

## **SESSION 2**

**Process and product innovation in  
the agricultural mechanisation**

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## **Economic Development, Agriculture** **and Mechanization**

### **A. Agriculture Economics and** **Mechanization**

1. Among all those who concern them-selves with the problems of agriculture, there are many who still feel that an answer has yet to be found to the question of whether or not farming should be considered an integral part of an economy, to all intents and purposes subject to economic laws, or whether it should be regarded as entirely independent and, therefore, not governed by those laws. The question is an old one that crops up every time problems in the industry call for new methods to solve them or do not come within the logical patterns normally applied.

The answer, with which I personally agree, is that the development of the farming industry cannot be tackled, any more than can that of those areas that provide its inputs, such as mechanization, unless we bear in mind that *agriculture is in every respect part and parcel of the economic system in all its complexity*. The fact that farming presents certain features that make it different from other industries, largely due to the biological substrate on which it operates and with which it interacts, is not sufficient to divorce it from general economic principles. In other words, it is not an anomalous sector, governed by special standards, but merely one of the many factors that go to make up an economic system.

Once we accept this premise, there follow from it various consequences that will become evident as we attempt to trace the scenario within which, in my opinion, agriculture, and therefore mechanization in that industry, is likely to develop in the near future.

2. Mechanization has been one of the main driving forces behind agricultural progress, and its function has, in the course of time, developed more and more, hand in hand with changes in the industry and in the economy as a whole.

Initially seen as a means of replacing labour with machinery, the introduction of machines in farming is therefore essentially comparable to what happened in other sectors.

Seen as a production factor, *machines may be regarded as a capital asset*, no less than natural resources, the land, labour, or managerial skill; and the pattern that emerges from this is a very simple one, though it makes it possible to pinpoint some important features. However, it must be borne in mind that the considerations we shall be putting forward may often present — in a contrasting, indeed at times contradictory way — two distinct levels, the micro — and the macroeconomic, each generating its own line of argument, and that it will therefore be necessary to make an effort to reconcile the two approaches.

3. An initial aspect is the *replaceability of labour with capital equipment*. To some degree, and depending on the type of production technology employed, on the aims and on the constraints, labour may be replaced by such equipment, while production remains constant. As regards the production system, this result is achieved through the optimization of production factors, both in individual companies and in the industry as a whole; but it may pose a series of problems externally, due to interaction with the rest of the economy, as previously mentioned. From this it follows, for example, that there are certain behavioural patterns that at times appear to be inexplicable from the point of view of corporate efficiency.

For instance, we have the over-mechanization of many farming companies, which acquire machinery, based not on the average use they make of such equipment, but on peak requirements arising from speci-

fic operations or certain junctures in the production cycle.

Outside the farming industry and within the context of the rest of the economy, we encounter all the complex problems associated with the mobility of labour and its tendency to gravitate towards more remunerative and/or less arduous employment.

Thus, there is an overall shrinkage in the agricultural labour force, both at individual farms and in the industry as a whole, so that plans have to be made to replace manpower by machinery.

4. Another point that emerges from this line of thought is that, *since machines are a capital asset, they are also, for those who use them, an investment.* Thus, the economic situation may be responsible for inducing farming entrepreneurs to bring forward or delay replacement of their machinery and equipment in the light of purely financial advisability, rather than for technical reasons or to optimize production. Hence we may find the narrow view of capital expenditure running counter to operating efficiency, and the decisions taken by the farming industry in given situations may also be interpreted as the sum total of individual decisions. For example, during the years when, throughout the European Community, inflation was the dominant economic factor, especially after the second oil crisis at the end of the seventies, the drop in disposable income, on the one hand, and the need to invest any money capital available, on the other, resulted in decisions for which there cannot be any other explanation.

5. Then there are the technological aspects. Capital equipment has, of its very nature, a high technology and innovation content. Moreover, in the area of agricultural mechanization, this fact has, throughout the past and right down to recent times, been strikingly evident. Currently, however, it somewhat receded in-to the background because of sensational developments in the so-called biotechnologies, on the one hand, and equally rapid change in information technology, on

the other. This innovatory function of technology has a twofold effect, both as an agent of internal change and as a means of adaptation to external developments. Thus, at the same time, it directly affects the need for innovation in other industries — suffice it to remember biological re-search aimed at obtaining produce that will stand up to mechanical harvesting — and stimulates reaction to changes taking place in the biological and chemical fields etc.

*We may therefore conclude that the technology content of capital is likely to influence production techniques, and therefore the relationship with other inputs, production structures, and corporate organization at the "micro" level, as well as, in the final analysis, the whole agro-industrial system on the macro-economic scale.*

## B. Scenarios

6. The ability to adapt and, even more, the degree of response to the interactions that develop with the rest of the agri-cultural system, are a key factor when it comes to analyzing the relationship between the economy and agriculture.

This is even truer and more important at the present stage of development of the industry, in which the speed of change and the economic turmoil, once typical of other sectors, now seem also to have become a feature of farming, thus causing a shock reaction in an industry that used, traditionally, to be much slower to develop. It is therefore worth trying, very quickly, to pinpoint the main factors in this present stage of agricultural development, bearing in mind that these will only give us brief summary indications. For a more complete analysis of each individual aspect we shall have to consult the voluminous literature on the subject.

7. Since half-way through the eighties, the farming industry has been having to face up to a problem rarely known in the

history of mankind. For, in the past, the main purpose of agriculture was to produce sufficient food to meet man's growing needs.

That meant having to deal with shortages. *Nowadays*, however, with the exceptions to be mentioned later, *the problem would seem to be just the opposite: in other words, the problem of managing and agricultural system characterized by plenty*. Of course, it has to be remembered that, taking the world as a whole, there are vast areas whose inhabitants are affected by malnutrition or famine, while excess production are a feature of the industrialized, that is the richest countries. Thus there exist, side by side, two totally different situations that nevertheless continuously interact: one of insufficient supply and the other of excess. The prospects for this awkward relationship are uncertain; yet undoubtedly, at least as regards the industrialized countries and that part of the world that is able to pay for its requirements, the problem of a fair part of the nineteen nineties will probably continue to be how to manage surpluses.

Confronted with this problem, which should perhaps more correctly be restated as the flexible management of agricultural production, the customary economic policy measures are entirely ineffective, and reorganization of the system is required — for it is from this situation that most of the farming industry's difficulties stem.

8. The worldwide imbalance as between supply and demand in the area of farm products may be said to be due in part to traditional aspects of agricultural production, which has always been marked by fluctuation and which, for that very reason, is a phenomenon that is liable to change. Nevertheless, it is also partly the consequence of overproduction by the system. Indeed, this fact was borne out at the EEC, when production quotas were introduced to reduce milk surpluses, the undesired result of which was to create, first, a beef, and then a grain glut. This

explains why it is best to deal with the problem as a whole, rather than by partial remedial action that only shifts overproduction from one area to another. The short-term effect may well be to enable subsidies to be cut, but nothing will have been done to solve the problem of agricultural surpluses in industrialized countries, which is of a structural rather than episodic nature, or an economic trend.

9. The situation is perhaps more serious than in the past because of the simultaneous occurrence of certain phenomena. *Above all, changes are taking place in the demand for agricultural food products*. The phase during which per capita consumption increase has come to an end, while the phase in which demand has depended on precise qualitative aspects such as protein and fat content, appearance, size, etc., is also drawing to a close. At the present time, demand is concentrating on a different kind of quality, such as the naturalness or health-giving properties of food, associated with the concepts of fitness and health, already recognized and well-known on the markets of the USA, Germany, or Great Britain; or, again, there is the trend in favour of "ecological" or "biological" foods, with all the ambiguities that such definitions may involve. Because of the halt in population growth and per capita rates of consumption, there is also a tendency for demand to cease to grow in quantitative terms, while a different type of demand is taking shape that will have repercussions on production methods, and therefore on the technologies employed and the quantities required.

10. *A similar trend is followed by another type of demand, directed at agriculture by the consumer, which no longer calls for goods or foodstuffs, but environmental services, open spaces in which to spend leisure time in other words, "naturalness" in this sense*. The main phenomenon here is therefore growing ecological sensitivity, a fact that cannot simply be dismissed as a passing whim, but must be treated as part of a development that

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hinges on two aspects. The first stems from living conditions in large cities, where people have lost touch with an environment whose praises are often sung and which is felt to offer a much better life. The second lies in higher incomes, which bring with them great spending power and ability to diversify in meeting ones need. Thus we have moved from satisfaction of the more basic requirements, associated with lower income levels into the area of luxury commodities, which are, however, felt to be equally necessary, and so must be satisfied. There is thus a call for naturalness, applied both to food and to the environment. Associated with this attitude are regrets for a past that people never knew and rejection of the present, as they flee towards an improbable future.

However, it would be a mistake to think that the citizen and consumer is prepared to go into reverse and retrace the path of evolution. What in fact he is asking for is a reinterpretation of eating and environmental concepts that, while such things as comfort, hygiene, and modern standards of security are taken for granted, will combine the latter with the requirements of naturalness, for which he is prepared, not only to wage political battles, but on which he is also prepared to spend an increasing share of his income.

11. Another highly significant factor, within the framework of current change, is the *internationalization of the world market for agricultural products*. This definition may be taken as meaning at least three different types of phenomena, all of them highly relevant to the subject under discussion. The first is the gradual de facto development of a single, huge world market for agricultural products, especially the commodities. It is a market that attracts products from various countries, and a degree of interaction takes place that at once time would never have been thought possible. In fact, this means an accentuation of the effect of structural over-capacity and, at the same time, the need to produce for this large market, ra-

ther than for a more limited local a national one.

The second phenomenon is the internationalization of models of consumption, and therefore the development of highly homogenous demand, no longer on a national scale, but for social classes, age-groups, and ways of life that are the same worldwide.

The third is the internationalization of the food industry. For example, as regards mergers and acquisitions, which are so well-known and self-evident that they call for no explanation. For the establishment of large multinational corporations in various countries and of groups operating all over the world are only further incentives to standardize demand, which the farming industry has to get to grips without losing time.

12. Hand in hand with all this there has been a rethinking of agricultural policy — in other words, of that area of economic policy concerned with the farming industry. Policies began to be redefined when it was realized that they were becoming more costly, especially in the more highly industrialized areas of the world, and that, moreover, agricultural subsidies were having a negative effect on the world market. Recent OECD estimates indicated that such subsidies were equal to 25% of the value of agricultural production in Japan, to 19% of such production in the EEC, and to 16% of US farming output. Moreover, this financial aid has often led to trade war, costs the taxpayer money, and is but an inefficient way of achieving the policy objective of bringing incomes in agriculture closer to the levels enjoyed in other sectors. The will to reduce subsidies does, theoretically, exist both in Europe and in the USA, but the obstacles standing in the way of a U-turn are considerable, and no concrete progress has, for example, been made within the framework of GATT, with the conclusion of the Uruguay Round expected in a year's time.

13. As regards the EEC, it may be said that, beginning in 1984, policy began to

move along the following lines: a) a general reduction in real prices, obtained by pegging the latter at current levels, b) the imposition of production quotas for the main surplus-prone products, c) a cut in the compensation paid to producers in ex-change for their willingness to withdraw their products from the market, and d) the introduction of stabilizing mechanisms linking prices with the supply/demand ratio.

At the same time, the Community has attempted to give a fresh boost to structural changes by pursuing a policy of "de-coupling": that is, by doing away with the link between the size of subsidies and the amount of production. In this way, it is felt it may be possible to reconcile the objective of improving agricultural incomes with the need to obviate the negative effects of expensive surpluses for which it is difficult to find an outlet on the world market.

The EEC "set-aside" regulation, for example, should be all part of this trend, since it aims to free arable land by taking it out of production and allowing it to lie fallow. Indeed, the significance of this decision is fairly clear, for the Community pays an indemnity to farmers who agree of their own free will not to cultivate a certain area for a given period. Alternatively, farmers may receive a smaller indemnity by undertaking to use the same land to plant forests or for pasture — that is, for less intensive uses. Thus the reversal in policy trends could not be more complete, while nevertheless sticking to the fundamental aim of improving farmers incomes.

14. Lastly, the EEC has decided to include in its more recent structural planning yet another guideline by introducing *incentives to use production techniques with a lower impact on the environment*. Here, too, we have a significant innovation in Community policy. For, in the past, the latter was never particularly concerned with this aspect, being content merely to control the finished product. Now,

however, the matter of the technologies to be employed in farming is being addressed head-on, which adds up to a significant change, probably due to the more important role now being played by environment, since the latter was enshrined in the 1986 Single European Act, thus becoming a factor in EEC policy on a par with agri-culture, which, of course, has figured ever-since the Treaty of Rome was first signed.

On the other hand, the path of environment-friendly technologies has been pursued by various countries, both within the Community and outside it. In other words, as with the food industry, increasing importance is being given to "softer" production technologies, so that the same trend exists in both stages of food production: first in food-processing and now in farming proper too.

15. *This trend towards softer production technologies has been made possible by technical developments of two kinds.* The first lies in a better understanding of the mechanisms underlying the various stages of production, leading to optimization of the whole process. This has made it possible to improve techniques, thus reducing costs as the final result of action taken on the means to be employed — in other words, by having better tools to do the job in hand.

The second has begun to have a profound effect on the biological substrate, on which the agricultural process takes place. This has been the field of the so-called biotechnologies, with specific reference to advanced research in genetics, but also in the area of biological methods for combating parasites and for protecting products against pathogenic agents.

According to the forecasts of experts in the industry, agriculture is still witnessing the maturity phase of innovations introduced in the past, and has therefore been engaged in the optimization of those innovations. In the last years of the next decade, and even greater intensity in the first years of the next one, we shall, however,

be seeing a whole series of highly significant new developments in farming.

16. By way of an example, and to move much closer to the present day, there is now a real and imminent prospect of being able to have substantial supplies of somatotrophine, a hormone, obtained by the same process of genetic engineering as that used to produce insulin for human use, that could, it is estimated, increase milk production by anything from 15 to 25<sup>0</sup>7o. That means we are in the presence of a far-reaching innovation that may have a significant effect on many aspects of animal husbandry, since the feed requirements of cattle will be different from what they are at the present time, and thus also on the structure of farms, land use, and agricultural machinery. On the other hand, it will be possible to obtain the same quantity of milk with fewer head of cattle: in other words, herds of the same size would produce much more milk, which in turn would mean more problems with surpluses.

### C. A New Approach to Production

17. The overall scenario now taking shape indicates that the farming industry will be faced with considerable problems of adaptation in the near future.

Expansion of the market, which, as regards the EEC, is likely to be the result when the Single Market comes into force in 1992, and policy changes under way throughout the world are bound to increase competitiveness among producers.

From this we may deduce a number of trends towards adaptation. The first, of a more conventional kind, lies in the continual drive for optimization in the use made of the means of production and, therefore — of particular interest to us — of machines. In the case of the latter, it will become increasingly important to ensure that size and design are best suited to meet farming needs, with the accent on the mutual adaptability of the machine

and the farm using it, and taking into account all the parameters that come into play in striking this complex balance. The first and most obvious factor is the relationship of the machine to the size of the farm. In many cases, the surface area to be managed is, however, much larger than that of the average farm. Joint use and management of machinery thus becomes necessary in order to achieve the optimal operating ratio.

Another problem involved in striking the correct proportions is the ratio between the amount of labour available to a farming company and its machinery. Here, too, we have situations that are theoretically easy to solve, but that, in practice, are far more complicated. In other words, the replacement of labour by capital is in fact far more difficult to effect with than people think, since for one thing, one is dealing here with whole units.

18. It is therefore against this background that we find empirical solutions being adopted in the various countries where problems of this kind are being grappled with. The most obvious one is the purchase and management of machines through co-operatives, or at least by companies of the simplified sort. In some countries, however, other models *have* been created to tie in with local situations, such as the "Maschinenringe" in Germany, of forms of "entraide" in France.

A feature of this area of development is the *emergence of agricultural service companies*, in which the entrepreneur, who may or may not be a farmer, supplies service for farmers who need him against payment. In this case, the farm delegates some of its functions to an external organization, being content merely to purchase such services. This phenomenon which is expanding strongly in Italy, allows the farming company greater elasticity and makes for the more effective running of machinery by the service organization.

Naturally, it also means diversifying the types of machines offered by the agricultural machinery manufacturers to meet the

requirements of the dual market thus created, and so we see the birth of two different, albeit complementary R&D trends.

19. Factors that need to be assessed with more care than in the past include the financial aspects of capital expenditure which farms in general, especially family businesses, tend to underestimate.

The decision taken by a farming company to invest in equipment is strongly conditioned by the financial basis of the farm and of the family, given the fact that most farms are family businesses. A typical feature of such enterprises lies in the fact that their immediate concern is not so much with maximum profits as with their own incomes. Consequently, decisions follow different parameters, and this explains the close link between income and the likelihood to purchase machinery. In addition, decisions are influenced by external factors, such as inflation, for the reasons already stated.

The problems involved in the correct management of a farm are therefore often dealt with in an apparently contradictory manner, which calls for special attention, among other things, from the machinery manufacturers.

20. *But increased competitiveness involves more attention not only to the optimization of processes, but also to the market — that is, to the changes currently taking place in demand.* For the farming industry it is going to be more and more important to meet new kinds of demand in such a way as to command higher prices for its products, or else to maintain higher prices for its products, or else to maintain higher market shares in the face of competition from producers in other countries. Obviously, this competition will, in its turn, attempt to get a foothold in the richer, more profitable market segments. Agriculture, therefore, must succeed in producing what the market wants, if possible adapting itself even quicker, so as to be ready to supply a given product the very moment consumer demand for it materializes.

All this is in line with market trends towards quality agricultural products, which offer new features and are more diversified. By this I mean especially the products that appear, to the eyes of the consumer, to be more health-giving, or nourishing, etc., to which reference has already been made, or that are in some way produced more "naturally" in the sense that word is understood by the consumer.

Becoming established in this market segment, which seems to be developing strongly everywhere and serves essentially the upmarket consumer, will call for changes and the ability to adapt production techniques and, consequently, mechanization.

21. This new demand focused on agriculture is, however, also directed at environmental services and non-productive land use, as is the "set-aside" policy. As the result, farming companies will also have to take into account the fact that the production factors, including machines, will have to be used differently from the way they once were. Mechanization has therefore to cater for farming activities of the extensive type, that is for production methods and techniques that involve low environmental impact. To this end, the common link is the biological factor, or at least the tendency to go for products that meet the consumer's "naturalness" requirements. Machines therefore have to be developed that meet these needs: for example, that perform fewer runs over the ground, or that, in the course of the same number of runs, perform several operations. As regards spraying with insecticides, optimal distribution of such products could, for instance, reduce the quantities used.

22. *Another interesting and stimulating area of research is concerned with machines suitable for use in conditions of extensive production, which therefore cost less to operate and are able to take care of large surface areas.* This is a new problem, because, up to the present day, the intensity of mechanization was in propor-

tion to the intensity of cultivation, which meant that higher costs could be covered by higher yields. Nowadays, the problem is related to set-aside and to the need to keep large areas of ground out of production without, however, neglecting them: in other words, in a standby situation that calls for new solutions.

Far more advanced, on the other hand, is the development of agricultural machinery for non-productive uses, as in the case of gardening equipment and hobbies in general that, while derived from "professional" equipment, has been adapted to other purposes.

The creation and management of green areas, formally used for agriculture, but that are now given up to environmental purposes, ranging from recreation grounds, golf courses, public parks, etc., right down to natural "bases", call for parallel development in machinery, and thus represent an aspect of demand in its own right.

23. To sum up, it may be said that the overall need for innovation, whether in products or in processes, also involves mechanization, which has to keep up with such innovation. On the other hand, as we have said, it is in the very nature of capital equipment that it be associated with this requirement.

While, for the time being, there seem to be no substantial novelties in the form of innovative products, the subject of the evolution of production processes is far more stimulating. For, in the course of optimizing the present, more conventional processes, the constant quest for competitiveness ensures continued improvement in the efficiency of machines. Even more promising is the introduction, in agricultural mechanization, of technologies such as electronics, that can contribute towards the achievement of objectives by lowering costs, optimizing the quality of work, and reducing tedious human effort.

24. The capacity for innovation may find a substantial outlet in research on, and the manufacture of new machines based

on "softer" technologies, able therefore to reduce, for example, the amount of chemicals used by replacing them with less harmful mechanical methods. Yet another area of interest, from quite a different angle, concerns the current introduction of such methods as biological pest-control, or biotechnological and genetic modifications, which will call for simultaneous adaptation in the field of mechanization. Lastly come uses of the environmental or less intensive, agricultural type.

The scenario is thus one in which the farming entrepreneur will be becoming more and more demanding towards the machinery he purchases, because he will apply ever stricter criteria in assessing the value of his investment, and he will be comparing what his machines can give him in exchange for the money he has spent. For, from the moment it is conceived, the machine must be regarded as a product that has to meet the requirements of the market to the maximum extent possible. It must therefore be able to replace human labour, but also other capital, with greater efficiency. It will have, on the one hand, to be in line with technological developments and the progress achieved in machine manufacturing technology and, on the other, with current developments in agriculture.

All in all, a highly stimulating scenario, especially bearing in mind the competitiveness of the industry — a competitiveness that, in the coming years, is destined to become keener.

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### **The industrial process of implementing innovative ideas to farm machinery**

The conversion of innovative ideas in-to practical products is a very complex

process, concerning not only the future of industrial companies, but also the development of the whole national economy. There is no growth without technical progress. The following overview is based on 11 years of my own work in industry, experience from industry consulting and some relevant publications.

### **Figures of the agricultural machinery and tractor industry in the FRG.**

The West German agricultural machinery and tractor industry seems to be a good example for innovative product development and therefore I would like to introduce you to some statistics, listed in figure 1. The "Landmaschinen — and Ackererschleppervereinigung (LAV)" associates all big companies. The value of the total production of all LAV-companies is about 7 billion DM (3.5 billion ECU), where both, tractors sold in the domestic market and other agricultural machinery come to 1.4 billion DM each — that is together 40%. About 60% of the production value is exported. As a consequence of this high export volume, the FRG. holds the third place in the tractor world market and the first place for other machinery, figure 2.

The production value of all LAV-companies has been achieved in 1988 by 42.400 employees giving a mean turnover of 164.000 DM (about 80.000 ECU) per employee. Due to some companies without membership in the LAV, the real production value of the FRG. is about 10% higher. The non-members are mainly manufacturers of on-farm machinery and implements.

### **Live-cycle of products and sources for new ideas**

The number of totally new developed products is comparatively low. Common practice is mainly to improve present pro-

ducts by innovative development. Figure 3 shows the typical live-cycle of a machine from the industrial point of view. Starting from the introduction of the product, the number of sold units per years has the typical shape of ascending, holding and declining. When reaching the culmination of the A-labeled product, further development towards the A + product must begin. Otherwise a decrease in turnover will follow.

Particularly in the beginning of the development of new or enhanced products, many good ideas are required. Figure 4 pointed out, where they might come from and how additional ideas can be produced. In this context the result of an older inquiry among 139 machinery producing companies is presented in figure 5. About 70% of all ideas came in those times from customers, exhibitions, conferences and competitors. Impacts from scientific re-search are included in the remaining 30%. Regarding our branch of industry nowadays, I feel, that research has moved to much more importance.

### **Contributions from scientific institutes**

The collected ideas must be analysed and evaluated by an advanced engineering group prior to the start of product development. An important step in this work is the balance of advantages and disadvantages (pros and cons). This shall be demonstrated by two ideas, generated by re-search work. The first example shown in figure 6 concerns a tire inflation remote control system. The fundamentals of this proposal have been worked out by different research institutes. The first commercially offered system will be shown at this years AGRITECHNICA at Frankfurt.

The second idea is still in the stage of discussion: the change in chassis concepts of utility tractors from rigid block-type to frame-type, figure 7. In order to reduce the strategic risks, we developed at my institute in the years 1984-1988 the "Munich

Research Tractor" with a frame-type chassis (Renius/Kirste). The elastic suspension and shielding primarily of the engine — as well as the transmission if possible — enables a great reduction in noise — e.g. 10dB(A) less stand-by level. Evaluating our practical experience, this is of appreciable benefit for both the user and the environment. Furthermore, increased flexibility to arrange and mount components is achieved. The customer gets better visibility, lower machine net weight and more convenient space for attachments. The flexible arrangement of components simplifies service and repair work. Finally, the frame can be utilized for cost-efficient integration of front loader and front hitch. These advantages are balanced by some disadvantages, where the big development step can be seen as the most important one.

As already shown before, many innovations are based on new ideas coming directly from the customers, e.g. the 40 km/h tractor versions. High speeds however created some new problems mainly vibrations on the road, often intensified by the masses of mounted implements. This problem however has been early investigated by research institutes, e.g. by Goehlich et.al. in Berlin, leading not only to a first suspended cab concept, but also to interesting compensation techniques, which will result now in a first commercially available solution on the coming AGRITECHNICA '89.

Another example for such an innovation by cooperation can be seen in the up-coming automatic front wheel drive activation by service brake foot pedal. In this case basic research was done at the TH Darmstadt by Breuer et.al. working very closely together with a tractor manufacturer.

Other basic research work for innovations in tractor hydraulics were carried out by Matthies et.al. in Braunschweig, leading to new concepts of several tractor manufacturers. Many further examples could be mentioned, but reasons of time

force me to continue on the topic of development methods.

### **The main schedule and the "project foundation matrix"**

Referring to figure 8, a first bar schedule shows the main activities of product development versus time. Promising ideas are picked up by product planning, analysed or even refined by the advanced engineering group, discussed with field people in a broader view and afterwards evaluated in terms of economics by use of a relatively high sophisticated process. It is the objective of this work to establish a well-defined product-project using innovative and pre-evaluated ideas. The most important activities are demonstrated in figure 9. This "project foundation matrix" must be seen as the center of a successful development of innovative products. It defines particular inputs of the four concerned areas of the company: Re-search and development, sales, factory and finance. These inputs concern not only the detailed description of the proposed project but also production costs and market prospects. Special requirements must be considered for some special market areas. Switzerland for example requires unusual low stand-by noise level, Scandinavian countries have a high safety standard, the USA have given outstanding priority to the principle of product liability, other countries e.g. South Africa give only permission to imports, if specific components are supplied by the home industry. In all these questions, development and sales have to cooperate very closely. Further important investigations concern necessary investments and available capacities in the referred areas.

The achieved first economic evaluation of the proposed project usually yields high losses, so that the procedure needs to be repeated with modified inputs until the balance indicates a profitable product. Improvements of the result are often possi-

ble, if functional specifications are leveled down to a compromise. Sometimes also the costs of factory investments can be cut by using the present production machinery with only some modifications. E.g. several tractor companies are running transmission housing production lines for more than 20 years with only some minor changes, although the transmission functions were improved in the same period of time.

In series production, competitive costs can only be achieved, if the individual machine types form a product family package, standardizing a great number of parts to save costs in production and logistics. Figure 10 shows the number of new tractors sold in the F.R.G. in 1986 versus rated engine power, covered by three tractor families L, M and H.

The main task for the sales department is to determine the future sales profiles and prices for the different market regions. These estimations require outstanding experience and overview and a highly developed communication in sales.

Figure 11 gives an impression of the necessary investments for the development and the factory including characteristic development times. In the first example of a new developed or improved tractor family, about 20-50 mill. ECU and 3 1/2 years of time are required for a major development project. The reason for this impressive expenditure and period of time is the very hard competition requiring first-class development and big series production to achieve adequate product costs. In comparison, the example of a fodder-beat harvester-chopper on the right shows considerably less investment costs. For the development of such a harvester, which was recently presented in my country and was based on an existing conventional harvester type, the costs for development and preparation of production are about 1 mill. ECU. A totally new concept is of course much more expensive.

Even if the project seems to be profitable in this stage of the "project founda-

tion matrix", it must be checked, whether the necessary capacities for the project are available or can be made available in the concerned areas, sometimes also outside the company. A typical distribution of the main budgets averaged over a longer period of time is presented in figure 12 for development departments in the tractor industry. 40% are required for maintenance of the current products. Another 35% are used for further development of existing products, 5% refer to research and advanced engineering, so that the remaining 20% are available to develop new products. There are of course major changes possible from year to year (mainly between the two bars in the centre). The figures will also vary, because of definitions. In the future 5% for research and advanced engineering will perhaps not be adequate for competitive innovations.

When the project is settled, different following activities must be established simultaneously, see again figure 8 and look at the three bottom bars. The first complete product layouts are carried out while product planning is still going on. After release of the development project the layouts are refined, later on, the design is worked out in detail. New components are subjected to lab tests as early as possible. Prototypes are built and tested later. The test results are returned to the design department.

Factory planning starts working at about the same time as the components are tested. Production machinery is modified or completely rebuilt some time later. Possible collisions with still produced "old" products need carefully planning. When production is planned for big series, it is profitable and helpful to test the production machinery early enough by a pilot series. Further changes due to the assembly experiences are introduced to the design documentation. Homologations mostly begin coincident with the production release. Starting series production, project management activities are completed. The maintenance department is now taking care

of the product. From the beginning of the project until start of production between two and six years are gone.

### **Product costs are mainly fixed by development**

During product development, the current project stage must be compared continuously with the schedule and the objectives by the project management. Regarding the costs, it is useful to know about the impact of the various departments on the final product costs, Figure 13. The numbers are based on many years of experience. With 70<sup>0</sup>70, the impact of research and development on the costs is obviously dominant. The following departments are production preparation by 15<sup>0</sup>70, production by 10% and sales with only 5% of the costs. Consequently, if a product is too expensive, the reason is probably a costly design. The overview shows too, that this cannot be compensated by the other departments, particularly not by production.

Figure 14 leads back to the ideas and the finally resulting costs. In the beginning of a development, a lot of ideas are necessary — no problem in the case of a good management. Canceling a non profitable project in an early stage can be a good decision, because development costs are yet low. With progress in time the conversion of ideas becomes more important than the finding of further new product ideas. Due to the increasing number of employees working on the project, development costs rise progressively. To stop the project in an advanced stage would cause an important loss of development costs, sometimes also of investments.

### **Major changes in objectives only in the case of emergency**

Also major changes in the development objectives lead to additional costs, main-

ly caused by the prolongation of the development time. Therefore, only urgent changes are considered, for example, if the background has changed during the engineering process.

Some urgent development changes might be an answer to innovative products of competitors. For instance, the introduction of a 40 km/h version on standard tractors had an unexpected great success immediately after its presentation by FENDT and SCHLUTER in 1980. Other companies were forced to follow. Even political changes as well as new standards may have some impact on the development of new products. A good example is the relatively fast introduction of noise-isolated cabs in the seventies (whereas nearly no progress can be seen for stand-by noise levels) Techniques for environment protection sometimes are coming up unexpected as the actual increasing use of plant-based hydraulic fluids for agricultural machinery. Tractors often work with the same reservoir for hydraulic and transmission oil. Unfortunately, commonly used wet brakes are not compatible with native fluids. This tendency was not anticipated, neither by research nor by the industry and will probably cause some corrections in current tractor projects, e.g. with the objective to separate the mentioned oil circuits.

### **Agricultural engineering has future**

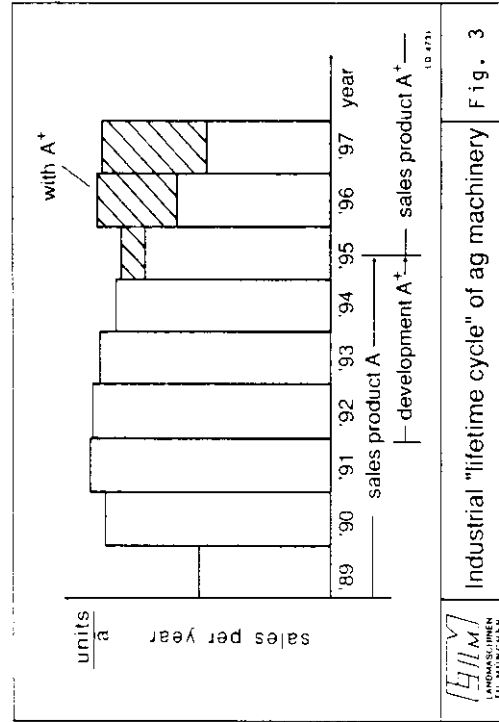
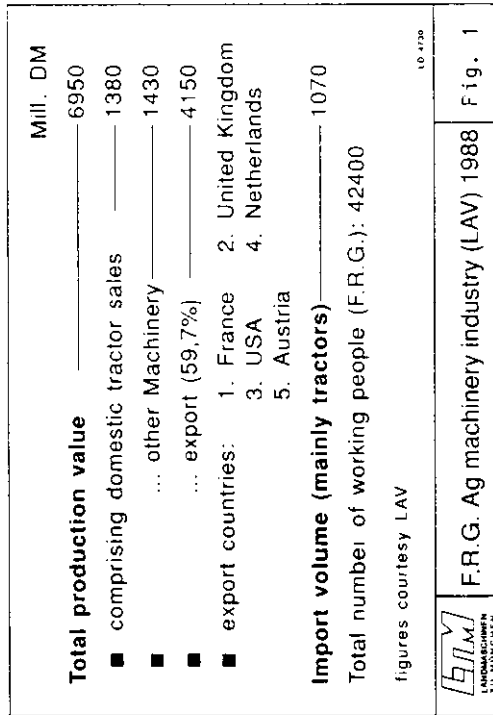
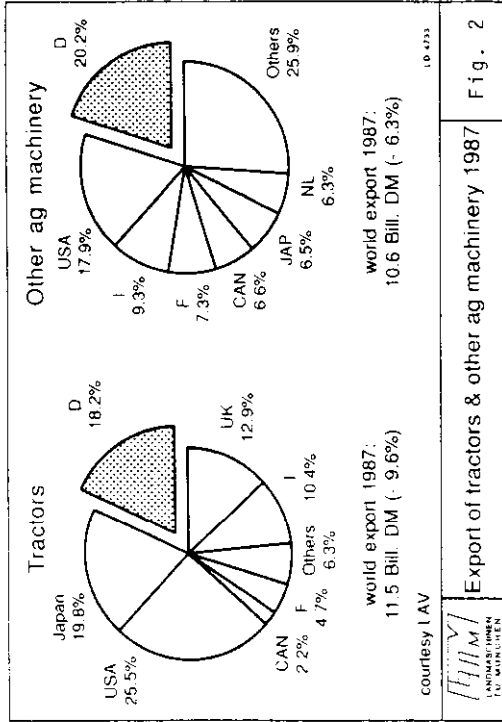
The industrial process to convert innovative ideas into profitable products is surely more complex today than it was in former times. On the other hand, horizons of business in industry have widened continuously. Products, which were developed and produced 100 years ago could of-ten be used only in a specific region, like Bavaria. Nowadays they are developed for application in many countries all over the world. Also the pre-investigating research has achieved high effectiveness today, due to progress in international communica-

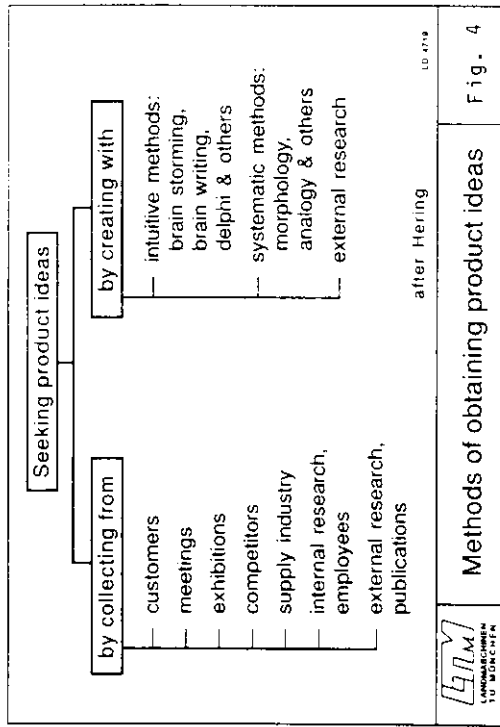
tions. In spite of these improvements, I still see possibilities to make further steps forward. Often even language is a barrier being very negative for national economy. Personal contacts worldwide are of particular help to prevent isolation. Good personal relations can also help to balance political instabilities. The history of the 20th century clearly showed, that an honest and free democratic structure is the

best basis for innovative products and hence welfare of the people. In all developed countries, innovations in agricultural engineering have been the basis for the development of industrial activities. The present overproduction of food should not let us forget, that long-term nourishment of mankind can only be guaranteed with innovative agricultural machinery. For this reasons, I think, it is worth doing.

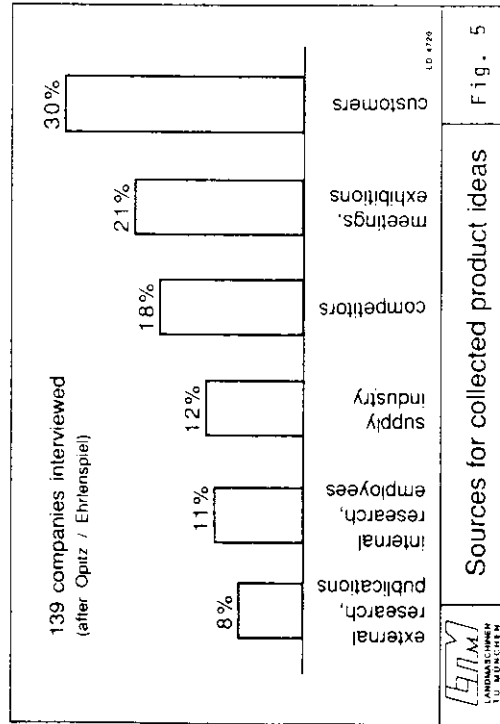
**THE INDUSTRIAL PROCESS OF  
IMPLEMENTING INNOVATIVE IDEAS  
TO FARM MACHINERY**

Prof. Dr.-Ing. Karl Th. Renius, Munich / F.R.G.





Pro	Contra
<ul style="list-style-type: none"> <li>■ Less soil compaction</li> <li>■ Less plant damage</li> <li>■ Less rolling resistance</li> <li>■ Less tire wear</li> <li>■ Improved dynamic overturn safety</li> </ul>	<ul style="list-style-type: none"> <li>■ Extra costs for compressor, tire valves, connecting elements and control</li> <li>■ Variations necessary in tractor &amp; trailer design</li> <li>■ In the first step: Less operational comfort</li> </ul>
<p style="font-size: small;">Note: Existing compressors for tractors without accumulator need relatively long period of time for inflating big tires.</p>	
<div style="display: flex; justify-content: space-between; align-items: center;"> <p style="font-size: small;">TU MÜNCHEN</p> </div> <p style="margin-top: 5px;"><b>Tire inflation remote control</b> <span style="float: right;">Fig. 6</span></p>	



Pro	Contra
<ul style="list-style-type: none"> <li>■ Reduced noise level by isolated components</li> <li>■ Much more design &amp; component flexibility. Light weight components possible</li> <li>■ Simplified service &amp; repair</li> <li>■ Frame used for front end loader &amp; front lift</li> </ul>	<ul style="list-style-type: none"> <li>■ Tractor with more parts</li> <li>■ Chassis stiffness must be properly designed</li> <li>■ Profound development step<sup>*)</sup></li> <li>■ Increased expenses for corrosion protection</li> </ul>
<p style="font-size: small;">*) Note: Temporary concept could perhaps use conventional block transmission with attached front frame.</p>	
<div style="display: flex; justify-content: space-between; align-items: center;"> <p style="font-size: small;">TU MÜNCHEN</p> </div> <p style="margin-top: 5px;"><b>Frame - chassis tractor versus block concept</b> <span style="float: right;">Fig. 7</span></p>	

