CONCLUSIONS AND RECOMMENDATIONS

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1. Foreword

Under the aegis of CIGR and with the sponsorship of UNACOMA, in 2006 two sessions of the 17th Meeting of the Club of Bologna were held:

1. in Bonn (Germany) on 3 Sept, during the joint AgEng2006-XVI CIGR World Congress, a **first session** on "**Information Technology for Agricultural Machines**";
2. in Bologna (Italy) on 18 and 19 Nov, during the XXXVII EIMA, a **second session** on "**Influence of Legislation/Subsidies, to Help Agriculture and/or Agricultural Mechanisation, on the Market of Agricultural Machinery**".

2. First Session

60 experts from **27 countries, in addition to different international organisations,** took part in the first session of the 17th Meeting of the Club of Bologna, held on 3 September 2006 in Bonn during the joint AgEng2006/XVI CIGR World Congress.

The topic under discussion was **"Information Technology for Agricultural Machines"** with keynote contributions by two speakers:

1. *Mr. Rainer Hofmann*, from AGCO GmbH (Fendt) Germany, with a paper on "**Software in Tractors: Aspects of Development, Maintenance and Support**";
2. *Mr. Bob Benneweis*, from CNH Canada, with a paper on "*Facilitating Agriculture Automation using Standards*".

2.1 Conclusions

The first paper (**Software in Tractors: Aspects of Development, Maintenance and Support**) was presented by Mr. Rainer Hofmann, electronic engineer working at the AGCO GmbH (Fendt) in Germany. In modern agricultural machines with electronic network systems, the software controls all vital functions. This situation creates an enormous dependency of the manufacturers to all aspects of software creation and the quality of the machine is practically defined by the quality of its software; any error can lead to a complete standstill of the machine itself. Due to the rising complexity of software, time and costs for software development are difficult to estimate and plans are hard to achieve.

In a general overview the actual state of software in tractors could be split into 5 main areas of applications:

1. *basic (tractor) control functions*: where basic is meant as generic functions which drive a definite mechanical part of the tractor;
2. *Human Machine Interface* (HMI): the drivers interface to the machine gets a very high point of interest in electronic and software design for a tractor. The art is to find a concept in a moving machine where the driver has to concentrate on other processes;
3. *automatic functions*: where the intention to rationalise human labour to perform the work of an agricultural machine leads to continuous increase and improvements of automation software;
4. *data management*: latest developments in society (requirement of traceability of food and its production processes, documentation of environment sensitive works like spraying pesticides or applying fertilizer) speed up this area of software in agricultural machines;
5. *service, support and manufacturing*: a wide range of software activities are necessary to provide service and

support for complex machines like modern tractors, combine harvesters and forage harvesters.

Software and its peripheral aspects will tremendously grow in agricultural machine industry in the near future. The need to produce agricultural products with economic methods will keep up the demand to increase efficiency of the machines and reduce input of man labour. On one hand the user (driver) of a machine should become able to run as many functions on one machine as possible. On the other hand, he will be enabled to run and control additional unmanned machines in parallel (remote control).

The control software of a machine will be embedded in a process-software controlling the whole agricultural procedure like soil preparation, planting, fertilising or harvesting. Field robotic with totally unmanned machines will become likely in closed areas.

It is obvious that the complexity (i.e. the number of modules and their interdependencies) will increase dramatically and continuously. This complexity will overlap tractors, implements, combines, etc., office software and following process software for food production. Engineering efforts and expenses will grow in the same direction: for design and development of software, for test and validation of software and for administration and support of software in production and service.

The second paper (**Facilitating Agriculture Automation using Standards**) was presented by Mr. Bob Benneweis, electronic engineer, who carried out all his career in Canada (SED, Field Technologies Ltd., Flexi-Coil and now CNH Canada). The fundamental standard is ISO 11783, which specifies a serial data network for control and communications on forestry and/or agricultural tractors. It standardises the method and format of data transfer between sensors, actuators, control elements, displays and storage units.

ISO 11783 provides interoperability and interchangeability of electronic units between different types of implements and implements from different manufacturers. It specifies a standard electronic interface that is similar to other standard tractor-implement interfaces, such as:

- three point hitch standards (ISO 730, ISO 789, ISO 2332);
- hydraulic remote connection (ISO5676, ISO 17567);
- PTO standard (ISO 500).

Other standards are being developed. The most important is ISO 25119, which provides safety requirements and guidance on the principles for the design of “high risk functional parts of control systems” used in agricultural and forestry machinery to ensure human safety. It applies to “high risk functional parts” of electrical/electronic/programmable electronic systems and as part of mechatronic systems. It does not specify which “dangerous critical” functions and which categories shall be used in a particular case.

The other standards are being developed:

- wireless sensor networks. It specifies wireless data communications between remote sensors, base stations and/or interfaces to wired networks for application in agriculture, including communication to management systems;
- headlands control. An individual controller records operator control actuations as the tractor-implement completes a turn between two passes in a field:
- map based rate control, which does a site and temporal specific control of implement operations based on available maps;
- automatic guidance, which performs straight and curved line paths;
- standard based operations;
- combined auto steering and headlands control;
- potential standard based automation implementation;

- planned tractor-implement control,
- autonomous implement safety.

The conclusions are that **standard based systems**:

- **assist** with the development of agriculture automation. They provide: the "foundation" of a control and communication serial data network; messages and protocol now available for implementing automation;
- **allow** the combining on implement single functions, through auto-steering and headlands control combined to provide non operator control of tractor-implement system operations;
- **facilitate** the rapid implementations of autonomous agriculture equipment: effort can be focused on the autonomous operations; efforts are not needed on a base system to support autonomous operations.

2.2 Recommendations

- **Having recognised** that automation and related standardisation are opening new lines to the conception and operation of agricultural machinery, including safety;

- **having noted** that new tractor and agricultural machinery developments are mainly dependent on electronics and software and that in this process standards are fundamental;

- **having recognised** that software should be developed to be independent from hardware and that it needs to be fully reliable;

- **having noted** that the use of software in agricultural equipment must be developed in a structural manner, using as many standards as possible, which must be proof and hardware independent;

- **having recognised** that information technology can help to increase efficiency of machines that is currently hampered or not exploited because of the slow response of humans;

- **having noted** that technological possibilities in automation of tractors are far ahead of potential application;

- **having recognised** that the massive information technology can overload the electronics and cause failure, as may do external conditions like thunderstorms, in such a manner that hardware problems may be mixed with the software ones with consequent unpredictability and safety;

- **having noted** that the continuing demand for energy efficiency, improvement in field operations and the integration of data to form systems for traceability will dictate the creation of increasingly complex software;

- **having recognised** that standards can play a key role in increasing interoperability and reducing the design costs for equipment and tractors;

- **having noted** that without software and electronics devices agricultural mechanisation could not be further developed and that the use of these devices must be improved through lower cost incidence, longer life and higher safety;

- **having noted** that the development of mechatronic systems require small steps;

- **having recognised** that agricultural machines have to work much longer than the cycle of new software generation;

- **having recognised** that there is a large gap between the trends and the actual farming, not only in the developing world but in the rich countries as well and that farmers should be aware on the use and limits of this technology;

- **having noted** that the application of software helps the design, but the dealer work is more complicated as he needs more training, more equipment and the profit of his operation is reduced and that the situation for the farmers is even worse.

The members of the Club of Bologna:

- **recommend** that world-wide markets require universal machines, with adaptations to regional features and national rules, depending on farm size, operation and labour costs, to meet local requirements for both developed and developing countries;

- **acknowledge** that information technology application must improve productivity, quality, efficiency and safety;

- **recommend** that the pace of standard development needs to be accelerated. Automation will be derailed if the proper standards are not in place. ISOBUS technology has to be completed in the near future and be adopted by all agricultural machinery manufacturing companies. In particular ISOBUS is the guarantee for small medium enterprises to survive;

- **recommend** that the companies encourage and advertise the use of existing standards, teaching the farmers "step by step" the features of electronic systems;

- **underline** that market demands regarding automation differ from area to area;

- **acknowledge** that a better education worldwide should be emphasized, in order to support the use of electronic features and that training operators in a better way is a must, together with an increased relation between manufacturers and customers. The dissemination of software technologies will depend on advisory and farmers education, in order to draw full benefits;

- **acknowledge** that the academic institutions of agricultural engineering are going to lose significant ground in electronics and automation due to inadequate training of students in these fields. Academic authorities should encourage their staff to be active in these areas;

- **recommend** that it is a must to improve the instruction book, so that the farmer (and the dealer) better understand the complex utilisation of their machinery. In addition it is necessary to translate the instruction books in a better way into the languages where tractors and machines are sold;

- **underline** that software development should be done "user friendly" and reliable as much as possible and that, when designing new machines, the manufacturers have to take into account the farmers' purchasing possibility and their skill as operators;

- **acknowledge** that the electronic control of the equipment is compelling farmers to renew the tractor and implement park with a probable loss of profitability. There exist models of development – like in Argentina and Brazil – where machinery produced with less technology are much cheaper with respect to the USA, EU, etc. manufactured items;

- **underline** that more attention is necessary for human safety, which will be first priority, especially in developing countries;

- **acknowledge** that in developing countries agricultural machinery are very simple and that software development must follow this feature to mark the needs of these markets;

- **underline** that the technology gap between industrialised and developing countries is greatly increasing. The manufacturers should keep in mind the developing countries as potential growing markets and adapt and provide ad-hoc systems with a flexible software for these emerging markets, keeping in mind the necessity to maintain labour employment;

- **recommend** to consider the differences between large-scale, middle-sized and small farmers, in order to meet their challenges for cost reduction, quality of products and a minor use of chemicals and fertilisers;

- **underline** to increase the co-operation between industrial companies, universities and farmers organisations, to facilitate the application of the technological possibilities. User communities should provide manufacturers their opinions on needed automation controls and the suggested specifications for these controls.

3. Second Session

50 experts from **23 countries, in addition to different international organisations,** took part in the second session of the 17th Meeting of the Club of Bologna, held on 18 and 19 November 2006 in Bologna during the XXXVII EIMA.

The topic under discussion was **"Influence of legislation/subsidies, to help agriculture and/or agricultural mechanisation, on the market of agricultural machinery"** with 4 keynote contributions by 6 speakers:

1. *Prof. Ettore Gasparetto*, University of Milan (Italy) and President of Club of Bologna, with a paper on "**The case of European Union**";
2. *Prof. Gajendra Singh*, Vice Chancellor of the Doon University (India), with a paper on "**The case of India**";
3. *Prof. Hugo Cetrangolo*, College of Agriculture of the University of Buenos Aires (Argentina), and *Prof. Fernando Schlosser*, Universidade Federal de Santa Maria (Brazil), with a paper on "**The case of Argentina and Brazil**";
4. *Prof. Silvio Kosutic*, Faculty of Agriculture of the University of Zagreb (Croatia), and *Prof. Milan Martinov*, Faculty of Mechanical Engineering of the University of Novi Sad (Serbia), with a paper on "**The case of South-East Europe**".

3.1 Conclusions

The first paper (**The case of European Union**) was presented by Prof. Ettore Gasparetto, University of Milan (Italy) and President of the Club of Bologna. European Union (EU) countries may be divided into 3 groups, different for geographical and political reasons:

- *6 Mediterranean countries* (**Med co.**), with typical Mediterranean crops and a strong necessity of irrigation in summer;
- *11 North-West countries* (**NW co.**), with continental crops and sufficient rain (France is halfway, but north crops prevail);
- *8 North-East countries* (**NE co.**), with continental crops and the remainder of former centrally planned economy.

Both the GDP per capita and the agricultural GDP per economically active person in agriculture are the highest for NW co. and the lowest for NE co., with an opposite status for the economically active population in agriculture. Irrigated land reaches 32% in Med co., 8% in NW co. and 2% for NE co. The most important share of capital stock is land in the Med co., livestock in NW and machinery in NE. The highest agricultural value commodity is the cow milk for 19 countries; exceptions are the pig meat in Belgium, Cyprus and Hungary, the olives in Greece and Spain and the grapes in Italy.

The percentage of subsidies is slowly going down in the EU, where the less distorting subsidies (depending on cultivated areas) are prevailing with respect to highly distorting subsidies (depending on the produced crops). EU agricultural production is decreasing since 1998, after the beginning of the subsidies reform, while tractor and agricultural machinery market maintain or even increase their sales.

The trade balance for agricultural machinery is positive in the EU, mainly due to the strongly active productions of Germany and Italy. Agricultural mechanisation follows the agricultural GDP trend: it is the highest in the NW co. and the lowest in the NE co.

The second paper (**The case of India**) was presented by Prof. Gajendra Singh, Vice Chancellor of the Doon University (India). India is the second largest country for its population in the world (1,100 million), with 70% living in rural areas. The share of agriculture on GDP has declined to 20% from 56% in 1950. About 52% of the population is still active in agriculture (142 Mha cultivated area, of which 57 Mha are irrigated). Farm holdings are small, due to a high population density.

The Government of India has taken many steps to favour farmers with minimum support prices for all main food and textile crops, in addition to subsidies for irrigation, fertilizer and electricity. Long-term credits are usually available for the purchase of mechanisation inputs.

There are 12 tractor, 2 power tiller and a number of agricultural machinery construction industries in India, in addition to about 1 million village craftsmen. In 2005 about 310,000 tractors were manufactured, with sales concentrated in the flat areas and in the North of the country. The average power of the tractor is at present 26 kW, while the tractor park is around 3.2 million. Power tillers are becoming popular in low land flooded areas and on hilly terrains, but their importance is much lower in comparison with tractors. As normal farmers cannot afford to own machines, custom hiring is preferred, with a consequent trend to higher capacity machines and higher power tractors.

Tractor export is increasing and in 2005-06 the industry exported almost 30,000 tractors, mainly to USA, South Asia, Malaysia, Turkey and East African countries. Agricultural tractor manufacturers are beginning to establish assembly and/or manufacturing plants abroad (USA, Australia, China, Poland, Turkey, etc.).

The third paper (**The case of Argentina and Brazil**) was presented by the Professors Hugo Cetrangolo, College of Agriculture of the University of Buenos Aires (Argentina) and Fernando Schlosser, Universidade Federal de Santa Maria (Brazil). Argentina has a total agricultural area of 174 Mha, of which 33 Mha are in production (19 Mha annual crops, 4 Mha annual forage crops, 8 Mha perennial forage crops, etc.). Main crops is soybean (38 Mt in 2004-05), followed by maize (20 Mt), wheat (16 Mt) and sunflower (3.5 Mt). The no-till area is increasing year by year and exceeds 16 Mha.

In Argentina the incentives are negative: the agricultural sector bears a heavy tax burden, with an export tax of 20% applied to cereal and oil grains, to oils and oil grain by-products. The tractor market is limited to a few thousand units per year (6,000-7,000), of which nearly 85% are imported. A similar

situation exists for combine harvesters (70-75% import on the total market of about 3,000 units), while more than 80% of direct-drilling machines are home made (with a total market of about 12,000 implements per year). On the contrary exports are limited, due to Brazilian competition and to understaffed qualified investigation and development departments in the industries, leading to no competitiveness.

The agricultural sector is efficient and competitive, aimed at worldwide markets in spite of the taxes applied to exports. The agricultural machinery market is mastered by the direct drilling technology.

Brazil has a total area of 851 Mha, of which 282 Mha are used for agricultural production. Other 106 Mha are already available for future agricultural development. Total grain production in 2006 amounts to about 120 Mt. Agribusiness is responsible for 30% of GDP, 42% of exports and 37% of manpower occupation.

Tractor production amounted to about 36,000 units in 2006, of which 20,000 were internal sales. The corresponding figures for the combine harvesters were about 2400 and 800. Import of agricultural tractors and machinery is very limited, while the greater exports are addressed to Argentina, USA and Venezuela.

There exist approximately 250 agricultural machinery manufacturers, mainly concentrated in the States of San Paulo and Rio Grande do Sul. Projections show that Brazil will be the world principal country for producing cotton and biofuels (from sugar cane and vegetable oils).

The fourth paper (**The case of South-East Europe)** was presented by the Professors Silvio Kosutic, from the Faculty of Agriculture of the University of Zagreb (Croatia) and Milan Martinov from the Faculty of Mechanical Engineering of the University of Novi Sad (Serbia). 6 countries were considered, with the following main features:

- Turkey has the highest surface (77 Mha) and agricultural land (26 Mha), while the relative lowest figures are for Croatia (5,7 and 3,1 Mha);
- on the contrary Croatia has the biggest GDP per capita (7,000 €) and Bosnia & Herzegovina the lowest (about 2,000 €);
- agricultural land per capita varies from 0.37 ha (Turkey) to 0.74 ha (Bulgaria);
- percentage of agriculture in national GDP is included between 7.6% (Croatia) and 16.0% (Serbia);
- cereal production (wheat, maize, etc.) is mainly concentrated in Turkey and Romania;
- average farm size is between 2.3 (Romania) and 5.9 ha (Turkey).

The main figures of agricultural mechanisation are:

- total number of tractors amounts to 1,700,000 units, of which 950,00 in Turkey;
- trable land per tractor varies from about 4 (Croatia) to 68 ha (Bulgaria);
- total number of combines is 63,000 units, of which almost 30,000 in Romania;
- tractor production is concentrated at 90% in Turkey (45,000 units per year).

All these countries will soon be EU members (Bulgaria and Romania) or intend to join EU (two are already candidate countries: Croatia and Turkey). Agricultural production plays an important role in their economy. All of them follow international and European standards.

Agricultural subsidies do not exist in Bosnia & Herzegovina, are limited in Turkey, Serbia and Croatia, are similar to EU subsidies in the two countries, which will soon join the EU itself.

3.2 Recommendations

- **Having recognised** that agricultural mechanisation is heavily influenced by legislation and subsidies, that this influence either in Europe or in other parts of the world should be clearly understood and that in addition stability and reliability are needed in legislation, both at national and at international levels;
- **having noted** that agricultural mechanisation correct and sustainable development is a complex mix of economy, sociology, infrastructure, soil and climate conditions;
- **having recognised** that when machines, besides working and harvesting, also gather information on soil, products, etc., then the link between legislation (e.g. food supply and safety, environment protection, renewable energy, animal welfare, …) and machinery becomes stronger and has a big influence for system production and new crops;
- **having noted** that in countries where farm size is medium/large there is a market for large companies and manufacturers of big and/or technologically advanced machines, while in countries characterized by small farms there is room for small manufacturers and less advanced machines, also affecting negatively mechanisation;
- **having noted** that world market features and prices and better life conditions will support the trend to bigger and specialised farms, to more information technology in the machines and to more links between farmers, suppliers, manufacturers and agricultural food industry;
- **having recognised** that not only large grain and forage farming should be considered, but also irrigation, livestock production, storage and processing;
- **having noted** that especially in the developing countries mechanisation is expanding with limited involvement of the academic world and that it is only based on external foreign contributions;
- **having recognised** that agricultural mechanisation should not have a negative impact on manpower employment.

The members of the Club of Bologna:

- **recommend** that politics regarding subsidies should be carefully adjusted to national circumstances including cost of environmental protection and alternative income sources;
- **underline** that worldwide standards (ISO, OECD, …) help to harmonise quality level of products as well as health and safety, taking into account that regulations should not overcome the development of mechanisation;
- **acknowledge** that attention should be paid to the proliferation of technical barriers to trade;
- **recommend** that it must be avoided to perform consecutive testing in different countries. It is necessary to establish agreements for worldwide test cycles, may be with different levels of requirements, in order to reduce the risks of protectionism and to help developing countries;
- **underline** that it is necessary to support and to better define the role of the universities and of the other research and development institutions in developing countries, concerning the new role of the agricultural machinery industry at a global level, in order to establish common links, co-operation and research activities;
- **recommend** that a data bank on agricultural engineering research institutions is established, so that contacts, relations, common researches may be facilitated and established;
- **acknowledge** that it exists a high gap between different areas in the world in terms of needs and opportunities: need

to feed a growing population (India); need for a better environment (Europe); opportunities of exports (South America). These needs should be connected to an increased productivity through mechanisation and to an improved technology in order to comply with traceability requirements, etc.;

- **underline** that standards and legislation should be agreed internationally, with the consideration of environmental legislation, since it affects agricultural production and agricultural machinery manufacturing;
- **acknowledge** that it is necessary to focus rural development as a world problem;
- **underline** that policy makers should respect decisions of former governments in order to guarantee a stable and predictable development frame. In effect the "reliability" of legislation, i.e. the predictability of the effects of legislation on the long- or at least the mid-term range, is of immense interest for investors , e.g. in renewable energy and resources;
- **acknowledge** that no-tillage systems should be emphasized outside North and South America, at least for energy crops, for biomass from food and non-food products;
- **recommend** that the influence of legislative measures relative to
- emission of ammonia green gases, animal health, welfare guidelines on the planning and the utilisation of agricultural machinery should be considered;
- **acknowledge** that a focus should be addressed to developing countries appropriate mechanisation, to study the effect of legislation/subsidies on the future of small farmers, who are the biggest majority of farmers in developing countries, as well the effect on the production of staple foods;
- **underline** that due to changes in economies and political conditions, farm equipment needs are going through a big change, to adjust them to meet the new opportunities, as following globalisation trade barriers are coming down and trade in agricultural commodities and farm equipment is increasing. Reduction in subsidies by developed countries to their farmers will provide better opportunities to developing countries to sell their products (both agricultural produces and farm equipments) in the international markets. This will help in improving the economic conditions of farmers in developing countries.