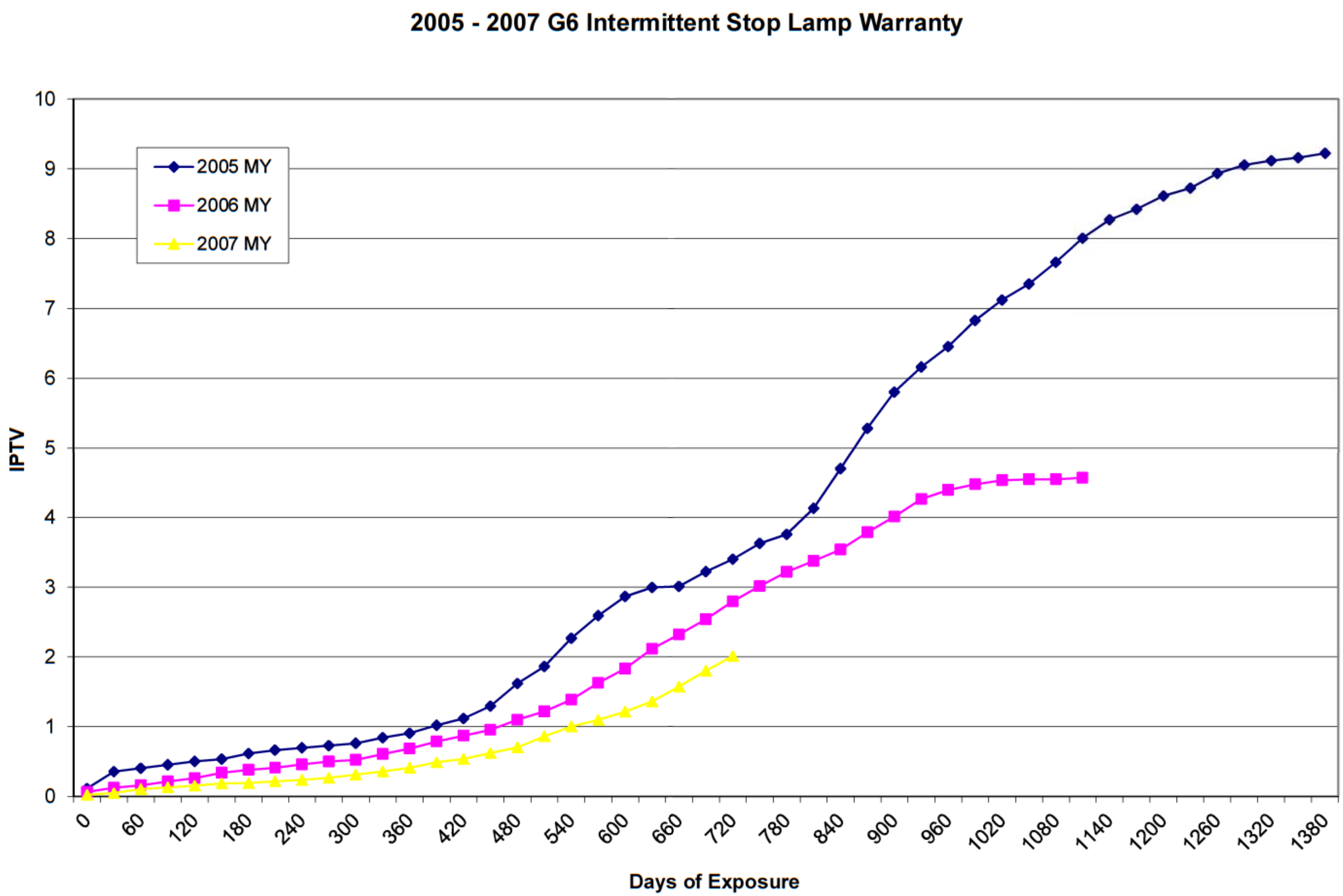
Intermittently Brake Lamps Do Not Function Correctly



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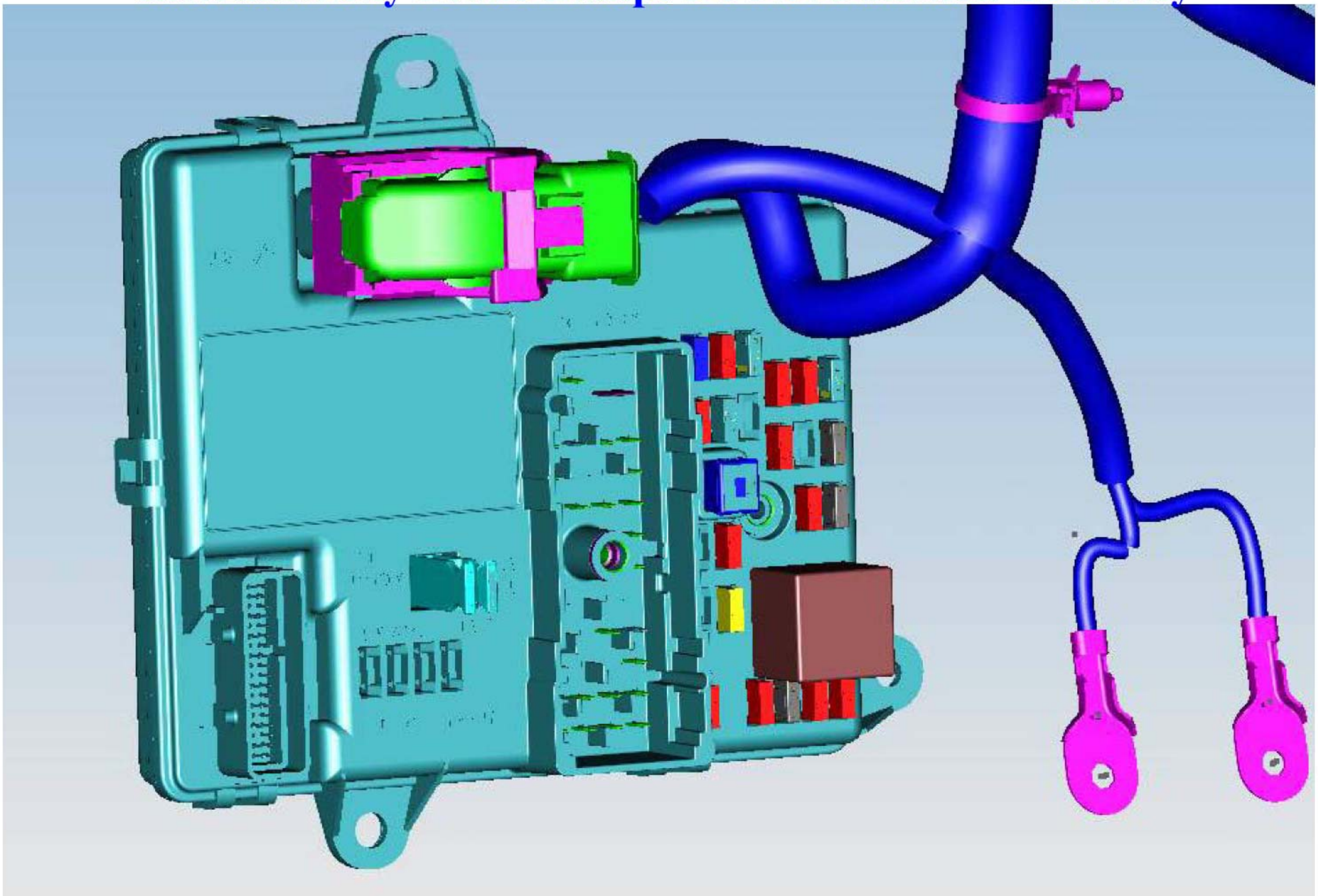
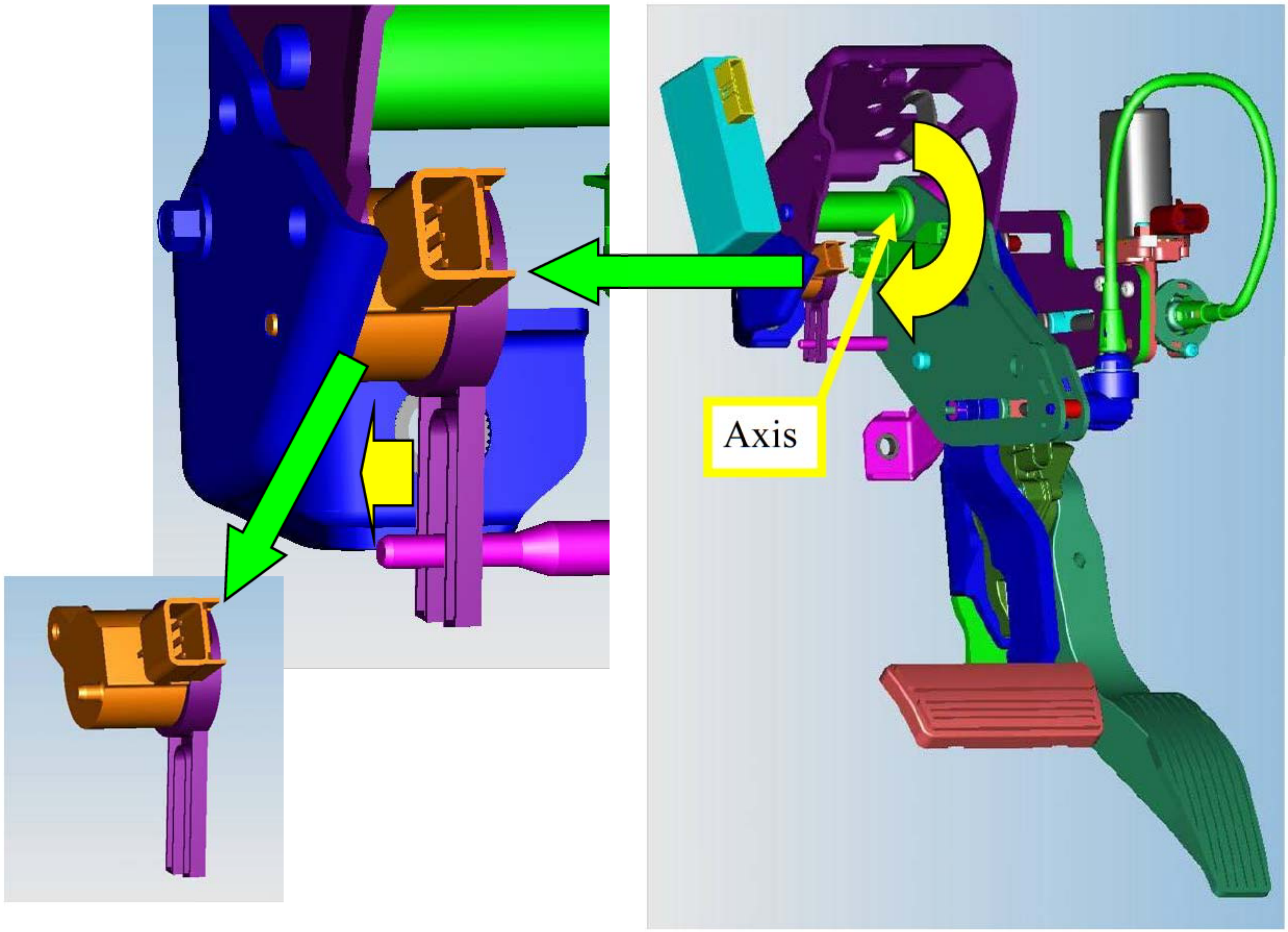
Intermittently Brake Lamps Do Not Function Correctly



2005 - 2007 G6 Brake Apply Sensing System

Pedal/Sensor Movement



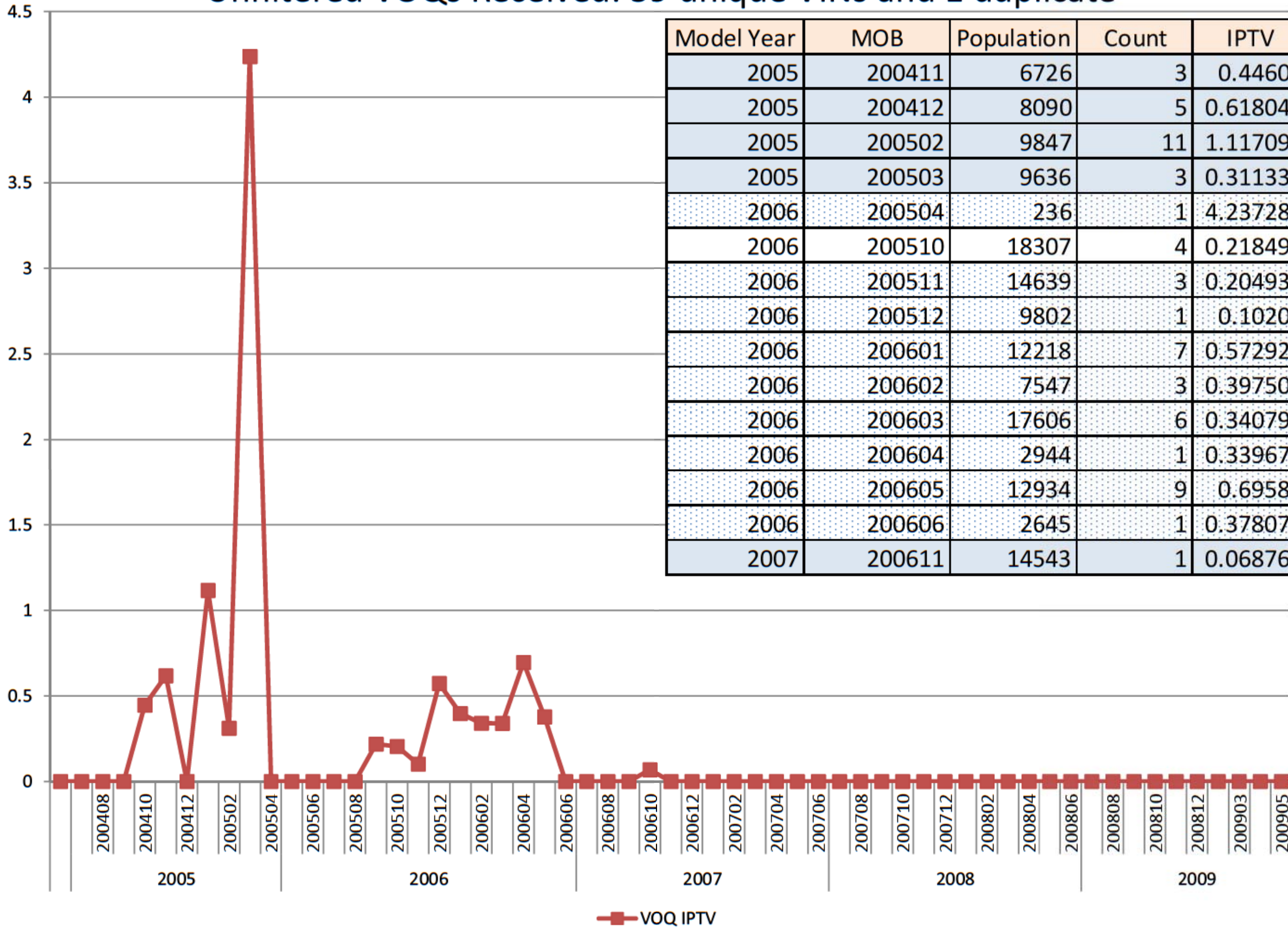
Brake Lamps Malfunction due to BCM Connector

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
9/9/2011	TC requested GM to provide 2006MY G6 Brake Lamp Malfunction, Outside Recall information request including population noted in TSB 08-05-22-009.

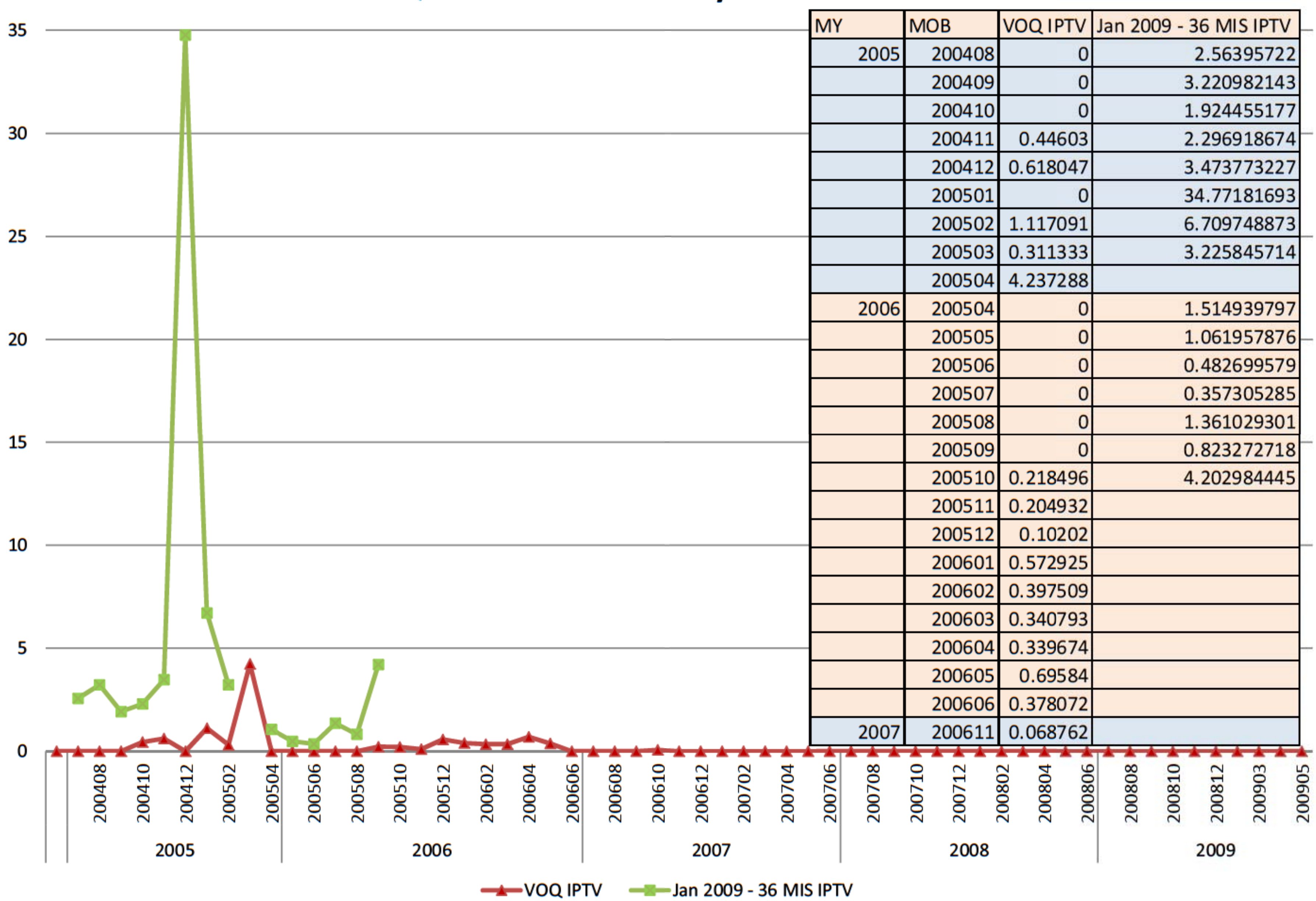
Closing Resume

Unfiltered VOQs Received: 59 unique VINs and 1 duplicate

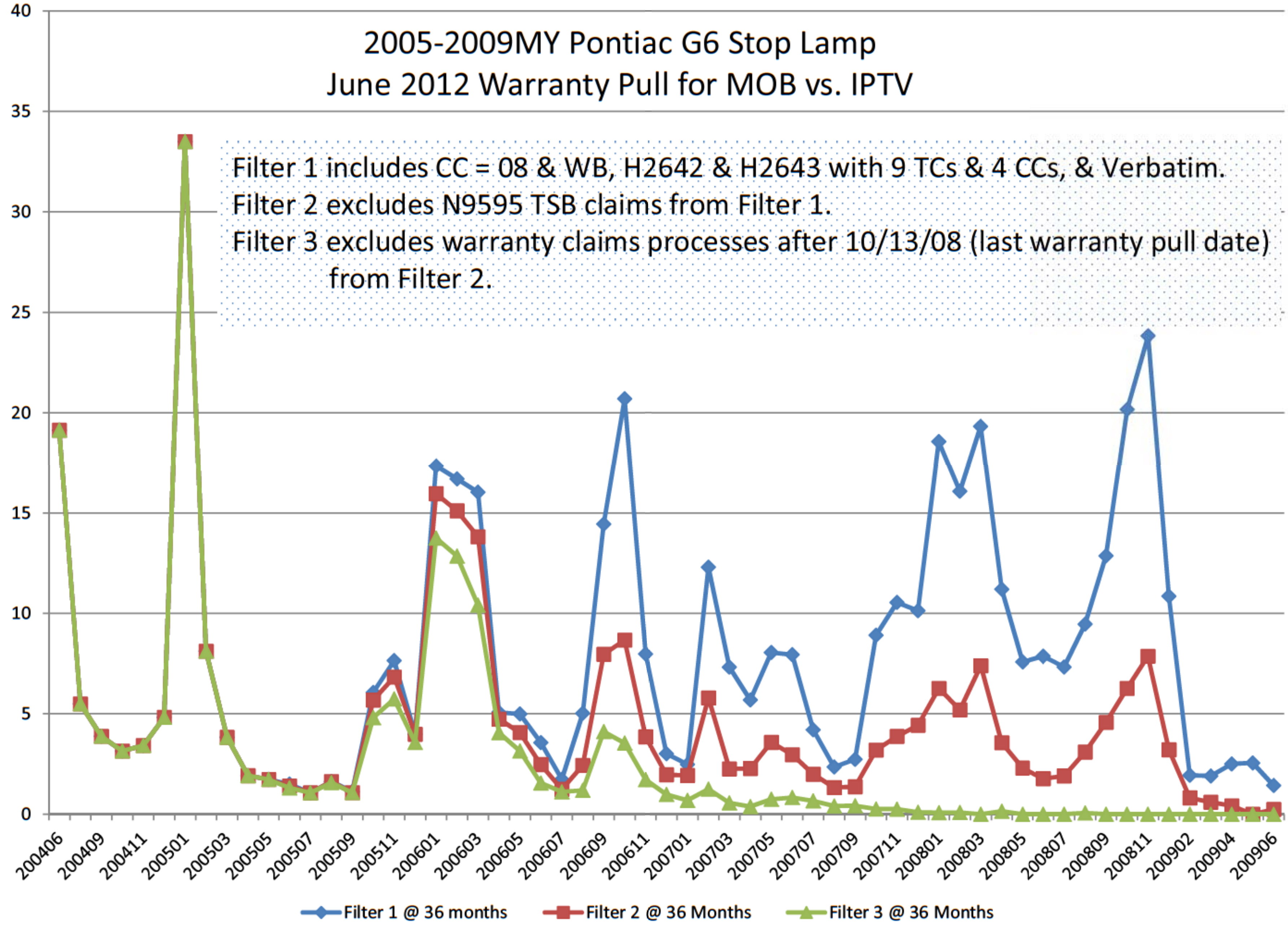


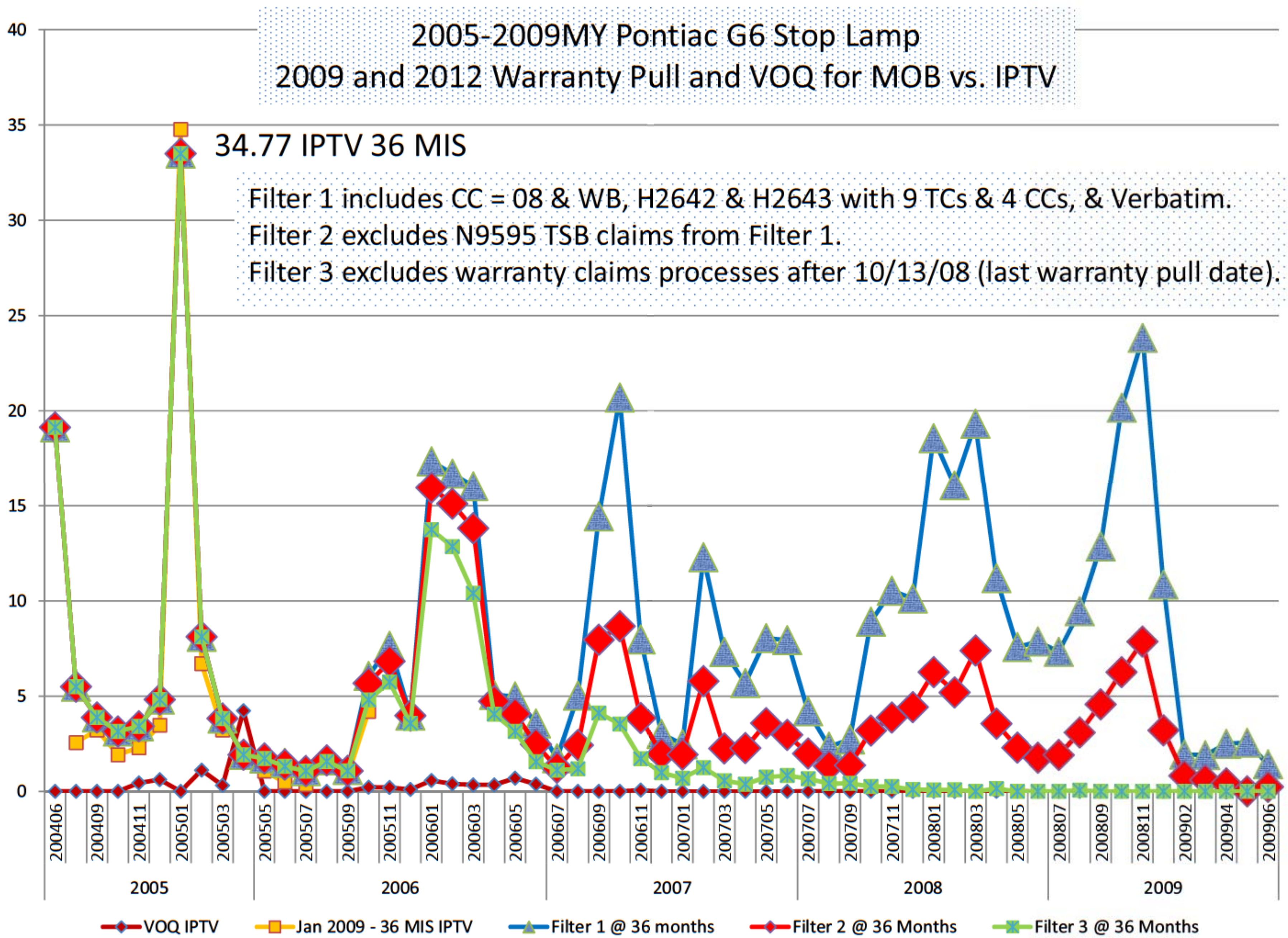
Model Year	MOB	Population	Count	IPTV
2005	200411	6726	3	0.44603
2005	200412	8090	5	0.618047
2005	200502	9847	11	1.117091
2005	200503	9636	3	0.311333
2006	200504	236	1	4.237288
2006	200510	18307	4	0.218496
2006	200511	14639	3	0.204932
2006	200512	9802	1	0.10202
2006	200601	12218	7	0.572925
2006	200602	7547	3	0.397509
2006	200603	17606	6	0.340793
2006	200604	2944	1	0.339674
2006	200605	12934	9	0.69584
2006	200606	2645	1	0.378072
2007	200611	14543	1	0.068762

VOQ and Jan 09 Warranty 36MIS Trendline



MY	MOB	VOQ IPTV	Jan 2009 - 36 MIS IPTV
2005	200408	0	2.56395722
	200409	0	3.220982143
	200410	0	1.924455177
	200411	0.44603	2.296918674
	200412	0.618047	3.473773227
	200501	0	34.77181693
	200502	1.117091	6.709748873
	200503	0.311333	3.225845714
	200504	4.237288	
2006	200504	0	1.514939797
	200505	0	1.061957876
	200506	0	0.482699579
	200507	0	0.357305285
	200508	0	1.361029301
	200509	0	0.823272718
	200510	0.218496	4.202984445
	200511	0.204932	
	200512	0.10202	
	200601	0.572925	
	200602	0.397509	
	200603	0.340793	
	200604	0.339674	
	200605	0.69584	
	200606	0.378072	
2007	200611	0.068762	


2005-2009MY Pontiac G6 Stop Lamp
June 2012 Warranty Pull for MOB vs. IPTV
Filter 1 includes CC = 08 & WB, H2642 & H2643 with 9 TCs & 4 CCs, & Verbatim.
Filter 2 excludes N9595 TSB claims from Filter 1.
Filter 3 excludes warranty claims processes after 10/13/08 (last warranty pull date) from Filter 2.
40
35
30
25
20
15
10
5
0
200406
200409
200411
200501
200503
200505
200507
200509
200511
200601
200603
200605
200607
200609
200611
200701
200703
200705
200707
200709
200711
200801
200803
200805
200807
200809
200811
200902
200904
200906
Filter 1 @ 36 months
Filter 2 @ 36 Months
Filter 3 @ 36 Months



2005-2009MY Pontiac G6 Stop Lamp
2009 and 2012 Warranty Pull and VOQ for MOB vs. IPTV
34.77 IPTV 36 MIS
Filter 1 includes CC = 08 & WB, H2642 & H2643 with 9 TCs & 4 CCs, & Verbatim.
Filter 2 excludes N9595 TSB claims from Filter 1.
Filter 3 excludes warranty claims processes after 10/13/08 (last warranty pull date).
40
35
30
25
20
15
10
5
0
200406
200409
200411
200501
200503
200505
200507
200509
200511
200601
200603
200605
200607
200609
200611
200701
200703
200705
200707
200709
200711
200801
200803
200805
200807
200809
200811
200902
200904
200906
2005
2006
2007
2008
2009
VOQ IPTV
Jan 2009 - 36 MIS IPTV
Filter 1 @ 36 months
Filter 2 @ 36 Months
Filter 3 @ 36 Months

Back-up

2012CY Update of G6 Stop Lamp Warranty Claims

2012CY Warranty Methodology

Started with 27,821

11,852 had correction-verbatim (42.6%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	10,316 (37.1)	363 (20.7)
H2642 Sensor, Brake Pedal	4,643 (16.7)	1,203 (68.6)
H2643 Sonsor, Brake & Accel	420 (1.5)	144 (8.2)
H2640 Pedal / Bushing	418(1.5)	7 (0.4)
H9991 Cust Concern NTF	8,531(30.7)	36 (2.1)
N9595 TSB	3,493 (12.6)	0
Total	27,821	1,753 (6.3)

2012CY Warranty Methodology

27,821 including 243 same day repair duplicates

A. All claims with labor code N9595 were determined to be responsive to the alleged condition.

3,490

B. All claims with customer codes 08 (Operation: Won't Turn Off) and WB (Warning Lights-Brake Lights) were determined to be responsive to the alleged condition unless the verbatim text indicated that the claim was unrelated.

C. Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 2.7 and customer codes in Table 2.8 were determined to be responsive unless the verbatim indicated that the claim was unrelated to the alleged condition.

D. The verbatim of the remaining claims were then read and a claim was determined to be responsive if the verbatim related to loss/malfunction of the brake/stop lamps.

20,167 (B–D)

E. The vehicle claims processed after 10/13/08 are excluded to compare with the original data.

2,168

F. All claims for vehicles covered by General Motors recall 08317 were excluded.
6/25/12 Status Affected: 8,012 Completed: 5,707 % Completion: 71.2%

1,753

2009CY Update Methodology

Started with 8,978 | 2,362 had verbatim (26.3%)

Labor Code	Started (%)	Filtered (%)
N4800 BCM	6,758 (75.3)	274 (17.5)
H2642 Sensor, Brake Pedal	1,984 (22.1)	1,157 (74)
H2643 Sonsor, Brake & Accel	227 (2.5)	125 (8)
H2640 Pedal / Bushing	6 (0)	6 (0.4)
H9991 Cust Concern NTF	3 (0)	3 (0.2)
Total	8,978	1,565 (17.4)

2009CY Update Methodology

For the subject vehicles, the regular warranty, goodwill warranty, and MIC service contract claims with stop lamp malfunction are summarized by model and model year in Table 5-1. For the subject vehicles the UWC service contract claims with indication of stop lamp malfunction are summarized by model and model year in Table 5-2. A summary of the warranty claims, including the information requested in 5(a-k), is provided on the ATT_1_GM disk; folder labeled "Q_05:" refer to the Microsoft Access 2000 file labeled "Q_05_WARRANTY DATA." A list of the labor codes, customer complaint codes and trouble codes used to collect the warranty data is provided in response to item No. 6.

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	Regular	579	754	232	1,565
Pontiac G6	MIC	43	25	2	70

TABLE 5-1: REGULAR WARRANTY AND MIC SERVICE CONTRACT CLAIMS WITH STOP LAMP MALFUNCTION

MAKE/ MODEL	Type	2005 MY	2006 MY	2007 MY	TOTAL
Pontiac G6	UWC	0	3	0	3

TABLE 5-2: UWC SERVICE CONTRACT CLAIMS

SOURCE SYSTEM	LAST DATE GATHERED
GART - regular warranty	13 Oct 08
MIC - service contract claims	14 Oct 08
UWC - service contract claims	23 Sept 08

TABLE 5-3: DATES PULLED

2009CY Update Methodology

8,969

The GM Global Analysis and Reporting Tool (GART-regular warranty) regular warranty database and the Motors Insurance Corp (MIC) service contract claims database were searched using the labor codes that may be related to the alleged defect, listed in Table 6-1. Universal Warranty Corporation (UWC) does not use labor codes or trouble codes.

The following process was used to sort these claims:

544
- All claims with customer codes shown in Table 6-2 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

6,800
- Warranty under labor codes H2642 (Sensor, Brake Pedal Position – Replace) and H2643 (Brake and Accelerator Pedal Adjuster Switch Replacement) with the trouble codes in Table 6-3 and customer codes in Table 6-4 were determined to be responsive unless the verbatim indicated that the claim was unrelated.

60
- The verbatims of the remaining claims were then read and the claim was determined to be responsive if the verbatim related to the alleged defect.

1,565

2009CY Update Methodology

Labor Code	Description:
H2642	Sensor, Brake Pedal Position - Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
N4800	Body Control Module Replacement
H2640	Pedal And/Or Bushing, Brake - R&R Or Replace
H9991	Customer Concern Not Duplicated
N2700	Switch, Stop Lamp - Adjust
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement-Product Allegation
Z1243	Inspection-Product Allegation Resolution

Table 6-1 Labor Codes used in Warranty and MIC Search

Customer Code	Description:
O8	Operation: won't turn off
WB	Warning lights: brake light

Table 6-2 Customer Codes used in Warranty and MIC Sorting

Trouble Code	Description:
1D	Broken
6C	Component-inoperative
6D	Component -intermittent
6F	Component -Open
3A	Misadjusted
9Z	No Trouble Found
3L	Out of Calibration
3X	Registers Incorrectly
6N	Connector - Partial Connected

Table 6-3 Trouble Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

Customer Code	Description:
OG	Operation: Excess Eff (Excess Play)
OJ	Operation: Inoperative (Harsh)
OF	Operation: Engage/Dis(Excess Eff)
O7	Operation: No Maintain Adj

Table 6-4 Customer Codes used in labor code H2642 and H2643 Warranty and MIC Sorting

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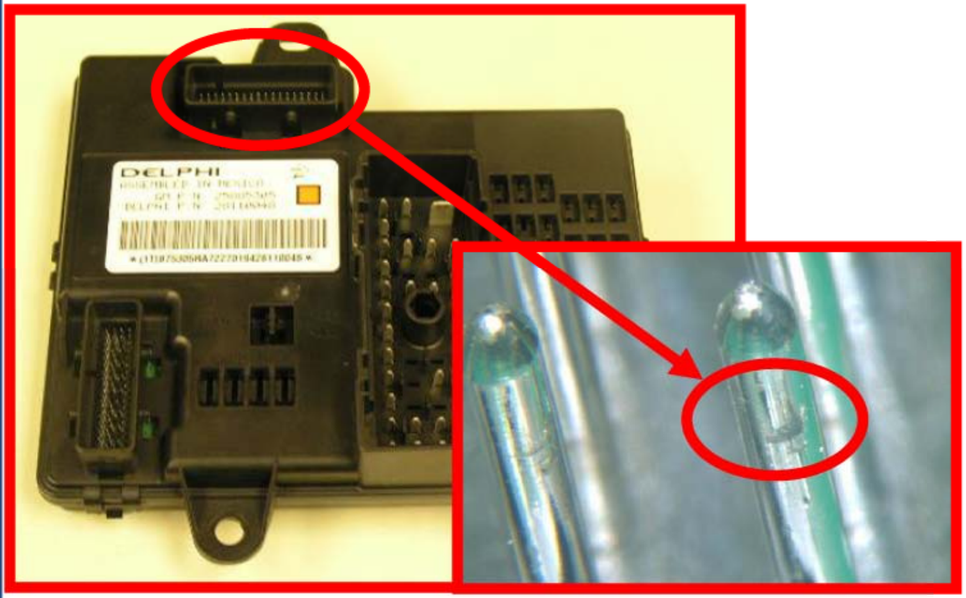
Rationale for 2009 Decision

Pontiac G6 Brake Apply Sensing System (BASS)

Condition: Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.



Effect of the Condition: A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

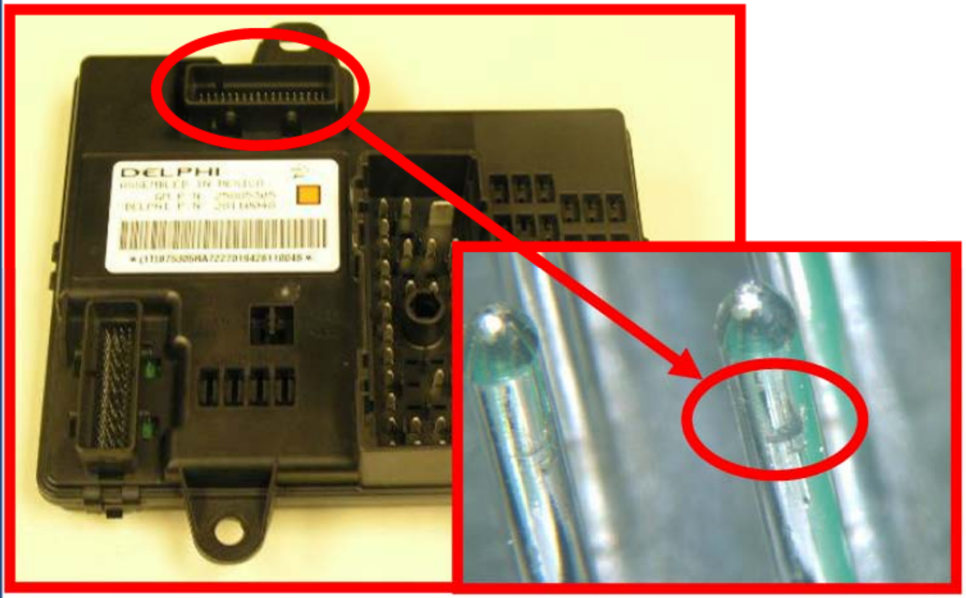
Model Years
2005 - 2006

Models
Pontiac G6

{ ** } Indicates Cost Information Redacted

Pontiac G6 Brake Apply Sensing System (BASS)

Condition: Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.



Potential Field Action: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Model Years
2005 - 2006

Models
Pontiac G6

Field Action Category
TBD

Population Affected
9,423

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Scope

2005 – 2006 Pontiac G6

Myear	GM of Canada	GM of Mexico	Pontiac Domestic	Grand Total
2005	1,348	49	7,933	9,330
2006	8		85	93
Grand Total	1,356	49	8,018	9,423

Immediate Improvement

Technical Service Bulletin 08-05-22-009 was issued to apply the lubricant on the BCM terminal as of 12/4/2008.

Projected Frequency

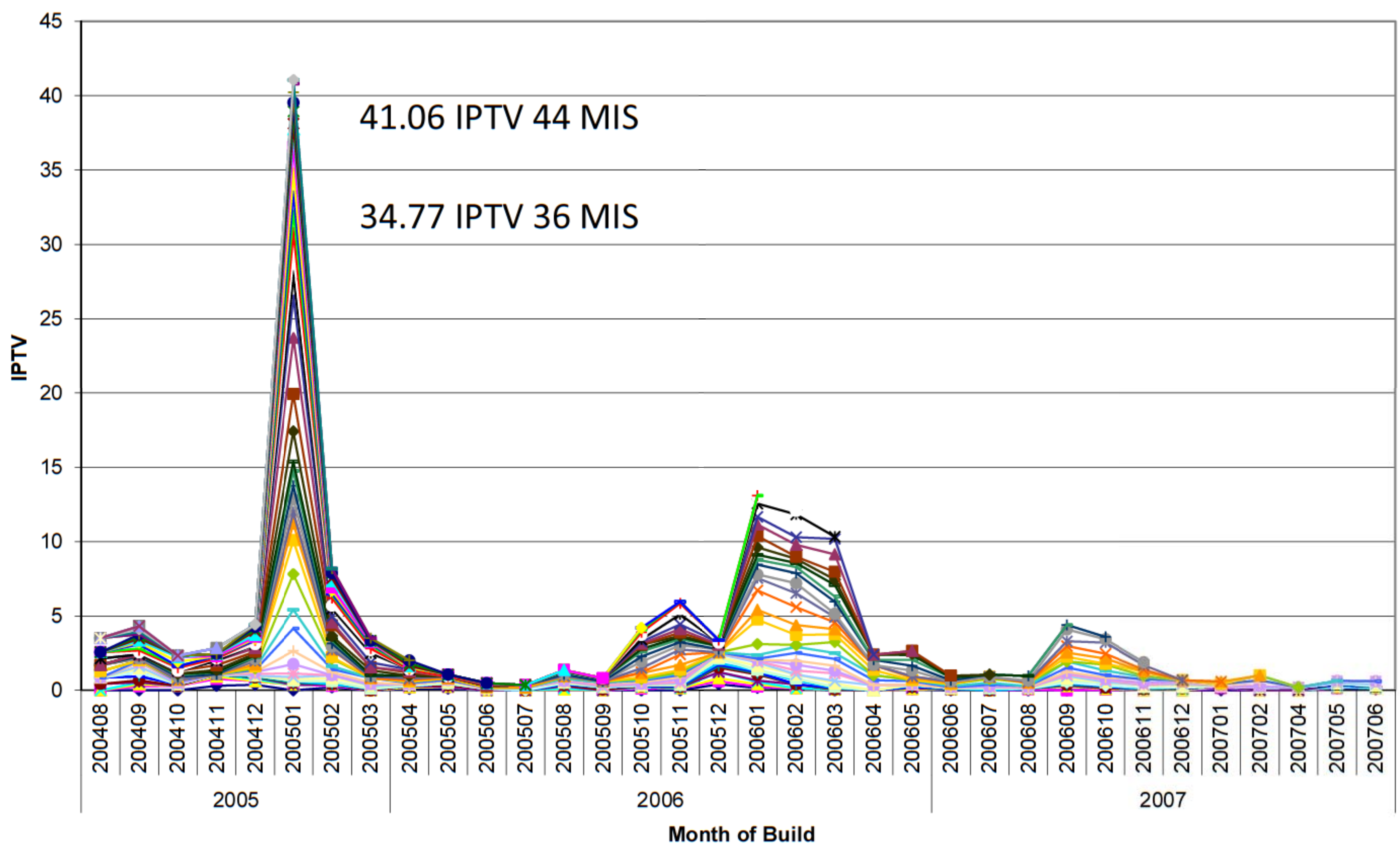
2005 MY 36 MIS Overall = 8.0 IPTV

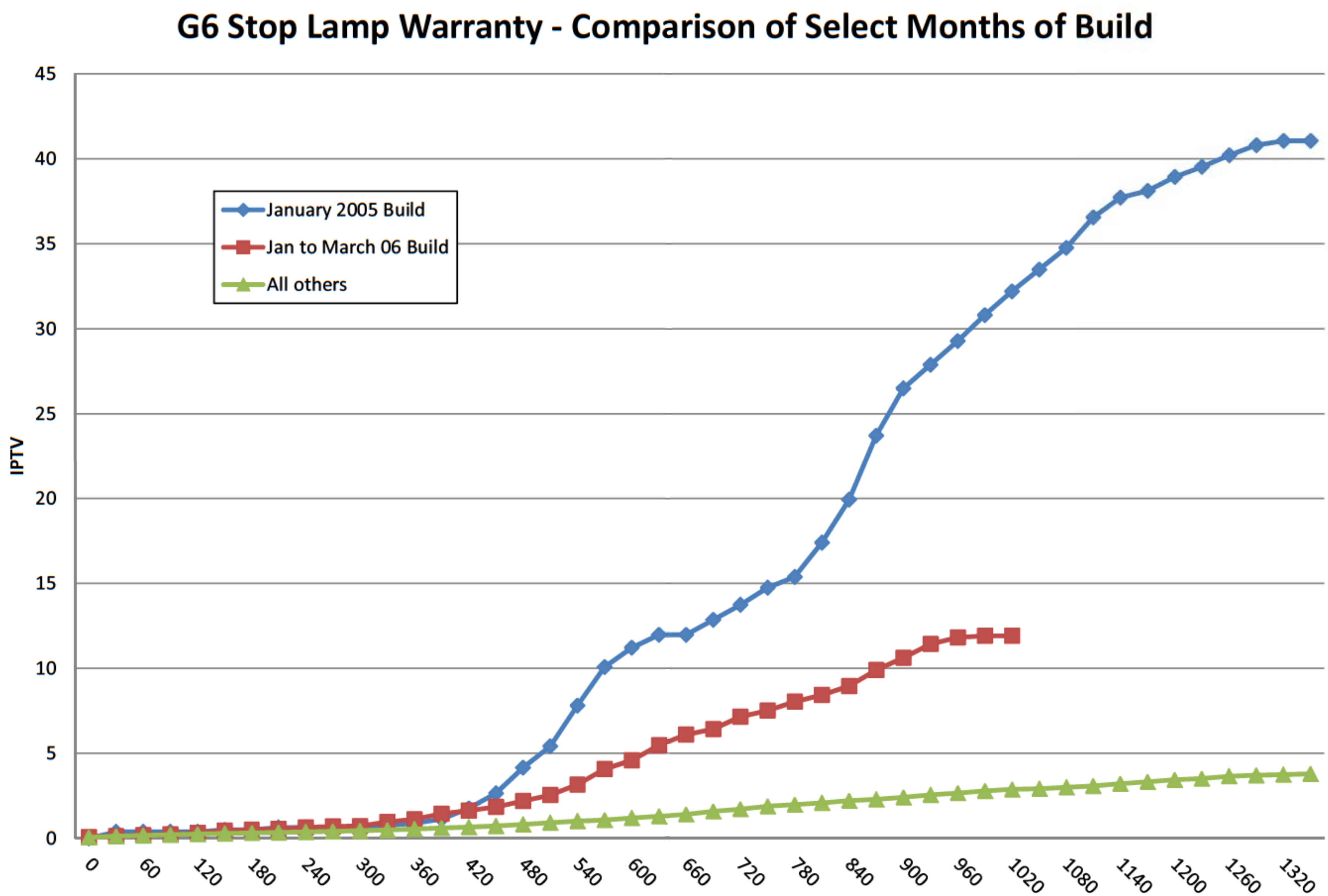
2006 MY 36 MIS Overall = 4.6 IPTV

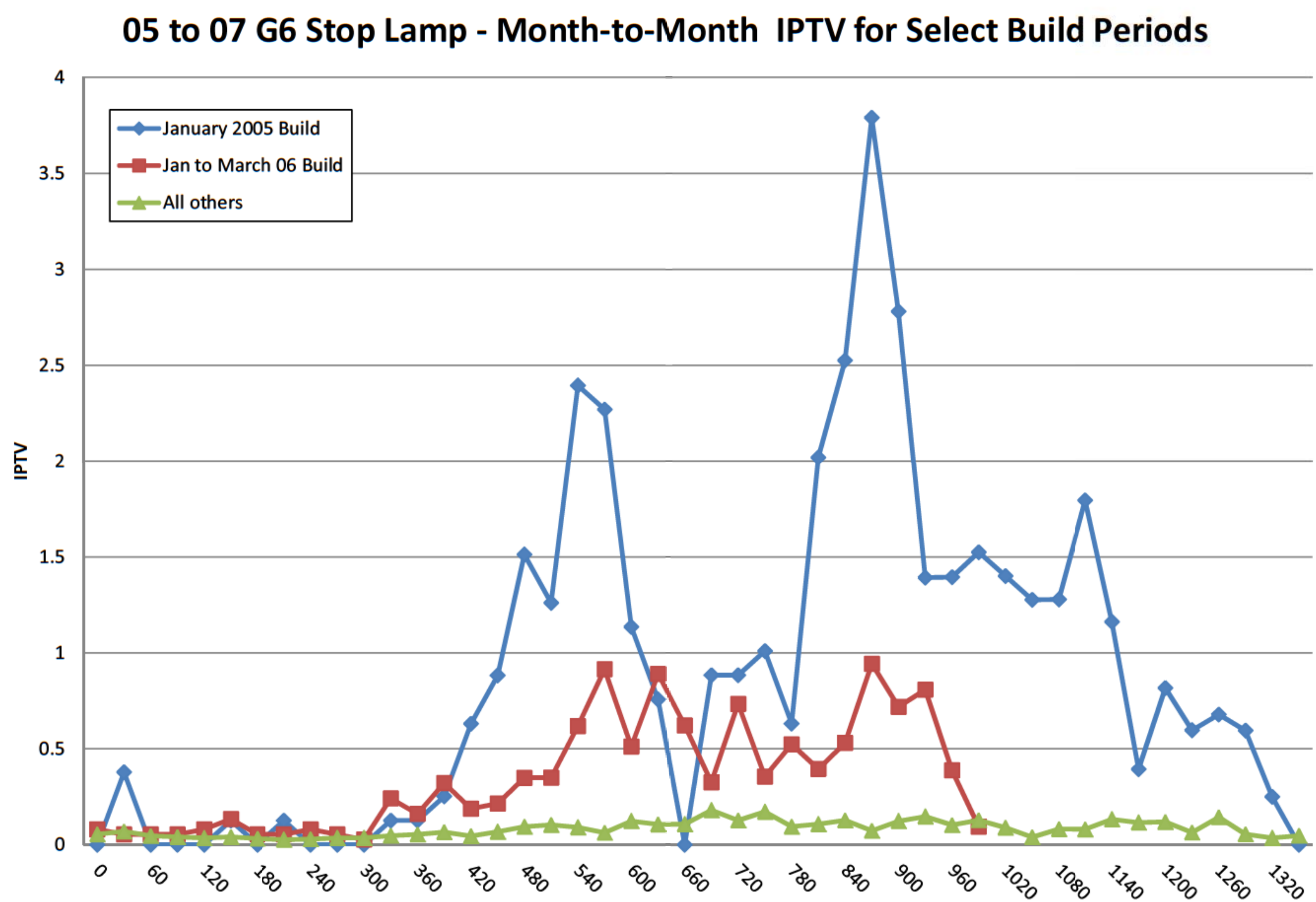
Build of Month January 2005 36 MIS = 34.77 IPTV

Build of Month January 2005 44 MIS = 41.06 IPTV

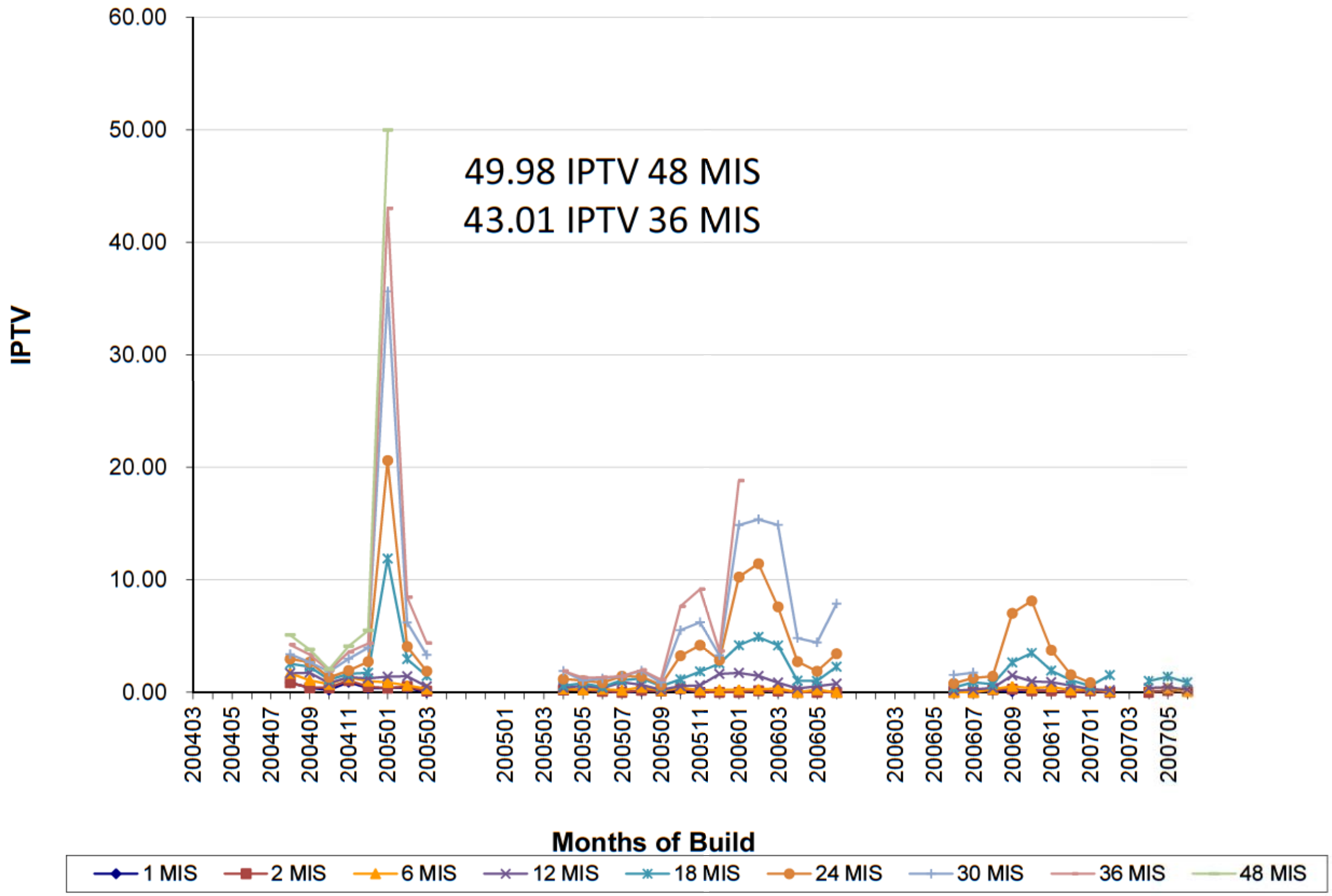
2005 - 2007 G6 Intermittent Stop Lamp Warranty



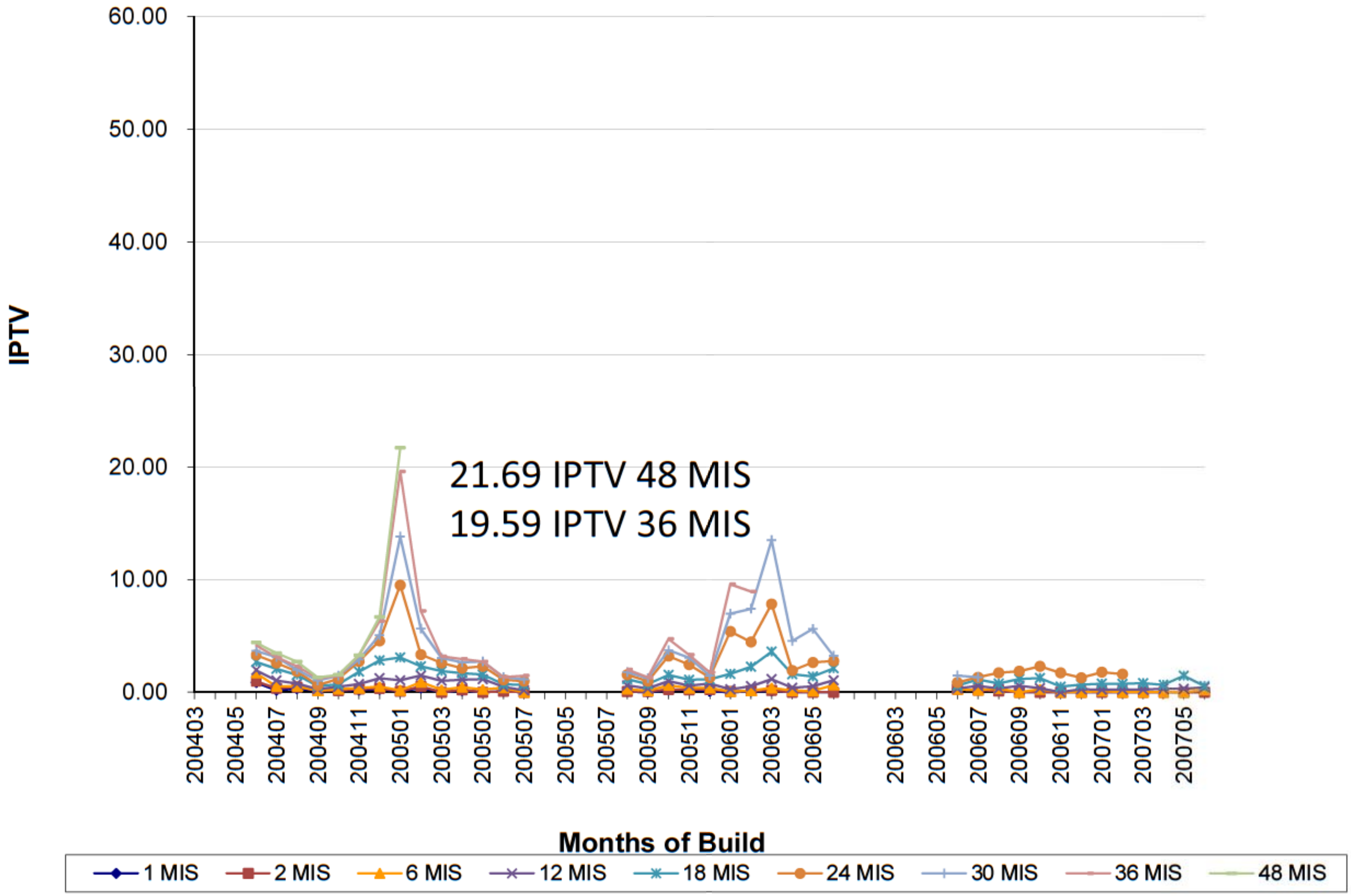

G6 Stop Lamp Warranty - Comparison of Select Months of Build
IPTV
45
40
35
30
25
20
15
10
5
0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
1080
1140
1200
1260
1320
January 2005 Build
Jan to March 06 Build
All others


05 to 07 G6 Stop Lamp - Month-to-Month IPTV for Select Build Periods
January 2005 Build
Jan to March 06 Build
All others
IPTV
4
3.5
3
2.5
2
1.5
1
0.5
0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
1080
1140
1200
1260
1320

Pontiac G6 Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



Chevrolet Malibu Stop Lamp Warranty with Labor Op H2642 Brake Switch Only



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Historical Rate Comparison

Rear lighting issues							
Vehicle	**Component**	**Recall**	**EOVP**	**IPTV**	**Reported by**	**Cause**	**Open Date**
00 - 04 Saturn L Series	Stop/Tail/Park lamp	Safety	Loss of all brake lights or park/tail lights (one side)	As high as 365 IPTV at 36 months	TREAD	Circuit board arcing, blown fuses, loose sockets	15-Feb-05
03 J car	Stop/tail/turn lamp	Safety	Loss of single stop/tail/turn lamp (CHMSL not affected)	343 (12 months)	Bulletin review	Grease removed from production	14-May-04
02-04 GMT360/370	Stop lamp	Safety	Loss of single stop and/or tail lamp (CHMSL not affected)	237 (13 months) 31% had lost function of both lamps (per survey)	TREAD	Loose bulb fit	6-Apr-04
00-01 ST utilities and 01-02 Chevrolet Astro and GMC Safari	Multifunction Switch	Safety	Loss of all stop lamps (CHMSL not affected)	214.3 (9 months)	NHTSA	Change from copper to brass for error proofing	6-Sep-01
97-99 Malibu	Stop lamp	N	Loss of single stop lamp (CHMSL not affected) - Replace entire lamp assembly	37 (36 months) - reduced to 4.6	NHTSA	Stainless contacts	
94 CK Truck	Brake Switch	Safety	Loss of all stop lamps and CHMSL	33.78 (36 months) (up to 360 in durability)	Transport Canada	Reverse Polarity	
04 - 05 Chevrolet Colorado, GMC Canyon, Isuzu I-280	Brake Switch	Safety	Loss of all stop lamps and CHMSL	31.3 (23 months)	NHTSA	Internal heat in switch	2-Dec-05
98-04 Mercedes SLK/SLK 230	Stop lamp	Safety	Loss of single stop lamp (CHMSL not affected)	821 (over 36 months)	NHTSA	The base of the socket can be subject to thermal deformation over time	22-Sep-05
95 Ford Villager, Nissan Quest, and Nissan Pickup	Stop/tail/turn lamp	Safety	Loss of single stop/tail/turn lamp (CHMSL not affected)	250 (12 months)	Warranty study	Change in the material of the plastic socket housing	
99 - 02 Volkswagen Jetta, New Beetle, Gulf	Brake Switch	Safety	Loss of all stop lamps and CHMSL or brake lamps on	117 (12 months)	NHTSA	Brake switch malfunction	

Production Improvement

Dielectric lubricant is applied in Orion plant for G6 as of 11/8/2008.

The lubricant will be applied in the Delphi harness assembly plant in August 2009.

Potential Field Improvement

Technical Service Bulletin 08-05-22-009 was issued to apply the lubricant on the BCM terminal as of 12/4/2008.

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Brake Lamps Malfunction due to BCM Connector

2004 -11MY Malibu, 2005 - 10MY G6, 2007 - 09MY Aura
Vehicle Population: 1,222,206 + 561,604 + 144,950 = **1,928,760**
Cost Estimate: TBD

ETQ Nxxxxxx

Condition:
Certain fretting corrosion in the Body Control Module connector causes an increase in resistance that results in a lower BAS signal voltage to the BCM.

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Effect of the Condition:
A driver in a following vehicle may not be able to discern the braking status of the vehicle in front of them. Operators whose vehicles have this condition may notice that the cruise control will not engage and the brake pedal requires additional travel to remove the gear shift mechanism from PARK. Additionally, the transmission converter clutch will not engage.

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Potential Field Action Category: TBD

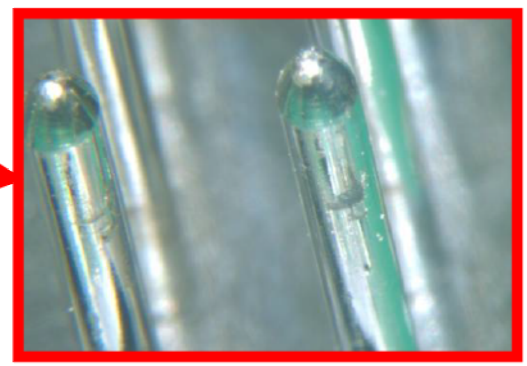
Brake Lamps In-operation due to BCM Connector

Potential Field Remedy: Apply dielectric lubricant (clear gel) on all the BCM C2 connector pins. Apply with a one-inch nylon bristle brush. (this will treat the pins against fretting corrosion).

Current Status:
TC inquiry is due on 21OCT11.
GM draft response is completed.

Immediate Improvement /Containment:

Responsibility: Engineering



2011CY Warranty Status

MY and Model

2004-2008	Chevrolet Malibu, Malibu Maxx	(GMX380)
2008	Chevrolet Malibu Classic	(GMX380)
2008-2011	Chevrolet Malibu	(GMX386)
2005-2010	Pontiac G6	(GMX381)
2007-2009	Saturn AURA	(GMX384)

Labor Op.

H2642	Sensor, Brake Pedal Position - Replace
H2643	Brake and Accelerator Pedal Adjuster Switch Replacement
N4800	Body Control Module Replacement
H2640	Pedal And/Or Bushing, Brake - R&R Or Replace
H9991	Customer Concern Not Duplicated
N2700	Switch, Stop Lamp – Adjust
N9595	BCM C2 Connector Repair per TSB
Z1241	Personal Property Damage
Z1242	RPR/Reimbursement-Product Allegation
Z1243	Inspection-Product Allegation Resolution

Customer Code	Description:
08	Operation: Won't Turn Off
WB	Warning Lights – Brake Lights

Trouble Code	Description:
1D	Broken
6C	Component - Inoperative
6D	Component - Intermittent
6F	Component - Open
3A	Misadjusted
9Z	No Trouble Found
3L	Out of Calibration
3X	Registers Incorrectly
6N	Connector – Partial Connected

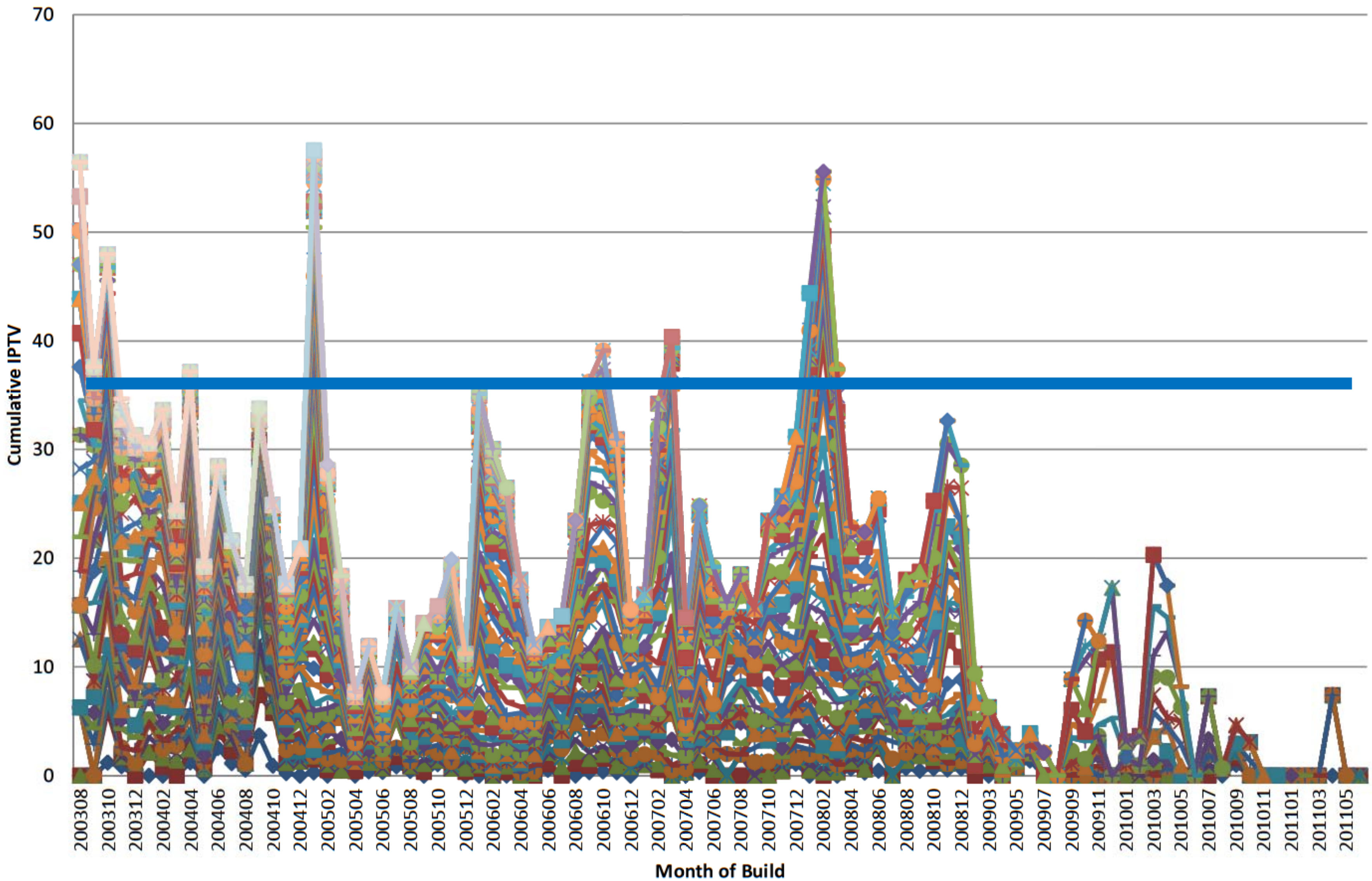
Customer Code	Description:
0G	Operation: Excess Eff (Excess Play)
0J	Operation: Inoperative (Harsh)
0F	Operation: Engage/Dis (Ecess Eff)
07	Operation: No Maintain Adj

Canada Only Filtered Warranty

Row Labels	Chevrolet	Pontiac	Saturn	Grand Total
in	**1049**	**819**	**140**	**2008**
A (in)	75	62		137
B (in)	326	223	15	564
C (in)	144	128	24	296
D (in)	504	406	101	1011
out	**1949**	**1384**	**81**	**3414**
DUP	859	681	24	1564
E (out)	1090	703	57	1850
unknown	**2014**	**1415**	**297**	**3726**
F (?)	2014	1415	297	3726
Grand Total	**5012**	**3618**	**518**	**9148**

A	All L-Ops + Cust Codes 08 and WB
B	H2642 & H2643 & TC 1D/3A/3L/3X/6C/6D/6F/6N/9Z & CC OG/OF/OJ/O7 (Tables 6-3 & 6-4 of PE 08-054)
C	Remaining L-ops with Related Verbatims
D	N9595 - TSB 08-05-22-009
E	OUT
F	Unknown

2004 to 2011 Epsilon - Filtered Brake Warranty
Included: 52% Unknown Warranty Records



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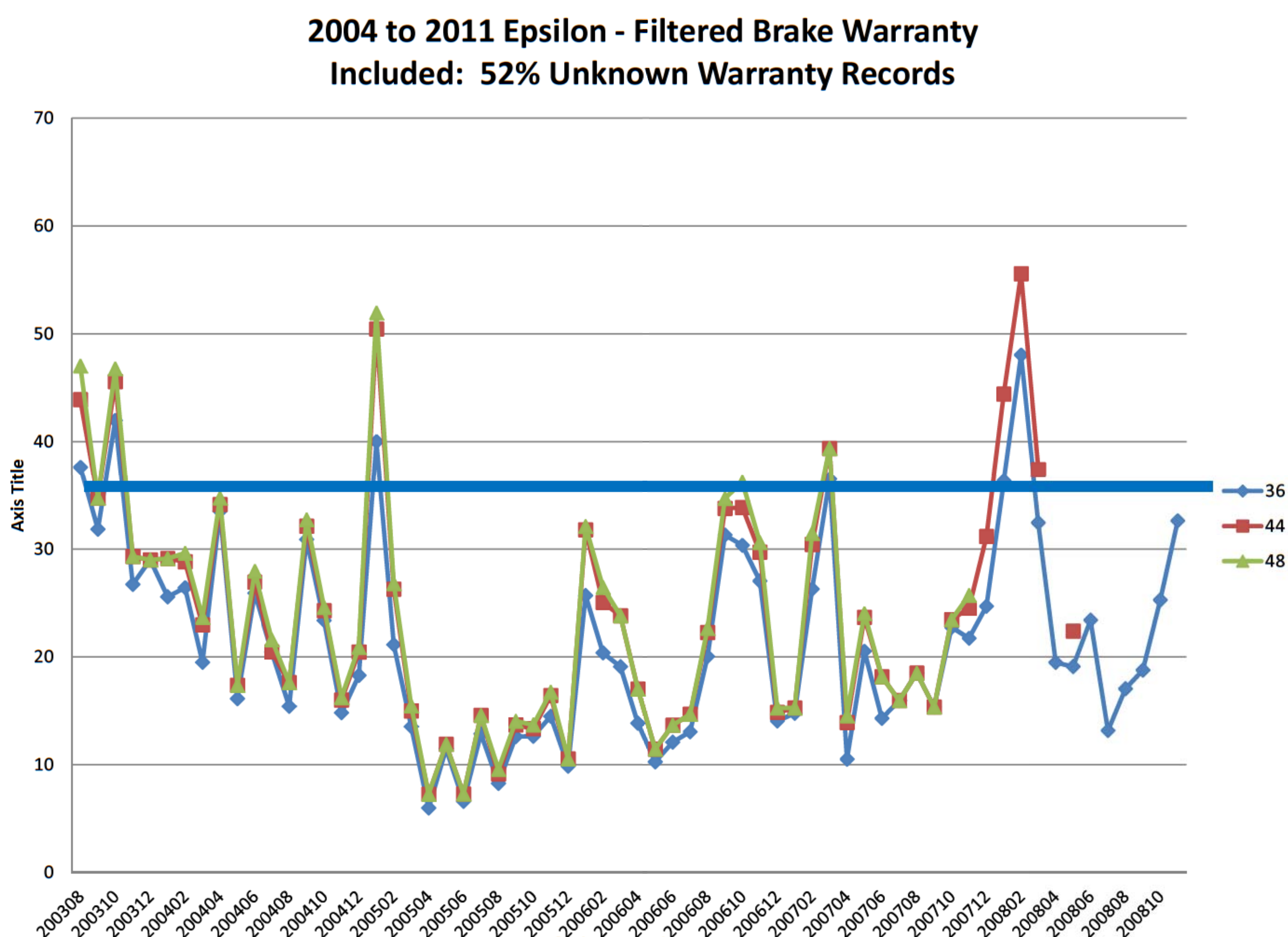

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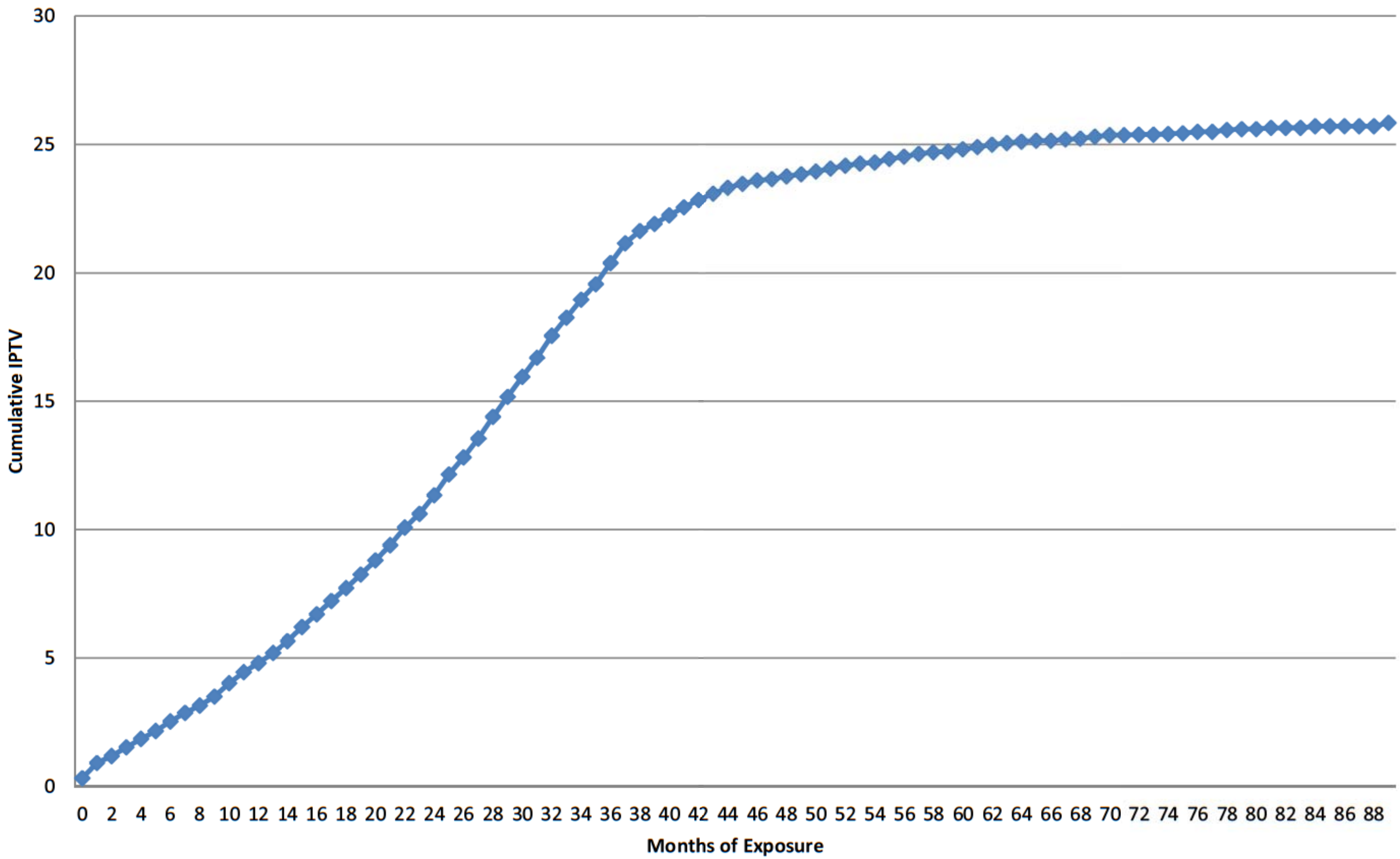
2004 to 2011 Epsilon - Filtered Brake Warranty
Included: 52% Unknown Warranty Records



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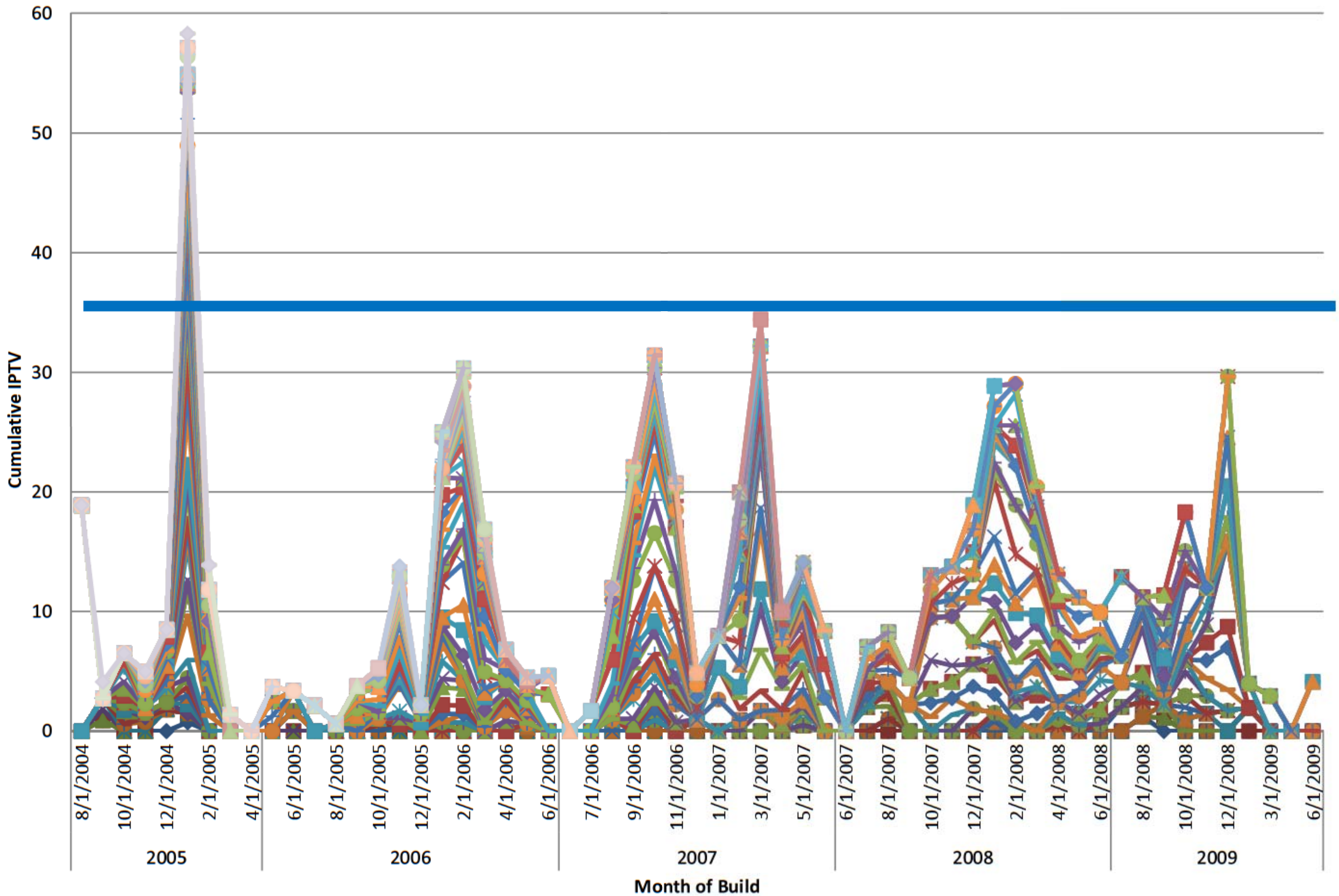
2005 to 2009 G6 Filtered Brake Warranty (Plus 54% Unknown)



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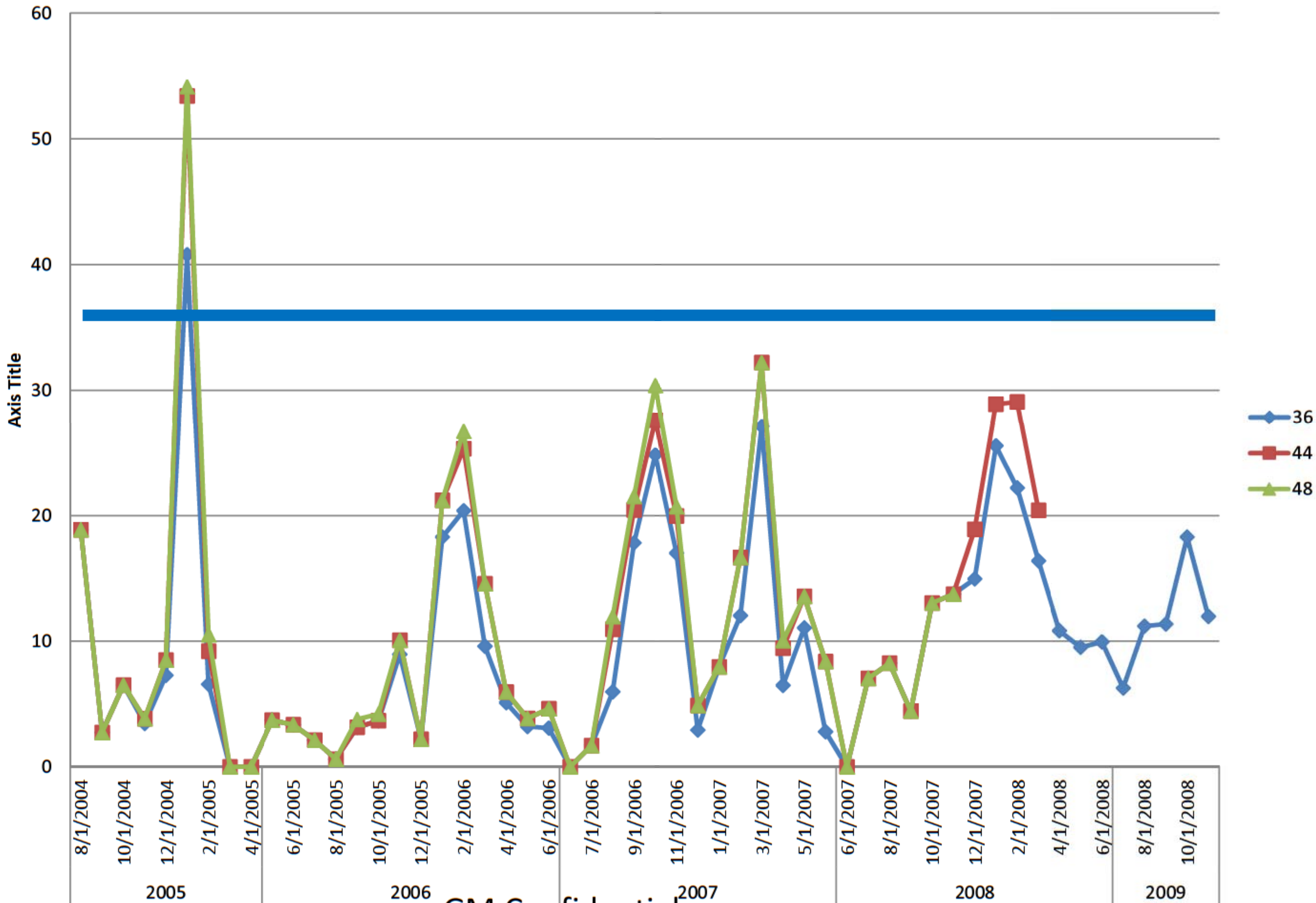
2005 to 2009 G6 Filtered Brake Warranty (Plus 54% Unknown)



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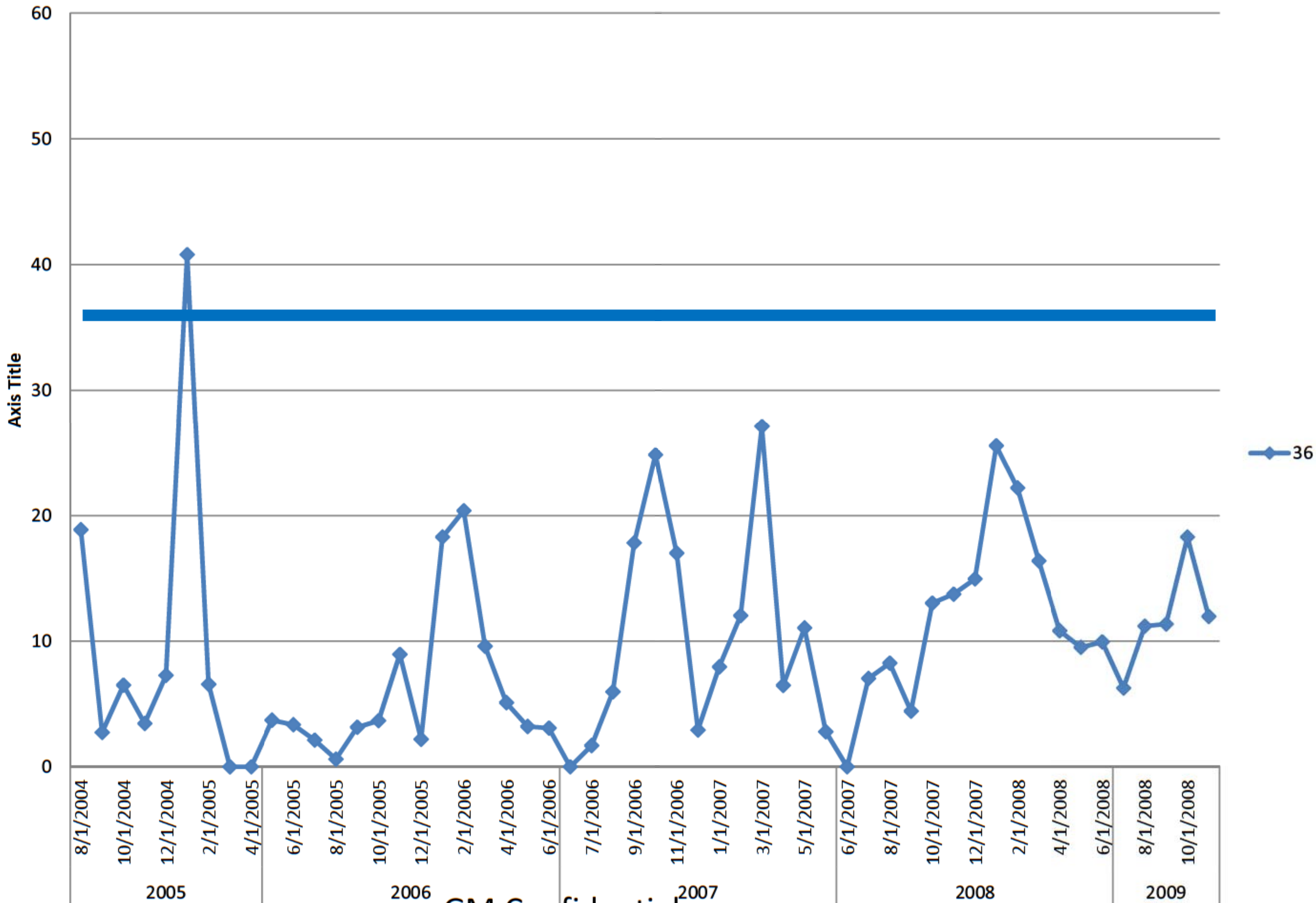
2005 to 2009 G6 Filtered Brake Warranty (Plus 54% Unknown)



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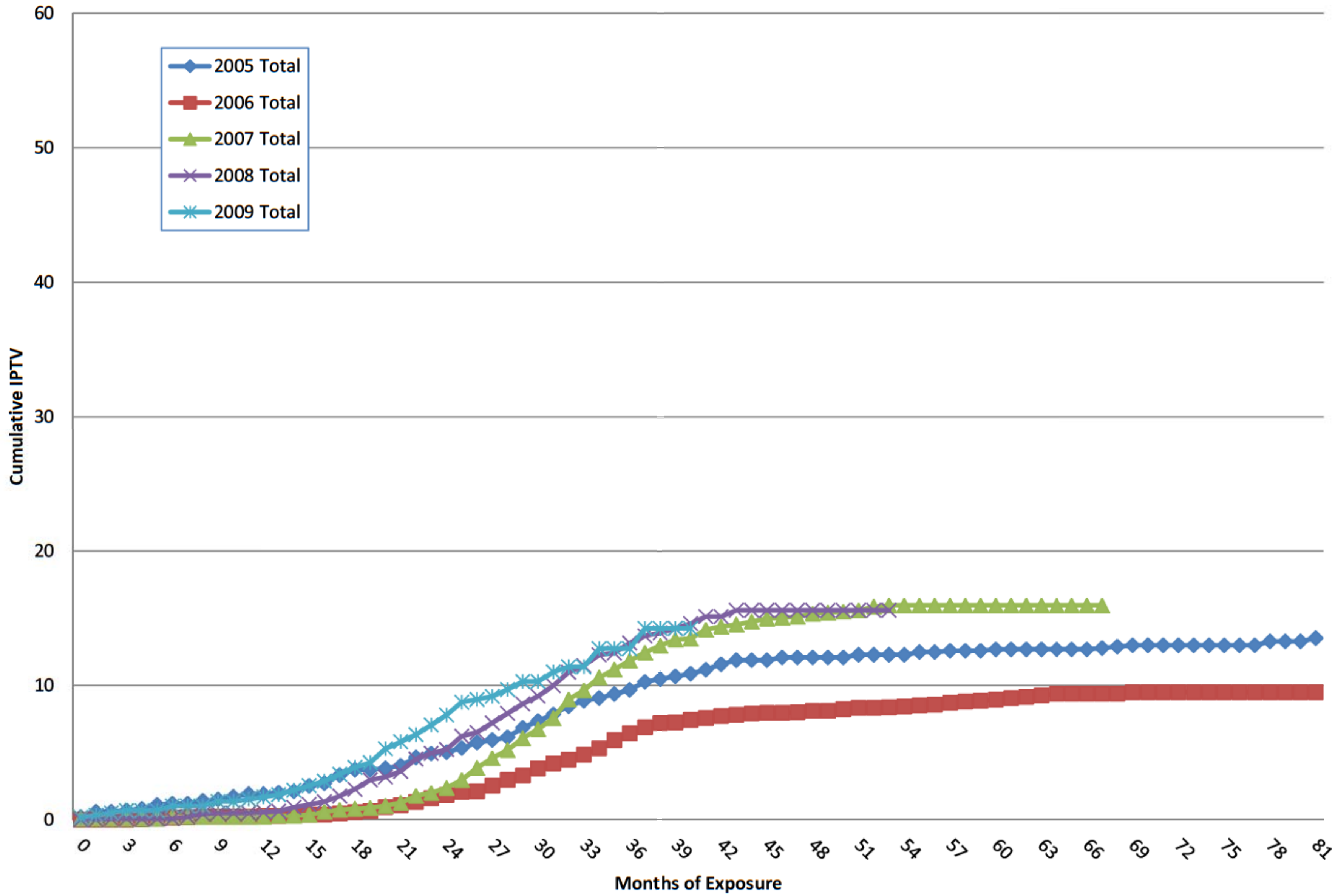
2005 to 2009 G6 Filtered Brake Warranty (Plus 54% Unknown)



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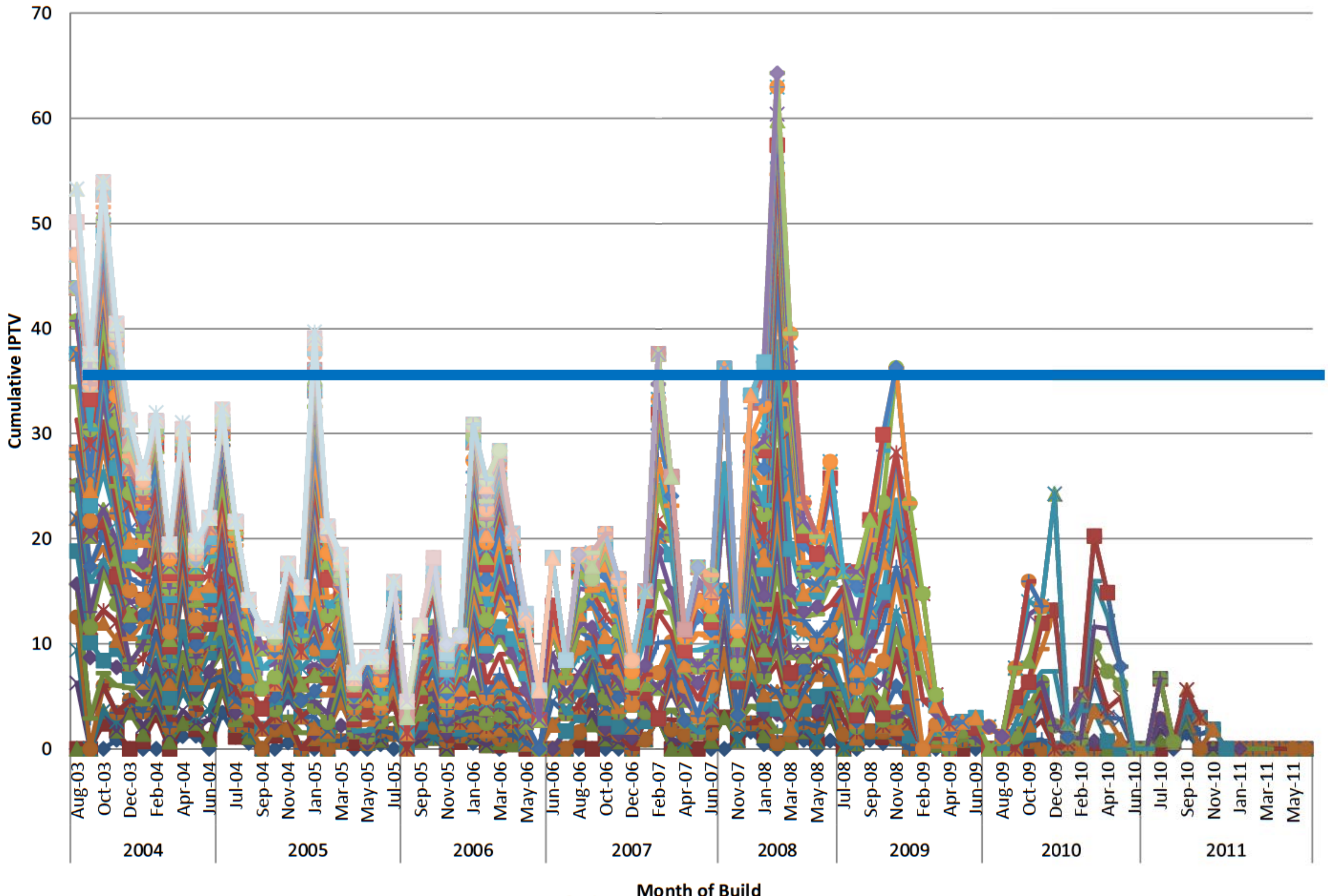
2004 to 2011 Malibu Filtered Brake Warranty (Plus 49% Unknown)



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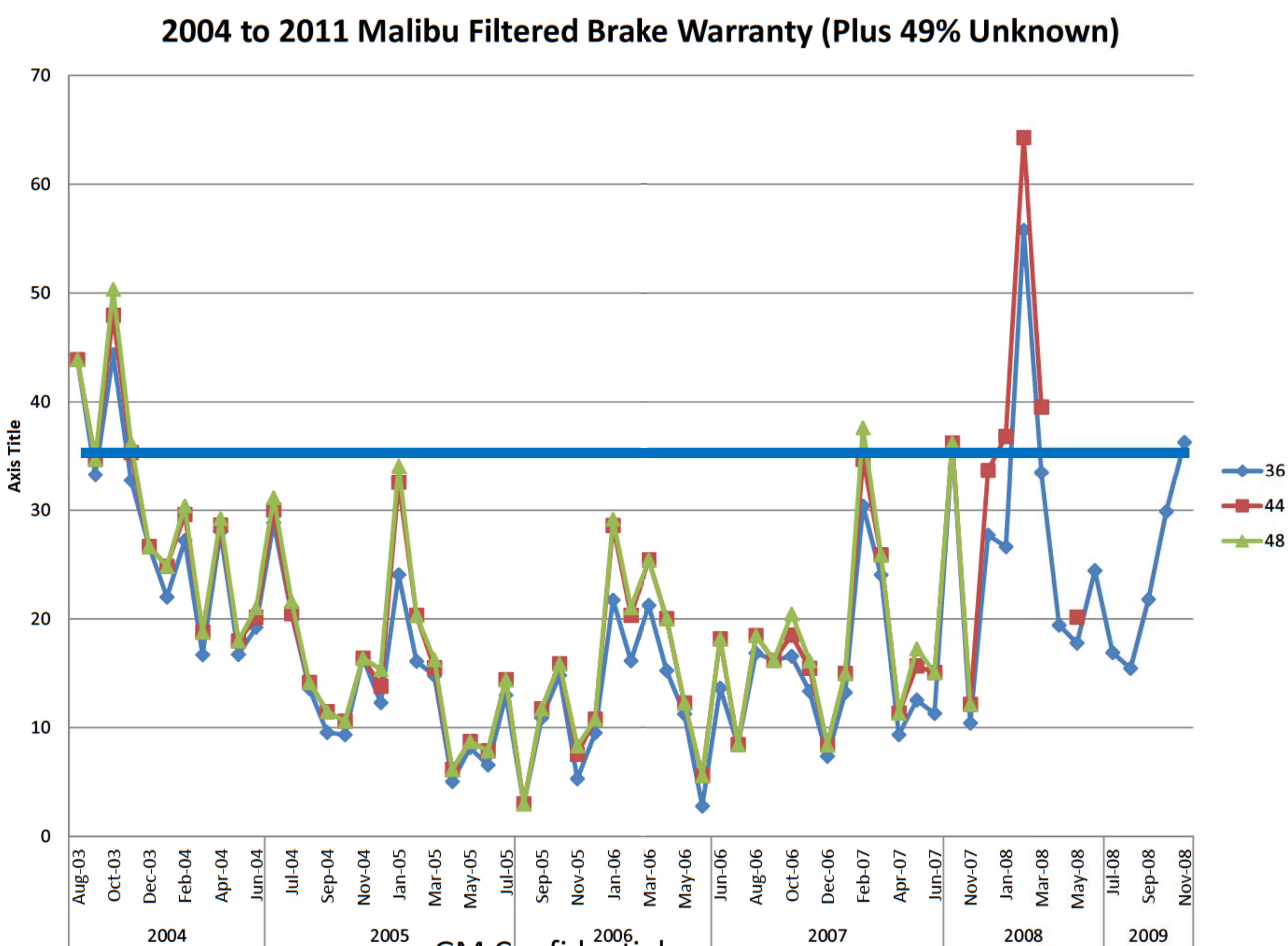

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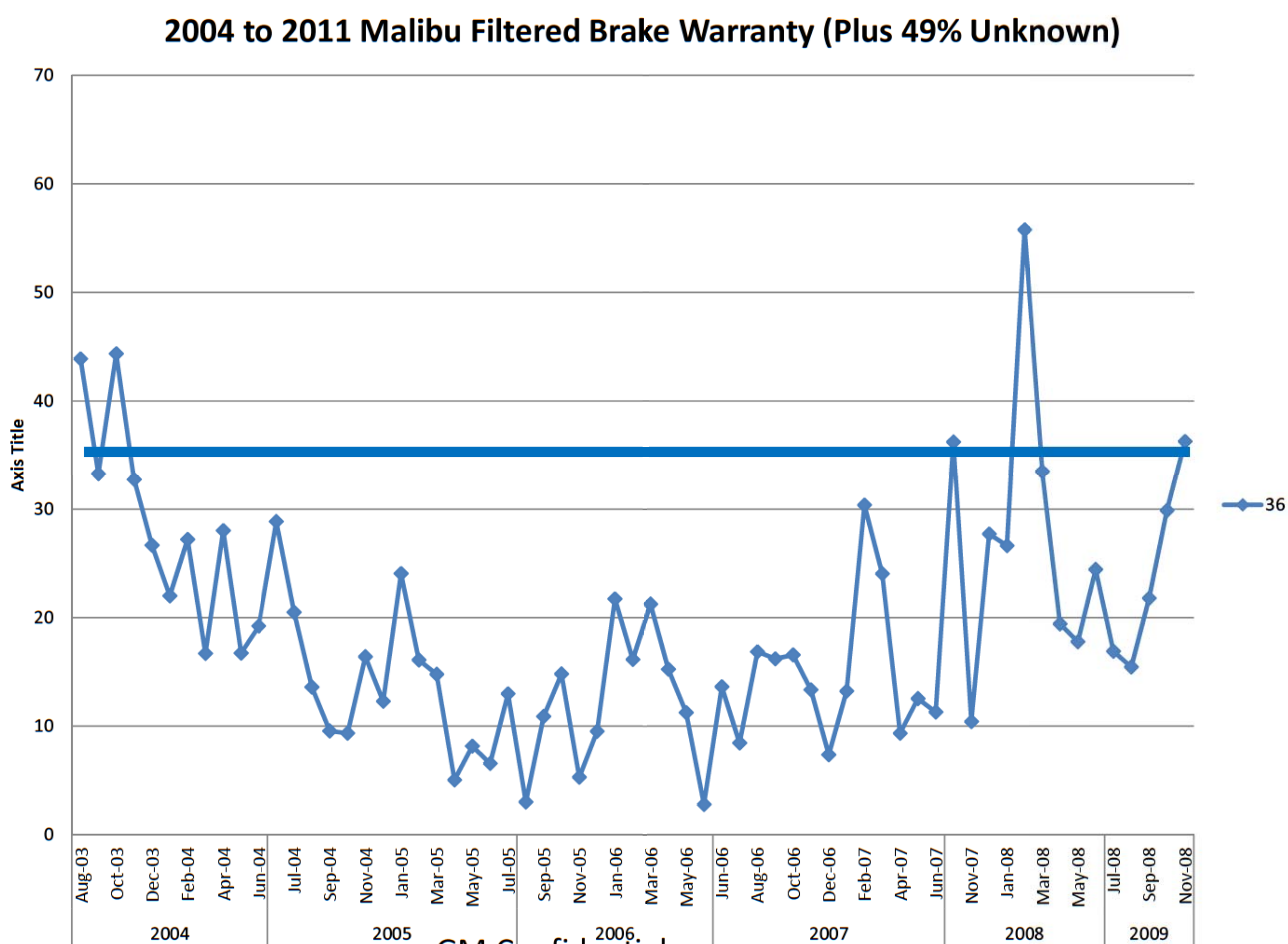

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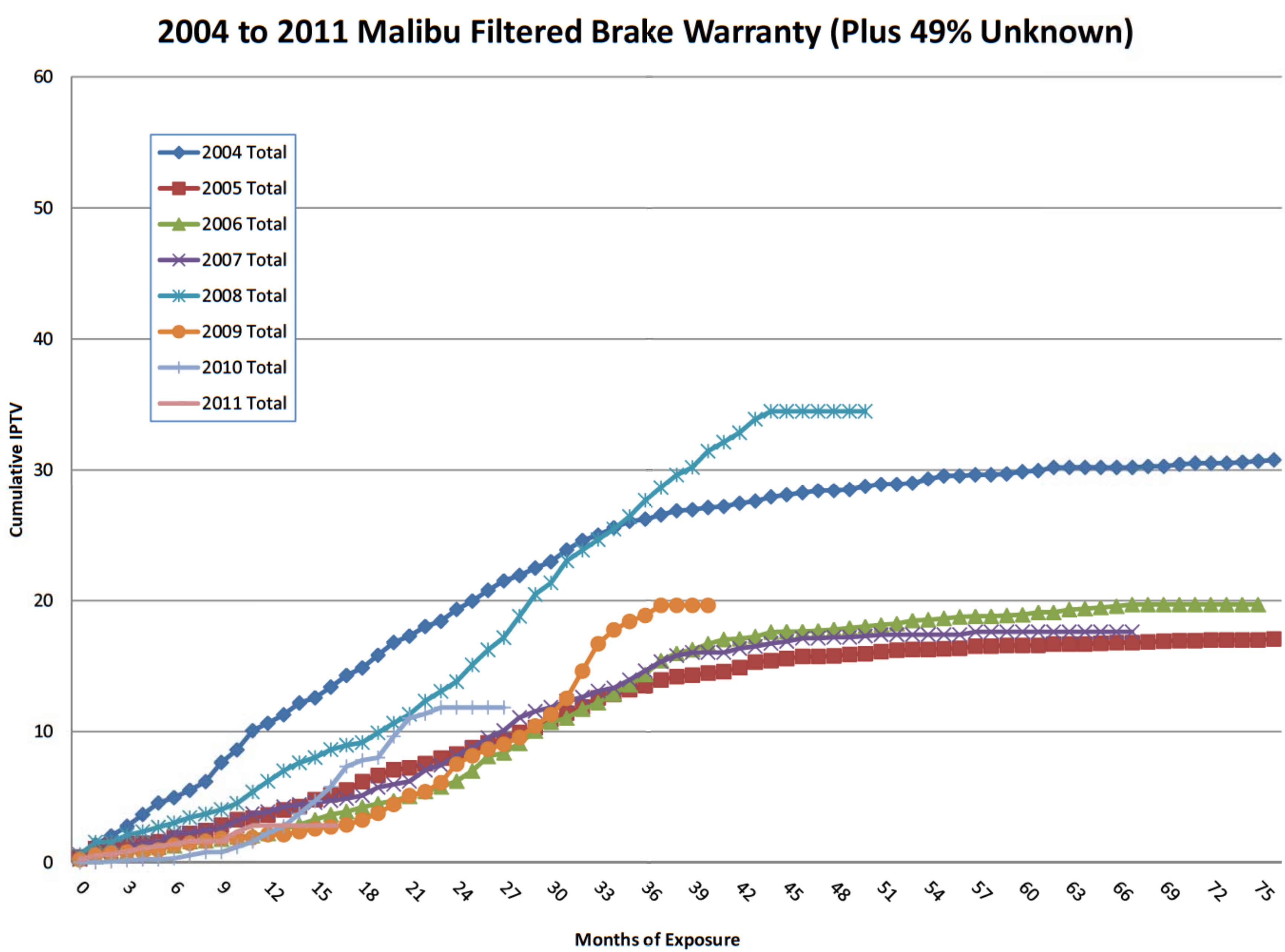

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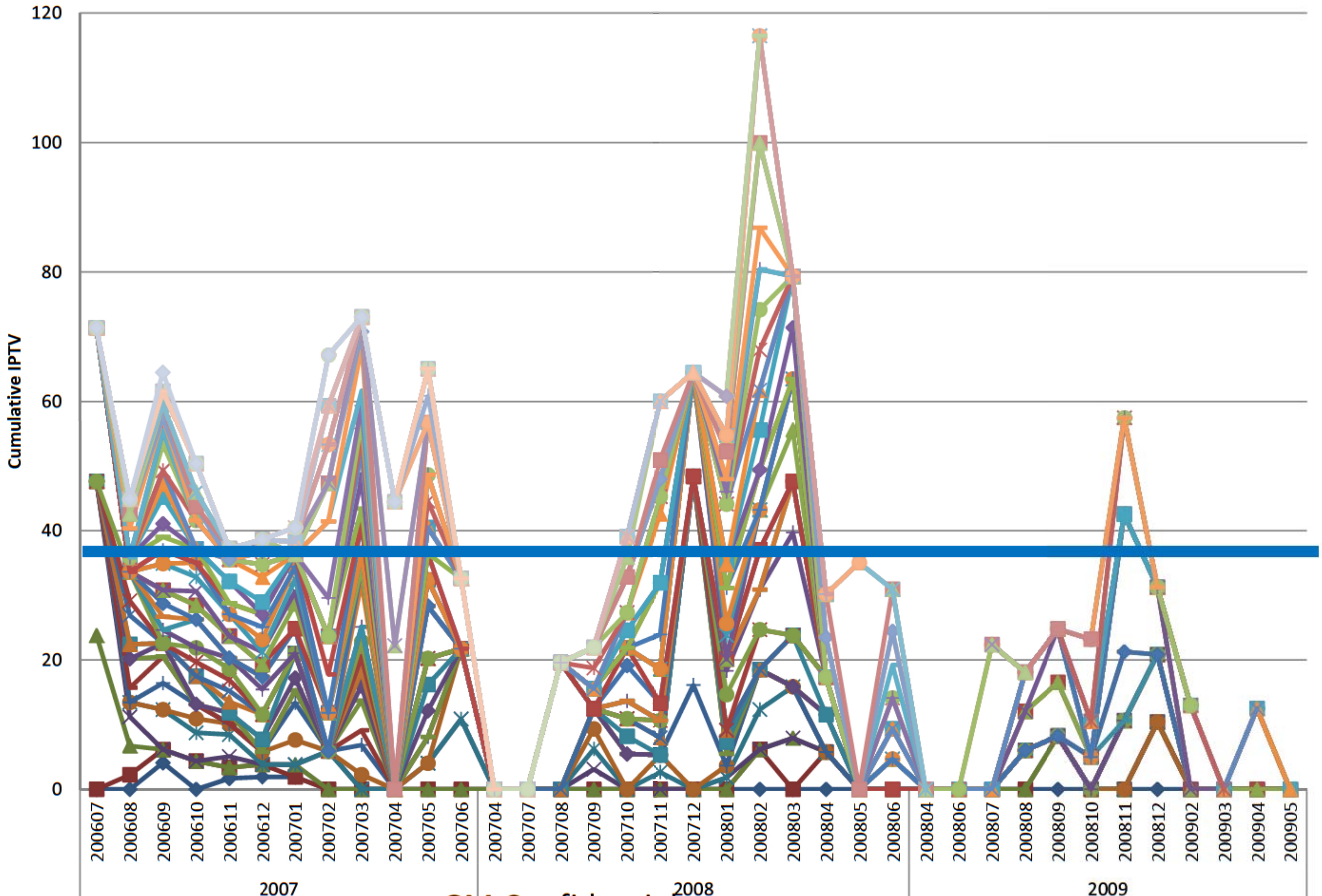
2007 to 2009 Aura Filtered Brake Warranty (Plus 71% Unknown)



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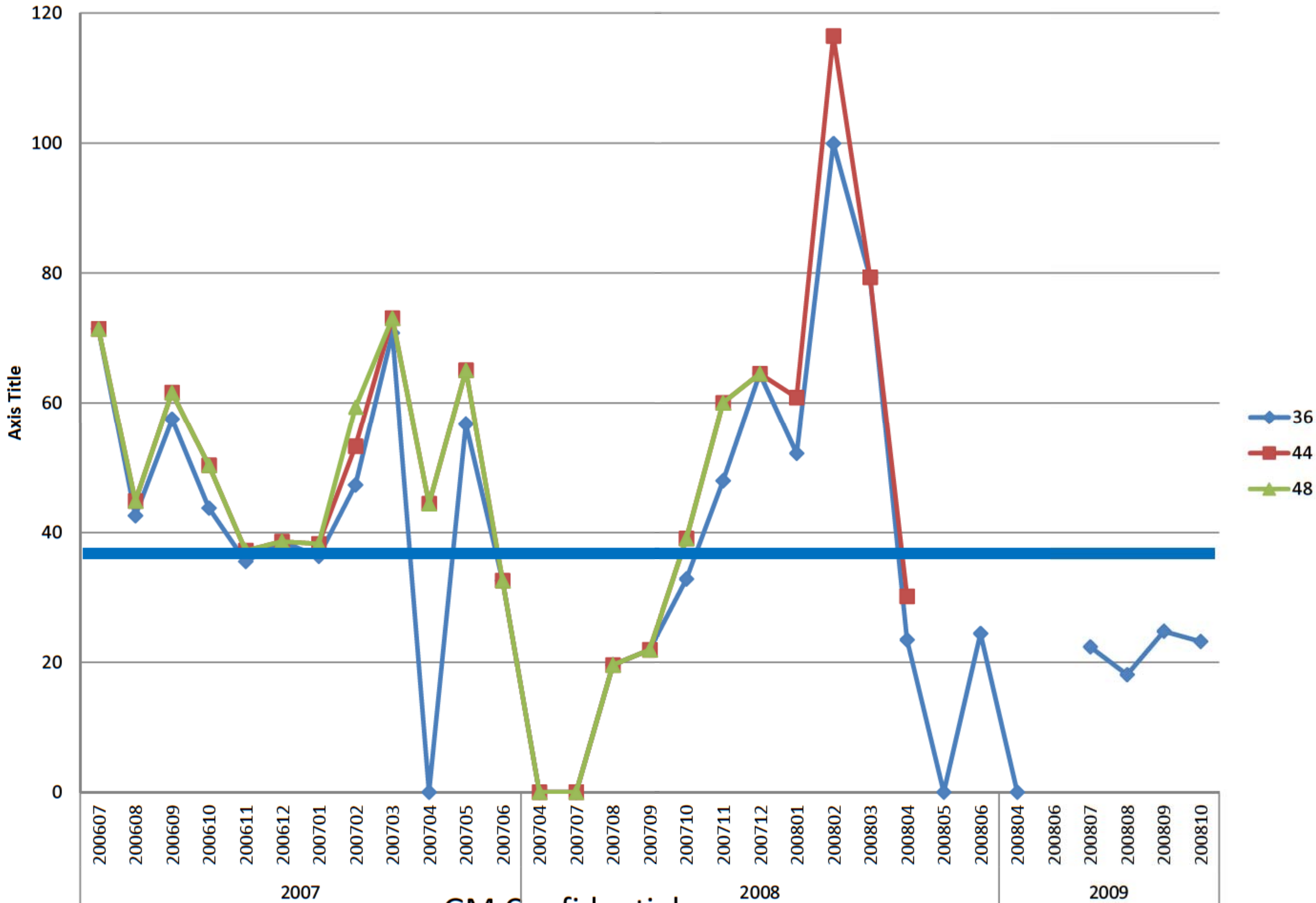
2007 to 2009 Aura Filtered Brake Warranty (Plus 71% Unknown)



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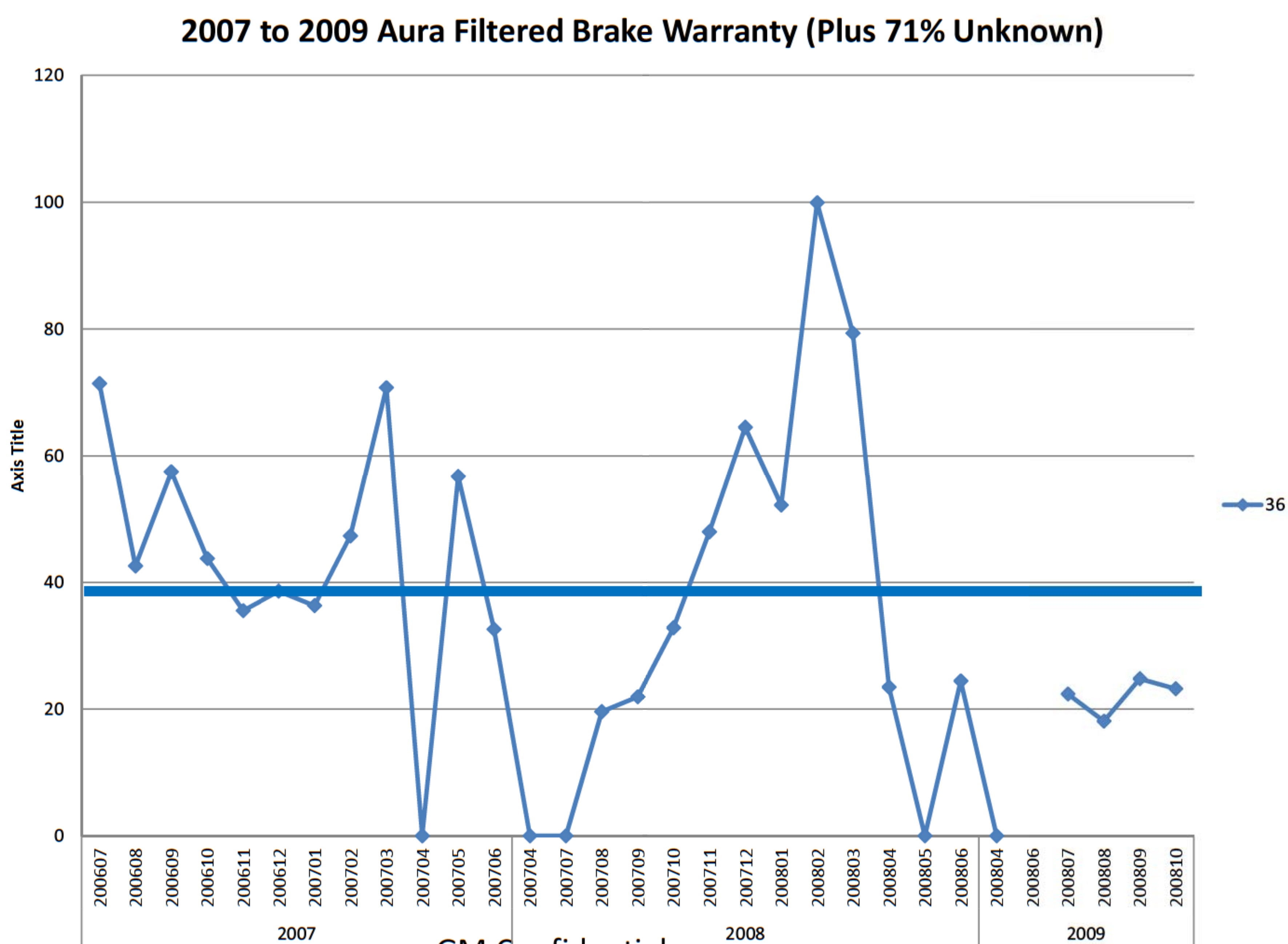

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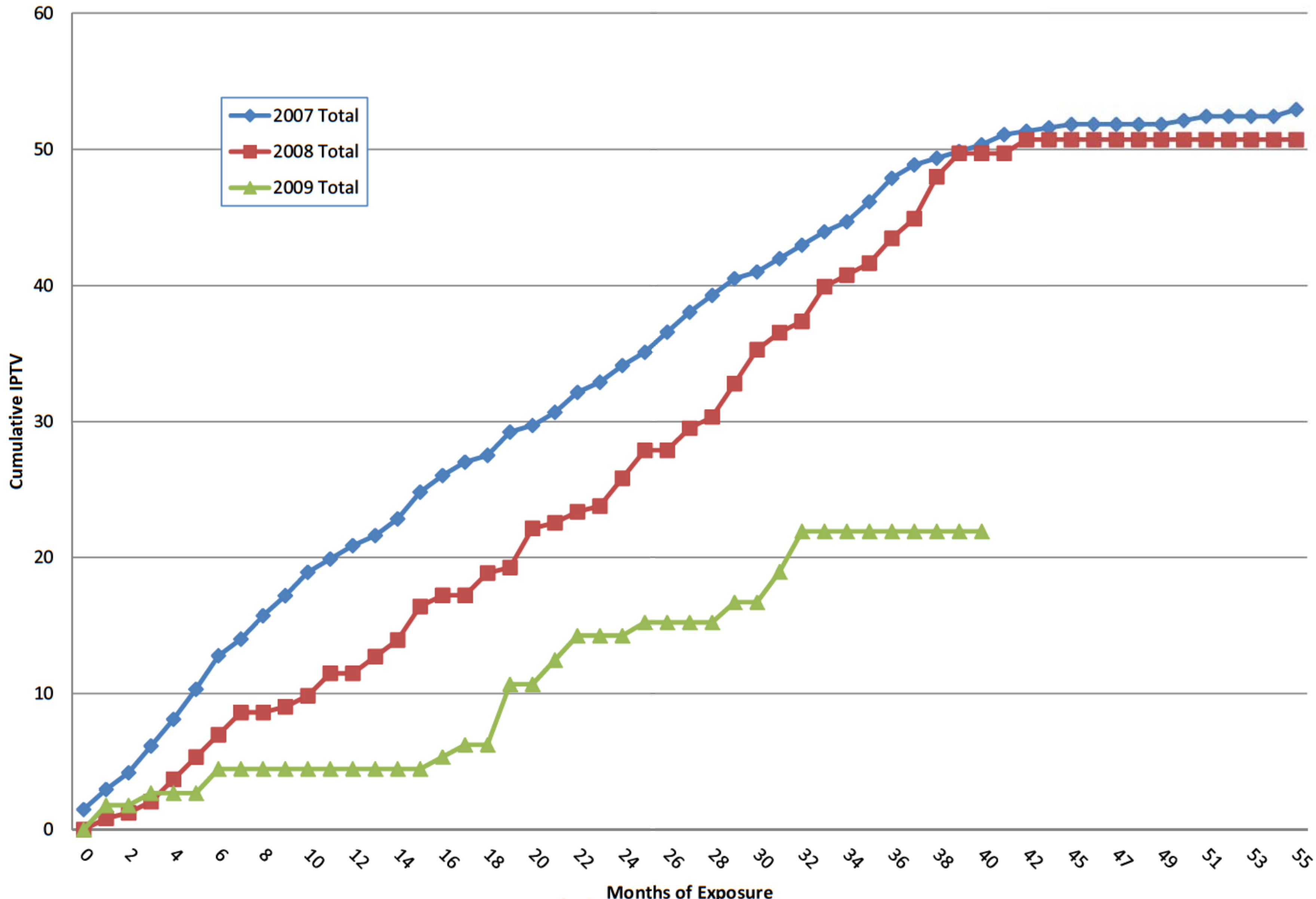
2007 to 2009 Aura Filtered Brake Warranty (Plus 71% Unknown)



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Individual State and Province IPTV

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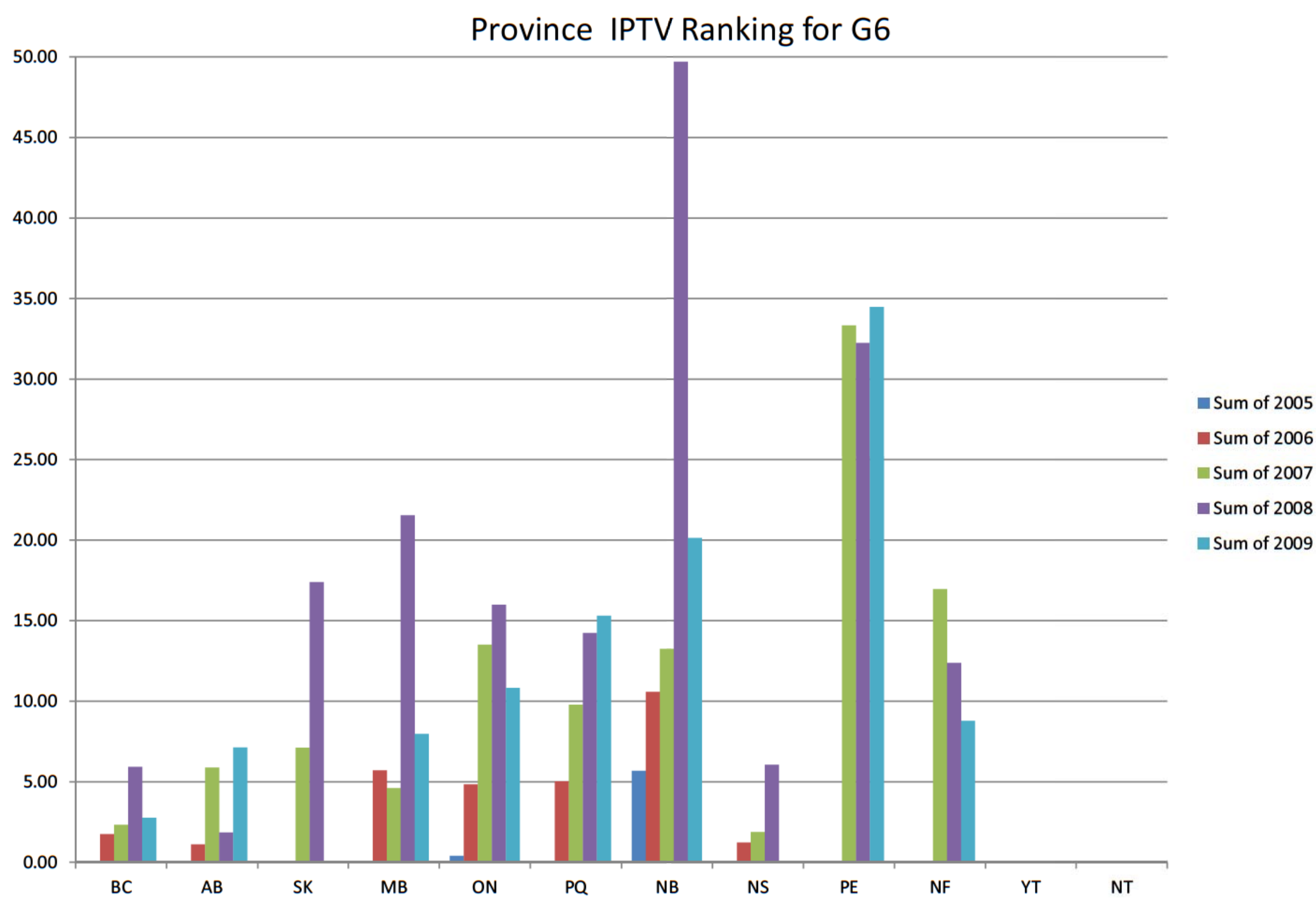

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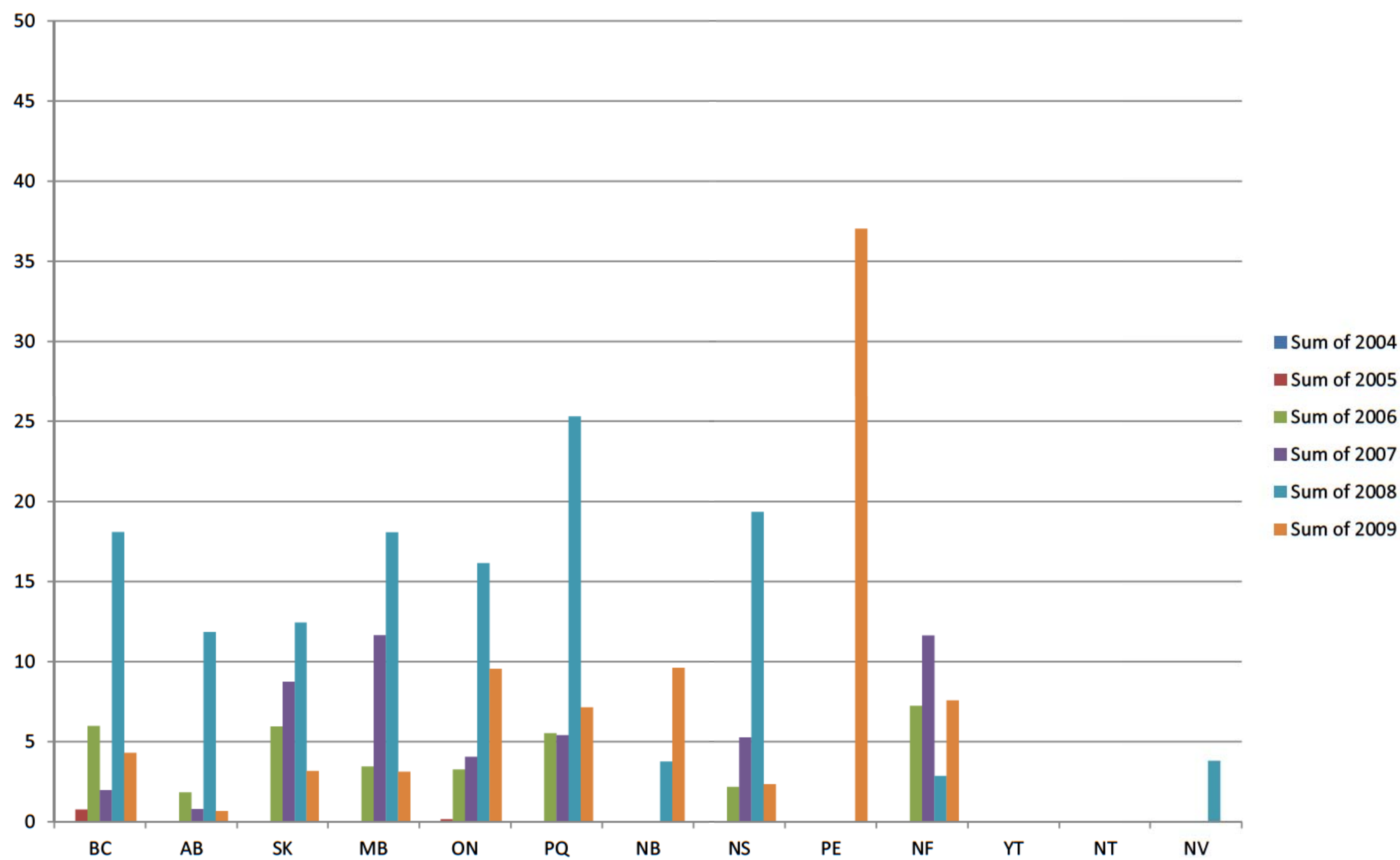
Province IPTV Ranking for Malibu



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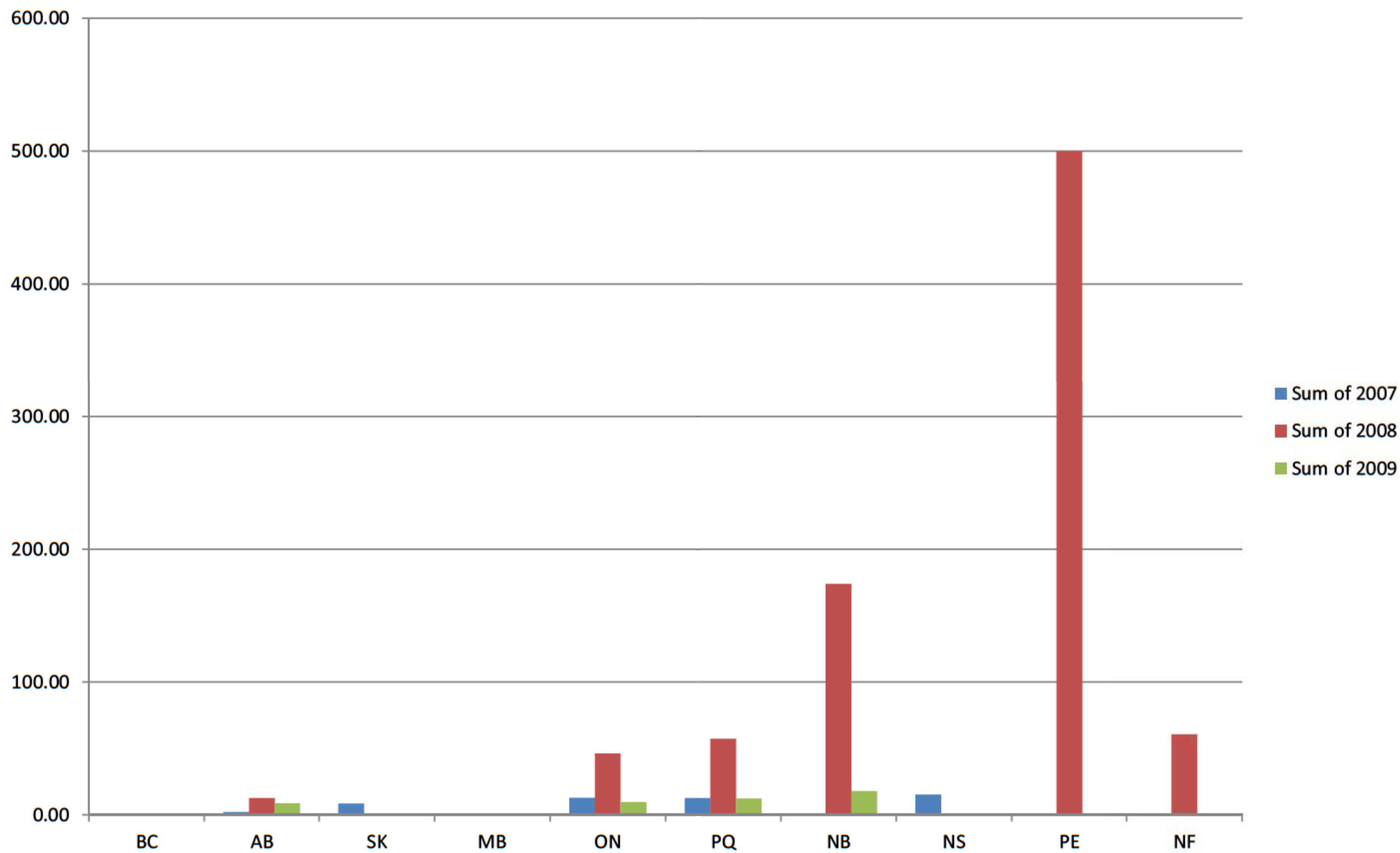
Province IPTV Ranking for Aura



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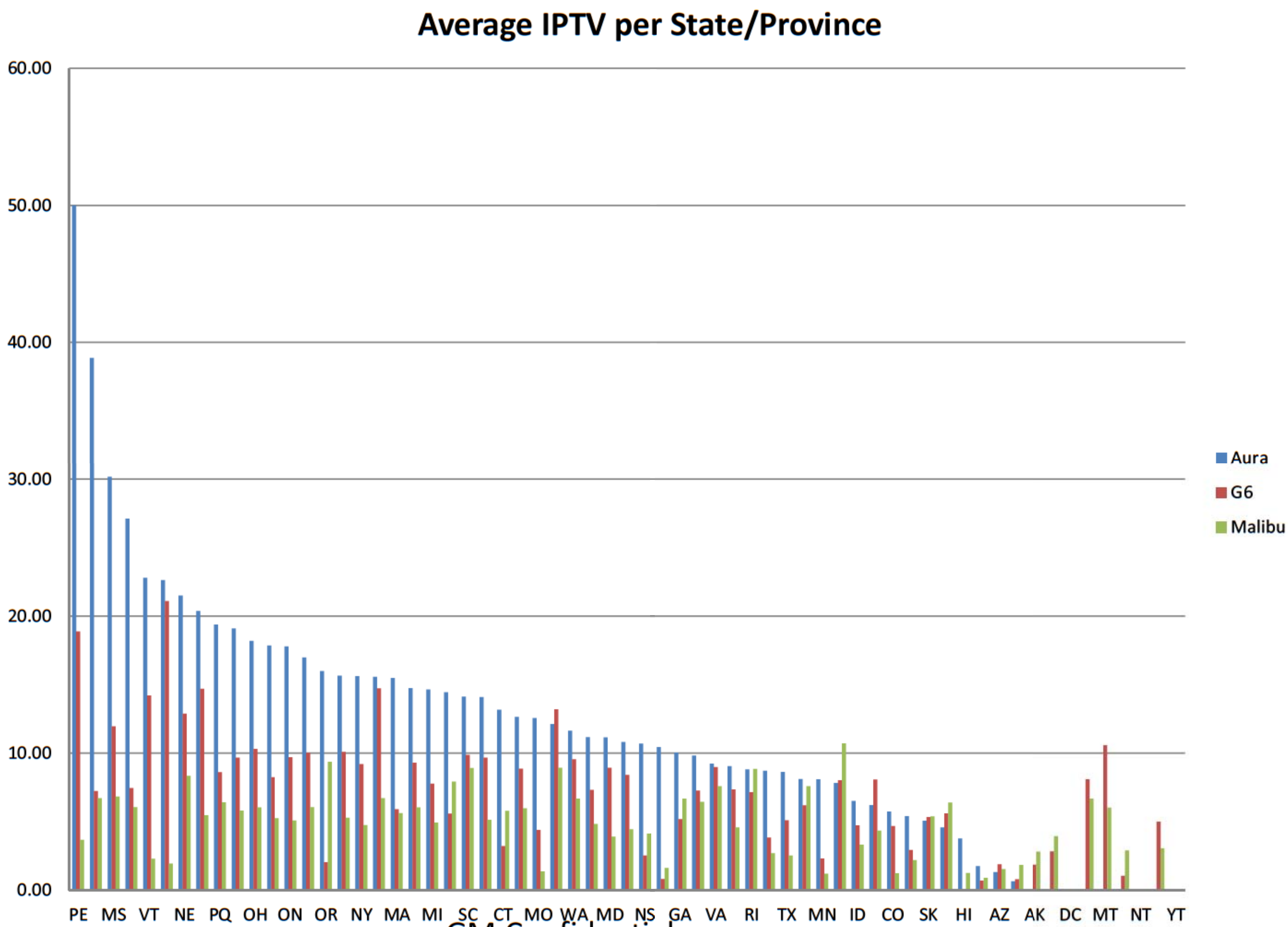

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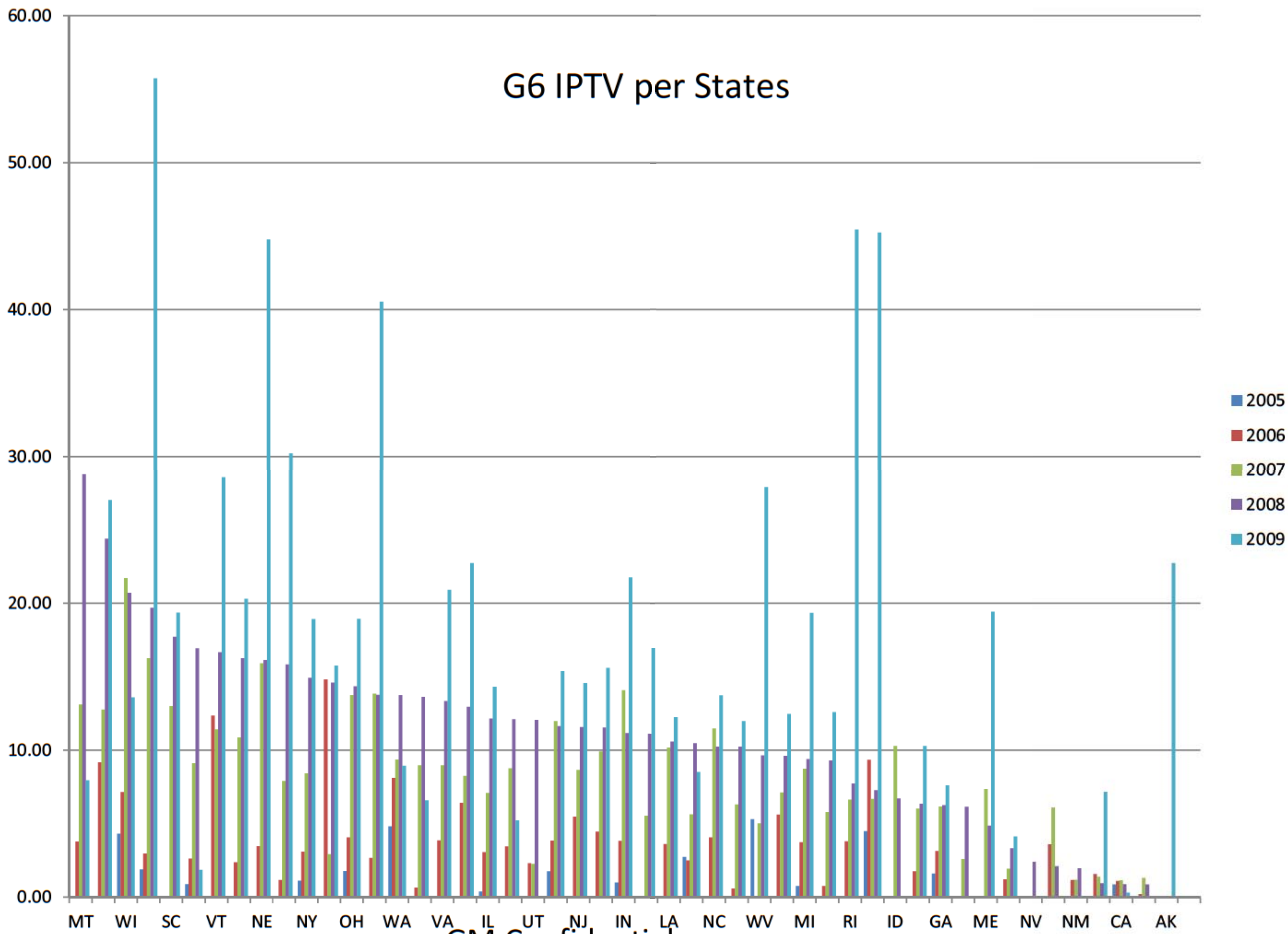

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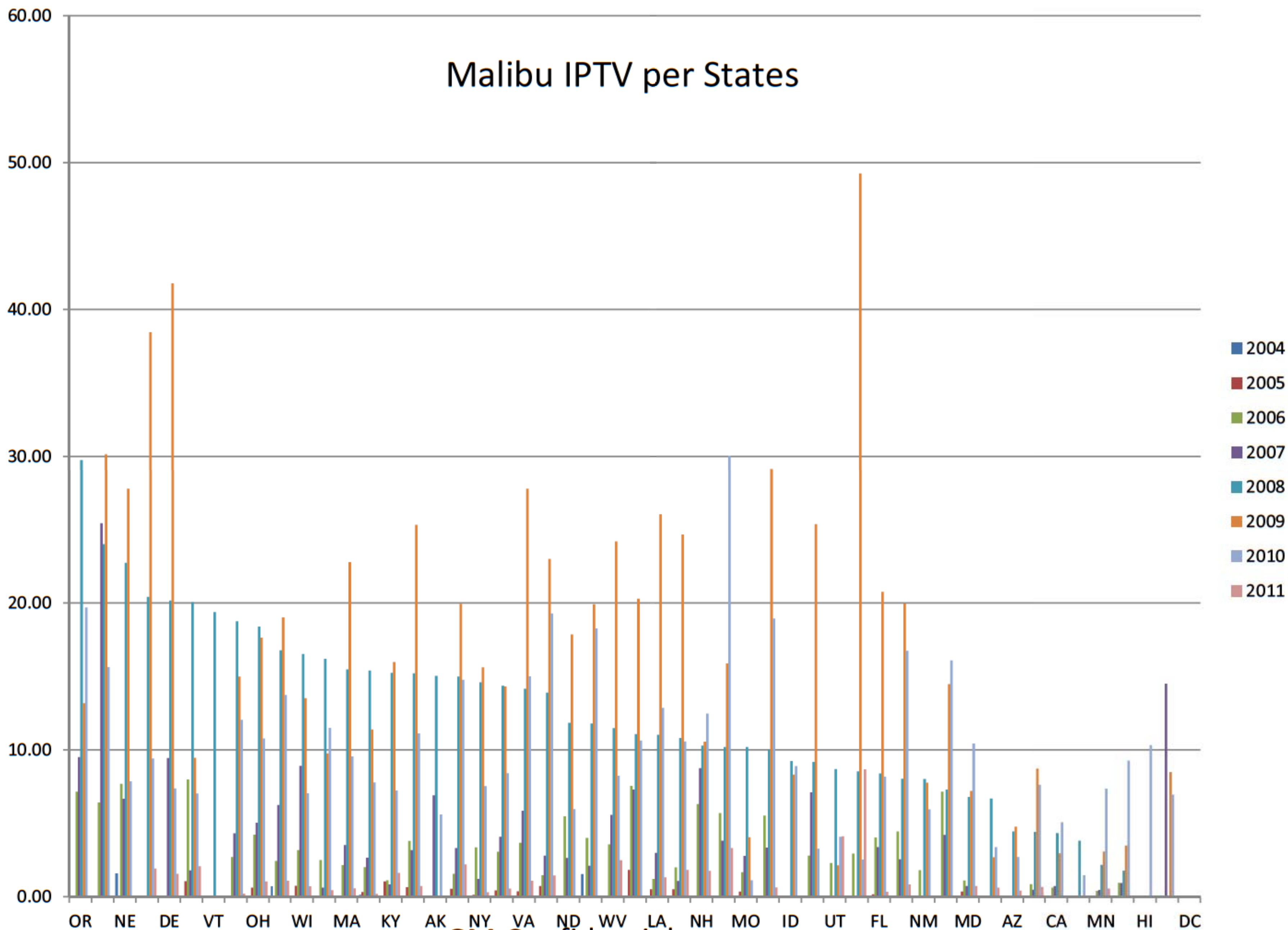

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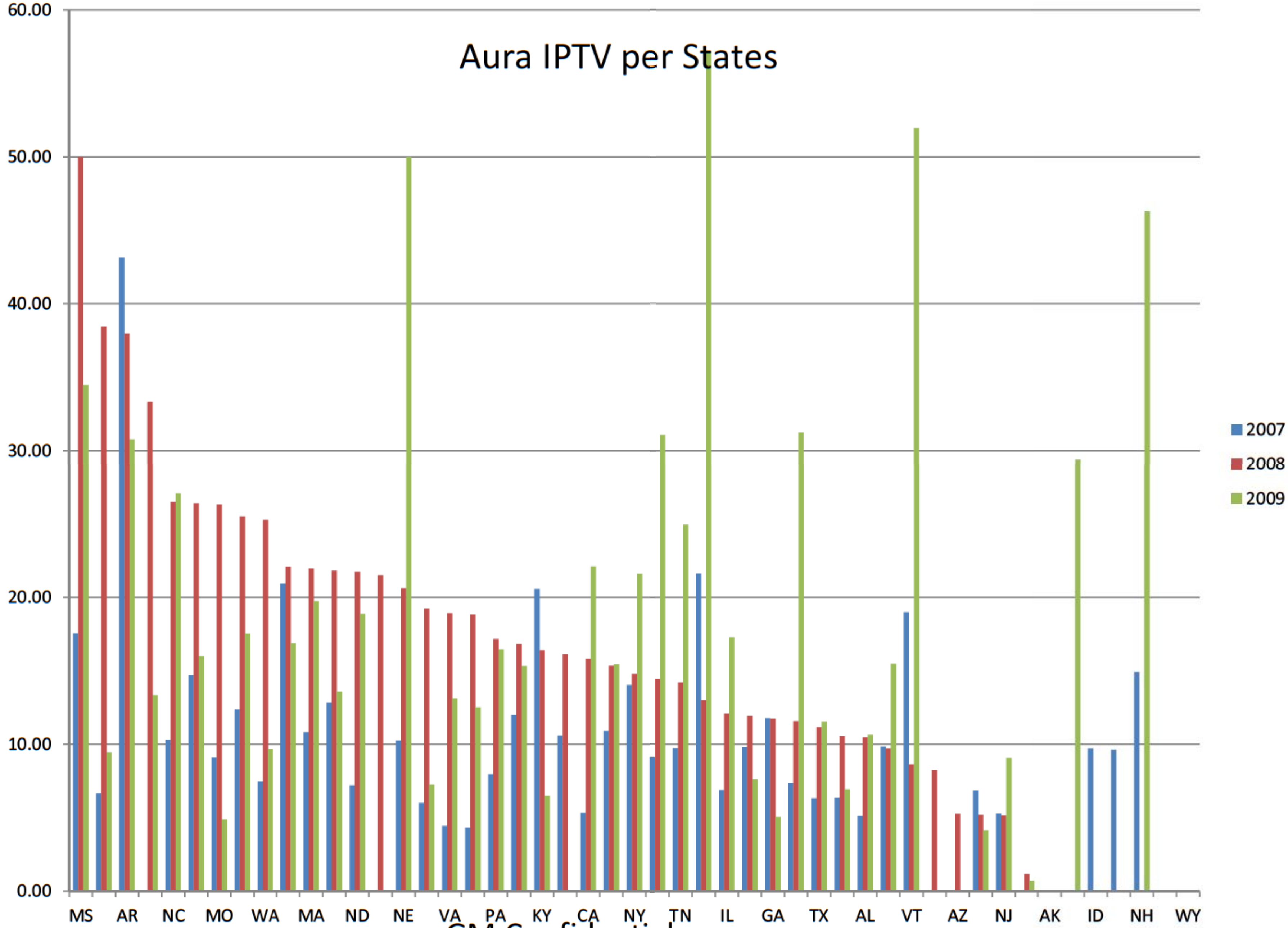

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The Body Control Module with different electrical harness architecture is used for the following platforms:

2004MY	Malibu, XLR	
2005MY	G6, Cobalt, Corvette	
2006MY	HHR, Solstice	
2007MY	Sky, Opel GT, Aura	- NEW MICROPROCESSOR
2008MY	New Malibu	

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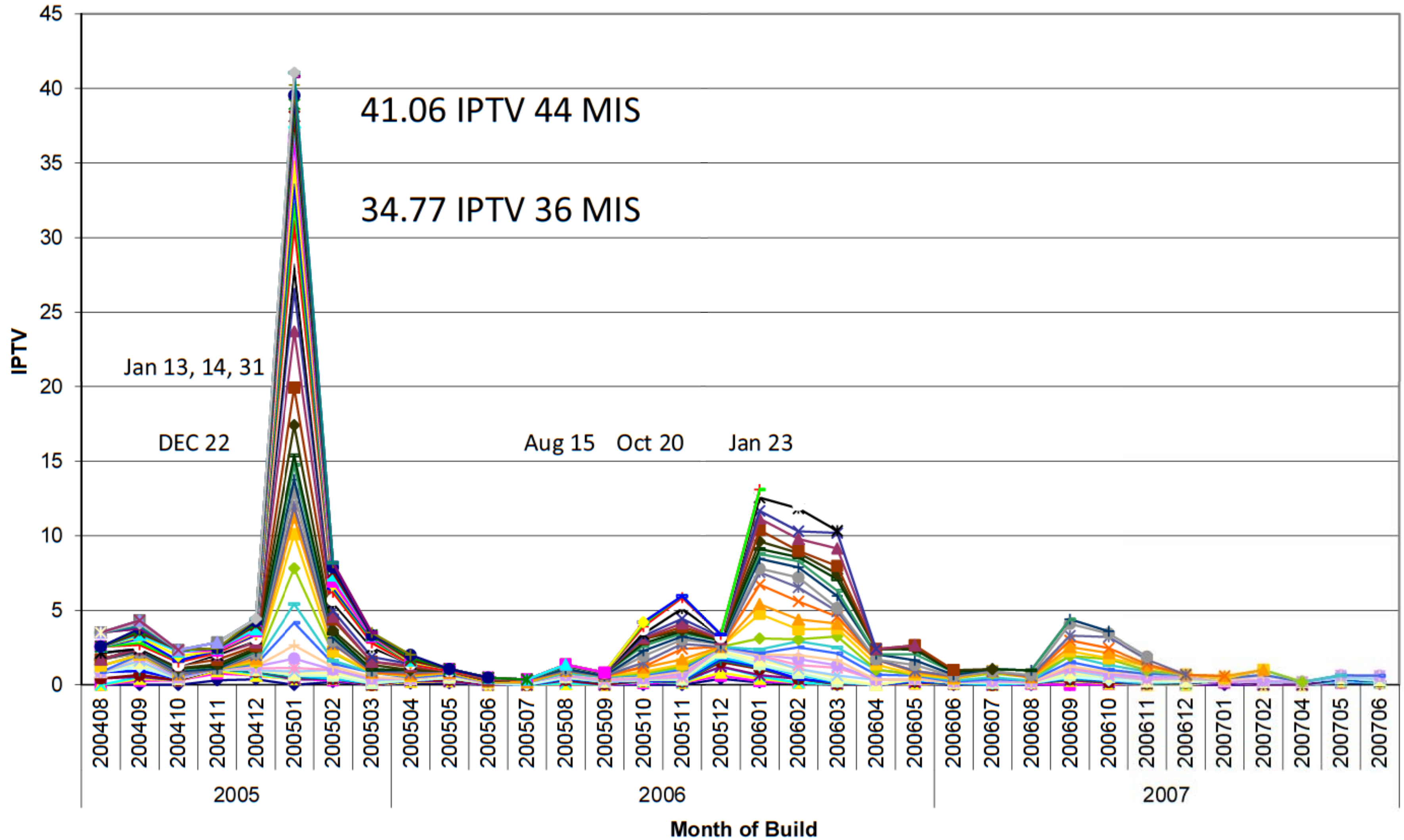
Technical Service Bulletin

#08-05-22-009: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTC C0161/C0277 Set (Perform Repair as Outlined) - (Dec 4, 2008)

Subject: Intermittently Brake Lights (Stop Lamp) Do Not Function Correctly, Extended Travel to Shift Out of Park, Cruise Control Inoperative, DTCs C0161/C0277 Set (Perform Repair as Outlined)

Apply dielectric lubricant (clear gel) GM P/N 12377900 (In Canada, use P/N 10953529) on the BCM C2 pins (apply with a one-inch nylon bristle brush) on all the C2 connector pins (this will treat the pins against fretting corrosion).

2005 - 2007 G6 Intermittent Stop Lamp Warranty



9 VOQs	2005MY: 4	2006MY: 4	2007MY: 1
20 VOQs	2005MY: 11	2006MY: 7	2007MY: 2

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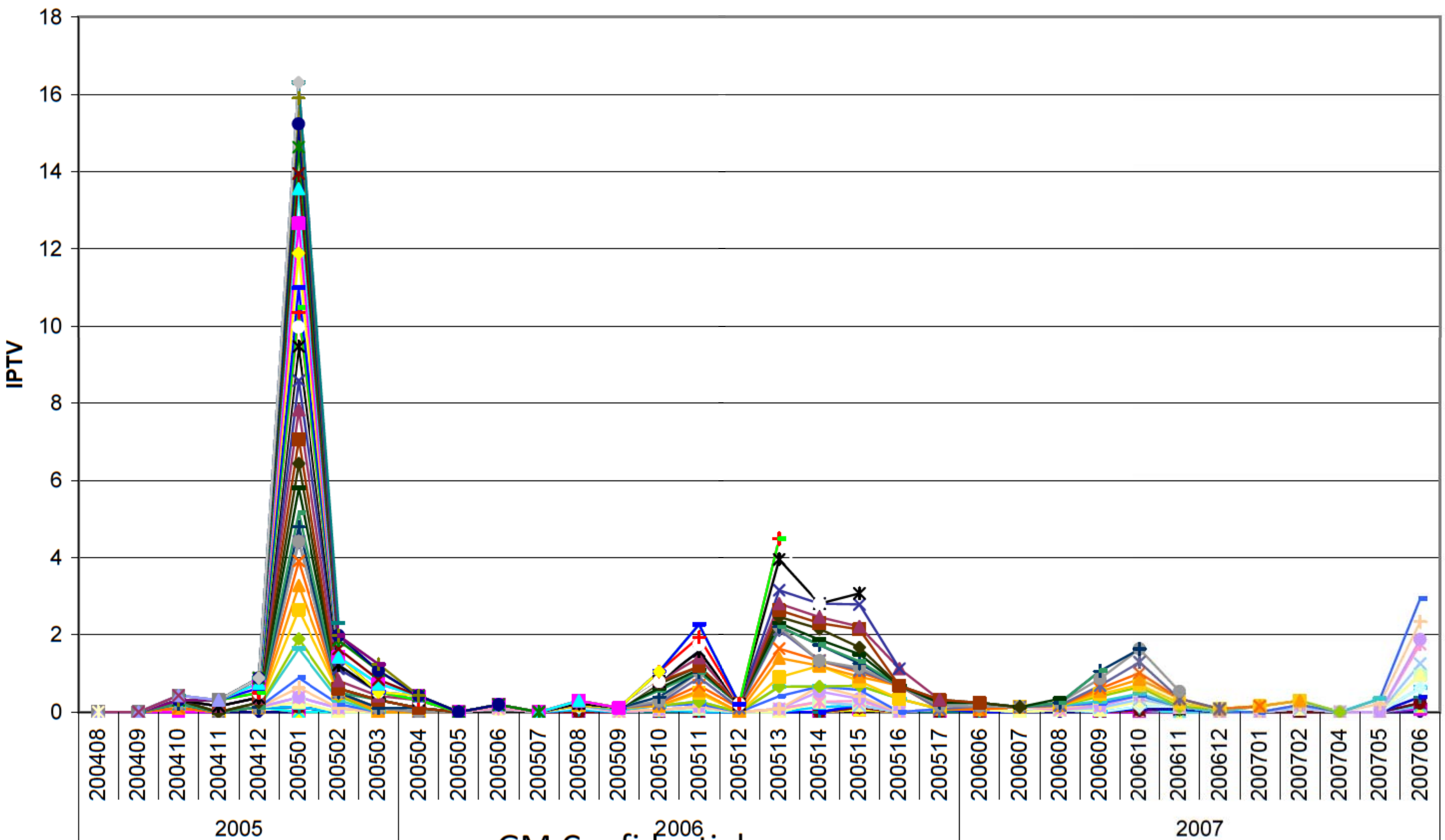
Weekly Production Volume for the Month of January 2005: U.S. and Canada

MAKE/ MODEL	Week 03JAN05	Week 10JAN05	Week 17JAN05	Week 24JAN05	Day 31JAN05	TOTAL
Pontiac G6	2,374	2,334	1,826	2,272	475	9,281

Myear	GM of Canada	GM of Mexico	Pontiac Domestic	Grand Total
2005	1,348	49	7,933	9,330
2006	8		85	93
Grand Total	1,356	49	8,018	9,423

2005 - 2007 G6 BASS – TAC and CAC only

2005 to 2007 G6 Filtered Stop Lamp Field Reports Data Only



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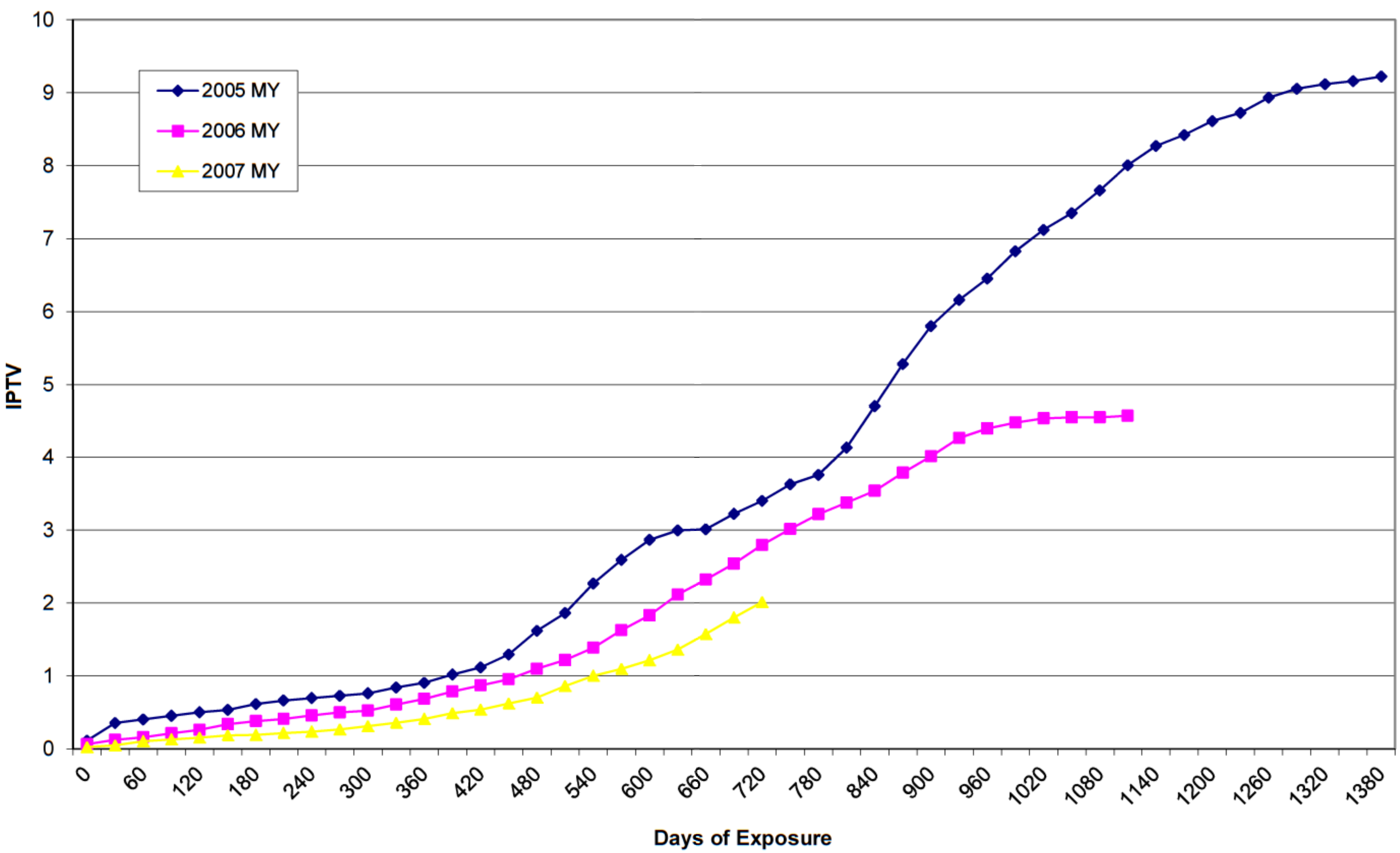
2005 - 2007 G6 Intermittent Stop Lamp Warranty



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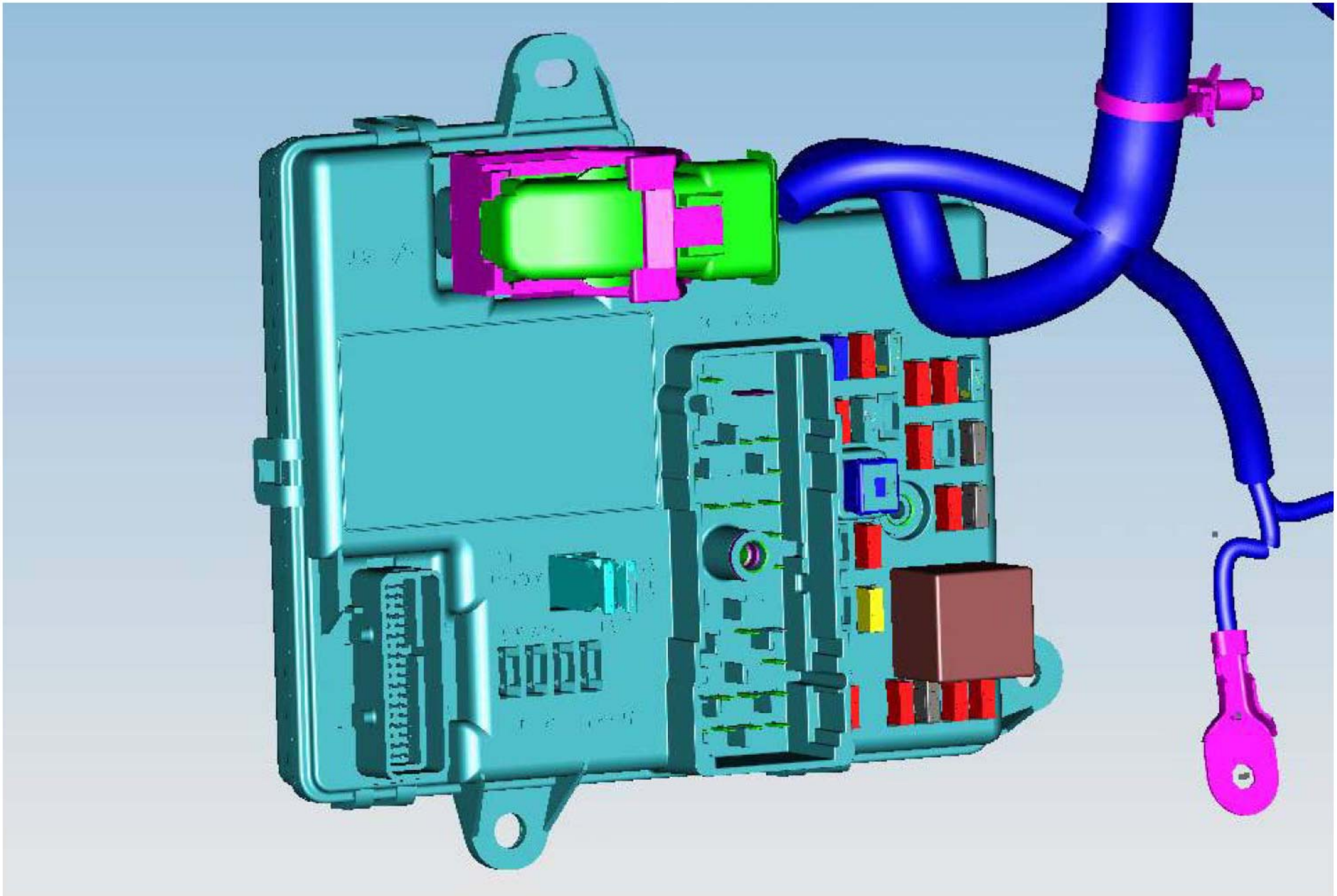

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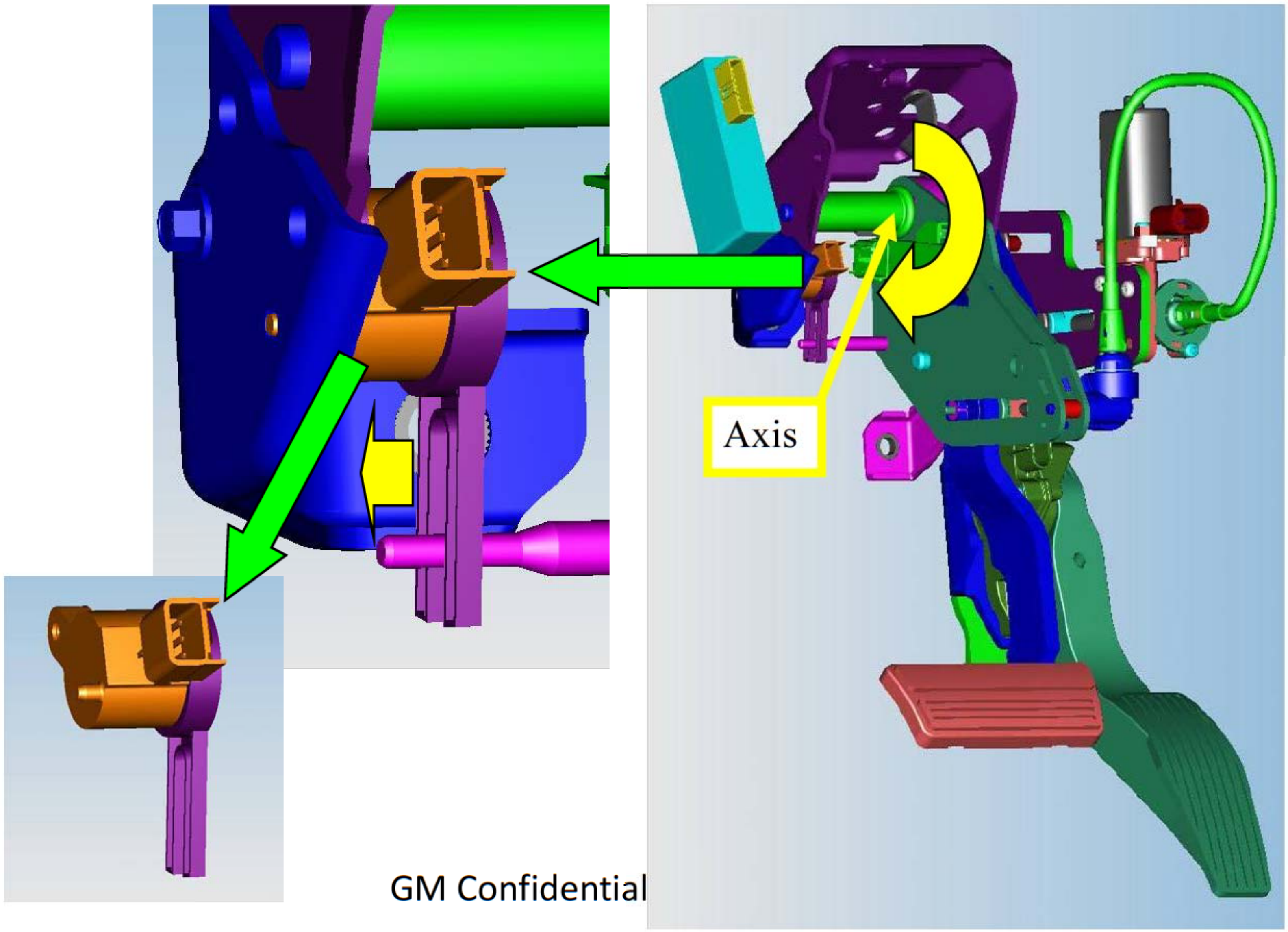
2005 - 2007 G6 Brake Apply Sensing System

Pedal/Sensor Movement



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Brake Lamps Malfunction due to BCM Connector

Chronology

9/15/2008	NHTSA ODI opened PE investigation with 9 VOQs
11/12/2008	GM responded and stated it is continuing its investigation
1/28/2009	GM notified NHTSA that GM is conducting safety campaign for 8,012 vehicles built in January 2005 for 2005MY and 2006MY.
1/30/2009	NHTSA closed the investigation stating that ODI's review of complaint rate for the January 2005 built month is 20 times greater than the remainder of the subject vehicle population and warranty rate is 11 times greater than the remainder of the subject vehicle population.
June 2012	NHTSA requested GM to provide 2005-09MY G6 Brake Lamp Malfunction, Outside Recall information.

Closing Resume

2005 – 2007MY G6 Intermittent Stop Lamp Warranty
This was reviewed in November 2008