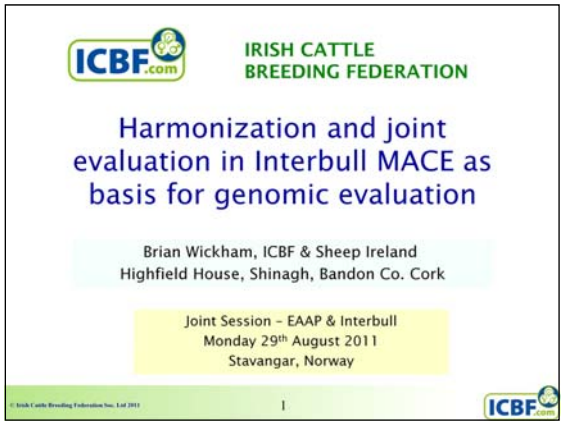


Thank you Chairman.

It is an honour to be the first speaker in this session devoted to Genomic selection - application, ownership, and economics in dairy cattle.

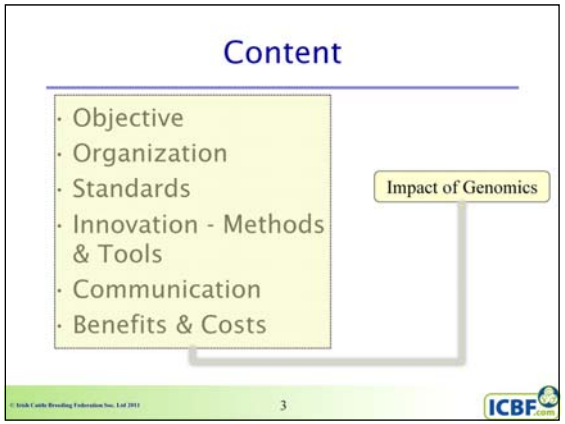
My presentation is focused on Interbull MACE, the structures that have made it possible and the extent to which this provides a good basis for genomic evaluations.

In putting this presentation together I became acutely conscious of the large number of people who have contributed firstly to the establishment of Interbull, and secondly to its on-going development and evolution. Today I wish to acknowledge one of these – Jan Philipsson. Jan in his role as Secretary of the Interbull Steering Committee, and as the guiding light of the Interbull Centre at SLU, has provided a perfect combination of vision, leadership, expertise, motivation and friendship. The dairy cattle breeding industry and dairy farmers world-wide are benefitting greatly from Jan's contributions to and through Interbull.

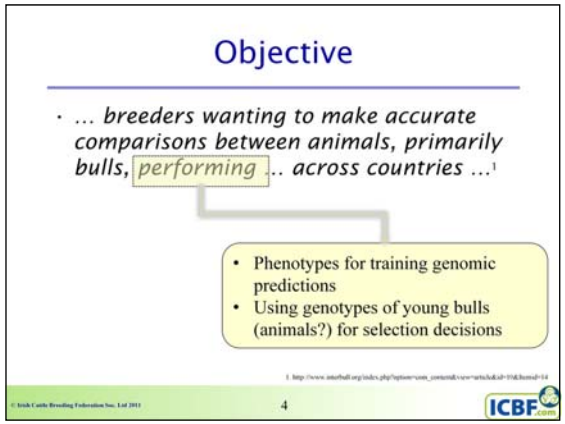
My approach is to identify and describe the key elements of Interbull by focusing on:

- Objective
- Organization
- Standards
- Innovation - Methods & Tools
- Communication, and
- Benefits & Costs

For each of these -



- I have highlighted the impact of genomic selection technologies, on each aspect of Interbull, using these cream coloured boxes. The key question being the suitability of the MACE Interbull structure as the base for ensuring the benefits of genomic technology to cattle breeding are fully realised world-wide. My focus is ultimately on the benefits to cattle farmers.



The reason that Interbull was established is summarised nicely in these words from the History section of the Interbull website:

… breeders wanting to make accurate comparisons between animals, primarily bulls, performing … across countries …

The focus of Interbull in partnership with its member animal evaluation units has been, and continues to be, on providing accurate evaluations of bulls used through AI, across countries. A key point is that the evaluations are primarily provided, after the fact, that is, after daughters have commenced a first lactation. This information until recently, was used to make most of the selection decisions on bulls, which by this time are typically five years or older, to breed female replacements in dairy herds world-wide.

That is now changing ….

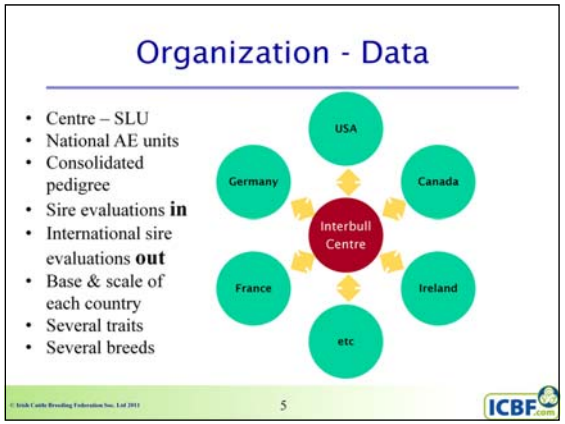
Click

… with genomics there need to be two significant changes to the objectives of Interbull.

Firstly, genomic predictions must be trained using a combination of known genotypes and known phenotypes for a suitably large and relevant population of animals. All countries, breeds, and populations stand to benefit substantially from access to phenotypes and genomics in other countries, breeds and populations.

Secondly, with accurate genomic predictions, bull selection decisions can and are now being made before they are one year old. This means that breeders now want to make accurate comparisons before they have daughters performing.

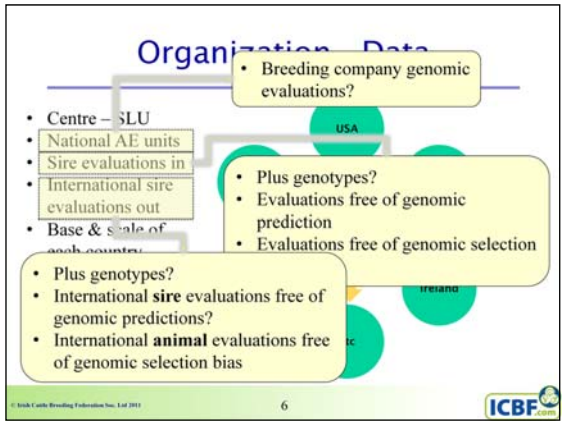
The objective of Interbull remains relevant but it needs to be extended to facilitate the training, and validation, of genomic predictions and also to support the provision of accurate comparisons of bulls (and cows) before performance data is available.



Interbull has established what has become known as the MACE system for international genetic evaluations. The key elements of this system include:

- The Interbull Centre located at the Swedish University of Agricultural Science (SLU) in Uppsala, Sweden. SLU was selected in an open tender to provide this service.
- National dairy cattle animal evaluation (AE) units is some thirty countries who send in:
  - pedigree data files which are consolidated at the Interbull Centre,
  - and files based on national sire evaluations,
  - for a range of trait groups and breeds.
- The Interbull Centre, or a subcontractors uses the MACE methodology to combine the pedigree and evaluation data to produce international sire evaluations which are sent out to the evaluation units. The MACE methods used account for genetic correlations of less than one between countries for the "same" traits.
- The international evaluations provided by the Interbull Centre are in the Base & scale of each country.

What is the impact of genomics on this system?



Firstly, several breeding companies, and some consortia of breeding companies, have started providing and marketing bulls on the basis of genomic evaluations produced outside of the traditional animal evaluation unit systems. Further, some of these are withholding the genotypes from the evaluation units. This is putting considerable pressure on the ability of the evaluation units, in relation to their national role and objective of providing accurate unbiased evaluations. What is the impact on Interbull?

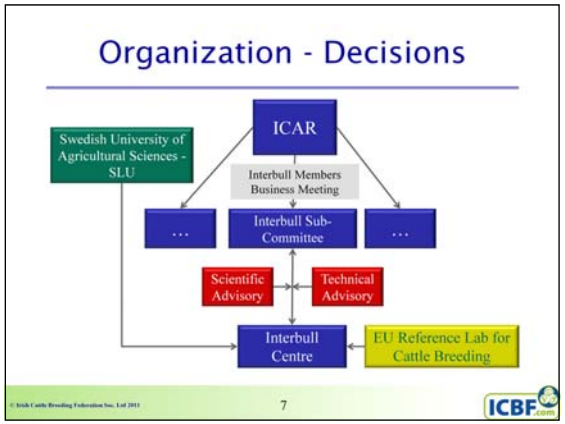
Click

Secondly, and perhaps alternatively, an extension to the data sent in to the Interbull centre should arguably include genotypes, evaluations free of genomic predictions and evaluations free from genomic selection bias.

Click

Thirdly, the outputs from the Interbull centre should arguably include genotypes, International MACE **sire** evaluations free of genomic predictions and International **animal** evaluations free of genomic selection bias but incorporating genomic information. The key point being that there are two needs: the need for evaluations that can be used to train genomic predictions and evaluations that can be used in selection decisions especially for young animals, males and females.

The MACE evaluation data flows provide a good starting point for extending the Interbull services to satisfy the information needs for genomic selection.



Interbull is an organisation with a well established and well proven decision making structure. This structure is largely unchanged from that established in 1991.

The key decision making body is the Interbull Steering Committee, a sub-committee of ICAR, which is accountable, through the annual Business Meetings to the members (primarily animal evaluation units) and to the wider community through ICAR and its reporting structures. The Steering Committee is aided in its decision making by advise from Scientific and Technical Advisory Committees. These committees play a very important role in ensuring Interbull's decisions are based on the best possible scientific and technical knowledge.

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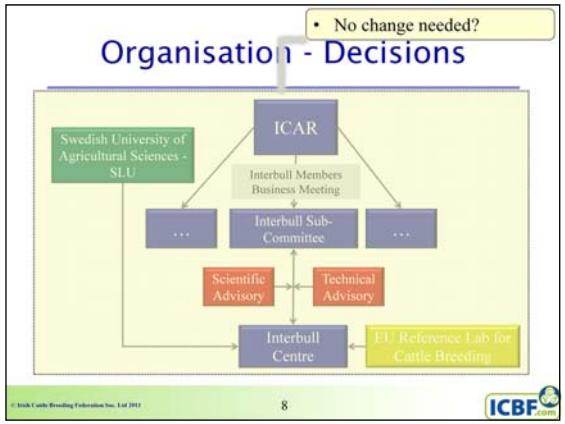
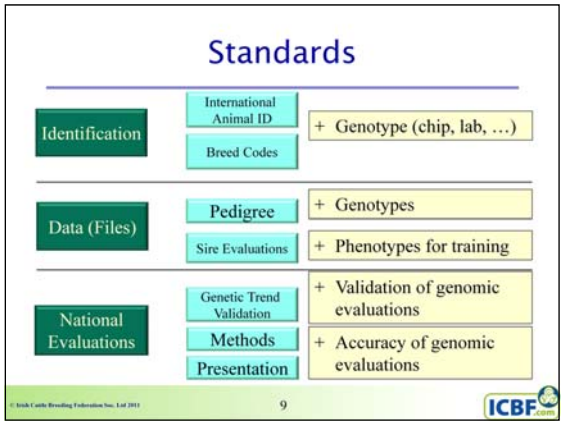


This structure which has been in existence for 20 years should be examined periodically and modified accordingly. However, at this point I cannot identify any significant changes that are necessitated by the arrival of genomic technologies.



Interbull, in keeping with the objectives of ICAR, has established a number of standards which have not only facilitated international genetic evaluations, but have also facilitated international trade in semen, embryos and livestock.

These standards include:

- Animal identification and breed codes – the Interbull ID which provides a world-wide unique ID, based on the ID of an animal in the country of its first registration. This system has proven suitable for males, females and has recently also been adopted for beef breeds.
- Data file layout and content for pedigrees and genetic evaluation data for use in MACE International evaluations. These file standards are also now used widely to facilitate the transfer of data for research purposes.
- Interbull's standards for countries to participate in MACE evaluations cover validation of genetic trends as a means of validating national evaluations, descriptions of models and methods used for national evaluations and recommended standards for information to be published as part of national evaluations. The impact on the quality of national evaluations of these standards has been very positive.

What new standards are needed to support genomic selection?

Click.

- **Identification** – there is a very real need to ensure consistent international identification of genotype results including laboratory, chip, SNP, allele. Arguably this is role for others – ISAG and the ICAR Working Group on Genetic Analysis. We just need a standard that can be used with confidence.
- **Data** – standards are needed for genotype files and for phenotype files for use in the training of genomic predictions. These standards need to address content, and layout. Interbull and its members have already gained considerable experience in working with and exchanging genotypes and phenotypes. Agreeing standards fits well with the role Interbull has been playing for MACE evaluations.
- **National Evaluations** – standards are needed for validation and for expressing the accuracy of evaluations that incorporate genomic data. Interbull has already made a good start in this arena.

To fully appreciate the context and impact of genomic evaluations we need to look to standards that are currently behind the scene of the current Interbull MACE evaluation system.

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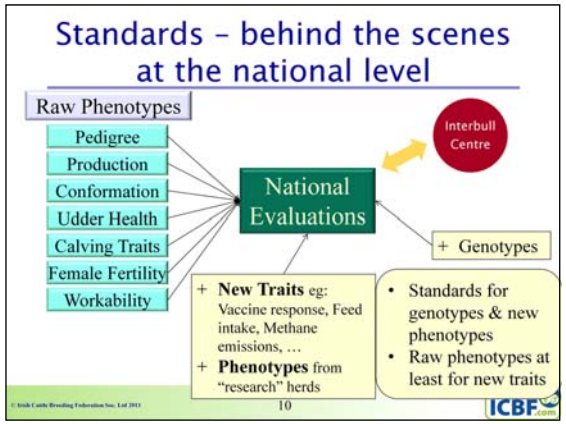

Interbull's MACE evaluations use the outputs of national sire evaluations. Behind the scenes in each country the raw phenotypes are combined with pedigree data to compute genetic evaluations for the range of traits and breeds now included in Interbull's MACE evaluations.

The standards and international guidelines for recording these raw phenotypes are the focus of other ICAR working groups and sub-committees. To a large extent we take this part of the Interbull MACE evaluations for-granted. Is this a safe assumption in a world of genomic selection?

Click

So far genomic selection has resulted in the accumulation of large numbers of genotypes from a rapidly expanding range of SNP chips (3k soon to be 5k, 50k and 800k). There is already a growing number of animals for which full gene sequences have been determined, at least in a research context.

Also, we are seeing research, both publically and privately funded, collecting a rapidly expanding range of phenotypes such as vaccine response, feed intake and methane emissions. Many of these phenotypes are expensive to measure and are being collected in "research" herds.

The challenges facing national evaluation units are two-fold:

1. How to incorporate this new data, which is accumulating nationally, into their genetic evaluations, and
2. How to incorporate this new data, accumulating in other countries, into their genetic evaluations.

I am hoping that these questions will be answered by the speakers that follow me.

However, there are two key points I would like to make in relation to the suitability of the traditional Interbull MACE model to assist.

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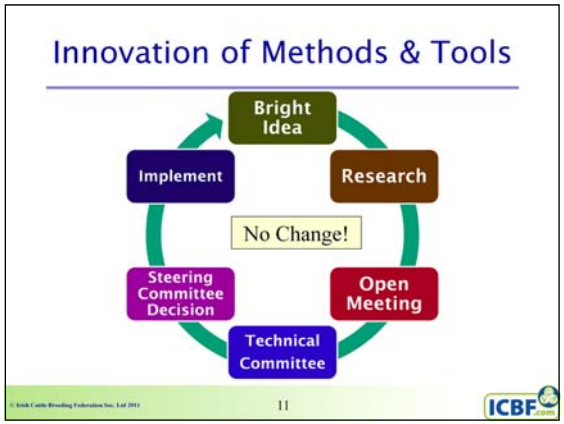
Firstly, Interbull and or ICAR, need to ensure the development of standards that cover genotypes and the new phenotypes as we must have systems which enable these to be shared (traded?) internationally.

Secondly, and this is where we have arrived at for **Interbeef** for all raw phenotypes, is that the raw phenotypes contain more information of potential value internationally than the sire evaluations, so that serious consideration should be given to expanding to scope of Interbull to consider genotypes and raw phenotypes at least for the new traits.



Interbull has a well established process for innovation especially with respect to the methods and tools that are used in providing MACE evaluations. This process of continuous improvement, under the guidance of the Steering Committee, has been following a series of steps:

1. The bright idea for an improvement.
2. Research largely funded outside of the Interbull budget to develop the idea, to assess the benefits, and to assess the practical implications of implementation.
3. The research results are shared openly – sometimes at the open meetings, other times in special workshops.
4. The technical committee is involved and advises the Steering Committee where the decision to implement is finally made.

This has proven to be a very robust process.

Does it need to change to accommodate genomics.

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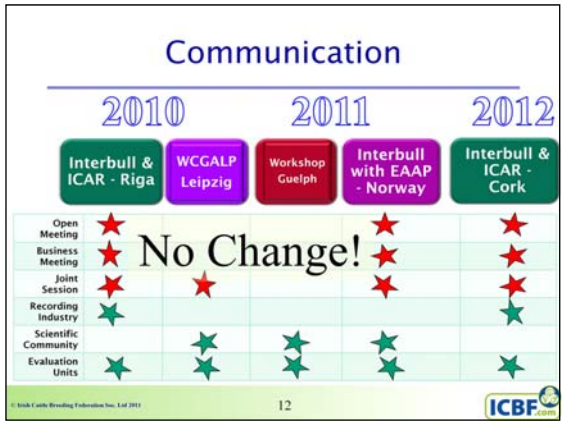
I do not think so.



A key element of Interbull is its communications with the scientific, research, evaluation units and wider breeding industry.

Look at how this is currently happening through meetings, joint sessions with EAAP & WCGALP and joint meetings with ICAR.

Do you know of a international structure that works and communicates better in any field? I do not.

This communication structure is the ideal base, and arguably is one of the reasons for the rapid adoption of genomic selection in dairy cattle breeding.

What change is needed?

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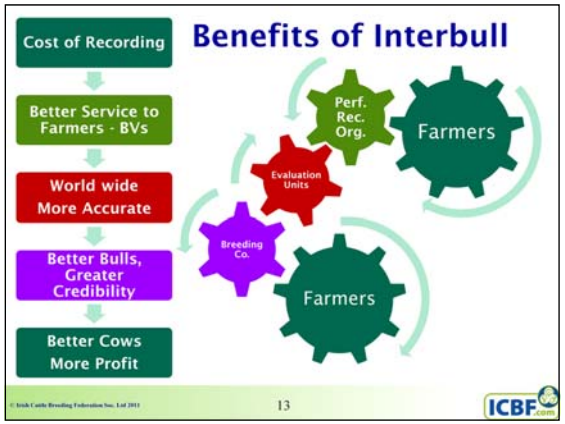
None!



This brings me to the final, and arguably most important, aspect of Interbull MACE. Are the benefits greater than the costs?

Since the costs of Interbull MACE are relatively small I will focus mostly on the benefits.

Interbull MACE delivers benefits through a process that starts with farmers and finishes with farmers.

Farmers are the source of virtually all the data used. The data is typically collected by performance recording organisations who pass it on to genetic evaluation units. Interbull works with the evaluation units who provide more accurate evaluations on the local base and scale.

It is the breeding companies, that is the companies that operate bull studs and provide semen and insemination services to herd owners, who, as a consequence of Interbull MACE are able to deliver better bulls, with greater credibility, to farmers.

The ultimate beneficiary is however the farmer who now has better cows, in an economic sense, and is thus able to improve the viability and sustainability of their business.

This is the model for Interbull MACE!

What is the impact of genomic selection on this benefit model?

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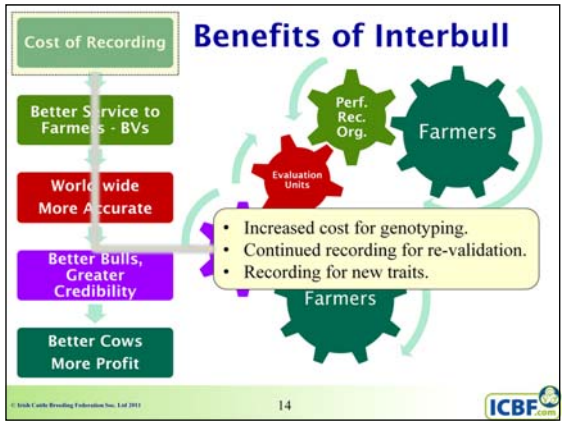

At the data source, the farmer:

1. There is a cost increase for genotyping
2. There is a need to keep recording as genomic predictions need to be refreshed and validated.
3. There are new traits to be recorded.

In short, there are increased costs at this end. This is not a primary concern for Interbull as long as this source of data is not compromised. A failure, due to extra costs or a perceived reduction on value, to record phenotypes and genotypes could ultimately compromise the ability of Interbull to facilitate the flow of information needed to ensure the future success of genomic selection.

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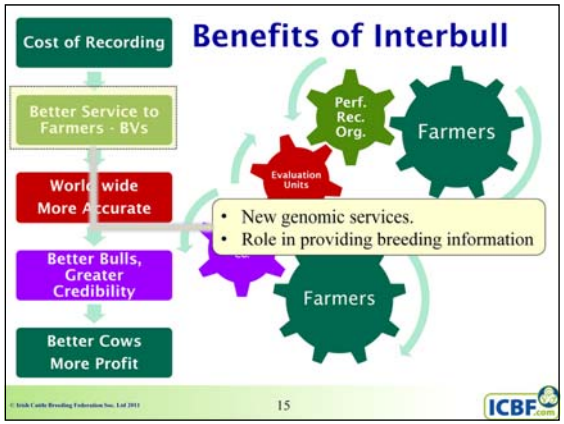

For the performance recording organisations genomics opens the opportunity to provide new information services and to provide more accurate breeding information on young animals.

These organisations are the source of the raw phenotypes that will be so important in future validation of genomic predictions.

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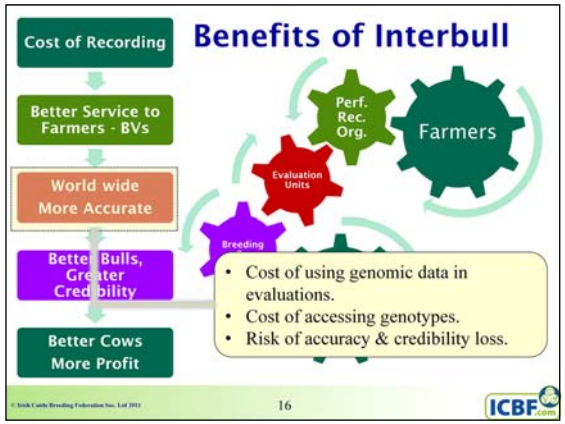

Genomics is presenting Animal evaluation units with major challenges:

1. Establishing systems, and accessing training populations, in particular with genotypes, by and large they already have access to phenotypes, requires considerable resource and expertise.
2. The reputation of Animal evaluation units, as being independent of bull owners, is also coming under threat where they become tied in with a limited number of breeding companies.
3. There is a particular issue with genomic pre-selection causing biases in genetic evaluations if the genotypes of the animals considered for selection are not available to the animal evaluation unit.

Given the close relationship between the units and Interbull this is an area where the current Interbull model needs to be reviewed to ensure it is appropriate in the era of genomic selection.

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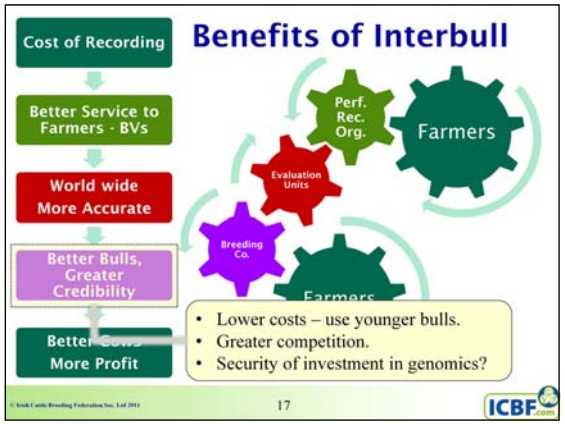

The breeding companies stand to benefit greatly from genomic selection. It enables substantial cost savings through the use of bulls at a younger age, and a reduction on the cost of progeny testing.

However, breeding companies face the risk of increased competition of new-entrants and the risk of being unable to reap the rewards of their investments in genomic technologies. Any failure to maintain investment levels is likely to compromise the ability of the breeding industry to deliver the benefits, and protect against the risks, of using genomic selection.

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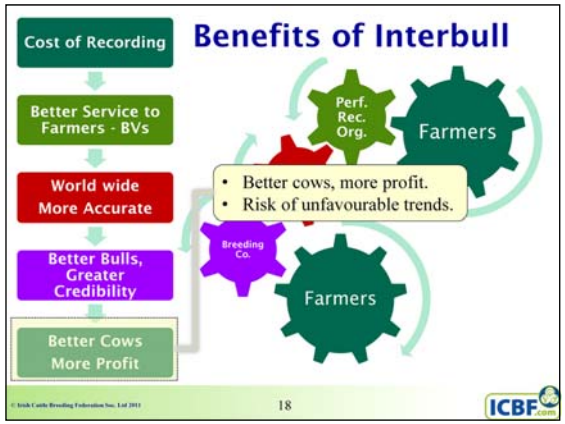

For farmers there is a very large potential benefit from genomic selection – "*double rates of genetic gain at half the cost*". Across the dairy industries in those countries participating in Interbull this is worth many hundred million €.

However, there are also a couple of risks that have the potential to reduce or even eliminate these benefits:

a. Unfavourable trends in traits not measured, and
b. A loss of genetic diversity.

Interbull is well placed to provide the information needed to monitor both of these risks, especially if it is able to monitor trends for those expensive to measure phenotypes – disease resistance, feed intake, green house gases ….

So, in summary:

Traditional Interbull is an excellent structure and base for helping the breeding industry to exploit genomics.

The structure and operations of Interbull need to be modified to accommodate this new technology.

The big challenge is to ensure farmers worldwide benefit from the use of genomic technologies and are protected from the risks.