

March 20, 2007

Comments to the Air Resources Board
regarding
California's Emission Warranty Information
Reporting and Recall Regulations and Emission
Test Procedures

Scott Carr, Ph.D.

Executive Summary

I have been engaged by the Alliance of Automobile Manufacturers to independently and objectively evaluate proposed changes to California's Emission Warranty Information Reporting regulations. In particular, the Alliance asked me to consider the validity of the ARB staff's cost analysis and the appropriateness of the proposed regulatory changes generally. This report documents my findings.

The following list is a brief summary of my main conclusions; additional background and detail is provided in the remainder of this report.

1. The ARB staff's cost analysis is fundamentally flawed and should be given no weight. In particular:
 - a. The cost analysis is based on insufficient data, and the cost estimates thus derived cannot reliably predict the costs associated with the proposed regulations.
 - b. The cost analysis is based on inappropriate and unrealistic assumptions related to, for example, the conditions in which recalls and extended warranties would be ordered under the proposed regulations.
 - c. The cost analysis excludes large and important categories of costs that would be directly affected by the proposed regulations, and this biases the staff's estimates of the economic impact of the proposed regulations.
 - d. Other relevant information that was readily available to the ARB staff, from public comments for example, was inappropriately disregarded.
2. The proposed regulations, by removing any consideration of the vehicles' overall emissions performance, actually contradict good engineering practice.

3. With regard to the proposed regulations, the ARB staff has not, to date, satisfied the ARB's goal of basing decisions on sound scientific and economic analysis.

Again, all of these concerns are described more extensively in the remainder of this report.

Thank you for the opportunity to submit these comments.

A handwritten signature in black ink, appearing to read 'S. M. Carr', with a stylized flourish at the end.

Scott M. Carr, Ph.D.
LECG, LLC

March 20, 2007

Comments to the Air Resources Board
regarding
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Reporting and Recall Regulations and Emission
Test Procedure

Scott Carr, Ph.D.

To whom it may concern,

I have been engaged by the Alliance of Automobile Manufacturers ("Alliance") to independently and objectively evaluate changes to California's Emission Warranty Information Reporting and Recall Regulations for Emission Test Procedures (the "EWIR regulations") that were proposed by the staff of California's Air Resources Board (ARB). In particular, the Alliance asked me to consider the validity of the ARB staff's cost analysis¹ and the appropriateness of the proposed regulatory changes generally. This report documents my findings. Please note that the conclusions and opinions expressed in this report are entirely my own; this report has not been subject to editing or approval by the Alliance or anyone else.

As to my professional qualifications, I am employed by LECG, LLC in Washington, D.C., and I am also a professor on leave from the UCLA Anderson Graduate School of Management. I hold the following academic degrees: a Ph.D. in Industrial and Operations Engineering and also in Business Administration, an M.S.E. in Industrial and Operation Engineering, an M.S.E. in Construction Engineering and Management, and a B.S.E. in Mechanical Engineering. I have experience in the automotive industry and in other relevant industries, and I have conducted extensive original research that is directly relevant to these issues. A more extensive CV is attached.

I have focused my attention and this report on corrective actions – recalls and extended warranties for passenger vehicles and light trucks in particular – that may be ordered by the ARB's Executive Director and staff when a vehicle group exceeds "a valid warranty claim rate threshold of four percent or 50 claims, whichever is greater" (for simplicity of exposition, I will simply refer to this as "the 4% threshold"). In simple terms, the

¹ "Supplement to the Initial Statement of Reasons" (SISOR). Mail-Out #MSO 2007-01. released January 23, 2007 by Air Resources Board.

proposed changes to the EWIR regulation that are the most relevant to this report are the following:

- Currently, the 4% threshold serves as a “flag” or signal that there may be a problem with a group of vehicles that will necessitate a recall, extended warranty, or other corrective action. The ARB Executive Officer and staff have the authority to order a recall or to allow the manufacturer to offer an extended warranty or other corrective action in place of a recall. The manufacturer has the right to contest a recall order by demonstrating that corrective action is not necessary for the vehicle group to remain in compliance with the relevant emissions standards.²
- Under the proposed regulations, the 4% threshold becomes *de facto* evidence that corrective action is necessary. A recall, extended warranty, or other corrective action is then to be ordered at the “sole discretion of the Executive Officer.”^{3,4}

The ARB staff’s motivation for the proposed changes is largely their belief that “manufacturers have exploited weaknesses in the regulations to avoid taking corrective action for some defective components,”⁵ and it appears from their reports that the ARB staff believes that the largest weakness in the current regulations is that manufacturers are able to avoid corrective actions by demonstrating that the vehicle group in question will remain in compliance with the applicable emissions standards even if corrective action is not taken.⁶

In my opinion, this is not a weakness of the current regulations but rather a strength. If the objective of emissions standards is to set limits on vehicle emissions for the sake of

² This paragraph necessarily paraphrases the more verbose language of the actual regulations and of others’ extensive descriptions of the current regulations; for example, see:

“Initial Statement of Reasons for Proposed Rulemaking” (ISOR). released October 20, 2006 by Air Resources Board. page 8-10.

³ ISOR, page 20: “Staff is proposing to establish that ... corrective action is triggered when the valid component failure rate exceeds four percent as based on a manufacturer’s EWIR reports.” From the proposed section 2170(b), “At the sole discretion of the Executive Officer, the manufacturer shall conduct a recall ... either as an alternative to or in addition to [an extended warranty].” Also see sections 2169, 2171, and the remainder of 2170 of the proposed regulations.

⁴ The proposed section 2174(a) provides for a limited public hearing about an ordered corrective action but it disallows the manufacturer’s right to challenge the ordered action with evidence that a corrective action is not necessary for its vehicles to be in compliance with the relevant emissions standards.

⁵ ISOR, page 6.

⁶ For example, see ISOR page 5: “In most cases where corrective action was not taken, manufacturers argued that the defective emissions component would not cause an emission standard to be exceeded, or that the OBD light would cause the owner to seek repair [without a corrective action],” and “this evidence reflects a weakness of the current regulations and their inability to remedy defective components, either by recall or other corrective action.”

protecting air quality, if the objective of recalls and extended warranties is to ensure that vehicles operate within these limits, and if we recognize that corrective actions are expensive to manufacturers and inconvenient to consumers, then we should not want corrective actions to be ordered except when the vehicles in question are polluting at a greater rate than what is embodied in the emissions standards themselves.

Examination of the ARB staff's cost analysis

The ARB staff claims that for the 2002 model year, "corrective actions involved 11 extended warranties (300,000 vehicles) and 15 recalls (130,000 vehicles)."⁷ I do not dispute these numbers, but I do note that they seem somewhat inconsistent with other documents produced by the ARB staff.⁸ The staff uses these numbers as the basis for cost estimates via the following steps:⁹

1. A per-vehicle cost of labor and parts is estimated for each "action" (i.e., for each extended warranty or recall).
2. For each action, the manufacturer is assumed to incur repair costs on:
 - a. "30 percent of the affected vehicles" (for extended warranties)
 - b. "93 percent of the affected vehicles" (for recalls)
3. Total cost of the corrective actions under the current regulations is estimated by multiplying these percentages by each action's repair cost and by the number of affected vehicles. This yields the following estimates:
 - a. \$32 million (for extended warranties);
 - b. \$9 million (for recalls); and
 - c. Total cost is thus \$41 million of which \$7 million is for heavy duty vehicles.

Next is to estimate what manufacturers' repair costs would have been had the proposed regulations been in place for the 2002 model year. The staff proceeds as follows:

4. It is estimated that corrective actions would have been ordered for 700,000 vehicles – I presume that the ARB staff came to this estimate by assuming that corrective action would be ordered for every vehicle family (or "test group") that exceeded the 4% failure threshold.

⁷ SISOR, page 12

⁸ In particular, the numbers seem to understate the number of actions on 2002 model year vehicles compared to the original ISOR and appear inconsistent with the ARB's "Annual Summary of In-Use Compliance Testing and Recall Activity" from 2004.

⁹ ARB Staff does not provide a thorough description of the estimation procedures used, so this description is somewhat speculative as to how the cost estimates were derived.

5. It is assumed that none of these 700,000 vehicles would be subject to recall because, “none would have clearly met the requirement for recall.”¹⁰
6. Using the per-vehicle repair costs and repair percentage as above, this resulted in estimated repair costs of \$66 million of which \$24 million is for heavy duty vehicles.

At this point, the ARB staff appropriately notes that the \$66 million estimate is a 61 percent increase over the original \$41 million.

The staff then refines this estimate as follows:

7. The \$24 million from heavy duty vehicles is temporarily set aside. This leaves:
\$66m - \$24m = \$42 million.
8. This is reduced by:
 - a. 43 percent “because about 43 percent of light-duty vehicles will be PZEVs, which already carry a 150,000 mile warranty”
 - b. 10 percent to account for “PZEV durability technology being passed on to non-PZEV vehicles.”

This reduces the total to: $\$42\text{m} \times (1 - .43 - .10) = \19.74 million.

- c. “an additional” 5 percent based on the new reporting process.¹¹

This gives: $\$19.74\text{m} \times (1 - .05) = \18.8 million.

9. After adding the \$24 million from the heavy duty segment back into this total, the staff concludes that,

“[T]he estimated costs of the revised warranty reporting program is \$42.8 million, close to the actual current program cost for 2002 model year [sic].”

Even if we accept this procedure and these assumptions and estimates as reasonable – and I do not for reasons discussed later – it would be incorrect to conclude that the *incremental* cost¹² of the proposed regulatory changes is $\$42.8\text{m} - \$41\text{m} = \$1.8 \text{ million.}$ Rather, to compute an incremental cost it is necessary to subject the original \$41m estimate to the same adjustments (i.e., steps 7 through 9 of the staff’s procedure) as the \$66m estimate from step 6. Applying these adjustments (except step 8c which presumes

¹⁰ SISR, pages 12-13

¹¹ The actual language in the SISR (page 13) is, “Staff also accounted for an additional five percent reduction for emission-related defects reported over the ten percent EWIR rate and will be determined to be less than a true four percent failure through the SEWIR process.”

¹² More specifically, the expected cost for each model year (beginning with the 2010 model year) of the additional repairs that will be incurred by automobile manufacturers as a result of the proposed changes to these regulations. Under very unrestrictive assumptions, this is also the expected additional *annual* cost.

that new reporting procedures are in place) to the \$41 million estimate from step 3 gives

$$(\$41\text{m} - \$7\text{m} - \$9\text{m}) \times (1 - .43 - .10) + \$7\text{m} + \$9\text{m} = \$27.8 \text{ million},$$

and the estimated incremental cost of proposed regulations is

$$\$42.8\text{m} - \$27.8\text{m} = \$15 \text{ million}, \text{ a } 54 \text{ percent increase.}^{13}$$

Thus, the staff's procedure indicates that automakers will incur substantial additional costs under the proposed regulations.

This \$15 million is a *more* valid comparison of repair cost "with and without" the proposed regulations, and it is arguably a "lower bound" on the expected incremental costs of the proposed regulations. It should not however be considered an accurate estimate because it is derived from a procedure and assumptions that are fundamentally flawed.

I will discuss four important flaws in the staff's analysis: (1) the data used are insufficient to provide reasonable estimates of future repair costs given the staff's procedure; (2) the analysis depends on assumptions that are inappropriate; (3) relevant costs were inappropriately excluded; and (4) other relevant information was ignored. I now discuss these in turn.

(1) Insufficient data: The staff's procedure attempts to use historical information as the basis for estimating future costs. The approach of using past experiences to estimate future effects is certainly ubiquitous and can be very useful – but, inappropriate procedures or data can also result in highly inaccurate estimates and incorrect conclusions. In the staff's analysis:

- Only 2002 model year vehicles were considered – this greatly limited the available data.
- Having estimated the repair costs for each corrective action (step 1 of the staff's procedure), the total (or aggregate) cost of repairs on 2002 model year vehicles was calculated by applying two "common factors" to account for the percentage of vehicles on which the manufacturers would incur repair costs – these common factors are .3 for extended warranties and .93 for recalls.

The problem with this stems from the following: (1) actual per-vehicle repair costs vary greatly among the corrective actions, (2) the fraction of vehicles actually repaired also varies greatly among the corrective actions, and (3) we have no reason to believe that the per-vehicle repair cost associated with a

¹³ It is not clear how the adjustments in steps 7 through 9 should be applied to the \$9 million recall cost. For the numbers reported in the text above, I took the most conservative approach and did not apply these adjustments to the \$9m. If these adjustments are applied to the \$9m, the estimated adjusted cost under the current regulations is \$23m, and the expected incremental cost of the proposed regulations is \$19.8m, an 86 percent increase.

corrective action is independent of the likelihood that a vehicle owner will seek repair.

This brings us to the problem in the staff's analysis: the use of common factors together with the three conditions listed just above greatly increases the amount of data necessary to forecast future years' costs with any reasonable degree of accuracy.

- The net result is that, in my opinion, the 2002 model year data are not sufficient to provide reasonable forecasts of future costs when used in this manner. I base this conclusion on my training and experience and also on a number of comparisons between the staff's costs estimates and data provided to me by automobile manufacturers.

To be fair, the ARB staff did introduce recalls into the analysis in a very limited manner. Specifically, they estimated that under the proposed regulations "the Chrysler case"¹⁴ would have been a recall of 72,000 vehicles at a cost of \$38 million, and they used this example to illustrate "how the annual cost of the program could vary."¹⁵ In reality however, this example only illustrates that 2002 model year data, which they assume would have had no recalls under the proposed regulations, are not sufficient to accurately forecast the cost of these regulations.

(2) Inappropriate assumptions: First recall that the staff identifies 16 recalls that occurred under the current regulations and assumes that all of these would have instead been extended warranties under the proposed regulations. This implies that for each of these 16 recalls exactly one of the following must be true:

- (a) An extended warranty was a more appropriate corrective action than a recall, but the recall was nonetheless ordered.
- (b) The recall was the most appropriate remedy, but the proposed regulations would have erroneously resulted in an extended warranty.

Or

- (c) The staff's assumption that an extended warranty would have occurred under the proposed regulations is unreasonable.

¹⁴ More formally, the "Daimler-Chrysler Corporation OBD Catalyst Case" described in ISOR, pages 6-8, and in Daimler-Chrysler Corp.'s public comment to the ARB of December 6, 2006 (pages 2-3)

¹⁵ SISOR, p.13

To consider whether (a) is plausible under the existing regulations,¹⁶ suppose that an extended warranty actually was more appropriate than a recall in one of the 2002 corrective actions:

- Presumably, the ARB Executive Officer and staff would have preferred for the manufacturer to have offered the warranty and not the (less appropriate) recall.
- Almost certainly, the manufacturer would also have preferred an extended warranty to the recall.¹⁷
- The ARB Executive Officer had the authority to allow an extended warranty instead of the recall.¹⁸
- Thus, all parties would have preferred the extended warranty, and the extended warranty would certainly have been the corrective action that was actually used.

And this implies that (a) is not plausible.

To consider whether (b) is plausible, suppose that a recall actually was more appropriate than an extended warranty in a 2002 corrective action under the proposed regulations:¹⁹

- Presumably the ARB Executive Officer would have preferred a recall over an extended warranty.
- The ARB and its Executive Officer and staff would have had the authority to order a recall,²⁰ and the manufacturer would not have been able to challenge a recall order.²¹
- A recall would have thus resulted.

¹⁶ Note that whether (a) might have occurred depends on the existing regulations but does not depend on the proposed regulations.

¹⁷ I base this conclusion, that a manufacturer will prefer an extended warranty to a recall when the former is the more appropriate remedy, on my interviews with automobile manufacturers and on my own experience and training. Note that this does not imply, nor do I believe, that manufacturers will prefer an extended warranty when a recall would be more appropriate.

¹⁸ Even though the existing regulations do not give the ARB the authority to order an extended warranty, the ARB and its Executive Director clearly have the authority to allow an extended warranty instead of a recall when that is the appropriate corrective action.

¹⁹ Whether (b) might have occurred depends on the proposed regulations, but it does not depend on the existing regulations.

²⁰ The proposed sections 2169(a), 2170(b), 2171(a) explicitly grant that authority. Indeed the ARB's proposals anticipate that the Executive Officer *will order a recall when that is the appropriate remedy* regardless of whether the failing component in question is an "exhaust after-treatment device" and regardless of the vehicle's "OBD status."

²¹ The proposed section 2174(a) would have precluded any meaningful challenge to a recall order issued by the ARB's Executive Officer.

And this implies that (b) is not plausible.

This leaves (c) as the only plausible explanation – that is, *the staff’s assumption that the 2002 model year recalls would have been extended warranties under the proposed regulations is unreasonable.*

An important mistake by the staff in this regard is the criteria they used to identify when a recall would have occurred. They assumed that no recalls would have occurred because “none would have clearly met the requirement for recall,” but this does not accurately reflect the criteria for a recall under the proposed regulations. Under the proposed regulations, recalls will occur at the “sole discretion of the Executive Officer” and not only when “requirements” (which are not clearly defined) are “clearly met.”

(3) Relevant costs excluded: The staff’s analysis only considers the direct costs of labor and parts that are incurred by the manufacturer of the vehicles subject to recall or other corrective action. This disregards other cost categories that are likely to be important. For instance:

- The staff states that “most manufacturers will experience either no or negligible additional compliance costs to build more durable parts, because ... most manufacturers have not hit the four percent threshold.”²² This is flawed logic. It is not possible for a manufacturer to simply improve those components which will fail at a rate in excess of the 4% threshold – this is because the manufacturer does not know in advance which components will fail at this rate. Instead, the manufacturer will incur compliance costs “across the board.”
- The staff states that “parts [from PZEV vehicles] will be used on the rest of the on-road fleet and any extra expenses will be small and can be passed on to consumers.” Based on my interviews with automotive engineers and my own expertise in engineering and materials science, the primary means of achieving additional durability of emissions components is by increasing the use of materials that are inherently durable such as stainless steel. These materials also tend to be expensive, so using these materials on non-PZEV vehicles will increase costs regardless of whether the parts were originally designed for PZEV use.
- “The staff believes that the cost of improving a part is relatively small compared to the total cost of the parts and labor levied for a corrective action.” It is clear from this statement that the staff does not understand that it can be enormously expensive and difficult to redesign a component that is already in production; to create new tooling with which to produce the component; to integrate the redesigned component into ongoing procurement, production, fabrication, and assembly processes; to introduce the component into the aftermarket and repair supply chain; and to do these things while maintaining productivity, quality, and service level.

²² SISOR, page 13

- The staff completely ignores indirect “costs” related to, for example, supply chain inventory systems, customer inconvenience, and loss of goodwill. I admit that these items are difficult or impossible to quantify, but I also think that the ARB staff should at least be aware of them and sensitive to the manner in which they may be impacted by the proposed regulations.

(4) Other relevant information ignored: In developing its cost estimates, the ARB staff ignored or rejected information from automobile manufacturers and other potentially useful sources. For example:

- Ford Motor Company publicly submitted a comment on the proposed regulations, and this comment includes some very specific and potentially useful information related to cost. For example:²³

“A test program to demonstrate 96% reliability (4% failure) would require extensive resources, including workload, cost and time. For example, in order to demonstrate ARB’s proposed 96% reliability (4% failure) at 95% confidence level, Ford would need to successfully run at least 73 vehicles to full useful life and show no failures,”

and

“to conduct a full program, it would cost \$20 million and substantially increase the development time and time to introduction for new vehicle and emissions control systems.”

- As another example, the ARB staff writes,²⁴

“A manufacturer provided confidential cost estimates to the Board on December 7, 2006. Staff evaluated the cost analysis and disagrees with the manufacturers findings. Much of the data is based on early 1990 era failures and does not account for improvements in emission parts and the development of OBD II.”

I have reviewed these confidential documents, and the staff’s comments appear to be directed towards the exhibits that were attached to the submitted documents. The first of these exhibits lists all of the manufacturer’s recalls and extended warranties that were related to California’s warranty and defect reporting requirements; this exhibit also gives the manufacturer’s estimate of total cost for each corrective action. The second exhibit in this document provides cost estimates of recent corrective actions under several different scenarios.

²³ Ford Motor Company Comments on Notice of Public Hearing to Consider Amendments to California’s Emissions Reporting and Recall Regulations and Emission Test Procedures, p.4, December 6, 2006.

²⁴ SISOR, page 14

Thus, while some of the data submitted by the manufacturer is from the 1990s, *the manufacturer also made a concerted and thoughtful effort to estimate the cost of recent corrective actions and this information was ignored and misrepresented by the ARB staff.*

Before moving on, I think it is appropriate to note that all of the costs described here are for repairs to vehicles operated in California and that corrective actions ordered by the California ARB and its Executive Officer and staff also result in corrective actions in many other states and even in Canada. As a result, the total cost to a manufacturer of a California-ordered corrective action is likely to be many times greater than the California-only costs.

A systems and engineering view of the regulations

From the ARB staff's reports on the proposed regulatory changes, it is clear that the staff wishes to evaluate vehicles' emissions control systems at a "component level" rather than at a "system level." For example, under the proposed regulations corrective actions would be ordered based only on failure rates of individual components and not on the overall performance of the emissions control system. In my opinion, this approach contradicts good engineering practice and is generally ill-advised.

As a relevant example of how this component level focus contradicts good engineering practice, note that the current regulations allow manufacturers to contest a recall order by demonstrating that their vehicles comply with emissions standards even without corrective action. This provides manufacturers with a very real incentive to minimize emissions from all their vehicles – the lower a vehicle's emissions when all components are intact, the more likely the vehicle is to avoid a corrective action if one of its components surpasses the 4% threshold. Or, to look at this another way, *the proposed regulations remove incentives for manufacturers to minimize vehicle emissions.*

To further illustrate why focusing only on individual components is ill-advised, consider that it can be possible for a complete system to perform unacceptably even though each of its components is intact and performing exactly as designed. At the component level, such a system appears perfect; at the system level it is failing.

At the system level, emissions control systems are "negative-feedback closed-loop systems." In non-technical terms, this means that the system's performance is continuously monitored (by, for example, oxygen sensors) and then adjusted to account for deviations from the desired performance. Additional detail along these lines appears in comments from engineers at Ford Motor Company,

"Manufacturers design 'safeguards' into their vehicles emissions systems. ... These safeguards include designing emission components and systems to be

redundant, to be self-adaptive and learning, and to contain safety margins commonly known as ‘headroom.’”²⁵

This is not to say that performance of individual components should be altogether ignored. For example, the current EWIR procedures monitor the failure rates of individual components *in order to identify system-level failure*, and the consensus among the engineers with whom I spoke is that this is an appropriate use of the warranty information. But, and this is an important distinction between the current and proposed regulations, whether the manufacturer incurs a recall or other corrective action ultimately depends on whether the *system* is actually failing with respect to the relevant emissions standards. The proposed regulations would eliminate this dependency, and, in my opinion, this is contrary to good engineering practice and is ill-advised.

Closing comments

The stated mission of the California Air Resources Board is:

“To promote and protect public health, welfare and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state.”²⁶

One of the ARB’s stated “Major Goals” is to:

“Base Decisions on Best Possible Scientific and Economic Information.”

As an engineer, as an economist, and as a concerned citizen, these seem very appropriate to me, and I think it is fair to consider whether the proposed regulations are consistent with these statements and whether other options would be preferable to the proposed regulations.

Are the proposed regulations based on the best possible economic information?

No – In my opinion, the economic analysis provided by the ARB staff is very flawed and should be given no weight. I am confident however that a more thorough and rigorous economic study conducted by people with the appropriate expertise in statistics, engineering, and the automotive industry would greatly illuminate the economic consequences of the ARB staff’s proposal. Without such a study, the costs of which would admittedly be non-trivial, the regulatory decision will not be based on the best possible economic information.

Are the proposed regulations based on the best possible scientific information?

No – Insofar as I have seen, the ARB staff has yet to bring substantial scientific expertise and experience to the question of how to best reduce automotive

²⁵ Ford Motor Co., op. cit., page 2

²⁶ From the ARB’s website, <http://www.arb.ca.gov/html/mission.htm>

emissions in the context of the current proposals. For example, let us momentarily assume that the proposed regulations would indeed lead to fewer component failures in emissions systems. Is it possible that this would lead to heavier vehicles and reduced fuel economy? Might this improved durability come at the expense of increased emissions from those more durable systems? Might it be better to tighten emissions standards than to require improved durability? In my opinion, all of these are possible and are appropriate for rigorous investigation, but, until then, it cannot be said that the regulatory decision is based on the best possible scientific evidence.

Thank you for considering this report,

A handwritten signature in black ink, appearing to read 'S. M. Carr', with a large, stylized initial 'S'.

Scott M. Carr, Ph.D.

LECG, LLC

Appendix 1: Referenced and/or relevant documents

“Initial Statement of Reasons for Proposed Rulemaking” (ISOR). released October 20, 2006 by Air Resources Board.

“Supplement to the Initial Statement of Reasons” (SISOR). Mail-Out #MSO 2007-01. released January 23, 2007 by Air Resources Board.

“Annual Summary of [2004] In-Use Compliance Testing and Recall Activity.” release date unknown by Air Resources Board.

“Federal and California Exhaust and Evaporative emission Standards for Light-Duty Vehicles and Light-Duty Trucks.” released annually by United States Environmental Protection Agency.

Public comments regarding EWIR, available on the ARB’s website:

<http://www.arb.ca.gov/lispub/comm/bccommlog.php?listname=recall06>

Blanchard, Benjamin and Wolter Fabrycky, “Systems Engineering and Analysis.” Prentice-Hall. 2005.

Hopp, Wallace and Mark Spearman. “Factory Physics.” McGraw Hill. 2000.

Ramanathan, Ramu. “Statistical Methods in Econometrics.” Academic Press. 1993.

Rencher, Alvin. “Methods of Multivariate Analysis.” Wiley. 2002.

Ross, Sheldon. “Stochastic Processes.” Wiley. 1982.

“Wards Motor Vehicles Facts & Figures.” 2006 edition, published by Ward’s Automotive Group.

Confidential reports and information received from various sources.

Appendix 2: Curriculum Vitae

Scott Carr, Ph.D.

Senior Managing Economist

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Washington, DC 20006

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Doctoral Degree

Ph.D., University of Michigan, Ann Arbor, Michigan, 1999

Business Administration and Engineering – Doctorate jointly conferred by The Michigan Business School (Operations Management) and the College of Engineering (Industrial and Operations Engineering)

Other Degrees

M.S. Engineering, Industrial and Operations Engineering, University of Michigan, 1994

M.S. Engineering, Construction Management and Engineering (Civil and Environmental Engineering), University of Michigan, 1993

B.S. Engineering, Mechanical Engineering, University of Michigan, 1986

Faculty Experience

UCLA Anderson School of Management – Decisions, Operations, and Technology Management, 1999-2007

Graduate-Level Courses Taught at UCLA Anderson

Competition and Industrial Organization [Ph.D.] – Game theoretic models of inter-firm interaction. Classic and seminal oligopoly models. Advanced game theory. Models of strategic interaction within complex production networks. Antitrust. Analysis and proof techniques, 2006

Managerial Model Building [MBA] – Mathematical modeling, analysis, and optimization. Linear, non-linear, and integer programming/optimization. Monte-Carlo simulation. Forecasting methods. Project Management models and tools. Application of optimization models in business settings, 2005-2006

Simulation Theory and Applications [Ph.D.] – Monte-Carlo, discrete event, and agent-based simulation for finance, marketing, and operations. The use of simulation in empirical research. Simulation of stochastic processes. Option valuation (both financial and real) using

simulation. Applications (e.g., simulation of intellectual property piracy across the Internet), 2004-2006

Management in the Information Economy [MBA] – Internet and telecommunication technology. Internet business models and strategy. Economics of information products and processes, 2003

Fundamentals of Operations Management [MBA] – Analysis of business processes. Formulating and executing business strategy. Service and performance measurement and metrics. Managing risk, variability, and uncertainty. Management of supply chains and production networks, 1999-2003, 2006

Dynamic Programming and Sequential Optimization [Ph.D.] – Dynamic programming, Markov chains and decision processes, solution and proof techniques, and structural results and proofs, 2000

Other Teaching

Ph.D. Dissertation Committees (including Dissertation Advisor) – topic areas including: competition economics, operations management, information technology, international business, simulation

Executive Education at UCLA Anderson – Various topics in the following programs (1999 – Present)

- Managing the Information Resource
- Creating and Leading the Project-Centered Organization (faculty director),
- Head Start – Johnson & Johnson Management Fellows Program
- UCLA Strategic Leadership Institute
- California HealthCare Foundation's Health Care Leadership Program
- Johnson & Johnson Healthcare Leadership Program

University of Michigan, Ross School of Business [BBA] – Operations Management, 1997

University of Michigan, College of Engineering [BSE] – Computer Programming, 1995

Recent Research

Scott Carr and Uday Karmarkar, "Competition in Multi-Echelon Assembly Supply Chains," *Management Science*, vol. 51, January 2005, 45-59

Scott Carr, Uday Karmarkar, and Deming Zhou, "Competition in Multi-Echelon Distributive Supply Chains," under review for *Manufacturing and Service Operations Management*, 2005

Dissertation Advisor for Ram Bala, Ph.D. (faculty, Indian School of Business), Dissertation title: *Pricing and Contracting Strategies for Software Products and Services*, 2004

Ram Bala and Scott Carr, “Pricing of Software Services,” under revision for *Management Science*, 2005

Ram Bala and Scott Carr, “Pricing and Market Segmentation for Software Upgrades,” under revision for *Management Science*, 2004

Scott Carr, Izak Duenyas, William Lovejoy, “Modeling Demand and Capacity Uncertainty under Competition,” Under revision for *Manufacturing and Service Operations Management*, 2003

Scott Carr and Reza Ahmadi, “Demand Uncertainty as a Driver of Gray Market Activity,” under review by *European Journal of Operations Research*, 2005

Scott Carr, Online Auctions with Costly Bid Evaluation, *Management Science* (special issue on e-Business) vol. 49, November 2005, 1521-1528

Scott Carr, “Market Entry and Structure Under Uncertain and Disparate Market Forecasts,” under revision for *Decision Sciences*, 2004

Scott Carr and William Lovejoy, “Choosing an Optimal Demand Portfolio for Capacitated Resources,” *Management Science*, vol. 46, July 2000, 912-927

Scott Carr and Izak Duenyas, “Optimal Admission Control and Sequencing in a Make-to-Stock/Make-to-Order Production System,” *Operations Research*, vol. 48, Sept.-Oct. 2000, 709-719

Scott Carr, *Essays on the Allocation of Scarce Capacity Among Multiple Market Segments*, Ph.D. dissertation, published by UMI

Professional Affiliations

- American Bar Association – Antitrust Law Section, Economics Committee, Intellectual Property Committee
- Institute for Operations Research and the Management Sciences (INFORMS) – Publications Committee
- Institute of Industrial Engineers
- LECG, Los Angeles (Affiliate) – Professional services for antitrust litigation and competition policy, 2005-2006

Recent Professional Activities – representative examples

- Economic modeling for anti-trust litigation (e.g., class-certification and merits stages of price-fixing litigation among chemical manufacturers) and mergers (e.g., merger simulation for medical device producers)

- Strategic projects for firms/organizations including: Kennecott Energy, TRW, Meade Optics, Federated Department Stores, Los Angeles Community Redevelopment Agency, Los Angeles Metropolitan Transportation Authority, Libbey-Owens-Ford, Deutsch Advertising and Six Flags Theme Parks
- Speeches/presentations delivered regularly at academic conferences
- Principal investigator in a project and grant to improve small enterprises' access to business expansion capital
- Member of editorial board for *Decision Sciences Journal* and frequent reviewer for *Management Science*, *Operations Research*, and other academic journals