

COST Action FA 1102
(Action start date: 20/11/2011 – Action end date: 20/11/2015)

Optimising and standardising non-destructive imaging and spectroscopic methods to improve the determination of body composition and meat quality in farm animals

PROGRESS REPORT 1/2
(Action start 20/11/2011 – Report date: 15/01/2016)

This report is submitted by the MC Chair on behalf of the Management Committee and is validated by the Scientific Committee of the COST Association.

Confidentiality: the document will be made available to the public via the Action page on the COST website except for Section II.D.

Executive summary of the Progress Report:

(max.500 words) (to be completed by Action Chair describing the Action's progress with achieving the Action MoU objectives and generating outputs and impacts – see Annex 1 definitions)

FAIM brought together >330 experts from 23 (27) EU-countries (and beyond) focused on non-destructive imaging and spectroscopic methods for the measurement of body composition and meat quality (MQ) in major farm animal species and devising standardised principles of carcass classification and grading (CCG) across countries. These are both necessary for the development of value-based-payment and marketing systems (VBMS) and to meet the urgent need for market orientated breeding programmes. FAIM had a number of clear objectives:

- To identify, optimise and standardise non-invasive in-vivo and post-mortem imaging and spectroscopic methods for the measurements of body composition and MQ in major farm animal species, to integrate automated systems for their objective assessment, and to facilitate effective data capture and management at the individual animal level.*
- To review and develop robust references from imaging technologies for measuring body composition.*
- To review and develop harmonised procedures for in-vivo, post-mortem and on-line imaging methods of predicting compositional traits.*
- To review and develop harmonised procedures for in-vivo, post-mortem and on-line imaging and spectroscopic methods of predicting meat quality in livestock.*
- To explore options for full automation and for semiautomatic methods, where results are obtained through human-computer interaction.*
- To review and harmonise methods and equipment for individual animal traceability to optimise management, breeding and permit the future use of genomics.*

FAIM has developed a strong functional network and corresponding collaboration of hardware and software manufacturers from the industry with livestock and imaging academic experts to develop the products required for implementing the scientific work. FAIM has helped to coordinate and strengthen scientific and technical research in the EU through improving cooperation and interactions with industry. This will be essential for achieving the required advances in CCG systems to measure carcass yield and MQ, to meet the industry need for VBMS, and to improve production efficiency throughout the meat supply chain.

FAIM has also supported the use of electronic-identification-system (EIDs) and related EU legislation, through showing additional benefits of feeding back abattoir data from individual animals for optimising management, breeding and providing phenotypic information, which will help to facilitate future implementation of genome-wide-selection. FAIM had a very ambitious programme with complex tasks to make progress in the development of the “full circle”-information flow, i.e. the feedback of valuable information obtained in the abattoir to producers and breeders. The organisational structure based on 4

I. Progress Report

I.A. COST Action Profile

Objective/ Aim

The main aims were to identify, optimise and standardise non-invasive *in vivo* (*iv*) and *post mortem* (*pm*) imaging and spectroscopic methods for the measurements of body composition and meat quality (MQ) in major farm animal species, to integrate automated systems for their objective assessment, and to facilitate effective data capture and management at the individual animal level. FAIM will generate knowledge, protocols and tools of substantial value to EU food and agriculture. Project outputs will be disseminated to industry, EU scientists and policy makers; they will be informed through the large quantity of high impact scientific publications, newsletters, public information and briefing papers produced. To fulfil this aim this COST Action will form a European-wide scientific and technology knowledge platform on the topic of optimising and standardising non-destructive imaging and spectroscopic methods to improve the determination of body composition and MQ in farm animals.

C.2 Secondary objectives

1. to review and develop robust references from imaging technologies for measuring body composition.
2. to review and develop harmonised procedures for *iv*, *pm* and on-line imaging methods of predicting compositional traits.
3. to review and develop harmonised procedures for *iv*, *pm* and on-line imaging and spectroscopic methods of predicting MQ in livestock.
4. if full automation cannot be achieved, a lesser option is provided by semi-automatic methods, where results are obtained through human-computer interaction.
5. to review and harmonise methods and equipment for individual animal traceability to optimise management, breeding and permit the future use of genomics.
6. to coordinate building of a data warehouse (database structures and software) enabling efficient data storage and access, matching compositional and MQ data (including meat hygiene info) with pedigree and other performance records. This will allow across flock/herd, breed and country evaluations.
7. to coordinate building of a 3D atlas/template per species as a reference tool for further research.
8. to ensure widespread knowledge exchange within and beyond the network, and to ensure dissemination of the results of FAIM. Experts from many countries will co-operate, prepare draft manuals by correspondence. A joint exercise is planned to check and validate methods and to familiarise experts across countries with the reference procedures.

Details

MoU:	4125/11	Start of Action:	21/11/2011
CSO approval date:	17/05/2011	End of Action:	20/11/2015

COST Member Countries and Cooperating State having accepted the MoU

Country	Date	Status
Belgium	04/10/2011	Confirmed
Croatia	30/04/2013	Confirmed
Denmark	20/10/2011	Confirmed
Finland	18/08/2011	Confirmed
France	12/08/2011	Confirmed
Germany	27/06/2011	Confirmed
Greece	02/08/2011	Confirmed
Hungary	23/08/2011	Confirmed
Iceland	25/06/2013	Confirmed

Ireland	11/08/2011	Confirmed
Italy	25/07/2011	Confirmed
Lithuania	30/11/2011	Confirmed
Netherlands	27/09/2011	Confirmed
Norway	23/08/2011	Confirmed
Poland	22/06/2011	Confirmed
Portugal	18/10/2011	Confirmed
Serbia	12/07/2012	Confirmed
Slovakia	29/07/2011	Confirmed
Slovenia	12/07/2011	Confirmed
Spain	06/07/2011	Confirmed
Sweden	15/09/2011	Confirmed
Switzerland	16/09/2011	Confirmed
United Kingdom	16/06/2011	Confirmed

Total: 23

Intentions to Accept the MoU

NA

Other participants:

Institution Name	Country
NA	NA

Contacts

Chair/ Vice Chair

Position	Name	Contact details	Country	Date of PhD:	Gender
Chair:	Prof Lutz Bunger	SRUC, AVS, Roslin Institute Building, EH259RG Easter Bush, Tel. +441316519338; Lutz.Bunger@sruc.ac.uk	UK	1979	M
Vice Chair:	Prof Armin M Scholz	Ludwig-Maximilians-University Munich, Livestock Center, Sankt Hubertusstraße 12 85764 Oberschleissheim; Tel. +4989218076040; A.S@lmu.de	DE	1990	M

Working Group Leaders

WG#	WG Title	WG Leader	Country	Date of PhD:	Gender	Number of participants
1	Body/ Carcass composition	Gerard Daumas	FR	N/A	M	>300
2	Meat quality	Dr Maria Font i Furnols	ES	2000	F	> 300
3	Algorithms	Prof Bjarne K. Ersboll	DK	1990	M	> 100
4	Traceability	Mrs Marchen Hviid	DK	None	F	> 50

Other positions if applicable (STSM Coordinator, WG Vice Leader, Task Force Leader...)

Position	Name	Country	Date of PhD:	Gender
Coordinator: Communication & Dissemination	Prof Charlotte Maltin	UK	1979	F
Coordinator: Training & Education	Prof Prisca V. Kremer	DE	2006	F
Deputy coordinator: Training & Education	Dr Maren Bernau	DE	2011	F

Action website: <http://www.cost-faim.eu/>

I.B. Progress with MoU objectives and deliverables and additional outputs

MoU objectives

MoU objective	Achieved Yes/ Partially/ No	Evidence of (partial) achievement including hyperlink to enable assessment of the achievement ¹ . Justification if full achievement is not foreseen
Main overall: Identify, optimise and standardise non-invasive <i>iv</i> and <i>pm</i> imaging and spectroscopic methods for the measurements of body composition and MQ in major farm animal species, to integrate automated systems for their objective assessment, and to facilitate effective data capture and management at the individual animal level. FAIM will generate knowledge, protocols and tools of substantial value to EU food and agriculture. Project outputs will be disseminated to industry, EU scientists and policy makers; they will be informed through the large quantity of high impact scientific publications, newsletters, public information and briefing papers produced. To fulfil this aim this COST Action will form a European-wide scientific and technology knowledge platform on the topic of optimising and standardising non-destructive imaging and spectroscopic methods to improve the determination of body composition and MQ in farm animals.	Yes	To date, FAIM has brought together > 330 experts from 23 (27) EU countries (and beyond) with the aim to optimise non-destructive <i>in vivo</i> (<i>iv</i>) and <i>post mortem</i> (<i>pm</i>) imaging and spectroscopic methods for the measurement of body composition and meat quality (MQ) in major farm animal species and to devise standardised principles of carcass classification and grading (CCG) across countries. FAIM Action members are active scientists and industry experts in the fields related to the WGs that correspond to the following areas: Body composition/carcass evaluation (WG1), Meat quality (WG2), Algorithms (WG3), Traceability (WG4). Through FAIM a functional platform/ network between scientists and industry experts has been developed and established. This network now facilitates knowledge exchange between industry and scientists and the collaboration of FAIM members for project applications and projects. Additionally FAIM has provided an email network for members wishing to get help/advice/information/contacts and to discuss points of interest from other FAIM members on numerous subjects facilitating the exchange of important information. The heterogeneity of FAIM provided special advantages for such an approach. In particular the advice from the FAIM network has been very important for those groups buying new imaging equipment and in helping them to decide on what software to use. Thanks to the reputation it has gained, FAIM was invited by the EAAP Committee to organise a one day symposium on the Topic "Carcass and meat quality: from measurement to payment" (Chair: Prof L Bünger) at the 2013 EAAP in Nantes (http://www.eaap2013.org/Programme/Scientific-Programme). This included 23 Oral and 20 Poster presentations, all on FAIM relevant subjects. This provided a good opportunity to present FAIM to other scientists and to explain, discuss and disseminate the work done within this COST action, and its possibilities, allowing the incorporation of quite a few new members. For further details see short report in FAIM II p4ff. Throughout the FAIM COST action particular attention was paid to ensuring that information and communications about FAIM were spread as wide as possible. In addition to the website, the publication of scientific papers (> 230), newsletters, FAIM specific books and a briefing paper, the STSMs, MC8 6-monthly meetings, local and national meetings and events, and the annual conferences provided excellent opportunities for word of mouth communication. This type of personal communication was particularly important for communicating to industry and policy makers, and led to a number of businesses

¹ The links to the outputs and deliverables will be used by the Action Rapporteur in assessing the progress.

		subsequently taking part in FAIM activities. Evidence of the increasing engagement and participation in FAIM over the funded period can be seen from the growth in conference attendees and the 563% increase in website traffic from 2012 to 2015. For details see FAIM reports I to IV (most importantly FAIM IV report) and the extracted WG reports (WG1 report; WG2 report; WG 3 report and WG4 report).
1. to review and develop robust references from imaging technologies for measuring body composition	Yes	The review and development of robust references from imaging technologies for measuring body composition has been particularly important and has been delivered by collaboration of FAIM members, as well as workshops and training schools e.g. Special Workshop WG1, and Training School at Rennes. The collaboration is evidenced by the various collaborative papers published in the reports from FAIM I to IV; in particular the paper from WG1 at FAIM IV report p67 highlights this work. In addition to scientific information and publications on references, FAIM also produced a directory of the imaging facilities available in the EU for measuring body composition entitled: Imaging facilities (CT & MRI) in EU for measuring body composition. This publication not only identifies facilities but also shows the diversity of equipment brands, the variations in parameters used for scanning and the different types of image analysis software being employed to interrogate the images. It is clear from all the output of FAIM (FAIM reports I to IV) that there is wide ranging research going on into the use of imaging for predicting compositional traits. For example in FAIM I –MRI - (Baulain p16) CT- in chickens (Milisits <i>et al.</i> p20), pigs (Lambe <i>et al.</i> p24 Kongsro p64), cattle (Brun <i>et al.</i> p47), DXA – (Scholz <i>et al.</i> p9). The FAIM action paid particular attention to keeping updated with the recent developments both in research and in industry as highlighted in the FAIM IV report (see papers by Hopkins, Gardner, Hinz, Thomson, Perry and Gilchrist pp17-34) The diversity of research together with the variations in infrastructure and software highlighted in the publication Imaging facilities (CT & MRI) in EU for measuring body composition serves to emphasise the need for further harmonisation and standardisation of procedures for using imaging methods for predicting compositional traits both in research and in the livestock industry. Following the work carried out within FAIM, the action participants have concluded that harmonised procedures for imaging based methods for the prediction of compositional traits cannot be developed or implemented commercially without further research work to achieve standardisation. This is clearly not within the scope of COST action funding. However, the FAIM action has now established a network of collaborators who are currently active in developing applications for research funding to achieve this very essential
2. to review and develop harmonised procedures for iv, pm and on-line imaging methods of predicting compositional traits.	Yes	

		step towards harmonisation. For details see FAIM reports FAIM I to IV and in particular the summary report for WG1 in the FAIM IV report WG1 report; and the booklet Imaging facilities (CT & MRI) in EU for measuring body composition.
3. to review and develop harmonised procedures for iv, pm and on-line imaging and spectroscopic methods of predicting MQ in livestock.	Yes	A review was done of the different technologies used to determine several MQ attributes. The review was presented at FAIM II and there is also key information in Chapter 9 of the Handbook. Furthermore, during the different FAIM conferences, several papers have been presented in which authors from many countries evaluated different technologies for MQ evaluation, some well-known such as NIRS and others newer such as laser backscattering imaging. For instance, at FAIM I, Fulladosa <i>et al.</i> presented dielectric time domain reflectometry to determine dry-cured ham composition and Clelland <i>et al.</i> presented the use of CT to evaluate meat quality in live sheep. At FAIM II Tsegay Berhe <i>et al.</i> presented the Raman spectroscopy to determine fatty acid profiles in pork, and Neyrinck <i>et al.</i> the use of NIRS to predict the quality of fresh pork for cooked ham production. At FAIM III Collewett <i>et al.</i> presented MRI to determine intramuscular fat in fish and Teixeira <i>et al.</i> the use of NIRS to predict chemical composition of goat meat. At FAIM IV Sarries <i>et al.</i> presented the MIR to the quality of foal meat and Perez-Palacios the low field MRI to predict the moisture and lipid content of pork loins. Since all these imaging and spectroscopic technologies need to be compared with a reference, harmonised procedures to determine these references for the selected MQ attributes were obtained from FAIM members reviewed and presented at FAIM III and a handbook was written that detailed all of them and presented at FAIM IV. The handbook includes 9 chapters, related with: (1) for protein, fat moisture and ash determination, (2) intramuscular fat and marbling, (3) pH value and water holding capacity, (4) muscle and fat colour, (5) instrumental tenderness-shear force, (6) fatty acid analysis, (7) sensory tenderness, juiciness, flavour and taint, (8) general aspects of chemometrics for the calibration and validation of spectroscopic technologies, and (9) future trends in non-invasive technologies suitable for quality determinations. For details see papers published in FAIM I to IV; especially see report WG2 and the MQ dedicated FAIM publication: A handbook of reference methods for meat quality assessment
4. If full automation cannot be achieved, a lesser option is provided by semi- automatic methods, where results are obtained through human-computer interaction.	Yes	Image analysis is central to the use of imaging. The work in this area was led by WG3 and in many instances was conducted jointly with other work on body composition, carcass and meat quality. For example, some of the training schools were held jointly with WG1 and WG2 participants at Oberschleissheim/Kulmbach and Rennes. Throughout the FAIM action training schools and STSMs were used in this way to integrate and support the wider training in and understanding of the challenges of image analysis in the context of body composition and meat quality. The interest in the work of WG3 grew considerably over the period of the FAIM action as evidenced from the rather small attendance at

		the training school in Lyngby in 2012 to the large and well attended training school in Copenhagen in 2015. Two well attended workshops were also organised by WG3. In addition, the ATAR (Software to analyse CT images with semi-automatic algorithms), developed by BioSS with SRUC in the UK has been made available to all FAIM interested parties. The STSM of Pau Xiberta has also dealt with this topic. In particular, thanks to the knowledge exchanged in this STSM, the <i>Visualpork software</i> has now implemented the algorithms to semi-automatically segment internal organs. WG3 has also established a Wiki in addition to the FAIM website, to provide a forum for discussion, a list of relevant software, and to facilitate communication within the field of WG3 and beyond. This Wiki will be maintained into the future beyond the timescale of FAIM to encourage on-going dialogue and future collaboration. For details see papers published in WG3 in FAIM I to IV; and for a summary see report WG3
5. to review and harmonise methods and equipment for individual animal traceability to optimise management, breeding and permit the future use of genomics.	Yes	Methods for animal traceability were considered both in terms of current commercial application in primary production and in processing, and in terms of current and future research into improvements and novel approaches. The FAIM action identified examples of best practice both in the EU and elsewhere. For example in the FAIM II report Peebles p86ff highlighted the practical use of electronic identification in Scotland, in the FAIM III report Davies and Milne p125ff discuss the practical use of electronic identification systems in Wales and in the FAIM IV report Navajas p124 –highlights traceability applications in production and breeding of cattle in Uruguay. Traceability without any tags has been demonstrated on meat cuts in Denmark (link). The same mathematical methods can be used for identifying animals. For details see papers published in WG4 in FAIM I to IV; and for a summary see the WG4 report.
6. to coordinate building of a data warehouse (database structures and software) enabling efficient data storage and access, matching compositional and MQ data (including meat hygiene info) with pedigree and other performance records. This will allow across flock/herd, breed and country evaluations.	Yes	The establishment of a cattle breeding database was discussed and presented at FAIM I (Pabiou and O’Connel p74). It is clear that issues of data protection and commercial confidentiality are major barriers, which have to be addressed and these were highlighted at FAIM IV e.g. by Navajas p124. Sharing of data between actors in a chain enables it to work like an integrated system. Some countries regulated the information chain especially for safety- and animal health reasons (see paper by Alvseike at FAIM II elsewhere 99 (Link)). A very successful Training School (49 participants) on “Big Data, Data Warehousing, and Data Analytics” was held in Lyngby, Denmark in August 2015.

		For further details see papers published in WG3/WG4 in FAIM I to IV ; and for a summary see report WG3 and the WG4 report .
7. to coordinate building of a 3D atlas/template per species as a reference tool for further research	partially	This has been achieved to the extent possible within the COST action framework. The membership of FAIM have concluded that the building of such atlases for each farm animal species is beyond the capability of a COST action because substantial amounts of funding and corresponding research work are required. This could have been realised only if there were national projects funded and FAIM would have coordinated them. Such funding was however not available despite such expectations when FAIM was being planned. A sheep and a turkey atlas were made available to all FAIM parties and a second improved Turkey atlas has been developed in Hungary during FAIM. However, the ambition to deliver 3D atlases for each farm species has not been fully realised. Extensive discussions were undertaken within FAIM as to the best means to achieve robust annotation and reconstruction. It has been concluded by the FAIM participants that there are several challenges which remain to be overcome before 3D atlases can be delivered, and this requires substantial funding beyond the scope of the COST instrument. It had been hoped that funds could be won within the time frame of FAIM, but unfortunately this has not been possible.
8. to ensure widespread knowledge exchange within and beyond the network, and to ensure dissemination of the results of FAIM. Experts from many countries will co-operate, prepare draft manuals by correspondence. A joint exercise is planned to check and validate methods and to familiarise experts across countries with the reference procedures	Yes	Knowledge exchange and dissemination has been a priority at FAIM and has been delivered consistently throughout the action. Knowledge exchange, communication and dissemination has been addressed in at least 3 ways; electronically, printed media, and face to face communications. Electronic media has focused on web-based tools such as the website and the wiki, social media, e-newsletters and emails. The initial traffic on the website at the start of the action was quite low, and appeared to be focused on the countries who were initially signed up to the action. By the end of Sept 2015, web traffic had increased 563% with clear interest from countries not extensively involved in FAIM particularly USA and China. Social media – facebook – was also used but did not appear to be as effective as had been hoped. Printed media were also generated throughout the action. In years 1-3 the focus was on the production of a book of abstracts of the proceedings of the annual conference, together with a report comprising reviewed and edited short papers from the majority of the presenters at each annual conference. The reports were compiled through extensive collaboration of both the authors and reviewers/editors of the reports (FAIM publications). Initially these reports did not contain the posters presented at the conference, but as the popularity of the conferences increased and exceeded the time available for presentations, the numbers of posters increased and there was a clear demand and need to include these in the annual conference report. So, from FAIM II onwards, the reports include some or almost all of the posters presented at the conferences. The abstracts and reports were widely distributed both as hard

		copies and through being made available on the website and via a FAIM DropBox. Particular efforts were made to ensure distribution beyond the FAIM participants, to industry, policy makers and interested parties to as many countries as possible. In addition to the reports two special publications were prepared. One is a <u>handbook</u> of reference methods for meat quality, which was developed in WG2 and which is also available at the <u>Researchgate website</u>. This handbook has been spread and a lot of researchers from different countries have shown interest in this book. In fact, it is now being used as a reference in an on-going European project to harmonize protocols between the different partners so it is acting to further communicate the work of FAIM. The second special publication is a directory of <u>Imaging facilities (CT & MRI) in EU for measuring body composition</u>, which was developed by WG1. This directory has already been widely distributed and is available on the FAIM website and the FAIM DropBox as well as at <u>Researchgate</u>. It further informs and spreads knowledge about the facilities available across the EU. The final form of communication has been active face to face communications. These have taken place in particular with industries, especially SMEs who are active in this area and who have ideas to contribute and also may be able to identify business opportunities in the area of FAIM. To that end it is notable that the Chairman's session at FAIM IV, comprised a high proportion of industrial speakers many of whom were offering novel insights and opportunities for both research and business (<u>FAIM IV</u> p22,28,29,34) In addition, the training schools, <u>STSMs</u> and workshops have also provided a very effective and direct means of face to face communication. There were <u>7 training schools</u> and 26 <u>STSMs</u> and seven workshops targeting this objective. It is of note that our training schools in particular served the purpose of point 8. For details see the <u>FAIM publication books</u> and the two additional books mentioned above (<u>handbook</u> and <u>Imaging facilities (CT & MRI) in EU for measuring body composition</u>)
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MoU deliverables (D) and Milestones (M)

MoU deliverable	Level of progress ¹	Evidence of (partial) delivery achievement including hyperlink to enable assessment of the delivery ¹ . Justification if full achievement is not foreseen
Y1,D1 Kick off meeting held	100%	Held 11/2011
Y1,D2 Website operational	100%	http://www.cost-faim.eu
Y1, D3 WG meetings held	100%	All in connection with the first annual conference FAIM I in Dublin, Sept 2012
Y1,M1 Possible and relevant technologies for traceability identified (WG4)	100%	Eartags with different types of Radio-frequency identification are in widespread use, and different systems were presented during FAIM I-IV . LF-RID in cattle, sheep

		and goat are mandatory in several EU-countries, and are also used in other vertical chains (New Zealand and Uruguay) (see WG4 presentations at FAIM I-IV. UHF RFID eartags were tested in pigs for flock identification (Denmark) (FAIM I, pages 88ff) Biomarkers to trace and predict quality in pigs (Holland) (FAIM I, pages 78ff) FAIM I and e-ID with DNA probes were tested in pigs (Spain). A review on systems in use for cattle has also been given at FAIM I ((FAIM I, pages 85ff). New technology like vision for the identification of either products (FAIM II) or animals (FAIM III) without using tags is the future for limit groups
Y1,D4 Workshop held	100%	Workshop = first annual conference FAIM I in Dublin, Sept 2012
Y1,D5 MC meeting held	100%	Link to Agenda/Minutes
Y1,D6 Residential camp (subsequently called training school)	100%	First TS in Lyngby May 2012: about image analysis and in October 2012 in Oberschleissheim/Kulmbach about "Imaging, meat quality and classification".
Y1, D7 10 Papers published	100%	See list of collaborative FAIM publications and list of FAIM member publications
Y1,M2 Relevant meat quality parameters for pig and beef, Identified (WG2 &WG3)	100%	These parameters were obtained by means of a survey and a questionnaire sent to different FAIM participants. The results of the survey were presented as a talk at FAIM I . A simplified list was prepared and discussed at FAIM II where an agreement was reached on the final selection of attributes, which were published at FAIM II booklet (p. 44).
Y2,D8 Interim report completed	100%	APC in Glasgow 2012
Y2,M3 Possible and relevant pm reference methods for carcass composition in pig, sheep, beef, and poultry identified (WG1 & WG3)	100 %	Possible and relevant reference methods were already identified at FAIM II (pages 14ff). Advantages and drawbacks of reference methods were described in FAIM II at pages 18, 22 and 27. The review by Scholz <i>et al.</i> 2015 (see FAIM publication list) summarizes in vivo and post mortem non-invasive (imaging) methods which can be used to measure body and/or carcass composition in pig, sheep, cattle and poultry. The accuracy and availability of the methods throughout the EU does not allow yet switching from reference dissection to a non-invasive imaging method like CT, for example, as the only pm reference method. → see also the FAIM paper Daumas <i>et al.</i> (2014, FAIM III p52ff) regarding the suggestion to use CT as pm reference method for pig carcass classification.
Y2,D9 MC meeting held	100%	MC Meeting in Hamar 26 3 2012- link to MC meetings
Y2,D10 Annual Conference held	100%	FAIM II held in Kaposvár; see this link for FAIM II publications.
Y2,D11 WG meetings held	100%	Held in connection with FAIM II (see line above)
Y2,D12 Workshop held	100% plus	First WG1 workshop in Lyngby in January 2013 about "Interlaboratory comparison between scanners". In addition to the workshops at FAIM II a full day symposium on the FAIM subject has been organised at EAAP64 in Nantes as a WG1 workshop
Y2,D13 Residential camp held	100 %	TS organised in 2013: October in Rennes, France about "Pig carcass composition measurement by CT and MRI. Living pig measurement by CT. From acquisition to data

		analysis": link to Programmes and reports etc.
Y2, M4 Relevant meat quality parameters for sheep and poultry identified (WG2&WG3)	100 %	This milestone was completed together with M2, because the questionnaire and discussion included all four species (pig, beef, sheep and poultry). The finally selected attributes for all four species are published in FAIM II booklet (p 44ff).
Y2,D14 Papers published	100 %	See list of collaborative FAIM publications and list of FAIM member publications
Y2,M5, Model describing the chain FARM to FORK and FORK to FARM developed (WG4)	~50%	It became clear during the FAIM Action that, to develop a full model requires funded research work. Without centrally or nationally funded projects a full model could not be developed. This aim was therefore too ambitious for the funding framework of a COST Action as no relevant national projects were funded at the time, however several systems have been developed: • FoodTag system is in use from fork to farm in DK (web link) • Silver Fern Farms in NZ (see for Buchanan in FAIM IV, pages 81ff) • Traceability - from food safety demand to business intelligence (see Siles at FAIM II p. 97) and Siles in FAIM III report pages 129ff • Farm to Fork individual traceability in Uruguay (see for Navajas in FAIM IV pages 124ff)
Y2,M6 Reference methods for all meat quality parameters in M2 and M4 defined	100 %	The reference methods for the determination of MQ parameters used in different laboratories was obtained by means of a questionnaire sent to FAIM participants. A summary of these methodologies was presented at FAIM III and is included in the booklet of this conference (p. 87-92).
Y3,D15 Interim report compl.	100%	APC in Plovdiv (see in this link for APC 2014 Plovdiv)
Y3,M7 Metrological documentation and handbook reference methods in M3 completed (WG1 & WG3)	Partially completed	A wiki type site for software used in image analysis in COST-FAIM has been designed and maintained throughout the action (Link). In addition to some general information about the WG3 team, the site provides a very useful reference resource providing a description of several software applications and algorithms that can be used to analyse and process farm animal images. The descriptions are broken down into categories: user friendly software, programme based software, and libraries for programmers. This makes the wiki helpful and suitable for a wide range of users. The wiki site also includes a useful list of publications, again organised into relevant categories, such as CT imaging, hyperspectral imaging, other imaging techniques, and video analysis. A short-term approach to establish a CT based reference method for the measurement of the lean meat % in pig carcasses was proposed at FAIM III (see pages 52ff) and discussed (p9). A specific workshop was organised (see below D16) to deepen the discussion on the reference method. It was concluded that such an agreement would need prior specific metrological work, including CT

		interlaboratory comparisons ("Round-Robin"). Most FAIM countries with a CT scanner took part in an inter laboratory comparison of CT scanners using a phantom developed by the Danish FAIM partners. The experimental phase, involving 6 (FAIM) CT scanners, started before FAIM but was analysed during FAIM and initiated a WG1 meeting in Lyngby in January 2013 where the results were discussed (for details see program and report here). Important results have been obtained, however more work is required as scanner effects were obvious but their exact quantification requires a coordinated EU approach involving all available CT scanners. A second simplified comparison was reported at FAIM IV (see SPB p67ff). It found substantial differences between scanners. Special research with appropriate levels of funding would be required to properly document the metrology of CT based reference methods. The handbook reference method has thus been adapted to focus on the CT (and MRI) methods of each FAIM organisation, describing both acquisition parameters and image analysis (see the Directory about Imaging facilities in EU for measuring body composition). See also comments of objectives 1 and 2. Further explanation has been given by the Editors of the directory of CT&MRI facilities (page 5)
Y3, M11 3D atlas of body composition for pigs and sheep completed (WG1&WG3)	Partially completed	See above table (objective 7). Dissemination of such atlases has been widened by FAIM and also the new Turkey Atlas produced by our Hungarian FAIM partners is disseminated via FAIM (link)
Y3,D16 Workshop held	100%	Special Workshop WG1 on Reference methods for carcass quality and composition has been held in Paris 11/2014. The WS described the required metrological work and evaluated the FAIM capabilities.
Y3,D17 MC meeting held	100%	Held 11-12/3/2014 in Thessaloniki (see in this link for MC5). Tasks for 2014 were discussed and the plan for FAIM III was developed.
Y3,D18 Annual Conference held	100%	FAIM III held in Copenhagen; see this link for FAIM III publications
Y3,D19 WG meetings held	100%	Held in connection with FAIM III; see line above
Y3,D20 Residential camp held	100%	Two TS organised in 2014: • May in Edinburgh about "Software tools to analyse DICOM images obtained from CT-Scanning"; • September in Girona/Monells about "Non-destructive online technologies to determine quality of meat and meat products: functioning principle and chemometrics": link to Programmes etc.
Y3,M9 Methods to cope with the challenge keeping the traceability developed (WG4)	100%	Several methods were presented during FAIM I-IV • Readers in the abattoir for RFID tags • Review of EID use in Scotland (see Peebles FAIM II, pages 86ff) • TAG (Technology, Agriculture and Greater Efficiency) project in Wales (see Davies p95 in FAIM II) • Traceability from food safety demands to business intelligence (see Siles at FAIM II p. 97)

		- Using DNA for auditing traceability systems (see Grassi p 101 in FAIM II CP) - Vision based meat tracking (see FAIM paper and in FAIM I conference proceedings P106) - Monitoring movement of pigs – trace by image analysing (see pages113ff in FAIM III and FAIM paper...)
Y3,D21 15 Papers published	> 100%	See list of collaborative FAIM publications and list of FAIM member publications
Y4,M10 Metrological documentation and handbook reference methods defined in M6 completed(WG2 & WG3)	100%	Information about the references obtained in M6 was collected and improved by means of additional research of the literature and it was used to write a handbook (chapters 1 to 7). This handbook was completed with chemometrics used to calibrate and validate new technologies against these references (chapter 8) and with information about available new technologies and its characteristics and main results obtained in MQ determination (chapter 9). See in this link for the Handbook
Y4,D22 Workshop held		Workshops were combined with the annual conference FAIM IV in Sept 2015
Y4,D23 Residential camp held	100%	Two TS organised in 2015: May in Girona/Monells about “Non-destructive online technologies to determine quality of meat and meat products: functioning principle and chemometrics” and August in Lyngby, Denmark about “Big Data, Data Warehousing, and Data Analytics”; link to Reports/Programmes etc.
Y4,M11 3D atlas of body composition for beef and poultry completed (WG1 & WG3)	Partially completed	For explanation see above in the previous table (objective 7)
Y4, M12 Value of each outcome for the interested parties (farmers, breeders, meat industry, consumers etc.) evaluated	100%	See FAIM I to FAIM IV books and two additional FAIM publications (see for the latter in Folder FAIM IV) The value of the outcomes achieved for example within WG2 are presented in the summary of WG2 achievements, and include training of researchers and students and technicians, knowledge about use of technologies to determine MQ, collection of references in a handbook, summary of imaging and spectroscopic technologies for MQ assessment and collection of the most used statistical methods to calibrate these technologies. The outcomes achieved can be helpful for the development of value-based payment and marketing systems, production improvement and optimization, improvement and development of market orientated breeding programs, optimizing meat processing needs, guide EU and/or national legislation makers, produce knowledge of practical application of spectroscopic and imaging technologies, calibration and validation of spectroscopic and imaging devices using reference methods, technology and software manufacturers.
Y4, D24 15 Papers published	> 100%	See list of collaborative FAIM publications and list of FAIM member publications
Y4, D25 Final Working Group meetings	100%	During FAIM IV in September 2015 in Edinburgh, there was a session for each WG in which the work done was presented and discussed among the participants.
Y4, D26 Final annual conference	100%	22-23/9/2015 in Edinburgh: link to all FAIM publications

held		incl. FAD
Y4, D27 Final Management committee meeting held	100%	21/9/2015 in Edinburgh: link to MC40 meeting
Y4, Final Report published	100%	Final report as FAIM IV and two additional publications (FAD)

Co-authored publications and FP7/ H2020 proposals

The co-authored publications and FP7/ H2020 proposals/ projects resulting from the Action are listed on the page following the “Additional outputs and achievements” section

Additional outputs and achievements

Please describe any other outputs and achievements that have resulted or are in progress, focusing in particular on those that contribute to the COST mission of “COST enables break-through scientific developments leading to new concepts and products and thereby contributes to strengthen Europe’s research and innovation capacities.”

FAIM was invited to organise at the 2013 EAAP in Nantes, a one day symposium (Chair: Prof. Lutz Bünger) on the Topic “Carcass and meat quality: from measurement to payment”. This included 23 Oral and 20 Poster presentations, all on FAIM relevant subjects, organised as WG1 workshop/meeting. FAIM also organized a workshop named “Workshop on Farm Animal and Food Quality Imaging (WFAFQI)”, held in Helsinki (Finland) on June 2013, preceding the Scandinavian Conference on Image Analysis (SCIA’13). Approximately, 30 people participated in the meeting.

The knowledge, expertise and reputation of FAIM was an important factor in the decision of two further countries (GR; PT) during the FAIM period to obtain a new CT scanner and/or gain access to one for measuring body and carcass composition in farm animals. One CT scanner in Germany has been replaced by a new one and Agroscope (Switzerland) based on the experience gained in FAIM bought a DXA-machine. Similarly, Estacion Experimental del Zaidin (CSIC, Spain) is planning to buy a new DXA machine.

In addition new collaborations have developed: FR helped IT in a pig scanning project. UK helped GE with a phantom to calibrate their old CT scanner vs. a new one (2015). DK helped FI (2015), DE helped EI and BE (work in progress) with the application of CT in national calibration trials.

DK (DMRI, mobile CT) and DE (CT, dissection team) organised a joint scanning and dissection trial in order to further evaluate scanning protocols and virtual dissection by CT (2015).

Numerous national project applications were supported by FAIM and by the expertise gained and by the enhanced reputation of participants funding has been achieved.

Enter in the table below only publications on the topic of the Action, co-authored by at least two Action participants from two different countries participating in the Action and for which the Action networking added value. A maximum of ten publications may be entered. If the Action has more than ten such publications the Core Group should select the ten most significant ones to include in the table below.

The full list of FAIM publications and collaborative FAIM papers can be seen [here](#).

NO.	Bibliographic data (including: Title, Authors, Title of the periodical or the series, Issue number or volume, Publisher, Year of publication, Relevant pages)	Main author	Number of authors	Action participants listed among the authors (Name, country and role ²)	WGs involved in publication	Date of submission (must be after Action start date)	Expected date of publication (if not already published)	Persistent link to publicly available version of the paper (if available) or the abstract	Is/Will open access ³ provided to this publication?	Is/ will COST be cited/ acknowledged in the publication?	Are/ will COST funds (be) implicated in this publication	Relevance to H2020 Societal Challenges ⁴ ?	Is it peer-reviewed?	Was the added value of the Action Networking necessary for the publication	Impact Factor (if applicable)
1	Various FAIM members and invited speakers 2012. FARM ANIMAL IMGAING, Dublin 2012,1, 1. FAIM via QMS Scotland, Edinburgh.	Maltin, C.A. (main editor)	>24	All authors, but invited speakers, are Action participants	1 to 4	9/2012	11/2012	FAIM I SPB Dublin 2012	yes	yes	yes	Food security	No	yes	High if applicable
2	Various FAIM members and invited speakers 2013. FARM ANIMAL IMAGING, Kaposvár 2013,1, 1. FAIM via QMS Scotland, Edinburgh.	Maltin, C.A. (main editor)	>20	All authors, but invited speakers, are Action participants	1 to 4	9/2013	11/2013	FAIM II SPB Kaposvár 2013	yes	yes	yes	Food security	No	yes	High if applicable
3	Various FAIM members and invited speakers 2014. FARM ANIMAL IMAGING, Copenhagen 2014,1, 1. FAIM via QMS Scotland, Edinburgh.	Maltin, C.A. (main editor)	27 plus	All authors, but invited speakers, are Action participants	1 to 4	9/2014	11/20124	FAIM III SPB Copenhagen 2014	yes	yes	yes	Food security	No	yes	High if applicable
4	Various FAIM members and invited speakers 2015. FARM ANIMAL IMAGING, Edinburgh 2015,1, 1. FAIM via QMS Scotland, Edinburgh.	Maltin, C.A. (main editor)	27plus	All authors, but invited speakers, are Action participants	1 to 4	7/2015	9/2015	FAIM IV SPB Edinburgh 2015	yes	yes	yes	Food security	No	yes	High if applicable
5	Various FAIM members 2015a. Imaging facilities (CT & MRI) in EU for measuring body composition,1, 1. FAIM via SRUC, Edinburgh, Scotland, Edinburgh.	Daumas,G. (main editor)		All authors are Action participants	WG1	7/2015	9/2015	FAD, "CT Directory"	yes	yes	yes	Food security	No	yes	High if applicable
6	Various FAIM members 2015b. A handbook of reference methods for meat quality assessment,1, 1. FAIM via SRUC, Edinburgh, Scotland, Edinburgh.	Font-i-Furnols,M. (main editor)	29	All authors are Action participants	WG2	7/2015	9/2015	Handbook	yes	yes	yes	Food security	No	yes	High if applicable
7	Scholz AM, Bunger L, Kongsro J, Baulain U and Mitchell AD 2015. Non-invasive methods for the determination of body and carcass composition in livestock: dual-energy X-ray absorptiometry, computed tomography, magnetic resonance imaging and ultrasound: invited review. Animal 9, 1250-1264.	Scholz,A.	5	Scholz AM (GE), Action vice chair; Bunger L (UK), Action Chair, Kongsro J (NO), Vice WG3	WG1	2014	Publ 2015	Paper	yes	yes	yes	Food security	Yes	yes	1.841

² MC Member/ MC Substitute/ MC Observer/ WG Member/ Training School Trainee/ STSM Recipient/ Other Action Participant

³ Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

⁴ H2020 Societal Challenges are "Health, demographic change and wellbeing"; "Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy"; "Secure, clean and efficient energy"; "Smart, green and integrated transport"; "Climate action, environment, resource efficiency and raw materials"; "Europe in a changing world - inclusive, innovative and reflective societies"; "Secure societies - protecting freedom and security of Europe and its citizens"

				leader; Baulain U (GE), WG- member											
8	Font-i-Furnols, M, Candek-Potokar M, Daumas G, Gispert M, Judas M and Seynaeve M 2016. Comparison of national ZP equations for lean meat percentage assessment in SEUROP pig classification. Meat Sci. 113, 1-8.	Font-i-Furnols, M	6	Font-i-Furnols, M (ES): MC member Candek-Potokar (SI): MC member Daumas (FR): MC member Gispert (ES): WG member; Judas, M. (DE): MC member Seynaeve (BE) WG member	WG1, WG2	~03/2015		Paper		Yes	no	Food security	Yes	Yes	2.615
9	Prevolnik, M., Andronikov, D., Žlender, B., Font-i-Furnols, M., Novič, M., Škorjanc, D., Candek-Potokar, M. (2014). Classification of Dry-Cured Ham according to the Maturation Time Based on Near Infrared Spectra. Meat Science, 96, 14-20.	Čandek-Potokar, M (SI)	8	Čandek-Potokar, M. (SI). MC member Prevolnik, M. (SI) MC member; Škrlep, M. (SI) WG member, Font-i-Furnols, M. (ES) MC member, Novič, M (SI) WG member	WG1, WG2	~10/2013		Paper		Yes	no	Food security	Yes	Yes	2.615
10	Picouet P., Muñoz I., Fulladosa E., Daumas G., Gou P., 2014. Partial scanning using computed tomography for fat weight prediction in green hams: Scanning protocols and modelling. Journal of Food Engineering 142, 146–152.	Picouet P.	5	Daumas, G. (FR): MC member Picouet, P. (ES) : MC substitute Muñoz, I. (ES), Fulladosa, E. (ES), and Gou, P.: WG members	WG1, WG3	2014	2014	Paper	no	yes	yes	Food security	yes	yes	0.5

FP7/ H2020 Proposals and projects

This table contains FP7/ H2020 proposals/ projects spinning off from Action activities and including in the proposing consortium at least three Action participants from at least three different countries participating in the Action.

NO.	Title	Name and country of main proposer	Number of proposers	Action participants listed among the proposers (Name, country, role ³ in the Action)	Funding agency submitted to	Date submitted	Date results expected	Result	Call identifier	Relevance to H2020 Societal Challenges ⁴ ?	Was the added value of the Action Networking necessary for the proposal / project?
Projects											
1											
2											
Proposals											
	List FP7/ H2020 proposals submitted as a result of the Action in this section of the table										
1	Virtual CAD/CAM and optimization tools for product design and complex decision support in raw meat production (MeatCAD)	Eli Vibeke Olsen, DK	17	17, Danish Technological Institute, DMRI, DK; Max Rubner-Institut, GE; National Institute of Chemistry (NIC), SL University of Girona, ESP IRTA, ESP Topigs Norsvin, NO Agrocampus, Rennes, FR ESA-Polytechnic Institute of Bragança, PT; University of Trás-os-Montes and Alto Douro, PT; Kaposvár University, HU; IFIP – Institut du Porc; F Animalia, No SRUC, Scotland, UK and BioSS UK Danish Technological University, DK Copenhagen University, DK Teagasc IRL	Horizon 2020						Yes, without FAIM this application would have not been prepared
1	TREASURE Diversity of local pig breeds and production systems for high quality traditional products and sustainable pork chains	Čandek-Potokar, M. from Agricultural Institute of Slovenia (KIS), Slovenia	25	INRA, France, WP3 leader PFOS, Croatia, partner UNIFI, Italy, viceWP3 leader LUHS, Lithuania, partner IRTA, WP4 leader, Spain	EC-REA under H2020	25.6.2014	21.11.2014	Accepted	SFS-07a-2014 Traditional resources for agricultural diversity and the food chain	Sustainable Food security	Yes
2	Supporting and integrating imaging technologies in Europe' acronym SIITE	Font-i-Furnols, Maria, ES		Lead Maria Font-i-Furnols from IRTA together with 20 partners who all worked in FAIM closely		Will be in March 2016					

I.C. Networking

Added value of the Networking

Please describe here the added value of the networking, highlighting in particular anything that would not have happened without the Action networking.

A widespread networking among more than 200 scientists and industrial experts arose from the first FAIM meeting in Dublin (FAIM I) where the organisers had made specific provision for time in the programme for networking. As a result of this and subsequent FAIM meetings 7 training schools, 26 STSM especially for ECIs/young researchers and workshops were organized. This provided considerable added value to the broader network because these STSMs and training schools would not have happened without COST funding.

In addition, the COST action funding of FAIM led to invitations for the FAIM members to contribute to various meetings and conferences. Several of the workshops were also organised as satellites to other conferences; this would not have happened without Cost funding.

The added value of networking was conspicuous throughout the FAIM action. For example, in WG1 the networking and discussions which arose from the network led to a wide ranging debate on the challenges of implementing CT vs dissection for carcase classification. The discussions were held both at the FAIM III meeting and subsequently at a special workshop in Paris. The outcome of the discussions was a paper for the EU commission. The networked group were also responsible for the publication of the directory of imaging facilities in the EU. None of these activities would have been possible without COST funding.

Similarly, in WG2 the networking added value is exemplified by the collaboration which underpinned the publication of the handbook of reference methods for meat quality.

Extent of the networking

Describe the extent of the networking among the participants in the Action. Were all participants integrated into the networking equally? Were those targeted by COST policies on Inclusiveness Target Countries (ITCs), Early Career Investigators (ECIs)/ Young Researchers, and gender balance fully integrated into the Action networking.

The contribution of FAIM to the general networking objectives are in short:

- FAIM Action has > 330 members or interested parties in the network representing 25 European countries of which 23 are official members of FAIM. Austria and Romania are not official FAIM member countries.

Among the 23 official members of FAIM, 7 countries were ITCs (Croatia, Hungary, Lithuania, Poland, Serbia, Slovakia and Slovenia) and Portugal was also included. All the ITCs as well as Portugal were well integrated, with an active participation in all FAIM conferences. A Hungarian participant was vice-chair of WG1 and Hungary hosted the FAIM II conference. A Slovenian participant was vice-chair of WG2 and Slovenia hosted a MC8 meeting. Most of the ITCs took part in STSM and/or training schools. Portugal participated additionally to a workshop

Additionally, among the members of the FAIM list, there are > 40 members who are from Austria, Romania, USA, Canada, Australia, New Zealand, Uruguay, Brazil or present multi-national companies, which cannot be allocated to one country.

- Gender balance: FAIM network members are about 1/3 females and 2/3 males.
- ESR: In the moment there are > 10% ESR of the official member countries.

A number of joint initiatives and achievements both at national and international levels have arisen thanks to FAIM COST Action. In particular:

- ATAR software, developed by BioSS in collaboration with SRUC (both UK) is now available to all FAIM partners and can provide the basis for further software developments allowing one software package to be used across all FAIM partners applicable to sheep and pigs and possibly other meat producing animals. There was a training school in May 2014 in Edinburgh especially on the use of this software and other relevant software to analyse CT images.

- As a result of a collaboration between IRTA (Spain) and Nofima (Norway) through a STSM (Pere Gou), knowledge about feasibility of NIR interactance hyperspectral imaging for on-line measurement of crude composition in vacuum packed dry-cured ham slices has been obtained and published in a peer reviewed journal to make it available to all the scientific community.
- There was a training school on non-destructive on line technologies to determine quality of meat and meat products in Monells and Girona in September 2014 that focused on these technologies and the chemometrics to analyse the data obtained. Because of high demand this TS was repeated in May 2015.
- As a result of two STSMs (Alessandro Ferragina on the utilisation of NIRS to determine meat quality between University of Padua (Italy) and Teagasc (Ireland) there has been exchange of scientific knowledge between groups and this knowledge was presented as a poster at the FAIM II Conference and it will be published in a peer reviewed journal. Also another STSM (Joel Gonzalez) between IRTA (Spain) and Teagasc (Ireland) working with NIRS allowed scientific knowledge sharing between groups and hopefully it will be translated to the scientific community.
- Wiki page for software evaluation has been established: A wiki page for software evaluation has been created by WG3 (mainly Jorgen Kongsro and Anton Bardera). Special emphasis has been put on links to a diverse range of different software for image/volume processing and analysis.

The networking in the FAIM action was considerable and grew steadily over the period of the action. This is evidenced by the increase in co-authorship of the papers published in the FAIM report. In FAIM I and II 19 % of the papers had authors from different member states, whereas in FAIM III and FAIM IV 30% and 47% of the papers respectively had co-authors from different member states. This provides clear evidence of a 1.5 fold increase in co-authorship, which had arisen from the increased networking opportunities due to FAIM.

All 23 countries involved in FAIM contributed to the action, for 20 of them this is evidenced by their published contributions to the FAIM papers or posters at the annual conference.

Gender balance was fully integrated across the action and care was taken to ensure balance was maintained wherever possible. The gender balance of the MC8 was 50% male and 50% female. Of the 26 STSMs that were undertaken, 17 (65%) were carried out by males and 9 (35%) by females. Of the total of 26 missions, 9 were carried out by ECIs/young researchers. The training coordinator worked to ensure where possible, that take up of STSMs was distributed as widely as possible across the FAIM participant member states, and that the places visited were also widely distributed.

The usefulness of FAIM as a functioning network has been proven already in the project application MeatCAD, in which the main FAIM partners were involved.

Similarly, links created and developed in FAIM have been successfully used to get the H2020 project Treasure, which involved cross-cutting regarding local pig breeds.

I.D. Impacts

The impacts that have resulted, or might result from the Action are described in the following table.

Description of the impact	Type of impact ⁵	Timing of impact ⁶
Enter one impact per line, and specify the type and timing of the impact.		
CT as post mortem EU reference method for carcass classification (directly/intended)	Scientific technological	Foreseen 5-10yrs
Greatly increased understanding of the use of and methodologies	Scientific	Achieved and

⁵ Scientific/ technological, Economic, Societal

⁶ Achieved/ Foreseen within 2 years/ Foreseen 2-5 years/ Foreseen 5-10 years/ Foreseen 10+ years

for imaging technologies in farm animals as a means to quantify body composition, carcass and meat quality.	technological economic	Foreseen 2-5yrs
Greater knowledge of other users of imaging technologies in farm animals across the EU and the location of the facilities	Scientific technological economic	Achieved
Wider recognition of the need to develop imaging systems for imaging large farm animals	Scientific technological economic Social	Achieved and Foreseen 2-5yrs
Improved use of standard reference methods for meat quality	Scientific technological economic Social	Achieved and Foreseen 2-5yrs
CT/MRI/DXA/US as standard performance test methods for livestock (directly/intended)	Scientific, technological	Foreseen-5 yrs.
Value based payment for farmers throughout Europe (indirectly, intended)	economic social	Foreseen 2-5 yrs
Career development and collaboration opportunities for 26 STSMs	Scientific, technological Economic social	Achieved and foreseen within 2 years
7 TS	Scientific , technological social	Achieved
Workshops	Scientific, technological social	Achieved
Out of the almost 100 papers presented in the FAIM action (FAIM I to FAIM IV) 48% comprised industry participants as authors or co-authors.	Scientific technological economic	Achieved, Foreseen within 2 yrs
Collaborative applications to Horizon 2020	Scientific technological economic social	Achieved, Foreseen within 2 yrs
Discussions with SMEs leading to possible collaboration	Scientific technological economic	Achieved, Foreseen within 2 yrs
Stronger understanding of research and development in the 23 FAIM partner member states and in non EU countries who have contributed to FAIM.	Scientific technological economic social	Achieved, Foreseen within 2 yrs
Improved understanding of the COST instrument	Scientific technological economic	Achieved
Increased experience of editing and publication	Scientific technological	Achieved

I.E Dissemination and exploitation of Action results

Describe the Action's dissemination and exploitation approach as well as all activities undertaken to ensure dissemination and exploitation of Action results and the effectiveness of these activities.
The FAIM COST action took a three part approach to dissemination and exploitation involving the use of published documentation, electronic media and face to face communications. Each of these approaches was underpinned by a range of activities. With respect to the published documentation, an annual report,

scientific publications and special publications were produced and disseminated widely. The website and emailed newsletters were the hub of electronic activities, and also provided electronic access to the publications and other documents. The use of both printed and electronic media was discussed amongst the FAIM participants and there was a clear demand for printed material in addition to electronic media as it was generally agreed that a printed document was an important physical means of raising awareness of the FAIM action. The face to face communications occurred in most of the FAIM activities including annual conferences, training schools, workshops, scientific meetings etc. All members of FAIM and particularly the MC 8 and MC 40 took the opportunity – where appropriate – to disseminate the activities and focus of the FAIM action.

The main focus of exploitation has been the use of FAIM to develop networks of likeminded parties which has allowed the exploitation of both knowledge and expertise, not only in training schools and workshops, but also through providing expert advice to colleagues, interacting with colleagues to develop funding proposals and through providing support for researchers and students both in FAIM partner countries and in home countries. In addition, the COST action has also allowed FAIM to exploit the expertise of associated countries such as Australia, New Zealand, Uruguay etc. (e.g. FAIM IV in Edinburgh) which has brought some important exploitable opportunities and information into the EU FAIM network. This is likely to have potential benefits for the Industry partners in the FAIM action.

Below are examples of the activities undertaken to support the dissemination and exploitation activities in FAIM.

Item/ activity	Target audience	Result	Hyperlink
FAIM I/annual conference 2012 report	Industry experts, policy makers and scientists across EU	This was the first annual meeting of the FAIM action, and 87 participants from 18 countries attended the meeting and engaged in the dissemination and exploitation activities. The meeting abstracts book was produced and distributed to participants, likewise the meeting report which was additionally distributed to academic, politicians and industry parties who did not attend the conference. These activities achieved both good engagement within the action and strong dissemination to a wider audience,	FAIM I in Dublin
FAIM II/annual conference 2013 report	Industry experts, policy makers and scientists across EU	Good participation with 100 participants from 23 countries. The audience participation was very active and the poster session was well attended. Industry engagement was notable, with industry sponsorship of several elements of the conference, e.g. the reception, the poster prizes etc. The meeting	FAIM II in Kaposvár

		abstracts book was produced and distributed to participants, likewise the meeting report which was additionally distributed to academic, politicians and industry parties who did not attend the conference. These activities achieved both good engagement within the action and strong dissemination to a wider audience.	
FAIM III/annual conference 2014 report	Industry experts, policy makers and scientists across EU	Good participation with 94 participants from 21 countries. The audience participation was very active and the poster session was well attended. Industry engagement was notable, with industry sponsorship .of several elements of the conference, e.g. the reception, the poster prizes etc. The meeting abstracts book was produced and distributed to participants, likewise the meeting report which was additionally distributed to academic, politicians and industry parties who did not attend the conference. These activities achieved both good engagement within the action and strong dissemination to a wider audience.	FAIM III in Copenhagen
FAIM IV/annual conference 2015 report	Industry experts, policy makers and scientists across EU	Good participation with 99 participants from 20 (incl. AU, NZ, USA, Uruguay) countries. The audience participation was very active and the poster session was well attended. Industry engagement was notable, with industry sponsorship of several elements of the conference, e.g. the reception, the poster prizes etc. The meeting abstracts book was produced and distributed	FAIM IV in Edinburgh

		to participants, likewise the meeting report which was additionally distributed to academic, politicians and industry parties who did not attend the conference. These activities achieved both good engagement within the action and strong dissemination to a wider audience	
Training school 1/2012	Industry experts and scientists across EU	12 participants from 5 countries interested in image analysis learnt the principals of image analysis and about software, which can be used for their analysis	TS WG1-4: Training course on image analysis, Lyngby, DK
Training school 2/2012	Industry experts and scientists/students across EU	10 participants across Europe (mostly from countries without a CT or MRI scanner) learnt about the use of such scanners, incl. also a DXA scanner and could compare the methods with manual dissection	TS „IMAGING; MEAT QUALITY: CLASSIFICATION“ OBERSCHLEISSHEIM/KULMBACH (October 08 – 12 2012)
further	Industry experts and scientists across EU	16 participants from various European countries (most of them without an own scanner) learnt the use of MRI scanning and the use of a mobile CT scanner) got hands-on experience in scanning a pig and a pig carcass and about the specific software used in Rennes for image analysis	TS WG1&2: From acquisition to data analysis: Pig carcass composition measurement by CT and MRI & living pig measurement by CT”, Rennes, FR
Training school 1/2014	Industry experts and scientists across EU	20 participants from various countries interested in image analysis learnt the principals of image analysis and about specific software for their analysis. They also saw the CT scanner in Edinburgh, which is mainly used for live sheep and they learnt how this is integrated into sheep breeding in the UK	TS WG1&3: “Software tools to analyse DICOM images obtained from CT scanning”, Edinburgh
Training school 2/2014	Industry experts and scientists across EU	34 participants from various countries interested in various	TS WG2: “Non-destructive on-line technologies to determine quality of meat and meat products: functioning principle and

		methods to assess meat quality. A TS is the best way to harmonise methods between labs. Experienced trainers taught students and scientist about new and standard say methods, especially non-invasive imaging methods	chemometrics", Monells, Girona
Training school 1/2015	Industry experts and scientists across EU	33 participants from various countries interested in image analysis learnt the principals of image analysis and about specific software for their analysis	TS WG2: "Non-destructive on-line technologies to determine quality of meat and meat products: functioning principle and chemometrics", Monells, Girona
Training school 2/2015	Industry experts and scientists across EU	45 participants attended and benefitted from presentations by: 1. Industrial providers of Big Data, Warehousing, and Data Analytical solutions 2. Examples of applications both from actual food-chain examples as well as inspiring examples from other domains.	TS WG3: Big Data, Data Warehousing, and Data Analytics, Lyngby
Workshops	Industry experts and scientists across EU	In addition to our annual conferences which brought industry experts and scientist together there were several workshops mostly on the basis of WGs but with participation beyond the WG members. Examples can be found on the right.	• WG3 organised a workshop named "Workshop on Farm Animal and Food Quality Imaging (WFAFQI)", held in Helsinki (Finland) on June 2013, preceding the Scandinavian Conference on Image Analysis (SCIA'13) conference. Approximately, 30 people participate in the meeting. • WG 1 and WG2 organised the before mentioned one day

			Symposium/workshop at the EAAP in Nantes • WG1 organised 2013 a special workshop on the Interlab comparison of CT scanners. • WG1 organised a workshop on the quantification of scanner effects 2014 in Paris
26 STSMs	Scientists particularly ESRs across EU	All STSMs were dedicated to the FAIM objectives and key for knowledge exchange. Many led to collaborative FAIM papers	Link to all STSM reports

I.F. Action success(es)

COST regularly communicates the successes of Actions. At this point in time what aspect(s) (outcomes and/ or impacts, rather than activities) of this Action is/ are the most suitable for communication?

Description of the success story	Dimension of the success ■ Breakthrough: scientific, technological or socioeconomic ■ Policy implementation (specify which policy) ■ Capacity building
Although traceability legislation has been introduced in the EU from animal health reasons and to be in control of animal movements it is now up to legislative bodies to demonstrate that the farmers have also other benefits from traceability. FAIM work on traceability helps implementation of EU legislation as farmers are more likely to use the technology when they see also an advantage for themselves. A project on beef and one on sheep running at SRUC in collaboration with industry partners demonstrates the value of carcass information feedback from the abattoirs back to the farmer to speed up breeding progress on the improvement of carcass quality and to optimise management decisions.	Help for policy implementation
The use of CT in farm animals as such is a breakthrough. Especially to use as a reference method and its integration into commercial pig breeding in Norway (see Kongsro pages 28ff in FAIM III) and in commercial sheep breeding in the UK (see Bunger <i>et al.</i> pages 22 ff in FAIM III) where annually over 3000 pigs and 500 to 800 sheep, respectively are CT scanned alive. FAIM members w/o a CT scanner gained substantial knowledge on imaging technologies and two countries got now access to a CT scanner, 2 countries were able to replace their existing one and one FAIM country decided to buy a DXA-machine; a second country is planning to buy one. For these processes FAIM support in different forms was of large importance.	Technological breakthrough and capacity building
FAIM has enabled EUROPE to move forward regarding harmonisation/ standardisation of CT as a reference method for body- and carcass measurement methods. FAIM conference attendees from Australia, NZ, Canada and the USA have repeatedly expressed their wish to have access to such network as FAIM as many of their attempts are single-handed and not networked. Further harmonisation/standardisation of imaging technology requires funded research work in a network e.g. for a Round Robin test. FAIM is such a network which can provide the backbone for such work. FAIM has coordinated national efforts in the development of possible on-line technologies for carcass evaluation and MQ assays.	Capacity building; networking between countries with and without a CT or MRI scanner.
The knowledge, expertise and reputation of FAIM was instrumental in two further countries (GR; PT) during the FAIM period obtaining a new CT scanner or gaining access to one for measuring body and carcass composition in farm animals. In GE Kulmbach an old CT scanner has been replaced by a new one. FAIM stimulated collaboration enabled the German institute to use a sophisticated phantom owned by SRUC to calibrate their new scanner against the old scanner, which was decommissioned in April 2015. Based on the experience gained in FAIM Agroscope (Switzerland) bought a DXA-scanner.	Capacity building and research coordination
Altogether 27 STSM and 7 training schools contributed substantially to the building of capacity of FAIM members	Capacity Building
Regarding meat quality measurement methods (WG2) it should be emphasised that in addition to NIRS many other, less known novel technologies have been presented, were tested and their pros and cons evaluated and discussed	Capacity Building

A substantial amount of work went into the Handbook of reference methods for meat quality assessment . The capacity building aspect of this provided value and usefulness e.g. in the new H2020 project <i>Treasure</i>	
CT scanners differ in their results and this variation needs to be quantified and the factors responsible for this variation need to be identified. It was FAIM work identified the need for such interlab testing of CT scanners to use CT scanning as a reference method alongside the well accepted dissection.	New scientific knowledge with high industry relevance has been gained, which could be only gathered because of networking between various scanner owners; research coordination
There were several PhD project linked with FAIM in which it has been shown that FAIM provided important expertise and helped such projects by granting STSMs and/or FAIM members acted as examiners for PhD defences. Numerous examples could be provided if required. e.g. (only a selection) • Carabús, A. (2015) Evaluation of live growing pigs of different genotypes and sexes using computed tomography. IRTA • Clelland, N. 2015. The use of computer tomography (CT) based predictors of meat quality in sheep breeding programmes. PhD Thesis, IEB, University of Edinburgh. • Donaldson, C.L. 2015. Spine characteristics in sheep: Metrology, relationship to meat yield, and their genetic parameters. PhD Thesis, IEB, University of Edinburgh.	International collaboration and training of PhD students and research coordination
FAIM remains a functional network capable of knowledge transfer, exchange of experience and collaboration helping especially countries without imaging facilities in decision making and making such facilities available e.g. France used their mobile scanner to enable Italy to use scanning capabilities in important industry trials.	Knowledge exchange between CT/MRI and DXA owning countries and to countries with conventional methods of carcass evaluation

II. Management Report

II.A. Overview of expenditure

Insert below in the yellow cells the summary of figures from the Yearly Financial Reports (YFRs) of completed Grant Periods and an IFR of any incomplete Grant Period – the Totals (non-yellow cells) will automatically sum.

	Grant Period 1	Grant Period 2	Grant Period 3	TOTAL
GP start and end dates	(01/01/2012-31/12/2012)	(01/01/2013-31/12/2013)	(01/01/2014-31/12/2014)	
Grant Holder institution	SRUC (UK)	SRUC (UK)	SRUC (UK)	
Meetings	EUR 53,039.12	EUR 84,301.24	EUR 65,426.58	EUR 202,766.94
Training Schools	EUR 15,615.67	EUR 13,659.01	EUR 27,996.45	EUR 57,271.13
STSMs	EUR 8,680.00	EUR 8,705.00	EUR 5,602.00	EUR 22,987.00
Dissemination	EUR 7,817.00	EUR 7,892.50	EUR 9,472.57	EUR 25,182.07
OERSA ¹	EUR -	EUR 2,205.88	EUR 2,836.31	EUR 5,042.19
Total Scientific Expenditure	EUR 85,151.79	EUR 116,763.63	EUR 111,333.91	EUR 313,249.33
FSAC ²	EUR 12,772.40	EUR 17,514.52	EUR 16,699.45	EUR 46,986.37
TOTAL	EUR 97,924.19	EUR 134,278.15	EUR 128,033.36	EUR 360,235.70

¹ OERSA = Other Expenses Related to Scientific Expenditure (e.g. bank charges)

² FSAC = Amount received by Grant Holder for Financial Scientific and Administrative Coordination

II.B. Budget and Participation management

II.B.1 Budget spent in relation to individuals/ institutions outside participating COST countries				
<i>STSMs from or to institutions from countries other than Participating COST countries</i>				
The table below describes the added value STSMs to approved institutions in IPC or NNC or Specific Organisations and any STSMs from an approved institution in an NNC to a participating COST country.				
<i>All our STSMs were in participating countries</i>				
Grantee	Host		Date	Topic and value added to the Action
Institution Country	Institution	Country		
Add home institution and country	Add host institution and country		Date	Describe topic of the STSM and the added value to the Action
<i>Invited Speakers</i>				
The table below highlights the added value of Invited Speakers from COST countries that have not accepted the MoU and/ or non-participating NNC, IPC or Specific Organisations whose participation at a meeting or Training School was reimbursed by the Action.				
Participant name	Institution	Country	Event date	Topic and added value to the Action
Malcolm Buchanan	Silver Fern Farms Ltd. New Zealand	NZ	FAIM I, 29/9/12	Individual animal Traceability from farm to boning room – A case study: Silver Fern Farms Ltd. (FAIM I book p 81 ff) Such an impressive example could not be found in the EU and it has been shown how traceability enables other technologies.
Harvey Ho	Bioengineering	NZ	FAIM II,	Parametric representation of the lamb

	Institute, The University of Auckland, New Zealand.		29/10/13	carcass based on computed tomography (CT) images (FAIM II book p 76 ff) Work aimed at building a robust yield predictive model based on an accurate description of a carcass built from CT scans which can be morphed to represent a particular carcass using any available information on the live animal and carcass
Candido Pomar	Agriculture and Agri-Food Canada, Lennoxville, Quebec	Canada	FAIM II, 29/10/13	Chemical composition of carcass tissues and its relationship with tissue mass and radio densities
Murk.J. Bottema	School of Computer Science, Engineering and Mathematics, Flinders University, Bedford Park, SA, Australia	Australia	FAIM III, 25/9/14	Vitamin A, marbling and connected sets (FAIM III book, p94ff) Marbling is an important meat quality traits and this talk attempted 3D quantification of marbling using biomedical image analysis and mathematical modelling
David Hopkins	Senior Principal Research Scientist (Meat Science), NSW DPI Centre for Red Meat and Sheep Development, PO Box 129, Cowra, NSW 2794 Adjunct Professor (CSU & UNE) Editor - Meat Science Editorial Board Member - Recent Patents on Food, Nutrition & Agriculture Editorial Board Member - Agriculture	Australia	FAIM IV, 9/2015	Australian view on lamb carcass and meat quality – the role of measurement technologies in the Australian sheep industry. Principals explained apply also for Europe but he demonstrated their implementation and here Europe could learn a lot. He explained automatic accurate methods of measuring carcass quality relevant to European abattoirs as well. Pages 17ff in FAIM IV David is also a key member of editorial Boards of FAIM relevant international journals
Elly Navajas	National Agriculture Research Institute, Uruguay	Uruguay	FAIM IV, 9/2015	Farm-to-fork individual traceability in Uruguay: applications in animal production and breeding. EN gave an excellent example for the integration of traceability of cattle into animal production and breeding. The Uruguayan National Traceability

				System is a national scale platform in which all cattle are traced from farm to fork, and all information at farm and abattoir level is recorded in two databases. This could serve as a demonstration project for other countries.
Cameron Craigie	AgResearch Limited, Ruakura research Centre, 10 Bisley Road, Hamilton, 3214, New Zealand	NZ	FAIM IV, 9/2015	Spectral imaging techniques for predicting meat quality –an Australasian perspective. CC highlighted the importance of non-invasive real-time prediction of meat eating quality in the processing plant. It has several advantages, allowing industry to: • Target carcasses for specific market requirements. • Market meat based on measurable quality parameters for increased product differentiation. • Inform the value chain of the impacts of management and breeding decisions on meat product quality for continual improvement. This is of high FAIM relevance.
Graham Gardner	School of Veterinary and Life Sciences, Murdoch University, Murdoch, WA 6150	Australia	FAIM IV, 9/2015	The development and calibration of a dual X-ray absorptiometer for estimating carcass composition at abattoir chain-speed. As in Europe there is in Australia currently no automated system for determining lean meat yield in lamb therefore their attempts to establish one is very FAIM relevant: • A dual X-ray absorptiometer system that can perform at 3 times the current fastest chain speeds in Australia, and provides highly precise determination of carcass composition has been designed for use within lamb abattoirs. • The images generated by this system also meet the visual requirements of a robotic boning system, diversifying the value of investing in this device. See pages 22ff in FAIM IV

Dissemination meetings

The table below highlights the added value of Dissemination Meetings financed from Action funds.

FAIM note: There were no additional dissemination meetings organised by FAIM. We consider our annual Conferences as fulfilling this purpose. There were very many industry representatives among the participants.

Participant name	Role	Country	Date	Location	Topic and added value to the Action
Add	Add	Add	Add	Add	Describe the speaker's topic and

					the added value to the Action
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II.C. Participants

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II.D. Specific issues

This section is confidential to the Management Committee, and the COST Association (Administration, Scientific Committee and Committee of Senior Officials); and is not included in the version of the report that is published on the COST website.

The Action encountered the following particular difficulties in the implementation of the Action (e.g. imbalances of participation across the Working Groups, inactive country representatives).

Describe the issue(s) here or write "no particular difficulties encountered".

- The lack of funds from European wide or national sources for research hampered the further development of CT phantoms and an associated round-robin test and the 3D work to develop corresponding 3D atlases.
- Although many FAIM members declared initially their interest in WG4-Traceability their focus turned gradually rather to WG1 and WG2 issues. The number of contributions/presentations in WG4 diminished over the time of FAIM.
- No further particular issues occurred

Write explanation here

During the action it became increasingly clear that the harmonisation between CT scanners requires more than just discussing common protocols, agreements on the software used for image analysis and on machine settings. There is variation in measurements between labs which is associated with the machine used. To evaluate the extent of this machine related variation requires a round-robin test which needs relative small but targeted funding. Although there were a few attempts inside FAIM to organise preliminary experiments (e.g. see [Monziols p67ff in the FAIM IV report](#)) a satisfactory solution was not achieved yet.

This study and FAIM showed that more funded research work on CT scanner metrology is needed to increase the harmonisation and standardisation between different CT scanners/protocols for the measurement of animal body composition. This requires special research with appropriate levels of funding so that between the various different countries and different machines can be achieved. This is a necessary step to establish a Computed Tomography (CT) based reference method for the measurement of lean meat percentage (LMP) in pig carcasses (see [Daumas et al. p52ff in FAIM III](#)).

When FAIM was initiated to produce 3D atlases for a few species seemed a realistic objective. However, COST Actions can only network projects for which research funding comes from other sources. National funding for the development of 3D atlases did not become available during FAIM, however Hungary managed to produce a [new anatomical Atlas for Turkeys](#) and FAIM made existing [anatomical Atlases for sheep and Turkey](#) available to the community.

The diminishing interest in WG4 work can only be explained by the national and international funding situation, which seems not to support much of such work in the moment. Some abattoirs attempted to establish traceability (e.g. Morrisons, UK in Turriff) but their progress is dependent on the financial resources of the companies. Further progress depends mainly on governmental push and legislation as the companies don't see any obvious market advantages when they implement such technology. However, in 2014 SRUC received substantial funding for 4.5 years for an Innovate UK project ("Solutions for sustainable lamb production and breeding for more taste and less waste to increase food security in the UK and beyond") which is based on the use of traceability to get carcass and meat quality information on individual sheep to use these data in genetic evaluations. This will have an enormous demonstration potential in the UK sheep industry and beyond.

Annex 1

Definitions:

COST Action Challenge (main aim)	"The research question addressed by the COST Action targeting scientific, technological, and / or socioeconomic problems"
COST Action Innovation	"The creation and / or development of new or improved concepts, products, processes, services, and / or technologies that are made available to markets, governments and society"
COST Action objectives	"COST Action objectives are the results that an Action needs to achieve in order to respond to meet its challenge. These are SMART (Specific, Measurable, Achievable, Relevant, Timely) and twofold: research coordination objectives and capacity building objectives."
COST Action research coordination objectives	"Achieving these objectives turns COST Actions from initially scattered teams into one transnational team and leverages the existing funded research. These objectives entail the distribution of tasks, sharing of knowledge and know-how, and the creation of synergies among Action participants to achieve specific outputs."
COST Action capacity building objectives	"Achieving these objectives entail building critical mass to drive scientific progress, thereby strengthening the European Research Area. They can be achieved by the delivery of specific outputs and / or through network features or types and levels of participation."
COST Action networking activities	"any activities organised by the COST Action (whether or not directly funded by COST) in order to achieve research coordination and capacity building objectives."
COST Action networking tools	"instruments through which eligible activities can be funded"
COST Action outputs	"direct results from the COST Action activities. These can be codified knowledge, tacit knowledge, technology, and societal applications."
COST Action impact	"the short- to long-term scientific, technological, and / or socioeconomic changes produced by a COST Action, directly or indirectly, intended or unintended."
COST Action deliverable	"a distinct, expected and tangible output of the Action, meaningful in terms of the Action's overall objectives such as a report, a document, a technical diagram, a software etc. Action deliverables are used to measure its progress and success."
COST Action milestones	"Control points in the Action that help to chart progress. They are also needed at intermediary points so that, if problems have arisen, corrective measures can be taken. A milestone may be a critical decision point in the Action where, for example, the MC must decide which of several technologies to adopt for further development (e.g. core group and MC meetings, mid-term reviews)".
Inclusiveness Target Country (ITC):	Current COST Member Countries targeted by the COST inclusiveness Policy ("Inclusiveness Target Countries" (ITC)): EU 13 (Bulgaria, Cyprus, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia, Slovakia), EU candidate countries (the former Yugoslav Republic of Macedonia, Montenegro, Republic of Serbia, Turkey) and potential EU candidate countries (Bosnia and Herzegovina). In addition, to comply with the EC criteria for 'Spreading Excellence and Widening Participation', Portugal and Luxemburg are included.