

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

Panel Members

César Dopazo (Chair)	Universidad de Zaragoza, Spain
Alain Bernard	Ecole Centrale de Nantes, France
Carlos Cesnik	University of Michigan, United States of America
Cristina H. Amon	University of Toronto, Canada
Michael Henshaw	Loughborough University, United Kingdom
Steven Schmid	University of Notre Dame, United States of America
Wayne Neu	Virginia Tech's, United States of America

R&D Units

Centro de Ciências e Tecnologias Mecânicas e Aeroespaciais (C-MAST)	Universidade da Beira Interior (UBI)
Centro de Engenharia e Tecnologia Naval e Oceânica (CENTEC)	Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (IST-ID)
Centro de Engenharia Mecânica e Sustentabilidade de Recursos (MEtRICs)	Universidade do Minho (UM)
Centro de Engenharia Mecânica, Materiais e Processos (CEMPRE)	Universidade de Coimbra (UC)
Centro de Estudos de Fenómenos de Transporte (CEFT)	Faculdade de Engenharia da Universidade do Porto (FE/UP)
Centro de Investigação e Desenvolvimento em Engenharia Mecânica (CIDEM)	Instituto Superior de Engenharia do Porto (ISEP/IPP)
Centro de Tecnologia Mecânica e Automação (TEMA)	Universidade de Aveiro (UA)
Centro para o Desenvolvimento Rápido e Sustentado de Produto (CDRSP)	Instituto Politécnico de Leiria (IPLEiria)
Laboratório Associado de Energia, Transportes e Aeronáutica (LAETA)	INEGI - Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial (INEGI/UP)
Unidade de I&D em Análise de Ciclo de Vida de Produtos e Componentes Industriais Soldados (ACVCIS)	Instituto de Soldadura e Qualidade (ISQ)
Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial (UNIDEMI)	NOVA.ID.FCT - Associação para a Inovação e Desenvolvimento da FCT

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Ciências e Tecnologias Mecânicas e Aeroespaciais (C-MAST)

Coordinator: Paulo Jorge dos Santos Pimentel de Oliveira

Integrated PhD Researchers: 25

Overall Quality Grade: VERY GOOD

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
- (B) Merit of the team of Integrated Researchers: 4
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 3

Base Funding for (2020-2023): 285 K€

Recommended Programmatic Support

PhD Fellowships: 3

Programmatic Funding: 218 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations

The "Centre for Mechanical and Aerospace Science and Technologies" (C-MAST) has the Universidade da Beira Interior (UBI) as its main host institution and two partners: Instituto Politécnico da Guarda (IPG) and Universidade Atlântica (UATla/EIA). It is unclear how the partner members will support the managing institution, and there were no identified representatives of IPG or UATla/EIA during the site visit. C-MAST is organized in two research groups: AeroMaS - Aerospace Materials and Structures; and EnerMeF - Energy and Mechanics of Fluids. There are also two cross-cutting thematic lines to provide cross-fertilization between the two groups: Space Systems; and Optimization of Production and Technological Innovation.

AeroMaS performs research on space structures and systems; composites, structures and nanotechnologies; multifunctional materials; sustainability and innovation. EnerMEF is pursuing research on optimization of energy systems; heat transfer and thermal systems; aerodynamics and aerospace propulsion systems; and computational models for rheology and magnetohydrodynamics/electrohydrodynamics.

This is a small R&D Unit with 25 Integrated Researchers (IRs). It is worth pointing out that C-MAST only had 14 IRs as recently as one year ago. The growth of 40% in one year was due to the advancement of postdoc collaborators to the status of IRs, possible due to a large funded project that the Unit received from the regional government. They feel that the addition of young faculty leads to a dynamic and sustainable approach that will foster continued excellence, but it was noted that quite a few of these IRs are invited Assistant Professors and their contracts will terminate within the next few months with no plan for continuation. Besides the 25 IRs, there are also 50 collaborators mentioned, yet no details concerning their profiles and roles have been provided.

Some of the IRs are internationally recognized with participation in international conferences, service on editorial boards, and service to international professional societies. There is also very strong international engagement and very successful outcomes of collaborative projects that support the high quality of work being produced by this Unit. The level of external funds from European projects and other national projects is very healthy, leading to a ratio of external funds to FCT base funding of 8.7:1.

C-MAST researchers have co-authored 175 papers with international scientists from 26 countries (U.K., Italy, Spain, Russia, Brazil, Cape Verde, Canada, USA, etc.). However 24 of those papers are with Iranian PostDocs working in their facilities (as presented in their slides during the site visit). Reporting these papers as international collaborations is thus misleading. Some of these cooperation activities have been financially supported by international research project grants from the European Commission and International Agencies.

Out of the five contributions reported for 2013-2017 two involved significant international participation. While this is a strong indication of their internationalization, their particular contribution to those activities is unclear.

One interesting additional contribution relates to human factors and ergonomics. Several PhDs dissertations were concluded in this area and two national patents have been awarded. One of the publications (on cultural determinants on industrial engineering-related human dimensions (accidents, manufacturing strategies)) was awarded best paper during one of the AHFE conference series. The team also leads the International Journal of Human Factors and Ergonomics. This is an area of strength that does not fit into the Unit main research activities.

For the next funding period, it is proposed to house this research under the AeroMaS/Sustainability and Innovation topic. The Unit has hired an invited Assistant Professor and has a group of three IRs in this area.

The five selected papers provided in the proposal have been published in prestigious international journals very appropriate for the kind of research being reported. The IRs have been publishing at an average rate of 4 journal articles per IR during the 2013-2017 period, besides strong participation on conferences and books/book chapters. There have also been two international patents filed in the same period. The number of PhD students graduated during the same period is low, averaging 0.3/year/IR. There was also a significant drop in the number of PhD students advised by C-MAST IRs from 2013 (20) to 2014 (4) which was attributed to funding discontinuities associated with the transition from FP7 to H2020.

The PhD students are excellent and seemed to be well integrated within C-MAST. They hold workshops twice each year, promoting interaction and research visibility within the Unit. The appointment of post-docs seems unusual, with several soon to finish their contracts with little anticipation of renewal. Also, it appeared they have limited access to funding for travel.

Regarding C-MAST plans for the next funding period, the two research groups, the heading topics within them, and the two thematic lines remain virtually the same. There are some new projects planned under the C-MAST basic structure but most are continuations of the existing ones. The Unit used the H2020 Strategic Vision reported societal challenges (food, water, secure, clean and efficient energy; smart transport; and climate) to associate the future impact of its research.

Moreover, there is strong awareness on team for the national and regional priorities that are impacting research topics that lead to interesting applied research and additional national/regional funding opportunities (e.g., precision agriculture and application to agriculture-food industry supported by Aeronautical and Mechanical Engineering science and technology push).

In the Unit overall budget planning, the level of funding being requested from FCT comprises 11% of the total. The funding request seems to be easily justifiable from past performance.

The Panel proposes awarding C-MAST 3 PhD Fellowships. The awarded Programmatic Funding is for hiring 1 Junior Researcher with PhD and for other needs.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Engenharia e Tecnologia Naval e Oceânica (CENTEC)

Coordinator: Carlos António Pancada Guedes Soares

Integrated PhD Researchers: 43

Overall Quality Grade: EXCELLENT

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
- (B) Merit of the team of Integrated Researchers: 4
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 737 K€

Recommended Programmatic Support

PhD Fellowships: 4

Programmatic Funding: 360 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations

Marine Technology and Ocean Engineering are historically consubstantial with Portugal.

The Unit investigates problems of specific national interest, including wave energy conversion and absorption off the Portuguese coastline (with one wave energy converter being patented), short-sea shipping and port operations, marine wave environment modelling, and all aspects of marine vehicle design - hydrodynamic, structural and vehicle motions. The Safety and Logistics group is also an important contributor to the Unit output.

The first 4 (of 5) contributions reported over the period 2013-2017 relate to the international recognition of Prof. Guedes Soares and not to the scientific and technical achievements of the Unit as a whole. Contribution 5 is a world recognition to the group status, but not a technical contribution. These should be reported under "Other relevant contributions in 2013-2017".

A National Patent was submitted and is now being transformed into an International Patent: "Combined Floating Oscillating Water Column and Backward Bent Duct Buoy Wave Energy Converter Device with the Application of Floating Breakwater".

The Coordinator has an excellent CV, with a high publication rate. The output of this Unit, with the ubiquitous presence of Prof. Guedes Soares, in terms of numbers of papers in international journals and presented at international conferences is very high. Many of these papers are highly cited and appear in top international journals. However, the scholarly record and activities of the coordinator far exceeds those of the rest of investigators.

What was not evident from the application is that the core group of researchers, the permanent faculty of Naval Architecture and Ocean Engineering at IST-ID, consists of only 7 people: 1 Professor, 2 Associate Professors and 4 Assistant Professors. Professor Guedes Soares is a co-author on nearly every publication of the Center and is a co-author of every publication highlighted in the application. Discussion with the students indicated that he is truly and actively involved in the work of each of them. Clearly, he is critically important to the success of this Unit. Furthermore, it is difficult to judge the quality of the contributions of the other members of the Unit independently of him. The Panel rating of this Unit reflects this difficulty.

An average of 4 PhDs are awarded every year. Both paper production and funding have reduced somewhat in 2017. The Unit is well balanced among the four listed research groups. Overall, the funding level seems extremely modest to support a group of its size. The pool of PhD students, most of them from overseas, is unlikely to remain with the Unit after graduation to contribute to it in the future.

The Unit displays a high level of internationalization. CENTEC has a significant degree of multi-disciplinarity, although most of the PhD researchers have backgrounds in Naval Architecture with structural aspects being predominant. The distribution of funding seems well balanced between sources, with a slightly high dependence on FCT.

Post-Docs are encouraged to apply for their own projects. Most of them write their own proposals and supervise PhD students.

Some members of the Unit are active in journal editorship and international professional organizations. They have organized many international conferences. They have strong collaborations with a number of foreign universities and research groups, particularly Chinese universities. China currently has a very active commercial shipbuilding industry.

The plan of activities includes maintenance of the current degree of relevance in their four main research areas. The ongoing activities of these groups are an appropriate use of the available talent. An intention to refocus some of their work into four new areas of current interest in the engineering community is listed. The "Subsea Production of Oil and Gas" topic is of interest to Portuguese companies working in Brazil and Africa, but the technical description of activities is superficial and somewhat vague. Through the Safety and Logistics Group, the Unit plans to maintain an emphasis on the areas of risk analysis, safety and reliability, and occupational safety. Many of these research lines will involve cross-disciplinary work between the groups. The organization of the R&D Unit is such that this type of cooperation could likely be achieved; however, no detailed plans to develop activity in the new areas were given. The "Blue Economy" research topic is just mentioned but no details are provided; it is apparent that a clear collaboration between industry and government would speed up the impact of this work. Moreover, this pivotal cooperation and the metrics of success are absent in the report. It would be important to define core competences and the strategic vision in those topics in terms of projects and international collaborations and publications.

Another challenge faced by this Unit is the lack of their own experimental facilities. Some testing is currently done in facilities either of the Civil Engineering Department of the IST or abroad. The application requests funding for the construction of a hydrodynamic test basin with wavemaking and carriage capabilities. This Unit could make an excellent use of a state-of-the-art hydrodynamic test facility. This facility would help in validating their numerical results. There is a concern that the funds requested will be too small to fund the size and quality of basin which would allow this group to garner the international attention they would be capable of if a more significant facility were available. Unfortunately, there are no detailed plans for this capability and even the size and location are undefined.

The Panel was concerned that more junior members of the Unit are probably not being prepared for leadership and no plan was presented to ensure the sustainability of the Unit in the future. While the Coordinator is convinced that the Unit would continue without him, no clear path to replace his important leadership was evident. IST is the only school in Portugal to have degree programs in Naval Architecture and Ocean Engineering. It is important to maintain a healthy program in this area and boosting the capabilities of this Unit in the future.

The Panel proposes to award CENTEC 4 PhD Fellowships and Programmatic Funding for hiring 1 Junior Researcher with PhD and other needs.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Engenharia Mecânica e Sustentabilidade de Recursos (MEtRICs)

Coordinator: José Carlos Fernandes Teixeira

Integrated PhD Researchers: 24

Overall Quality Grade: VERY GOOD

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
- (B) Merit of the team of Integrated Researchers: 3
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 3

Base Funding for (2020-2023): 353 K€

Recommended Programmatic Support

PhD Fellowships: 2

Programmatic Funding: 224 K€.

Justification, Comments and Recommendations

The Mechanical Engineering and Resource Sustainability Center (MEtRICs) is a relatively small Unit with 24 integrated researchers. Of these, 5 from New University of Lisbon (UNL) (managing institution), 2 from Center for Residue Valorization (CVR) (participant institution) and 17 from the University of Minho (UM). This strategic combination brings together engineers and biologists, and the connection with CVR put them in good stand to fulfil their mission. Another 37 members are integrated members (no PhD), most of which are PhD students. In addition a substantial number of students (45 PhD students) develop their projects and dissertations within the Center, as documented by the number of MSc theses completed every year under supervision from integrated members (average of 70/year).

The five contributions the Unit considers most important of those provided in period 2013-2017 by Integrated Researchers are a combination of engineering development and outreach. The Unit struggles to identify truly high impact research. While the leadership in the organization of the International Conference WASTES is impressive, it is not production of scientific new knowledge. The other contributions are relatively modest.

The main publications in 2013-2017 authored by Integrated Researchers have been published in journals fitting with the core scientific topics of the Unit. The five selected papers are in good journals, but overall the contributions appear to be modest. With a broader view, the Unit members have published international communications (50) and scientific papers (50) in recognized international journals. The numbers of citations and publications have been improving throughout the period, which is commendable. One additional important point is the construction of prototypes (3) to validate some of their concepts.

There are currently four research areas that will continue into the proposed period:

- **Energy Conversion:** this is a strong area for the team, addressing valorization of biomass and wastes. The biomass recovery is a significant challenge identified in new European directives, as well as carbonization processes and boiler optimization. Moreover, they are targeting some of the studies to conform to national-specific needs. One example of this is the gasifiers adapted to the Portuguese sizing needs, a topic they started a few years ago and now have identified an industry partner to pursue it. Finally, the Unit is anticipating new legislation that will address polymeric wastes, not covered by current legislation—an indication of leadership initiative in the field.
- **Food Technology and Wellbeing:** this area is significantly evolving and starting to be focused on food bio-nano packaging (using wastes) in cold temperature processing. This activity shows strong integration with the mechanical engineers from UM on 3D printing technology. Along those lines, they are taking advantage of the MIT-Portugal program to integrate 3D cellular printing (MIT) with MeTRICs nano particles (funded by FCT). The integration with CVR provides coverage on life cycle assessment for sustainability. In the wellbeing area, the activities are more modest and focused, among other things, on a food manipulator for people with deficiencies.
- **Advanced Engineering Systems:** Previously they had a group in advanced engineering design. These are being re-organized into micro- and nano-fluids and added value design. Multiple projects estimated in 5 MEuros focused on cyber-physical systems, the context of Industry 4.0, and networked systems. The Computer Graphics Center at UM is an added value.

- Structures and Vehicle Engineering: This seems to be the most applied activity they have. Under this topic they are focusing on supporting thermo-electrical generators (with Energy Conversion) by addressing the thermal controllers and generative cooling of engines (which takes advantage of Bosch being local). The activity in biofuels, with development at the UNL and testing at UM/CVR shows another good example of integrated research exploiting existing capabilities. Other studies involve an in-wheel motor to retrofit existing cars and lightweight structures with cellular materials. The vehicle engineering per se is under-represented in their effort, but seems adequate based on current funding levels.

Of note is that the Unit has started working in micro-fluids and nanofluids with the addition of a new Integrated Researcher (PhD from Japan, now at UNL). The activities focus on processing and analysis of micro-fluidic systems and shows promise for future impact. This new area of research on micro-/nano-fluids deserves very careful elaboration of its viability.

Regarding the proposed efforts for the next funding period, the Unit has presented an adequate governing body and management plan for its needs. Their targets for the next period are so ambitious that they seem unrealistic. They will certainly be hard to achieve without developing much strong external funding, yet they have no clear plan to develop it. For example, during the last funding period they have graduated an average of ~4 PhD/year, but they target 12 PhD/year with the same number of Integrated Researchers. They also desire to increase their scientific production by 50%, but there was no clear plan as to how that will be achieved (other than increasing the number of postdocs).

Among their major concerns is “ageing members” yet they seem to not have the means to address it. For the next period, one of their strategic goals relates to the development of a network of collaborations with international partners in key areas such as North America (USA), South America (Brazil), Europe (Germany, France, Italy, Spain, Greece, Poland, Czech Republic and Romania), Asia (Japan) and North Africa (Tunisia and Morocco), through scientific projects and training. They have the background to achieve it.

According to their own mission statement: “Mechanical Engineering and Resource Sustainability Center (MEtRICS) mission is to provide technical solutions for a cleaner, safer and sustainable world and we aim to be a leading institution in this field.” However, they seem to be pursuing too many individual topics for a group of this size. They may be spreading themselves too thin to be able to make a significant impact in all those fields or become a leading institution in some subset of them. The Unit should consider focusing their effort further, or at least clearly prioritize them in order to achieve their goals. It is the opinion of this Evaluation Panel that the Structures and Vehicle Engineering area is the best candidate to analyze its continuity. This area is under-represented in the overall production of the Unit and is an area covered in other Units (it is not unique to MEtRICS).

An increment of international funding in particular from European Commission projects is strongly recommended. The Unit needs infrastructure upgrade and new equipment.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Engenharia Mecânica, Materiais e Processos (CEMMPRE)

Coordinator: Bruno Miguel Quelhas de Sacadura Cabral Trindade

Integrated PhD Researchers: 74

Overall Quality Grade: EXCELLENT

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
- (B) Merit of the team of Integrated Researchers: 5
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 1110 K€

Recommended Programmatic Support

PhD Fellowships: 6

Programmatic Funding: 475 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations

The Panel visited the University of Coimbra - Center for Mechanical Engineering, Materials and Processes (CEMMPRE) on November 6, 2018. A presentation was performed by Prof. Bruno Trindade to outline the Unit and their activities. This is a relatively large Unit, with 74 integrated members with PhD, 63 members without PhD, and 25 collaborators. The Center used to involve three universities – Coimbra, Porto and Trás-os-Montes –, but in 2018 and on it will only be Coimbra. It will be referred to as "The Unit" in this report.

The Unit comprises six specialization areas: Intelligent manufacturing; Design and Testing; Surface and Interface Engineering; Bioengineering; Nanomaterials and Nanotechnology; and Advanced Sensor Systems. These are organized within two main groups: Mechanical and Intelligent Manufacturing; and Materials and Processes.

The Unit is well-led, with recognized senior faculty and a distribution of faculty at all levels. If anything, there is a shortage of junior faculty, as will be discussed below.

The Unit is establishing a new PhD program in Tribology, and partnering with the University of Leeds (UK), Luleo (Sweden) and Lubjiana (Croatia) in this effort. This places Coimbra among the world leaders in tribology, as all of these universities are well-known for their longstanding tribology research programs.

Strengths of CEMMPRE:

1. They had a budget of almost 3 million euros in 2017, which was broken down by 56% national funding, 27% FCT, and 17% international.
2. The metrics are very impressive. They produced 51 books and 818 scientific papers in 2013-2017, which is a very respectable outcome for a group this size. There are some very well-known and active researchers in the group.
3. There are 78 projects ongoing. Dr. Trindade showed a list, with titles and funding sources.
4. The Panel expressed a concern over the lack of industry interest in the Tribology Program and manufacturing research. This was a point of confusion at first; CIMMPRE explained that the budget for 2018 concerned just the approved projects, no projections. They already received four projects this year, with a budget of over 1 million euros. It later became clear to the Panel that CIMMPRE is only allowed to have a projected budget based on industry funding that is already received. Pending research funds cannot be reported. There are consistent and good levels of industry funding for the group, although sometimes the applied research and consulting-type activities are performed/processed by a different group.
5. A panelist asked whether or not Advanced Sensor Engineering and Bioengineering have overlap, since the Advanced Sensor Engineering program mostly described biosensors. The staff considered the question and explained that there are biosensors, but there are also other sensors that can be used in many fields.
6. The new Tribology PhD program was discussed. They were asked if they foresaw any issues finding a sufficient number of PhDs for this program. For comparison purposes, their masters program has 120 candidates for 50 positions. They do have problems getting students from Europe. The system in Europe means that everybody has 5 years of a

subject and don't want to more than a masters in tribology. People from other areas apply. They don't know if they will have sufficient candidates, but their suspicion is that they will have enough and the program will be successful.

7. The Unit has considerable experience in the development of coatings for tribological purposes. They were asked if any of their coatings have been applied in real circumstances in industry. They considered this question, and then answered that there is one in the aeronautical industry, two registered marks in coatings applications. In addition, they have launched spinoff companies in this area. Many companies have interest interest in their coatings. This seems modest, but with some potential.

8. It was noted that they enjoy 40% women in their department, and mechanical engineering is usually much lower. It is a recognized trend, they have areas that attract more women like bioengineering and tribology. They are happy with their efforts to date, and the Panel encouraged them to continue in this fashion.

9. They have a number of faculty that are approaching a reasonable retirement age. They were asked if they had a human resources policy, with respect to planning for the future and empowering young researchers. They answered that their senior faculty will still be active for ten years, so it's something they know they need to consider but it is not urgent yet. They wish to empower and promote their junior faculty. They noted that part of the issue has been the Portuguese system, since there have not been senior slots that can be filled by junior faculty. They recognize the importance of the issue.

10. Their proposal gives no details about organization of conferences, colloquia and/or seminars. Dr. Tridade says that they do organize them, their last one was two weeks ago, when they hosted a conference on microscopy and microanalysis, with 80 researchers. Their web page is supposed to advertise this information, but was changed this year and is not complete yet.

11. The Panel asked what was their policy regarding open publications? Their response was that they allocated funds for supporting open publications, which can be quite expensive. They recognize that the community is moving towards open access. They are monitoring the situation, but costs are high.

12. Regarding the meeting with the graduate students:

a. There were 10 attending, of which only one was female. This is counter to the hiring trends of the department.

b. The graduate students were very positive on the whole. They enjoy their research and experience at CEMMPRE, and spoke highly of their advisors.

c. 4 of the students are from Brazil, they came because their advisors are famous.

d. Problems were expressed about grants. Portugal has had problems supporting PhD studies. PhDs with grants are not encouraged enough.

e. The students expressed concern that post-docs are going away, and PhDs are highly competitive.

13. Regarding the meeting with the post-doctoral researchers:

a. There were 8 present, 3 of which were women.

b. They advise masters and phd students.

c. They don't generally get together formally, other than parties at Christmas and the like.

d. One is the PI of a project - he has two from FCT and some from industry. Others have applied, but not funded yet. They are encouraged to develop their own funding.

e. They were asked if they had interests in staying in academia. They warned that professor positions are very rare in Portugal. They think that there are very few positions, even for exceptional candidates. They think they perform good research, but the prospects are bleak.

f. Asked if they want to add anything, they say they could have more positions. They know not everyone can be a faculty member. They feel the opportunities are worse in Portugal than in other countries in Europe.

14. Regarding the meeting with the senior faculty:

a. Nine faculty attended, including three women.

b. They spent some time clarifying answers given to the Panel's questions, and the corrected and expanded answers are contained above.

c. A problem they have is finding students and researchers. Gifted students take grants elsewhere in Europe because the stipends are larger. Some countries pay 2500 euros per month, here they are restricted to 1000 per month. They recommended that some select grants be developed for Portugal that are larger than normal to be used to retain the best people in Portugal.

Weaknesses/concerns of CEMMPRE:

1. As discussed above, the partner institutions are no longer part of CEMMPRE. The Panel asked the reasons for the dissolution of the partnerships. Dr. Tridade explained that the decision was made by the other universities. The reason was that the University of Porto instituted a policy that encouraged researchers to participate in only University of Porto Centers. If they collaborate with another Center, the other Center has to pay their salary. This led to the integrated researchers from the other schools withdrawing from CEMMPRE.

They were asked what is the anticipated impact of the restructuring. They responded that the management is more concentrated, and they don't believe this represents an added risk. In many ways, nothing changes, coordination is easier, there are two remaining groups that have many interactions.

2. The Panel asked the status of the External Advisory Board. Between 2013 and 2017, CEMMPRE went through a complicated period of reorganization. They had an Advisory Board, but the old Advisory Board was not consulted since it was not clear what their contribution will be. They have not decided whether or not to continue with the old board. The Panel believes that Advisory Boards can have great utility, and CEMMPRE should reinstate such a Board.

3. Although there are quite a few really excellent researchers, the CVs vary quite a lot in quality; judging the team as a whole there are a few weaknesses.

4. There seems to have been a period of substantial uncertainty resulting in a recent re-organization. The effect of this on the team is not yet clear and has not yet been properly tested.

Summary:

This is a large, active, and talented group. The senior leadership is world-class, and they have built an international collaboration network that is very strong. The Panel felt that this is an institution is exemplar in Portugal, and is worthy of support.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Estudos de Fenómenos de Transporte (CEFT)

Coordinator: Joao Bernardo Lares Moreira de Campos

Integrated PhD Researchers: 24

Overall Quality Grade: EXCELLENT

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
- (B) Merit of the team of Integrated Researchers: 5
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 437 K€

Recommended Programmatic Support

PhD Fellowships: 4

Programmatic Funding: 338 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations

CEFT focuses on Transport Phenomena (heat, mass and momentum) with Chemical Engineering and Mechanical Engineering applications and with membership from chemical and mechanical engineering from FEUP and Polytechnic Institutes in Portugal. CEFT integrates concurrently multiple approaches to research, which include modeling, numerical, experimental and theoretical work, and to involve researchers with different backgrounds (e.g., engineers, physicists and mathematicians). The main research themes address both advanced traditional topics (e.g., Hydrogen PEM fuel cell technology and systems for Hydrogen production and storage, biofluids and multiphase flows) and emerging areas (e.g., complex fluids, smart fluids, ionic liquids, biomass and elastic turbulence).

The Unit Coordinator is a PhD in Chemical Engineering from Porto, with a long list of international publications (81) on a variety of topics. Various Integrated Researchers have good CVs. The young IR, who has been awarded an ERC Starting Grant (on Elastic turbulence) has a large number of publications. The Team has high publication rate and emphasizes scientific excellence. The 5 selected papers in 2013-2017 have been published in good quality journals on fluid flows.

The External Advisory Board 2018 report, signed by Professor M. Escudier, states that rating this Unit as "Very Good" does not do justice to the "Excellent" quality of the Research Groups. A diversification of funding sources is also recommended; during 2013-2017 54% of the funds came from FCT. Currently, 50% of funds guaranteed for 2019 come from European projects. Funds from international private sources should also increase. Portuguese companies are still "not buying" the Unit's fundamental research output. There is a list of submitted and approved patents over the last years.

Significant progress has been made regarding broadening the research funding beyond FCT. Since the last review, CEFT has obtained funding from international sources including one ERC Starting Grant and 7 projects from the European Commission as well as from private sources. It is notable that 40% of CEFT members are women, particularly as the Centre involves Mechanical Engineering, the engineering discipline that traditionally has the lowest percentage of women. The rich cultural diversity of researchers coming from a number of countries (e.g., Portugal, Spain, Brazil, Egypt, Iran) is also praiseworthy as diversity of all sorts brings different perspectives, which not only enrich the environment but also enhance the research outcomes.

CEFT has been effective at nurturing and promoting the careers of young researchers, who display highly enthusiastic attitudes. The size of the group is thought to be an advantage as they have the opportunity to interact daily at the "research spaces". However, it is also recommended to have weekly or bi-weekly meetings, particularly among PhD students and PostDocs with formal agendas, which include research project presentations along with updates on the challenges and outcomes. With the successful launching of the spinoff "Reinforce Optimal Performance, Lda", based on cork composite technologies, it will be beneficial to share the best practices so to encourage and facilitate more spinoffs.

The presentations by the leadership team, the students and postdocs were excellent, and the questions from the Panel were thoroughly addressed both after the presentations and during the visits to the laboratories.

The vision is strategic and clearly articulated, and the execution plan is well thought out. The goals of renewing the scientific leadership and providing increased ownership in the decision process to CEFT junior members is commendable and most welcome; however, the actions to achieve these goals appear to require more thinking to better articulate them and successfully implement them.

The goal of increasing the number of PhD students is strongly embraced by the Panel. In addition to the recommendations provided above, the Review Panel also encourages CEFT to (i) strengthen partnerships with industry and seek more opportunities to apply the fundamental knowledge generated, (ii) augment research funding from non-traditional diversified sources, and (iii) continue increasing the international visibility of both CEFT and the innovative research of Portugal.

A long list of topics to be investigated in 2018-2022 was presented with some detailed activities to be undertaken, some with international partners. There are also ongoing conversations with two groups from DEQ-FEUP (LSRE and LEPABE) for a joint application for an FCT Associate Laboratory.

The Panel proposes to award CEFT 4 PhD Fellowships and Programmatic Funding for hiring 1 Junior Researcher with PhD and other needs.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Investigação e Desenvolvimento em Engenharia Mecânica (CIDEM)

Coordinator: Maria Teresa Ribeiro Pereira

Integrated PhD Researchers: 13

Overall Quality Grade: WEAK

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 2
- (B) Merit of the team of Integrated Researchers: 3
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 2

Justification, Comments and Recommendations

The production of this Unit is largely hampered by the fact that it is comprised of a loosely associated group of teaching faculty members at a Polytechnic Institute, Instituto Superior de Engenharia do Porto (ISEP). Eleven of thirteen integrated members with PhDs are from the Mechanical Engineering Department which has a total of 94 faculty members. (The table of numbers of personnel lists 14 integrated members with PhD in 2017). They each teach 12 hours per week. The Unit had 16 members in 2013 and has been slightly declining in membership. As a Polytechnic, no PhD degrees are awarded and the opportunity to work closely with PhD students does not exist, except with a small number (5 currently) of students that are co-supervised with other institutions. Some of the current PhD students are also teaching full time (12 hours). The constraints of working within this environment are perhaps a contributor to the limited research output to this Unit. However, other Units associated with polytechnics seem to have overcome this limitation.

The Unit consists of four areas of study which are not closely related. The two areas with the highest productivity are the Mechanical Materials area, which is concentrated on composite materials and adhesive joints, and the Industrial and Management Engineering area.

The Mechanical Materials area seems to be doing the bulk of the Unit's work. Another researcher with PhD, an adjunct faculty member at ISEP, does notable work in the area of CFD of Geophysical flows. The Industrial and Management Engineering group produces a number of, mostly conference, papers but very few of those reviewed seemed to be of high scientific impact. Little evidence of international recognition of Unit members was found. National recognition in the form of a few research projects with Portuguese companies was noted.

The critical weak points for this Unit are both the quantity and the quality of publications in important international journals and the absence of funding for significant research projects. The members of the Unit put emphasis on attending and presenting papers at conferences, rather than on publishing in international journals. Some members of the Center have written books or major book chapters. A significant number of the listed international journal publications are actually conference papers that have been bundled into proceedings issues. The work that is done and published is, with maybe 2 or 3 exceptions during the 2013-2017 time period, highly applied. This is reflective of the type of research contracts they are conducting. During the visit, the Panel was told of a large new research project they have been awarded called SMARTCUT. For this project, the work of CIDEM is limited to testing cutting tools that have been developed elsewhere. While bringing in a significant (for this Unit size) amount of money, this kind of work is not likely to enhance the research reputation of the Center. A lack of cohesion and synergy of the work of the members of the Unit was perceived by the Panel during the visit.

The Sustainable SME project is listed as one of the five highlighted contributions of the application. CIDEM will, as a part of this project, provide guidance to help small and medium-sized companies comply with an EU directive that companies report on sustainability and circular economy aspects of their business in addition to financial aspects. CIDEM is to produce guides and a website, but no results to this point were discussed although scientific papers and a book were promised in the application. During the visit, the Panel was shown a copy of this book. The application lists that the total budget for this effort is 315 kEuros but the CIDEM portion, according to the resumé of the project Principal Investigator is about 66.8 kEuros over 2 years.

Another of the noted contributions is the “framework agreement” between an Integrated Researcher and the company MEGAJOULE Inovação. The work involves conducting CFD studies pertaining to wind energy farms. Turbulence model parameters are being tuned to match the output of the MEGAJOULE code WINDIE to atmospheric turbulence measurements. This research work has involved supervision of ISEP MSc theses and co-supervision of PhDs with two other universities. An attempt to run LES is being explored. Students were also hired by the company. MEGAJOULE uses the WINDIE code in its consultancy business.

One Integrated Researcher is cited as the co-chair and founder of the International Conference on Business Sustainability, which has been held annually since 2013 in Povoia de Varzim, Portugal, and is jointly sponsored with the University of Minho. He is also on the editorial boards of four journals including the International Journal for Quality Research which has published works from the Unit.

It was noted that four of the five international journal articles listed on one resumé appeared in one special edition of the journal Materials Science Forum (Advanced Materials Forum VI), which is actually the collection of the transactions of the International Materials Symposium, organized by the Portuguese Materials Society.

The Unit team, as a whole, does a modest job documenting its research work. Many of the resúmes in the application listed no work for many years with the latest entries being from 2006 and 2008 in two cases. In several cases the ORCID site listed publications not listed on the resúmes. Of perhaps greater consequence, at the time of application review, the English version of the website for this Unit listed no entries under the Projects, Publications, Training, or other sections since 2011. During the visit, the Panel was told that it had just recently been updated. It should be noted that the External Advisory Committee has continually urged the Unit to develop better visibility and timely maintenance of the website.

The plan for the future is to continue with the same four research areas but to encourage significant expansion in applications for research funding and partnerships with other universities to foster co-advising of PhD students. The former Unit Coordinator stepped down in June 2017. The current Coordinator was elected by the membership to assume the Coordinator position at that time. With the new leadership came implementation of a new “roadmap” for funds distribution. FCT funding is distributed within CIDEM according to the personal productivity of the members and the impact of the journals in which they publish. Funding decisions are to be taken by the management board consisting of four of the 13 members and including guidance from the advisory board. The application further states that the group will discuss removal of members not publishing. There is a risk, with such a small group, that implementation of this policy will be hampered by the involvement of a significant fraction of the membership making critical decisions which concern them individually. It could be argued that the new leadership has not had sufficient time to significantly change the performance of the Unit.

A new strategy calls for an increase in the impact of scientific papers and the number and importance of projects with private companies but it does not mention how this will be achieved. The creation of several new research fields in innovative areas including biomechanics, bioengineering and smart materials is mentioned but the availability of members to spearhead these new fields is not addressed. This plan seems to call for significant dilution of very limited human resources. It was mentioned that new people could be hired under new contracts to advance the new areas but there is no indication that the current membership of the Unit has the means to be successful in obtaining these contracts. During the visit, the coordinator mentioned that CIDEM researchers have submitted many project applications that were not funded. The need for strategies to achieve a greater success rate in proposals was discussed and the importance of coaching was highlighted by the coordinator. Nevertheless, the research credentials of many of the PhD members are not strong and there are no clear niches in which the Unit has the opportunity to excel. The Panel was told that when members start to be productive they leave the Unit for other units/universities. It was concluded that CIDEM lacks a compelling vision for future activities and specialization. The Panel was also concerned that CIDEM lacks ambition. There is nothing listed under item 14, Aspects of the Plan of Activities Involving Requests of Programmatic Funding.

For the 2013-2017 timeframe, total funding from FCT was about 22 kEuros per year with other funding (apparently mostly from Portuguese companies) averaging about 25 kEuros per year. The budget presented lists expenses of 93 kEuros per year for 2019-2021 and 101 kEuros for 2022. The projected budget anticipates a large increase in activities but with no concrete explanation of how this will be achieved.

The budget justification section lists 139 kEuros in equipment to support the materials testing area out of a total equipment budget of 162 kEuros – 39% of the 415 kEuro total 5 year budget. It is assumed that the materials research

area will be significantly increasing their research funding if they are to support this level of expenditure, but no explanation of how this will be achieved was offered.

Finally, the Unit should be encouraged to rethink the strategy of diversification and to focus instead on a narrower area of research endeavor in order to build critical mass and to pursue more boldly the areas in which they have the most strength. The option of incorporating the various members of this Unit into larger R&D Centers, either in Porto or elsewhere was posed to the Senior Researchers, and should not be discarded when defining a future master plan.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro de Tecnologia Mecânica e Automação (TEMA)

Coordinator: António Manuel de Bastos Pereira

Integrated PhD Researchers: 44

Overall Quality Grade: VERY GOOD

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
- (B) Merit of the team of Integrated Researchers: 4
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 606 K€

Recommended Programmatic Support

PhD Fellowships: 5

Programmatic Funding: 335 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations

The Centre for Mechanical Technology and Automation (TEMA) is the main research interface of the Department of Mechanical Engineering, aligned to University of Aveiro commitment for innovation, quality and international recognition in the areas of Engineering Education, Research and Cooperation with Society.

TEMA is focused on sustainable industry (especially SMEs) and to the wellbeing of people, translated into two main future mobilizing projects: Sustainable Manufacturing Solutions and Technologies for the Wellbeing.

Sustainable Manufacturing Solutions is focused on the development and innovation on manufacturing engineering and technologies, with subsequent industrial applications. It is intended to increase productivity, improve products quality and reduce waste in production processes. The strategy on Technologies for the Wellbeing aims to increase the quality of life of society by means of engineering systems, focusing on people and their needs.

TEMA comprises 81 integrated researchers from which 69 has a PhD. TEMA supported the training of more than 340 Master and 50 PhD students along the period. 48 PhD students are supervised. TEMA researchers form one multidisciplinary group with competences in the fields of applied mechanics, modelling and simulation, nanoengineering, biomechanics, transportation technologies, applied energy, together with transdisciplinary areas.

TEMA got many contracts (39) from public and private structures but only one at international level. TEMA researchers organized several international events. More globally, even if it is mentioned a cooperation with 45 countries, the international cooperation policy will have to be strengthened mostly concerning collaborative projects at European level.

TEMA researchers published 864 papers in international peer-reviewed journals. National and International keynote lectures were delivered in the areas of computational mechanics, biomechanics, plastic forming, nanotechnology, transportation systems and applied energy.

22 patents were submitted (national and international), being 10 already registered. Regarding models, software applications (34) were created for specific purposes, for both fundamental and applied research, as well as industrial applications. The majority of the models are intended to be used as open-source, with some being part of commercial modelling/simulation packages. TEMA has recently presented a "NanoTechnology Usability" (NTU) management-support index for the translation of nano-based research outputs to the market. TEMA headed four spin-off initiatives.

For 2018-2022, the research topics are still the same.

The first project, entitled "Sustainable Manufacturing Solutions", takes advantage of the interventional character of mechanical engineering in the industrial sector, emphasizing innovation in the manufacturing sector and promoting the sustainability of the involved resources, leading to cost-effective, high added-value, high-quality services and products.

The second mobilizing project, "Technologies for the Wellbeing", aims to contribute to the society quality of life, with engineering systems providing solutions to people and their needs, together with the corresponding societal challenges. A third goal is to really build up a Research Infrastructure. The Research Infrastructure aims at a rational and efficient management of material and human resources of TEMA (including its 12 laboratories), its vast array of scientific equipment in a large diversity of areas to be used towards the Society needs, making the Research Infrastructure an "open facility" for a number of end-users (academic, research and industry). TEMA claims that this would be the unique centralized mechanical engineering infrastructure in Portugal.

The management structure of TEMA is coherent with what is expected by FCT.

The goals in terms of KPIs are reasonable with respect to the size and the reputation of this Unit (Scientific publications: 1000; Patents (including utility models): 20; Dissemination and communication events: 80; European projects: 5; National projects: 70; Partnerships/networks: 20).

The University of Aveiro, with its integrated structure, allows the articulation and harmonization of the teaching and research environments, including the overall management of ethics in research and innovation. The Ethics and Deontology Council is the advisory and support governing body for these matters. The Council is responsible for promoting reflection and contributing to the definition of appropriate guidelines for the establishment and consolidation of a policy of safeguarding ethical and deontological principles in all fields of activity. ("Ethics Issue 3: Tissues", "Ethics Issue 7: Environment and Health and Safety", Ethics Issue 4: Protection of personal data of the Ethics Self-Assessment).

With respect to the 64 PhD researchers, the Unit asks for several PhD fellowships in different doctoral programs (Mechanical engineering: 20 (5 every year); Energy systems and climate change: 8 (2 every year); Nanoscience and nanotechnology : 8 (2 every year). In addition, the Unit asks for 3 new PhD researchers, which is justified.

Concerning budget, it is expected to use around 22% of it to increase existing equipment with a predicted value of 1.95 MEuros. 2/3 of the budget comes from FCT (3% coming from basic funding; the rest of the funding is coming from competitive calls). Only 6% come from international sources. They are trying to get more and they have obtained some.
Remarks during and after the visit

They ask for 36 fellowships, what is unrealistic. Actually, 10 PhD are achieved per year. In fact they have the money to get more integrated PhD researchers but they have a lack of opportunity for PhD grants.

Publications: 26 per IPR in five years (5/year).

Expectation: over five years, 70 projects? Realistic? Yes, 50 only for 2018.

Policy for patents and IP transfer? No direct contact with industrial companies related to technology transfer

Manufacturing: an example of a project with a real innovation: Improvement of lubrication during milling operation, to improve the quality, to decrease the use of lubricant (with biodegradable fluids).

10 technicians within the 69 Integrated Researchers (they take into account people who have contracts in 2018).

It seems there are fluctuations in the number of Integrated Researchers depending on the projects and of their duration. They try to secure people with respect to the large number of equipment and needed related competencies.

They have a group of people to favor the application to European projects.

Meeting with PhDs:

(Many PhD students are from Portugal. One lady from Bielorussia).

Background: Physics engineering with a company (Bosch).

Good feeling with the PhD supervisor. Sharing of the time between university and company.

PhD with a company. Chemical reaction on a fuel cell. Some cooperation with Brazil. Help them to fabricate their samples. Teach about electrochemical issues.

Master in Porto. Biochemistry. Opportunity for PhD in electrochemistry. Like conditions, access to a lot of equipment. Fellowship from Biellorussia (?).

TEMA organized an annual meeting (this year it happened twice) to present their work. There is an organizing committee PhD students are part of it. They share more with students working in the same building. They have some meetings where companies are invited as well as previous students. The contacts with supervisors are good and based on regular meetings, even daily meetings. They are stimulated to publish in journals.

Meeting with post-docs and young investigators/researchers:

PhD in TEMA followed by a Master in Science and Technology management (to broaden the skills). Numerical simulation. Fluid mechanics. Post-Doc position now. Part of a project.

Collaboration with Argentina. Polymer processes. Publication of a paper.

Close connection to industry. Two representatives of spinoff companies. Access to means in the lab. Innovative medical devices. 1) Application of electromagnetics (get energy from the waves). Prototype at small scale. No experience at sea. 2) Optimization software to reduce energy/water cost (-20% of pumping cost). In the past some freedom to investigate potential market and business model.

One is leading 2 projects and collaborating in 3 additional projects. Collaborating in 4 projects. 1 project and one external collaboration. One is supporting person for building up applications for projects and involved at European level for entrepreneurship.

They are supervising some master students (one to four), some of them are supervising PhD students.

Meeting with the board members

Securisation of jobs. 11 new contracts with the help of FCT + 12 more contracts from projects, mostly for lower levels. At upper level, they are not completely secured except for those who have faculty positions.

FCT has an important role in TEMA. Good evaluation means ability to sustain some high level positions. Recent evolutions occurred last year with new contracts with the university.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Centro para o Desenvolvimento Rápido e Sustentado de Produto (CDRSP)

Coordinator: Nuno Manuel Fernandes Alves

Integrated PhD Researchers: 17

Overall Quality Grade: EXCELLENT

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
- (B) Merit of the team of Integrated Researchers: 5
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 5

Base Funding for (2020-2023): 291 K€

Recommended Programmatic Support

Programmatic Funding: 270 K€, including for 2 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations

The Centre for Rapid and Sustainable Product Development (CDRSP) is a multidisciplinary research centre aiming at becoming a Centre with worldwide impact in the field of Direct Digital Manufacturing (DDM) based on Additive Manufacturing (AM)/3D printing. To fulfill its objectives, CDRSP aims at continuing balancing strengths in the Computational and Mathematical Methods, Advanced Materials (including sustainable materials and up-cycling wastes as well as natural materials) and study of Novel Manufacturing Processes, in a basis of both applied (60%) and basic research (40%).

The Centre comprises 18 Integrated Researchers (17 of them have a PhD), producing on average 2.0 papers in peer-reviewed international journals per annum over the period 2013-2017 (papers published in high quality journals (Q1 (40%) and Q2 (33%)). The 5 chosen publications are four papers in high-ranked journals and one book dedicated to multi-scale polymers co-edited by two researchers of the Unit and published by Springer. The Center also comprises 60 collaborators at the date of the application (78 members in total with over 40% women; 10% international members; 60% with international experience). CDRSP Researchers have given 216 presentations in national/international conferences (64 keynote/invited talks). CDRSP researchers received 22 national/international awards/prizes and their research activities/achievements have been reported/highlighted by different Portuguese and International media (TV-5; Radio-2; Newspapers-14). CDRSP has been very active in the organization of different events at national and international levels. Instead of reports from, 11 endorsement letters from 2 Industries (Germany, Portugal), 9 University Res. Centers (UK, Brazil, India, Korea, Italy,..) are presented, all rather positive on the Unit achievements.

The Unit is quite young (created about 20 years ago) and the founder left four years ago to Manchester. The actual Director of the Center, Dr Alves, 51 year old, defended his PhD in 2006 and he is Associate Professor. Most of the researchers are young, except Prof. Mitchell (very experienced person and highly skilled in the field of Polymers) who joined the Center in 2010 as an invited Professor and in 2014 as Vice-Director of the Center.

CDRSP lab has adopted an efficient organization. CDRSP management and organization comprise a Board of Direction, supported by a Scientific Council and a Scientific Commission of International Mentoring (International Advisory Board), as well a General Assembly. The Board of Direction is constituted by one Director and two Vice-Directors, while the Scientific Council integrates senior research members of the CDRSP holding PhD degree. The General Assembly comprises all CDRSP members and the Commission of Mentoring includes important and well reputed Portuguese and International Personalities from academia and industry. Three full-time staff members provide CDRSP administrative support.

CDRSP's Director is Member of IPLeiria Management and Academic Councils, participating in the definition of IPLeiria strategic plan. He is also the appointed person to represent all IPLeiria Research Units in its Academic Council. CDRSP is actively engaged on entrepreneurship actions through one of its PhD integrated researchers, who is a member of the Administration Council of the Business Specific Opportunities (companies' incubator - OPEN) - a non-profit private institution for the promotion of innovation and employment. This has allowed a strong collaboration between the Centre and the industry, facilitating knowledge transfer and valorization.

CDRSP researchers have supervised PhD students (5 awarded, 8 others ongoing). PhD candidates have internal meetings (every 2 months) and sometimes with external experts. They have also meetings within companies. Their general feeling is very good. Some of the post-docs deliver lectures to Bachelor students of the IPLeia. They are expecting contracts and some of them aim to create their own companies.

CDRSP and University of Coimbra are preparing a new Doctoral Programme on Direct Digital Manufacturing (it is expected to start in 2019). The number of postdoctoral fellows has been significantly increased from 1 (2008-12) to 7 (2013-17). CDRSP has welcomed last year projects of licenciatura (49 advised) and master students (52 advised, 15 other ongoing). In addition, they have created a new International Master Programme in Engineering for Direct Digital Manufacturing that has started in September 2018. A new innovative Master Degree program on Mathematics for Industry will also be proposed for accreditation. During the last period, CDRSP has promoted exchange of students/staff with other partner institutions at Brazil, Finland, Italy, Germany, UK, USA, India, Algeria, Kazakhstan, Pakistan, Poland, Ukraine, and Canada.

CDRSP has state-of-the-art research facilities, comprising 11 Laboratories mainly dedicated to DDM domains and managed by PhD researchers.

CDRSP is leading the Portuguese Additive Manufacturing Initiative (PAMI) which includes more than 150 researchers from 6 Portuguese institutional partners, to be extended in the next 5 years, to other national and international partners. CDRSP receives funding from PAMI network, to strengthen the relationships between academia, industry and municipalities. In this context, they have a plan to develop the program about digital manufacturing and digitalization more widely. They have also created training workshops for technicians, sharing experience with researchers and engineers. They have also deployed efforts in favor of entrepreneurship.

The Center is autonomous with respect to funding. They got more than 97 M€ during the last 5-year period with a lot of contracts and projects and they are part of several networks, at national and international levels.

The main contributions selected by the R&D Unit (most of them are niche but innovative realizations) relate to:

- 1) Novel computational and mathematical methods for AM/3DP (new tri-graph structures, automatic generation of conformal cooling channels).
- 2) Novel manufacturing processes (hybrid bio-manufacturing device, large-scale AM robotic system).
- 3) Controlling and characterization of multi-scale materials (construction and characterization of materials at multiple scales).
- 4) Novel bio-constructs for bone, cartilage and skin regeneration (Ti6Al4V-PEEK hybrid cellular structure, 3D printed PCL-PEGDA scaffold as promising candidate for TMJ disc regeneration, cross-linked gelatin meshes for skin regeneration).
- 5) Industrial innovation and transformation of the manufacturing industry and society (12 M_ with 3/4 from companies).

For 2018-2022, the global strategy is to work on an universal printing machine (3D and 4D), combining multi-materials in order to use some stimuli effects to transform the shapes and the behavior of the manufactured objects. This is ambitious, challenging but highly motivating. These techniques will also be applied to bio-printing with the so-called 4D-DDM approach in order to strengthen the impact of the bio-printers in the medical field. A specific issue will be addressed: the exploration of cell cultures in the manufactured scaffolds. Ethical concerns are taken into account. More exhaustively, the following topics are guiding the future research:

- 1) The development of an Universal 3D-printer.
- 2) The use in AM of different materials from the forests (Rosin, fibers, cellulose).
- 3) Tissue engineering (scaffolds for bone regeneration, biomanufacturing systems, articular cartilage (platform), hybrid electrospun).
- 4) Mathematical and computational modeling (multiscale modeling and computer simulation).

The objectives and action plan of CDRSP have been described as well as the strategy and means to achieve the work. The goals seem ambitious. The budget for the next period is partially detailed and justified. In 2018, some more projects have already allowed to secure part of the future budget. The Center has a real autonomy with respect to the investment for the equipment.

There is a legitimate demand for hiring two additional PhD researchers (post-docs or experienced persons with PhD) with core competencies in the two main fields of investigation: applied mathematics in the field of Additive Manufacturing; experimental issues for bio-manufacturing. There is no additional demand for Programmatic Funding.

It is important to support the Unit and its activity. Promising researchers are part of this Center. There is a need to increase the number of Integrated PhD researchers able to supervise PhD students.

Excellent productivity and outputs; Excellent report. Highly focused work. Clear ideas and exhaustive description of activities, social and economic impacts. Many international contacts. Industry collaboration. Highly innovative ideas. Clear pathway and targets

It is apparent that the Unit has progressed quite significantly over the last few years and is achieving good quality publications as well as practical impacts.

They are doing very important and relevant work in the area of additive manufacturing, particularly in the area of biomaterials. They have made significant contributions and seem to produce a large number of publications for a small group. They have been very successful at securing outside funding, which is further testament to the importance of their work. While their institution is a polytecnico, they do not seem to be hampered by the lack of Ph.D. students. They fill this void through partnerships with other entities.

The CVs of the researchers look good, mostly. This seems a strong faculty, with good junior faculty and senior faculty. Not many seem to be profession leaders, but also all seem active. The group has garnered many international awards for their work. They have been invited to give a large number of keynote talks at conferences. While much of their work is applied, it has a strong impact on society. Some of the many publications they produce are in less than top quality journals.

The stated plan of research activities is consistent with the capabilities of the Unit. The plan includes a commitment to free access dissemination of results, advanced training and partnerships with other entities. The administrative organization is formal and well conceived. The external advisory board reports given are 11 letters from individuals who apparently reviewed a report of the Unit's 2013-2017 activities. Only two of those mention having visited CDRSP, one as a researcher having visited 4 times for work with students and one mentions a visit in 2016. The application states that the external advisory board visits once per year. The requested FCT funding is about 10% of their total funding.

The visit confirmed the high quality of the research activities in this Unit; Excellent vision and plan to get there. The plans are technically good and well-focused; Excellent PhD programme and good students.

This is a very impressive place. They work very closely with the local plastics industry and are basically an R&D department for them. They do an extensive amount of work with extrusion based additive manufacturing at all scales. They have also done quite a bit of work on biological applications. While perhaps not world leaders, they are close in some areas. Geoffrey Mitchell is a dynamic leader who seems to instill excitement and motivation in the young people working there. The students are happy with their work and what they are learning.

The Panel proposes to award 2 PhD Fellowships and Programmatic Funding for furthering internationalization and other needs.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Laboratório Associado de Energia, Transportes e Aeronáutica (LAETA)

Coordinator: Pedro Manuel Ponces Rodrigues Castro Camanho

Integrated PhD Researchers: 281

Overall Quality Grade: EXCELLENT

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
- (B) Merit of the team of Integrated Researchers: 5
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 4930 K€

Recommended Programmatic Support

PhD Fellowships: 12

Programmatic Funding: 990 K€, including for 4 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations

LAETA is a very large organisation: the core is a dynamic, connected community of 281 Integrated Researchers with PhD (IRs), 154 collaborators and 151 PhD students. It includes 4 management institutions (INEGI/University of Porto, IDMEC/IST-University of Lisbon, ADAI/University of Coimbra, AeroG/University of Beira Interior) and 32 participating institutions. There are large qualitative and quantitative disparities between the 4 management Institutions. Also, the cohesion and collaboration of the various RGs within the Unit was unclear from the application. During the visit, several examples were given of how their recent reorganization has help encourage collaboration between the various locations. LAETA would benefit by continuing to encourage internal collaboration, especially among the graduate students. Equipment should also be shared among groups. Little mention was made of collaboration with other FCT funded R&D Units.

LAETA research has been organised into a matrix form, with cross competences and challenges between Research Groups (RGs) and Thematic Lines (TLs) of Transport Technology, Aeronautics and Space, key Enabling Technologies, and Future and Emerging Technologies. Previously research activities were grouped in well-defined scientific domains of: Characterization of materials; Manufacturing; Mechanical design; Aerospace technologies; Intelligent systems; Energy and environment; Forest fires and detonics; Biomechanics. This is quite a lot for one Unit, making it hard to define its identity and ultimate its externally recognized scientific leadership.

Apart from activities in Manufacturing and Industrial Management, Mechanical Design and Engineering Design, Automation and Energy, the Unit also list items like Biomechanics, for which the coherence with Aerospace Engineering is unclear. Furthermore, 3 out of the 5 contributions for 2013-2017 are not associated with "Energy, Transport and Aeronautics". The Panel was concerned that the addition of new research lines (e.g., Biomedicine/Health Engineering) could dilute the core competencies of the Unit in Mechanical and Aeronautical efforts which are declared targets in LAETA and areas of need for Portugal.

Some progress in integrating groups from different geographic regions is being pursued, although more is needed; a 2-day conference every 2 years is insufficient. The evaluation Panel recommends increasing the frequency of meetings, which could be organized by PhD students and will be valued by them.

PhD students indicated that some courses (e.g., Energy) are taught in one institution and taken by video-conferencing by students in other institutions. It is clear that the supervision of PhDs is good.

Although the post-doc and early career researchers believed there were good opportunities for women to be promoted, it was notable that there was only one woman in the senior team and none in the theme lead and co-ordinators team. LAETA promotes the careers of young researchers; some have gone to be faculty at good universities around the world. They have good examples of high-impact work. However, with the number of IRs it is expected that they produce high-

impact work. It was not possible, however, to assess the impact contribution among individual integrated researchers or even sub groups.

Coordination of such a large Unit is very difficult, but they have a very professional structure. Splitting LAETA into smaller Units could be considered, but is not recommended, unless it forces a stronger focus on the core competencies.

Further collaboration among groups within LAETA is recommended (e.g., IDMEC/Porto, IDMEC/IST and AEROG (UBI)) in the areas of composites, aeronautics, transports, vibration, computational and experimental techniques and manufacturing technologies.

Research collaboration among IST, UP and UBI in Aeronautics and Space and also in areas of advanced materials, engineering systems and Multidisciplinary Optimization, and Structural Health Monitoring and UAV Design should be fostered. Further collaboration in national and international research of several groups in LAETA, mainly IST and Porto, would enhance the Unit potential.

The track record of LAETA in 2013-2017 includes the publication of 2220 papers in international journals, 163 books and 231 book chapters, 2644 communications in international conferences and 743 in national ones. Of particular merit is that, while investigators perform fundamental research and publish well, they are also concerned with knowledge transfer, with 23 Spin-Offs created in 2013-2017.

The 20 selected publications have been published in high impact international journals and show the capacity of the Unit to publish its results at the highest level of excellence. Surprisingly no publications on Forest Fires appear in this list.

Regarding advanced training, the Unit had 227 PhD theses and 1452 MSc dissertations. LAETA also developed 35 pilot installations, supported 56 patents and received funding from 801 projects. The R&D Unit scientific production represents about 2.6% of the national production in all R&D fields and 14% in engineering. The number of PhD theses corresponds to 2.5% of the national annual average.

The improvements from 2013 compared to the current evaluation period are very positive:

- Papers in International Journals: +60%.
- PhD Theses: +72%.
- MSc Dissertations: +46%.
- Books and Chapters: +190%.
- International and national projects: -34%.
- Patents: +4%.

The 34% drop in projects during the period was justified due to the overall financial challenges in Portugal.

External Advisory reports indicate that it may be difficult to recruit highly qualified PhD students at INEGI. This will represent a significant challenge based on the large number of requested fellowships for the beginning of the new funding period.

Overall, the outputs of this Unit are impressive.

Although the IRs include excellent CVs, with members contributing significantly to editorship, acquisition of awards (90) and organizing international events, there is a wide spectrum of expertise within the Unit.

The CVs of the IRs responsible for the Thematic Lines and for the RGs are very good. The functional role of the Emerging Technologies TL was not clear. It appears that this is largely a horizon scanning activity, but the way in which this advises the Unit and its power to implement strategy does not appear to be formalised.

The External Advisory Board is composed of experts with excellent CVs.

Previously the gearing for FCT funding (1:6) has been very good. 23% of the requested funding will come from FCT, which is reasonably low compared to some Units. Expected funds from International public and, particularly, private sources should significantly increase.

LAETA should increase international research and innovation projects, both public and privately funded. The new organization model for LAETA should reinforce synergies among researchers (management and participating

institutions) to promote multidisciplinary research. The 2 “anchor programs” to be proposed for every TL are important and a good use of FCT funds. Collaborative preliminary research (exploratory) will launch TLs, foster internationalization and create seeds for participation in competitive projects (EU and companies). It is suggested that LAETA will encourage young researchers to submit proposals to the European Research Council Starting Grants (ERC-StG) and will provide seed money for researchers recommended for funding in the second phase of the evaluation of the ERC-StG.

Further transfer of results to new and existing companies should increase. A dynamic exchange of ideas between the academic, economic and industrial sectors, a series of thematic open days will be organized.

The “Mechanical Design” and the “Design and Experimental Validation” groups are strong, and are doing well at an international level. They have clear and coherent directions for their future development. They should be appropriately supported.

The “Combustion and Energy” team has limited diagnostics and relies on international collaborations for access to advanced diagnostics. The group would benefit from having direct access to modern diagnostics. The “Forest Fire Group” has a large challenge to understand the scaling problem; the group could benefit from investment in modern diagnostics. This research theme could initiate collaboration with groups in CFD.

The Panel proposes to award 12 PhD Fellowships and Programmatic Funding for 4 contracts of new Researchers with PhDs for furthering internationalization and other needs.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Unidade de I&D em Análise de Ciclo de Vida de Produtos e Componentes Industriais Soldados (ACVCIS)

Coordinator: Ana Maria da Gama Mateus Cabral

Integrated PhD Researchers: 12

Overall Quality Grade: WEAK

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 2
- (B) Merit of the team of Integrated Researchers: 3
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 2

Justification, Comments and Recommendations

ISQ does inspection and engineering services in many areas. They are an interface institution between academia and industry. The Unit is composed of 56 researchers with only 14 with a PhD. Within the others, only 2 of them are registered for a PhD. This R&D Unit is being established within a technological development service company, and it professes to offer industry support in applied research in any area without regard to research specialization of its staff. The Unit was created in 2004 with a mission to operate scientific lines to develop skills and help the national scientific system.

Their strengths include:

1. They discussed non-destructive testing (NDT) as an area of specialization, with a desired extension to additive manufacturing (AM). They also focus on materials characterization. (See Drawback #6, below, for a further discussion of this topic.)
2. They have a large number of research lines proposed, including environment and safety, water quality, energy, metrology, materials behavior, welding and robotics, industrial automation, maintenance and structural integrity of equipment, non-destructive testing, industrial organization and sustainability, quality and training. (See Drawback #2, below, for a further discussion of this topic.)
3. They have been criticized in the past regarding certain metrics (as mentioned in their application and at the site visit). The main activity was in the sustainability area. They did the most improvement in conferences and workshops. (See Drawback #3, below, for a further discussion of this topic.)
4. They are not driven by the projects they have. At the site visit it was explained to the Panel that they are agile. This does make evaluation of future plans difficult, but in theory, make efforts more impactful.
5. The graduate students working at ISQ are very happy and enthusiastic about the work done at ISQ, and were appreciative of the chance to work on relevant industry problems. They stated that the advantage of ISQ was that they are trained to stay close to industry needs. They are satisfied with their supervision. They have to organize their time carefully, because they spend some time at their university and some at ISQ.

Areas that are unclear:

1. The scientific merit of the team of Integrated Researchers, especially those with PhD, is very difficult to analyze and to characterize. Apart from the participation and leadership to some projects and the participation to a few platforms at the European level, it is difficult to really find solid evidence of international and national recognition of researchers and more widely of the Unit. There does not seem to be any research leadership in the Unit.
2. The construction of the expected funds is not clear. The total is a bit more than 3,2 M€ but it is difficult to understand how it has been defined. Concerning the Programmatic Funding request (including the plan of hiring new researchers with the associated co-responsibility of institutions with legal autonomy for hiring processes), the Unit applies for two PhD fellowships and 8 new researchers with PhDs in the new areas, especially additive manufacturing, corrosion inhibitors, asset management and machine learning. Their request for new researchers with PhDs is: 3 in 2019, 3 in 2020, 1 in 2021, 1 in 2022. The justification of these positions is poor.
3. 8 new positions are requested in the fields of competences of the Unit. These new positions should serve the research strategy of the Unit. This number seems to be quite large, compared to the low number of PhD students currently in the Unit.

Areas that need improvement:

1. The five recent contributions are in crowded areas, and have no strong metrics to show their value. It was also confusing that the topic of Earth Observation Data analysis was listed as a recent contribution; however, at the site visit, it was emphatically described to the Panel as an area that is not present but is an area of future growth. The Panel was confused as to how it can be a recent contribution but also be an area that is not present.
2. Researchers were asked to identify the area that defines their team, what is the area of focus. They had much discussion on this topic and could not provide a clear answer to the Panel. Some said efficiency and water. Others suggested non-destructive testing. Resource efficiency is what they eventually stated as their area of focus. Even the Earth observation focus area is supposed to affect efficiency. The large number of specialization areas suggests a lack of a strategy. Simultaneous pursuit of so many topics is far more likely to diffuse efforts, attention and resources, and make ISQ's impact lower in all of the areas. It would be far better to pick a few topics for specialization, where their knowledge is a strength, ISQ is unique from other institutions, and could be a cornerstone of an effective research organization.
3. In a 2016 report, the weaknesses identified were: a) Low performance on scientific production, and b) low engagement with post graduate students. In that report, many key metrics were being met, but the group was deficient in peer-reviewed journal articles and numbers of PhD students (number of Masters was acceptable). Of course, these are not orthogonal. A rationale was argued to the Panel that the metrics should be changed for them because they are not integrated into a university. Even so, it seems that the metrics described are still lacking. In the last period, only 18 papers have been published in peer-reviewed journals, which is clearly not enough with respect to the number of permanent researchers.
4. ISQ is dedicated to improving all of their scientific metrics. It is not clear that their plan is not to have improved metrics as a byproduct of their research efforts or if their strategy was to have metrics. That is, it looks like metrics are their goal, not a measure of whether or not they are achieving their research goals.
5. In the organization chart, the head of institution does not seem to report to anyone. This cannot possibly be the case; if it is the case, it cannot be justified. Usually the head of an institution reports to a board.
6. Some of the topics suggested for future work are far more involved than is apparently understood by ISQ. For example, they wish to develop models of additive manufacturing, incorporate sensors and work on validation. It was not clear how they could contribute with a person dedicated to the topic. For example, Los Alamos National Laboratory in the US has had a team working on process modeling for almost a decade. To contribute to the additive manufacturing knowledge base, they would like to invest in development of modeling tools. However, these are crowded and very difficult areas that require dedication and sustained efforts – it is not clear that ISQ's culture allows this. The claim is that NDT of AM is new, but it is not. Hewlet-Packard has commercialized such technology in their Jet Fusion machines, so it is not clear how their recommendation would not be an extension of established science to new machines.
7. Their rationale for research efforts is not clear. One researcher explained "Methodology applied to industry, we work with processing industry for aeronautic applications, testing new process, looking for assembling aeronautic parts. With Cambridge, we are applying for industrial symbiosis projects. We got funded in SCALAR project to assess benefits of symbiosis, what will be the economic and environmental benefits. We tried to understand at a national level how such concepts can be used in Portugal. We are working with some regions to do circular economic investments. This is research because it has not been done til now." Of course, there might be incorrect grammatical expressions, but ignoring these, the real problem is that there is much discussion with buzzwords without any clear focus or strategy. The Panel was very concerned at the lack of sophistication in their strategy. No roadmap was presented; no articulation of a compelling research strategy was given.
8. A lengthy meeting occurred with the senior faculty. There was apparently no consensus on topics for future emphasis. The team should reflect on an agreed upon strategy.
9. Part of the budget (4%) is mentioned for patents registration and maintenance, but no details are given related to those patents. No elements are given related to any creation of spinoff or startup companies. Very few comments are given related to prototypes and products that have been developed. This is very surprising because the Unit declared that technological transfer is an important issue to be achieved.

Evaluation Panel: ENGINEERING SCIENCES AND TECHNOLOGIES - Mechanical Engineering and Engineering Systems

R&D Unit: Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial (UNIDEMI)

Coordinator: Virgílio António Cruz Machado

Integrated PhD Researchers: 42

Overall Quality Grade: EXCELLENT

Evaluation Criteria Ratings

- (A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
- (B) Merit of the team of Integrated Researchers: 4
- (C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 750 K€

Recommended Programmatic Support

PhD Fellowships: 6

Programmatic Funding: 290 K€.

Justification, Comments and Recommendations

This is a highly focused and productive Unit. During the period 2013-2017, it has increased the number and quality of the publications. It has performed well in terms of grant capture and achieved 20% of its income from international funding sources.

The UNIDEMI was founded in 2003 with 15 integrated researchers; it brought in researchers from other Centres, so its size and scientific output increased dramatically in the first five years. In the last five years, the number of researchers has stabilized and its focus is on increasing quality standards on publications and research.

The metrics since 2013 are impressive. The Unit plan is to respond to modern developments, believing it is positioned to excel in Digital Advanced Manufacturing because it has both Mechanical Engineering and Industrial Engineering and Management.

The UNIDEMI mostly addresses applied research, with very little theoretical work. However, the impact of the applied research is excellent and the strong involvement of the Unit in EU projects is testimony to its success at providing exploitable outputs. The Unit is working with a number of industrial partners to realise its research in real products. Both the report of past activities and the strategy for the future is justified by evidence and clear (quantifiable) metrics.

One point to note is that whereas the Mechanical Engineering areas had a high success rate in terms of PhD completion, the Systems Engineering Management area did not perform as well, with several non-completions. This was attributed to a higher proportion of part-time students that have employment commitments. The Unit is aware of the problem and are trying to address it but this should feature as a definite plan for improvement in the next period.

Overall, there appears to be a strong emphasis on technology transfer and it was noted that as well as good industrial exploitation, the research is used well to inform the teaching.

There are three research areas, namely:

- The Systems Engineering and Management (SEM)
- Manufacturing and Technology Automation (MTA)
- The Fluid and Structure Engineering (FSE)

The first two are performing well, but FSE is under-resourced (2 integrated researchers) and has a much lower level of achievement than the other two.

The leadership of this Unit is of a high calibre, with a clear strategy for further advancement. It was particularly impressive to note that more junior researchers had a clear understanding of the strategy and a commitment to it.

UNIDEMI has been very successful at recruiting impressive graduate students. The type and quality of research was the motivation for applying to UNIDEMI for most of the students. The faculty described the students as a "pool" and this means that students may work with multiple members of faculty. The students spoke very positively about this

experience. Students interact frequently with their supervisors and receive good support. The main area for development in terms of PhD students should be the introduction of a formal seminar programme with external speakers and the opportunities to present their own work. PhD students are positively encouraged and supported in publication.

Junior staff are required to teach approximately 12 hours per week. Most seem to have established good working relationships with industry and are pursuing worthwhile research projects. The mechanical engineering laboratories are reasonably well-equipped but with some deficiencies. The researchers reported that in cases where specialist equipment is not available, arrangements are in place for them to use it at other institutions in Europe. They have built most of their own apparatus and machines for additive manufacturing. For IT topics the facilities appear to be adequate.

The Unit presented the following aims:

1. Excellence in research and development activities.
2. Develop international team.
3. Increase value from dissemination of scientific/technological results.

This is supported by the following core competencies in research:

1. Advanced manufacturing: converging areas already developed.
2. Using digital platforms and artificial intelligence in a circular economy.
3. Composite structures, some extension to aerodynamic phenomena, heat transfer, free surface flow modelling.

The main plank of the Unit strategy is convergence of the mechanical and industrial/management areas. This is well planned with a clear idea of what success will look like and how to get there. There is a desire to introduce a stronger element of human factors and societal aspects into the multi-disciplinary research, but it was noted that at least another two researchers with appropriate backgrounds (ergonomics and risk/safety) are required to adequately resource this ambition. To enhance the human factors/organisational aspects of the research, post-docs have been hired with experience of sociology and a professor in ergonomics and this has already yielded some interesting results. It was noted that such specialisms have a very different approach to research methodology and careful thought must be given to the integration of these "soft systems" aspects. The importance of increasing capacity in these disciplines in order to achieve more fruitful convergence is noted. Greater capacity in human-machine interaction will be beneficial, but it is important to be clear about the Unit focus of expertise in this well-populated research area.

The area of Fluid Dynamics has reduced capacity: there are now two members of faculty in this area, whereas it was presented that five are needed. The plan is for new appointments to move away from areas of previous specialism (fluid-structures) to areas more closely aligned to manufacturing programmes. This is to be commended and the Unit is encouraged to consider appointments that will become part of a multi-disciplinary team in manufacturing research.

Internationalisation has been strong and this should continue.

An area worthy of particular support in the future is the work of Telmo Santos on NDT; this is of particularly good quality. This entails NDT of bacteria cells to detect micro defects. It was noted that magnetic fields, radiation, vibration, and electromagnetic induction have been around for a long time, but no new physical phenomena have been investigated. This approach uses a biological phenomenon of non-pathogenic bacteria cells to detect micro defects (a few microns), similar to using penetrants. They are exploring life of bacteria, with small dimensions, making a chemical that decreases surface tension and allows them to penetrate small defects. These then respond to electrical fields. UNIDEMI has a funded project in this space. The technique is very low TRL, but feasibility has been shown and small defects have been detected. The researcher has been selected for a second stage ERC grant.

The strategy of convergence between mechanical and industrial engineering should be implemented and the recruitment to support this in the human factors / ergonomics areas is encouraged.

Any recruitment into the fluids area should be to enable more effective integration into the manufacturing areas. Investment in new, unrelated areas of fluid mechanics is discouraged.

The research area of NDT using biological phenomena and the area of welding of shape-memory alloys should receive preference with respect to investment in order to fully exploit these strengths.

The NDT area and the development of human factors as a contribution to convergence should be the priorities for the programmatic funding and PhD allocations.