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16. Abstract

Ricardo has combined existing hardware teardown studies with a study of the software development costs to develop incremental cost and weight impacts of Pedestrian Automatic Emergency Braking systems (PAEB) for passenger vehicle with a gross vehicle weight rating (GVWR) of 10,000 lbs. or less. Ricardo evaluated three different systems: Toyota Camry Safety SenseTM PAEB system, Subaru Outback EyeSight® PAEB system and Audi A8 PAEB.

Through research into system specifications and interviews with industry experts, Ricardo concluded that the PAEB system (Hardware and Software) could not be differentiated from all the rest of the Automatic Emergency Braking system (AEB) vehicle features. Specifically, AEB functionality relies on object detection capabilities in both the system hardware and software. PAEB functionality is achieved by improving the system object detection where pedestrians are concerned, primarily through software improvement. Additionally, Ricardo found out that the burden for software highly depends on how disruptive the ADAS is; the development of new and novel functionality requires greater development effort than the adaptation and modification of existing systems. Systems that were likely adapted from existing ADAS software functionality are referred to as "follower" while systems where much of the functionality required novel development are referred to as "disruptive". ADAS software cost is driven by system functionality, performance and confidence level requirements, as required by OEMs and their suppliers to comply with existing standards, regulations, and perceived customer requirements.

The Toyota Camry AEB system is part of Toyota Safety SenseTM P which has a Pre-Collision System (PCS) and uses a combination of radar and camera with sensor fusion. Ricardo consider this system as a "follower". The end user incremental costs and weights for the Toyota Camry camera system estimated to be $237.33. The Toyota Camry system weighed 883g.

The Subaru Outback, equipped with EyeSight®, uses a stereo camera system only for AEB. The system has a unique stereo camera module that can detect distance and speed of objects in front of the vehicle without the need for a radar sensor. Ricardo consider this system to be a "follower". The incremental cost of the Subaru camera system is estimated to be $288.36. The weight of the Subaru Outback AEB system is estimated to be 2478g but more than half of that total was for incremental wiring; the stereo camera module itself weighed 785g.

Toyota Camry and Subaru Outback AEB systems relied upon a processor that was shared with the vehicle and therefore was not included in the incremental analysis however the image detection System on a Chip (SoC) cost was added.

The Audi AEB system employs a forward-looking visible camera, an infrared (IR) night vision camera, a long-range radar, two forward-side looking short range radars and a first-to-market automotive grade laser scanner (LiDAR.) In addition, a central Driver Assistance Systems (DAS) controller coordinates the sensor inputs and incorporates AEB functionality. The European version of the A8 offers level 3 autonomous driving capability that Audi calls 'Traffic Jam Pilot;' the US version of the A8 does not offer all the functionality due to varying local regulations. Ricardo consider this system to be a "disruptive" system. The incremental costs and weights for the AUDI PAEB system estimated to be $1,826. The AUDI system weighed 5,077g. Image detection System on a Chip (SoC) is included in the dedicated ADAS controller.

17. Key Words	**18. Distribution Statement**		
PAEB, ADAS, DAS, Pedestrian, Automatic, Emergency, Braking, System,	This report is free of charge from the NHTSA Web site at www.nhtsa.dot.gov		
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