EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Brussels, 23 June 2017

COST 041/17

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "Combatting anthelmintic resistance in ruminants" (COMBAR) CA16230**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action Combatting anthelmintic resistance in ruminants approved by the Committee of Senior Officials through written procedure on 23 June 2017.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA16230
COMBATTING ANTHELMINTIC RESISTANCE IN RUMINANTS (COMBAR)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. "Rules for Participation in and Implementation of COST Activities" (COST 132/14);
b. "COST Action Proposal Submission, Evaluation, Selection and Approval" (COST 133/14);
c. "COST Action Management, Monitoring and Final Assessment" (COST 134/14);
d. "COST International Cooperation and Specific Organisations Participation" (COST 135/14).

The main aim and objective of the Action is to create a network; foster the scientific exchange of knowledge required to combat anthelmintic resistance and bring acknowledged experts in the field of sustainable control of helminth parasites in livestock, together to support the implementation of new tools and approaches in the field.. This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 52 million in 2016.

The MoU will enter into force once at least five (5) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14.

COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

TECHNICAL ANNEX

OVERVIEW

Summary

Helminth parasitic pathogens cause severe disease and are amongst the most important production-limiting diseases of grazing ruminants. Frequent anthelmintic use to control these infections has resulted in the selection of drug resistant helminth populations. Anthelmintic resistance (AR) is today found in all major helminth species across Europe and globally. COMBAR will advance research on the prevention of anthelmintic resistance in helminth parasites of ruminants in Europe and disseminate current knowledge among all relevant stakeholders. By gathering parasitologists, social scientists and agricultural economists, COMBAR will bring together a multi-disciplinary blend of scientists that do normally rarely interact. Inclusion of SMEs and industry in the consortium will facilitate the dissemination of knowledge and novel technologies to the animal health playing field. COMBAR will integrate novel developments in the field of (i) diagnostic tests; (ii) vaccines to protect animals from infection; (iii) anti-parasitic forages, (iv) selective treatment strategies and (iv) decision support tools. By evaluating those novel technologies and assessing their economic trade-offs and barriers to uptake in a European coordinated approach, COMBAR will tackle AR.

Areas of Expertise Relevant for the Action	Keywords
● Veterinary science: Veterinary medicine (miscellaneous) ● Animal and dairy science: Parasitology ● Animal and dairy science: Prevention and treatment of infection by pathogens (e.g. vaccination, antibiotics, fungicide)	● anthelmintic resistance ● ruminants ● diagnostics ● socio-economics ● sustainable control

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination

● To bridge the gap between the different disciplines that have developed individual approaches to tackle AR in ruminants: diagnostic development, vaccine research, targeted selective treatment approaches, decision support.

● To bring on board techniques and knowledge from previously untapped areas of science, more specifically, (i) the economic sciences to understand the financial benefits and trade-offs involved in implementing new methods and (ii) the social sciences to understand human behaviour with regards to helminth control practices

Capacity Building

● To organise training in new techniques enhancing sustainable helminth control practices, e.g. Novel laboratory and point-of-care diagnostics for helminth infections and AR; Non-chemoprophylactic control approaches; Modelling helminth epidemiology and control measures; Economics of animal health and production; Socio-psychological science methodologies in animal health research.

● To establish links with the private sector and organise dissemination activities to achieve translation of the novel technologies and insights to the market.

1) S&T EXCELLENCE

A) CHALLENGE

I) DESCRIPTION OF THE CHALLENGE (MAIN AIM)

Cattle, sheep and goats are parasitized by various helminth species, the most important being the gastrointestinal nematodes (GIN) and liver fluke. These pathogens can cause severe disease and affect productivity in all classes of stock, and are amongst the most important production-limiting diseases of grazing ruminants in Europe and globally (e.g. www.discontools.eu). Essentially, all herds/flocks in a grass-based production system are affected and the major economic impact is due to sub-clinical infections causing reduced growth and milk/wool production. A recent comprehensive study, funded by the EU-GLOWORM project, investigated the economic burden of helminth parasitism on the EU livestock industry. Results indicated a staggering annual loss of €2.3 B in dairy cattle and €1.1 B in meat production from sheep caused by GIN alone.

A major constraint on the control of helminth infections in livestock is treatment failure due to anthelmintic resistance (AR). Frequent, indiscriminate or inappropriate use of anthelmintic drugs to control these parasites has resulted in selection of drug-resistant helminth populations. AR is now widespread in all the major GIN of sheep and in liver fluke, and is an emerging problem in cattle parasites. If no alternatives to current control procedures become available, pasture-based livestock industries will suffer major economic losses or may even become financially unsustainable. Previous research projects have attempted to tackle AR nationally but have achieved limited change in the way anthelmintics are used. It is therefore time to coordinate and exchange research efforts at European level. The main aim of this proposed COST Action is to create a network; foster the scientific exchange of knowledge required to COMBAT AR and bring acknowledged experts in the field of sustainable control of helminth parasites in livestock, from across Europe and beyond, together to support implementation of new tools and approaches in the field. This will be delivered through networking, communication and education tools provided via the COST framework to: (i) assimilate existing scientific knowledge between participants; (ii) discuss and agree future research priorities and (iii) share technical know-how, best practice advice and novel approaches with key stakeholders.

II) RELEVANCE AND TIMELINESS

Antimicrobial resistance (AMR) has been identified as one of the most important health threats across the globe. AR, which is also part of the broader AMR phenomenon, is now established as a major constraint on sustainable livestock production worldwide and affects multiple helminth and host species. A systematic review of the scientific literature was recently undertaken to record the distribution of AR in the major GINs affecting sheep, goats and cattle across Europe. This study revealed that AR in GINs was widespread in Europe, being reported in all five GIN genera and across 16 European countries, with the potential for high regional prevalence (e.g. reaching up to 93% for benzimidazole (BZ)-resistance in goats in Western France). Multi-drug resistance (MDR), was confirmed in sheep and goats in 10 European

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countries, but is likely to be considerably more widespread than reported. AR is leading to the inability to control helminth parasites sustainably and is impacting negatively on the productivity and efficiency of the European livestock sector.
In order to address the problem of AR, innovative strategies are required, involving the use of improved diagnostic tests to detect AR, selective worm control strategies that slow down the development of AR, protection of animals by vaccination and software tools that support smart treatment decisions. Major efforts are needed in order to integrate these different aspects of helminth control; to disseminate up to date knowledge on a European scale and to accelerate developments by bringing this new knowledge and technology to the various stakeholders in animal health. In the era of antimicrobial resistance, where there is an increasing realization that the way anti-infective pharmaceuticals are used must be changed, the time to devise guidelines on how to manage and prevent the spread of AR is now.

B) SPECIFIC OBJECTIVES

I) RESEARCH COORDINATION OBJECTIVES

The general objective of this Action is to advance, consolidate and disseminate research and knowledge on the prevention of AR in helminth parasites of ruminants. Previous research has resulted in the evaluation of innovative strategies to mitigate AR. More specifically, through the development of (i) novel diagnostic tests for helminth infections and detection of AR; (ii) vaccines to protect animals from infection and prevent further spread; (iii) targeted selective drug treatment strategies and (iv) decision support tools. However, none of these initiatives can tackle the spread of AR on their own. Researchers from these different disciplines need to interact for developing more comprehensive and effective means to manage AR and, moreover, to implement these tools in the field. So far, the knowledge of each of these disciplines has largely remained concentrated within specialised research projects and associated consortia.
The aim of this Action is, therefore, to bridge the gap between the different disciplines that have developed individual approaches to tackle AR in ruminants. This will result in new, smart combinations of alternative and complementary technologies and best practice guidelines. In order to reach the major players in the animal health industry, it must be understood how veterinarians, farmers and pharmaceutical companies perceive helminth control and how proposed approaches to tackling AR can be implemented successfully under different environments and husbandry practices throughout Europe. Therefore, techniques and knowledge from previously untapped areas of science need to be brought on board, more specifically, (i) the economic sciences to understand the financial benefits and trade-offs involved in implementing new methods to fight AR and (ii) the social sciences to understand human behaviour with regards to helminth control e.g. anthelmintic product choice, and barriers to uptake of best practice advice.

II) CAPACITY-BUILDING OBJECTIVES

Several innovative technologies (from diagnostics to vaccination and decision support tools) to combat AR in ruminants have been proposed, but have so far only been employed in narrow geographical or experimental settings. It is key to spread and further develop the knowledge to combat AR across Europe and bring these novel technologies to the animal health sector. This Action will, therefore, place strong emphasis on the organisation of training in new techniques and establishing links with the private sector to achieve translation of these novel technologies to the market. The technical know-how of the network will in this way support efforts to take new tools to market and enable them to be more fully used by veterinary practitioners and farmers.
Therefore, training workshops and STSMs will be organized on specific topics:

- Novel laboratory and point-of-care diagnostics for helminth infections and AR.
- Non-chemoprophylactic control approaches.
- Modelling helminth epidemiology and control measures.

- Economics of animal health and production.
- Socio-psychological science methodologies in animal health research.

In addition, the Action will organize pilot studies on market introduction of multi-species diagnostic tools and an Exhibition/Fair to showcase academic technology to animal health companies both at national and European level.

C) PROGRESS BEYOND THE STATE-OF-THE-ART AND INNOVATION POTENTIAL

I) DESCRIPTION OF THE STATE-OF-THE-ART

Cattle, sheep and goats are parasitized by various helminth species, the most important being the gastrointestinal nematodes (GIN) *Ostertagia ostertagi* and *Cooperia oncophora* in cattle and *Haemonchus contortus, Teladorsagia circumcincta*, and *Trichostrongylus* spp. in small ruminants and the liver fluke, *Fasciola hepatica,* in both hosts. These parasites can cause severe disease and affect productivity in all classes of livestock, and are amongst the most important **production-limiting diseases** of grazing ruminants in Europe and beyond (www.discontools.eu).

Currently, parasitological diagnosis of helminth infections in livestock is rarely carried out because it is mostly based on microscopic examination of faecal samples for parasite eggs, which is comparatively labour intensive and consequently expensive. Recently, ELISA-based diagnosis, using non-invasive bulk tank milk samples, has become commercially available for *O. ostertagi* and the liver fluke *F. hepatica* [1, 2]. These tests were shown to provide meaningful herd worm infection status information and associated production impact assessment at low costs. Most recently, microbead-based multiplex assays for the simultaneous detection of antibodies directed against *C. oncophora*, *F. hepatica* and the bovine lungworm *Dictyocaulus viviparus* have been developed for both serum and bulk tank milk samples [3]. Rapid DNA-based diagnostic tests are also under development and evaluation e.g. multiplex tandem PCR (MT-PCR) [4] and Loop-mediated Isothermal Amplification (LAMP) methodologies [5]. These new diagnostic tools now await implementation in routine flock and herd health monitoring programs and potential further extension to incorporate additional infection and health parameter analysis.

Control of helminth infections in ruminants is today largely dependent on the strategic use of anthelmintic treatments. Within the EU as a whole, annual sales of anthelmintic drugs for controlling these infections in ruminants have been estimated to be approximately €400M [6]. However, continual, frequent anthelmintic use has resulted in the selection of drug resistant helminth populations. **AR** is today found in all major helminth species and in some countries even to multiple drug classes.

To detect AR and to monitor its development and spread, reliable and user-friendly **diagnostic tools** are needed. At present, AR confirmed after treatment failure has become very obvious in the field and has resulted in disease and/or poor animal performance. As AR cannot be reversed, early detection of AR is crucial to avoid associated production losses. Multiple complex processes are involved in the development of AR at the cellular and genetic level and this has, thus far, prevented the development of routine molecular tests to detect AR. The one exception to this situation is resistance to the BZ anthelmintics (BZ-R), which is associated with the accumulation of specific mutations in the parasites' beta-tubulin gene [7]. Based on this knowledge, sensitive and field applicable tests for the analysis of BZ-R in ruminant parasites have been recently developed [8, 9]. However, to date respective tests for other drug classes like the macrocyclic lactones, arguably the most important drug class are lacking, and the available BZ-R tests only really work well on single parasite species or isolates, not genuine multi-species field samples. The current de-facto test for AR detection in all drug classes is thus the *in vivo* 'faecal egg count reduction test' (FECRT). Because this test is labour-intensive and expensive, and commonly agreed protocols for interpretation of results are not available, this has limited the geographic range and number of farms included in surveys into the extent of AR in Europe and beyond. Consequently, meaningful information on the distribution and extent of AR in Europe is limited [10]. With improved diagnostics and closer harmonisation of study design and interpretation, sampling of a larger number of farms in more countries should be feasible and would provide a more accurate picture of AR in ruminants across Europe, facilitating up-to-date advice on effective and sustainable parasite control. This is important to improve our understanding of the risk factors associated with the selection of AR and how this is related to climatic conditions and farm management systems.

Measures should be taken to avoid or slow down further selection for AR. To this end, **alternative control strategies** that do not rely or rely less on anthelmintic drugs have been developed to the proof-of-concept stage [11]. A promising non-chemoprophylactic control approach is the use of vaccines to protect animals from infection and prevent further spread of disease and AR. Recently, a vaccine against *Haemonchus contortus* was developed [12]. The vaccine is now commercialized in Australia (Barbervax®) and market authorization is pending in other countries. Experimental vaccines against the bovine GIN *O. ostertagi* and *C. oncophora* and against the liver fluke are being further developed to reach commercial application. Also anti-parasitic forages have shown promise to consistently reduce parasite load when applied under short-term, controlled conditions. Finally, selective drug treatment strategies have been shown to slow down the development of AR. These treatment strategies are classed as either targeted treatments (TT), when anthelmintic usage is reduced by only treating the whole flock or herd when there is a high parasite challenge or production loss; or targeted selective treatment (TST) strategies, when treatments are restricted to certain individual animals within the flock or herd. In sheep and cattle, treatment decisions can be based on parasitological parameters (e.g. faecal egg counts, specific antibody levels e.g. using bulk tank milk), morbidity parameters (e.g. diarrhoea index, dag score, FAMACHA©, serum pepsinogen concentration) or production parameters (e.g. growth data and milk yield). There is real potential to automate some of these TT/TST strategies to make them more attractive to farmers, to support efforts to commercialise such systems and to encourage more widespread uptake across the industry.

II) PROGRESS BEYOND THE STATE-OF-THE-ART

Recent research has proposed novel techniques and ideas to tackle AR. These technologies now need to be further developed, validated and integrated in existing advice and practice, requiring a coordinated approach.

Faecal egg count (FEC) and faecal egg count reduction test (FECRT) methods were standardised and sampling strategies for the FECRT were established. However, the major limitation of the FECRT remains the time and the cost to conduct FECs on a representative number of individual animals. Promising results have been obtained in pilot studies using composite faecal samples for GIN and liver fluke in sheep [13, 14]. This decreases the work load and cost of conducting FECRT. To further increase user-friendliness, portable FEC-kits need to be tested, containing a new generation hand-held microscope and a mobile phone application for image capture. Automated image analysis for specific worm egg quantification and identification was recently developed using novel machine learning algorithms. Species identification in the diagnosis is necessary, but current techniques (based on larval cultures) take at least 7-10 days for meaningful results to be obtained. Recently, **molecular/DNA-based tests** (qPCR, MT-PCR, LAMP) have been developed for precise identification of major GIN species of sheep [15] and cattle [16]. Using these novel tools to detect AR (FECRT with composite samples and automated species identification), now offers the potential to conduct international surveys to map the distribution and extent of AR in GIN and liver fluke in ruminants throughout Europe.

Most prototype **vaccines** against GIN and *Fasciola* have been tested in artificial infection models, and few field data are available on the effect of helminth vaccines on pasture infection levels and animal productivity [17]. Since anti-parasitic vaccines do not induce sterile immunity in vaccinated animals, and generally only target single parasite species, vaccination protocols will need to be integrated with other parasite control measures, including monitoring of parasite infection levels, pasture management and TT/TST. A logical way to do this is by using **predictive models of parasite epidemiology**. Recently, novel models, predicting the impact

of climate change on epidemiological patterns, have been developed. These models should now be employed to simulate integrated worm control scenarios in different geographic regions and under climate change scenarios. Successful simulation of novel integrated worm control strategies first requires interaction between experts from different disciplines, for example to decide on appropriate input parameters for various countries, and input from different specialized research projects.
The implementation of TST approaches is likely to greatly benefit from the availability of robust, reliable and user-friendly **decision support systems (DSS)**. Although some systems already exist, such as automated weighing scales, capable of sorting animals according to target weight, more developments are needed in the future. More specifically, these DSS should integrate the different available diagnostic and control options (vaccines, TT/TST) and assess the expected economic impact, allowing well-informed decisions to be made by the end-user.

III) INNOVATION IN TACKLING THE CHALLENGE

Parasitic helminth infections have a major impact on the efficiency of livestock farming. In the past, animal health research has provided effective worm prevention strategies. These strategies, however, have lost their efficacy and can no longer be considered sustainable. Current diagnostic and TT/TST approaches should be integrated with other parasite control options, such as grazing management, including specialized anti-parasitic crops, and helminth vaccines in order to further reduce reliance on anthelmintics. Specific topics covered in this Action will include improved monitoring of parasitic helminth infections and AR, how different technologies can be combined in order to increase their effectiveness in combating AR and the commercial application and long-term cost-effectiveness of these new approaches. Classical parasitological techniques are still the reference diagnostic methods in many countries, including most inclusiveness target countries (ITCs). By upscaling these techniques through harmonized laboratory and interpretation protocols, mathematical modelling and mobile phone applications, diagnosis of helminth infections in ITCs will also be brought to the next level.
These novel technologies and concepts alone will not suffice in driving the required change. A major shift in attitude and mind set of the whole industry will be required to put these principles into practice. The adoption of sustainable parasite control practices by farmers is hampered by the lack of cost-effective diagnostics on the one hand and the low price of anthelmintics on the other [18]. Attempts have been made in the past to translate new approaches into applicable control programs, e.g. the SCOPS and COWS industry initiatives in the UK [19]. However, recent research showed a limited uptake of the presented best practice advice [20]. This emphasizes the need to understand the factors affecting the industry's (farmers, veterinarians, companies) behaviour, in order to optimise communication and better understand how sustainable parasite control practices can be incorporated into farm management in sympathy with other important drivers, such as social and economic factors.

D) ADDED VALUE OF NETWORKING

I) IN RELATION TO THE CHALLENGE

Participants from the following countries have already contributed to this Action: BE, CH, CZ, DE, DK, ES, FR, GR, IT, NL, PL, SE, SK, UK. COMBAR will comprise a mix of participants whose expertise lies in cattle parasites, sheep parasites or both. While some participants work mainly on GIN, others work primarily on liver fluke or both. The experience of participants active in small ruminants (mostly situated in the southern part of Europe) will contribute to analyse the issue of AR in cattle. The consortium includes not only teams with specific expertise in diagnostics of AR, diagnostics of helminth infections, TT/TST, grazing management, parasite vaccines, but also in economics of animal health and socio-psychological research. Therefore, approaches and results from one host-parasite system can be effectively translated to other systems and the network will allow interaction between different research disciplines. The inclusion of partners from the Czech Republic and Slovakia adds further value to the Action and will stimulate application of the results in a wider range of countries. By gathering parasitologists, social scientists and agricultural economists, the Action is bringing together a world-leading, multi-disciplinary blend of skills and expertise to tackle the challenge of AR. Inclusion of SMEs and close interaction with industry in the consortium favours the dissemination of knowledge to the animal health end-user, and the application of scientific know-how to the design and commercialisation of market-ready tools based on the new approaches described above. All participants are actively involved in generating relevant field data through nationally (and internationally) funded projects and COMBAR will leverage these efforts to validate new diagnostic tests in multiple settings across Europe.

II) IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

No other current or planned European research programme exists that has the same aims and goals as this Action. In the recent past, a number of EU projects have worked on particular aspects of helminth control in ruminants. PARAVAC (FP7, 2011-2015) focused on the development of vaccines against GIN, lungworms and liver fluke in ruminants. GLOWORM (FP7, 2012-2014) focused on development of diagnostic tests, modelling the epidemiology of GIN and evaluating TT/TST strategies. CARES (EMIDA-ERA-net 2012-2015) studied herd management and plant-based anthelmintics to improve GIN control. CAPARA (COST, 2008-2012) focused on the control of helminth infections in goats specifically. There are also 2 ongoing projects: PARAGONE (H2020, 2015-2019) that continues the vaccine development work for animal parasites, and PROPARA (CORE-Organic-ERA-net 2015-2018) focusing on control approaches in organic ruminant production.
The difference this COST action will make is that the expertise from the different research will now be combined and actively integrated to **COMB**at **AR**. For instance, approaches that combine different control methods (chemoprophylaxis with bio-active forages or vaccination) will be elaborated. Inclusion of partners focusing on software, diagnostics and technical product development will enhance the translation of the results to practical tools. Furthermore, by bringing in experts in economics of animal health and socio-psychological sciences, the proposed solutions will be confronted with an economic realism as well as with non-economic factors that determine the uptake of the proposed changes by the end-user. In the initial phase of COMBAR a comprehensive search will be made of national and international projects and those that are relevant to the proposed action will be approached with regard to how liaison can be of mutual benefit (e.g. by sharing costs of a symposium and sharing scientific knowledge), but without any duplication of effort.

2) IMPACT

A) EXPECTED IMPACT

I) SHORT-TERM AND LONG-TERM SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS

Scientific impacts: Partners of this Action will benefit from improved knowledge of the outputs of each other’s projects. This will accelerate cross-pollination and enhance the impact of previous research in the wider domain. Hence, for example, research on vaccines and on targeted anthelmintic treatment will be combined to better consider how helminth vaccines could be most effectively used alongside anthelmintics in the field. Discussion of the cross-cutting relevance of research results will extend through the workshops to unsolved problems of highest priority for future research, ensuring a lasting legacy and long term scientific impact. Long-term impact will also be achieved by developing a common approach to the measurement of AR in the field, such that nationally funded surveys and studies on risk factors for, and active management of, AR can be analysed together for greater effect. Further, specific instruments will seek to integrate socio-economic methodologies into scientific research on AR. This will have long term benefits in achieving a more refined understanding of the economic and socio-cultural context of parasite control in livestock, and promote creative, bottom-up and sustainable solutions to AR in future research. Crucially, this will support translation of existing scientific knowledge into impact in the field, increasing exploitation of previous results.

Technological impacts: Groups engaged in nationally funded research aiming to generate advanced diagnostic tools for helminth control and the detection and measurement of AR will benefit from collaboration, including discussion of methods and approaches, exchange of materials, and ring-testing on laboratory and field-derived material. This is likely to accelerate the production of commercially viable diagnostic tools that are effective and useful across Europe, with its diverse helminth populations. Integration of research on diagnostics with that on parasite control (including TST and vaccines) will ensure that the technologies produced are highly relevant to the management of helminths in the field, and will increase the chances of successful application and commercialisation. Impact of research on vaccines will be enhanced by being embedded in the context of integrated parasite control on farms, including economic and human factors, such that the technological impact of candidate vaccines will be improved. Integration of modelling on parasite control and climate change will help to aim research outputs at future challenges and ensure lasting relevance of technological solutions. The socio-economic theme running through the proposed Action will ensure that technical impacts of the supporting nationally-funded research are considered at an early stage and at pan-European level, within the relevant socio-economic and cultural context: this will contribute to the business case for outputs considered for commercialisation.

Socio-economic impacts: The fact that helminth parasites are a major constraint on the productivity and economic viability of grazing livestock production in Europe guarantees that any positive impact on their control will have a positive socio-economic impact. Particular to this Action, integration of scientific and technological outputs with social and economic drivers of farming practices will greatly enhance the relevance of participants' research to parasite control in the field. Through the proposed instruments, this approach will be extended across Europe, such that scientific and technical advances by each partner are more widely applicable across European society than might otherwise have been the case. Decision support elements of the Action will be adapted to the socio-cultural context of target regions, which could only be achieved by the large multi-partner consortium proposed. Recommendations concerning the sustainable use of anthelmintic drugs, and novel control strategies, will be produced and adapted for maximum impact on policy. Thus, specific "best practice" advice will be prepared for the farming industry, animal health stakeholders, and policy makers at European and national levels, so that government and industry throughout Europe can gain maximum benefit from the insights generated by the Action. The steps to maximise pan-European societal and economic relevance of the scientific and technological outputs of contributing nationally-funded research (above) will strengthen the basis for practical application and commercialisation of tools arising from this work. Economic impacts of selected outputs (e.g. altered parasite control supported by new tools) will be measured in different regions, such that projected benefits can be up-scaled to a European level. This will support recommendations for change in practices, and provide solid evidence to justify future research and commercial planning.

B) MEASURES TO MAXIMISE IMPACT

I) PLAN FOR INVOLVING THE MOST RELEVANT STAKEHOLDERS

The most relevant stakeholders are: the farming industry; animal health professionals; the pharmaceutical industry; government policy teams, especially ministries of agriculture and the general public. These will be engaged at European and national levels by specific instruments and outputs as follows:

The farming industry arguably stands to gain first from sustainable helminth control, insofar as it will enhance the long-term profitability and viability of their businesses. Nevertheless, implementation of new tools and approaches from previous research has encountered significant barriers to uptake, which are only partially understood. For this reason, farmers and their representatives will be involved in the Action from the outset. Where possible, farmer focus groups will be involved in nationally-funded field research to generate better understanding of the issues impacting on uptake of sustainable approaches to parasite control, and to elicit possible solutions from the farmers themselves. The results will be used to influence the design of control strategies and recommendations and communicated to the main farming organisations which may further disseminate it to their members, for example on European (Copa-Cogeca), but also at other international and national levels. Representatives from the farming industry will be invited to selected workshops, and to comment on draft reports aimed at each sector.

Animal health professionals play a key role in supporting and communicating with farmers during the implementation of disease control plans. Sustainable parasite control is already embedded in herd and flock health plans in many European countries, but is often not actively reviewed in the light of changing epidemiology or information from diagnostic tests. A specific workshop on the dynamic integration of sustainable control into health plans will be scheduled. Specialist sheep, goat and cattle veterinarians will be invited to contribute (in person or by telecommunication as resources permit). The Action will interact and communicate with the Federation of Veterinarians in Europe (FVE) and routes for dissemination to practising veterinarians and other actors involved in distribution of anthelmintic drugs will be explicitly considered below (dissemination and exploitation section).

Action will make use of established contacts with the major **pharmaceutical companies** with direct interests in anthelmintic drugs and vaccines; as experts in bringing new products to market, they will be given the opportunity to contribute to spin-off projects that evaluate the implications of changing epidemiology, technology and strategy on the place of their products in parasite control. In this regard the Action will serve as a useful and transparent repository of expertise within which partnerships can be sought. Action will also seek contact with **SMEs active in diagnostics, services to livestock sector and bio-active forages**. Two such SMEs have already contributed to this Action.

Governments will be kept appraised of the added value of the network to nationally-funded research projects. Additionally, recommendations on sustainable parasite control including novel tools and strategies developed within the consortium will be prepared and circulated to relevant government departments at national and European levels before being finalised, to give them an opportunity to comment. Through the interaction with IFAH-Europe, the consortium has access to contact lists of the relevant agricultural, health and research ministries throughout Europe.

Society at large will benefit from improved, sustainable control strategies for parasite control in grazing ruminants, with well-integrated novel tools. This will reduce the dependence of the sector on state aid by improving its profitability and efficiency, and reduce the cost of animal products and their environmental impacts. The challenge of parasite control on farms experiencing the effects of global change and drug resistance, and the solutions being developed by research groups across Europe and their sources of funding, will be communicated to the public as part of the dissemination strategy.

II) DISSEMINATION AND/OR EXPLOITATION PLAN

COMBAR aims to enhance productivity of ruminants across Europe through improving sustainable control strategies for helminth infections. Therefore, a thorough dissemination strategy of outputs and practical tools to the scientific community, stakeholders and end-users in animal health is crucial, that includes support for translation of technical outputs.

Internal **dissemination activities,** including yearly *group meetings* and *scientific reports*, will be undertaken during the Action in order to calibrate (based on participant responses) specific research activities. At each meeting, a plan for dissemination efforts will be put in place so that dissemination will not just be *ad hoc*. Considerations for this planning will include upcoming results, linkage to relevant events, compilation of a list with our top-30 target audience organisations and a communication plan how they can be reached, on several occasions over time (press release, social media, targeted mailing). The 24-month and final Action assembly will be opened to key scientific and industry experts, stakeholders and end-users in animal

health. During these meetings, participants will present achievement against specific objectives and practical outputs.
COMBAR will develop a logo and a Action-specific output style (for documents and presentation purposes) and apply a variety of **dissemination tools** to communicate results of the action and ensure that best practice is communicated to farmers and their veterinary advisors, enabling progressive adoption of sustainable parasite control strategies:

- A *website* will be used as a dynamic vehicle for broad dissemination of results.
- A COMBAR profile will be made on *LinkedIn, ResearchGate* and in other professional and social media to establish discussion groups for the different working groups and disseminate information to professional organizations that are followed by farmers, veterinarians or the wider public interested in health and agricultural themes.
- Participation at key *scientific conferences* and publish the results in *peer-reviewed international scientific journals.*
- Participation at key *veterinary conferences* and *continued professional education platforms for the veterinary profession* and publish the results in the veterinary press.
- Inclusion of the results in the *veterinary curricula* of veterinary faculties and exchange of the *educational materials* among faculties.
- Distribution of appropriate *lay publications* and *practical guidelines* in the professional and farming press.
- Distribution of *flyers, posters* or *brochures* at *networking events* such as farmer's days.

Our dissemination activities will be informed by a database where the different dissemination activities are compiled to assess the quantity and quality of dissemination efforts, set realistic targets and strategically steer dissemination activities. The impact of these activities will be assessed through a stakeholder survey in the middle and at the end of the Action.
Exploitation of Action’s results will be considered alongside the aims of complementary national projects. Intellectual Property implications and commercial exploitation of diagnostic and software tools, developed during the Action, will be dealt with through confidentiality agreements signed by all participants when they enter the Action. Given that COMBAR aims to leverage and synergise national research efforts, however, rather than execute a stand-alone research plan, the most relevant route for exploitation will be to support practical implementation of existing research outputs. This will be achieved by pooling expertise on diverse new approaches to diagnosis and control, integrating this knowledge into decision support systems that will work across European settings, and feeding technical know-how into the planning of commercial partners.

C) POTENTIAL FOR INNOVATION VERSUS RISK LEVEL

I) POTENTIAL FOR SCIENTIFIC, TECHNOLOGICAL AND/OR SOCIOECONOMIC INNOVATION BREAKTHROUGHS

This is an ambitious Action and a structured risk profile will ensure short-term impacts while also opening the possibility of long-term transformational change in the research area and its influence on sustainable food production. The main potential for breakthroughs comes from the fusion of approaches from previously separate disciplines, around the central focus of managing AR. In particular, explicit consideration of the human element of parasite management in livestock promises to lead to step changes in how the problem of AR is addressed in future research, and in the design and implementation of sustainable control methods. This is innovative and the outcomes hard to predict, but in other fields such as conservation biology, integration of human behaviour into predictive models of the biology of target species has transformed understanding and the effectiveness of intervention strategies. COMBAR will seek such a transformative impact by embedding social and economic sciences in relevant national and EU research programmes. Secondly, calibration and, where possible, standardisation of field-ready diagnostic tests for parasite infection and AR will enable comparison of otherwise isolated national-level studies and surveys, by generating coherent datasets for epidemiological interrogation. Consequent alignment of effort will underpin up-scaled mapping and analysis of risk factors for AR, as well as factors that influence the uptake and success of alternative approaches to control. This has the potential to drive a breakthrough in the evidence on which recommendations for sustainable AR management are based, which is both broadly applicable and locally adapted, overcoming fragmentation and contradictory results from disparate studies. Along with early and planned stakeholder engagement and integration of socio-economics, this has the potential to coax consensus from the key players on the way forward for combating AR in Europe. These lofty ambitions are complemented by an eminently achievable agenda for scientific and technological co-operation, stemming from exchange of best practice methodology, expansion of the scope of laboratory and field evaluation of new tests and interventions, and training of young researchers in interdisciplinary methods. Through assimilation, critical review and integration of knowledge on current and near-future technologies for parasite diagnosis and control, the COMBAR grouping will produce specific guidance for application of the state of the art to practical management of AR in diverse settings in Europe. Moreover, identification of key gaps in close and early consultation with stakeholders will drive the future research agenda, and define the route to market for field-ready technologies. This compilation exercise will be prioritised for early action, and will plot technology readiness levels (TRL) of available tools, in order to drive those at the appropriate TRL through to field application within the lifetime of the Action, and identify outstanding research needs for the others. In this way the transformational scientific impacts of the COMBAR collaboration will be complemented and preceded by enhanced and visible impacts on the ground, whose uptake and economic impacts will be measured where applied.

3) IMPLEMENTATION

A) DESCRIPTION OF THE WORK PLAN

I) DESCRIPTION OF WORKING GROUPS

WG 1: Improving Diagnosis
Objective: To prioritise, evaluate and implement cost-effective methods for the diagnosis of helminth infections and AR.
The development of low-cost, easy-to-use, multiplex and/or pen-side diagnostic systems for the major helminth infections of ruminants is of high importance to implement diagnostic approaches in helminth control. Currently, each institution and country is using its own diagnostic system. Moreover, most novel tests are only available in a few well equipped research institutions (e.g. MT-PCR, LAMP or bead-based multiplex systems), and mostly not yet in the field. There is a need to compare the performance and cost-effectiveness of the different available diagnostic platforms across countries. In WG1, the Action will exchange knowledge of the available diagnostic tests/platforms across the consortium and prioritise tests with a broader applicability or industry appeal and high TRL.
The detection of AR has been improved and made more cost-effective by the use of composite faecal samples and the development of DNA-based methods for precise identification of the parasite species surviving anthelmintic treatment. These technologies now need to be further validated and disseminated over the COMBAR parasitological research institutions and where appropriate implemented in commercial veterinary diagnostic labs. Tasks 1.1 and 1.2 can largely be achieved by Training Schools (TS) and Short Term Scientific Missions (STSM), while Task 1.3 and 1.4 will be additionally supported by nationally funded research projects in selected member state countries.
Task 1.1 Harmonize and validate diagnostic tests for helminth infections and AR based on composite samples across laboratories, including standardisation of sample collection and processing.
Task 1.2 Prioritize, assess TRL, and transfer the technology of recently developed prototype diagnostic tests/platforms [e.g. multiple tandem-PCR (MT-PCR), Loop-mediated Isothermal Amplification (LAMP), bead-based multiplex systems (e.g. Luminex®) and pen-side FEC methods].

Task 1.3 Conduct market analysis and develop business plans for commercial test introduction, leveraging technical know-how of participants to support SME and industrial partners.
Task 1.4 Assess the extent of AR in ruminants using field surveys in selected/relevant COMBAR countries, to define the needs for and economic contribution of new technologies.
Deliverables:
D1.1 List of harmonized, validated and newly introduced diagnostic tests across European laboratories, and TRL of new but not yet commercially available tests.
D1.2 European market analysis for at least 1 novel diagnostic test.
D1.3 Updated maps of occurrence and extent of AR in ruminants in Europe.

WG2: Understanding the socio-economic aspects
Objective: To develop, disseminate and apply methods to study the economics and human behaviour in the field of helminth control in ruminants
There is a lack of understanding of economic effects at farm-level of novel parasite control approaches. Such information is critical before well-founded recommendations can be given. Moreover, in contrast to earlier beliefs, a farmer's management decisions are not only based on rational economic considerations, but also depend on intrinsic factors like attitude, risk perception, social norms and trust. Socio-psychological models can help to identify intrinsic motivations on farmers' decision making processes. Conceptual models that identify all the important factors to predict farmer behaviour can be developed based on theoretical models from human behaviour sciences. Because the available literature on farmers' behaviour in animal health is limited to specific non-parasitic issues and a general understanding is missing, qualitative research is necessary to fill the gaps in the literature, and to construct working hypotheses for quantitative studies. This will be addressed by in-depth interviews and focus group meetings including the different stakeholders in helminth control: farmers, veterinarians and external experts (covering farmer and animal health organisations, academics and industry). Based on the results of the qualitative research and the scientific literature, theoretical frameworks will be drawn, which then will be validated using large-scale surveys. Tasks 2.1, 2.3 and 2.6 will depend on TS and STSM. Tasks 2.2, 2.4 and 2.5 are additionally supported by nationally funded projects.
Task 2.1 Train the participants in the principles and methods of the economics of animal health. The training will focus on animal health decisions at farm level subject to resource scarcity and budget constraints and include practical real-life examples.
Task 2.2 Study the economic effects of novel parasite control approaches as identified in WG3, and integrated them into market assessment and business planning in WG1 and WG3.
Task 2.3 Train participants in the theory and methods of socio-psychological research relevant to animal health. The theory will include grounded theories from behavioural and health psychology. Methods will include the conduct of in-depth interviews and focus group meetings.
Task 2.4 Conduct standardised in-depth interviews and focus group meetings in different European countries to identify the most important barriers and motivations for the adoption of sustainable GIN control strategies, and feed these into exploitation assessments in WG1 and WG3.
Task 2.5 Develop and validate conceptual model(s) that predict farmer behaviour with regard to helminth control in ruminants in different settings (countries, production systems).
Task 2.6 Develop a communication strategy to promote sustainable helminth control methods based on the insights from the validated behavioural models.
Deliverables
D2.1 Workshop on the economics of animal health and GIN control.
D2.2 Workshop on socio-psychological research relevant to animal health.
D2.3 White paper on the current barriers and motivations for the adoption of sustainable GIN control strategies and methods to overcome them.

WG3: Innovative, sustainable control methods

Objective: To develop practical and sustainable helminth control strategies that integrate current insights from diagnostics, TT/TST approaches, epidemiology, vaccinology, farm economics and human behaviour.

Researchers across Europe have developed a panel of indicators that can be used to optimise anthelmintic usage, and slow the development of AR without compromising animal productivity in sheep, cattle and goats. Several experimental anti-helminth vaccines are available and anti-parasitic forages have shown good efficacy. Further coordination, debate and experiments are required for these technologies to replace current practices or alternatively, to see how they can be integrated. Such evaluation will depend on the use of predictive models of parasite epidemiology to explore a multitude of scenarios. Moreover, novel approaches should be supported by Decision Support Systems (DSS) to guide effective action by the producer. In addition to technical advances in the available diagnostic inputs to such a system, outputs must be cognisant of economic and other drivers of farmer decisions in order to effect the behavioural change that is needed to underpin sustainable worm control. WG3 therefore seeks to combine refined understanding of both parts of this equation (WG1 and WG2) to devise and assess effective DSS for worm control across a range of European ruminant production systems. This requires prioritisation and consensus across the consortium but, more importantly, active engagement with potential end-users at an early stage in the development process. Task 3.1, 3.2, 3.4 and 3.5 will depend on TS and STSM. Task 3.3 is additionally supported by nationally funded projects.

Task 3.1 Compile a database of evidence-driven alternative control approaches that have been trialled in Europe and globally, noting information inputs, processing, application and outcome, and any observed hurdles between proof of concept and practical application in a commercial setting.

Task 3.2 Broaden the concepts of alternative control approaches to different ruminant sectors in Europe, taking account of variation in production and social context. Use underpinning knowledge and practical experience within the consortium to support members in efforts to refine, validate and evaluate such approaches in new environments.

Task 3.3 Evaluate impacts of future changes in parasite challenge, farm management and novel control tools on current TT/TST and DSS based strategies. This will include predictive modelling, e.g. climate change impacts on parasite biology, integration of vaccination, bioactive forages and grazing management into *refugia*-based parasite control, simultaneous control of multiple parasitic infections, and shifts in farmer attitudes and behaviour over future decades.

Task 3.4 Conduct gap analysis of information needed for further development of decision support tools, in terms of technical hurdles as well as farmer attitudes and economic-social constraints. This includes understanding the user needs for DSS, to be sought from the start of the Action through industry partners and farmer focus groups.

Task 3.5 Engage with animal health advisors and professional organisations to discuss how sustainable parasite control approaches and DSS can be integrated in existing professional advice, and where applied, measure the impact of past and inter-current dissemination initiatives on parasite control practices.

Deliverables

D3.1 Database of evidence-driven alternative control approaches.

D3.2 Scientific papers on the conceptual, *in silico* and/or *in vivo* evaluation of integrated control strategies.

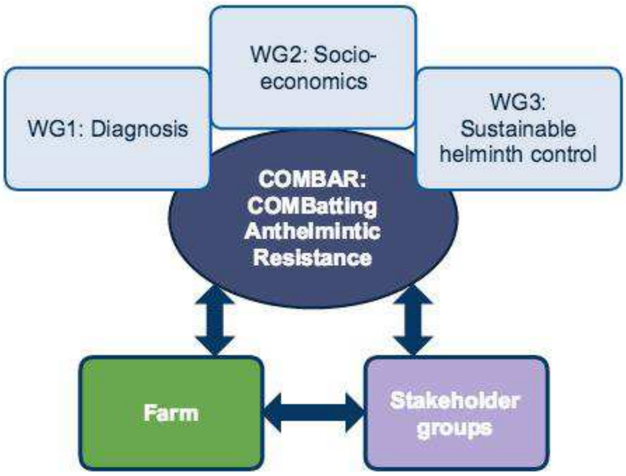
D3.3 Road map for further research and development of DSS.

D3.4 Report of “best practice” guidelines for sustainable GIN control for knowledge institutions, animal health workers and professional organisations.

II) GANTT DIAGRAM

	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WG 1 Diagnostics																
Task 1.1 Harmonization and validation	■	■	■	■												
Task 1.2 Prioritization and technology transfer					■	■	■	■	■	■	■	D1.1				
Task 1.3 Market analysis and business plan for commercial test introduction									■	■	■	■	■	■	■	D1.2
Task 1.4 The extent of AR in ruminants using field surveys	■	■	■	■	■	■	■	■	■	■	■	D1.3				
WG2 Understanding socio-economic aspects																
Task 2.1 Theory and methods of economics of animal health	■	■	■	D2.1												
Task 2.2 Economic effects of novel control approaches					■	■	■	■	■	■	■	■				
Task 2.3 Theory and methods of socio-psychological research			■	■	■	D2.2										
Task 2.4 In-depth interviews and focus group meetings					■	■	■	■								
Task 2.5 Conceptual models of farmer behaviour									■	■	■	■				
Task 2.6 Communication strategy													■	■	■	D2.3
WG3 Innovative, sustainable control methods																
Task 3.1 Database of evidence-driven alternative control approaches in Europe	■	■	■	D3.1												
Task 3.2 Broaden the concepts of alternative control approaches					■	■	■	■								
Task 3.3 Integration of novel approaches in current control strategies					■	■	■	■	■	■	■	■	■	■	■	D3.2
Task 3.4 Gap analysis and user needs for DSS					■	■	■	D3.3								
Task 3.5 Engage with animal health advisers and professional organisations									■	■	■	■	■	■	■	D3.4

III) PERT CHART (OPTIONAL)



IV) RISK AND CONTINGENCY PLANS

This Action addresses the major current challenges within the domain of helminth control in ruminants. Several risks are inherent to the ambitious nature of this Action. Some objectives are based on expensive field surveys (mapping AR) and farmer interviews/questionnaires. This will require additional funding from national research programmes and our own resources. Participants from several countries (FR, BE, ES, UK, IT, SE) have already confirmed that this additional funding will be available. This guarantees the availability of novel data with a wide geographic extent. In addition, the need for all countries taking part in COMBAR to find additional funding and collect local data will be emphasised and a strategy will be developed to enhance fundraising at national and European level.

This is a unique Action because it explicitly aims to integrate different sub-disciplines of parasitology. This will require scientists to abandon some long-established traditions and dogmas and find new common ground and strong leadership skills from the Management Committee.

The Action goes beyond the traditional disciplines in parasitology and aims to integrate social science research and economics. Also, this will require time to find a common language and common research objectives. However, economics and social science research is currently emerging in the area of animal health research and the Action has economists and social

scientists already from several countries (BE, FR, NL, UK) who have agreed to participate in this COST Action, ensuring a true broadening of the approach to sustainably control parasites beyond the traditional disciplines.
To mitigate the associated risks of the Action, a dedicated progress meeting will be held when the Action is half-way to evaluate the course of the Action and to change priorities if needed. In addition, 2 external experts will be invited to comment on the course of the Action by inviting them to meetings and these experts will also participate in this progress meeting.
There is a risk that new diagnostic and control tools intended for application require further research before being ready, and/or do not meet user needs. This will be mitigated by establishing and ranking TRL of those tools, and by early engagement with stakeholders to identify and address user needs.

B) MANAGEMENT STRUCTURES AND PROCEDURES

COMBAR belongs to the “Food and Agriculture” domain and the organization of this COST Action will follow rules and regulations as described in the “Rules for Participation in and Implementation of COST activities Procedures for Implementing COST Actions” (doc. COST 132/14). The coordination of the COST Action will be managed by a **Management Committee (MC)** consisting of a maximum of two designated members from each country that has joined the Action by accepting the Memorandum of Understanding (MoU). At the kick-off meeting, the MC will elect a Chair and a Vice-Chair from two different participating COST Countries by majority vote. At the same meeting, a leader and vice-leader for each of the 3 WG will be elected. A Core Group, composed of the Chair and Vice-chair, WG-leaders, STSM coordinator and gender balance/early career investigator (ECI) monitor will be established within the MC to support the Chair in his/her duties and to manage STSMs. The COST Action will begin with the kick-off MC meeting, followed by MC meetings, organized in association with the workshops and during other relevant meetings.
The MC Chair will oversee the contractual, ethical, financial and administrative management of the whole Action. For the scientific coordination, the MC Chair will collaborate closely with the WG leaders, who are responsible for monitoring progress and ensuring milestones are met and outputs delivered, in collaboration with the respective task leaders. The administration office, embedded in the host infrastructure of the Action coordination, will have responsibility for the financial management of the Action. The core group will review progress against the Milestones and Deliverables with the aid of written progress reports. The MC, including all members, is the ultimate decision-making body of the action, responsible for the overall direction of the Action.

C) NETWORK AS A WHOLE

The organisation of this Action will follow rules and regulations set by COST guidelines to be applied in an Action specific way as appropriate. The network as a whole will be administered by a Management Committee (MC) in close collaboration with the COST Office. As described in the COST rules, the MC will be convened by representatives of the Parties. The MC will elect a Chair, at least one Vice-Chair, a STSM Assessment Panel, and a Web Master for the website of the Action. The MC will set up three Working Groups (WG 1-3) and appoint a leader and deputy for each WG. Each WG leader will be responsible for achieving goals and milestones and for reporting their achievements to MC based on a predefined timetable. COMBAR aims to prepare next generation leading researchers by providing networking opportunities and training to ECIs, paying particular attention to the promotion of female investigators. For this, an ECI will be appointed to monitor the participation of ECIs and maximise their opportunities as well as to monitor the gender balance and advise corrective measures to the MC if needed. Several ITCs are already included in this Action (PL, SK, CZ), but special efforts will be made in the first months of the Action to include more ITCs as well as Near Neighbour Countries (NNC) in the Action for establishing a real pan-European approach to AR research. Institutions from NNC will be contacted using each individual participant’s network as well as targeted internet searches for scientific institutes working on

AR or associated fields. Animal health research and extension institutes from IPC such as Argentina, Brazil, Uruguay, Australia and New Zealand will also be invited to join. AR has been a pressing issue in these countries for a longer time than in Europe and a lot of mutual benefits can be expected from knowledge exchange. Several participants of COMBAR have already collaborated in individual projects with partners from these countries and these contacts will now be made available to the whole network.

COMBAR will be implemented through a concerted action, which means that research is carried out and financed by the active national grants of participating scientists, while COST provides the necessary management. The coordination of research and exchange of data between the participating laboratories in different European countries will be achieved by realising the common milestones/deliverables of different WGs as described in section 3.1.

COST offers a number of instruments which will prudently be used by this Action. Major organization and planning will be performed within the MC. Initially the MC will meet once, the Action will come into force (within the first 3 months) and set the different WGs. Thereafter, the members of the WGs will meet in separate meetings or meetings combined with the MC meetings and annual general conferences. MC meetings will take place once each year, and meetings of the Core group will take place every 6 months, preferably linked to general conferences and WG meetings. This will ensure efficient coordination of the activities and discussion about the objectives and critical points of the programme. Each WG will arrange a meeting within the first year to plan its activities (plan and coordinate the different meetings, STSMs, publications, training schools, etc.).

In the first MC meeting, the location of the first general conference will be decided. MC will elect a Conference Organising Committee (COC) each year that consists of the local organiser and representatives of each WG. The COC will be responsible for organising the general annual conference. The local organiser chairs the COC and reports its progress to MC. Different WGs through their representatives in COC will contribute to setting the scientific programme of the conference. COCs are convened for one year and in each general conference the location and COC of the next conference will be decided by MC.

Dedicated mailing lists will be established as a mean of communication between different members of MC and WGs. If necessary, decisions regarding approval of STSMs or other matters related to the Action will be made through votes delivered via these mailing lists.

An effort will be made, depending on the budgetary possibilities, to finance at least 6 STSMs each year for students to exchange know-how between laboratories in different member states as defined in the rules of COST. During the selection process, priority will be given to ECIs such as post graduate students or postdoctoral fellows. The selection of applicants will be the responsibility of the STSM Assessment panel, consisting of 4 members (representatives of each WG as well as the ECI monitor) and the MC Chair, which will be authorised to assess proposals and to decide on the ones to be funded after consideration of COST rules and procedures. In some cases, external advice may be sought. The criteria for assessing applications, which will be in line with the Actions objectives, will be announced on the website available to potential applicants. Special care will be taken to avoid any bias on the grounds of gender, age or nationality, including by ensuring a gender balance on selection panels.

The Action foresees organising 4 or 5 Training Schools (see section 1.2.2). The MC chair and members will help WGs in organising those training schools and will follow COST rules and procedures for its organisation and selection of participants. Priority will be given to ECIs in taking part in the training school.

An overview article together with specific output results will be published as a special edition of a scientific journal in the final year of the proposed Action detailing the achievements of this programme.

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