



Enabling Science through European Electron Microscopy

Report on engagement with industry

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Revision history log

| Version number | Date of release | Author | Summary of changes |
|----------------|-----------------|-------------------------|---------------------------|
| V0.1 | 23.6.2019 | J Walmsley, R Holmestad | Initial draft |
| V1.0 | 23.02.2021 | J Walmsley, R Holmestad | Revised version |
| V2.0 | 23.02.2021 | Peter A. van Aken | Approval of draft |
| V3.0 | 01.03.2021 | Peter A. van Aken | Approval of final version |

Introduction

Previous EU projects (ESTEEM and ESTEEM2) have shown that there is a high threshold for participation of industries with limited experience of advanced TEM in the transnational access (TA) schemes. Therefore, ESTEEM3 wants to have a more proactive approach to industrial engagement. CAM and NTNU act as Industrial Liaison Officers (ILOs) for ESTEEM3 and will share responsibility for coordination of this task. In particular, greater industrial use of TA is actively being sought and given positive weighting when assessing TA applications. There will be an emphasis on attracting small and medium-sized enterprises (SMEs), as defined by the EC, whose TA results can be treated as confidential according to the rules of the work program. By the end of the project, sustainable relationships with a range of industrial partners will have been established and documented through NA and TA activities. Experience is being shared with other relevant projects.

CAM and NTNU act as the first contact point for any company not familiar with TEM, but which wish to use the ESTEEM3 services.

Documenting ongoing industrially oriented initiatives and activities

The initial list of industrial contacts that has been established (M4) has been updated.

As described in the initial plan, two brief questionnaires have been distributed to the consortium and to industrial contacts:

1. Consortium members were asked for basic information to help understand how industrial collaboration has been established and developed, what level and type of industrial access, which is provided, balance of long and short term activities, levels of confidentiality and open research and funding models (direct, industry/state).
2. Industrial contacts have been asked for information about how they make use of TEM access, if their requirements are met, additional needs and awareness of ESTEEM3. The requests were forwarded through the relevant consortium contacts.

The intention is to give an insight into the way that industrial interaction within the consortium works. This will allow practices and strategies to be shared, contribute to developing industrial understanding within the project with respect to development of European TEM environment, and give guidelines on how to proceed in potential new proposals. The questionnaires are described below.

Generating and distributing publicity information

As described in the initial plan, Euronovia has updated the project web-pages to provide an industry portal to encourage industrial uptake of TA, <https://www.esteem3.eu/industry>. The pages will be further updated during the second half of the project and include further reports of industrial activities, where these can be made public. The number of completed industrial TA projects is lower than anticipated at this stage, due to disruptions caused by the Covid-19 pandemic. The first example of published results from an industry TA access has been published.

- Industrial outreach has been part of presentations and publicity meetings at conferences. This activity is described further in the next section and will be continued during the second half of the project.
- Web and brochure/flyer material has been updated during the project on an ongoing basis.
- At the end of the project relationships with a range of industrial partners, arising from NA and TA activities will be summarised.

Meetings and conferences

ESTEEM3 has had a presence at conferences, at which industry was likely to be represented. Communication has been through booths and consortium members including notification of ESTEEM3 in presentations. Activities that have been planned and carried out up to the present date are described below:

Dedicated industrial symposium - The Advanced Materials Show, Telford, UK, 10th–11th July 2019

This is a regular annual meeting in the UK that brings a wide attendance, primarily from the UK and Europe, <https://advancedmaterialsshow.com/>. One of the IL officers attended the 2019 symposium, <https://advancedmaterialsshow.com/app/uploads/2019/11/ams-cuk-2019-showpreview-web.pdf>.

The symposium was attended by a wide range of industry and academia, including associations. Several contacts were made, where ESTEEM3 TA seemed to be relevant. These included associations and initiatives providing services, generally to specific materials sectors.

- European Ceramics Cluster <http://www.cerameurop.com/>.
- Collaborative Outreach in Applied Surface Engineering Technologies (COAST) - <https://www.uk-cpi.com/coast>
- Materials Innovation Factory (MIF), University of Liverpool <https://www.liverpool.ac.uk/materials-innovation-factory/>
- The Innovation Network for Advanced Materials (INAM) Berlin <https://www.inam.berlin/>

- Nanotechnology Industries Association (NIA), <https://nanotechia.org/>
- Centre for process Innovation (CPI) <https://www.uk-cpi.com/>

SMEs were also represented at the symposium and these included:

- Radisurf , <https://www.radisurf.com/> , Risskov, Denmark.
- Abalonyx, <https://www.abalonyx.com/>, Oslo, Norway.

Initial contacts have been followed up. Generally, there were no immediate requirements for ESTEEM3 TA. Networks and clusters agreed to circulate information about ESTEEM3 within their organisations. A TA application was made by one the SMEs and has been approved. The main value of the visit was to obtain a direct insight into a range of industrially oriented organisations through formal contact-points. While there was definite interest and a clear general need for TEM, the impression, both at the time and after subsequent contact, is that a very proactive approach is needed to identify specific TEM needs and to realise TA proposals.

Academic conferences where electron microscopy is the main topic;

European Microscopy Congress (EMC) 2020, 23-28 August, Copenhagen. The ILOs were part of the organising group for a session called “*Microscopy in industrial applications*”, at the European Microscopy Congress (EMC) 2020, 23-28 August, Copenhagen, along with Dogan Ozakaya and Lisa Lautrup from Johnsen Matthey and Sandvik, respectively.

There was a good response to the session. Twenty-four abstracts were received. Of these twelve had primary or co-authors with industry affiliation. Alvaro Mayoral Garcia, INMA-CSIC University of Zaragoza /Shanghai Tech University accepted an invitation to give an invited lecture, entitled “*Directly atomic observation of zeolites and zeotypes.*”

Due to the Covid-19 pandemic, the EMC conference was deferred by the organising committee to take place in 2024 in Copenhagen, with bidding for the next conference delayed until the same date. Consideration will be given to reorganising the session at this conference although it will take place after ESTEEM3 has formally finished.

More academic materials conferences with ESTEEM3 booth;

ESTEEM3 had a presence at two conferences in 2019:

- EMRS Spring meeting 2019, May 27-31, Nice.
- EUROMAT 2019, 1- 5 September, Stockholm.

On both these conferences, ESTEEM3/Euronovia had a manned booth with roll-ups, where conference participants could stop by and ask questions. See picture in Appendix 2. Many industrial participants were informed about TA possibilities. Activities at international meetings and conferences were restricted during 2020 due to the Covid-19 pandemic. Activities during the remaining part of the project will be reviewed in a final update of this report.

Consortium members attending conferences are asked to provide feedback and the ILOs will coordinate with Euronovia, as the latter takes the lead in representing the project in international fora. A list of conferences and workshops, where ESTEEM3 has a presence, will be maintained and details of industrial contacts or input will be made.

Exchange of information and ideas with other infrastructure projects and networking organisations

Experience has been shared with two other European infrastructure projects, this has included a joint webinar and online discussions. It is instructive to compare the differences and similarities between these and ESTEEM3.

The University of Antwerp is active in both ESTEEM3 and the EU H2020 European Soft Matter Infrastructure (EUSMI) project, <https://eusmi-h2020.eu/>, which made it a natural choice to establish a dialogue. The project manager is Dr Yi Liu at the Forschungszentrum, Jülich. Contact was made with Dr Anna Stenstam, CR Competence AB, Sweden, who works as a dedicated Industrial Liaison officer. EUSMI runs from 1 July 2017 to 31 December 2021 and offers integrated project support across 5 Work packages (WPs), WP1 Spectroscopy and rheology, WP2 Scattering and diffraction, WP3 Imaging, WP4 Synthesis and up-scaling, WP5 Supercomputing. As of December 2020, the project has 19 industrial projects, 10% of the total, with 26% of these being from SMEs.

The range of techniques offered contrasts with ESTEEM3, which focuses on one key technique. This means that EUSMI activities are larger and require more project management and coordination.

Contact has also been established with the Open Innovation Test Bed (OITB) for Electrochemical Energy Storage MATerials (TEESMAT) project. TEESMAT runs from 1 January 2019-31 August 2022. It focuses on Industrial applications and will establish 25 funded industrial User Access Cases (UACs).

Similarly to EUSMI, TEESMAT is building larger projects with a requirement for project management across a range of institutions and competences to run projects. The projects are exclusively industrial,

and the UACs will have the ambition of being generic test cases to establish sustainable platforms across a broad range of characterisation techniques.

ESTEEM3 and EUSMI organised a joint webinar on 9th December 2020, Opportunities of Transnational Access for Industries within ESTEEM3 and EUSMI. A short presentation of the TEESMAT project was also included in the Webinar.

Two ESTEEM3 presentations were made to the TEESMAT consortium, at a Webinar on 15th January and at the TEESMAT General Assembly on and 20th January 2021.

TEESMAT does not include TEM in their long list of characterization techniques, so there is a clear opportunity for interaction. Three options for further collaborations were suggested.

- To make ESTEEM3 TA applications to explore specific potential applications of TEM to battery technology studies.
- To apply for ESTEEM3 TA as an extra component of TEESMAT UACs.
- To publicise ESTEEM3 within the battery community to encourage companies to make separate applications for ESTEEM3 TA.

The need to have a robust route for establishing NDAs and protecting IP was emphasised as essential for the TEESMAT consortium, reflecting the exclusively industrial focus. The ESTEEM3 provisions were discussed and seemed to meet the requirements.

The ESTEEM3 leadership has been in contact with the Nanotechnology Industries Association (NIA). The ILOs started the process in their institutions of becoming members of the organisation, but this has been on hold and will be revisited during the remaining part of the project.

Status of Industry TA

As of 31st January 2021, 9 industrial TA applications have been approved. This is a significantly higher than the level achieved in ESTEEM2, however, this compares with the stated objective at the end of the ESTEEM3 project of 25 industrial TA.

Feedback from Questionnaires and Consortium

Two questionnaires were distributed, one to consortium members and one to industrial partners. For the latter, the invitation was forwarded by consortium members.

Consortium member questionnaire

Feedback was received from 8 of the consortium members. They reported a wide range of industrial funding levels, from significant direct industrial project funding to none. Categories, in which industrial funding feedback was provided, are:

- Fully funded confidential research

All reported small “task” activities, generally with occasional/frequent frequency. Longer-term funding, such as PhD students/postdocs, was occasional but reported by 5 of the respondents.

- Fully funded open research

Respondents reported occasional smaller or larger open tasks.

- Co-funded – share of public funding

Three of the respondents reported frequent funding of this type of project.

- Undergraduate, Masters projects, etc.

Two of the respondents reported frequent undergraduate and Masters’ level projects being funded by or carried out in cooperation with industrial partners.

The areas of industrial interaction reported for the last 5 years were broad, with the semiconductor industry, chemicals/catalysis and pharmaceutical/health being featuring strongly and structural materials being highlighted by at least two consortium members. These were mostly long-term interactions with large companies. Cooperation with companies with respect to data-processing, as described by Julich above, was included in the feedback, as was the long-term cooperation of the type described by Cambridge for the pharmaceutical consortium.

Industry questionnaire

The number of responses was disappointing, with only 9 replies registered by February 2021. However, some qualitative insights can be obtained from these. The questionnaire has been kept open and the overview can be updated, if further replies are received.

- There was a reasonable geographical spread of responses.
- Generally, responses came from larger companies, with the majority having over 1000 employees, with 1 SME.

- The importance of TEM to the company was generally rated from medium to high importance. This is, of course, biased by the fact the questionnaire was forwarded by consortium members, but confirms that for some companies TEM access is extremely important.
- Three of the respondents had their own TEM facilities. This is interpreted as meaning that contact with consortium members is still valued for reasons such as access to advanced facilities, technique development, competence building and recruitment. This aspect could be explored further.
- Surprisingly, 4 of the respondents were not aware of the ESTEEM3 TA scheme. This suggests that there is scope for the consortium to publicize ESTEEM3 among their existing industrial contacts. At the same, 3 had made use of TA in other platforms, so they were familiar with the ideas. It would be interesting to know about, which platforms were used and their access models. This may be addressed directly, to a degree, through discussions with other infrastructure platforms.
- Access cost was reported as being an important barrier for increasing use of TEM by 4 of the respondents. While IP did not seem to be a significant concern, it was listed as important by 5 of the respondents. This may suggest that companies find that IP can be protected effectively during interaction with the consortium.
- Participation in open projects and in publication of results was regarded positively, with 7 if the respondents assigning medium to high importance.
- With regards to type of access, performance of short term tasks, long term research initiatives and performing TEM as part of integrated studies were each prioritized by 2 or more of the respondents, with long term initiatives being regarded as the best type of interaction by 5. A strong preference for operation of TEM infrastructure by an experienced research was indicated although 3 of the respondents attached value to their own staff having access to the infrastructure or operation by PhD students or postdocs.
- With respect to workshops, online information and direct discussion with experts, the second two categories, were the most desirable. This is presumably because web-based material is the most convenient and direct discussion is likely to be most relevant.

Some of the most relevant feedback came from responses in the comments section. This feedback is collated below and is not quoted verbatim.

Respondent 1 comments;

- Before acquisition of in-house equipment, the company was more active, when it comes to external access. IP issues was one of the main drivers for the acquisition as well as fast response on results.

Respondent 2 comments;

- Adopting of beam line approaches in synchrotron sources, including agreements, could be considered as an effective way to interface with industry.
- It would be desirable to create lines of analysis in typical materials. A typical example could be to establish oxidation state mapping of Li in battery materials using EELS.
- Where analysis routes are not established, demonstrate analysis on a test material to establish a procedure. This could be done at a lower price than for a future commercial rate carried out for publication, if agreeable to the company. In the longer run, a company needs to know, what they will get for a specific fee.
- The TEM environment could consider establishing longer term projects to develop specific applications for a range of materials using public/company shared funding and use these to establish charge for specific pieces of analysis and interpretation.

Feedback from the Consortium during the JRA meeting

A discussion on Industrial outreach was held with the consortium at the end of an ESTEEM3 JRA progress meeting on 2nd February 2021. The current status of WP 3.3 was briefly presented and the consortium members were invited to provide feedback.

One theme is the importance of highlighting the benefits of ESTEEM3 to industry outside provision of TA. This is reflected by the presence of 5 SMEs in the ESTEEM3 consortium. Generally, the interaction with these companies, and others, is to develop technology that is central to their businesses. This technology will then later be available to the whole TEM community, including industry.

Examples of interaction with Industry outside TA,

Julich provided specific examples of interaction with companies within the TEM business area. This includes companies inside and outside ESTEEM3.

Quantum Detectors, <https://quantumdetectors.com/>,

- Regarding software and interfaces for their cameras, as well as Open Source readers for their data formats.

Attolight <https://attolight.com/>

- Is being established.

Direct Electron, <https://www.directelectron.com/>

- Open Source readers for their data formats.

CEOS, <http://www.ceos-gmbh.de/de> ,

- Architecture and interfaces for instrument control and data transfer.

Gatan, <https://www.gatan.com/>

- Open Source readers for their data formats, (DM3, DM4, K2 IS raw data)
- Live data processing. Starting with K2 IS, in the future also K3. Google/PSF
- Python scripting in GMS.

pnSensors, <https://pndetector.com/w/en/>

- Open Source readers for their data formats

Nion, <http://www.nion.com/>

- Processing of data, specifically integration of LiberTEM and processing in Nion Swift

Hitachi, <https://www.hitachi-hightech.com/eu/products/science/?version=>,

- Control interfaces.

SerialEM, <https://bio3d.colorado.edu/SerialEM/>

- Integration of Python scripting
- Participation in Google Summer of Code through Python Software
- Foundation (Google funding students doing Open-Source development)

Noticeable positive effect is growing support for Open Source and open interfaces towards a more collaborative relationship between users and manufacturers. Manufacturers see the benefits, when the community takes over some of the development tasks, such as developing and maintaining application software for scientific use (HyperSpy, pyXem, Pixstem, LiberTEM, etc.), and perceive this as added value to their products and not as a threat to their business.

UK examples of academic/industry TEM cooperation

A UK example, that includes strong industrial access to TEM alongside direct industrial participation is the electron Physical Science Imaging Centre (ePSIC) facility at the UK Diamond light source, [ePSIC](#). This provides TEM access following a synchrotron access model and includes access to facilities that are directly funded by Johnson Matthey. Academic access is based on scientific application, while a proportion is reserved for commercial access, [Diamond access](#).

Another example of academic/industry cooperation is given by the hosting of the Cambridge pharmaceutical cryo-TEM consortium, [Cambridge cryo-consortium](#), at Cambridge University. This is described in further detail by Sadir *et al.*¹ Confidential access is provided to 5 companies, in addition to the University and the laboratory for Molecular Biology (LMB) <https://www2.mrc-lmb.cam.ac.uk/>. One aspect that is highlighted is in-house investment in industrial TEM facilities as a development of competence and industrial research initiated in the consortium facilities.

Discussion and activities for the duration of the project

The present report will be updated in M40. The main engagement activities in the initial plan have been based around information gathering, publicising ESTEEM3 to industrial audiences, making direct contact with industrial contacts and comparing experience with other infrastructure projects that provide industrial access.

A direct measure of industrial engagement is the level of industrial TA uptake. At present, this is behind the initial targets of the project. This has been compounded due to suspended activities because of the Covid-19 pandemic. However, the proportion of industrial relative to academic applications has increased during the most recent 12-month period. This is, to a degree, due to direct approaches to industry by the ILOs and others. As an example of this, the ILOs are aware of three industrial TA applications that are in preparation or recently submitted.

It is clearly challenging to encourage industrial uptake and a proactive approach appears to be necessary. The ILOs will follow-up ongoing initiatives, such as contacts established during the

¹ Sader K, Matadeen R, Castro Hartmann P, Halsan T, Schlichten C. Industrial cryo-EM facility setup and management. *Acta Crystallogr D Struct Biol.* 2020 Apr 1;76(Pt 4):313-325. doi: 10.1107/S2059798320002223. Epub 2020 Apr 6. PMID: 32254055; PMCID: PMC7137108.

remaining period of the project. This will include following up of contacts established, for example materials associations, from participation in industrial symposia.

Another consideration is to provide input into the best approach to industrial engagement by the European TEM environment. This is from both a strategic point of view and with respect to alignment with requirements of funding bodies, particularly within the EU.

The underlying ambition is to establish a strategy to develop the strongest possible cooperation between the TEM environment and industry. This should include companies that develop TEM technology and competence and the in-house industrial TEM research base.

Communication with other infrastructure projects is beneficial. Parallel to the ESTEEM3 project, there has been some activity to make better synergies between different infrastructures through the ARIE consortium, [ARIE position paper](#), where electrons participate as eDREAM. This consortium submitted a proposal to the Horizon Europe Green Deal call, where offering research infrastructures to industry is an important role. Collaboration with other infrastructures allows for a constructive exchange of ideas as well as opportunities for applying industrial TA. The interaction with TEESMAT is particularly relevant to the last case and will be pursued.

The way industry is addressed in future initiatives is an important consideration for the consortium. The RI program in Horizon Europe does not continue the INFRAIA networks, but is more mission oriented. The experience gained in ESTEEM3, with respect to TA and other aspects of industrial engagement, will help inform this discussion. While it is not clear, how industrial engagement will be prioritized, it will be valuable for the consortium to have a flexible strategy that anticipates requirements and can be communicated to the ERC and other funding bodies.

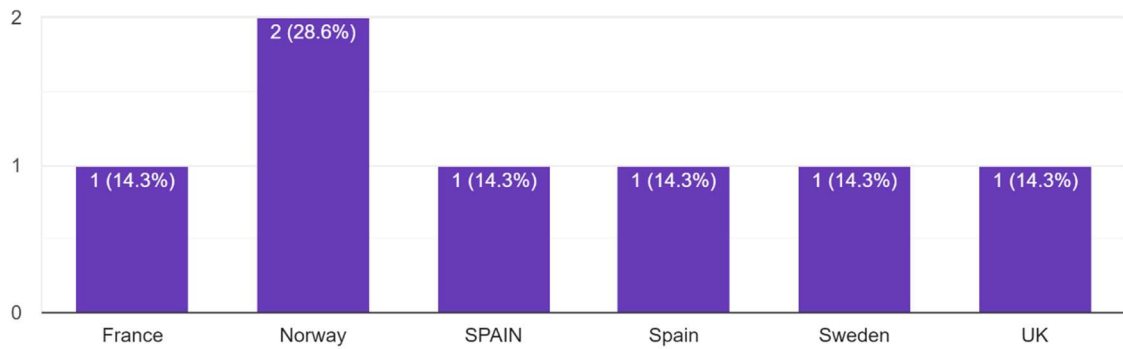
Industrial outreach activities during the remaining part of the project will include:

- Encourage further industrial TA applications by following-up initiatives for the first half of the project.
- Continue discussions with other infrastructure projects about TA and industrial outreach.
- Provide input with respect to industry relevant to future consortium strategy and funding.
- Represent ESTEEM3 at conferences and consortia, including a possible rearrangement of the EMC industry session.
- Document industrial interactions of the type described by Julich more broadly across the consortium.
- Discuss webinars and other communication tools with industrial members of consortium.
- Assist Euronovia with updates of industry section of project webpages.

Appendix 1, graphical representation of feedback from industry questionnaire

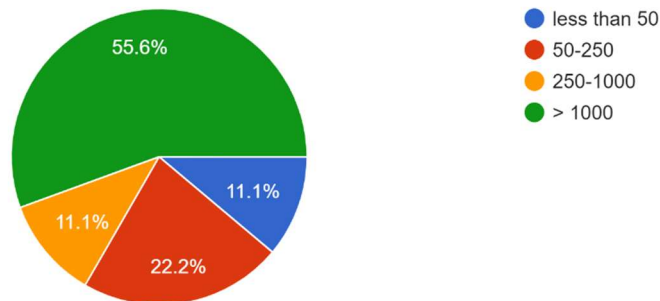
In which country is your company located?

7 responses



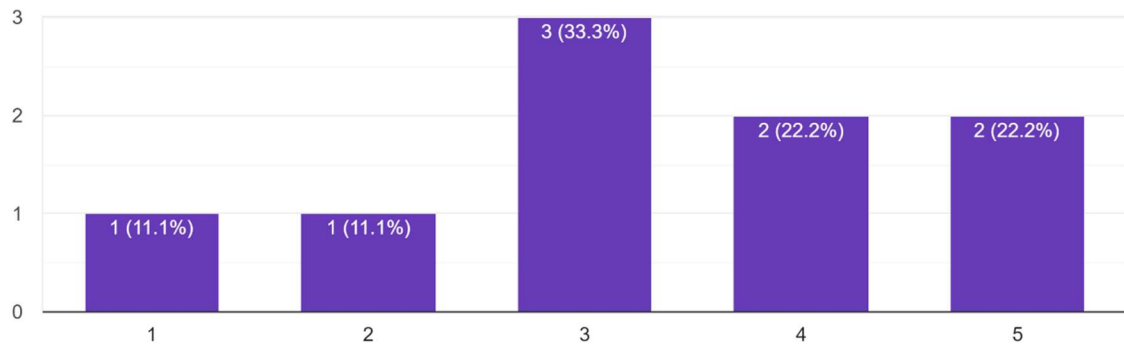
How many employees are hired in your company?

9 responses



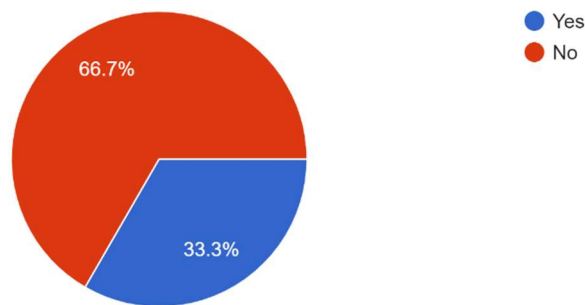
How important is TEM to your R&D activities?

9 responses



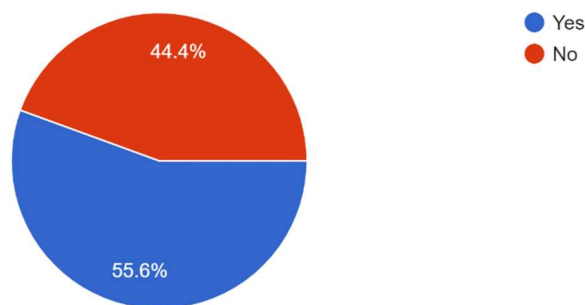
Do you have access to TEM in-house?

9 responses



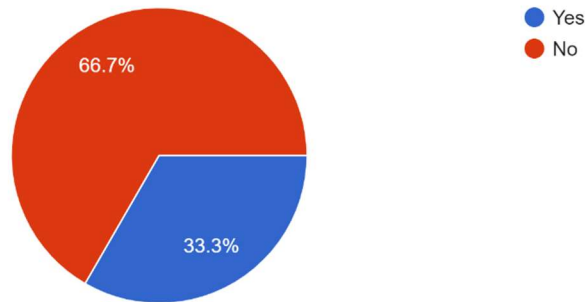
Are you aware of the ESTEEM3 Transnational Access (TA) scheme (<https://www.esteem3.eu/>)?

9 responses



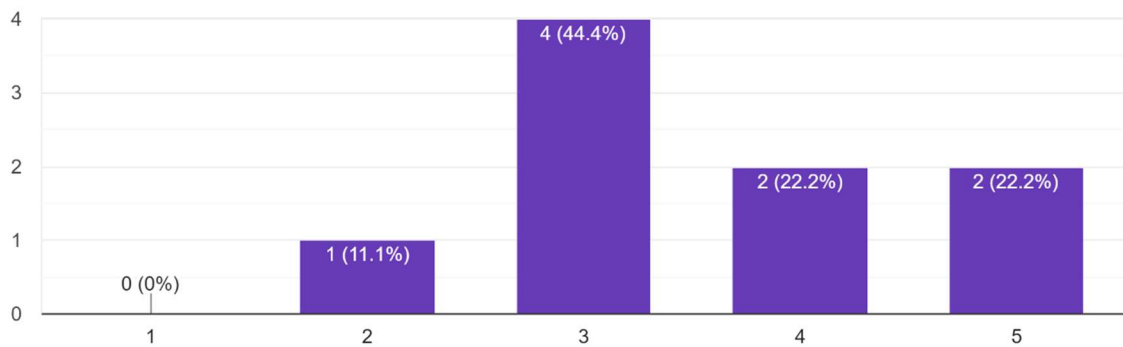
Have you made use of TA for characterisation in other EU or other platforms?

9 responses

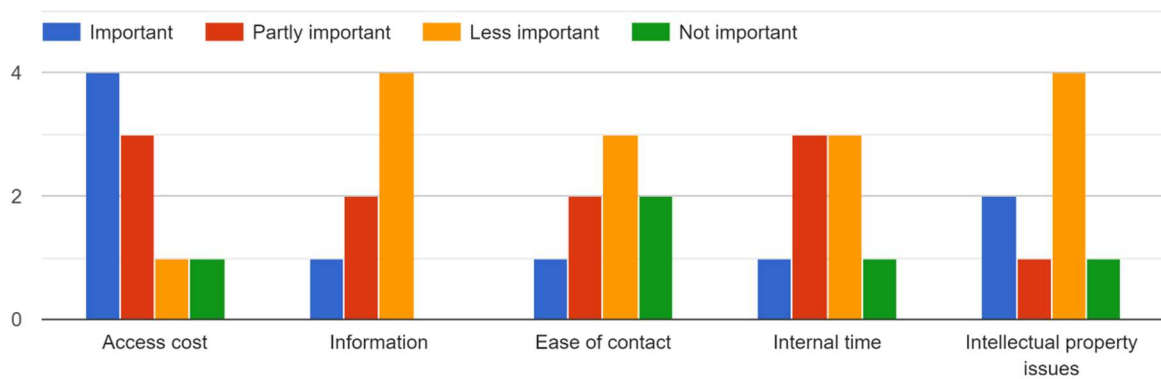


How valuable is access to TEM infrastructure for your company?

9 responses

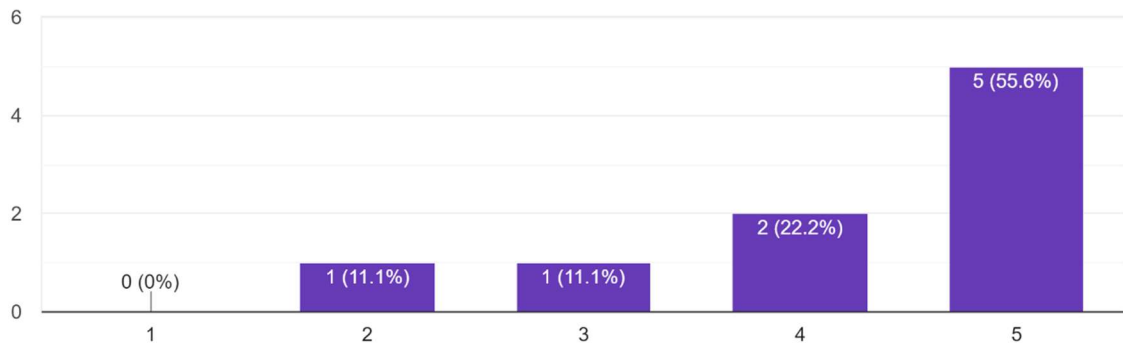


What are the main barriers for you to increase your use of advanced TEM?



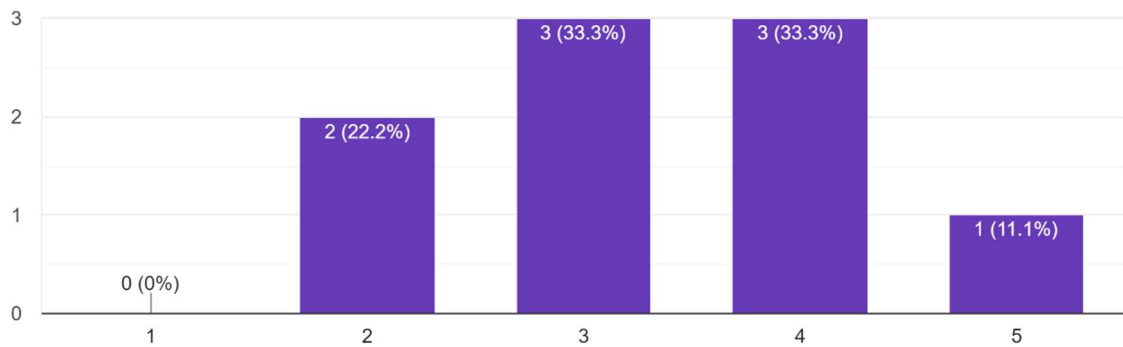
How important is confidential research for your company?

9 responses

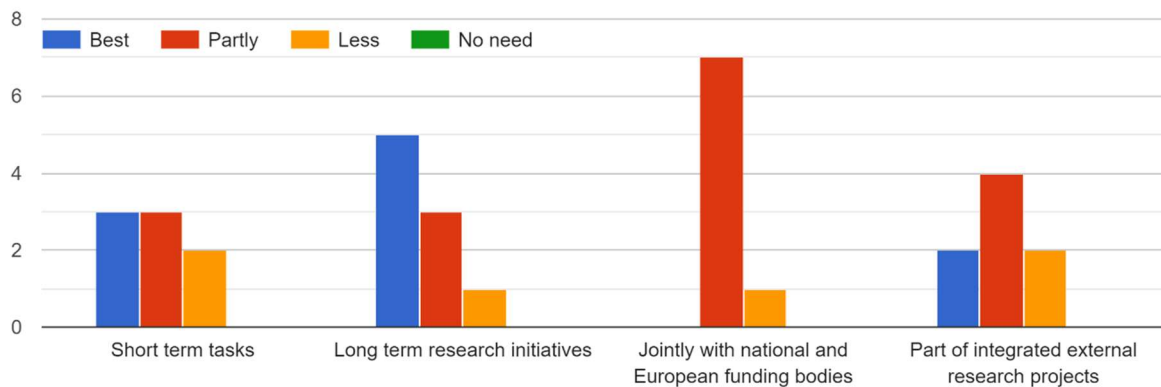


How does your company value participation in open research (results are published) ?

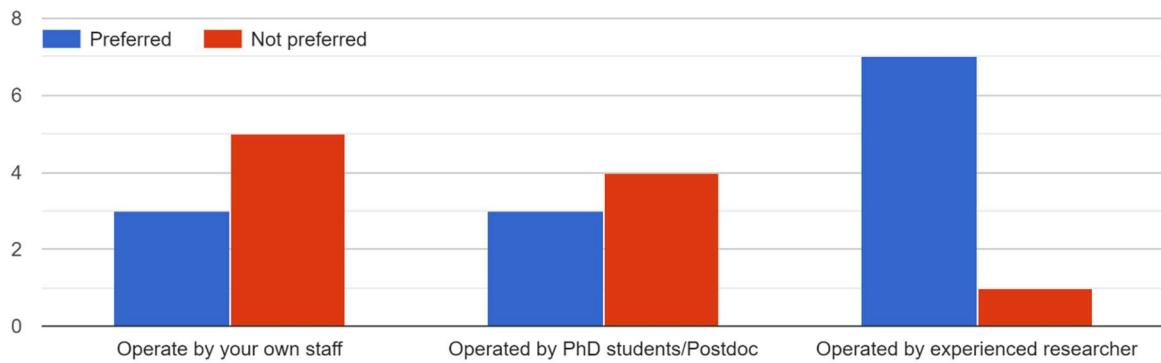
9 responses



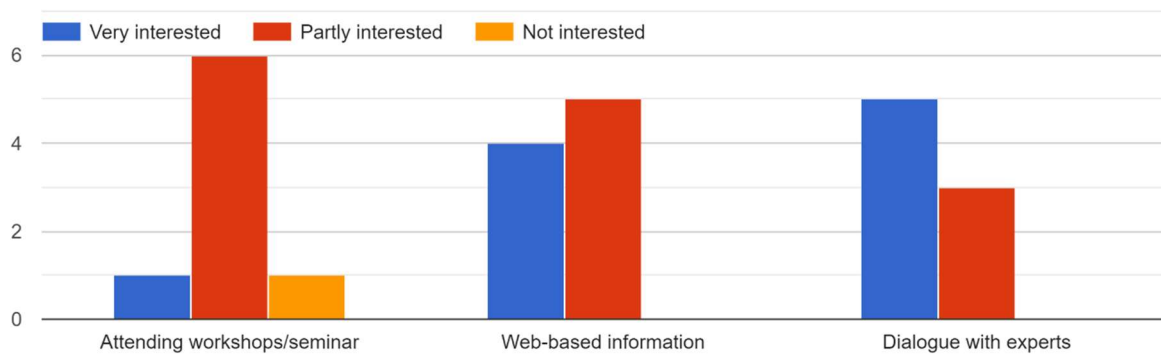
What kind of TEM access suits you and your company?



What is your preferred method of access to TEM research infrastructure?

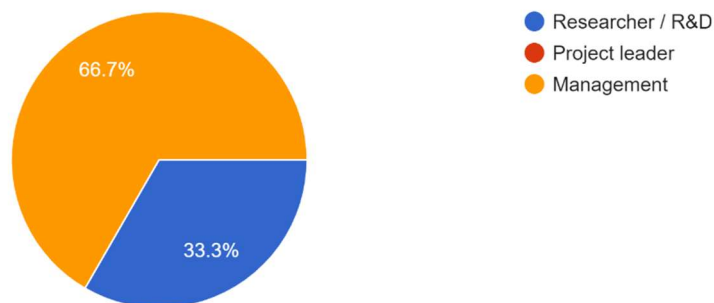


Would you be interested in learning more about advanced TEM?



What is your position in your company?

9 responses



Appendix 2, picture from ESTEEM3 booth at EUROMAT, Stockholm, September 2019.



Randi Holmestad and Eva Olsson in front of the ESTEEM3 roll-ups made for conferences.