

This document includes the text submitted by a consortium co-ordinated by ADAS to the Call for Expressions of Interest (EoI) for support from Wave 3 of the Government's [Industry Strategy Challenge Fund](#) (ISCF). The ISCF forms part of the [Industrial Strategy](#) which aims to boost the productivity and growth of all business in the UK, across all sectors of the economy. The Wave 3 Call was for looking for broad ideas of challenges that could be supported with government investment from April 2019 that meet the 'Grand Challenges'. This is the start of a process that would involve further industry, policy and academic consultation, it is not to fund specific projects or consortia outright.

This Wave 3 EOI is separate from the ISCF Wave 2 funding of £90million for '[Transforming Food Production](#)' (TFP) that was announced by Greg Clarke in February and for which briefings have been taking place. 'Transforming Food Production' is led by Innovate UK and BBSRC and will support development and exploitation of new technologies by businesses for the benefit of the agriculture and food industries. There is undoubtedly a large need and public benefit for support for innovations in agri-tech which this programme will make a real positive transformation too.

However, we also see a real need for a transformation to 'knowledge' in agriculture, both in terms of sharing and utilising existing knowledge but also in terms of how new knowledge is generated and 'best practice' determined and shared. After consultation and deliberation we considered that the 'Transforming Food Production' programme would not directly address the challenge of 'knowledge exchange' in agriculture at the scale required to meet the size of the opportunity presented here.

We therefore created a consortium with a vision of how the agricultural knowledge and innovation system in the UK could be transformed to put the farmer at its centre. We believe this EOI is innovative enough and transformative enough to be worthy of consideration by ISCF in addition to the funding of TFP. We have been inspired by the success of recent farmer-centric initiatives including [Yield Enhancement Network](#), [Innovative Farmers Field Labs](#), [AHDB Monitor Farms](#) ADAS' [Agronomics](#) and [BASF Real Results](#) which demonstrate approaches where farmers are fully engaged in the generation of knowledge. We also acknowledge the importance of agronomists/advisors and the supply industry in the knowledge ecosystem in the UK, along with the academic sector. However, the UK's agricultural knowledge system is highly fragmented with many competing interests. We see a real need for models that allow inclusive collaboration and co-ordination across the industry, and we believe that appropriate investments in digital and social infrastructures could enable systematic co-ordination to develop, hence our submission for Wave 3 ISCF support.

This EOI was submitted by the consortium below on 18 April, we should get a response by 18 May. Whatever the response we are keen to push forward the ideas within this proposal, and seek genuine inclusive cross-industry support & participation for this approach. Your comments and feedback would be very gratefully received.

Daniel Kindred, ADAS, 20 April 2018

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Application Title: **Farm-PEP: Farm Productivity Enhancement Programme**

Estimated Timescales: Start April 2019, 3 years

Partners:

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Project Summary [In one sentence concisely articulate the challenge with no jargon. Say what the challenge is, why it is worth solving and what the positive impact would be if it was addressed. 40 words max]

Agricultural productivity can be doubled by an industry-led transformation of the UK's knowledge generation and dissemination system to become truly farmer-centric; integrating digital infrastructures and upskilling networks (empowered through data exchange, AI and farmers' ideas) will maximise farmer-learning and progress.

[40]

Scope: Alignment with grand challenges [Identify which of the following 'grand challenges' your challenge relates to: clean growth, ageing society, future of mobility, or artificial intelligence and the data economy.]

Artificial intelligence and the data economy.

- 1. Describe your Challenge** *[Provide further information about the challenge, including: (i) a clear, non-technical description of why it is worth solving, why now and why government should be involved, (ii) a summary of how it will be possible to judge when the solution has been developed and the challenge addressed? (iii) the real-world impact of the challenge, including who the main beneficiaries would be if it was solved and the impact it would have on the general public, (iv) Addressing the challenge cannot be achieved through 'business as usual'. This expression of interest does not relate to activity already funded by other means. You must show clear business leadership for the challenge. Max 500 words.]*

UK agricultural productivity has stagnated for two decades, yet global demands for food, biofuels and carbon capture will mushroom(1). To compete post-Brexit, UK farmers must make progress urgently(1). On-farm knowledge is vital for this and recent farmer-centric initiatives (EIP-Agri Operational Groups(7), YENs(19), Monitor Farms(2), Field Labs(10) & Agronomics(18)) demonstrate clear potential to energise farmer-led innovation and improvement(6,7,12) with inclusive collaborative engagement across the industry. Almost all farms are SMEs but Agri-Tech investments in exploitable IP are not applicable to improved husbandry and farm learning. Our cross-industry consortium's (Appendix E) challenge is to institute emerging technologies of AI, machine learning and semantic analysis within a farmer-centric Productivity Enhancement Programme(PEP): multiple farmers becoming facilitated co-creators of the knowledge that is vital to farming progress. Public investment in social networks, AI technologies, digital tools and key actors' skills can transform knowledge generation, flows and use in agriculture, revolutionising farm husbandry and accelerating progress.

Agriculture is characterised by multiple independent farmers, restricted by time for training and innovation. Farming differs from other manufacturing industries due to huge biological noise, bringing uncertainty, unpredictability and unquantified risks. Also, farming must address substantial welfare and sustainability challenges including livestock health, resource-inefficiencies of crops/stock, air/water emissions, climate change, globally-finite resources, and loss of agrochemicals/pharmaceuticals through regulation and evolving resistance.

Biological science has moved from farm and field, to cellular and molecular scales. Research on the questions that really matter on-farm at field scale (e.g. soil effects on crop yields) lack public funding. Furthermore, the myriad of interacting factors that affect performance on-farm (many of which are largely irreducible i.e. weather, soil, machinery, roots, stocking strategies, time-pressures and farmer mind-sets) cannot be extrapolated from finer plot/pot scales. Yet UK arable farmers annually face the challenge of optimising for site and season the many and complex decision options arising from their different species, varieties/genetics, soils, feeding/cultivation systems, climatic conditions, agronomic inputs, rates, timings etc.

For various reasons, few scientists pursue agronomy, farm design or husbandry (in part due to reduced funding available), and farmers have become disengaged from science. Thus the implementation gap from research into application on-farm is significant; due both to its relevance and the communication gulf between scientists and practitioners. Additionally, knowledge exchange (KE) and research landscapes in the UK suffer from being highly fragmented (2) and sometimes competitive. Farmers are inherent innovators and experimenters, learning by comparing different practices across fields and seasons and building bespoke knowledge over time, but with questionable rigour and haphazard communication. Farmers respond to peer-to-peer learning -- the most compelling trigger to change practice is witnessing successful adoption(8) -- but this process is informal, with little benchmarking or support, inevitably causing progress to be slow.

Advances in AI, digitisation and peer-to-peer networking offer powerful novel models for digitally connecting farming and science. Creating such a comprehensive integrated approach for this would put the UK in the vanguard of 21st century agricultural technology, providing opportunities for UK players to instigate and increase sustainable food production globally.

2. **What is the opportunity for productivity growth?** *[Explain how addressing this challenge would have a positive impact on productivity growth, including: (i) which areas of the economy would see productivity growth, and (ii) the potential wider social or non-market benefits of solving this challenge, such as improvements in health or environment. Max 300 words.]*

If farmers' knowledge and innovations are supported with sufficient intensity and incision, we estimate(17) agricultural productivity (which largely drives farm profitability) could double in ten years. This estimate is supported by large inter-farm and within-farm variation in crop and livestock performance, and by greater advances in productivity observed by competing nations (e.g. NL, IT, US and FR).

Productivity opportunities identified recently(1) include: advanced breeding and phenotyping techniques (increasing conversion efficiencies and resilience of breeds/varieties), on-farm sensing and precision farming, development of non-edible markets, realignment of storage and distribution systems, interoperability of IT systems, standardisation of audit requirements and sustainability metrics, value-chain integration, enhancing soil health, widening habitat diversity, and smarter water management. Additional themes offering productivity or sustainability enhancements are: protecting crop and livestock health, optimising crop/livestock nutrition, and processing to enhance the value of primary and co-products(2).

Considerable opportunities arise in meeting public aspirations for safer, fresher and more nutritious products, with clear provenance. Advanced prediction tools can drive more targeted use of pesticides and pharmaceuticals, and realignment of storage and distribution systems

The missing link between opportunities and application on-farm lies in developing a UK programme for productivity and profitability which bridges major communication gaps, inspiring widespread behavioural change and embedding innovation. This proposal interconnects and harmonises existing and emergent tools on-farm for generating, experimenting and sharing data, so farms can research, monitor, audit, benchmark, and more efficiently manage their production and business. Across all farms, such a programme offers massive steps forward in addressing the commercial, environmental and health challenges that society faces.

Countries advancing productivity elsewhere in Europe(5), owe success to nurturing relevant knowledge (across all skill levels) through creating systems for farmer-centric enquiry and learning that bolster the trust of the farming community, and simultaneously delivering robust, repeatable outcomes at commercial scales. Inspiring widespread behavioural change and embedding innovation. This proposal interconnects and harmonises existing and emergent tools on-farm for generating, experimenting and sharing data, so farms can research, monitor, audit, benchmark, and more efficiently manage their production and business. Across all farms, such a programme offers massive steps forward in addressing the commercial, environmental and health challenges that society faces.

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3. What is the market opportunity? *[Identify the market opportunity associated with this challenge. Briefly summarise relevant evidence of the global value and potential growth of the relevant market or markets. Max 300 words]*

The immediate market for Farm-PEP is all UK farms and all their support industries. If 44,000 UK farm holdings, each of 80 ha, adopt the farmer-centric philosophy and improve their production by say just £120/ha on average (e.g. less than 1t/ha grain), the annual benefit would be ~£0.4 billion. After five years the return on the initial investment suggested for Farm-PEP (Question 7) would be ~45:1. The latest evaluation of Field Labs shows over 90% farmers would recommend this approach to their peers(10).

Annual UK agricultural production is currently worth ~£20 billion, and could probably be doubled in a decade(Question 2), given a successful Farm-PEP, because productivity in grass, cereals, oilseeds, potatoes, fruit and vegetables could ultimately double or treble, for milk it could increase 5-fold, and in lamb, 3-4 fold; opportunities for growth in beef, pig and poultry sectors are between 25-80%(17). Major parallel opportunities are identified to increase conversion efficiencies of inputs, and to improve utilisation of co-products e.g. through anaerobic digestion.

The secondary opportunity (for UK entities to become providers of agricultural enhancement and extension expertise globally) is also very large, for example in facilitating the massive agricultural transformations required in the newly advanced economies of Asia and South America. China(6) is making major investments as part of its rural vitalization programme and China is looking especially to UK for collaboration (e.g. supported by Teresa May's visit to CAAS in Feb. 2018). Considering the larger shortfalls from potential productivities of farms abroad, the global market opportunity for Farm-PEP can only be massive.

Additionally academia (through both research and education) will be essential partners and additional beneficiaries of Farm-PEP because they are increasingly being funded to fulfil 'challenge-led' research and to show 'impact'; impacts will be immediately demonstrable and assessable through Farm-PEP.

4. What evidence is there of UK strengths and competitive advantage? *[Explain how the UK has the research and development capability and business readiness to meet the challenge. Identify: (i) the relevant UK research strengths, (ii) the industry supply chain needed to address this challenge at scale, and the relevant UK industrial strengths, and (iii) how the UK has the capacity to be a world leader in addressing this challenge, and what the likelihood is that UK companies will be able to take advantage of the global opportunities that arise from the development of successful solutions. Max 500 words.]*

Brexit is a huge immediate spur for change and innovation in UK agriculture(2), and over decades the UK industry has shown a laudable aptitude for change. Despite stagnant productivity currently, the industry uses multiple inputs and advanced mechanisation so is closely conversant with complexity and optimisation. Modest sizes of farms and fields, and high soil variability, encourage finer-scale monitoring and management than in global regions with more extensive agricultural systems. Additionally, depletion of government funding for on-farm advice has encouraged a strong farmer-funded support sector which maintains high levels of farmer engagement and an openness to technical innovation. Commercial development of digital agricultural systems is also well advanced so UK constitutes an attractive testbed for new technologies of all sorts. Knowledge and skill levels are generally high, due to farm enlargement, de-staffing, along with improving education and training, although time-pressures on staff are also high. Social networking between farmers and their supporters is developing strongly.

High population density dictates close public scrutiny of farming methods and operations; as across Europe, laws and regulations require close stewardship of the farmed environment, with specific constraints targeted to protect air and water quality and biodiversity. Farmers are conversant with detailed record-keeping.

Farming organisations have a rich mix of national and more international interests; many multi-national companies are heavily involved. The independent sector (e.g. Innovation Centres, ADAS, CABI, NIAB) has an international outlook. They engage strongly with commerce, encouraged by the absence of a Government Extension Service.

Agrometrics has established the world's first data platform for agri-food using Sir Tim Berners-Lee's pioneering notion of the semantic web which transforms data exchange and trading by achieving interoperability without any need for data standards.

R&D centres are characterised by academic excellence, and are increasingly required to demonstrate impact at the societal level. UK has world class research record in agricultural science as well an established network of social scientists in the agricultural context which provides insights into learning, innovation, and adoption of new technologies.

Arising from the disconnects between the disparate players described above, and thus the UK's fragmented AKIS(16), increasing recognition is now emerging in both policy circles and the farming industry of the power of peer-to-peer learning. Experience from all our farmer-centric initiatives (Appendix-A) demonstrates that harnessing the power of individual farming businesses to adopt, assess and learn the outcomes of new ideas does cause uptake of relevant solutions and increase productivity. For example farmer-led research in Field Labs(10) bridges the dichotomy between research and farming; farmers report over 90% learning and high rates of management change resulting directly from group KE and co-design of trials. Success is attributed to experimenting on farmers' own farms in direct collaboration with both peers and experts; learning outcomes are amplified by seeing results in their own, and other, systems. Our proposal is thus to turbo-charge these farmer-centric activities with a comprehensive socio-digital infrastructure, to benefit all sectors of UK agriculture and horticulture, and then to employ this globally, for the benefit of the UK economy.

5. What is the demand from industry? *[Describe the level of industry demand in the UK for ISCF support to solve this challenge. Describe (i) the main UK-based stakeholders with an interest in this challenge, providing a list of supporters as an appendix, (ii) how co-ordinated industry and academia are currently, and whether they could effectively come together in multidisciplinary partnerships to provide leadership around this challenge, (iii) the evidence, where available of the extent to which industry would be willing and have the resources to co-invest to solve this challenge. If your challenge is selected it is critical it has a director to run it. Please indicate who would be a suitable leader for your challenge, preferably someone from your proposal team. You can submit an appendix with relevant supporting information, such as a list of supporters (from industry, academia or elsewhere) and letters of support. Do not provide in-depth economic or market analysis at this stage. This will be co-ordinated by UK Research and Innovation during the assessment phase. Supporting information must be in a PDF format no larger than 1MB. 500 words, plus Appendix.]*

The UK's agricultural research, information, knowledge, innovation and advisory system (AKIS) is fragmented, and needs co-ordination(16). Prime responsibilities for most crops and stock lie with the levy-funded AHDB. Pulses (PGRO) and sugar beet (BBRO) have voluntary levies; poultry has no levy. AKISs generally follow a top-down model(8,16). AHDB is however now evolving a peer-to-peer AKIS through its Farm Excellence programme (e.g. Monitor Farms), being keen to build this on farmers' ideas and data. ADAS is the largest contractor delivering independent research and knowledge exchange (KE) for AHDB and others. ADAS recently developed field-scale testing processes (Agronomics, Appendix-A) which confer statistical robustness on farm-trials. ADAS has also established the YENs (Appendix-A;19) which work across industry to understand constraints to productivity field-by-field. Cross-industry support for YENs and Agronomics come from levy-bodies, distributors, manufacturers, breeders, academic establishments and agri-tech companies (Appendices B,E) with >300 farmers and >30 sponsors now contributing. Innovative Farmers is a not-for-profit farmer-centric network with over 1,000 farmers engaged in 'Field Labs' to date. It has significant industry support and academic collaboration, creating strong impact for farmers from a proven facilitated approach(Appendix-A,10), but needs scaling-up.

Farmers increasingly use peer-to-peer communication as a key source of knowledge, through social media like The Farming Forum, Twitter & Facebook, and farmer networks e.g. BASE (Appendix-A). Essential pillars of any farmer-centric AKIS are: (i) common conceptual frameworks (ii) meaningful metrics and (iii) trusted tests(18). These can be formalised in Farmers' Innovation Groups (FIGs) such as YEN and Field Labs to find how key constraints might be overcome. Being entirely industry-funded to date, these have lacked the investment to reach all farms, but they successfully demonstrate a collaborative approach and they elucidate the potential to transform the AKIS model so it addresses any farming issue (e.g. managing blackgrass, diseases, soil-health, feed-conversion, livestock health, grass leys, cultivation systems). To extend this approach and provide scalability, interoperable digital solutions are required to facilitate discussion, data exchange, visualisation, benchmarking, analysis, message distillation and sharing of new knowledge, using new AI approaches and building on the rapidly developing sensing technologies and data systems now becoming commercially available.

Advisors and the supply industry play a crucial role in supporting farmers decision-making, conducting 1,000s of plot trials each year to support their services (although results are not peer-reviewed or published). Plot data are valuable, but extrapolations to field-scale (and vested interests) cause distrust amongst some farmers. Agri-businesses are now recognising new models of farmer interaction involving field-scale testing (e.g. BASF 'Real Results') and new digital services. The Leadership Group and supporters for Farm-PEP (Appendix E) loudly articulate the demand for a farmer-centric AKIS(3) and show ample potential Champions for this challenge. The consortium partners connect with everyone in agriculture, and aim to enhance existing services, networks, skills and communication channels rather than duplicate or compete with them. Delivery of the Farm-PEP will depend

on inclusive collaboration across the industry, and we are confident we can achieve this, plus co-investment, given the buy-in we've already demonstrated.

6. Why is ISCF support needed? [Max 300 words]

Explain how ISCF will add value and why existing or planned investments from industry, government or the research base are not sufficient to address this challenge. Explain:

- how things are done today and what the limits of current practice are from an industry and technical perspective
- what is new about the approach you are proposing for tackling the challenge
- why now is the right time to invest to address the challenge
- how ISCF will address a critical gap in current funding to address this challenge.

For an effective UK AKIS, the many fragmented initiatives across the UK need co-ordination at farm level(16): no individual organisation could viably invest alone in the necessary socio-digital infrastructure; a multi-agency approach is needed to span the multiple scales, sectors, issues & boundaries.

Innovate UK supports companies developing solutions as products or services, and substantially adds to this with ISCF-Wave-2 investment in 'Transforming Food Production'. However, this model doesn't directly support farming innovations that improve husbandry or farm-system designs, because no protectable IP/RoI is created for exploitation by individual companies; the potentially large benefits are shared across thousands of farms and their supporters.

Academia is motivated by novelty and curiosity; BBSRC has primarily supported work at molecular scales; near-farm research has been unfashionable. UK government (England in particular) lags behind other countries in funding research and KE of direct relevance to farming. Social-science could formalise and validate the field-scale farmer-led approach, especially to engender trust relationships, whilst new statistical and AI approaches will also need academic support. This connected model has validation within Europe; Netherlands is the most productive agricultural nation and centrally recognises farmer-study-groups as key in their AKIS(18).

Digital solutions are being offered by most farm-facing companies, from start-up to multinational. Each aims to integrate data-sets and become a one-stop-portal for farmers, but vested interests and competition means no single commercial platform will win-out. A central trusted platform is needed to broker and coordinate exchange of data, services and products at farm-level, in farmers' interests, enabling a digital marketplace to develop. Government, through Agrimetrix, is working towards this, and can now gain impetus by becoming demand-driven through this farmer-centric AKIS.

Farmers are restricted by profit-margin, time, risk-aversion and insufficient research knowledge. Central support for farm enquiry is vital to make this an integral part of agricultural progress.

7. What level of funding is needed? [Provide an estimate of the amount of funding needed over 3 years to address this challenge from (1) ISCF & (2) Industry. ISCF funding comes from UK Research and Innovation and business and the public sector working in partnership. Max 50 words]

Wider and detailed budget and co-investment model for Farm-PEP will be developed in consultation with industry (Appendix B&D). AHDB are central to delivery & funding.

Scale of investments required: ~£40m digital infrastructure: ~£40m for development demonstration and validation.

~£40million from ISCF plus ~£40M cash & in-kind industry co-investment, including AHDB.

Appendix A: Examples of successful bottom-up Farmer-centric Knowledge Exchange

Yield Enhancement Networks (YENs): ADAS initiated a Cereal YEN in 2012 to support farmers in innovating for improved cereal productivity. This and other YENs have been entirely supported by industry. They use competition to ensure trustworthy yields, met data, crop sampling and images to enable benchmarking of meaningful crop performance metrics between peers, and basic scientific principles to estimate crop potentials, hence to reveal field-by-field scope to enhance performance. Grain yields have ranged from 6 to 16 t/ha, average 11 t/ha (40% above UK average yields, but averaging only 54% of potential). YEN sponsorship has increased from six companies in 2012 to 30 now, with all contributing by supporting growers' entries and/or supporting YEN processes, and 75% also contribute cash to support YEN management. Cereal YEN entrants have increased 50% year on year over 5 years to ~200, new YENs have started, and overseas YENs are in train. Thus the YEN concept is proven, popular and has potential to roll out across all crops and stock, and all countries. However, YENs run on generic software (Agrimetrics began facilitating farmer registrations in 2018, but no resource is available to automate data acquisition, processing, analysis, presentation or reporting e.g. for benchmarking). YEN growth is thus seriously constrained by the limited funds available from commercial marketing budgets and by its 'manual' data processing. However, YEN procedures are fundamentally all open to automation and thus to cross-industry dissemination and adoption, offering huge potential scalability. As well as benchmarking, YENs were always intended to facilitate and support on-farm experimentation whereby farmer entrants could test new ideas for yield enhancement. In spring 2018, an EIP-Agri grant has been awarded for 48 yield tests, enough to test ~8 ideas. YEN Yield-Testing will employ the recently developed 'agronomics' approach to confer scientific robustness on farmers' comparisons.

The Agronomics Approach: Agronomics is the science of field-scale farming; at its heart it exploits spatially defined data, now available on most leading farms, to enable robust comparisons of farming decisions e.g. in simple 'tramline trials'. This approach will transform the generation and flow of farming knowledge because any farmer can now check or test any decision, advice, product or idea. Digital recording brings analogous transformation to livestock farming. Thus farmers relationships with their supporters and suppliers are due to change; no longer must they trust advice extrapolated from small scale trials conducted at a distance in different conditions. Now, with adequate support and facilitation, they can start to create a knowledge-base bespoke to their own farm, and validate this by sharing and benchmarking with other farms. Thus in the near future advisors will provide new services, by facilitating the quest for better knowledge and faster progress field-by-field and farm-by-farm. Prototyping of this approach across three seasons and >300 fields, supported by AHDB, BASF, Frontier, Agrii, CF and now EIP-Agri, shows that normal levels of uncertainty in yields from small plots can be at least halved in tramline trials, and major scope exists for even greater precision. By moving to exploit this transformation, risks and uncertainties in farming will diminish, and the sophistication and precision of farming knowledge will grow. Furthermore the UK science community stands to lead the globally relevant new science of agronomics, whereby fine effects, e.g. due to soil variation, can be quantified precisely. However, effecting this change will require substantial investments in workforce skills and digital facilitation, as well as in science. And the major benefits in productivity and sustainability will be dispersed across multiple farms, without scope for wide-scale commercial exploitation of protectable IP. Thus public investment is justified.

Innovative Farmers Field Labs (10) were started in 2015 by a consortium of Duchy Future Farming Programme, including the Soil Association, LEAF, Innovation for Agriculture and Organic Research Centre. They enable groups of farmers to collaborate with researchers to co-design small farmer-led practical on-farm research (Field Labs). Dissemination occurs through events and open-access interactive web-portal. BBSRC & AHDB are among sponsors and Rothamsted, University of Reading, Bristol, ADAS & NIAB collaborate as research organisations.

AHDB – Farm Excellence Programme (2): Since 2013 AHDB has been pursuing a knowledge exchange programme based around farmer-to-farmer learning, including Monitor Farms, Strategic Farms and farm business groups jointly undertaking benchmarking using FarmBench.

The Farming Forum was founded by farmer Clive Bailye and is the most widely used discussion forum in the agriculture industry, with >250,000 unique visitors each month. Informal online farmer-farmer knowledge exchange has rapidly increased, with many farmers now citing this as their prime information source. There is a very active community of leading farmers on Twitter, with co-ordination through groups like [#AgrichatUK](#) & [#Clubhectare](#), as well as Facebook farming groups.

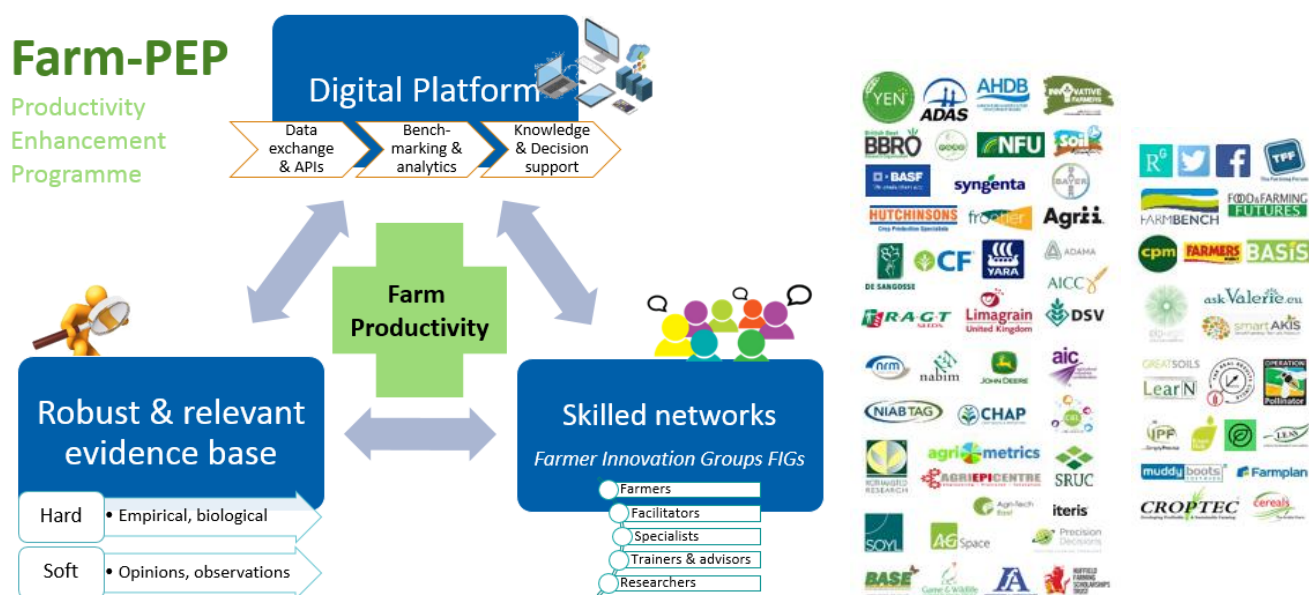
BASF Real Results came out of collaboration with ADAS Agronomics, supporting a network of 50 leading farmers to test products for themselves. Other Ag Chem companies are clearly keen to develop deeper relationships with growers; Bayer has Xpro Farmers Club and Syngenta has Root Matters.

BASE UK (Biodiversity, Agriculture, Soil and Environment) is a farmer-led member organisation representing those interested in Conservation Agriculture. It is driven by the enthusiasm of farmers to test and share ideas based on the principles of conservation agriculture.

EIP-Agri (9) is EU's approach to supporting knowledge & innovation in agriculture, very much adopting a bottom-up co-learning philosophy, with farmers forming Operational Groups with experts. The UK is under-represented.

Farm-Inn has been initiated by Rothamsted Research to enable ideas from farmers to be tested by scientists, with sufficient scientific support. Farmers can suggest project ideas that will be assessed by Rothamsted.

Appendix B: Outline description of the **Farm-Productivity Enhancement Programme (Farm-PEP)** to transform the UK *Agriculture Knowledge & Innovation System (AKIS)*, with industry partners already engaging in farmer-centric KE, and communication channels that need to be utilised:



The Farm-PEP makes the transformation to a farmer-centric AKIS by facilitating the generation, distillation and exchange of knowledge within a digital infrastructure that connects people and allows data to be shared and analysed. Crucially it also supports the development of social structures to facilitate the support of farmer-led networks and transdisciplinary teams (10, 12; **Farm Innovation Groups**; FIGs) and to support the interaction of scientists and experts in the distillation of knowledge and best practice from the evidence base. It seeks to build on existing skills, networks, relationships, KE channels, databases, web services & tools, rather than duplicate or compete. Delivery of Farm-PEP will depend on inclusive collaboration across the industry, for which we are confident we can achieve full participation and co-investment, given what has been demonstrated by YEN etc.

Tasks are set out in Annex C, grouped by 7 streams: 1/ **Co-ordination & Design** of the AKIS will require full & inclusive industry consultation with appropriate academic input; 2/ **Digital Infrastructure** will be built to support the needs of the new AKIS, the specification will inevitably evolve so agile software development will be used; 3/ **Support for farmer-centric networks** will provide resources (e.g. protocols), and most crucially training, so that large numbers of FIGs can be established and managed successfully, current advisers being given the skills to facilitate FIGs; 4/ The **system for distilling evidence** into knowledge and into best practice messages will be designed on the principles of the 'What Works' concept (4). Crucially this needs to address how to deal with the new types of evidence available from on-farm data and collated views from social media, and also how such evidence can inform and be exploited by the sciences of agriculture; 5/ **Scientific support** will be required from multiple sources to support the activities above; 6/ **Pilot FIGs** will trail-blaze the approach allowing demonstration, validation and evaluation. We will start by scaling-up existing initiatives, then farmer engagement will dictate priorities, but possible new FIGs include soil carbon enhancement, blackgrass control, grassland management, livestock conversion or rearing efficiencies, livestock health; 7/ Continued **exploitation** will be addressed from the outset, and funding models for sustaining Farm-PEP in the long term will be fully explored.

Illustration of how FIGs will work in the Farm-PEP:

A website will be created for knowledge exchange & discussion that enables access to research and current best practice advice, with links to social media (TFF etc.), farm management software and commercial websites, tools & apps. This will likely be hosted by AHDB and will be open to all. Anybody (farmer, advisor, industry, scientist, policy maker, student ...) can identify a challenge/problem/issue that they feel is worth investigating, and check whether it is already being addressed by other FIGs (or internationally in EIP-Agri Operational Groups etc.). Anybody can form a potential new group by starting a thread in the discussion forum. Anybody can join, follow, share, comment or express an interest in a group. If there is sufficient support a relevant trained FIG facilitator will help attract relevant experts, researchers, stakeholders and industry interests. The next step is for the FIG to decide if it needs funding to address the issue, or if it can be tackled informally together. Funding could be found via multiple routes: crowd funding, charitable funding such as via Duchy Future Farming Programme in Innovative Farmers, commercial sponsorship (as in YEN), company support (e.g. BASF Real Results), AHDB funding, government funding (e.g. Defra, UKRI, BEIS, EU EIP-Agri), academic councils (UKRCs) or through Farm-PEP

strategic support. We propose that the Farm-PEP should test a funding budget that is allocated democratically by members, experts and levy payers, via an online voting or credit system.

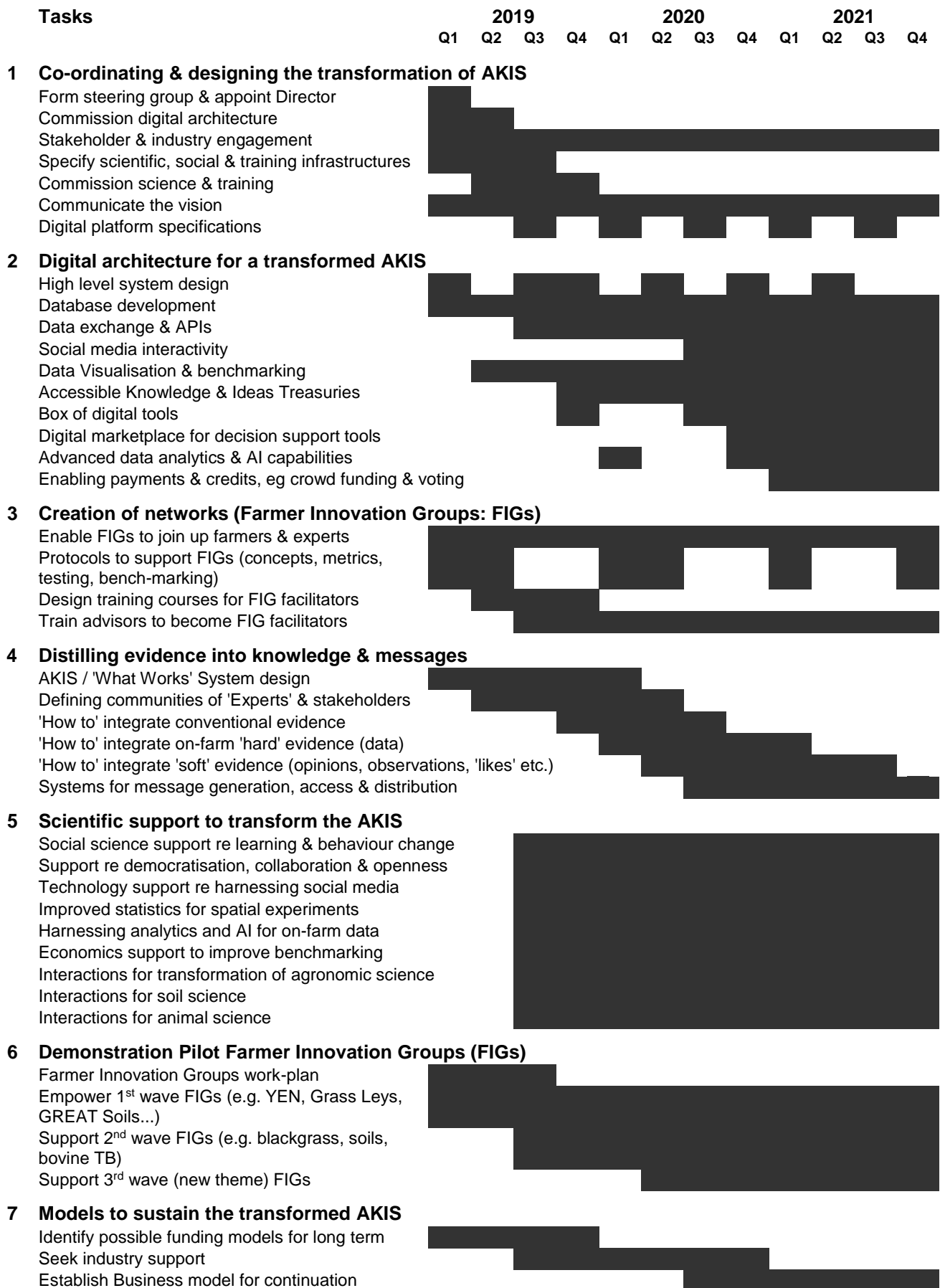
Once established the FIG will follow a systematic approach to the collation, generation, integration, distillation, interpretation and publication of knowledge, all facilitated by a trained facilitator & integrator but involving all members of the FIG (**bold** indicates what is done by people in the FIG, *italics* what is supported digitally) :

1. **Collate existing knowledge** – *using online knowledge repository, including access to*
 - scientific literature, AHDB reports, EIP-Agri, industry data & reports, farming press articles, discussion forums, tweets & Facebook
2. **Agree** state of established '**Best Practice**' & identify major uncertainties & innovations: *publish online.*
3. **Agree the conceptual framework** to understand the problem: *publish online*
4. **Agree** the important **metrics** to measure or consider: *publish online*
5. **Brainstorm ideas** to tackle the problem: *hold Ideas Labs and record online in 'Ideas Treasury'*
6. **Set-up** appropriate & co-ordinated on-farm **measures & tests** of ideas & hypotheses, *supported by:*
 - *Online toolkits for measures by satellites & smart phone apps, precision farming technologies, yield mapping etc. & interaction with farm management software.*
 - *Mapping tools and resources to help setting up, managing & recording field-scale trials.*
 - *Tools to aid crop, animal, soil & economic benchmarking.*
7. **Share data** with facilitator and trusted researchers: *facilitated by easy on-line data exchange.*
8. **Analyse data:** *platform enables spatial analysis of tramline trials, cross-site meta-analyses, benchmarking, visualisations & AI analytics.*
9. **Agree conclusions & messages:** *supported by online consultation within the FIG and externally.*
10. **Publish new knowledge:** *feeds directly back into knowledge repositories.*
 - *Where appropriate develop algorithms that feed into decision support tools.*

Appendix C: References

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Appendix D: Outline GANTT chart for Farm-PEP work-plan:



Appendix E: Collaborators & Expressions of Support

This EOI is co-ordinated by ADAS and involves the organisations leading the developments in farmer-centric research and knowledge exchange: (i) the Agriculture & Horticulture Development Board (AHDB) who are prime organisers and funders of the UK's Agriculture Knowledge & Innovation System (AKIS), (ii) Innovative Farmers (represented by the Soil Association & Prof Tim Benton), (iii) Countryside & Community Research Institute (CCRI, at University of Gloucestershire) and (iv) Agrimetrics (the gov't funded Innovation Centre established to support the agri-food system with big data and related technology), and with guidance from NFU and a team of leading farmers (see below). This consortium connects with all the companies and organisations in UK agriculture, many of whom have been consulted about this EOI (see below). If successful we would fully consult with industry to achieve full participation and co-investment in this work. It will be crucial to avoid duplication and competition with other initiatives; rather we seek full inclusivity and maximum interoperability between partners and platforms.

In amassing expressions of support, we have focussed on farmers, farming organisations and academia:

FARMER LEADERSHIP TEAM (identified below) & Farmer Supporters :	
Wicklesham Estates, Oxford Farming Conference & CPM	Tom Allen-Stevens, Director, Chair & Editor <i>Comment:</i> I believe this route to the adoption of new digital technologies and data management could herald a new Green Revolution that would resonate, not just across the country, but across the world. What's particularly remarkable about this proposal is the cross-industry support I believe it would leverage and galvanise, with considerable resulting productivity gains, if given the catalysts of public funding and government strategic backing.
TWB Farms & The Farming Forum	Clive Bailye, Partner & Founder <i>Comment:</i> I am 100% onside with your thinking that knowledge exchange and particularly farmer to farmer experience is without doubt key to a sustainable and progressive future. It looks like a good and hard to argue with proposal. If there are ways we can be involved and help either via the forum or in my capacity as a farmer I am happy to do so.
W Bradshaw & Son and Chairman NFU Crops Board	Tom Bradshaw, Partner & Chairman <i>Comment:</i> Farmers trust information being imparted from other respected growers and are open minded about implementing changes in their businesses that appear to have been successful on other peoples farms. As a part of this benchmarking helps break down barriers and gives a much greater understanding of what is working within individual farms and offers a real chance to give a productivity shift. There is definitely a need for this to be expanded much further across the farming industry.
HS Temple & Son & AHDB	Paul Temple, MD, Main AHDB Board member <i>Comment:</i> Productivity has shown disappointingly slow growth in the UK compared to many other countries. New technologies have continued to flow into the industry though the impacts are not showing in the commercial environment. AHDB strongly believes that this is a result of the gap between research and growers and this is our number one priority. We fully support this project to bridge that gap.
DVH Price & Son, AHDB Board & Research & KE committee.	James Price, Partner, Board member & Chairman <i>Comment:</i> I have worked with YEN since its inception ... It is by far and away the most up to date and informative information that we have as an industry for improving the productivity of our businesses, it is also totally unique as no other industry would share information so freely. I can add weight that the industry sees the YEN approach as very important for the future of British Agriculture.
Mr & Mrs M Partridge	Philip Partridge, Partner <i>Comment:</i> As we move into uncharted waters of Brexit, I for one feel more confident going forward with the knowledge and practical support that being involved with YEN and the Monitor Farm / AHDB has given me. The long disconnect between scientists and farmers is over, and now must be fully embraced by the industry as a whole if we are to feed and power the future generations.
Decoy Farm, EEAS	Andrew Riddington, Owner, Chair of Development Committee <i>Comment:</i> As a farmer and adviser to industry, I would enthusiastically promote the need for more collaborative work between farmers, scientists and technologists. Practical data derived from multi-sources and from practicing farmers will be very important to improving productively so would offer my support for this programme.
JN Fuller-Shapcott & Co	David Fuller-Shapcott, Director <i>Comment:</i> As an early member of the Yield Enhancement Network, and more recently of the BASF Real Results circle, I wholeheartedly support the concept of cascading the hugely valuable lessons (and practices) that continue to emerge from the YEN approach. I have been farming for 30 years and am still learning through the YEN – long may it continue
Westcott Farm Part'ship, NFU Crops Board, West Country Grain	Michael Hambly, Partner, Board & Vice Chairman <i>Comment:</i> YEN has produced a fascinating community that has exchanged ideas and really explored mechanisms to lift yields and excellence. Thorough interpretation of results and linkage with detailed understanding of crop physiology is helping me to understand how to improve productivity. Now that the range of crops involved is growing this is a fascinating initiative delivering real benefits to crop farmers; it's potential impact should not be underestimated.
Sentry Farms (...represents 60,000 acres)	John Barrett, Director <i>Comment:</i> We are keen to support this initiative , having engaged with YEN, AHDB CropBench & BASF Real Results. It gives the opportunity to learn from others as well as giving clear focus on trying to improve our outputs for the benefit of all stakeholders.
Brixworth Farming Company & PDA	Ian Matts, Director & Co-ordinator <i>Comment:</i> I ... support this proposal. The pressures placed on land managers are only likely to increase as we move forward with greater volatility and uncertainty... Productivity still remains at the forefront of farm businesses, and the need to reduce our costs per unit of production will be key. As a joint venture business we believe collaboration is key ... include[ing] collaborating on innovative ways of operating and [sharing] the findings from on farm trials and research. Involvement in the YEN has helped us to see what is possible on other farms to understand what is practical to implement ourselves.
Rising Sun Farm & AHDB	David Blacker, Partner & Monitor Farmer Research that is delivered in this format is highly regarded by farmers. The industry needs much more on farm / in field research that connects farmers and scientists together

Farm PEP Eol submission for ISCF Wave 3 consideration

AGRICULTURAL INDUSTRY:	
AHDB	Jane King, Chief Executive <i>Comment:</i> The data is clear, UK agricultural productivity is falling behind that of our main competitors. To address this decline we need a new approach to knowledge exchange and the research work that underpins developments in the industry. We need to focus on solutions to the main problems constraining productivity and we need innovative methods that accelerate the uptake and application of new knowledge, farmer led and farmer driven programmes to deliver real change on farm. AHDB fully supports this proposal which will transform the UK research and knowledge exchange landscape.
BASF plc	Rob Gladwin, Head of Technical Management, N Europe <i>Comment:</i> There are a number of opportunities to drive agricultural productivity forward ... One is to harness research and ensure it's farmer centric. ... A typical example is soil and soil health ... agronomists should also be engaged to ensure the gaps in knowledge are correctly identified ... BASF as an innovation driven business identifies strongly with vision proposed here ...
Nabim	Joe Brennan, Policy and Research Officer <i>Comment:</i> UK millers rely on competitively priced grain from British farmers. Knowledge exchange is integral to increasing farm productivity and the UK milling industry supports the development of new tools to facilitate this process.
Innov. Farmers & Soil Association	Tom MacMillan, Director of Innovation <i>Comment:</i> The strategic case for supporting farmer-centred innovation is increasingly clear, offering opportunities to promote genuinely sustainable and resilient improvements in productivity ... This proposal brings together initiatives that are pioneering such approaches in the UK. By coupling the grassroots entrepreneurship of approaches such as field labs with digital data and novel analytics, it brings power, scale and wider relevance to a farmer movement that is already gaining traction and results on the ground.
East of England Agricultural Society	Jeremy Staples & William Haire, CEO & Business Development Manager <i>Comment:</i> The obvious opportunities for significant productivity improvements at farm level have been achieved. Advances now will come from less obvious sources and will require a new approach to identify, understand and evaluate their effectiveness. Engaging with farmers to develop a "farmer-up" flow of ideas and data is a concept we believe farmers will support.
Dodgson Consulting & EEAS	Geoff Dodgson, Owner & Trustee <i>Comment:</i> The concept of engaging the worlds of science and practical farming on one data-platform is, to me, one of the most creative moves to engender true knowledge exchange, as opposed to knowledge transfer which all too often only goes in one direction.
BASE UK	Steve Townsend, Secretary <i>Comment:</i> This initiative exactly matches the ethos of the BASE group, to efficiently share and create better information on how farming can made more economical and sustainable. The BASE group (157 members, >80% farmers) will be 100% onside with your plans
Syngenta Ltd	Derek Scuffell, Syngenta Science & Technology Fellow <i>Comment:</i> I support this challenge. Future farming in the UK faces the perennial pest and productivity challenges and our tools are reducing as we meet those challenges to enhance productivity in a sustainable way. There is compelling evidence that data and digital approaches can deliver real productivity for the farmer, but this is predicated on great data and knowledge exchange.
Microsoft	Dr Matthew Smith, Director of Business Development <i>Comment:</i> Supporting more effective knowledge exchange is definitely worth exploring. Anything new should be built through small experiments and be natively multichannel with the evolving heterogeneity of social channels in mind, so a person seeking help can effortlessly post to all the social channels desired recipients are using. Key is not standardisation but interoperability.
IAR Agri Ltd.	James Wallace, Director <i>Comment:</i> I strongly support your team in submission of the "Farm-PEP" Challenge. The challenge is to develop the ability to establish what is successful on the local soil type and growing conditions and for farmers and agronomists to share the knowledge.
Frontier Agriculture	Dave Robinson, Head of innovation and KE
Limagrain	Ron Granger, Arable Technical Manager
ACADEMIA & INNOVATION CENTRES:	
SRUC	Colin McEwan, Director of Commercialisation & Innovation <i>Comment:</i> The strength of this proposal is that is farmer-centric, and will transform the infrastructure required to generate and utilise knowledge ... It clearly builds on the success of the existing YEN, Monitor Farms and Field Labs. .. SRUC is fully committed to the concept of researchers, consultants and industry working closely together and is therefore fully supportive of this EOI.
Agri-Food and Biosciences Institute	Dr Ethel White, Head of AFBI Plant Testing Station <i>Comment:</i> This Farm-PEP initiative is timely and necessary. We need to develop processes and software in conjunction with farmers themselves that most effectively deliver knowledge into farmers' hands enabling them to adopt practice & enhance productivity. We are happy to support such a comprehensive sector-wide initiative and would be keen that it should include Northern Ireland.
University of Cambridge	Profs Christopher Gilligan & Howard Griffiths, Co-chairs of Interdisc. Research Centre in GFS <i>Comment:</i> You can say that you are in positive discussion with the co-chairs of Interdisciplinary Research Centre in Global Food Security at Cambridge about an academic collaboration.
University of Leeds & Innovative Farmers	Prof Tim Benton, Dean of Strategic Research Initiatives & Chairman <i>Comment:</i> I'm very happy to offer what support I can for this (either as Chair of IF advisory group, or as an academic at Leeds).
University of Nottingham	Prof Murray Lark, Professor of Geoinformatics <i>Comment:</i> The use of advanced modelling and spatial statistics to improve decision making at farm scale from large data sets is a central theme in the Future Food Research Beacon at UoN, and I am keen to engage in collaboration with this proposed programme.
British Geological Survey	Dr Ben Marchant, BGS Statistics Lead <i>Comment:</i> This initiative utilises new and innovative statistical methodologies in a manner and at a scale that is directly relevant to farmers and their decisions. The development & communication of such methodology is core to BGS statistics research.
Rothamsted Research	Prof Achim Doberman, Director <i>Comment:</i> This initiative is important for accelerating the transformation of the farming sector, including better translation of basic science done in institutes and universities.
Agri-EPI Centre	Dr Dave Ross, CEO <i>Comment:</i> Agri-EPI recognises the importance of delivering innovation to agri-food supply chains, ... Agri-EPI is an enthusiastic supporter of the ISCF Wave 2 Transforming Food Production bid, and if there were an opportunity for additional support to agri-food through ISCF, Agri-EPI would be an enthusiast supporter.