# Report on the BioImaging UK Hardware Infrastructure Community Consultation

## *A BioImagingUK White Paper*

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# Context:

The UK is a global leader in the development and use of advanced bioimaging methods. Research is increasingly interdisciplinary in nature, with collaborations between biologists, chemists, physicists, mathematicians, clinicians and engineers required to develop innovative imaging techniques and technologies to answer complex biological problems. The use of state-of-the-art biological and biomedical imaging equipment is supported by many universities and research institutes through support for advanced bioimaging facilities. A handful of these facilities form the UK EuroBioImaging Node, which have been operational since January 2023, and are open to researchers across the globe. Several UKRI-funded central open access facilities are also centres for bioimaging, including the Diamond Light Source and Research Complex at Harwell. Despite the strong local technology base, the UK currently has no large-scale coordinated infrastructure to support open access to advanced bioimaging equipment. The UK EuroBioImaging Node serves this purpose at a very small scale (7 sites with fixed capacity) and is limited in technology scope with a notable lack of medical imaging representation. There is also no dedicated funding for researchers accessing these sites - a significant barrier to broader adoption. Data handling, storage and analysis is a critical part of any bioimaging experimental workflow and facilities struggle to support their users in all these areas due to lack of dedicated servers, staff and expertise. This significantly limits the potential discoveries and impactful outcomes from life science research, restricts training opportunities for all researchers and results in a lack of data sharing and re-use. These problems are particularly evident in smaller institutions where support for equipment and technical staff is prohibitively expensive. These hardware and data problems could be addressed through formation of a co-ordinated national infrastructure framework that enables funded open access and data analysis/sharing, democratising bioimaging for all researchers spanning different domains and sectors.

A community consultation workshop was convened on the 8th November 2023 to discuss a way forward for bioimaging hardware and data infrastructure in the UK. Over 110 individuals spanning the full breadth of career stages and types registered for the workshop, from >50 institutions across the UK, as well as from industry. The outcome of the survey questions following the consultation are provided as Annex 1.

### Objectives:

1) To assess the demand, feasibility, and strategy for providing access to bioimaging core facilities with a focus on the UK EuBI node, regarding:
    a. expansion of biological imaging
    b. inclusion of biomedical imaging
    c. development of data analysis nodes
2) To explore funding models, opportunities, user needs, and barriers in bioimaging technology development.

**High-level summary of outcomes/recommendations:**

- *Conduct an analysis of current EuBI UK Node usage and instrument capacity to inform on expansion decisions.*
- *Survey all facilities to understand current capacity and potential for Node expansion.*
- *Carry out a UK-wide landscape mapping exercise to identify biomedical imaging equipment and capacity.*
- *Develop plans for a national imaging data analysis resource to unite approaches, drive innovative solutions and support capacity building for the community.*
- *Consult with EuroBioImaging to develop a realistic plan for a centralised access support fund to complement a future hardware infrastructure bid.*
- *Work with funders to co-develop realistic, regular funding opportunities for large scale imaging technology development across all domains, with consideration for FTE (staff) inclusion.*

# Consultation outcomes in detail:

## 1. Facility access and expansion of UK EuroBioImaging Node

### Expansion of UK EuroBioImaging node

Overall, there was strong interest in - and support for - node expansion. A consensus emerged around the importance of first gathering data on current node usage within the UK and across EuBI to inform any expansion decisions. Understanding the demand and popularity of specific technologies is crucial for determining the need for additional resources and identifying potential technology gaps.
Additional points raised:

- Unique and niche facilities, such as high throughput electrophysiology, are not currently catered for and should be explored. Opening out to a wider audience will help with viability, providing there is enough spare capacity.
- Notable absence of data-sharing infrastructure and need for improvement in this area.
- Potential lack of publicity preventing user uptake. Euro-BioImaging are investing significant resources in this area, but perhaps not always reaching the intended target audience.
- For biomedical imaging, an example was given from Southampton University, which opened access to its imaging facilities, and this acted as a successful pump-primer for larger regional activities. A key benefit was that it led to more strategic regional planning, which in turn helped to avoid competitive bids.

**Recommendation:**

- Conduct an analysis of current node usage, user demands and staff plus instrument capacity to inform expansion decisions.

### Barriers to offering access to the UK Biological Imaging node

- Limited capacity, especially in terms of staffing rather than time available on instruments, presents a significant bottleneck. Facilities, particularly in electron microscopy (EM), face challenges due to insufficient staff.
- Affordability is a major concern. Exploring ways to reduce costs for users, possibly by integrating access costs into grant applications, is recommended. See below for funding model discussion.
- There is a lack of basic knowledge about imaging among potential users. Bridging this knowledge gap is essential for meaningful discussions.
- Facilities can struggle to engage their local community in using advanced equipment, often due to resource commitments and the need for student/post-doc project time.
- Biosecurity issues, including transportation of GMOs, cross-contamination and impact on neighbouring labs, hinder external access for animal studies.

#### Biomedical-specific barriers:

- Obtaining ethical and regulatory approvals, especially for clinical and preclinical experiments, is a time-consuming challenge.
- Challenges around moving patient groups to geographically distant imaging facilities, particularly for studying specific diseases or specialised cohorts.
- IT/security and data protection, including GDPR compliance, pose challenges for both clinical and non-clinical scanning. Full data-sharing systems are not fully in place.
- The potential market (i.e., number of end-users and likely number of hours that a piece of kit might be used by external users) is not fully understood and therefore the return on

investment in making kit available is poorly understood. We could gain a better understanding of this by learning from existing biomedical nodes in Europe.
    - Lack of awareness of potential users around availability of suitable imaging infrastructure to realise their research ideas. To eliminate the need for potential users to identify sites themselves, establish a mechanism for them to propose ideas and be matched with suitable imaging infrastructure.
    - Rapid technological development makes it difficult to maintain competitiveness and attractiveness as a node.

## Inclusion of Biomedical Imaging in the UK node

As noted above, several key areas require consideration with respect to the inclusion of biomedical imaging – largely related to governance, data sharing, and logistical challenges. The importance of considering biomedical imaging beyond clinical settin gs were raised, encompassing non-clinical imaging centres, cognitive neuroscience, neurodevelopment/ ageing assessment, and engineering/methods development. There was strong support for a UK-wide landscape mapping exercise to identify biomedical imaging equipment held at various institutions and current capacity. A quick survey within the breakout room revealed a diverse range of biomedical imaging infrastructure, including:

- Pre-clinical (animal): (MRI; Optical; Photoacoustic; MPI; Ultrasound; PET; SPECT; CT; External beam irradiation (coupled with CT) for treatment guided therapy. Proton beam therapy)
- Clinical (human): (MRI (Low field MRI 3T, 7T, 11.4 T; ultra strong gradient); MEG; SPECT/ PET-CT/ PET-MR including total body PET-CT and photon counting CT.

In terms of prioritisation for access, needs differed between communities. The clinical imaging community voiced a need for prioritising access to high cost, high end technology with low throughput. Others from the preclinical/animal community suggested an urgent need for access to low maintenance cost, high throughput platforms - e.g., optical imaging techniques.

**Recommendation:**

- Carry out a UK-wide landscape mapping exercise to identify biomedical imaging equipment and corresponding capacity.

## Requirement for dedicated UK data analysis Node

Data analysts are integral to the entire imaging project, engaging with users from design through collection to interpretation. The group identified many challenges in image data analysis and discussed whether a single or multiple dedicated UK data analysis nodes should be developed to help solve these issues.
Major challenges and identified needs:

- Image analysis is a major bottleneck in many imaging projects, exacerbated by a common lack of coding knowledge.
- Capturing and managing metadata is a significant and complex problem in the context of image data analysis and image data FAIRification and sharing.
- A centralised hub or portal, referred to as the BioDAT Node, to provide guidance and coordination covering all steps of the image data cycle.
- More coordinated training for image analysts is essential, and a list of willing image analysts for collaboration on the BioDAT node was proposed.
- Universal problem of funding image analysis and the challenge of integrating analysis costs into equipment use.
- Lack of capacity in the UK to form an image analysis node without extra funding.

Considerations:

- Location, cost and duration of data storage and access from external collaborators
- Issues related to bandwidth, speed, connectivity and security.
- Need for unified pricing structures.
- Large data transfer systems are critical.
- Intellectual property issues in a distributed model

**Recommendations:**

- A national imaging data analysis resource is critical; funding for this infrastructure should provide a contribution to image analyst staff costs with remainder from host institutions.
- A distributed configuration of data analysis nodes was generally favoured due to the breadth/diversity of topics and the need for specialist knowledge.
- Analysts could split their time between local and national projects, providing connectivity across the UK.
- Carry out a UK-wide landscape mapping exercise to identify image analysis capability and capacity.

## Design and administration of core funding for Imaging Facility/Node access

A centralised, dedicated funding mechanism was proposed where users apply for funds to facility/node access. This approach would streamline the funding process and simplify administration. The funds should be flexible to support user needs, but prioritise travel and consumables, with some also earmarked for training. If sufficient funds are available for facility access, the facility should invoice central node to make administration as easy as possible. The challenge of VAT was highlighted, and it was suggested to inform the community that ideally, VAT should not be charged as these visits are treated as collaborations, not service provision. If unavoidable, users should be advised that they can claim VAT back. An interesting perspective was suggested where a node is funded prospectively, addressing all barriers from the outset, and funds awarded directly to institutions would be deemed for medical research and therefore VAT exempt. This approach contrasts with reactive/retrospective adjustments to operational practices. For biomedical imaging, the TRAC/cost-recovery model is unrealistic for academic researchers, and alternative models, such as involving external users, are therefore attractive. There is substantive interest from industry, particularly in total body PET from pharma/SMEs. This presents an opportunity for collaboration and potential funding for more effective cost recovery. Indeed, it was more broadly felt that the excellent UK technology base could strongly benefit industry users, particularly SMEs which have limited resources and technical expertise to undertake complex advanced bioimaging.

**Recommendations**:

- Convene a working group to develop bioimaging modality-specific requirements to be accessed with centralised funds.
- Consult with EuroBioImaging Nodes to understand current approximate user costs and the different national funding/administrative mechanisms for facility access for different imaging workflows.
- Develop a high-level cost plan for a centralised access fund to be considered as part of any future hardware infrastructure bid to lower barriers, democratise technology access and enable agility in undertaking pilot or high risk-high gain experiments not funded through other mechanisms.

## 2. Technology Development

*Need for dedicated infrastructure fund to run alongside access fund to support cutting edge technology development.*

The bioimaging, biomedical, and data breakout groups had different perspectives on this and highlighted different needs for each community:

Within **biological imaging** there are different types and levels of technology development, some of which are compatible with service provision and some of which are not. Workflow development, which can occur in core facilities, provides easy wins to enhance facility functionality or capability. However hardcore technology development is generally incompatible with science service due to consistency and configuration issues. There are also challenges of linking technology development to biology and end-user needs, for example there is rarely colocation between developers and end-users. Complex home-built systems are challenging to hand over and tend to become obsolete when the developer moves on. Plus, many researchers prefer commercial or turn-key equipment, creating a barrier for home-built kit usage and bespoke requirements for specific experimental workflows. The consensus for bioimaging was that response mode funding for technology development already exists but the duration of grants are unrealistic as they are too short.

In contrast, the **biomedical imaging** community stated that in university imaging centres, colocation of tech developers and application specialists is common, with physicists/engineers working concurrently with psychologists/psychiatrists/neurologists and radiologists. They agreed it was important to have a parallel infrastructure fund, However, such an infrastructure fund should not be limited to the equipment, and must include funding of staff (e.g., postdoc model, or embedded technical research professional) to help with continuity/ 'hand-over' over of expertise to new staff members, and to build research capacity.

The **data community** strongly recommended that technology development should include method development for AI/ML and platform development, e.g., OME-ZARR, Napari, (both currently funded by CZI), expansion of the BioImage Archive and/or resourcing for OMERO, linking through to GLP/auditability for value capture by particularly SME/industry. Platforms for federated data access to harness (and search) existing repositories were also suggested. The success and impact of the CZI Essential Open-Source Software funding for maintaining and developing critical software were highlighted. Despite its importance, this had previously only been possible as a side project. In general, funding for technology development would be highly valuable in this field, as the UK is falling behind in terms of image analysis infrastructure, despite our excellent and internationally recognised research base in this field.

**Recommendations**:

- Work with funders to co-develop realistic, regular funding opportunities for large scale imaging technology development across all domains, with consideration for FTE inclusion.
- Technology developers to consult with the community to ensure all future funding bids consider end user needs and priorities.
- Develop plans for larger scale bioimaging data infrastructure and joined up community approaches to realise this ambition.

**The bioimaging community** proposed that complex correlative/multimodal workflow development and sample prep were two key growth areas. Additional areas for consideration were:

- Cross-scale Multi-modal imaging, particularly the ability to track ROIs across modalities.
- fMRI combined with 2-photon and STED to image neuronal activity at multiple scales.
- Mass-spec imaging, especially 3D and combined with spatial-omics.
- vEM: multi-mode FIB-SEM, including correlative sample processing after lift-out; navigating to the right place by using microCT or near InfraRed branding for fiduciary markers.
- Single-objective light sheet designs (fast and gentle 3D)
- MINFLUX
- Expansion Microscopy in combination with other advanced imaging methods, especially super-resolution
- Adaptive optics
- Label-free, real-time and non-invasive methods
- AI to complement high-throughput (content-aware)

Barriers here are the colocation of multimodal instruments, lack of expertise and lack of understanding from end-users about what might be possible plus reluctance to use non-turnkey instruments. Funds are lacking to develop many of these technologies and pipelines that do not fall under one technology development.

**The biomedical group** listed the following opportunities that primarily could reduce the cost and/or increase portability and accessibility:

- Low field MRI - could act as triage in GP surgeries before going to higher end kit, or 'democratise MRI' meaning giving much broader access in low resource settings.
- Room temperature magnetoencephalography (MEG) with optically pumped magnetometers is emerging as a much cheaper solution to cryo-cooled SQUID-based methods, with much lower running costs.
- Miniaturisation of mass spectrometers - portability is important e.g., for forensics, where every crime scene could benefit.
- Detector development - more sensitive and faster detectors are needed for CT/ PET-MR. Finer pixel pitches/ photon-counting. Portable/modular CT systems would be advantageous.
- Development of X-ray sources - e.g., liquid metal sources (which are brighter than solid anode cone-beams), allowing hard-X-ray phase contrast imaging. X-ray speckle imaging etc. (scattering/absorption/MRS). Soft X-ray, cryo X-ray.
- Compact Light Sources

Barriers include intellectual property management as most technology development includes industrial partners; data analysis/interpretation/validation, especially if new image contrasts are generated; training for medical professionals; sustainable funding as 'one-time' funding is not workable for expensive pieces of equipment with expensive service contracts; access/ maintenance contracts not always eligible costs on grants.

**Recommendation**:

- Consider these priority areas for future growth and technology development and work with community and funders to co-develop tractable approaches to deliver.

# ANNEX

# UK Hardware 08 Nov

08 - 14 Nov 2023

Poll results

Multiple-choice poll

Survey (1/9)

0 4 3

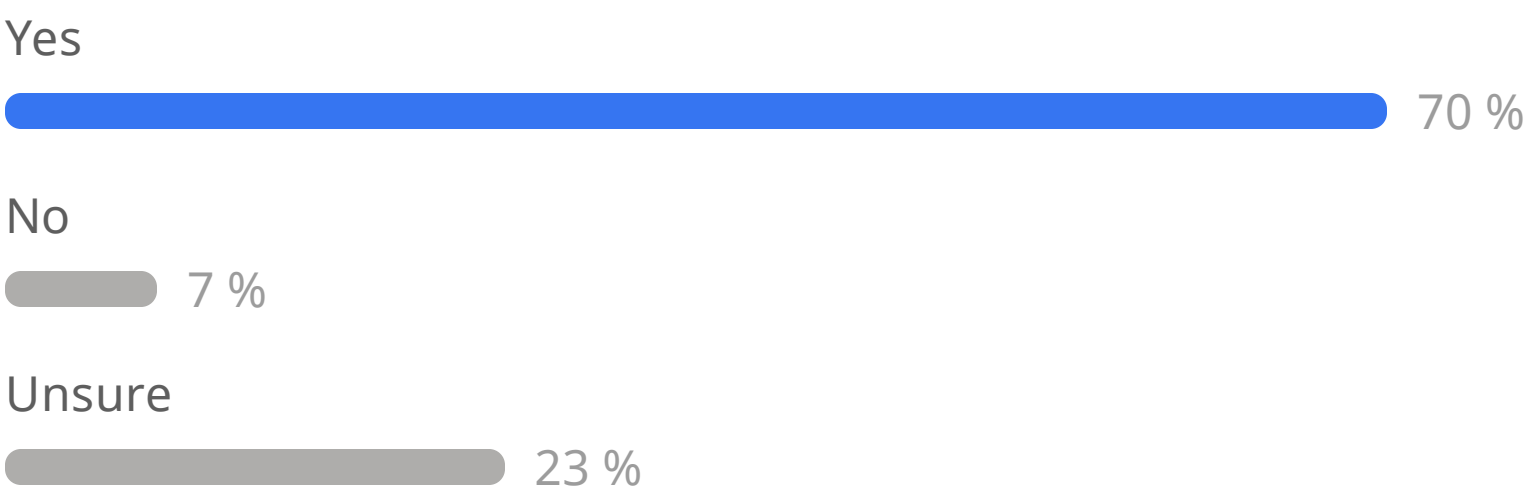
## Should we have a dedicated, co-ordinated open access UK bioimaging infrastructure?

Multiple-choice poll

Survey (2/9)

## Should we expand the UK EuBI Node?

0 4 3

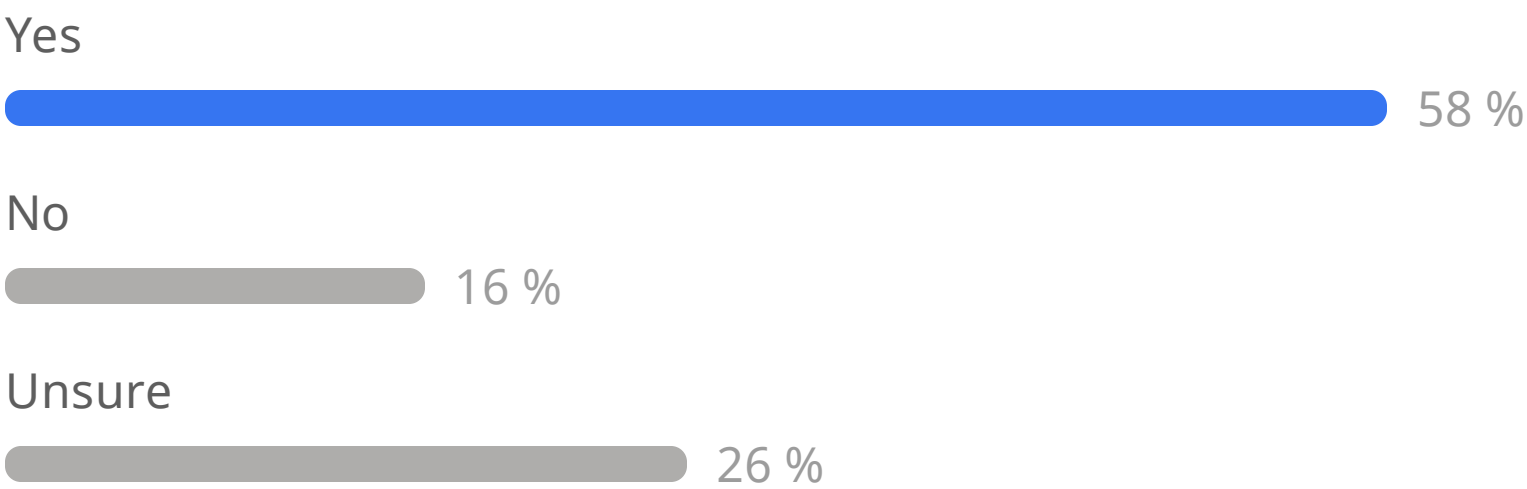


Multiple-choice poll

Survey (3/9)

## Should we prioritise specific technology gaps where we have most demand?

0 4 3

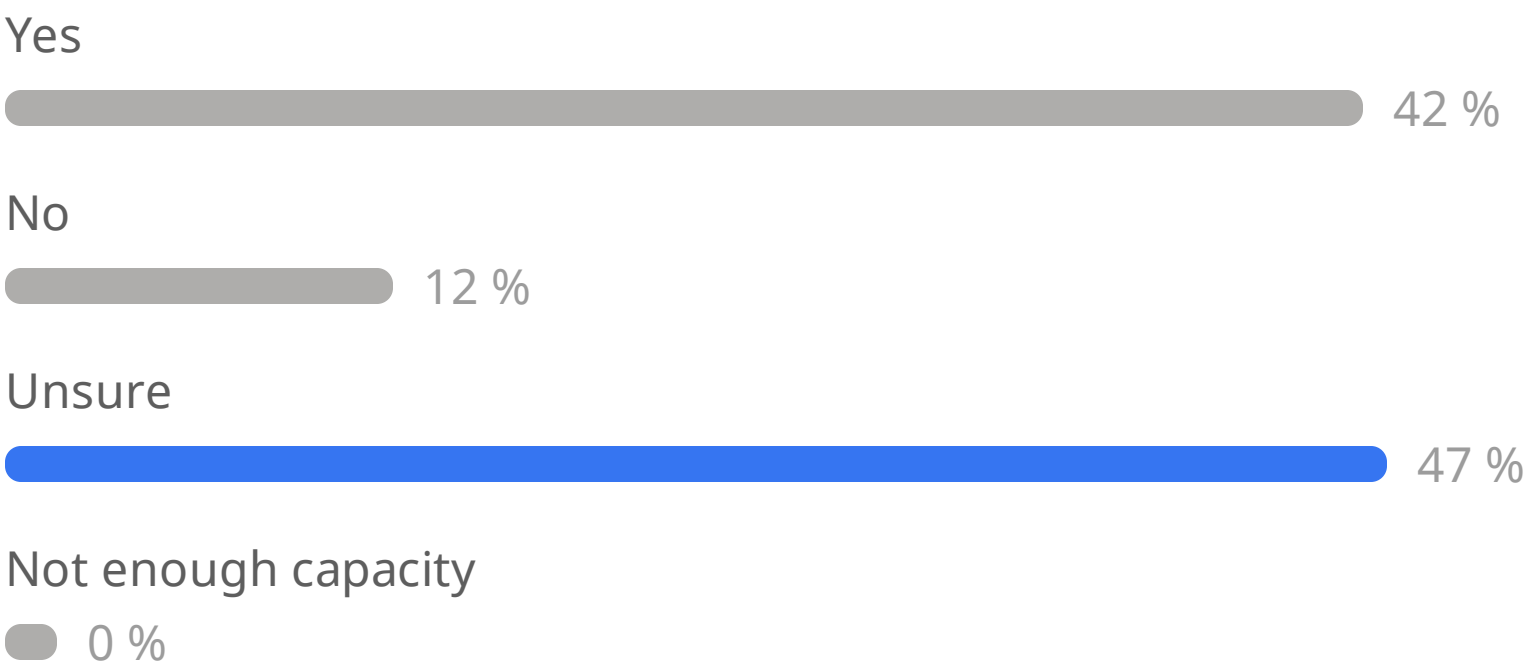


Multiple-choice poll

Survey (4/9)

0 4 3

## If we have enough capacity, should we include biomedical imaging in the UK Node of EuBI?



Survey (5/9)

0 1 4

# If yes, which medical imaging technology should we include in the UK Node?

(1/2)

- MRI, PET and CT for preclinical as well as clinical applications
- human and animal MRI, MEG
- Nano MRI, photoacoustic microscopy
- It would be good to see some access to biological X-ray imaging included in future technology provision.
- Will leave that to the experts to decide!
- the question about prioritising 'technology gaps where we have the most demand' is badly formed. do you mean prioritise gaps or prioritise areas where we have the most demand?
- But it isn't as simple as that, it likely would need a dedicated node being set up from scratch to address the multiple challenges of incorporating access into eisting facilities and this would be very expensive to build, equip and staff.
- Mass Spectrometry Imaging

Survey (5/9)

0 1 4

# If yes, which medical imaging technology should we include in the UK Node?

(2/2)

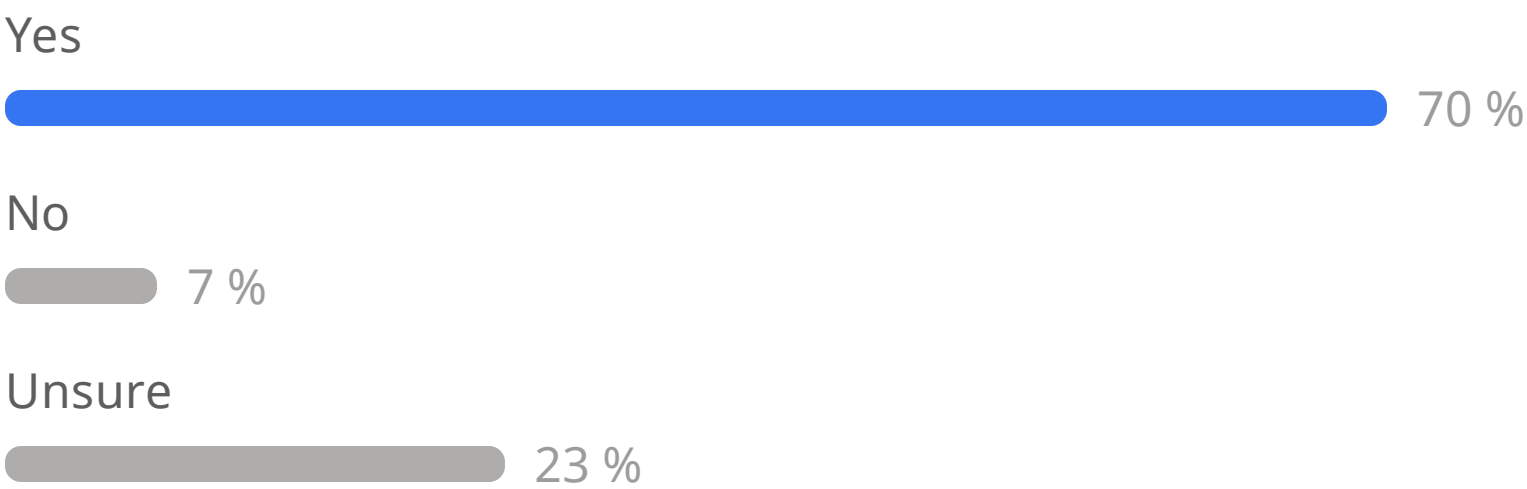
- PET/CT, SPECT/CT, MRI to feed pipeline into clinical translation. Nuclear imaging provides the greatest possible sensitivity, MRI provides the greatest resolution....however these are just suggestions!
- Apparently more than a single technology/machine there is need for biomedical imaging-related image analysis and know-how related to data sharing and metadata curation
- CT imaging
- MicroCT
- PET, MRI and CT perhaps
- Preclinical imaging

Multiple-choice poll

Survey (6/9)

# Should we have dedicated UK data analysis nodes?

0 4 3



Multiple-choice poll

Survey (7/9)

0 4 3

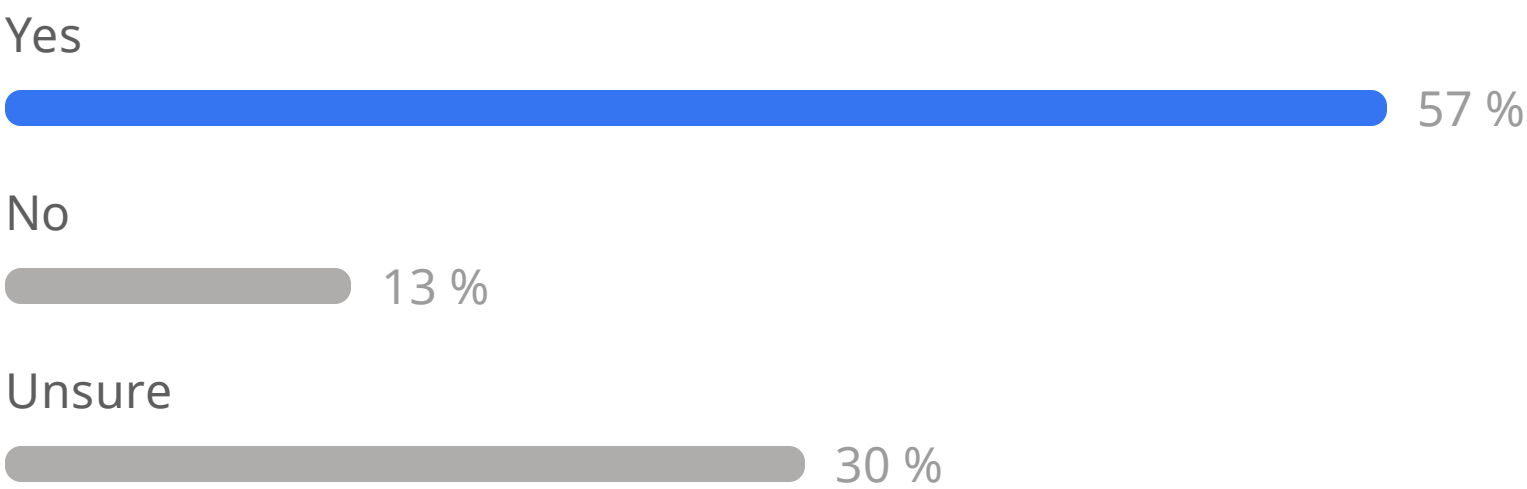
## Should we have dedicated core funding for facility or Node access?

Multiple-choice poll

Survey (8/9)

0 4 7

## Do we need a dedicated technology development fund to run alongside access fund?



Multiple-choice poll

Survey (9/9)

0 4 7

## Should anyone receiving tech dev funds only do so if they then share their equipment within the infrastructure?