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SmartCow: an integrated infrastructure for increased research capability and innovation in the European cattle sector

an integrated infrastructure for increased research capability and innovation in the European cattle sector

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SmartCow
an integrated infrastructure for increased research capability and innovation in the European cattle sector

EXECUTIVE SUMMARY

Background

The Scientific Advisory Board (SAB) is composed of international leaders recognised for their scientific expertise in a field of importance to SmartCow. It will provide the Executive Committee with strategic feedback regarding the project progress and contribute to maintain scientific and technological excellence of the project. Scientific Advisory members will be invited to attend the project meetings and workshops where appropriate to provide advice for improvement and/or reorientation of the project, and to get their feedback on project outputs. They will have access to the EC periodic reports, deliverables and publications (prior the beginning of its activity, each member will enter into a non-disclosure agreement). The Scientific Advisory Board will be also requested to evaluate the sustainability of the SmartCow, and to provide advice when applying for an advanced community.

Organisation	Name	Expertise	Country
Federal Institute for Animal Health, Institute of Animal Nutrition, Braunschweig	Prof. Dr. Sven Dänicke	Ruminant Nutrition and Physiology	Germany
University of British Columbia	Prof. Jeffrey P. Rushen	Animal Welfare, Animal Health, Animal Ethics	Canada
AAC - Lethbridge Research Centre	Dr. Karen Beauchemin	Ruminant Nutrition, Emissions	Canada
Iowa State University	Prof. James Reecy	Cattle genetics and genomics, Animal trait ontology, Computational biology	USA
INRA-IFREMER	Dr. Marc Vandeputte	Research Infrastructures (AquaExcel^{2020} coordinator)	France
Agroknow	Dr. Nikos Manouselis	Computer Engineering, Management, sharing and discovery of agricultural data (co-founder and CEO of Agroknow)	Greece

Objectives

The objective of the second report of the SAB was to give feedback on the progress made by the project after three years and advices for the last months of the project and beyond.

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Methods	The second periodic report and the slides of the annual meeting hold in October 2021 were provided to the SAB members together with a template including general and more specific questions to the different WPs. All SAB members were invited to answer to the general questions and to the specific questions depending on their fields of expertise.
Results & implications	Four of the six members were available to fill the template and give their feedback on the project. The SAB members underline the quality of the management of the project and the fact that despite the pandemic situation the project was able to maintain most activities and to make significant progresses. They point out the unique collaboration across partners to develop harmonized protocols, standardize techniques, and collate data across institutions. They express very positive comments on the different activities conducted in the project and on the main outputs, in particular the Book of methods, the successful TNA programme, the interaction with stakeholders, the training of young scientists, and the results of research to improve methodologies in cattle nutrition, to develop proxies to predict feed efficiency and emissions, and to use activity sensor data to early predict cattle health disorders. The main recommendations addressed by the SAB to the SmartCow consortium to strengthen the outcomes and the impact of the project are to encourage scientists to use the ontologies in their papers, to promote the Book of Methods, to continue to publish the findings of JRAs in good quality, peer reviewed international scientific journals, and to be more intentional about getting the findings of the project directly implemented in industry. For the future, SAB members are thinking that i) a continuation of joint European cattle research is urgently required to cope with the future political and societal challenges, ii) there would be strong justification for a SmartCow 2 to continue this work into future years, and iii) the creation of a European Research Group (ERG) to continue exchanges between partners and the participation to the Agroserv proposal to continue TNA activity are reasonable perspectives. The SmartCow executive committee will consider the valuable recommendations of the SAB members for the last months of the SmartCow project (extended until end of April 2022), to implement the roadmap of the SmartCow ERG that will be signed for 4 years, and to seize opportunities for new projects according to the calls for proposals for research infrastructures in Horizon Europe.

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SmartCow
an integrated infrastructure for increased research capability and innovation in the European cattle sector

What is your opinion on the work performed by the project so far?

a) Quality of the results reached so far
b) Quality of the management of the project
c) Other comments on the work done by the project Partners

Prof. Dr. Sven Dänicke	All WPs made good progress in achieving project objectives, although this was still difficult under ongoing pandemic conditions. Despite ongoing Covid-related constraints, I am confident that most objectives can be met as planned.
Dr. Karen Beauchemin	a) The quality of the research is very high and extremely relevant to the E.U. and globally given the recent signing of the International Global Methane Pledge to reduce methane by 30% between 2020 and 2030. The science generated is very important in terms of measurement and mitigation of enteric methane and will serve as important groundwork for international mitigation efforts. b) This is a very complicated research project with many different partners, conducting multiple work packages with numerous deliverables. On top of the complicated structure, Covid-19 has imposed an added level of constraints. The project management has been able to keep the project mostly on tract despite these difficulties. c) The work (and published book) of standardizing methodologies and methane measurements is an important accomplishment. This handbook will serves as a useful guide for other researchers, especially young career scientists. Transfer of "know-how" from experienced researchers to early career researchers and students is important for subsequent generations.
Prof. James Reecy	a) Quality of the results reached so far i) Each of the work packages has been able to complete the tasks that were established in the beginning of the project. ii) The output between WP varies greatly, but this was by design iii) The development of databases of facilities and protocols is very valuable. However, this is something that will be time consuming to maintain over time. (1) It was nice to see how these efforts will help other disciplines in the future, e.g., expansion of ontologies iv) It was nice to see that the project has worked to remain in communication with stakeholders v) The work done to standardize protocols and to test/validate facilities is very important. Very few projects that this approach to ensure that the results they are getting are as trust worthy as possible. b) Quality of the management of the project i) The project has been very well managed. I am impressed how well the leadership team has worked together over these interesting times c) Other comments on the work done by the project Partners i) I hope that the foundation developed in this project can be leveraged to future success.
Dr. Marc Vandeputte	The project has globally reached its objectives, which were rather ambitious, and this despite of Covid-19. The partners and the management should be appraised for that

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2) Do the results obtained so far match the promises of the project? What are the most significant results that should be highlighted from your point of view? (*You can comment the following items according your area of expertise and interest)*

Mapping of RIs, harmonisation of methods, ontologies and data sharing (WP1, WP3)

Prof. Dr. Sven Dänicke	Interactive map was improved by implementing filters for various cattle categories as one task of **WP1**. By doing so, dairy and beef cattle research facilities are easily recognizable for possible future potential users. Project aims are generally achievable. The open book of methods is regarded as an important output of SmartCow within the frame of **WP3**. The consortium is further encouraged to promote this book through either a book review or an opinion paper to be published in an open access journal. This would make the open book easily recognizable for all involved in cattle research and to foster the idea of using standardized methods of research for a better evaluation and comparability of generated research results.
Dr. Karen Beauchemin	Mapping of RIs, harmonisation of methods, ontologies and data sharing (WP1, WP3): Harmonizing methods, especially the ring test of methane chambers and identifying critical points, is important and ensures quality methane data are being collected in the project and in subsequent studies. Data sharing is leading to important meta-analysis.
Prof. James Reecy	This is a good resource that appears to be very through. It will be time consuming to maintain these resources, except for the ontologies as they will continue to be built upon.

Transnational access (WP2)

Prof. Dr. Sven Dänicke	For WP2 in general; projects which were launched for the calls are partly finished, ongoing and just started. Only a few projects were withdrawn for technical reasons or for failing co-financing possibilities. Overall, it can be stated that the large number of projects covering a broad field of important scientific questions related to important issues in the cattle sector were managed in such a way that European networking became quite obvious. As this networking was a main goal of SmartCow the large number of performed projects indeed reflected the successful progress of the overall project goals.
Dr. Karen Beauchemin	Interesting to see the participation of the private sector in terms of committing to conducting research studies at these facilities. This is important as some of the mitigation solutions, especially diet related, will come from industry. Industry working with the research community will advance the adoption of mitigation at the farm level.
Prof. James Reecy	The processes developed and followed by the project team members appears to have been very effective.
Dr. Marc Vandeputte	The objectives here have been mostly reached, which is not easy for a starting community. This highlights the relevance of the SmartCow infrastructure.

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Dissemination activities, stakeholder engagement, training activities (WP4)

Dr. Karen Beauchemin	This is a strength of the project. On-going dissemination can be difficult to implement during a research study, especially with Covid-19 restrictions. The web page has greatly improved over the course of the project and there have been numerous training initiatives and presentations. Producing a SmartCow video will be an asset.
Prof. James Reecy	The project has been very intentional in its dissemination of research findings, which is good.
Dr. Marc Vandeputte	The project has participated in a number of workshops and has performed a large number of trainings. This is key in ensuring visibility, and for training a new generation of researchers The book of methods is a great achievement, and the idea of a living handbook is excellent (although this implies finding how to make it live in the longer term). The book should however be more publicised In general, projects results on the website are present but seem a bit scarce. Only one publication (the handbook). Is it a lack of update?

Joint research activities:

Refinement of gold standard methods in cattle nutrition (WP5)

Prof. Dr. Sven Dänicke	Calibration of respiration chambers available in the European infrastructure was performed as a task of **WP5** in most of the available facilities in spite of the ongoing pandemic situation. These ring tests are quite important for comparing experimental results regarding methane emissions and to get an impression about variance to be expected. Moreover, based on the statistical evaluation of the test results and the derived calibrations correction factors were derived enabling to report standardized methane emissions. This is a quite important outcome of the work package as respiration chamber results generated across Europe become better comparable than in the past which might also contribute to more harmonized data base usable by scientists, managers and decision makers. Meta-analysis of Nitrogen balance dataset revealed interesting insights in the relationships between overall N-fluxes in cattle and sources of errors in estimation of N-retention based on balancing the fluxes. Planned publication of these evaluations is highly recommended to make data base and models of evaluation available for a broad readership.
Dr. Karen Beauchemin	The objective was to standardise operation procedures for digestion trials, N balance procedures and methane emissions. The ring test for the respiratory chambers identified the weaknesses at each facility, which helped standardise operational procedures for methane measurements. For the digestion and N balance studies the data sharing and meta-analysis identified the experiment to be a strong source of variation, which can be attributed to operational procedures. It is not clear whether this will lead to the researchers identifying procedures that need to be standardized across locations. As noted in a previous assessment report, it can be difficult to standardize these kinds of measurements due to the unique circumstances at each research location, combined with disagreement among researchers on what constitutes a best practice.
Prof. James Reecy	This may be one of the most impactful efforts of the project. The improvements made will have a long-term lasting impact. The ring test have made a huge impact on the ability of folks to trust the quality of the data. This work is to be commended.

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Dr. Marc Vandeputte	Global comment on WP5, 6 and 7. I think the work done in the JRAS has been performed to a high level, and really brings potential for improved services. It needs to be better publicized, especially in peer-reviewed publications, as these will form the basis for future science based on the findings of the JRAs.

Proxies of nutrient efficiency and emissions and their components (WP6)

Prof. Dr. Sven Dänicke	Great efforts were made by WP6 to test a number of proxies for feed efficiency by using either scientifically based indicators or parameters available at the farm level. A great potential was shown for some of them while for others rather loose associations were stated and require further data.
Dr. Karen Beauchemin	The project has made good advancements in terms of assessing proxies for methane. Some of the work has been published, with other publications expected in 2022. This work will need to be validated in subsequent directed studies, but it is still noteworthy.
Prof. James Reecy	Proxies of nutrient efficiency and emissions and their components (WP6) The standardization of protocols is important. This helps in the comparison of data across projects. This will be important, as larger and larger datasets will be needed to address higher order questions that cannot be done with a single experiment.

Sensors techniques to assess cattle behaviour, health and efficiency (WP7)

Prof. Dr. Sven Dänicke	Integration of sensor data, as a main objective of WP7, into management decisions plays an increasing role in the view that number of farms decrease while number of animals per farm increases at the same time. In this situation continuous recording of vital and health traits by using sensors is very useful to ensure taking immediate action when relevant deviations are recognized. Moreover, sensor data were also shown to be useful as predictive measures. Here, sensor-derived activity and vital pattern before calving were shown to be a promising tool for prediction of post calving risk for certain metabolic disorders and infectious diseases.
Prof. James Reecy	Sensors techniques to assess cattle behaviour, health and efficiency (WP7) This work is important if we are going to make the jump from time-consuming expensive assays to something that is more timely and cost effective. All of this will be important as we try to implement these traits in the industry.

Ethics and 3Rs implementation (WP8)

Prof. James Reecy	It appears that the ethics board was helpful in making the efforts even more impactful. This was nice to see the processes developed and used were very helpful, for example the Material transfer agreement. Parties knew what was expected of them.

3) Do you see any problem emerging in the project or do you have some worries about it?

Prof. Dr. Sven Dänicke	The ongoing pandemic situation might delay finalizing experiments and reports etc. which should be considered by the project management agency.
Dr. Karen Beauchemin	No major concerns. Most deliverables are achievable and on time (with the extension). Some further outputs from the study may occur after its completion.
Prof. James Reecy	Just what is the continued impact of COVID on all things.
Dr. Marc Vandeputte	I see no emerging problems, but it would be good that the results are published in peer-reviewed journals to give them more impact

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4) Would you have any suggestions to improve the outputs of some tasks of the project, the exploitation of the results and the impact of the project?

Prof. Dr. Sven Dänicke	The consortium is encouraged to publish an opinion paper on the book of methods in an open access Journal with high priority (see above) as I regard this book as a main output of the project strongly projecting into the future of European and global cattle research.
Dr. Karen Beauchemin	The authors are encouraged to continue to publish the findings in good quality, peer reviewed international scientific journals to increase the visibility and impact of the project.
Prof. James Reecy	It would be nice to see the project be more intentional about getting the findings of the project directly implemented in industry. The communication with industry has been good, would love to see direct impact result. Age old problem for most projects.
Dr. Marc Vandeputte	It is difficult to see the impact of the ontologies. Ontologies are conceptually important, but become useful only insofar as they are used. It would be good is all researchers implied in the project (project members and TNA users) used the ontologies in their published papers

5) What are your feelings about the plans for the future of SmartCow?

Prof. Dr. Sven Dänicke	I hope that the plans of the consortium for continuation the project within another frame of European funding will be successful. Again, as the consortium contributed a good piece of net-working in cattle research and strengthened its collaborative character a continuation of joint European cattle research is urgently required to cope with the future political and societal challenges.
Dr. Karen Beauchemin	A lot of work has gone into establishing this unique collaboration across groups. Emphasis was on developing harmonized protocols, standardizing techniques, and collating data across institutions. Additionally, some very sound basic understandings and principles have been developed. Based on this ground work there would be strong justification for a SmartCow 2 to continue this work into future years, using SmartCow as a spring board. The harmonization of standard operating procedure and coordinated approach to research will help the European cattle sector as a whole to face the challenges of sustainable production, in terms of production economics, animal well-being, and environment (efficient use of resources, enteric methane mitigation). Additionally, the project creates tremendous opportunities for development of highly-skilled trained young researchers to ensure future capacity within the cattle sector.
Prof. James Reecy	Overall, I believe the that the project has been very successful. The foundation laid here has the potential to continue to have impact well beyond the scope of the current project.
Dr. Marc Vandeputte	The best would be to obtain a SmartCow 2 in the next INFRA WP. The alternatives envisaged until then (ERG for exchanges between partners and Agroserv for TNA) are reasonable ones.

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6) Synthesis and comments by the SmartCow coordinator and Executive Committee members

The SAB members underline the quality of the management of the project and the fact that despite the pandemic situation the project was able to maintain most activities and to make significant progresses. They point out the unique collaboration across partners to develop harmonized protocols, standardize techniques, and collate data across institutions. They express very positive comments on the different activities conducted in the project and on the main outputs. In particular SAB members highlight following achievements and results of SmartCow:

- The interactive map of cattle RIs and the database of technologies and equipment
- The book of methods as a living handbook
- The improvement of cattle ontologies
- The successful TNA programme and in the industry involvement in TNA projects
- The improvement of the project website, the good interactions with stakeholders and the training programme targeted to young scientists
- The ring-test to better calibrate and standardize methane measurements made in respiration chambers
- The identification of source of variation and errors in digestion and N balance studies to make datasets more comparable across installations
- The assessment of available proxies to predict enteric methane emissions and feed efficiency, and the identification of proxies that requires further data.
- The promising results from data of cattle activity and behaviour obtained by sensor techniques to predict certain metabolic disorders and infectious diseases.

The main recommendations and questions addressed by the SAB to the SmartCow consortium to strengthen the outcomes and the impact of the project in the last months and to prepare the future of the project are:

- Commit the resources needed to maintain and update of the interactive map and the RIs data bases as it may be time consuming.
- Encourage scientists to use the ontologies in their papers to reinforce their dissemination.
- Promote the Book of Methods through the publication of a book review or an opinion paper
- Continue to publish the findings of JRAs in good quality, peer reviewed international scientific journals to increase the visibility and impact of the project.
- Be more intentional about getting the findings of the project directly implemented in industry
- For the future SAB members are thinking that
    - A continuation of joint European cattle research is urgently required to cope with the future political and societal challenges.
    - Based on this ground work there would be strong justification for a SmartCow 2 to continue this work into future years.
    - As there is no more possibility to continue as an advanced community in Horizon Europe work programme, the alternatives envisaged until then (ERG for exchanges between partners and Agroserv for TNA) are reasonable ones.

The European Research Group agreement (ERG) to continue the SmartCow consortium on the basis of in-kind contributions is under signature and will start from the 1st February 2022 for 4 years. The recommendations of the SAB members are very valuable to define the roadmap of the ERG. During the last months of the SmartCow project (the project was extended to 30th April 2022) and the first year of the ERG we will put the main efforts on the valorisation and the dissemination of the results obtained in SmartCow (JRAs, collaboration in TNA projects) as scientific publications in peer reviewed journals and through the organisation of the final conference of the project and of a second SmartCow session at the

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annual EAAP conference in Porto. In the ERG we'll also put efforts on the enrichment of the SmartCow Book of Methods, on the dissemination and the effective use of animal traits ontologies and on training activities for young scientists.

If the INFRA-SERV proposal AgroServ is accepted, we'll have to develop a new TNA programme, more focussed on the agro-ecological transition of cattle breeding, and TNA services that integrate as much as possible, plant, animal and food science along the food chain. We'll also start a reflexion about the opportunity to develop a proposal to the next INFRA-TECH calls scheduled in 2023-24 that could be focussed on "tools for phenotyping and monitoring livestock in the context of climate change and the agro-ecological transition".

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