SOME ACTUAL PROBLEMS OF MEDIUM-TERM TECHNOLOGICAL DEVELOPMENT STRATEGY IN THE HUNGARIAN BUS INDUSTRY

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Summary

The paper deals with the most important problems of the medium-term technologica development strategy of the Hungarian commercial vehicle — mainly bus — industry. After a discussion of the main trends of technological development in the bus industry, the paper analyzes in detail the basic components of the technological development policy, especially the problems of modern bus body planning and dimensioning.

Introduction

The fundamental factors determining an export oriented company strategy were dealt with in a previous study by the authors [1], along with the likely development in the world economy on which the medium- and long-term strategy of Hungary's commercial road vehicle (mainly bus) manufacture should be based.

Of the active components of world economy treated in our previous study, it seems necessary to reconsider here the impact of the problems that capitalist world had on the manufacture of commercial road vehicles (in other words, the world situation of passenger car and commercial vehicle production).

The analysis completed at the end of 1980 is still valid in a general way. It should be noted, however, that the much-heralded export drive of the Japanese car makers has failed to unleash keen competition in Western Europe as was been expected by many observers. Instead there is a sort of static warfare, with fairly rigid front lines [2].

Consequently, it is highly likely that a significant increase in productivity, a more effective economic management and, last but not least, the host of technological innovations adopted in vehicle manufacture were the measures that stopped the Japanese drive, without practically any need to revert to protectionism. The "Japanese effect" is none the less felt, and a relatively significant movement of capital has occurred from passenger car towards commercial vehicle manufacture — an essential development in our view (Fig. 1).

An analysis of the present situation shows that the Japanese challenge has definitely enlivened Western European vehicle manufacture, in general, and commercial road vehicle manufacture, in particular. Simultaneously with

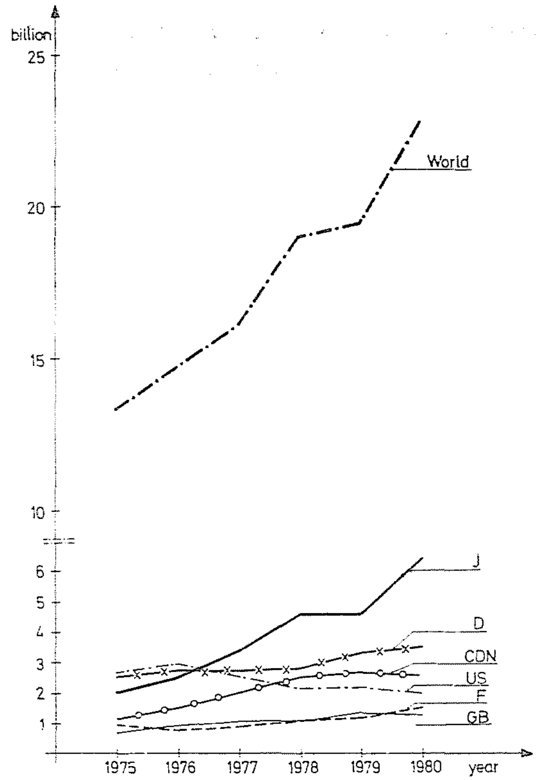

Fig. 1. Trends in Commercial Road Vehicle Export (for Major Exporters): 1) S, billion: 2) World: 3) Year

the effective "protection" provided for passenger car makers, commercial vehicle manufacturers launched an "offensive" in Western Europe, as a result of which European exports showed a marked increase in 1980—81. However, *as a consequence of the general decline in world trade* (slackening investments and decreasing transport requirements) *the upward trend is flattening out*, the number one task being now to strengthen market positions. (In fact, there are difficulties in selling, e.g. IVECO had to wind up bus manufacture in Mainz, DB can utilize a mere 75 percent of their coachbuilding capacity and the minor bodymakers have some difficult problems to cope with.)

Some forecasts have predicted a slow upswing from the second half of 1982, but it is unlikely that the 1980 level could be attained in 1983. The slump in bus manufacture has hardly affected the export ratios of commercial road vehicles; the market positions of the leading capitalist countries did not change much, or — to put it more accurately — no relevant conclusions could be made as yet, because the probability of the duration of the recession period cannot be calculated (or rather the problem could only be treated properly by a separate analysis for the entire vehicle industry).

The above-mentioned innovations have certainly made the manufacture of commercial road vehicles *more effective and competitive*, at least in certain firms in Western Europe; moreover, it still holds true that the Japanese are less powerful in this field in both Europe and the US. The inroads made on the US market by the West European commercial road vehicle makers represent an exceptional achievement, having taken the form of not only exporting vehicles, but also taking over manufacturing plants. (For example, Daimler Benz have purchased "Freightliner" and "Euclid", both of them important makers of heavy trucks in the US.)

It must be stressed that the high *capital investment* in the West European commercial road vehicle manufacture was aimed not so much at increasing productive capacities, but almost entirely to achieve *technological development* and, to a lesser extent, *rational re-organization*. A major West European drive is being launched to export commercial road vehicles to developing countries, and even a number of subsidiary companies have been established in third-world countries (e.g. Kässbohrer, Daimler Benz, MAN, Auwärter, IVECO, in which bus manufacture plays an eminent role).

Thus in accordance with the previous study by the authors, the West European commercial road vehicle manufacturers have, by and large, succeeded in *maintaining their positions*.

This fact fortifies our arguments concerning the medium- and long-term strategy of Hungary's bus industry, among others as to the necessity to co-operate with the major Western European commercial vehicle manufacturers.

In other words, *developing the technology* of bus (commercial road vehicle) manufacture is a problem of "yesterday and today" rather than of "tomorrow and the day after". Consequently, it is *extremely urgent* to explore the *possibilities of co-operation* with the major West European manufacturers of commercial road vehicles (mainly with those engaged in producing main assemblies and/or only trucks). Simultaneously, the *possibilities of competition* should be fully exploited with the minor firms, and also the idea of establishing (perhaps jointly owned) subsidiaries in the developing countries may be considered. Moreover, mutually profitable co-operation connections should be established with the CMEA countries. These complex problems are closely related to technological development.

It needs to be stressed again that all short-term strategies, and the medium- and long-term ones even more so, *must be based* on an appropriately high standard of technology.

Without an intensive technological development, the position of Hungary's bus export might weaken on the capitalist markets, in the third world and on the CMEA market alike. The situation arising in the absence of a sound technological development would justify the view of the prophets (whose pessimism is groundless) that *Hungary's bus industry was a giant with feet of clay.* In our opinion, if technological progress can be achieved, bus manufacture will remain an effective area of the country's developing industry.

The present study deals mainly with the most important problems of a *medium-term technological development strategy.* The problems associated with the electronic development of road vehicles are not treated here in detail, because — in view of its extreme importance — the subject deserves a separate study [6].

Aims of Technological Development

As mentioned in the Preface, the highly developed capitalist countries that determine the production of commercial road vehicles, and also buses, have achieved a really significant progress in technology over the past few years. As a result, mainly the *quality* of products has improved. It is expected that progress would continue over the years to come. The results achieved so far indicate that the technological progress of the past years has already improved the marketability of sophisticated products, facilitating the capture of new markets, or — for 1982 — maintaining the positions occupied so far.

The information obtained from the field of commercial road vehicle manufacture indicates that the large-scale technological progress is constantly expanded by novel elements (e.g. electronics).

Beside being one of the strongholds of Hungary's vehicle industry with a considerable position also in the bus manufacturing industry of the world, Ikarus has some sound and durable market relations, and in certain respects internationally outstanding technological experiences. Regarding both its production value and its export ratio, bus production ranks high in Hungary's machine industry. In spite of the economic difficulties plagueing the world, the profitability of the branch is rather good, whereas productivity is well above the domestic average. This can be supported by the following quotation: "... labour productivity of the Austrian metal processing and machine industry exceeded the Hungarian level by 64% (in 1975, in the sub-branches suitable for comparison). Among the engineering sub-branches, only a single Hungarian one has exceeded the Austrian standard to a significant extent ... road vehicle manufacture. Here the Austrian labour productivity was less than 50 percent of the Hungarian one". [3].

For the Hungarian commercial road vehicle manufacturing industry, the task of keeping in step with world progress is a realistic aim, even in medium-term technological development. So much the more, because it is high time that new models be added to the existing product range of Ikarus, and the oldest ones be gradually eliminated. The Mark 200 bus family has retained its marketability in both capitalist and CMEA markets, and through the incessant product development that has continued with since the launch day. But, as regards certain technical and traffic engineering parameters, the *Mark 200 buses cannot be updated much longer* to meet the ever more stringent requirements of the world market. Quantitative development cannot be justified by the present state of the market, but *qualitative improvement* is demanded more and more, even in the CMEA market. It is sufficient to refer to the latest technological developments in the Soviet Union, which might represent a medium-term challenge to Ikarus, in its most important market.

Attaining a world standard requires a specific strategy in both manufacture and product characteristics, based on different solutions of technological development. This follows from the trends existing in technological progress and the actual conditions prevailing in Hungary's bus industry, first of all in the background industry.

It should be mentioned in this context that for buses no such thing as a uniform world standard exists. Actual reference levels are established by climatic, social and economic conditions, valid at a given place and time. This would of course not exclude the existence of more or less uniform standards (requirements) for certain technical-economic parameters in the world market, e.g. fuel consumption and service intervals.

Main Technological Development Trends in the Bus Industry

The significant technological progress achieved in manufacturing commercial road vehicles and buses is associated with the changes that characterize the vehicle industry reaction to certain fundamental changes in world economy.

As a consequence of the ever rising fuel and raw material prices, mainly those of oil and oil derivatives, the demand for low-consumption cars has suddenly increased. And this trend is likely to remain with us until the end of the 'eighties.

Technological development shows the following fundamental trends in bus manufacture:

a) Cutting fuel consumption, by — improving specific fuel consumption (lit/kW/h) through updating engine design, and operating fuel consumption (lit/km) through improving engine regulation in operation. (To quote an appropriate example for the latter: following the achievements of Toyota and Fiat, AUTOKUT of Hungary has developed a so-called combined charging method, which has become a world-wide success.)

b) Meeting environment protection requirements mainly through cleaning exhaust gases and cutting the road noise level of vehicles. This calls for improving engine design and engine mounting, as well as engine regulation during operation. Moreover, catalyzers and noise dampers must be installed (the combined charging mentioned before is suitable also to diminish toxic exhaust fumes).

c) Meeting safety requirements to a higher degree than before by improving active (e.g. more effective brakes, anti-skid devices) and passive safety (e.g. more rigid body structures). Improving the so-called traffic partner protection also comes under this heading (this aspect calls for improving bumpers and some other body elements).

d) Improving driving and riding comfort. Decreasing internal noise level is of the utmost importance in this field, and this also refers to vibration. Passenger compartments must meet the ever increasing requirements (heating, draft-free ventilation, special facilities like lavatories and bars, as well as ergonomically designed passenger seats, better lighting, etc.).

e) Location and elimination of defects must be accelerated and servicing intervals must be come longer. The vehicles must be made suitable for maintenance based on technical condition tests. As a precondition, modern defect displays are to be developed, along with connection facilities to diagnostic test equipment.

f) Increasing the service life of vehicles. This can be achieved by developing main assemblies that last longer, reasonably co-ordinating their service periods and giving better corrosion protection to bodies.

g) Operating costs can be cut and yearly mileage increased by developing the service network. This calls for a better supply of spare parts, which would also improve the marketability of buses.

h) Increasing the flexibility of design of commercial road vehicles, along with the flexibility of manufacturing techniques, in order to meet individual requirements of buyers as fully and quickly as possible.

i) Although *electronics* appeared on the scene, as the latest stage of development it is the most important. These novel methods promote major steps of development in designing and product quality alike. As regards passenger car making, the first results appeared in 1981 (mainly from Japanese firms). In coachbuilding, electronics are likely to gain general acceptance in 1983 to 1985.

j) International co-operation is also characteristic of the development of company organization and production systems, as well as for technological progress (e.g. the headway made by IVECO, an Italian—German—French company). Instead of pressing on with the exportation of finished products, subsidiary companies are established and know-how is sold to both the developing world and the developed countries. Also specialization in sub-assembly manufacture is gaining ground.

The trends of technological development outlined here can be specified in detail, e.g. for individual sub-assemblies or manufacturing processes. But it is apparent from what has been stated so far that Hungary's bus industry is *facing a major technological challenge* that demands quality improvement in products, manufacture and marketing alike. Failing to meet the challenge would result in losing marketability at once. Quality development is also important for maintaining *long-term stability of all markets* open to us. Beside the natural endowments and potentialities, this aspect has a decisive role in establishing a strategy for technological development.

Basis for a Medium-term Technological Development Strategy for Hungary's Bus Industry

Potentialities

Generally speaking, the technological development in progress in Hungary's bus industry is quite significant, and usually falls in line with the international trends. Without aiming at completeness, let us list a number of fields where technological development is going on:

- improving corrosion prevention of bodies
- developing flexible methods in manufacturing bodies for individual buses and short series made in co-operation with capitalist firms
- updating technology at Rába Works to increase engine power and improve rear axles
- manufacturing under licence modern hydraulic power steering units at Csepel Automotive Factory

As regards the development of other sub-assemblies and fittings, the *domestic background industry* is still in a less favourable position.

Developing the *entire bus industry complex* of the country is clearly *infeasible*, and it would be even less feasible to extend the internal complexity of the Ikarus Works. Consequently, internal and external co-operation should be intensified, the production process be distributed among more contractors and the import of components be stepped up. The latter should of course be based on the assumption that Ikarus would stabilize its existing markets and gain further segments of the capitalist market, since, owing to the difficulties encountered in foreign trade, i.e. the lack of balance in convertible currencies, this is an important precondition of embarking upon such a venture. Over and above the still increasing total sales figures, the market position has another advantageous characteristic: assembly plants operating soundly in Cuba, Iraq and Algeria. At the same time, competition is getting keener in the capitalist market (e.g. while Ikarus pioneered the introduction of articulated buses into the US, MAN has succeeded in exceeding our sales figures through its subsidiary company over there). "Quality superiority" cannot be "automatically" maintained in the socialist markets either, and in the long run this problem is likely to be encountered even in the Soviet market.

Owing to the advantageous market positions, the existing high-capacity and, in many respects, highly sophisticated production facilities may well be capable to bear the burden of further development, provided that a sound financing scheme is adopted.

Outlining a Medium-term Development Strategy

In the knowledge of the situation outlined above, it is advisable to adopt a *selective* (or differentiated) *technological development strategy*, consisting of the following elements:

a) Development based on independent research in fields already employing modern design and technology. This is advisable mainly for bodies and axles etc., as well as for improving the quality characteristics of production techniques, and rendering them more flexible.

b) Follow-up type research and development. This may be adopted for certain sub-assemblies, by adapting the experiences of leading manufacturers to domestic conditions (engine design, gearbox).

c) Buying licences and know-how. To quote an example: the effective development of power steering. Gearbox, engine and air-conditioning plant are the likely sub-assemblies in this field.

d) Development through co-operation in production (in essence the direct application of development achievements). Although the likely fields are the same as specified for buying licences and know-how, from the point of view of economics, this is a different method.

e) Direct import, without any domestic development. For the time being, this could be adopted mainly for electronic elements, as well as for sub-assemblies specified by foreign buyers.

The above mentioned strategy elements should be proportional to the requirements of individual markets. Moreover, internal proportions of the strategy are likely to change with the introduction of a new model series. In practice this means that the novelties approaching "world standard" and resulting from technological development will first appear in the buses intended for export and made in co-operation with capitalist partners, in the beginning mostly from imported components. Thereafter, the measures taken to strengthen the positions on capitalist markets will have to be extended over the entire production process, so as to secure the positions gained, in the socialist market.

The concrete tasks specified under Par. *a)* through *j)* in Chapter 3, as well as the methods specified under Par. *ad* through *ed* in this Chapter, carry different weights in development, depending partly on the material and intellectual resources available, and partly on the likely effectiveness of development targets. Although in a somewhat controversial manner, development targets can be divided into two groups at the moment:

A) *"Hard" targets for development*, the results of which are marketable anywhere. To quote a few examples:

- enforcing the idea of economizing with power and material in design and production alike;
- reducing maintenance requirements of vehicles in operation;
- increasing service life and aiming to bring about a balance in the service lives of sub-assemblies;
- increasing travel (transport) performance (seat capacities, space utilization etc.)

B) *"Soft" targets for development*, the results of which are marketable only in certain regions, due partly to climatic reasons, and partly to lack of financial means. A few examples are quoted below:

- developing a construction that would save the environment from unnecessary damage and be as accident-proof as possible;
- increasing riding comfort (ease of swinging, heating, ventilation, air-conditioning, steps lowered at bus stops, lower floor height etc.);
- increasing driving comfort (electronic controls and instruments, automation, radar-controlled spacing distance monitor, ice sensors etc.);
- luxury equipment and facilities (tv, radio, lavatory, bar, lounge, aircraft passenger-type reclining seats, special upholstery, double glazing etc.);
- installation of diagnostic on-board instruments.

Attaining the "hard" objectives is necessary in order to *stay in the market*, whereas the "soft" ones to *gain new markets*. The division of development targets in this manner applies to the present situation. It is expected that in the course of the 'eighties some of the Category B targets (e.g. environment protection, accident prevention) would be transferred to Category A. This means that the abovementioned categories should at all times be so established as to suit the prevailing market situation.

The technological development strategy outlined here essentially applies to products and production techniques. However, technological development should also include marketing. In that respect, the sound functioning of the already existing assembly plants is a great achievement, but their extension is a must, perhaps in the form of establishing new subsidiary companies, mainly in the developing countries with sufficient funds. In view of their high ratios of unemployment, the developing countries are likely to prefer establishing assembly plants to buying finished products.

It is also absolutely necessary to expand and improve the customers' service network. Beside raising international credits, it is advisable to embark upon joint undertakings with e.g. Hungarian and foreign firms supplying equipment to assembly plants and service stations.

To attain individual targets of technological development involves their interaction, either facilitating or hindering the introduction of novel methods. In order to demonstrate that extremely complicated correlation system and throw light on the development targets listed earlier by catchwords only, let us deal in detail with the subjects of the *economical use of materials and increasing service life*, along with the research and development tasks associated with them. It is so much the more useful to deal with these subjects because in this field development can be effectively undertaken by relying on our own resources.

Detailed introduction for specific Development Target

Developing a modern and highly realistic method of dimensioning bus frames is among the top ranking tasks of technological development in the bus industry. Since our design and manufacturing characteristics differ from those of foreign firms, no method can be imported, but a good one must be developed at home. Our markets, and therefore the operating conditions of our products, are more diversified than those of our competitors. Following from the different road conditions and drivers' mentalities, a model that has been a success somewhere might not be automatically marketable everywhere.

Owing to the effects dealt with earlier, as well as a consequence of the ever keener competition in the car market, it is expected that the leading European car makers would make great efforts to improve dimensioning methods for commercial road vehicles and buses.

Only *complex vehicle structure and body modelling, designing and dimensioning systems* that can meet the different technological variants of market demands in a flexible manner could serve as basis for a successful and high-standard road vehicle industry, and the economic objectives cannot be achieved without such an industry. For practical purposes this means that the operating conditions of the product must be taken into consideration as early as the designing stage. The designers must know many details of the market the product is aimed at, among others road and climatic conditions, the supply of vehicles in general, ergonomic characteristics, cultural standard of transport, and keep in mind all these particulars throughout the dimensioning process.

In our days, research is mainly directed at calculating the dynamic loads arising during operation, so as to be able to determine the likely defects and service life of road vehicles. In order to acquire a more thorough knowledge of this problem, the following particulars must be cleared:

— description of the structure as a function of operating time;
— statistical evaluation of working loads;
— analysis of travel speed distribution;
— road distribution of the area in question;
— traffic conditions, drivers' mentality, modes of operation;
— temperature effects and climatic conditions;
— in the knowledge of the above-mentioned statistics, a realistic load data of the frame structure must be produced.

In short, the following *differential stochastic equation* must be solved, at least approximately, for every market (in other words, a differential equation of the vehicle as a vibrating system) [4]:

$$\mathbf{M}(t)\ddot{\mathbf{x}} + \mathbf{K}(t)[\dot{\mathbf{x}}] + \mathbf{S}(t)[\mathbf{x}] = \mathbf{F}(t)$$

where (.) = stochastic dependence on time
[.] = non-linear relation
$\mathbf{M}$ = mass matrix
$\mathbf{K}$ = damping matrix
$\mathbf{S}$ = stiffness matrix
$\mathbf{F}$ = vector of excitation
$\mathbf{x}$ = displacement vector of frame structure

In the following, let us take a look at the main groups of design tasks:

Many of the researchers write multi-degree freedom, linear or non-linear, equations of motion for vibrating systems by the finite element method, solving them by means of simulation, as a function of time. In order to obtain appropriately detailed results for statistically evaluable duration testing, the method demands much computer time and, owing to the many degrees of freedom involved, a highly complicated programme, and is therefore very costly and lengthy. Consequently, not even the biggest capitalist companies would undertake to develop such computer programmes, but hire programmes developed for space technology instead (e.g. from NASA). Although the characteristics of the structure tend to change with time (due to e.g. corrosion and wear), the above mentioned test methods consider the model of the tested structure constant as a function of time.

Commercial road vehicles (buses, trucks) are operated under different climatic and servicing conditions, and by drivers of different mentality. This is why a comprehensive dimensioning method suitable for fitting all information accumulated so far (on traffic characteristics and engineering structures, respectively) into a uniform system, and for detecting the lack of information by a system approach, is required. In absence of such a uniform theory, car manufacturers perform lengthy operation tests (clocking at least 100 thousand kilometres) on many test cars (not less than 50 per model). Following from the smaller series and higher production costs, commercial vehicles offer less chance for extensive testing. As a consequence, apart from individual subassemblies and structural units, the likely service lives of commercial vehicles must be calculated already as in the design phase, and design engineers have to base their decisions on the results of such calculations.

Road vehicles are subject to ever changing static and dynamic loads throughout their service lives. It is advisable to classify the arising loads and the stresses, along with the designing process of the frame, as illustrated in Fig. 2, where the aspects of classification have been chosen to suit the character of load, the structure of the relevant equations and the method of their solution, respectively.

Load	Static method of calculation		Dynamic method of calculation	
Deterministic	Dead weight of structure	Calculation of likely value	Service load of stationary engine under constant load	Knowledge of time dependency (solving of differential equation)
Random-like	Pre-stressing	Calculation of distribution function or moments	Road excitation of vehicles	Knowledge of performance density spectrum for a stationary ergodic case
	Useful load		Varying operation of vehicles and cranes	Time function solution of an adequate number of realizations System identification

Fig. 2. Classification of stressing and modelling methods for bus frames

As apparent from Fig. 3, the new method of dimensioning proposed is based on the analysis of a "constant" operation, and is aimed at establishing realistic load and stress statistics for vehicles through combining traffic characteristics and vehicle design procedures. The fundamental stress is obtained from the stochastic trans-excitation of the vehicle, travelling over an uneven road surface. Transient conditions of operation can be followed by other methods, requiring relatively little computer time, and the results obtained are suitable for integration with stress statistics.

So as to render the designing process economical, the structure dimensioning system should be suitable to establish stress statistics for commercial road

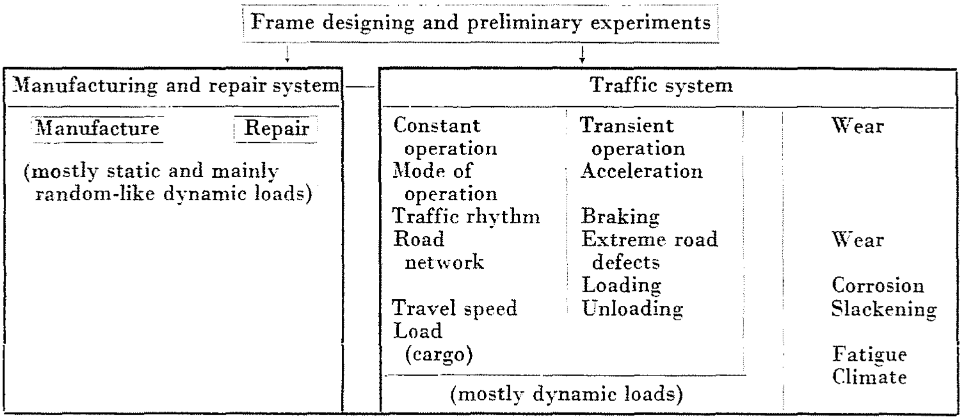

Fig. 3. Dimensioning System of bus structures

vehicles operated under different geographical, traffic, temperature, load and travel speed conditions by a relatively simple spectral method for a linear road excitation — frame stress relation [4]. As regards a non-linear — frame stress relation, stress statistics of commercial road vehicles should be estimated as accurately as possible by means of linearized models, based on parameter estimation [5].

Economic Results Attainable Through Such Development

With an appropriate data bank available for the individual types of vehicles, and having performed the fundamental dimensioning calculations of a given commercial road vehicle model, several objectives are attainable:

a) Knowing the data series for the traffic situation in a novel region of operation, the expectable service life of a certain type of bus can be estimated. Thus by pre-estimating the life expectancy of a given structure, a concrete market offer can be made, and warranty services and spares supply be organized.

b) In order to achieve the life expectancy specified by the buyer, the structure can be modified to suit the actual operating conditions. Moreover, in the knowledge of the necessary modification, buyers can be informed about the added costs.

Both methods would improve the manufacturer's image in the market, thus rendering useful assistance in the ever intensifying competition.

c) Realistic stress statistics obtained for individual frame elements also facilitate more reliable programmed element fatigue testing (by microprocessors).

Fundamental Conclusions

The timing of the technological development strategy outlined here is no doubt open to discussion, especially with a much more detailed knowledge of financing options. What is beyond doubt is that as regards its details and co-ordination, the strategy is justified and timely. Hungary's bus industry must not drop out of the world-wide process of technological development, since this would not only entail direct economic damage to the country's economy, but would also do much harm to the Hungary's competitiveness on the world market. It is perhaps sufficient to refer to the delay suffered by Hungary's railway rolling stock industry development.

At the same time, keeping in step with world progress would obviously entail advantages, the ratio of the necessary expenditures and the gains attainable to us, in other words the effectiveness of technological development in the bus industry, could be further improved. But this calls for an action in due time, i.e. while the main trends of progress are still in the process of unfolding. Retaining our competitiveness without suffering any major loss of impetus depends first of all on technological development, and — keeping the domestic experiences in mind — time is a decisive factor in this respect.

References

1. KOZMA, J.—MAGYAR, I.—MICHELBERGER, P.—VÁRLAKI, P.: Export oriented industrial development strategy in Hungary's bus industry (Közgazdasági Szemle, 1982, 7—8).
2. KOZMA, J.—MAGYAR, I.—MICHELBERGER, P.—SÁLYI, B.—VÁRLAKI, P.: The establishment of a development strategy for Hungary's bus manufacture to cope with world economy changes Per. Polytechnica Transp. Eng. *10*, 139 (1982).
3. NYITRAI, F. (Mrs.): Hungary's economy in international comparison (Társadalmi Szemle, 1981. 12).
4. KERESZTES, A.—MICHELBERGER, P.—GEDEON, J.: Some problems and developments in commercial road vehicle fatigue design and testing. International Journal of Vehicle Design, *1*, 440 (1980).
5. MICHELBERGER, P.—VÁRLAKI, P.—KERESZTES, A.: An Identification Approach for the Stochastic Model of Commercial Road Vehicles. Proceedings of American Control Conference, Vol. 1. Washington, 1982.

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