Transportation R&D Technology: The Diagnostic Motor Vehicle Information Concept, 1969-1981

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An overview of the role of safety and economics of the diagnostic motor vehicle inspection (DMVI) concept is presented. The purpose of providing diagnostic inspection separate from repair was to provide information to automobile owners and operators about their vehicles. They would use this information as a basis for authorizing only those repairs that were really needed and thus avoid authorizing unnecessary or fraudulent repairs. End users would also benefit from reduced life-cycle costs, reduced pollution, and increased safety. However, the safety focus of the program has led to a DMVI facility configuration that is uneconomical. These factors are discussed and a systems analysis methodology is suggested that can be used to optimize the design of the DMVI facility. The methodology applies the technique of maximizing the marginal effectiveness of available resources. These resources consist of the appropriate equipment and labor complements that support specified levels of diagnostic inspection.

The number one consumer complaint of the past decade has been about the automobile repair industry. Testimony in Senate hearings by the Federal Trade Commission indicated that consumer complaints related to the automobile stood at 30 percent compared with 7 percent for all consumer products (Automotive Repair Industry Hearings before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, U.S. Senate, 90th and 91st Congresses, Parts 1-6, July 1972). They also reported that automobile-related complaints take longer to settle than complaints for other consumer products. The federal government reported that end users spend from $42 to $50 billion/year on the repair and maintenance of their automobiles. Of this, several studies estimated that from $13 to $17 billion is spent on repairs that were unnecessary, improperly done, or not done at all (1). The economic, social, and political implications of this situation are wide ranging and complex.

The Motor Vehicle Information and Cost Savings Act of 1972 (P.L. 92-513) represented the federal government's response to end-user concerns about the high cost of automotive maintenance and repair and their dissatisfaction with the repair industry. The Act was based on information obtained, in part, from an investigation started in 1968 by the Antitrust and Monopoly Subcommittee of the Senate Judiciary Committee. It was a four-year investigation that heard from dozens of witnesses who provided more than 4000 pages of testimony (see Legislative History of P.L. 92-513, p. 3962). In addition, the staff of the Senate Judiciary Committee and the Subcommittee on Antitrust and Monopoly collected more than 60 000 exhibits and interviewed several hundred individuals who were not witnesses in the formal hearings. Testimony and evidence was received from every segment of the automobile industry, from manufacturers to independent service establishments. The exhibits included thousands of letters from irate motorists. The Act was based on a great deal of information that documented the enormity and complexity of the repair and consumer problem. The Act was passed by Congress in 1972 in response to the great tide of end-user complaints in the late 1960s.

The centerpiece of this legislation was embodied in Title III, Diagnostic Demonstration Projects, which called for motor vehicle diagnostic inspection demonstration projects to be conducted by the National Highway Traffic Safety Administration (NHTSA). There were two critical aspects of the diagnostic concept as envisioned. First, the vehicle was to be diagnosed by an independent inspection facility with no vested interest in automobile repairs. Second, the vehicle owner was to have the option of taking the vehicle to a repair facility of his or her choice with full assurance that the repairs would be performed properly and at a reasonable cost.

Although in a complex scenario that involved manufacturers, the repair industry, parts suppliers, equipment manufacturers, and automobiles of different makes, models, and years of manufacture in an arena of steady technological and regulatory change, it was believed that it was practical to provide diagnostic information on the condition of the automobile to the end user. Such diagnostic information would help the end user avoid authorizing unnecessary repairs. In this way, a diagnostic facility would sell to the end user information on the condition of his or her vehicle. This information would then be used to authorize only those repairs that were truly needed and thus avoid questionable expenditures.

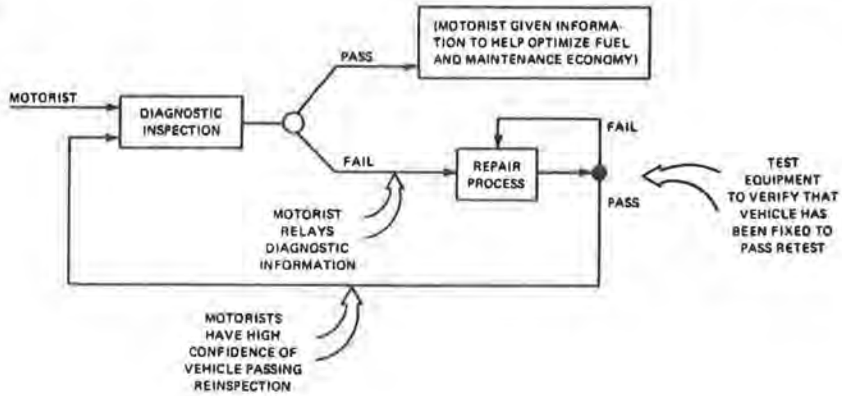
DMVI CONCEPT

As envisioned in the legislative history, the ideal high-volume diagnostic inspection station would supplement the existing automotive repair and service industry. The quality of the process would thereby be improved and the overall costs would perhaps be reduced. As shown in Figure 1, the availability of diagnostic motor vehicle inspection (DMVI) facilities would encourage separation of the diagnostic and repair functions that currently are not now separated in the service industry (2).

Ideally, a diagnostic inspection facility would use standardized and highly automated inspection equipment and data-handling techniques to pinpoint the vehicle components that caused failure of the safety, emissions, noise, or fuel-efficiency inspection standards. The motorist would then take his or her vehicle to a repair establishment and relay instructions to the mechanic concerning the necessary work. On completion of the work, the mechanic would have access in his or her own shop to suitable diagnostic equipment and/or procedures to check the results of the work, consistent with inspection standards. The end user would then be able to return to the inspection facility with confidence that his or her car would pass the motor vehicle reinspection. Through such a system, the motorist would be spared repeat trips between the inspection facility and a repair establishment trying to pinpoint the vehicle's malfunction and having it repaired adequately.

Diagnostic facilities in the late 1960s and early 1970s consisted of certain basic equipment that included a lift, engine analyzer, dynamometer, alignment tester, an assortment of hand-held tools, and an emissions analyzer. Inspections then, as now, consisted of visual checks, measurements, and automatic evaluations. The information was passed to the end user by means of an oral discussion and a piece of paper with varying amounts of relevant

Figure 1. DMVI concept.



diagnostic information. In some cases, the facility that performed the diagnosis also performed limited repairs and adjustments. The facility personnel also served as consultants to the repair industry and the end user. The facility personnel assisted the end user to perform his or her own repairs and reinspected the vehicle after it was repaired to ascertain that the repair was performed and to evaluate the quality of the repair. Figure 2 (3) presents a typical lane-type diagnostic inspection facility.

DMVI, 1969-1981

The configuration, equipment and labor complement, and diagnostic inspections recommended and in practice today are not fundamentally different from those that existed 12 years ago. Today's configuration of lanes and/or bays is essentially the same for brakes, alignment, body, lights, suspension, and exhaust system but with upgraded electronic equipment for engine analysis and emissions inspections, increasing numbers of smaller cars, diesels, and vehicles with front-wheel drive.

Another facet that has not changed in the past 12 years is the fact that facilities, as configured, are marginally economically viable. The economic success of these diagnostic facilities has been limited and temporary. Commercial diagnostic inspection fees are based on the estimated labor time required for the diagnosis plus, in some cases, an equipment amortization charge. In 1980 dollars, the commercial diagnostic inspection fee is on the order of $25, and it is not sufficient to operate the facility, pay all labor costs, and make a reasonable profit. In the few commercial facilities still operating, the diagnostic fee is considered a loss-leader that will draw repair work to the shop. Commercial facilities have reported that at least 50-75 percent of inspection customers usually request that repair work be performed by the diagnosing facility. Table 1 (4) lists diagnostic inspection fees reported by commercial establishments.

Not-for-profit facilities are subsidized by their membership; they operate at a loss or just break even. They report that patronage drops off after an initial spurt of interest. Occasional publicity campaigns are needed to revive interest. Without performing repair services, the diagnostic facilities are not economically viable.

To date, only a few inspection facilities have approached the ideal system described earlier. No state has implemented such a diagnostic inspection system. Also, many vehicles are not subject to any kind of mandatory periodic motor vehicle inspection (PMVI). We have reached a crisis in the DMVI concept as configured. Before the DMVI concept is put to rest, however, the following questions need to be answered.

SAFETY FOCUS

What is the objective of DMVI? The symptom of a problem is end-user dissatisfaction with the repair industry. Information on the condition of the vehicle was believed to be the answer. However, the information was to be based on the safety criticality and emissions of the vehicles; minimum cost and fuel economy were to be by-products of this safety focus. Safety is the primary role of NHTSA; consequently, there was a safety focus on the DMVI concept.

The fact that mechanical defects are frequently a contributing cause to about 10 percent of all traf-

Figure 2. Hypothetical diagnostic inspection lane.

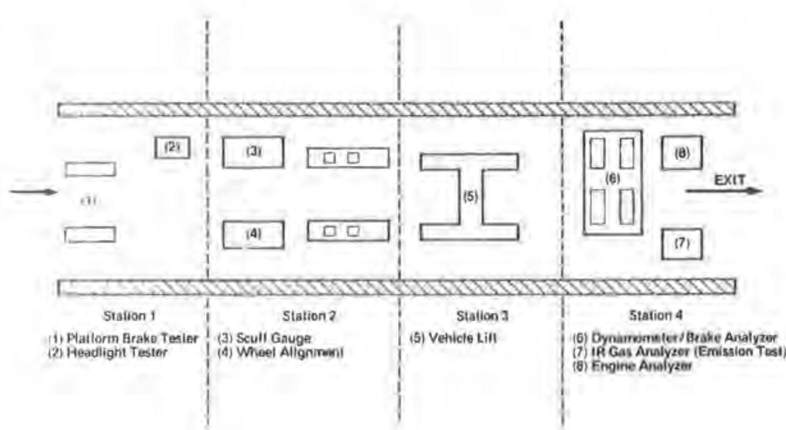


Table 1. Commercial diagnostic inspection fees.

Commercial Diagnostic Inspection Facility	Total Inspection Process Time (min)	Inspection Fee (1980 $)	Estimated Hourly Fee ($)
Auto Lab	45	24.95	33.27
Automotive Evaluation Center	60	21.00	21.00
Automotive Performance Specialists	52	30.00	34.62
Avocation, Ltd.	75	28.50	22.80
Call Carl	58	21.95	22.71
J.C. Penney	73	20.88	17.16
Montgomery Ward	60	18.95	18.95
Avg	58.5	22.95	23.54

fic accidents (rather than a sole cause) complicates the task of identifying the impacts of demonstration experiments on traffic safety (5). Furthermore, 90 percent of all accidents are caused by the driver--thousands yearly kill themselves and others through drunk driving, a majority shun the use of seat belts, and most states do not have even the most rudimentory form of PMVI. Consequently, programs aimed at getting people to wear seat belts, enforcement of the 55-mph speed limit, more strict laws that govern the driving habits of teenage drivers, and getting drunk drivers off the road may have a great deal more potential for improving safety than motor vehicle safety inspection.

This focus on safety may have placed constraints on the solution, perhaps to the detriment of the original intent of the legislation, i.e., to assist the end user to avoid excessive repair costs. On the one hand, a well-maintained automobile means a safe automobile; on the other hand, "too much safety" can lead to excessive maintenance.

Suppose we set aside the safety focus of the current DMVI program and focus instead on determining what form of DMVI can help the end user minimize the cost of operating and maintaining his or her automobile by using the DMVI concept. What impact would this change in emphasis have on the configuration of the diagnostic facility? How might this change the equipment and labor complement of the DMVI facility and the total cost to the end user of maintaining his or her automobile?

ECONOMIC FOCUS

Perhaps the question should be, What level of DMVI will save the end user money, provide a profit to entrepreneurs, and yield a vehicle that is safer, more fuel efficient, and with lower emissions?

Having identified the objective as saving the end user money with safety, fuel economy, and minimum emissions as the by-products of an economical and reliable automobile, the next step might be to approach the design of a DMVI facility from this point of view. The following questions should be answered. First take a look at where the end user is spending most of his or her after-market repair dollars. It may be that these components may offer the greatest potential for savings. The following lists the major automotive subsystems for end-user expenditures (6-9):

Item	Annual Expenditures (%)
Brakes	22.5
Tires and wheels	21.9
Engine	11.4
Suspension	11.1
Under the hood	9.0
Exhaust	5.8
Alignment	4.4
Steering	3.7
Electrical	3.2
Lighting	2.6
Body	2.1
Other	2.3

The first step is to estimate the fraction of consumer expenditures in the automobile after-market by item; that is, estimate the market share by automotive component. Of particular interest are high expenditure items. For example, if $50 billion were spent last year by end users for the above items, then 22.5 percent of $50 billion was spent on the brakes subsystem, or $11.25 billion.

The next step would be to estimate or calculate the amount for each item that is considered to be a questionable expenditure. For example, if $11.25 billion was spent on brakes and one-third of that is considered to be possibly misspent, then the questionable expenditures for brakes is one-third of $11.25 billion, or $3.75 billion/year.

However, not all of the $3.75 billion/year of questionable expenditures can be saved by a DMVI program. A certain amount of the questionable expenditures may be due to prudent repair practice, such as the replacement of wheel cylinders; some may be due to the desire or convenience of the owner or operator of the vehicle, and so on. Some analysis will be required to estimate what percentage of the questionable expenditures may be recaptured for each subsystem. For example, for brakes, suppose that 30 percent of the questionable expenditures can be avoided by an effective DMVI program; that would amount to $1.125 billion. If this $1.125 billion applies to a national fleet of 100 million passenger cars, then this would amount to $11.25/vehicle/year for the brakes subsystem.

A similar procedure would be applied to each subsystem to determine the percentage of questionable expenditures and the percentage that might be avoided by a DMVI. The high-ranking subsystems would be the focus of the DMVI to provide the end user with the greatest service with the objective of saving him or her money on the maintenance of their automobiles (see Table 2).

MAXIMIZING MARGINAL EFFECTIVENESS

A DMVI facility would then be configured by using the above information and applying the incremental effectiveness technique to maximize the marginal effectiveness. [Several applications of this concept can be found in Rudwick (10).]

Applying the technique entails the application of a very simple rule. The rule is that resources should be allocated to provide the maximum increase in effectiveness (or return, or benefits) per unit resource used. In this problem the marginal effectiveness might be measured by the increase in worth of the next level of DMVI. The unit of resources is the equipment and labor in the DMVI for a particular level of inspection. For example, for the brakes subsystem, level 1 might be a platform test, level 2 might be a platform test plus wheel pull, etc. The effectiveness of any level might be expressed by

$$E_i = nC_i + dD_i + (t-d)A_i \tag{1}$$

where

i = level or depth of inspection,
n = number of vehicles,

Table 2. Costs of repairs by subsystem.

Item	Cost ($ billions)		
	Annual Expenditures	Questionable Expenditures	Capture
Brakes	11.25	3.75	1.08
Tires and wheels	10.95	2.40	0.50
Engine	5.70	1.50	0.20
Suspension	5.55	3.25	0.94
Under the hood	4.50	0.80	0.07
Exhaust	2.90	0.40	0.20
Alignment	2.20	0.50	0.30
Steering	1.85	0.30	0.23
Electrical	1.60	0.20	0.14
Lighting	1.30	0.40	0.30
Body	1.05	0.15	0.08
Other	1.15	0.08	0.08
Total	50.00	13.80	4.12

d = number of discovered defects,
t = total number of defects per vehicle,
Ci = cost of DMVI per vehicle,
Di = average repair costs for discovered defects per vehicle, and
Ai = average repair costs for undiscovered defects per vehicle.

The incremental or marginal effectiveness, then, would be

$$\Delta Ei = Ei{+}i - Ei \quad (2)$$

The baseline effectiveness, in this case, would be the situation with no inspection at all, which is level zero:

$$\begin{aligned} Eo &= 0\,Co + dDo + (t-d)Ao \\ &= dDo + (t-d)Ao \end{aligned} \quad (3)$$

The application of the concept of maximizing the marginal effectiveness when assigning resources is described below.

Consider a structure that indicates the incremental effectiveness obtained by the assignment of the nth complement of equipment and labor to the subsystem or component that provides the next greatest return. Such a compilation will be the basis for applying the key decision rule to be followed in allocating resources; that is, always assign the next equipment or labor complement to that subsystem or component that will yield the highest marginal effectiveness of all of the assignment choices available. Thus, while there are many possible choices involved in the first allocation decision (i.e., assign the first equipment or labor complement to any of the many possible items), the highest marginal effectiveness is obtained by assigning the first complement to the first inspection item.

Hence, decision one will consist of allocating the first equipment or labor complement to the subsystem or component that will provide the greatest return to the end user and patron of the DMVI facility. This procedure can be continued as long as there are additional inspection equipment and labor complements to be allocated and their allocation does not exceed the economic feasibility constraints that provide economic incentives to users and returns a profit to the investors in the facilities.

The application of the concept of maximizing marginal effectiveness will do the following:

1. Establish the economic feasibility of a commercial DMVI,
2. Identify the key variables and interrelations,
3. Show whether an economic focus provides attractive safety benefits, and
4. Provide policy information required for consideration of DMVI by state and local governments.

I believe that data are available from NHTSA's Special Project and National Accident Sampling System, Hunter's Service Job Analysis, Chilton's, etc., to do a reasonable job of estimating the average repair costs for discovered and undiscovered defects. Economic data for the baseline case might be gleaned by comparing normalized area automobile after-market data for states with and without motor vehicle inspection. In a similar fashion, the total number of defects for a group can be estimated as well as the probability of detection at a specified level of inspection. Maybe the economic model should be restructured and parametric analyses performed to examine these factors and settle once and for all the issue of the sound and promising concept of a DMVI.

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