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PROCEEDINGS
OF THE 7th MEETING
OF THE FULL MEMBERS

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XXVII EIMA

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CONCLUSIONS

AND RECOMMENDATIONS

45 **Expert** from 25 **countries** attended the 7th Club of Bologna Meeting - held under the auspices of CIGR - discussing the two following subjects: (1) *"Cooperation between Industry and Research Institution"* and (2) *"Mechanization requirements for Low-Input Sustainable Agriculture (LISA)"*. The meeting reached unanimously the following

Conclusions and Recommendations

1. Cooperation between Industry and Research Institutions

This question was considered both from the standpoint of research institutions and from the point of view of industry, with contributions from the following keynote speakers: *K.Th. Renius* (D), *B. Legg* (UK), *B. Chèze* (F), *P. Celli* (I), *H. Cetrangolo* (Arg.), *T. Yotsumoto* (Jap.) and *D. Wilkens* (D).

The papers dealt with the general issues of future needs and the advantages to be gained from better cooperation, but also went into specific examples of successfully-implemented collaborative projects.

These studies, undertaken in various countries - Argentina, Germany, Japan, Italy and the United Kingdom - confirm the effectiveness of cooperation between industry and research institutions. The ingredients for this success are various but they include:

- the creation of an innovation in a research institute, perceived by the industry to be a potential winner as a product;
- the need for a product to meet requirements of farmers and/or restrictions placed on agriculture by Government policies or interventions;
- a need felt by industry to improve their product coupled with the recognition that their own expertise needed to be supplemented.

It should be emphasized that University and Institute researchers welcome the opportunity of working cooperatively with industry in such research.

Following extensive in-depth discussion, the participants **agree** that this type of cooperation is, at present, insufficiently developed because industry tends to view contacts with the research sector as a time and money consuming activity. In addition, the pursuit of long-term ideas may be secondary to existing problems within companies and the actual production and marketing problems they are facing. This attitude is reflected in poor attendance by industry employees at scientific conferences. It has however to be noted that a similar lack of interest in cooperation can be found among some members of the scientific community also who prefer to pursue their own interests.

However, it is universally acknowledged that closer collaboration between the two sectors - whose activities are of reciprocal interest, given the diversity of experience, subject matter and timescale constraints - can be one of the keys to successful business. It can allow new products to be developed faster, more effectively and at a lower cost. Such advantages are all the more important in the current context of rapidly-changing globalized markets, where the trend is towards "total quality" methods, with a consequent strong demand for radical innovations in products and agricultural systems.

The participants are unanimous in **confirming** that, in any case, a modern and effective form of cooperation must necessarily begin with the joint "generation" of new ideas before moving on to the delineation of concepts and, finally, to the development of a product and the evaluation of its viability in the agricultural context. This approach offers many interesting opportunities, especially to small and medium-sized companies, and should also prove to be of interest to the technical training sector at various levels.

From the research standpoint, the hatching of new ideas in preliminary brainstorming sessions with experts from both sides is an opportunity to compare notes and evaluate within the various agricultural systems radical innovations -

machines, components and systems - that may become industrially viable in the medium term. On the industrial development side, the short-term benefits of collaboration should essentially be sought within the domain of solving practical technical problems, including the analysis of how to most effectively employ machinery in an agricultural context. A parallel consideration is the problem of technical training, to which research institutions can make a fundamental contribution, also in terms of promoting dissemination of information relating to innovative machinery.

The participants are therefore unanimous in **recommending** that every possible effort be made to develop effective forms of collaboration between industry and public research bodies. This involves laying the institutional framework for cooperative ventures applicable at product (electronics, safety systems, new materials, etc.) and process level, to define mechanization systems suitable for implementing new cropping methods geared towards improved quality and reduced environmental impact and for promoting and assisting transfer of technologies.

Due recognition is given to the fact that cooperative efforts involving several companies are not always successful because it is difficult to establish who or which of the participating enterprises owns (and can therefore market) the resulting innovations. This becomes more complex when patents are involved. Nevertheless, the participants believe that the following initiatives would lead to improved understanding and collaboration between industry and research organizations.

Training

- Universities should require students to spend time in industry.
- Universities should offer continuing technical education opportunities for industry staff.

Communication

- Professional societies should adapt their activities to be of greater value to industry.
- Industry should consider organizing technical exchange meetings at which they choose the agenda.
- More brainstorming sessions should be organized between individual research organizations and industries (including small companies).

Partnerships

- Partnerships with several complementary industries as well as with several complementary research organizations should be encouraged. They have to be as permanent as possible.
- Industry/research collaboration must be professionally structured and managed.

Specific actions for research organizations

- Research organizations must continue to generate new ideas. This can be guided by technology foresight.
- Working with industry must be valued and rewarded and taken into account in decisions on promotion and tenure.
- Research organization must understand and respect industries' priorities and time pressures.
- Staff with industrial experience must be employed; or experience gained through industry/research exchanges (both ways).
- Research organizations should have a panel of advisers from industry and end-users to check whether their research is relevant to industry and users.

Specific actions for industry

- Industry must participate in national and regional discussions of research priorities.

- Many companies have special problems that can best be overcome through collaboration with complementary companies.

2 Mechanization requirements for Low-Input Sustainable Agriculture (LISA)

This topic was first dealt with in 1991, at the 3d Full Member's Meeting, with introductory talks by *R. Hegg* and *J. Matthews*. The Club decided to return to this issue, with a keynote paper by *A.A. Jongebreur*. The goal was to review the progress made during the past 5 years, and to determine the extent which machinery meets the criteria for LISA, defined as an activity that is ecologically sound, economically viable, socially justified and humane.

Following extensive in-depth discussion, the participants **agree** that the attainment of LISA depends primarily on reducing soil erosion, agrochemical and nutrient consumption, and on rationalizing energy usage.

In this connection, they acknowledge the progress made by certain countries, and the promising potential of new electronically-controlled machines and the use of special models, which can reduce chemical application by up to 50% by optimizing the boom position and taking air velocity into account.

The participants **consider it essential** that these innovations be developed and marketed, in order to achieve those general advantages that will help to promote LISA. The emphasis should change from "low input" to "sustainable". The Club recognizes that "low input" is a relative term that will have different values in developed and developing countries. For example, FAO 1995 reports that 70 countries of the world would be unable to feed their populations by the year 2000 unless they adopt more intensive farming systems. Efficient use of inputs taking into account the environmental impact, should be the goal, not necessarily "low" inputs. The Club also recognises that soil, water and air resources are most crucial to the long term sustainability of agriculture. Soil is probably the most critical of these resources because of the long time frame required for recovery. Mechanization and irrigation practices must be designed to minimize soil erosion, salinity and other soil degradation problems.

Organic farming practices may be useful as a research tool, to indicate ways in which conventional agriculture can be changed to decrease dependence on agricultural chemicals.

The Club **recommends** that every possible effort be made by agricultural policy-makers and equipment manufacturers to create favourable conditions for farmers to implement sustainable agricultural practices on the entire cultivated territory. This will involve:

- the development of improved methods for evaluation of the environmental impact of farming activities;
- measurement of progress in a holistic manner applying engineering and economic criteria i.e. the cost/benefit of sustainable practices with due consideration for the environmental impact;
- site specific (spatially selective, precision agriculture, etc.) practices and technologies designed to improve the efficiency of use of fertilizers and pesticide inputs and thus to reduce the potential for environmental degradation;
- decision support systems that may employ advanced satellite communications to achieve optimal yields with minimum environmental impact;
- continued efforts to use energy efficiently in agriculture as a key element of sustainable agriculture and use of renewable forms of energy such as biomass energy where appropriate;
- high priority for health and safety concerns of farmers and the public;
- an additional innovative push, geared towards developing tractors and implements that incorporate the latest advances in engineering technology;

- a comprehensive information and training campaign, to instruct farmers on the necessary actions for achieving the basic objectives;
- the wholesale participation of research institutions, collaborating with industry to identify innovations, and to promote the rational application of new processes and techniques.

CONCLUSIONI
E RACCOMANDAZIONI

45 **Esperti** provenienti da 25 **paesi** hanno partecipato al 7° Meeting del Club of Bologna - promosso sotto gli auspici della CIGR - per discutere i seguenti due temi: (1) *"Cooperazione tra Industria e Istituzioni di Ricerca"* e (2) *"Esigenze di meccanizzazione per l'agricoltura sostenibile a basso input (LISA)"*. Dopo una approfondita discussione i partecipanti hanno unanimamanete raggiunto le seguenti

Conclusioni e Raccomandazioni

1 Cooperazione fra Industria e Istituzioni di ricerca

Questo argomento è stato considerato dal punto di vista sia delle istituzioni di ricerca, sia dell'industria con contributi scritti presentati dai seguenti relatori di base: *K.Th. Renius* (D), *B. Legg* (UK), *B. Chèze* (F), *P. Celli* (I), *H. Cetrangolo* (Arg), *T. Yotsumoto* (Jap) e *D. Wilkens* (D).

I rapporti hanno riguardato sia argomenti generali relativi alle esigenze future ed ai vantaggi acquisibili con una migliore cooperazione, sia argomenti specifici relativi ad esempi di progetti di collaborazione sviluppati con successo.

Questi studi, svolti in diversi paesi - Argentina, Germania, Giappone, Italia e Regno Unito - confermano la validità di una cooperazione fra industria e mondo della ricerca. Le ragioni di questo successo sono varie ed includono:

- la creazione di innovazioni ad opera di istituti di ricerca, accolte dall'industria come potenziali vincitrici sul mercato;
- l'esigenza per un prodotto di soddisfare le richieste dell'agricoltura e/o i limiti posti dal Governo e/o da politiche d'intervento;
- l'esigenza dell'industria di migliorare i propri prodotti verificandone la validità nel contesto agricolo e attivandone l'impiego.

In questo quadro è da evidenziare che gli Istituti di ricerca accolgono con piacere l'opportunità di un lavoro comune con l'industria.

Dopo ampie e approfondite discussioni, i partecipanti **concordano** nell'affermare che questo tipo di cooperazione è, allo stato attuale, insufficientemente sviluppato in quanto l'industria tende a volte a considerare i contatti col mondo della ricerca come inutili perdite di tempo. Inoltre, l'individuazione di nuove idee per il lungo termine può risultare di secondaria importanza rispetto ai problemi tecnici e di mercato che l'industria è costretta a risolvere quotidianamente. Questa tendenza è riflessa nella scarsa partecipazione di persone qualificate del mondo dell'industria a conferenze scientifiche. Va, tuttavia, notato che un atteggiamento simile si ritrova anche presso alcune componenti del mondo scientifico che preferiscono dedicarsi ai propri ristretti interessi di ricerca.

Tuttavia, è stato universalmente riconosciuto che una più stretta collaborazione tra i due settori - le cui attività sono di reciproco interesse data la diversità delle esperienze, delle competenze, delle tematiche e delle tempistiche - può essere una delle chiavi di successo delle attività imprenditoriali. Ciò in quanto può portare a nuovi prodotti da sviluppare più rapidamente, in maniera migliore e a più basso costo, una volta accertatane la validità e la rispondenza alle esigenze agricole. Questi vantaggi sono sempre più importanti nel presente contesto di mercato globalizzato in rapido cambiamento nel quale la tendenza alla "qualità totale" comporta l'esigenza di una crescente ricerca di innovazioni radicali di prodotto per nuovi sistemi agricoli.

I partecipanti **confermano** unanimi che, in ogni caso, una moderna ed efficace forma di cooperazione deve necessariamente iniziare con la generazione comune di nuove idee per poi delinearne i concetti e, infine, provvedere allo sviluppo del prodotto e/o delle conoscenze. Questo approccio offre opportunità molte interessanti specialmente alle piccole e medie imprese e dovrebbe essere di interesse anche per la formazione tecnica ai vari livelli.

Dal punto di vista della ricerca, la definizione di nuove idee in sessioni preliminari di esperti di entrambe le componenti è un'opportunità unica ai fini dell'accertamento della validità, nei confronti dei vari sistemi agricoli, di innovazioni radicali (macchine, componenti, sistemi) che possono divenire di interesse industriale nel medio termine. Dal punto di vista delle imprese, i benefici a breve termine di una collaborazione dovrebbero essenzialmente essere incentrati sulla risoluzione di problemi tecnici, incluse le analisi di quale sia il migliore impiego delle macchine nel contesto agricolo.

Una considerazione parallela riguarda il problema della formazione tecnica alla quale le istituzioni di ricerca possono portare un contributo fondamentale anche dal punto di vista della divulgazione di informazioni relative a macchine o processi innovativi.

I partecipanti sono, pertanto, unanimi nel **raccomandare** che venga compiuto ogni possibile sforzo per sviluppare effettive forme di collaborazione fra industria e istituzioni di ricerca. Questo con riferimento alla creazione di accordi cooperativi sia per la definizione di nuovi prodotti, sia per l'individuazione di sistemi di meccanizzazione adatti a sviluppare nuove pratiche agricole mirate a migliorare la qualità e a ridurre l'impatto ambientale, sia per la promozione del trasferimento tecnologico.

E' stata data particolare attenzione al fatto che sforzi cooperativi coinvolgenti diverse società non sempre hanno avuto successo a causa delle difficoltà di stabilire quale delle ditte partecipanti sia la detentrice dell'innovazione prodotta. Ciò diviene ancor più complesso quando vi sono di mezzo problemi brevettuali.

Comunque, i partecipanti ritengono che le iniziative sotto elencate, possano portare a una migliore comprensione e collaborazione fra mondo industria e mondo della ricerca.

Formazione

- le Università devono fare in modo che i loro studenti possano trascorrere un certo tempo nell'industria;
- le Università devono offrire le opportunità per una educazione tecnica permanente al personale dell'industria.

Comunicazione

- le società professionali devono adattare le loro attività al fine di cooperare al maggiore interesse dell'industria;
- l'industria deve considerare positivamente l'organizzazione di riunioni tecniche periodiche;
- un maggiore sviluppo di riunioni tecniche di alto livello deve essere promosso fra istituti di ricerca e industria, incluse le piccole imprese.

Compartecipazione

- la partecipazione continuativa fra più imprese complementari e organizzazioni di ricerca deve essere incoraggiata;
- la collaborazione industria/ricerca deve essere professionalmente sviluppata e gestita.

Azioni specifiche per le organizzazioni di ricerca

- le organizzazioni di ricerca devono generare con continuità nuove idee. Ciò può essere guidato dalla preveggenza tecnologica;
- la collaborazione con l'industria deve essere valutata e considerata nelle decisioni sulla promozione;
- le organizzazioni di ricerca devono comprendere e rispettare le priorità industriali e le relative tempistiche;
- uno staff con esperienza industriale deve essere utilizzato, così come l'esperienza acquisita attraverso scambi reciproci industria/ricerca;
- le organizzazioni di ricerca devono essere assistite da specialisti dell'industria e degli utenti agricoli finali allo scopo di controllare che le ricerche svolte siano coerenti con le loro esigenze.

Azioni specifiche per l'industria

- l'industria deve partecipare alle discussioni a livello nazionale e regionale per la definizione delle priorità di ricerca;
- speciali problemi industriali possono essere risolti mediante una piena collaborazione di varie società fra loro complementari.

2 - Esigenze di meccanizzazione per l'agricoltura sostenibile a basso input (LISA)

Questo argomento era stato già discusso nel 1991, nel corso del 3° meeting del Club, con la presentazione di due note introduttive di *R. Hegg* e *J. Matthews*. Il Club ha deciso di riesaminarlo sulla base della presentazione di un rapporto introduttivo di *A.A. Jongebreur*, allo scopo di verificare i progressi acquisiti negli ultimi 5 anni e di determinare se e quali macchine incontrano i criteri su cui è impostata la LISA definita come un'attività ecologicamente sana, economicamente percorribile, socialmente giustificata e umana.

Dopo approfondite discussioni, i partecipanti **concordano** che il raggiungimento degli obiettivi della LISA dipendono, preliminarmente, dalla riduzione dell'erosione del suolo, del consumo di fitofarmaci e fertilizzanti, nonché dalla razionalizzazione dei consumi energetici.

In relazione a ciò, riconoscono i progressi raggiunti da alcuni paesi e il promettente potenziale offerto da nuove macchine controllate elettronicamente compresi i modelli speciali atti a ridurre i consumi di fitofarmaci sino al 50% attraverso il controllo della velocità dell'aria e la posizione degli spruzzatori.

I partecipanti, inoltre, **considerano essenziale** che analoghe innovazioni siano sviluppate e commercializzate al fine di raggiungere quei vantaggi generali in grado di aiutare la promozione della LISA.

L'enfasi deve spostarsi dal concetto di "basso impiego di inputs" a quello di "sostenibilità", Il Club, infatti, riconosce che il termine "basso input" ha un significato relativo ed assume valori differenti nei paesi sviluppati ed in quelli emergenti. Ad esempio, il rapporto FAO del 1995 informa che 70 paesi saranno incapaci di alimentare la loro popolazione all'anno 2000 se non potranno adottare sistemi di coltivazione più intensivi. L'uso sufficiente degli inputs tenendo conto del rispetto ambientale dovrebbe pertanto essere l'obiettivo anche se non necessariamente coincidente col termine "basso". Il Club, inoltre, riconosce che le risorse suolo, acqua e aria sono le più critiche causa il lungo tempo richiesto per il loro recupero. La meccanizzazione e le pratiche irrigue devono essere tali da minimizzare la erosione del suolo, la salinità e altri problemi di degradazione del suolo stesso.

Le pratiche per l'agricoltura organica possono costituire un utile strumento di ricerca al fine di individuare le strade entro le quali l'agricoltura convenzionale può essere modificata al fine di diminuire la sua dipendenza dagli agrochimici.

Il Club **raccomanda** che ogni possibile sforzo venga fatto dai responsabili delle politiche agricole e dalle industrie al fine di creare le condizioni favorevoli per gli agricoltori per sviluppare pratiche agricole sostenibili sull'intero territorio coltivato. Si dovranno, di conseguenza, coinvolgere:

- lo svilupppo di metodi migliorativi di valutazione dell'impatto ambientale delle attività agricole;
- la misura del progresso, in chiave olistica, mediante l'applicazione di criteri ingegneristici ed economici come, ad es., l'analisi costi/benefici delle pratiche sostenibili tenendo nelle dovute considerazioni l'impatto ambientale;
- lo sviluppo di pratiche e tecnologie di precisione progettate per migliorare l'efficienza dell'uso dei fertilizzanti e dei fitofarmaci e, quindi, per ridurre il pericolo di degrado ambientale;
- la continuazione degli sforzi per la razionalizzazione dei consumi energetici e l'introduzione di energie rinnovabili, incluse

quelle da biomassa, come chiave per raggiungere un‘agricoltura sostenibile;

- la priorità massima per la salute e la sicurezza degli agricoltori e del pubblico;

- una spinta innovativa addizionale a mezzo dello sviluppo di trattori e di operatrici incorporanti a più recenti avanzamenti dell’ingegneria;
- un’informazione comprensiva e compagne di formazione per gli agricoltori sulle azioni necessarie a raggiungere gli obiettivi di base;
- la completa partecipazione delle istituzioni di ricerca, in collaborazione con l’industria, per identificare innovazioni e promuoverle mediante l’applicazione di nuovi processi e nuove tecniche.

SESSION 1/A

COOPERATION BETWEEN RESEARCH INSTITUTIONS AND INDUSTRY: THE POINT OF VIEW OF THE RESEARCH INSTITUTIONS

Chairman: Mr. Bernard CHEZE, FRANCE

Cooperation between industry and research institutions: the point of view of the research institutions

by ***Karl Th. Renius***
Germany

1. Introduction

Isolation means building up walls against effective brain work and information flow (**Fig.1**). Removed walls lead to cooperation and teamwork. My colleague K. Ehrlenspiel has placed this graphic demonstration on the very first page of his latest book [1]. It explains well the principle of cooperation which is not only important for the business within a company or a research institution but also outside.

"Global playing" may today be one of the most important strategies for successful business and can only be realized by a high level of cooperation. The same can be said for the research world-driving, forexample, the activities of CIGR or those of our Club of Bologna.

Underdeveloped is in my opinion however in many countries the cooperation between industry and research institutions. The situation can, for example, be read from agricultural engineering conferences regarding the percentage of delegates from industry. We are proud in Germany, that a 50% quota at our national conferences is not unusual. If we would analyze international conferences, 5% delegates from industry would often be the standard, which is in my opinion not acceptable. The key for improving this situation can be seen in a better cooperation, for which the willingness must come from both sides.

The technological levels of the various countries of the world are so different [2], but I think we need in spite of this situation a dream or a vision of something like "global playing" also for the links between research and industry.

2. Fields of cooperation

It is a proved principle to include as many fields as possible in cooperations between universities or other scientific institutions and industry. The survey of **Table 1** represents three typical areas for universities, each with five main subjects. Let me please illustrate these 15 items by some comments, own experiences and examples from the viewpoint of an agricultural engineer within a faculty of mechanical engineering.

2.1 Research
In the column of research, the first subject addresses Fundamentals meaning basic research. Impulses are often initiated by the university, but they should obviously consider economic benefits to be expected from research projects of this kind.

As an example I would like to mention the story of the active EHR damping system, which has been developed by BOSCH and FENDT based on research of Hesse [3] and Gohlich et al [4]. The first step was a research project of Hesse, which he carried out in the German Federal Research Centre for Agriculture (FAL) and which led to the introduction of the first commercial electronic draft control system EHR by BOSCH and DEUTZ in 1978. The break through to mass production was achieved after the introduction of the force sensing bolt in 1982 [5]. At the end of 1995, BOSCH had produced a total of 495 000 draft sensors. In the late eighties, BOSCH changed the control system from analogue to digital data processing. Supported by public funds Gohlich et al investigated now the potential of the digital EHR for an active damping system. Computer simulations demonstrated, that the mass of mounted implements can be used to improve the ride comfort for high speed driving on poor roads, which was well known to be critical with conventional tractors. The first commercial system [6l came out 1989 by BOSCH and FENDT and is meanwhile world-wide accepted. Extra first costs have been very low as mainly concerning software.

Research in Concepts & Systems (item 2 of **Table 1**) can help to better define products in the very early planning phase - industry is therefore very interested in good approaches of this kind.

As an example for concept research you may allow me to mention the "Munich Research Tractor", presented in early 1988 and demonstrating the potential of frame concepts versus the well known block concept. Our results were seriously putting the famous block design rule of Henry Ford (Fordson tractor 1917) in question [5, 7] and 4 1/2 years later, John Deere came out with two completely new designed tractor lines ("6000" & "7000") with a frame concept similar to the one of our research tractor.

As an example for systems research I would like to address the introduction of the CAN-bus as main internal digital information line for agricultural tractors by FENDT company 1993. Due to a very close cooperation between several research institutes and companies the CAN-bus will probably be standardized world-wide for digital tractor-implement information systems [8]. Only some month ago (1996), FENDT introduced for the first time (optional) such an open BUS-system using a signal connector according to the German Standard DIN 9684, Part 2 (publication expected 1996).

Regarding research for Components, impulses are often given by industry, sometimes in the early phase of advanced engineering projects. Capacity of companies for research is very limited, sometimes only a few percent of the total development budget which therefore results in a continuous interest in cooperations.

As an example, I would like to mention the broad research activities being carried out for infinitely variable transmissions at our University on two characteristic fields: For passenger cars under Prof. Hohn [9] and for tractors in my own institute [10]. A common passenger car project concerns an infinitely variable hybrid transmission. It could be settled in 1993 as "DFG-Sonderforschungsbereich 365" with 6 institutes participating in Munich. Several large passenger car companies support this big project supplying parts and prototype components - the same in a smaller scale is done by several typical supplier companies.

Cooperation has also excellent chances to develop updated Development methods. A wide field concerns the improved integration of information systems for design, calculation, simulation and production processes[1, 7]. Another field can be seen in developing updated tools for product quality [11]. The application of random load fatigue analysis for calculating and testing of mass-products can be regarded as a typical field for cooperation in this context [12]. It may be of interest, that the world-wide first publication of a load collective came from the two agricultural engineers W. Kloth and Th. Stroppel in 1932 [13], based on a cooperation of a German research institution with the national industry.

Finally cooperation in research can also cover the field of Trends & Statistics. As an example I would like to refer to the annually published German "Yearbook Agricultural Engineering" [14] which covers almost all disciplines of agricultural engineering in, for example, 34 articles. Their typical structure does not only concern the general progress in science but also typical practical machinery trends - in several articles also statistics for technical specifications and for market figures. This yearbook is produced now in the 9th year (since 1988 in German, since 1991 bilingual German/English) in a very close cooperation between the German ag machinery industry ("Landmaschinen - und Ackerschlepper - Vereinigung", LAV, im VDMA), the VDI -MEG ("Max-Eyth--Gesellschaft Agrartechnik im VDI", the KTBL ("Kuratorium fur Technik und Bauwesen in der Landwirtschaft e.V.") and about 30 agricultural engineering personalities - many of them professors and scientists from universities and research institutions.

2.2 Consulting

The close cooperation in the above mentioned fields results in a potential for consulting, typical fields are listed in **Table 1**. All university professors in mechanical engineering have industrial experience - usually five to ten years in the mid or upper management. Such practical experiences simplifies considerably understanding for both parties in the case of cooperations.

Consulting on Product strategies is typically based on the know how from the research in "concepts & systems", "components" and "trends & statistics". Consulting in this area is often required by companies starting business in a new field. We do, for example, help an automotive company in India to start with development, manufacturing and sales of a completely new tractor line for local conditions.

A typical tool for product strategies of the industry can be seen in common meetings of professors and managers in seclusion - if possible, far away from the daily business and lasting one or two days. We have in Germany very good experience with this specific type of cooperation and I could nominate several products, which have been resulted from meetings of this kind.

Another field concerns Patent evaluations, often in cooperation with an attorney carrying on a lawsuit or in cooperation and on behalf of a court of justice. These activities are sometimes very important but just as little popular as you have always one colleague against you.

Easier to handle in this aspect are Technical problems, which companies have with current products or with new developments, sometimes close before a market introduction. For example, the work rate of a new developed machine is, even after improvements below the expected value and it ìs perhaps not possible to increase the dimensions. Consulting in connection with cooperation can be very successful in this case and in the same time can become a nucleus for a new field of research with promising prospects.

Cooperations for Standards are sometimes required to create a better scientific base, mainly for safety standards. As an exarnple I would like to mention many cornrnon activities which have been carried out to find the "right" test specifications for safety frames of tractors. It was possible to define test energies, which cover the energy input for about 95% of practical overturn accidents and to reduce the number of fatal accidents in Germany by more than 90% [5].

Although industry is paying good salaries, it is often difficult to find the right personalities for Open positions, mainly for management levels. Confidential consulting by professors is usually done charge-free, sometimes as a "thank you" for good cooperation in common research projects.

2.3 Training

Within a faculty of mechanical engineering it may be typical having 10 to 20% of the Diploma candidates working on their thesis in a close cooperation with a company. This is a proven remedy not only for the subject but also for the candidate to get a chance to be hired. The procedure requires however a proper direction and control by the professor or his staff.

A high level of cooperation with industry is mostly possible for Ph.D. candidates working on common projects. The benefits are in principle the same as for diploma candidates but the level is of course higher and the procedure much more complex. In some cases, this type of cooperation enables the candidate to be later on appointed by the company for a position one level above usual.

If engineers are interested to become familiar with new technologies or to update their skills, they sometimes need intensive training. Many training courses for Company staff are offered by universities often in cooperation with training academies, same for different kinds of Advisers and consulting personalities.

All these training activities are well in line with guidelines of the university and the ministry of education as well. Distinct political support bears encouraging working conditions resulting in a good climate and successful activities [15, 16] .

3. The role of societies

Societies can represent an important platform for cooperations between universities and industry, **Fig. 2.**

Fig. 3 demonstrates - as an example - the organization of the German Society of Engineers, VDI.

Regarding the world-wide activities of engineer societies, organization systems may be best in the US. Germany is however outstandingly successful in several subjects of cooperation. The following discussion relates to the keywords listed in **Fig. 2**.

The typical scientific Meeting in engineering is, for example, sometimes attended by more delegates from industry than from universities.

Societies are also important for Research and Education. The VDI-MEG has, for example, a working group of German university professors in agricultural engineering to take care of relevant subjects in this field by regular meetings and to prepare adequate information exchanges between universities and industry. This working group "Arbeitskreis Forschung und Lehre" has a long tradition and a high reputation within the German agricultural machinery industry.

Cooperation is often also required for development of Regulations and standards, now concentrated on CEN (Europe) and ISO (world). People from industry, research institutes, test institutes and other authorities (such as health & safety assurances) are getting together in many working groups, mostly using English as working language. National and international standardization activities are typical subjects of cooperation. They were assisted by strongly defined research projects, if necessary.

Public relations as another area of cooperation between universities and industry being supported by societies has a wide span from the publication of professional and scientific articles to political engagements in areas such as "environmental control" or public "suspicion of technical progress".

Finally also personal matters can be subjects in societies, such as open honorary Positions and Awards.

4. Management and budgets for research

A typical research project which shall be carried out in cooperation with industry, should be structured in characteristic phases and milestones as demonstrated by **Table 2.** Many benefits are coming out of presentations and discussions - they play therefore an important role in the schedule. Another typical principle is, that some first preliminary research results should be available at the time

when the application for public funds is submitted. This principle needs advanced activities which are easier to achieve with industrial support - another reason for cooperation.

A typical budget for such a research project is set up by **Table 3**. Costs are typically shared in Germany between university, industry and public funds - often about one third for each party. In many cases, the scientist is paid by the public fund. This is the main reason that research institutions of German Universities sometimes have more scientists paid from public funds than by the university. As the government is interested in this principle, good political support is given to this type of financing [16].

The main interest of industry is of course the use of the results for new products or procedures [7]. Some innovations which have been prepared this way by research for agricultural tractors, are listed in **Table 4**. Four case studies of tractor innovations have been outlined by the author for a management congress [17].

In spite of so many prospects, human motivation may remain the most important factor of success. Last year during a meeting for students in a successful German company (organized by

VDI-MEG) one of the managers explained the role of motivation by defining the typical "Winner" and "Loser" as demonstrated by **Table 5**. What we need, is of course something like a fleet of winners to initiate and to carry out the difficult business of cooperation between industry and research institutions.

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Tab. 1 - University duties in engineering having potential for cooperation with industry

RESEARCH	CONSULTING	TRAINING
Fundamentals	Product strategies	Diploma students
Concepts & Systems	Patent evaluations	Guest scientists
Components	Technical problem	Ph.D. candidates
Development methods	Standards	Company staff
Trends & Statistics	Open positions	Adviser

Tab. 2 - Running a research project in agricultural engineering regarding technical innovations

National coordination of research fields
Presentation of a project to industry, discussions
Corrected project definition
Firstresearch works, presentations
Application procedure for financing
In-depth research phase, presentations
Final presentations & reports, Ph.D. thesis
Innovation carried out by industry

Tab. 3 - Typical budget for a research project (p.a.)

University	Staff	US$	53000	------------↓
	Cash	US$	3000	Typical staff:
				1 Scientist
				0.5 Technician
Industry	Material	US$	47000	0.5 Worker
	Cash	US$	3000	1.0 Others
				2 Dip. thesis
	Staff	US$	53000	---------↑
Public funds	Cash	US$	18000	
		Σ US$	177000	

Duration of a typical project often 4 years ⇒ total DM 1.2 Mio

Tab. 4 - German tractor research: examples

SUBJECT	RESEARCH	PRODUCT
Safety frame	T.U. Munich (Sohne, Schwanghart)	1.4 Mill. tractors 1.1.1977
Front wheel drive	(Sohne, Sonnen, Holm, Steinkampf)	>90% market share 1991
EHR	Fed. Res. Centre, FAL (Hesse)	BOSCH/KHD 1978
4 Wheel braking	TH Darmstadt (Breuer, Simutis)	Steyr Optistop 1984
Wet brake losses	T.U. Munich (Reiter, Renius)	J. Deere 1986
Load-Sensing	T.U. Braunschweig (Harms et al.)	Most companies 1987-93
Test specifications	T.U. Munich (Renius)	Several transmissions 1988
Active damping	T.U. Berlin (Gohlich, Ulrich)	BOSCH/Fendt 1989
Flat eng. bonnet	T.U. Munich (Renius, Kirste)	Deutz-Fahr 1991
Frame chassis	T.U. Munich (Bacher, Renius, Kirste)	J. Deere 1992
Frontaxlesusp.	T.U. Berlin (Gohlich, Weigelt)	Fendt 1993
50 km/h	Several (Gohlich, Breuer, Kutzbach)	Fendt 1993
CAN bus	(Auernhammer, Artmann, Biller et al.)	Fendt 1993
CVT	T.U. Munich (Renius, Sauer)	Claas, Fendt 1996

Tab. 5 - Winner versus loser (courtesy Sauer Sundstrand)

THE WINNER	THE LOSER
is always part of the answer	is always part of the problem
always has a program	always has an excuse
says, "Let me do it for you"	says, "That's not my job"
sees an answer for every problem	sees a problem for every answer
sees a green near every sand trap	sees 2 or 3 sand traps near every green
says, "It may be difficult, but it's possible"	says, "It may be possible, but it's too difficult"

Fig. 1 - Improved cooperation by removing wall effects (courtesy K. Ehrlenspiel [5])

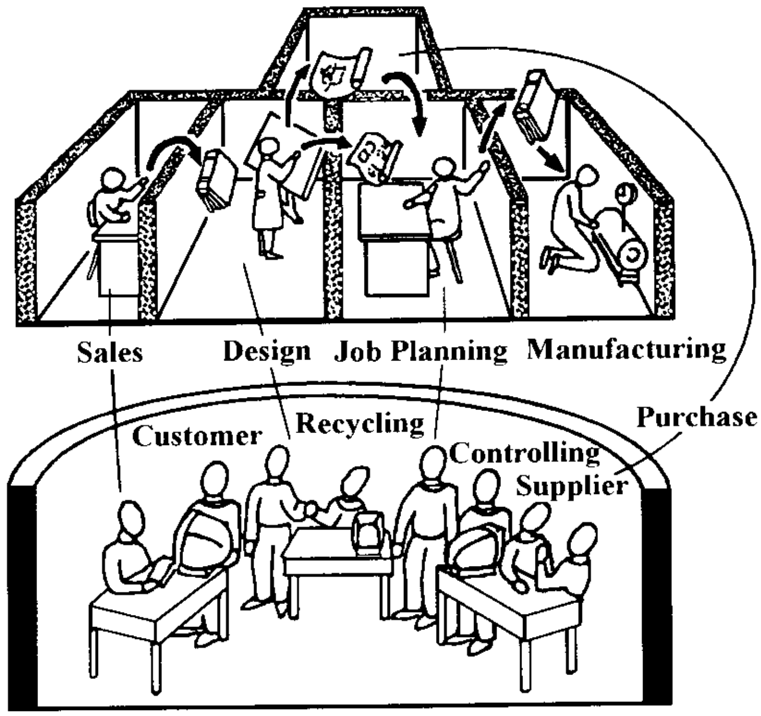


Fig. 2 - Societies linking universities and industry

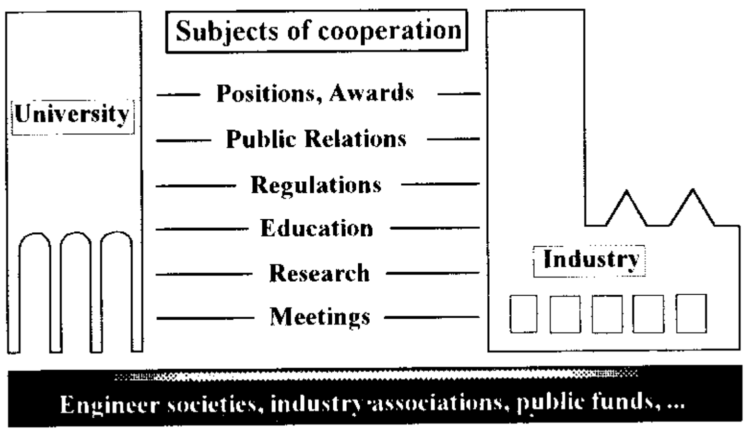
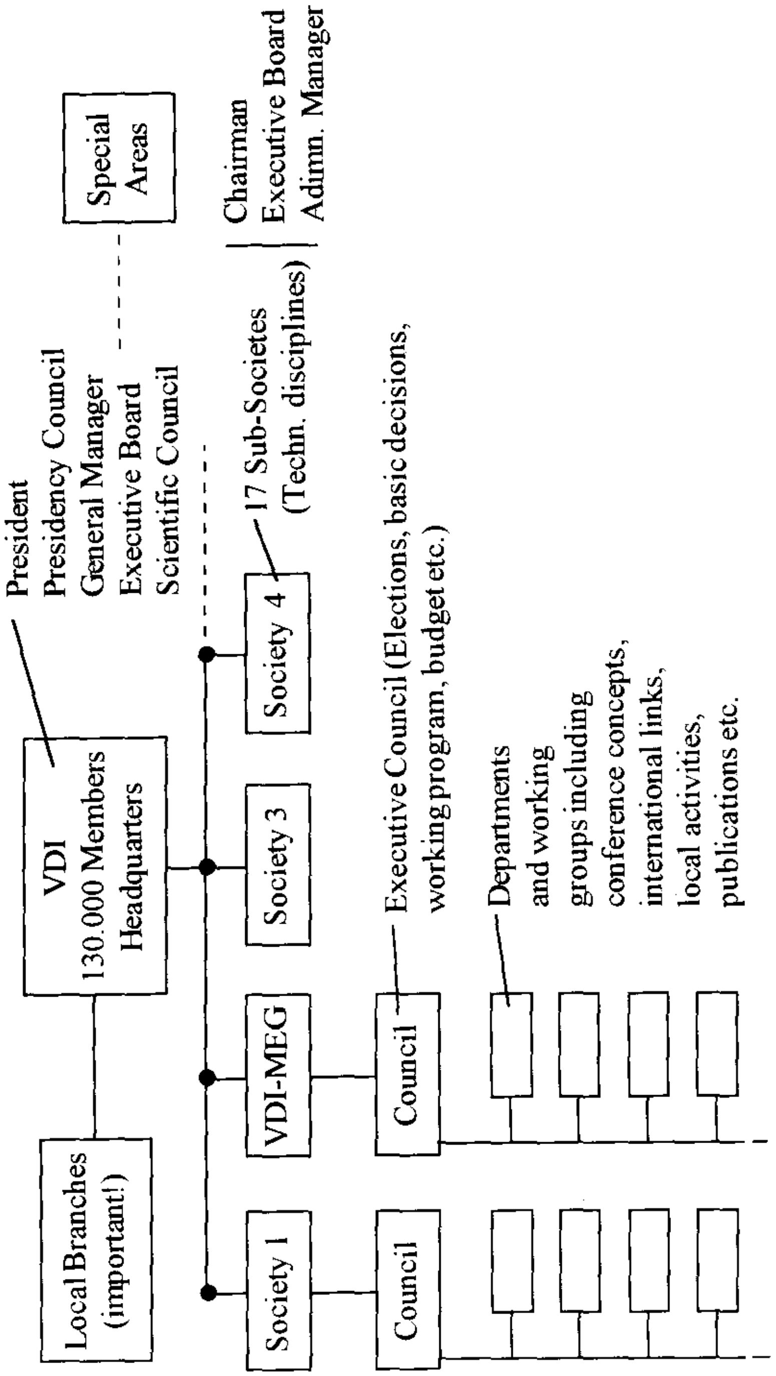


Fig. 3 - Verein Deutscher Ingenieure (VDI), structure



Cooperation between industry and research institutions: the point of view of the research institutions

by **_Brian Legg_**
UK

1. Introduction

Silsoe Research Institute was founded in 1924, and although its name and its address have both changed several times it has been committed to research, development and testing of agricultural machinery throughout the 72 years. It has also, I believe, been very successful, and has made a substantial contribution to almost every aspect of agriculture from cultivation and seed drilling through to harvesting and storage, and from animal housing and transport through to hygienic processing in the abattoir.

However, the political climate in which we operate has changed dramatically in recent years and this requires understanding and response from industry if the successful interactions of the past are to continue.

Until about ten years ago, our annual grant from the Government came with very broad objectives and we were free to interact with industry as we thought best. Now, all of the Government's funds must be fought for competitively and for most we must agree in advance to a detailed programme with milestones and performance indicators. So we must pay very careful attention to what is being demanded by our paymasters, or the next research contract will go elsewhere.

Our two major Government sponsors are the Biotechnology and Biological Sciences Research Council (BBSRC) and the Ministry of Agriculture, Fisheries and Food (MAFF) and both are required "to ensure that Government expenditure on science and technology is targeted to make the maximum contribution to our national economic performance and quality of life". The BBSRC is committed to basic research and the development of new technologies. It is keen that we should interact closely with industry, but equally determined that its funds should not be used for product development for which industry should pay. MAFF spends quite a large part of its research funds in support of Government policy, for example, collecting information on the emission of greenhouse gases, or nitrate leaching. It also funds research to enhance the competitiveness of agriculture; but although it sees the machinery industry as a useful route for the delivery of new technology, it does not accept any responsibility to support it.

The results of these changes are:

- much of our Government funded research still produces new ideas and new technologies that are of importance to the agricultural machinery industry;
- we have much less freedom to turn those ideas into new machinery ourselves, and must work with and be funded by industry if this is to happen.

So close interaction with industry is vital, and I would like to show how we are trying to achieve this at Silsoe.

2. Technology interaction

There are three phases to most interactions (**Fig. 1**) and although the boundaries are not as sharp as the figure suggests it is worth considering each separately with the opportunities and problems that arise.

2.1 Phase 1: generation of new ideas and technologies
The UK Government provides about 25% of our total funding so that we can do basic science and develop new technologies. Although this is recognised as a creative activity that should not be too tightly constrained it is also clear that we must work in areas that are likely to lead to real value to the country in the fullness of time. In

order to identify these winning technologies the Government has invested heavily over the last three years in an exercise called Technology Foresight. This is a structured approach to asking industry and the academic community what technologies are likely to give the best returns. Fifteen industrial groups were identified, of which one was Agriculture, Natural Resources and Environment (ANRE). The conclusions of all fifteen were then viewed together to identify those areas likely to make the biggest impact. These are summarised in **Table 1**, indicating those specifically mentioned by the ANRE, Food, and Health and Life Sciences Panels. It is interesting to see where technology is perceived to be moving the fastest and to debate how many of these will have direct relevance to the future agricultural machinery industry.

We have also set many procedures in place at Silsoe to try to ensure that we are aware of industry needs. These include a Board of 14 Governors of whom 9 come from various sectors of the agricultural industry, including machinery. We also have four strategy groups to represent field crops, horticulture, animal production, and food; and these meet approximately once a year to discuss how our research skills should best be used to match the industry's needs. In addition to this there are a very large number of contacts made between individual staff and the machinery industry at shows and exhibitions, at Standards Committees and at conferences and workshops.

Despite all this activity, I am still concerned that we are not interacting as effectively as we should at this early stage and that many more real benefits could come if my staff had more brainstorming sessions with manufacturers. We have recently begun to do this with a few of the larger European companies, but I would like to expand the activity further.

2.2 Phase 2: concept development

If the interaction in phase 1 is effective, it will identify new approaches to old problems, or completely new opportunities. But these new ideas will often need considerable research to show whether they are as good as they first appear and whether they are both technically and economically sound. This phase is quite distinct from product development. Indeed, one cannot be sure that there will be a marketable product. So there is still a considerable element of risk, and the UK Government will fund up to half the cost through its LINK scheme if industry will fund the rest. The EU also funds many projects on the same basis.

The UK LINK scheme invites bids in designated programme areas (**Table 2**) and each proposal is carefully vetted to ensure that the research is in the concept development phase and not simply funding product development that should be fully funded by industry. The Government will match the input, in cash or kind (e.g. as equipment or staff time) from companies that have a research or manufacturing base in the UK. European companies can participate in LINK, but their input will not receive matching funds. European companies can also bid to the Agro-Industrial Research (FAIR) framework IV programme in which industrial participation is always welcomed and is often mandatory.

Although the administration associated with these joint schemes can be horrendous, they provide real opportunities for machinery manufacturers, especially smaller ones who have great difficulty raising the total funds needed to develop new concepts. We have managed or taken part in many LINK and EU funded projects in areas as diverse as high speed potato grading, flax fibre decortication (**Fig. 2**), patch spraying, integrated control of tractors and implements (**Fig. 3**) and orchard spraying.

2.3 *Phase 3: product development*

In phase 3, the company has identified a market opportunity and has decided to develop a new product. It must now devote major resources to a carefully planned development schedule. In the past the Research Institute might have continued to support this phase of the collaboration, but as I have indicated we can no longer do so or we will lose our Government support. So, do we need to be involved at all? The answer is an emphatic “yes”! Where research institute engineers have been involved in the generation of new ideas and the development of new concepts they have a wealth of knowledge and experience that the industrial partner ignores at his peril. I am not, of course, suggesting that we could or should do the production engineering. Industry is far better than we are at that. But production engineering inevitably demands many changes to the machinery used in the concept phase, and the consequences and possible pitfalls can only be foreseen by someone who has been intimately involved throughout. There may also be subsystems that still need to be developed, and the research institute might have a contribution to make.

Another reason for industry providing the full cost of this phase is that they must have full control of any patents that arise if they are to protect their investment. Where the Government has contributed to the funding, its investment must also be protected, and it will expect a controlling interest in patents and a share of income generated.

3. Factors that impede successful interaction

Technology interaction is an essentially human activity, and depends totally on individuals who understand and respect one another. This was somewhat easier when research institute staff were trained primarily as agricultural engineers and so spoke the same language as their industrial counterparts. Today's research, however, often demands the more specialist skills of an electronics engineer, a chemical engineer or of a physicist or mathematician. I believe that these qualifications allow them to make a greater contribution to industry, but only if time is taken to remove any prejudice or distrust and for close interaction to take place.

Another problem is that Government and industry rarely see eye to eye over the boundaries between the different phases. Government is naturally trying to pull funding out as early as possible whereas industry often, although not always, would like it to continue! Sometimes Government staff make unrealistic demands, for example expecting industry to make a major contribution to the R&D but then stipulating that sales must be restricted to the UK so that UK producers reap the benefits. Such restrictions are unlikely to be acceptable to companies that normally operate internationally to recover their development costs. At the same time, industries must accept that the UK Government will no longer fund strategic research unless they are also willing to contribute.

The negotiation of intellectual property rights (IPR) can be complex and often delays the start of jointly funded research. The basic problem is that the parties are trying to agree how to handle all possible future scenarios at a time when it is not even known for certain that any patentable IPR will arise; and agreement must be reached on ownership, control and income. I feel that lawyers could help greatly if they would draw up a series of statements of principle that should be signed at the start of collaborative research, leaving detailed negotiation until after the invention has been made. Perhaps other European countries have better ways to handle this than we do in the UK.

Perhaps the most serious obstacle, however, is that companies taking up new technologies must be thoroughly familiar with the technology and with the market place. All too often we find that traditional companies who know the market well, are not willing to invest in new technologies; and hi-tech companies who are keen to diversify do not know the agricultural market well enough to make sound judgements on the potential value of new ideas. Agricultural machinery companies have succeeded where they are large enough to make major investments and recruit staff with new skills, or if they are small, by forming partnerships with suppliers of electronics and computing equipment.

4. Successes

Although I have discussed the changing politics of Government funded research and some of the problems of ensuring that the results are used, we continue to have considerable success in many areas of our research programme. This has led to collaborative research with no less than 93 industrial organisations over the last 2 years, of which 41 are machinery manufacturers. We also hold 43 patents of which 34 are being exploited, although many of our closest collaborations with industry (highlights listed in **Table 3**) are in areas where no patentable ideas have been identified.

5. Conclusions

- UK Government now expects all industries that might benefit from R&D to contribute to it;
- Engineering technology is moving extremely fast, and companies that wish to survive must keep up to date;
- Industry and academic research engineers must talk and share ideas in all of the phases of R&D (see **Fig.1**);
- Many companies, European wide, are benefitting from research being done at Silsoe Research Institute. Don't be left out!

Table 1 - Research priorities identified by technology foresight

The **Technology Foresight Programme**, which was launched by the Government White Paper, has confirmed a wealth of opportunities for the Institute. The final report of the Steering Group of the Technology Foresight Programme 1995, with its summary of cross-sectoral strategic themes and generic priorities in science and technology, is particularly valuable as it gives a broad view of areas that are moving fastest. Of the 27 generic priorities identified, 16 are primarily engineering science and technology, but for almost all of these the real challenge for the next decade is how they can be extended and applied to biological systems. Several more are primarily biological, but with a necessary input from physical sciences and mathematics. For each of the six strategic themes the most relevant science topics for this Institute are listed below with comments on the challenges for engineering in the biological industries. Most of these topics have also been identified by the individual panels relating to the biological industries, and this is indicated by showing: (A) Agriculture, Natural Resources and Environment; (F) Food; and (H), Health and Life Sciences.

1. **Communications and computing power**
Communication with machines
Telepresence, multimedia
Software engineering
Information management (A), (F)
Modelling and simulation (A), (F)

<u>Challenges in the biological industries</u>: model based decision-support; communication between animals and production systems; modelling and control of complex, variable processes - often non-linear and with uncertainty in model structure and parameters; interpretation and feedback of observable properties of biological processes.

2. **New organisms, products and processes from genetics**
Bioinformatics (F), (H)
Chemical and biological synthesis
Genetic and biomolecular engineering (A), (F), (H)

<u>Challenges</u>: data processing and pattern recognition; modelling the consequence of molecular change on performance and properties of whole organisms; biochemical engineering and separation processes.

3. **Advances in materials science, engineering and technology**
Materials
Biomaterials (A), (H)
Materials processing technology

<u>Challenges</u>: hygienic, cleanable materials; production and separation of materials from plants and animals; raw material quality.

4. **Getting our production processes and services right**
Sensors and sensory information processing (A)
Design and systems integration
Automation (A), (F)
Process engineering and control (F)

<u>Challenges</u>: coping with the inherent variability and fragility of biological products; coping with animals that are sentient beings; the need for remote sensing because of hygiene constraints.

5. **The need for a cleaner, more sustainable world** *Risk assessment and management (A), (F), (H)* *Environmentally sustainable technology (A)* *Clean processing technology (A)* *Energy technology* *Life cycle analysis (A)* Challenges: an open and intensive production system; agriculture as a source of clean raw materials and clean energy; highly variable production processes depending on local environment; optimisation of agricultural systems for profit and environmental sustainability. 6. **Social trends** *Health and lifestyle (A), (F), (H)* *Demographic change (H)* Challenges: animal welfare; hygiene and microbiological safety; engineering and information to provide safe and acceptable solutions to problems. All of these areas fall squarely in the remit of Silsoe Research Institute; many had been identified by us as priorities several years before Technology Foresight and are now essential parts of our research programme; other areas are covered by university departments, sometimes in collaboration with us.

Table 2 - LINK programmes relevant to agriculture

Food/Agriculture
Advanced and Hygienic Food Manufacture
Agro-Food Quality
Technologies for Sustainable Farming Systems
Horticulture
Aquaculture
Competitive Materials from Non-Food Crops
Sustainable Livestock Production
Biosciences/Medical
Biological Treatment of Soil and Water
Biochemical Engineering
Engineering
Design of High Speed Machinery (now terminated)

Table 3 - Highlights of recent technology interaction - Silsoe Research Institute

Fibre	Built and delivered to the customer a full-scale decorticator for the mechanical extraction of fibre from linseed straw. 4 commercial companies were involved in the development.
Grain	Second licence signed for the construction and sale of stripper headers in North America for wheat and rice.
Rice	Collaboration with IRRI developed the pedestrian stripper gatherer for small rice fields and over 250 units have now been made in 5 countries.
Milking	Joint commercial development of a robot for milking cows with Alfa-Laval, the world's largest manufacturer of milking equipment.
Mushrooms	Signed agreement for the development and construction of a robotic harvester based on the Institute's design.
Pigs	Following a commercial evaluation, an image-based system for accurately weighing individual pigs is being commercialised by a UK company.
Potatoes	Developed and incorporated into a commercial unit the capacity to sort and grade 80 potatoes per second.
Potatoes	Identified major cause for non-uniform distribution of anti-suppressant fog in potato stores which led to redesigning commercial equipment.
Poultry	In conjunction with commercial hauliers incorporated new designs for air-flow on lorries to minimise stress during transit of both day-old chicks and broilers.
Poultry	North American licensee has started the commercial production of the poultry harvester. Sales from the two European manufacturers are rising rapidly.

Fig. 1 - Phases of technology interaction

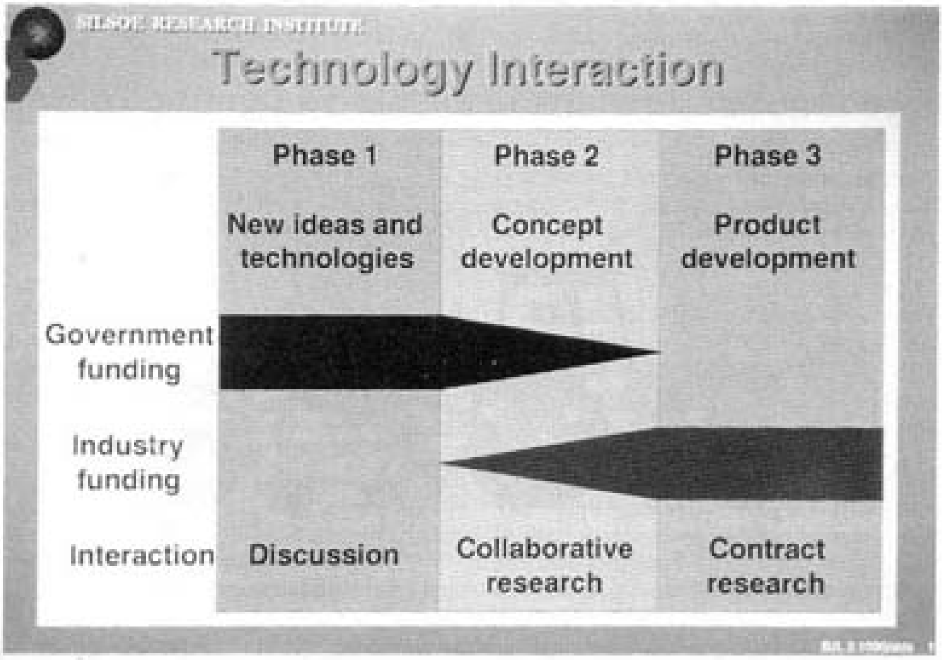
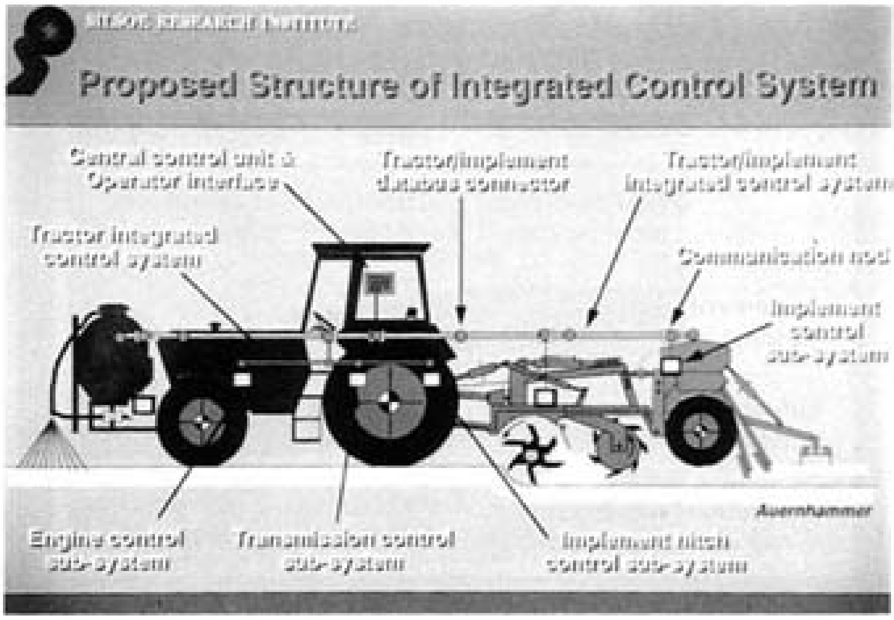


Fig. 2 - Prototype flax fibre decorticator

Fig. 3 - Integrated control of tractor and implement



Cooperation between industry and research institutions: the point of view of the research institutions

by ***B.Cheze***
France

Two "success" stories have been presented. Remember that some others are far less successful. In particular, the selection by research institutions of the industry to cooperate with is a key question:

- whether you choose the leading one or a competitor;
- to choose a machine manufacturer rather than a component manufacturer;
- what level of financial participation can you reasonably ask, and do you ask some "starting"funds before the work to be undertaken to check the real will of the partner, or do you wait for the payment after the commercial success;
- are you conscious of the level of responsibility you are involving the manufacturer when you propose a highly risky project (new product, new market)?

Here are some of the questions research people are facing, among many others, when they want to push forward some new ideas likely to interest industry, at least from their point of view.

But, at first, what type of research are we proposing to the industry?

While basic or fundamental scientific research is used only by great industrial groups sufficiently staffed and financed to develop their own applications (in chemistry, genetics, computer science), most manufacturers of farm equipment are looking for results coming from the so-called "applied" research.

This applied research - some prefer to say application of science - originates first from industry itself: 80% is a figure given in a certain number of publications in this field.

Most of the technological problems occurring during the production of machines are solved internally or with the help of specific laboratories, often financed by the industrial branches.

It is therefore important for research institutes to have a better knowledge of their position in the "interactive" line (very often a non straight line) between scientific research, technology and the needs expressed by the users (or society) (**Table 1**).

The "plus" generally brought by them lies in the introduction and the integration of multidisciplinary knowledge and know-how coming from the general development of science and technique.

More and more publicly funded centres are asked to work in priority to fit the needs of the society, like quality of life, employment, welfare. Any research leading to more profit for one or few manufacturers has to be totally or partially paid back to the public sector, generally through a contracting procedure.

What are the advantages and the drawbacks for a research centre to contract with industry? (Table 2)

It is obvious from all the experiences described that the earlier the industry is associated with the research team, the greater the idea is likely to come to the market.

But, more and more, innovation and diffusion of new technologies are linked. The capacity for the industry to learn and to use technologies developed in other sectors is a key for their future. It is sometimes necessary that research people follow the development of their inventions inside the factory itself, at least for the time needed by the industry to qualify their own researchers in the correlated new fields of know-how (artificial intelligence).

Are always technological advances a priority for end users?

End users, in the field of agricultural mechanisation are mainly farmers. From an ambitious program developed some years ago by CEMAGREF, in France, we tried to compare the increase of income to the farmers that were likely to pay more to have tractors with better performances as a result of advanced research, and the increase of income using a software called "GEDE", also a product of CEMAGREF coming from the team of research in economy.

Without using this software, aiming at optimizing the combinations of cultivation's to obtain the better net income (varieties x acreage x price with the same level of time and labour force), the profit gained from the tractor technology itself is limited to 9% (**Table 3**).

Through optimizing, it reaches 44% for a "classical" tractor, 55% for a "high tech" one.

Moreover, if one can increase its acreage of 28 hectares - still with the same labour force - the increase reaches 101% (% referring, like the previous ones, to the actual situation of no optimization, with an ordinary tractor, on 132 ha)

This example shows the necessity of a complementary research in technology and in economy, both interesting the manufacturers, and could explain why farmers might place at a higher range of priority an investment on management, rather than on high-tech.

Are strategic priorities between research and industry in accordance?

It seems interesting to compare where research and industry are placing their major investments for the years to come.

A meeting was organized in Paris, on June 1993, with the major public funded research institutes belonging to the European Union Club of Advanced Engineering for Agriculture (EUCAEA), to establish a list of main research themes on which a high priority is put.

Without any connection, the European Union of Agricultural Machinery Industry has undertaken in 1994 a strategic study on its development.

Table 4 shows the priorities for research institutions, and, for industry, the sectors in which money is invested in priority.

It is clear that new technologies are less crucial than cost saving in production lines and total quality of final products.

At that time, research in generic technologies was still high, but their applications are more oriented now towards other sectors than farm equipment (a general trend in Europe).

Except specialized Technical Universities, more oriented towards industry, this trend will increase, at least in Europe.

Table 1 - Interactive line between research, technology and users

Research (scientists)		**Engineering (technologists)**		**Marketing (final users)**
SCIENCE	→ ←	**TECHNIQUE**	→ ←	**MARKET**
Creation of knowledge		***Integration of knowledge***		***Sale of products***

Table 2 - Advantages and drawbacks connected with the association between research and industry

ADVANTAGES	DRAWBACKS
• a closer contact with the real needs • more means given to the research teams • from concepts or ideas to prototypes • precise time management of work • reputation,references • possible employment of researchers	• research subjects not always very attractive for "scientists" • precise and time consuming for justification • confidentiality and restrictions or control on publications • respect of schedule (time, results) • limitation of partnership, more priority given to a limited private sector

Table 3 - An example of the increase of income using a specific software [Source: CEMAGREF (1991)]

STRATEGIC CHOICE	ACREAGE (HA)	TRACTOR TECHNOLOGY	INCREASE OF INCOME
No optimization	132	classical	base
=	=	high tech	+ 9%
With optimization	**132**	**classical**	**+44%**
=	=	**high tech**	**+55%**
=	**160**	**high tech**	**+101%**

Table 4 - Research institutions and industry priority [Sources: ERECO (1994), CEMAGREF (1993)]

RESEARCH INSTITUTES	INVESTMENTS IN INDUSTRY
1.Generic technologies (sensors, information technology, modelling of complex systems) 2.Management of rural area, landscaping 3.Economy of farm management 4.Quality assessment of products 5. Sustainable agriculture 6. Energy 7. Animal welfare	1.Cost saving in production 2.Total quality of products 3.New technologies 4.Better services 5.Share of European Union market 6.Increase export 7. Extend range of products

DISCUSSION

Prof. Hans Jürgen HELLEBRAND
Germany

I think new ideas are the key to successful cooperation: Brian Legg gave us many examples. And concerning the process for generating and discussing new ideas, we heard just now from Bernard Chèze that there is an interaction between scientists, engineers and consumers, and that research institutions and industry have different strategies. Now the question is: where do the ideas come from? What is their source, and who initiates the discussion? Perhaps it's the universities, because they are interested in doing research in a new field, or perhaps it's industry, because they see the potential to earn money in a new market. These are two different motivations, and I would ask Prof. Renius if he can tell us something about the origin of new ideas: whether they start at the university level or originate from industry. Or does the source vary depending on the subject.

K.Th. RENIUS

Well, that's a good question, and here's how we handle that: I have a list of potential innovations for tractors. Everything I pick up I put on that list, which we then discuss from time to time with tractor manufacturers. Mainly with the company Fendt, because they are already familiar with this procedure. This is a good tool, which you can use to set priorities, to assess the interest of the company, to discuss the different levels of interest that naturally exist between researchers and manufacturers. So, in answer to your question, this is the tool I use. In tractor engineering it may be easier than in other fields, and I agree with Bernard Chèze that sometimes interests are different, of course. But I think that, ultimately, we must try to align the interests of industry and research as much as possible.

B.J. LEGG

I would just comment that you perhaps need to distinguish between two slightly different aspects. The first one is: where do completely new technologies come from? It seems to me that any industry like a machinery manufacturing industry must be looking outside itself for new technologies. For example, very accurate navigation was not invented by an agricultural machinery company, and I think it probably never could have been; ultrasonic sensors to give very precise height adjustments would not have been invented by an agricultural machinery company. So I think completely new technologies must always come from specialists in that field. The second thing, of course, is spotting the way in which a new technology can be used to give benefit to agriculture. Probably that is nearer the category that Prof. Renius was speaking of. All right, somebody notices that we can now navigate very accurately, but somebody else has to think of precision agriculture and using that new technology to give benefit to agriculture. And that second stage is also very important. So I think you do need some new technologies from outside and must keep your ears open for completely new things from outside. But then there's also looking for how they can be applied.

Dr. Amir U. KHAN
USA

My first question is for Prof. Renius: you just mentioned that you deal primarily with the company Fendt. Doesn't that raise questions with other manufacturers, who might argue that your institution is providing a service that favours one major company? The second question I have is for Prof. Legg: how do you get so many of these companies coming in? In one of your projects, for instance, you had about ten or twelve cooperatives working together. How do you manage to bring them all together and get them talking to each other? I find it very difficult to understand how that problem can be overcome.

K.Th. RENIUS

It is indeed very difficult to cooperate with all the companies. But Fendt is the only 100% private company in Germany, in the tractor business, so we have to give them a certain priority. Despite this preference, however, almost all the other tractor companies are still interested in maintaining contacts with us and participating in projects. The only exception is one company—with a very big green and yellow logo—that is not so interested because it fears some technology transfer to Fendt. I don't want to go into that too much, but with this one company we do have certain problems. With the other ones we don't, though, and I very much appreciate Brian Legg's idea of overcoming this problem to form multi-company, multi-academic partnerships. I think this is an excellent approach, which in Germany we do not yet have for agricultural engineering. But in other fields, such as internal combustion engines, German industry has formed "research clubs" in which several companies pool their money, which is then distributed to the research world: and everybody can make an offer. In this way, almost all the companies get the results at the same time. This is a very important idea for the future, to overcome the priority problem, also in connection with publishing procedures. We all know that, if you cooperate with a single company, you cannot publish all your findings; this becomes easier to handle by taking this route of partnership between many companies and research institutions.

B.J. LEGG

The first thing I'd say is that it's not easy. It takes a lot of hard work and, as I already mentioned, in some cases it takes over a year to get a partnership together. And when you've done that you'll find that one company gets taken over and drops out and you have to start all over again. So you have to be very determined. But of course, industry doesn't work in isolation either: quite often, when you go to a company, you find they're already working with other companies. For example, when we went to work with New Holland, they were buying their electronic controllers from Lucas Technology; so it was quite natural for them to say: "if we're developing a new control system, we would like them involved". As a totally independent company, but a company that they work with anyway. In fact the idea of bringing in a cultivation company then I guess would have been decided between New Holland and ourselves, because we needed an implement to work on. And clearly that company will get some benefits too. But it's very much a matter of bringing together people who have got a clear interest in working together. If you look at the fibre one, the initial idea came from a seeds company who wanted to get added value from the linseed seed. They then needed somebody to make the machine, and so we approached a company who is a major manufacturer of textile processing equipment. But they, in fact, didn't make all of their machine: they bought some components from a company in Scotland, who made the rotor that rotates at high speed to remove the fibre from the stems. And so that company became involved because their component was being used. Having done that, they said that it's no good extracting this fibre unless we know there are industries that will use it. So we need users who will look at the fibre and say "this is high quality or low quality", and what they are willing to pay for that fibre: is it going to be a commercially viable venture. So there were two companies who were potential users of the fibre: one in fact was the National Rivers Authority, who wished to use the fabric to protect river embankments to stop erosion. What I was trying to show was that the interests of the companies must be complementary, and they must all be needed if a new product is to be successful in the marketplace. But it takes a lot of work.

Prof. Axel MUNACK
Germany

I would like to comment on one of the examples mentioned in Prof. Renius's presentation: I am referring to the CAN-bus. This is an open agricultural bus standard on which development began in Germany over ten years ago. And the problem here is that, in addition to governmental funding, there is also governmental interest in this project, because the government realised that this work could be a basis for environment-friendly agricultural production. In fact, to implement precision agriculture you need a lot of electronics, and you need compatible electronics. Therefore, the government identified this project as strategic for environment-friendly agriculture, and decided to fund it. So this was not simply a bilateral cooperation between industry and research, it was a triangle between government, industry and research. The problem we faced over the years of its development was that the industrial contribution was continually changing with variations in industrial interests. In the beginning we had six partners, then this went down to two, then these two changed to a different two and so on. So in this respect it was not very easy to cooperate with industry. Looking back, I think a better approach to developing that kind of standard would have been to choose an industrial consortium or association as a partner, rather than individual companies. What ultimately emerged was that an industrial multi-partnership could have been handled better if all the industrial partners had agreed to pay their money into a fund, with this fund acting as the partner in the project. I think it has always caused problems to have a number of different industrial partners, all looking out for their own interests, and this could have been avoided by having them join into an association which could then have acted as the partner in the project.

K.Th. RENIUS

I can perhaps give one example where we've already done this. In Germany we have an organisation something like UNACOMA, called the LAV, which sometimes sets up projects concerned with standards or safety issues. One or two projects a year are typical. And this is very successful, because in Germany you can get 50% of the budget publicly funded. So this is a first step, and perhaps we can continue and extend this principle.

B. CHÈZE

The critical problem is: who is going to adapt the bus? Is it the tractor companies who will lead the way, or is it the machinery manufacturers? I was told in one case that a tractor company was not at all interested in taking the initiative, because it considered that to be the responsibility of machinery producers. Consequently, nothing moved forward.

A. MUNACK

I think that, for a long time, most of the industrial partners were unwilling to directly push that system. But nowadays they are becoming interested, particularly Fendt, who has developed an internal tractor bus that uses the same components. So it was not a big step, at this point, to make that open bus, which could also be connected to all the equipment which is fitted onto tractors. I think the tractor has gained importance in certain respects, because it has become a universal system, and this is underlined by these types of universal and open-bus standards. Therefore, I believe that tractor manufacturers are currently the leading experts in building components for that bus system.

Dr. Derek H. SUTTON
UK

Could I suggest that perhaps we're forgetting one of the other players or stakeholders in the exercise, and these of course are (as Bernard Chèze mentioned earlier on) the end users, whoever they may be: farmers, contractors. Particularly when we're talking about where the ideas come from, surely the farmer, end user or contractor must come into the scene. Otherwise we perhaps fall into the trap of developing technologies that don't have a use, solutions that are looking for a problem. I wonder how this is being dealt with. Does the industry believe that it knows exactly what the farmer needs, what the user needs, or—picking up on Prof. Munack's suggestion that we have a triangle—maybe we should make the triangle into a circle and ensure there is ongoing dialogue between the end user and those who are developing solutions to the end user's problems. We must define and identify the problems in the proper sort of detail from the outset, so that we don't end up with solutions that are looking for problems. One example is the point I think Bernard mentioned, of the driverless tractor that perhaps wasn't marketable because nobody actually wanted to buy it now. Technology is undoubtedly very time and location specific, and that would depend on where you are and what stage of technological development that place has reached. But: don't forget the end user.

B.J. LEGG

In this connection, I perhaps should have said that one of the largest contributors to the LINK programme in the UK have been the producers. Most agricultural commodity producers now have a levy, handled by a central organisation which in turn manages a research fund. For example, there's a home-grown cereals authority that takes a levy on cereals when they're sold to the miller. And then they have a research fund. They are able to put that as industry money into LINK programmes. I guess that gives a way of adding a user input into the formation of a multi-company partnership. *I think that's an important point to add.*

K.Th. RENIUS

To go back to the statement about the end user: I wouldn't say "don't forget the user": I would say "address the user". If we look at ISO 9000 and total quality principles, and summarise the 40 mm-thick book of the ISO 9000 standard, we can say the fundamental message is: user satisfaction.

B. CHÈZE

I'd just like to say that this can be rather complicated, because: who is the real user? What are his needs, etc.? Sometimes they might answer that they're not interested in technical advance unless it costs less than, say, 100 dollars. This can be a factor that impedes the development of technology, so we must take this aspect into account.

Prof. Bill A. STOUT
USA

I want to bring up a problem and raise a question here, which perhaps some of our industry people can answer. I speak from the university viewpoint, as a professor and recent vice president of ASAE. The problem I would address concerns the trend towards reduced industry participation, particularly in ASAE, and I think the same problem exists in your ag-engineering sector. Sometimes industry quite frankly says "look, the work in universities is largely irrelevant to our needs". That may be harsh and a bit overstated but, nevertheless, I think it does reflect some industry attitudes. In the US at least, industry used to pay for memberships in professional societies, and they no longer do that. That may be understandable but, taking that a bit further, industry in some cases will not allow time away from work to attend professional meetings. And that's one of the venues where discussions between universities and industry occurs. So my question is, how can we bring industry back to the table. I'm sure we in the universities need to change, to become more relevant. But you do have to understand the environment that we're in: we operate in a "publish or perish" environment. That's too bad, but it's a fact. So my question is: how do we bring industry back to the table, or how do we go to industry. Maybe some of those who have already spoken can give us some answers.

Mr. Yoshisuke KISHIDA
Japan

Prof. Stout's point is a very important one. In Japan, too, many machinery companies do not rely on university research. However, I believe university research institutes have an excellent capability to develop new products and technologies. I have visited many institutes and universities throughout the world, and my impression is that they all suffer from a chronic shortage of research funds. Prof. Legg mentioned cooperation among research institutes that work together to promote certain special projects. I think that is one way to achieve good, strong results which we can then offer to industry. However, if all the universities and institutes continue working separately, we cannot obtain the good, strong results that are needed to attract industry. I would like to suggest one thing for the future, for the many important problems we need to solve, such as automation and robotics: I have observed that many institutes and universities do a lot of duplicate research. Perhaps we should review the research priorities in each institute and university and then, for the top research priorities, we could form a group of those who are strong internationally to promote this research. In this way, we might be able to achieve those very strong results that can attract industry back to university and research institutions.

B. CHÈZE

I think this is an issue we'll probably go back to, looking at the industrial side of the question, because it has many problematic aspects. Technology is not a neutral issue, it has great strategic importance and significant economic *consequences, so it's a very delicate question. You have some good ideas, and I think industry can probably also give us their point of view.*

K.Th. RENIUS
I can perhaps offer a partial answer to this question. Many years ago, we had a similar problem in Germany. We contacted the leading personalities in industry, and it was possible to organise a meeting on research priorities. You see, if someone is forced to consider these problems, its also easier to get him into a meeting, so the initiative was quite successful. And from this meeting, which took place in Berlin, many very interesting projects emerged. A second strategy that I believe to be effective is to ask managers from industry to take over responsibility in the societies. In the case of John Deere this proved extremely successful. Before we did this, John Deere had been sending three people to the national meetings. However, when it became possible for some personalities to take up management positions within the society, this increased by a factor of five to ten, though the quality of the meeting was about the same. So these are two small *answers which may perhaps be of some help.*

Prof. Richard O. HEGG
USA
I'd like to ask both Brian and Karl a question concerning the trends that you see in cooperation between industry and academia from the mechanisation viewpoint. Karl spoke specifically about mechanisation, whereas Brian covered other areas. Has cooperation been increasing over the past five years, and how would you compare that level of cooperation to the non-mechanisation areas of ag-engineering? Is there more cooperation? And do you see an increase in cooperation in mechanisation areas versus the non-mechanisation areas?

B.J. LEGG
We've probably been through a dip, and are seeing a rise again now. I think twenty years ago, when government funded all of research and there was no question about trying to get money from industry, that wasn't an issue. The work was done in very good collaboration with industry; it was free collaboration, and worked very well. Over the past ten years or so, however, we've been through a period where we've been having to say: "look, we'd love to work with you but you must pay". Initially, that actually turned off a lot of collaboration, but now companies are beginning to accept that that is the new basis on which they will have to operate. So the new regime is perhaps gaining acceptance. I would say, therefore, that, certainly in the last five years, we have seen an increase in the willingness of companies to come on board with joint projects and contribute to them. Sometimes they contribute in kind—they may donate a tractor or a piece of machinery—and sometimes they put in labour to help with experiments, and so on. Often they contribute with cash. So I think we have been moving in the right direction. But what I'd say is there is also a recognition in some industries that they should be outsourcing their research, and I think this is stronger in companies—well, I was going to say the pharmaceutical companies: of course they want their in-house research as well, but they've defined very clearly what is their essential in-house research, and they've defined what they're going to buy from outside. I've heard pharmaceutical companies talk about this, where they actually show you a diagram and say: "we've decided we're going to do this ourselves, because it's so important; but this and this and this is not absolutely critical, so we'll buy that from universities". I think some other industries are ahead of the machinery companies in terms of thinking through clearly what they're going to do themselves and what they need to buy in from outside. I believe that change of attitude has still got to develop further, within the machinery companies.

K.Th. RENIUS
I would like to agree, and add that outsourcing is on the increase primarily in smaller and medium-sized companies. This is because well-managed companies recognise that research is more expensive if they do it themselves. Very often they don't have the necessary people, the staff, and if they hire the staff they cannot get rid of them when they are no longer needed. This is a problem in Germany too: the flexibility of labour and manpower. My answer is therefore similar to Brian's: outsourcing principles are becoming more important today than in the past: in the mechanisation areas, and mainly for medium and small companies. I could give you examples, but of course the details are confidential in this area.

Mr. Malcolm E. MCKAY
Australia
My comment relates very much to the topics we've just been discussing: I think one of the keys to interaction with industry lies in the ability of the research organisations to demonstrate their capacity—their ability to actually achieve results. Most times this means ending up in the marketplace: some of their activities need to have made the full progression from research concept through to the marketplace. And one of the things that must happen to make this occur—this goes back to the comments Bill made—is that the nature of research organisations needs to change. But that's very difficult, to say that universities need to change, or that state departments of agriculture need to change. One way in which we've approached it most recently, over a period of three years now, is to create a permanent joint venture activity, which becomes the research organisation. The particular one I'm talking about, the one that I direct, is a joint venture between the university, the state department of agriculture and a group of consulting engineers. In that group we have a philosophy that covers a lot of the concepts that Bernard put forward earlier—we look at the science, the engineering and the end-user aspects. Because the research organisation itself has a much broader view of what its task is, to go from concept to marketplace, it's much easier to demonstrate that to industry: to say that

this is what we are trying to achieve. We don't believe that our task stops at the end of a concept or somewhere along the way. Our task is to be partners with industry from concept to marketplace. The advantage that can come from that sort of arrangement is that it's permanent concept. However long it lasts it's still a permanent concept, in which the research organisation is no longer a university with a "publish or perish" type mentality. That can still happen within a joint venture, quite successfully, and the trick of managing the joint venture is to try and allow each of the organisations to achieve their own aims while collectively achieving a much broader aim that has a bigger impact on industry. I'd also like to comment on what Brian mentioned earlier, about industry being users, and their committees and how they set priorities: in Australia there's a very similar system. One of the things we're always remarked is that the end user's set of priorities is always different from the researcher's set of priorities, just like Bernard had his lists for industry and research. My view—and this comes back to the comment that Derek made—is that, in terms of timescale, the view of most end users encompasses a five or ten year window, whereas researchers, if they're doing their job properly, have a much wider view: they probably don't have much of a focused view of their immediate future but are looking at ten to twenty years down the track. The problem is to try and give that amalgam of views the perspective that you're looking at, and I think the joint venture concept also contributes significantly to that amalgamation of time frames.

B. CHÈZE
I support these ideas. I think that both researchers and end users have to make an effort to somehow find a common language or level of comprehension.

B.J. LEGG
I would just like to ask a question of Malcom Mckay: how are those joint ventures funded? I think you didn't mention what industries were involved. You said consultancies and state departments, but which industries are taking part in those?

M.E. MCKAY
It is funded by totally generated contract research and development. In three years we have built up a portfolio to three million Australian dollars. A vast variety of industries are involved in this type of concept: the sugar cane industry, the mechanisation and environmental aspects, the intensive animal industries, housing and waste treatment, soil compaction, control of traffic within the cotton industries... So there's a very wide range of agricultural industries and a very wide range of technologies that are being serviced in this manner.

Prof. Ali Mahmoud EL HOSSARY
Egypt
I would raise an issue, which perhaps represents the case of developing countries. Our research is undergoing a process of privatisation, and the government is asking us to approach industry to cooperate in funding. But, unfortunately, we have medium-scale and small-scale mechanisation industries, and their response has been disappointing. I remember the good old days of Dr. Khan, when he was in Egypt: he established a kind of consortium with the industrial companies, and tried to govern them. But unfortunately, since his departure their attitude has changed, and they now believe that it is the government's responsibility to fund research. On the other hand we have fertiliser and pest control, which are completely funded now by the private sector. So my question to Prof. Legg is: how is the government contribution organised in your country? Do you have a fixed budget, or is it a variable, conditional contribution based on priorities? What is the level of government interference in these matters?

B.J. LEGG
Approximately a quarter of our funds come from a research council and they are for us to develop new technologies, do the underpinning science and so on. We are judged on that according to the papers that we publish, as Prof. Stout was saying, and we have to show that we're publishing strong papers in international journals with that source of money. Even that quarter is now competitive: we have an assessment every four years, when our performance is compared with eight other research institutes in the same council. This comes to a head in March 1997 so I'm quite sensitive to this at the moment If we do badly, our funding will go down over the next four years. If we do well, then it will go up over the next four years. So that accounts for a quarter of our money. Then roughly half our money, at the moment, comes from the Ministry of Agriculture, Fisheries and Food; but most of that is on a fully competitive basis. They now advertise areas in which they wish to have research done, and we can bid for research in those areas. Sometimes they will come to us with a particular problem and—they know we have the expertise—will we do work for them. And in those cases it's a single contractor that's approached. But that is becoming more competitive as time goes on. And finally, the remaining quarter of our money—which is, again, fully competitive—comes from a whole range of sources including Europe, some other government departments, industry and the producers. So that quarter of our funding is also fully competitive.

Dr. Pavel KIC
Czech. Rep.
I work at the university of agriculture, which depends on the Ministry of Agriculture. But I am a member of the technical faculty, so we have relations with the Ministry of Industry. And many of our programmes are connected with environmental issues, so we also have to do with the Ministry of the Environment. Therefore, ours is an interesting branch that gives us the opportunity to participate in many projects connected with different ministries. But in practice it is clear that in some cases—for example the construction of tractors, or the

construction of milking machinery—industrial manufacturing companies are also involved. My first question is: how can you interest companies in certain projects which, from the practical standpoint, do not offer immediate benefit to industry? For example, some new technologies should perhaps be developed for housing animals. In some cases it may be important to also study more theoretical aspects, like properties of agricultural materials, or the problem of ventilation in animal houses, which is connected with a need for new software and a need for new building materials. How can we involve industrial companies in such projects, where the profit is not so clear in the short term? My other question has to do with the decision-making process: we have commissions from different branches who decide on the priority of the various projects. I'd like to know if in other countries there are committees devoted specifically to agricultural engineering. For example, our submissions to the Ministry of Agriculture are put in the same group as certain genetics and biological projects. Do other countries have commissions that are specifically focused on agricultural engineering?

B.J. LEGG

First of all, where the research is concerned with environmental issues or animal welfare issues, our government will fund that research right through, almost to the end product being available for sale. In many cases, the end user does see a benefit in using that technology. If you look at animal welfare, for example: animal producers and animal transporters in the poultry industry are very aware of public opinion, and they're very keen to show that they are treating animals in a humane way, because their reputation depends on it. There are some fairly militant groups in the UK, who will attack companies—sometimes physically attack companies—if they're not seen to be following good practice. So quite often, if the solution can be developed, then a company is willing to take it up. In other areas, again, there needs to be a commercial benefit if a farmer is going to follow a changed policy. For example, we believe that patch spraying—controlling the sprayer to spray just where the weeds are—will catch on primarily because there is an economic benefit as well as an environmental benefit. If there is no economic benefit, then I think the government has to consider bringing in legislation or putting some other control in place to make sure that the technology is taken up.

Mr. Bernard BONICELLI
France

I am not sure whether progress is driven by research or by industry. I don't know which of the two has the superior know-how, the best progress. I also believe that there is some duplication, but that it exists in both in research and in private companies. So it's a global question: what are the costs in each? And how different are they? Another point is that we will increasingly be seeing new technologies that originate from other industries. An interesting example is GPS: this didn't come from agriculture, but it has proved to be a very good technology for our sector. I think that these technologies coming from other industries will make it possible to achieve good developments in less time. However, there is the problem of cooperation between the other industries and the agricultural industry. There's also a major communication problem between persons who come from different working cultures and have different objectives. For example, it is very difficult to strike a good compromise between the objectives of public organisations, of industrial organisations and scientific organisations. I think the answer lies in a greater physical integration of persons working in laboratories, both private and public. This is difficult to do but it's very effective. It is also very difficult to apply modern organisational methods, to have well-managed dynamic projects. Lastly, I believe greater specialisation of laboratories is necessary: for example that public organisations do more control of machinery, and industry more research on basic technology. It's also necessary to have less competition between organisations, because this is not always beneficial. Finally, I think it's necessary to have a major effort, a good offer for research institutes, and a good definition of technical problems and strategies for industrial partnerships.

K.Th. RENIUS

To reduce "inefficient competition"—let's call it this way, because there are also certain types of competition that are highly beneficial—you should perhaps try to set up something like a national regulatory council for ag-engineering research. Because it's in everybody's interest not to do the same work in three separate places. Our experience with that has been excellent: all the agricultural engineering professors meet once a year, and discuss research priorities. So a lot of duplication is prevented. To my knowledge, you do not have this in France.

B. BONICELLI

I think the organisation in France is not so bad, but I think in Europe there are some problems with research programmes.

B. CHÈZE

Just a small comment on the situation in France. Fortunately, we do have institutions that try to prevent the misuse of state funds. So I must say that it's more of a European problem. Now, Brian talked to us about these FAIR research programmes, and it's clear that Europe is aiming to develop European research. This attempt to coordinate, and perhaps even to specialise, is certainly a move in the right direction. But at the same time, Europe wants to have industrial people participating in European research projects. This is also the purpose of creating—it *takes time—an European industrial network, precisely to build up European industry.*

Prof. Pierre F.J. ABEELS
Belgium

First, a comment on the last question. In Belgium we manage a form of coordination between industry and research, in the shape of a committee that is active during the exhibition period—the international week of agriculture held in central Brussels. This is a major opportunity to lay the groundwork for economic and technological coordination between industry and research. At least one representative from each of the major Belgian laboratories gathers to meet with representatives from industry, who ask for certain tasks to be undertaken—on a voluntary basis, without support: that's not a problem, and it works. My comments arise from the remarks made by Bill Stout and Dr. Sutton. My first comment is that man—the human conceiver—is becoming less and less important in research activities, even at the universities. Everywhere, we are submerged by computers, and it's the computers that are doing the work, not the people. So Mr. Renius's first slide is often turned upside down: instead of a large act you have small offices, with some people having to run from one to the other. It's the professor, the director, who has to coordinate the computer work for development, and a lot of work is done just to access the computer's potential. There is a very big loss of time, because you have to manage your own following the computer technology. As a result, we find industry is saying: "no need for men, it's too expensive, and the computer is enough". My second comment is that, as another member already mentioned, I can never see very clearly how practical feedback from the end user goes back to affect technical improvement. It's a bit like those forms printed by car manufacturers, which you must fill in with all your remarks and suggestions when you buy a car. Now, I have never seen those remarks taken into account in the next model. So in the car industry at least, the designer's office appears to be working in isolation. Consider the difference between fashion shown in the media and the styles commonly worn by people in the street: I believe exactly the same gap exists between research and practice. My third remark concerns the fact that the validation mode in the world of science, versus technology, comes from academia. Why is this so? Because the model for science awards comes, for us, from medicine. All the progress highlighted by gifts, awards and recognition, are scientific advances in medicine. Why are those engineering successes not coming from industry instead of from academia? I believe that if some research is successful in Germany it is because they have something other countries don't have, technical universities, whereas other countries have more "academic" universities where the evaluation can often be quite different. It would be interesting to formulate a proposal that our engineering awards, the recognition for our engineering work, should come from industry instead of from academia, at least at a certain level. Perhaps technology has very high improvements. Does silicon valley represent high scientific or technical improvement? We must make a choice.

Prof. Giuseppe PELLIZZI
Italy

During the discussion, I tried to think of what we could include in the conclusions and recommendations of this session. I was a little bit surprised by the fact that no-one from industry has participated in the discussion, which seems to make the debate a little one-sided. I think one point to make is that cooperation between research institutions and industry can take place at various levels. We need to identify what are the capabilities and knowledge that industry lacks, and that we can offer to industry, in order to solve those problems that they themselves are unable to solve. In other words, we need to offer complementary knowledge. One possible type of collaboration is the study of long-term problems, which industry is unable to solve because it must focus on its day-to-day production pressures. A second type of collaboration could involve providing industry with information concerning the agricultural aspects of a new product or idea. For instance, Karl Renius mentioned infinitely variable transmission: what are its implications from the agricultural point of view? My feeling is that industrial companies such as tractor manufacturers do not always understand the agricultural aspects; I have some doubts about whether they fully understand the problems of soil compaction, for example. So I believe one possible role for researchers is that of providing guidance on such issues. Another possibility is helping industry with technology transfer to developing countries. Very often, technology is transferred without any adaptation whatsoever to local conditions, from the pedological, climatic and economic points of view. And if you visit Africa or other developing countries, you'll find veritable cemeteries of technology from Italy, Germany, the UK and so on, because these technologies cannot be used in those countries. I think we must underline these types of activities, that we are able to offer to industry. That is not in the direct interest of industry, whose immediate problem is to respond to market forces. I should like to know if you agree on integrating this into the conclusions and recommendations.

Dr. Uri M. PEIPER
Israel

I would like to give the point of view of a small country with a very small agricultural engineering industry. The main consumer, or target, of most of our research work is usually the farmer. And as we must rely on imported machinery, in most cases, we try to follow what Prof. Pellizzi just said in terms of adapting machinery. In the past few years we've been seeing more and more interdisciplinary research work, in which we have to consider not just agricultural engineering problems, but also those of other fields such as horticulture and animal husbandry. I think this is one way to promote agricultural engineering research: getting all the disciplines together and trying to do more joint work. A large part of our *funding comes from agriculture itself—about 0.4% of agricultural income is devoted to research and development in all fields, not only in ag-engineering of course—so in order to use this we must cooperate. Our efforts to cooperate with European countries in agricultural engineering research have failed so far, as far as I know, because there is not a common interest. If we have certain soil compaction problems, which are probably far more severe than in Europe, the European tractor manufacturers do not pay too much attention. So we have to use the agricultural tractors coming from Europe, or from other countries, and try to make the best of it. One of the problems we encounter in agricultural engineering research and development is this: say we decide to develop a machine that 100% meets the needs of a certain branch of agriculture—and my best example for that is the development of a paprika harvester, which was a very good machine: two or three machines are sufficient to harvest the whole yield of the entire country. And trying to sell these machines to other paprika-growing countries is just not working, because most of them have enough hand labour. So these are a few problems that I would add to the discussion, without having full solutions to them.*

Dr. Arturo LARA LOPEZ
Mexico

It seems to me that we in the universities must change our attitude a little bit: instead of thinking of ourselves as working for industry on a certain project, it would be better to think of ourselves as working with industry. We are trying to move in the direction of working as a team with engineers from industry, in defining problems as well as in actually carrying out the projects. Another problem is that, in evaluating the performance of professors, universities give the greatest weight to publication of papers and to performance in the classroom, but I think it would be very important to give more weight to innovation for industry. This does not necessarily have to be a published paper; it can take the form of a report or a similar document which, with certain agreements, we can sometimes partially publish. But it's very important to increase the weight given to work with industry in evaluating professors, if we want to motivate them to do that kind of work. Moreover, I believe one of the major tasks of universities is the generation of new ideas. It is important to understand that the generation of new ideas is also part of the education that universities provide to students and, in that respect, the university needs freedom for continuing that kind of work. So we think that not all the work has to be linked with industry. The universities also need to educate young people, giving them all the intellectual freedom that is necessary to generate truly revolutionary ideas. I can see, from many of the examples that have been explained here by Prof. Renius and Prof. Legg, that specialised groups in universities are very well-equipped for undertaking interesting projects with medium-sized industrial companies. For example groups with highly specialised knowledge transmission design, or finite-element analysis; they have an excellent opportunity to do very specific work for industry.

Dr. David J. WHITE
UK

I wanted to take up a point raised by Mr. Chèze in his contribution. In one of his slides he listed various pros and cons of collaboration with industry, and one of the drawbacks from the researcher's standpoints was the restrictions that might be placed on publication. Now this is a very real problem, it does exist, but I don't think that it should be exaggerated. During my seventeen years' experience working in industry I did run into this problem from time to time. But I found that if you were sufficiently persistent, your colleagues at the sharp end of the business—that is to say the application end—would eventually concede that you should be allowed to publish, after what they regarded as a decent delay to give them an edge in using the results. And I think that that is the line that you have to pursue in pleading to be allowed to publish. My present occupation, as many of you know, is editor of the Journal of Agricultural Engineering Research. In this capacity I do in fact see many papers that are very clearly leading to applications. In fact, if they are, the author frequently gives an acknowledgement to an industrial sponsor, or at least mentions towards the end of the paper that the work is going to be taken up, and that a product will result from it. So I think one has to emphasise that there are such success stories, and indeed, this is true of some of those mentioned by our speakers today. Brian Legg mentioned the poultry transporter: well, this is the subject of current papers in JAER: we had one paper on it in September and two in October. Those papers deal with the basic work done in wind tunnels and on full-scale transporters, to discover the pressure distributions around the vehicle which determine the air flows within the vehicle. This is all work that it has been possible to publish. So I think one has to seek out what you might call the pre-competitive aspects of the research, and plead that you should at least be allowed to publish those. Brian also mentioned robotic milking, on which we have had papers in the journal not only from Silsoe but also from the very substantial work done in Wageningen. Brian also mentioned pig weighing, on which we do in fact have a paper within the refereeing system at the moment. Occasionally, we get requests from industry to be allowed to reprint of articles that we have had in the journal. This is because someone has published a scientific article, industry wants to take it up to develop a product, and they decide that it would be beneficial to them to give us that as a piece of publicity. Most often, it happens with instrumentation. So if you have done some good work you want to publish, but the industry which helped or sponsored you is reluctant, I think this is a point that you could put to them: that they should build on it and perhaps use it for publicity.

B. CHÈZE

You're right, and you know better than I do the strategies adopted by researchers to publish in a way that doesn't *damage the industrial partner. Generally you can publish a part of the work you're doing, without stating the application, approaching it from a more general scientific point of view. Or you wait two or three years after the results have been already been patented, and publish afterwards. I think that this is a key problem between research and industry. One more point, for Prof. Pellizzi, is that we do have some representatives from industry in the room, particularly some Japanese colleagues who are very interested in the research aspects.*

A.U. KHAN

I wanted to comment on the productivity of research institutions in developing countries. Having worked in that whole region almost all my life, I'm quite familiar with the institutions in North Africa and Asia. Unfortunately, the results of most of these institutions have never been taken up by industry. This is a sad state of affairs, and a tremendous amount of money is being lost in these activities: government funding is being given, but nothing is coming out of it. I have been observing this problem for many years, thinking what can be done to improve the situation, and a couple of things come to mind: Firstly, most of these institutions are heavily academic-oriented. All of their people have zero experience in industry, and so they don't know what is really required to make a marketable machine. Yet they dabble in trying to design machines: you'll find a great many prototypes lying around in every institute, not one of which is being produced commercially. So I think this is a major problem from the developing countries' point of view, because a lot of funds are being thrown into it, without getting any results. I think some years ago a number of developing countries moved away from the universities and established institutes under the Ministry of Agriculture or the Ministry of Industry. But the basic character has not changed and they are still doing the same kind of thing. I believe some guidance is needed on this subject, and we have many distinguished people here who have experience in this area. It will be nice to see what can be done. My view is that the universities, at least in the developing countries, should not dabble in product development, because they don't understand the requirements for a marketable product. Consequently universities should focus more on research—applied research, as far as possible—rather than dabbling with developing products. The research institutes, on the other hand, are the ones who should take product development as their major focus. But to do that, their staff needs to gain some industrial experience, and I think there ought to be a rule that the director must have some industrial experience. With such a rule I have a feeling that the ideas and thoughts would automatically percolate down, and eventually lead to improved products. Another important method, that has been successful in certain cases is this: we began cooperating with industry by selecting a manufacturer and asking him what product he wanted to develop, and then working closely with him; he had a lot of practical inputs, understood the market and educated us on what to do. So I think this kind of interaction would be very helpful, and perhaps this subject has not been touched on enough. I'm very impressed by the papers that have been presented and the level of cooperation that exists in Germany, the UK and other countries. But the situation in developing countries is very sad, and this must be looked into.

Dr. Oleg S. MARCHENKO
Russia

I would like to go back to Prof. Pellizzi's remarks. It seems to me very important to point out the international aspects of cooperation between research and industry. First of all, transfer of ideas is no harm, only success. Purchasing licences for new products or new technologies will be successful or not depending on how they are introduced into agriculture or industry. But transfer of technology—for example machinery—into agriculture in different countries is extremely important and, where there is a good range of choice, we will have good results. As an example, I would like to mention the problems we have in Russia. We are going through difficult times, due our economic reforms and the transition to a market economy. This is causing major problems not just in agriculture but also in industry, which is at a standstill. What about agriculture? The technology we have now, compared with that of developed countries, has a specific energy consumption that is four or five times higher, and a specific labour consumption that is maybe 10 times higher, per pound of product. This means that we need to transfer very efficient, high-level technology and machinery in order to compete with imported food. In Moscow, for example, we now have 70-80% of food imported from western countries. And our local production is going down, in spite of the fact that the quality of our food is superior. There is therefore a need to transfer high-level technology and advanced machines in order to decrease the specific consumption of energy, labour and resources in agricultural production. In this connection, I would like to give a few examples. We have transferred production of a forage harvester from Germany, and created a joint venture in Saint Petersburg. I opposed this initiative, however, because it was a very old model, and we have other examples of successful transfers of new machinery. For example, multi-purpose type, which is much more effective, and which we hope will be a very successful product. Another example are western grain harvesters, which we try to put into production without any adaptation. So, I agree fully with Prof. Pellizzi, that it's necessary to adapt new technology for regions such as Russia, which is a very big country in which local conditions—pedological and climatic conditions—differ greatly. Some financial industrial groups help their local regions to buy certain technologies from the United States, for example. And for Siberia—this is much more effective in Moscow than for Siberia. But in spite of that they pay big money because they don't ask anybody, they don't check it beforehand. Without this of course it's impossible to buy new technology. I tried to put this in order and, within the framework of the Russian National

Committee on Agricultural Engineering (CIGR National Association), to create a special committee for the examination and approval of major new technology-purchase contracts. We know that it's necessary to buy new high-level machines in order to raise our own technical level. But I failed, because there were too many persons involved with a vested interest in these purchases. Now, we are again trying to create special international centres for testing and certification of foreign machines. And we hope that some experts would like to help us to organise some international centres for testing and certifying foreign machines. This method will, I think, prove to be more effective and rational. That is why I want to underline these remarks, which Prof. Pellizzi made, and I can see that it's necessary to include in the conclusions and recommendations his proposals to pay more attention to the international aspects of cooperation between research and industry.

Dr. Anthony WYLIE
Chile
I have a comment and a question. The comment concerns a point mentioned earlier, about cooperative projects within different industries helping to finance research. I'm not a researcher, but the experience that we have had is that, when you have generic cooperation for a subject which interests everybody, then everybody cooperates. But the problems start when you start thinking: "well, who pays more, amongst the private companies?" And people want those who have the bigger market share to put up more of the money. So that's all right when it's for public service, as it were, but as soon as you start getting into things which are potentially of commercial interest, the people who pay more want more. So you get into a conflict about who owns what is developed. And this is why I can't help but agree with what has been mentioned, that the cooperative system doesn't really work, unless they are non-competing companies. With competing companies it's not very easy. My question is directed more to the academic or research management issues. When you have a "publish or perish" system you have a pretty clear way of measuring productivity—I have to ask the academics to excuse their work being called "productivity". But in any case output, to use a different word, is measured by publication. But what happens when you get into a scene where it's not "publish or perish" it's "publish and perish", which is where you have the industry in with it. How do you work it out when you have a mixture of funding which is not responsible for publishing, and others publishing. How do you manage that within your organisational structure?

B.J. LEGG
I'm not sure we've got all the answers to that, and I don't want to give a pat answer. I'll say what we are doing, although I think more is still needed. We've tried to indicate to staff that we value not only publications but that we also value collaboration with industry and ideas going through to be taken up. The danger is that, when you do that, people who don't like writing stop writing, and say "well, I'm doing other things". And of course that isn't acceptable. Another thing I'd like to say is that within a research group we usually have a balance of basic research, funded through the research council, as well industry contracts. So within a group that might be of between ten and twenty people, we'd expect there to be some who are perhaps stronger on the writing and some who are stronger on the industrial collaboration. As long as the group is providing a good balance between those, then I would be fairly happy. Two issues arise from this. One is promotion for individuals. Within the system in the UK, the responsibility for promotion is now being delegated to institutes, and the rules of promotion allow industrial collaboration and successful transfer of technology to be counted towards promotion. In fact the last two who were promoted both achieved that on the basis of close industry collaboration, with less publications than would have been allowed perhaps five years ago. And so I think that is happening. But of course if they wanted to transfer to a different part of academia, if they wanted to move into university, then they may not appreciate the same standards and they might have more difficulty. So, although I think within the institute we can handle it, it's not so easy if people want to move around within an academic career. But I think you've got to make a clear statement of what you want, what you value, and then make sure you really give value to all components of that.

H.J. HELLEBRAND
The question I would put concerning the publications issue is: what is the role of patents? I was faced with this problem when I was looking for a new type of spectroscopic device for the carbon determination of soil, which had been studied in the States five or six years ago and might be very useful for site-specific farming. We tried to find out who was producing this device, and we were told that it was a world-wide patent but nobody was producing it. This device has been developed by a public foundation at a university, and it's still not on the market even though five years have already gone by. So I wonder whether this question of patents might hamper cooperation between industry and research institutions. My institute too, is fully funded by public money, and we are asked to publish everything. We had a discussion with an industrial company, whose name I won't mention, and they told us that we had to wait a little bit with our publications—that it could be discussed after they gave the go-ahead—but then we saw that some other institutes had started working on the same topic. So in this case time is money. You have to be quick; on the one side with industry and on the other side with publications. Now I don't know what your experience has been in this field. Do patents hamper or support cooperation between research institutes and industry?

B. CHÈZE
For patents we generally have contracts with industrial companies, stating that if they do not use the patent—if they do not come out with an industrial product within a

certain time, generally three years—we can go and see another manufacturer. This is very important; otherwise a manufacturer can keep your project under his belt, and block all possible developments. Sometimes, though, the research is too advanced for industry's development capabilities, or for the demand of the marketplace. If it's too early, you'll have research that may be good but is non-applicable.

B.J. LEGG

What I'd say on patents is that one shouldn't patent unless you've got an idea that really has a very large potential in the marketplace. Ten years ago we used to patent everything we discovered: we were probably producing seven or eight patents a year at one time, most of which never earned a penny. And I think, if anything, they were probably obstructing uptake in the marketplace. So I'd say that first of all you do need a professional assessment of whether an idea has got major potential or not; and if it hasn't, don't patent it: publish it. If it has got major potential, I would say that if it still needs a major investment from a company to take that idea through to the market, then you have to have patent protection. Otherwise, companies won't make that investment. So those really are the two criteria. Firstly: does it really have big potential? And secondly: is it something that now needs major investment from the company? Perhaps over a period of two or three years before they can get to market, because no company wants to invest major money for three years and then find that all its competitors have got the same technology, because they won't get their investment back.

K.Th. RENIUS

From my standpoint, I would say that we are not interested in collecting patents. And we are not disappointed if a company patents something that is partly based on our research and our ideas. So we are happy if there is success, and things are going forward. For example the Fendt company is applying a pivot suspension, this was an idea that came from my institute, and they have patented it. I am not at all unhappy about that, because we are funded by the taxpayers' money--this is of course a little bit different from some other institutions--so we also have to give something back to industry, free of charge. This is my personal experience with patents.

A. MUNACK

I think that, when speaking of cooperation between industry and research institutes, we should also devote a few words to the boundary conditions under which this cooperation has to take place; I mean the legal framework under which we are forced to operate. I have come to that question because, starting next year, we will have a deduction of 20 % of all the money that comes in trom industry. The federal research institutes have to pay this 20 % research tax, which goes to the federal and minister of finances. So I would like to put the question here, to the international community: are there any other unnecessary restrictions in other parts of the world, or is this a purely German problem that we are facing now? If other countries also have similar restrictions, I think the Club could have a vote against that.

Ir. A.A. JONGEBREUR
Netherlands

I'd like to make a few comment from my country. First of all, I want to say that I recognise the situation described by Brian Legg: this is very much the case in the Netherlands as well. We have a large number of small private companies with relatively low budgets for research and development. So in my institute, and this is also true for other institutes, we have a large number of small projects which we are carrying out for those companies. The situation has been improving of late because the government--the Ministry of Agriculture and the Ministry of Economic Affairs-- are supporting the private companies, helping them to pay for research and development projects in institutions. I think this is a positive trend that we've seen over the past year, and which will continue also in the coming years. Many remarks have been made concerning industry, and one point of fundamental importance to the agricultural engineering sector is that industry must be more active on the research agenda, both natiollally and internationally. Prof. Renius said something about the EU: I think industrial companies must devote greater effort to convincing national governments and the EU to support research in the field of ag-engineering. I believe the companies are not active enough in promoting their field, and if they don't pay attention to this aspect then the total budget for agengineering will eventually decrease.

U.M. PEIPER

I just wanted to share with you, in connection with what has been said earlier, that in our institute we try to credit people for patents, but we credit them even more if a patent is adopted by industry and a real product results from it. That receives at least the same credit as a good published paper in review literature. So the problem is, and will probably be even more so in the future, to strike the right balance between these types of patents, good research, and good publications. But this is something we'll probably have to live with, and I think it's worthwhile to promote and encourage researchers to come out with good patents that will also be taken up by industry.

Y. KISHIDA

Institutes in different countries have different systems for promoting research with industry. Perhaps, in the future, we should develop some standardised forms of collaboration to achieve fair competition. Because, as Prof. Renius said, all research institutes in universities are taxed by the government. In Japan, the general trend is towards open sharing of information--of the knowledge produced using the taxpayers' money. Therefore, if research institutes in different countries have different systems for contracts with industry, this could cause some *problems in the future. Perhaps we should develop a standardised internatiollal framework for partnership contracts with industry, defining how to handle patents, publication of results, or the cases in which results should be kept confidential. We need to address this issue.*