A new UK research funding agency

Written evidence submission to the House of Commons Science and Technology Committee's inquiry on an ARPA style agency.

June 2020

1. Summary

In the Queen's speech of December 2019 the government commitment to an ARPA-style agency was described as 'a new approach to funding emerging fields of research and technology. It will provide long term funding to support visionary high-risk, high-pay off scientific, engineering, and technology ideas, and will complement the UK's existing world class research system'[1].

The Royal Society of Chemistry (RSC) welcomes the government's interest in ensuring a thriving UK research and innovation system. However care will need to be taken in order to set up an agency of this type in the right way. In this written submission we aim to present some of the learnings from current analogous models in the US, and address some of the committee's wider questions using these insights.

We cannot assume an exact replica of the US analogues would be beneficial if simply transplanted into the UK system as is. The agency should complement the existing research landscape, with any new model needing to take account of the inherent systemic differences between the UK and US research systems, and wider cultural differences. The consultation and process of developing this new agency must show that the government understands and takes into account these wider differences.

Summary of Recommendations

Taking the above into consideration, and based on the evidence we have collected on the working of analogous agencies in the US, we recommend:

1. That diversity and inclusion is built into any new agency from the beginning, to ensure a thriving science community[2]
2. Ambitious, excellent Programme Managers with experience of research and innovation, to monitor portfolios of projects
3. A balanced approach to reporting and bureaucracy, which allows the Principal Investigator (PI) time to do the science
4. Mission areas that should be decided via discussion with the community, to draw in a broad range of expertise
5. In order to be impactful, grants should be large and long-term

Further, more detailed recommendations are covered in the relevant sections.

Evidence

As part of our evidence gathering to inform this work we interviewed 5 experienced researchers within our community based in the USA. They had received grants from ARPA-E, DARPA or both, and in one case they had been a Programme Manager for ARPA-E. Insights from these interviews has been used to inform and illustrate our recommendations. However the voice of these researchers does not necessarily represent the views of the RSC, or of our community as a whole.

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[1] The Queens Speech, Background Briefing Notes, December 2019

[2] We define diversity broadly, including race, age, disability, sex/gender and gender reassignment, sexual orientation, and other characteristics.

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2. Background

ARPA, the Advanced Projects Research Agency, was formed in 1958 for the purpose of forming and executing research projects to expand the frontiers of technology and science, reaching 'far beyond immediate military requirements'. ARPA was later repurposed to do 'high-risk, high-gain', long term basic research (after the formation of NASA), a position that was reportedly embraced by the nation's scientists and research universities.[3]

The agency was renamed the Defense Advanced Research Projects Agency (DARPA) in 1972, and during the early 1970s it emphasized direct energy programs, information processing, and tactical technologies, making it more mission/application oriented.

The difference between the ARPA and DARPA models is hard to define, but generally ARPA was perceived to have a curiosity driven basic science remit, with the focus on 'good ideas', with applications being secondary. Although it was set up with a budget comparable to DARPA's current annual budget ($3.427bn in 2019[4]), during ARPA's main years of operation it had around a third of the current annual budget of DARPA (inflation adjusted). DARPA has a focus on applied research, as its projects are intended to have military applications. Some see DARPA as having fallen foul to more bureaucracy and reporting, reducing its potential for real transformational change in comparison to the original ARPA.

Key features of both the ARPA and DARPA model:

- **Programme Managers** (on limited contracts of 3 to 5 years) who oversee a portfolio of programmes in a broad area, and have the autonomy to monitor, fund or cut projects that are not performing, allowing a high level of flexibility. At DARPA, the Project Managers still have to convince the director that ideas for projects could improve US military capabilities.
- **Autonomy** to move outside of the traditional governmental structure for funding R&D, and what is seen as immediately strategically important for the department/government, with large grants, and go for the best science and innovations instead. Although current iterations have a parent department which sets the high level focus e.g. defense, or energy innovation.
- **Freedom to fail**, and fund risky projects.

Recommended questions for further investigation

- What is the appetite for risk in the UK, and how should this be managed?
- What types of research will this UK agency fund – is the description 'blue skies' appropriate, or will the missions have a more 'applied' focus?
- For it to succeed long term, how can it be made independent from potential political influence?
- This type of funding requires sustained investment over a reasonable period of time to see returns, how will this expectation be balanced with a short trial period to test the model and its suitability in the UK system?
- With a high level of autonomy, how will the agency be set up to make accountable, unbiased decisions?
- How will the government ensure excellent and inspirational leadership, to ensure this agency grows out of a time of national uncertainty, and brings in exceptional and committed talent from a variety of sectors?

3. Where could a UK ARPA sit in the landscape?

Summary: DARPA and ARPA-E have defined spaces in the American landscape, and are known as the place to go for high dollar amount, targeted research, and 'out of the box' ideas.

Recommendations:

- **UK ARPA should take on challenges that are not covered by current funding agencies.**
- **Research funded by this agency should have a mission-driven focus on applications.**
- **In tandem, the government needs to maintain provision for curiosity-led science, as an equally important endeavour.**

[3] 'Where Wizards Stay Up Late: The Origins of the Internet' by Matthew Lyon and Katie Hafner
[4] https://www.darpa.mil/about-us/budget

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- **The government, working alongside UKRI, should consider a more thorough mapping of the UK research funding landscape to inform plans for the new agency.**
- **The government needs to determine who the 'customer' should be in a UK ARPA - this could be sectoral or departmental.**
- **In order to build prestige, UK ARPA grants should be high value, specific, and long term.**

How do ARPA-E and DARPA fit into the American landscape? What kind of research do they fund?

DARPA has been part of the American funding landscape, in one form or another, since 1958. In that sense it is an established part of the innovation system, and has had time to build credibility.

The funding at both ARPA-E and DARPA centres on mission-driven research with clear applications. However these missions often push the boundaries of what is possible, with 'high risk' projects focussing on seemingly distant goals, 'where you turn the thinking on its head'. Some interviewees said that this type of agency funds a specific kind of project that might be an 'out of the box', risky idea. Others said that there was no single government agency they would tap into to get this kind of money for their research, with ARPA-E forming a useful niche.

> 'What ARPA-E is really set up to do is to look for new opportunities, and bring new perspectives. Maybe take on topics that a traditional bureaucracy probably is inherently incapable of taking on.'

This tolerance of risk was mentioned by a few interviewees as something that may be more common in the American research culture.

> 'Of course in the US entrepreneurship is highly encouraged in the universities… if you failed in launching a start up, I think in the US it's usually viewed positively... I'm not sure other places have the same mentality.'

We found that there is a general understanding amongst researchers we spoke to of where this type of agency sits within the US system – what it can and can't fund, and where else you can go for different kinds of funding. One interviewee said that 'if you're a technology readiness (TRL)[5] 1 or 2 you should go for National Science Foundation, or the basic energy science. Then if you're 3, 4, 5 then you go for ARPA-E'.

UK ARPA should take on challenges that are not covered by current funding agencies.

It's clear that ARPA-E and DARPA are both primarily mission driven, however there was an acknowledgement that basic or discovery science can sometimes form part of the pathway to achieving that goal, and as such shouldn't necessarily be rejected from the scope.

> 'I explain to students who are interested in joining my group that we aim to do fundamental materials chemistry that is valuable beyond the application that we're targeting, but it must have an energy application to be interesting.'

The general sentiment from our interviewees was that in order to appropriately use government money in this way, the science should have some kind of real world application. The set-up of these schemes means that there may not always be time to probe some of the fundamental science behind the work that is done in DARPA or ARPA-E funded projects, but sometimes the fundamental science does hold a wider important role in answering issues or roadblocks in the applied space. This chimes with what the RSC has previously heard from the global chemistry community. In a survey conducted for our Science Horizons report 82% of respondents agreed that considering the applications of research is a 'duty' for scientists[6]. Alongside this 94% of respondents identified funding for curiosity-driven research as important for the advancement of the chemical sciences, showing the need for diverse streams of funding.

Research funded by this agency should have a mission driven focus on applications.

[5] Technology Readiness Level (TRL) is a method for labelling the maturity of a technology, from TRL 1 which covers basic research, to TRL 9 which is a proven system, ready for market.
[6] Section 4.1, Science Horizons, The Royal Society of Chemistry

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In tandem, the government needs to maintain provision for curiosity led science, as an equally important endeavour.

What gaps in the current UK research and development system might be addressed by an ARPA style approach?

In Annex 1 we have included a table which attempts to illustrate some components of the UK funding landscape, it should be noted that this is a preliminary analysis and therefore may not be completely representative.

The relatively newly set up Industrial Strategy Challenge Fund (ISCF)[7] seems to be the fund that most closely resembles what a UK ARPA might look like. It exists to bridge the gap between academic research and real world demonstration of technologies, with industry being one of the main partners. ISCF challenges are centred around the UK Industrial Strategy, and can be described as 'high risk'. However often for the more high risk areas, a proportion of the funding comes from industry. This could be where an ARPA style fund finds a niche, with the funding for high risk projects covered in full by the government.

The government, working alongside UKRI, should consider a more thorough mapping of the UK research funding landscape to inform plans for the new agency.

How does the overall mission and 'customer' influence the agency?

It is currently not clear who the 'customer' of the new UK agency might be, or whether it might cover a particular sector. Both ARPA-E and DAPRA have clear sectoral focusses, and in the case of DARPA the US Department of Defense acts as a customer for its innovations. From the evidence we have gathered, the 'customer' of each agency helps to harmonise and influence the mission setting both at the top level and in individual projects.

> 'I think there is benefit in having a unified mission that connects all of the programs. In the case of DARPA it is defense, but you could build a DARPA around something else. It could be health, it could be energy like ARPA-E, but a shared mission I think is important for uniting the programs and the program officers. And I think it doesn't matter what that is … I just think that helps with the narrative.'

The 'customer' for the agency affects how the research is run. For ARPA-E the government is not a major consumer of energy products, so for the federally funded energy research the government's role is viewed as financial assistance before the innovations get taken up by private sector investors. Researchers are encouraged to look for investors to take up the project once ARPA-E's involvement is over.

> 'Every project at ARPA-E has a technology-to-market type of element. Every project has to show that you are not just doing scientific research, you're developing a viable technology and you have a plan for where you will take these technologies.'

In the case of building this type of agency in the UK, care should be taken to understand the unique innovation environment, and how to ensure a pipeline to commercialisation of technologies. There will need to be clarity on who owns any IP associated with projects funded by the agency.

The 'customer' is a key focus of both the ARPA-E and DARPA models in 'pulling through' technologies. The government needs to determine who the 'customer' should be in a UK ARPA - this could be sectoral or departmental. Analysis is needed to understand what would work best.

What funding should ARPA receive, and how should it distribute this funding to maximise effectiveness?

One thing that come out strongly from our interviews was that a key draw of these types of agencies was the 'high dollar amount' received in grants. One interviewee had been on multiple $10 to $20 million programmes from DARPA, each distributed between collaborators and lasting for four to five years.

[7] Industrial Strategy Challenge Fund, UKRI website

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This doesn't necessarily mean a massive overall agency budget, but rather distributing the budget into larger, high profile chunks of money, as opposed to smaller more dispersed grants. Distribution of larger grants was perceived as giving more attention and prestige, and highlighting the chosen missions.

In fact, DARPA and ARPA-E's overall budgets are relatively small compared to other US departmental agencies such as NSF and NIH. But the amount the researcher receives on an ARPA-E grant is 'about twice as much money as NSF on an annual basis'.

> 'DARPA, I think it sort of punches above its weight in terms of it's … like the amount of money versus the amount of publicity that they get.'

The current proposed budget for this new UK agency was announced as £800m over 5 years. The government should think carefully about how to distribute the grants, potentially focusing on a small number of well-defined mission areas.

Our work with the chemistry community, particularly our recent Breaking the Barriers[8] and Science Horizons[9] reports, showed that longer term funding is seen as both essential for true scientific advancement, and for retention of a diverse research workforce. Currently, grants are mainly fixed term with little option for follow on funding other than by reapplying for a new grant. To provide continuity in research over longer time periods, the government could consider introducing the possibility of follow on funding, should a project be successful.

In order to be prestigious, UK ARPA grants should be high value, specific, and long term.

4. The role of the Programme Manager

One of the main components of a successful ARPA type agency are the Programme Managers, who should be independent, ambitious, and technically able.

> '*I can't emphasize more about how important the programme manager[s] [are]'*

Recommendations:

- **The role of the Programme Manager should be clearly defined, along with the skills, experience and ability needed; we provide our observations on this below**
- **Diversity considerations should be built in to both the recruitment process and role of the Programme Manager**
- **The position should be made attractive enough to get the best candidates from across the world**

In both ARPA-E and DARPA Programme Managers are given the autonomy to devise funding calls, select programmes, and manage the research process. They are themselves highly regarded and skilled researchers from various sectors: academia, industry or venture capital firms. Relationships with Programme Managers can vary, as the role depends so much on the person in it, but most researchers we spoke with were positive about their experiences.

We heard about the important balance between a Programme Manager being closely involved in the programme without being tempted to do the research themselves.

> 'They [the Programme Managers] themselves are trained scientists, they're very experienced, so there is a very delicate balance that they need to strike between not micromanaging the research and doing things they want to do instead of giving us the freedom to explore what we propose.'

> 'So, the job of a program director [Programme Manager] is to identify a big challenge. And your job is to invite the community to solve the problem, not for yourself to solve the problem.'

[8] Breaking the Barriers, Royal Society of Chemistry
[9] Science Horizons, Royal Society of Chemistry

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Key to their success is a sense of ownership and responsibility for the work, ambition to drive it to succeed. A grander vision is needed when moving from managing 10 to 15 people, to 20 or 30 labs.

> 'I think that the agency giving the Program Managers certain autonomy of how they can best run their program is really, really important.'

This often comes down to personal pride, wanting to 'make a splash for themselves, they're trying to catalyze the next big invention or industry'. This means Programme Managers can be perceived as 'aggressive' with timelines and budgets, and that they have freedom to cut programmes that aren't performing.

> 'I've heard that a lot of the [DAPRA] PMs are pretty competitive with one another as well'

Another explanation for the success of this role is the short term appointments, giving people a deadline by which they have to make their mark.

> 'So DARPA and ARPA-E, all the ARPA agencies have temporary staff. All of us were brought in for a fixed term, three years, four years, DARPA can be up to six years. However, after that time you have to go. Now, we debated a lot at ARPA-E why such a model would it be successful. It's because one way to combat a bureaucracy is to give people terms.'

We outline our observations on the skills, experience and abilities needed in Programme Managers.

- **Experienced, trained scientists, from various sectors**
- **Ability to take a balanced approach in giving research teams freedom and direction**
- **Ambition/enthusiasm to drive scientific discovery**
- **Confidence to take appropriate risks**
- **Management skills**

The relatively flat structure of these models, with a high level of autonomy at each level, are part of what make them unique. Devolving decision making power to a single Programme Manager may make for an agile funding model, but could potentially introduce an element of bias, especially in a pressurised environment. The government should consider how to combat this, and make the funding decision making processes as fair and transparent as possible. One possibility could be introducing a small programme management team, of around three people, to broaden the technical expertise, spread workload, and combine ideas.

While temporary contracts and a competitive culture may be appealing to some, care should be taken to tailor the agency to the government's aims, while promoting inclusion, diversity and equality of opportunity. In order to promote truly innovative and novel thinking, there should be recruitment of as diverse a range of Programme Managers as possible.

Diversity considerations should be built in to both the recruitment process and role of the Programme Manager.

The obvious challenge, therefore, is attracting the excellent people needed to run the agency. Many mentioned that being a Programme Manager was seen as good for career development, especially when moving between institutions, or into a director role.

> 'If you can build a culture so people view the experience to more than pay for itself for whatever next they want to do, then that's how you make it work'

Some of the freedoms given to the Programme Managers are seen as particularly attractive, for instance the high levels of autonomy, creativity to come up with and run programmes, and the ability to work outside their normal area of expertise.

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> ‘When we were interviewed [to be a Programme Manager at ARPA-E] part of the interview was … so the first hour where you talk about what you have done, technically, and the second hour, you have to pitch to the agency what you will do if you've been given the money. And it is highly recommended that you pitch an idea that's completely outside of your own technical expertise. That you have not worked on, to show that you can think outside what you normally do.’

The combination of these factors can make a unique experience, and ideally a wide pool of applicants would allow for the best candidates.

The position should be made attractive enough to get the best candidates from across the world.

5. How the programmes work

‘The DARPA and the ARPA-E models are purely milestone driven. Because the end goal is not a paper. The end goal is a specific technology, and the most of the time the deliverable is hardware, it's not a bunch of reports.’

Summary: The flexibility of the ARPA model allows certain parts of the process to be highly collaborative within the research community. The milestone focus when running programmes is necessary, but if not properly managed can have negative effects.

Recommendations:

- **Inclusion of the community in direction setting for programme calls**
- **Highly rigorous internal processes for setting up calls and awarding funding**
- **Incentivisation of researcher collaboration, especially across sectors**
- **Clear communication during milestone setting, with a balance between ambition and flexibility**
- **Further work is needed to investigate if UK ARPA should use stop/go milestones**
- **The bureaucratic management also needs to be excellent**
- **Diversity and inclusion should be built into the agency from the beginning**

Setting up the call

Researchers from ARPA-E reported an internally rigorous process in setting up calls.

> ‘They are very critical towards each other internally first, so I think that that process is really rigorous so that when the program comes out I think it's usually very, very well thought of’

There is also extensive involvement of the community in the direction of research, and testing out ideas, bringing together different sectors.

> ‘So we collect all these people, we talk a lot to a lot of people, we hold a workshop and then people brainstorm and they provide a lot of the detail, the input in shape, helping to shape the content of the program.’

This is similar to some processes in the UK system, for instance EPSRC are currently running a ‘Big Ideas’ initiative, in which they are asking for ‘adventurous and exciting ideas from the wider research community’ that will enable them to build business cases for future funding calls. [10] The ISCF also works with the community to collaboratively build programmes.

As part of our Science Horizons report the RSC engaged with more than 750 scientists worldwide to identify the key areas of chemical sciences that will underpin the solutions to major societal challenges, and transform technological advances in the future. This shows that this type of collaborative exercise is possible on a wide scale, with input from a diverse range of scientists, and that the research community is enthusiastic about large scale advances.

In ARPA-E, applicants are allowed to respond to any criticism of their grant application.

[10] EPSRC website, Big Ideas

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> ‘Well what ARPA-E did, which I thought was quite good, is that they actually allowed the proposers to respond to review or criticism. So that was an innovation, which was I thought very valuable because sometimes you do get reviewers who really don't understand what is being proposed. So being able to clarify has been a good thing.’

The application and award progress is highly rigorous, with only the best groups being funded.

The community should be included in direction setting for programme calls.

Highly rigorous internal processes for setting up calls and awarding funding.

Milestone focus

Our interviewees from both agencies said that once the award is agreed, milestones are negotiated between the Programme Manager and the PI, and these set up the pathway to the overall goal or mission of the project. The overarching project may include collaborators from across academia and industry.

> **‘**All my programmes are highly collaborative between other labs. It's basically one of the nice things about DARPA funding mechanisms, it allows me to work on a problem that I could not accomplish in my lab alone. Really requires a really diverse group of expertise. And some of those experts come from companies, too.’

Incentivisation of researcher collaboration, especially across sectors and disciplines.

There is also a set timeline of go/no go check in points where the researchers have to report progress to the Programme Manager.

> ‘Usually this is done backwords – you start with the end deliverable and the minute details of what will be delivered are agreed. Once this is done the sequence of the project is constructed back from this point.’

There were mixed views on potential positive or negative impacts of having such strict reporting structures, but there seems to be an understanding amongst researchers as to why projects with missions need to be designed around milestones.

Some views included:

- Once you have met the milestone, you are expected to be done with that research and don’t have the freedom to continue investigating
- There is little opportunity to explore other interesting areas of science you may stumble across on the way to a milestone. This led to researchers funding ‘side projects’ with other money
- Even when achieving the goals set ‘you may not have the luxury of really understanding why’
- Aggressive milestones can help motivate researchers and students to work harder, create a sense of ownership and achievement

There was some acknowledgement that different Programme Managers may approach the milestone setting and reporting cycle differently, with some favouring ‘stretch goals’ which focus more on scientific understanding, than creating a device or other tangible output. The points above demonstrate the earlier observation that whilst these projects are very much mission-driven, the fundamental science behind them is part of the bigger picture in pushing the boundaries of knowledge that will support future technologies.

It is generally agreed that some level of reporting and review is helpful for progress. It may be interesting to consider how a well-designed milestone focus, where goals are negotiated with the researcher and build in latitude to consider a range of wider positive outcomes e.g. including pushing frontiers of knowledge, could help move away from publication as the primary marker of academic success. This could form part of a system of more diverse drivers of career progression.

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One thing that is common is that the eventual goal and prior milestones are highly ambitious, to the point of introducing a level of risk.

> ‘The programme officer has promised the moon, and I have to be like, look, we can't give you the moon, we can give you something that's like the moon, is that going to be good enough. And so there's this push-pull negotiation where I'm trying to bring them back down to reality and they're trying to push me up to some unrealistic goal. And I mean that's the kind of healthy push pull that pushes us to be a little bit more ambitious, pushes them to be a bit more realistic.’

Clear communication during milestone setting, with a balance between ambition and flexibility.

Directly linked to the ambitious goal setting and strict go/no go milestones is the ability of Programme Managers to quickly cut projects that aren’t performing. One interviewee suggested that there is an expectation that some programmes (or ‘performers’) will be cut as a way to de-risk the Programme Manager’s portfolio, and to try and ensure more successes.

> ‘And that's a common strategy too is maybe they fund four projects for the first year and they see ‘performers’ as it is, as they call them. So they'll fund four performers and then after year 1 maybe they'll cut two, and there's two left. And after… [a year] then they’ll cut down again’

How this is dealt with often comes down to individual Programme Managers. One ex Programme Manager we talked to said that often they would find ways to work with an underperforming team, and try and rectify the situation.

> ‘We know research does not always progress linearly and when they get into trouble we actually brainstorm with them. Say if this half looks less than promising, what other options do we have?’

It is common, they said, that projects might have a ‘pivot’ or slight change of direction during the course of the research. However this interviewee also conceded ‘for a given project different program directors might have reached different conclusions’, so a lot still relies on relationships and individual motivations.

One thing common with our interviewees was the feeling of constant pressure or threat of having their funding removed. In some ways this can take away from the research itself, or change the focus of the PI.

> ‘it's extremely stressful, and every time I go through this I say, why do I go for ARPA-E funding?’

> ‘…it takes a lot of my bandwidth. I think that's maybe one of the major drawbacks is that I spend my time worrying about whether or not my funding is going to be cut, and making sure that my reports to my program officers really look good and are really, you know, going to help them defend the program. I would rather be spending that time doing something else. So that threat takes some time away from [the research].’

Some interviewees said that better communication could help the situation of a project being cut, along with time and resources to wrap up research that is ending.

It should be mentioned that this is very different from the way government funded research currently works in the UK. The government should take care to scope this possibility before considering an introduction, to understand how this would work within existing UK funding frameworks and UK research culture. Failure to assess and understand this element thoroughly before introducing this could discourage some researchers from applying to the UK ARPA, with implications on the scope of research and diversity of the applicants. It is also important that this type of funding is not at odds with a secure research career and the benefits that come with that (e.g. paid leave), as this is essential for a progressive research culture.

Though government research doesn’t normally follow this format, SMEs are more used to go/no go milestones as used by investors. As long as there is good communication of expectations, SMEs may largely benefit from a system

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that allows rapid allocation of funding. However it should be designed to appeal to a wide range of different research types.

Our evidence base here is useful as a starting point, but incomplete. More work is needed on how the wider US funding system supports ARPA-E and DARPA, and the researchers that interact with them.

Further work needs to be done to assess the potential implications for research (including on diversity) if this fund were to use stop/go milestones. It may be that wider support or changes are need in the UK funding system to allow for this, and to encourage the risk taking needed to support ambitious goals.

As discussed in the previous section, excellent Programme Managers are one of the main components of a successful agency. Equally important is competent bureaucratic management, and the agency should be set up to be as organisationally efficient as possible. The budgetary management on some ARPA-E programmes, which in this case was provided by a third party company, was seen as so time consuming that one interviewee said it was far better to be a co-PI than a PI.

The bureaucratic management also needs to be excellent.

Inclusion and Diversity

Finally, we heard how this differing attitude to the 'risk' of projects, along with the pressure on Programme Managers to succeed in their areas, can have negative effects on the diversity of PIs funded, especially within DARPA.

> 'My impression of DARPA is that it is a little bit more of an old boy's network.'
>
> 'They want to pick people that they trust will be able to execute. So if you have a relationship with someone and you know that they're a good performer, you're likely to pick them again because you've worked with them before you know they're good.'

Interviewees who talked about this agreed that it was something the agency could improve upon. However as 'delivering' is so built in to the DARPA missions, it's hard to encourage existing Programme Managers to bring unknown PIs into the project. An encouragement of this kind of inclusion needs to be built into the agency.

> 'If there is a way to ensure that you're bringing in new people into the fold, then a fraction of those new people are going to become your stars, and then they're going to lead the program, and you might not have been exposed to them otherwise.'

One interviewee suggested that although the culture is highly competitive, with the right support in place, for instance accessible mentorship, young researchers from a range of backgrounds could thrive. One recommendation from our Breaking the Barriers report was that in order to support the progression of women in science there should be more long-term contracts for early career researchers.[11] There could be a built in requirement, or incentive, for a certain number of the high value, long term awards to go to teams involving, or led by, less established researchers.

Diversity and inclusion should be built into the agency from the beginning, for instance through an incentive to fund up and coming researchers as well as known performers.

[11] Page 30, Breaking the Barriers, Royal Society of Chemistry

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Contact

The Royal Society of Chemistry would be happy to discuss any of the issues raised in our written evidence in more detail. Any questions should be directed to policy@rsc.org.

About us

With about 50,000 members in over 100 countries and a knowledge business that spans the globe, the Royal Society of Chemistry is the UK's professional body for chemical scientists, supporting and representing our members and bringing together chemical scientists from all over the world.

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6. Annex 1 – UK Research funding landscape

	Innovate UK	ISCF	ERC grants	QR funding	EPSRC	ARPA type model[12]
Target recipient	Companies mainly	3 pillars – academic led, collaborative R&D, and industry demonstration	Individual academics	Universities and institutions	Academics mainly, but depending on grant could include companies	Academia and companies
Size of recipient group	Single, or small groups of businesses	Dependent on challenge	Single person/group	Whole institutions	Varies, could be individual research groups or institutions, or groups of collaborators	Groups of labs up to 10/15
Size range (in local currency)	£116,00 average[13] per recipient	£100 million+ per challenge area. Around £2 million – £20 million for individual projects	€1.5 million - €2.5 million per grant	Varies by institution according to quality, but up to £100 million	£870,000 average[14] per grant. Programme grants are typically £4 million - £6 million over 5 – 6 years.	$10 million - $20 million over 4-5 years
Risk Level	Variable, some higher risk investments	High – often with higher risk projects they are match funded with industry.	Variable, depending on the goals of the researcher	Variable, as distribution decided by the university, but general spent strategically[15]	Variable, but generally lower risk	High risk – big technological advances
Can include fundamental research?	No	Yes – but mainly focussed on translation of technology	Yes	Yes	Yes	Only if supports application
Challenge Based?	Yes	Yes – based around the Industrial Strategy	No	No	Mix	Yes – based around departmental focus
TRL[16]	4+	3-6 (bridging)	1-3	1-3	1-3	3,4,5 sometimes 6,7 for ARPA-E, could be higher depending on project

[12] An approximation of the elements on an ARPA style model, taken from information about ARPA-E and DARPA
[13] Average spend on current projects, Innovate UK's 2016/17 funding reports
[14] Mean grant size, EPSRC 2017-2018 funding rate data
[15] Empowering UK universities: how strategic institutional support helps research thrive, Wellcome
[16] TRL allocations, EPSRC information on The Funding Landscape

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