# Chemistry
# Supporting UK Composites Growth

July 2015

A report for the KTN Ltd

By The Materials Chemistry Special Interest Group

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# Contents



## 1. Executive Summary

This report describes conclusions from work to explore the expansion of the UK Composites strategy to include a Materials Chemistry contribution, and presents the process undertaken and the results obtained. It identifies needs and opportunities for chemistry R&D to address the challenge of accelerated materials design and development for composites through (1) a virtual "molecular design" stream, to exploit the latest advances in computational modelling of material properties and performance' in material design from nano to product scale, and (2) a Physical stream to develop technology, provide scientific underpinning and integrate the advances in multi-scale modelling with composite materials design. We propose the development of a programme of work, comprising both cross cutting chemistry themes and industry sector aligned activities from across the two streams.

The Materials Chemistry SIG make the following recommendations to KTN on how to progress this programme:

- KTN to take responsibility for development of a proposal for the programme of work, recognising that this role requires interaction with and support from other working groups and relevant funding bodies including EPSRC, Innovate UK and the STFC. First step should be an industry "materials chemistry" roadmap for composites
- KTN to facilitate engagement between the chemistry and the scientific computing communities to explore alignment with the molecular design stream and discuss development of a virtual program to facilitate composite material development. The issues of data and IP ownership should be considered and computing funding streams explored.
- KTN and CGP to work with the Automotive Council's Manufacturing Group to ensure that the chemistry requirement within the Affordable Composite Structures and Components proposal is well defined and supported.

Additional activities and approaches for consideration:

- Carbon fibre development and manufacture is a key UK industry priority and KTN should support cross-sector collaborative work (eg with HVM Catapult, UKTI) to facilitate development of UK proposals on affordable carbon fibre production for next generation product needs

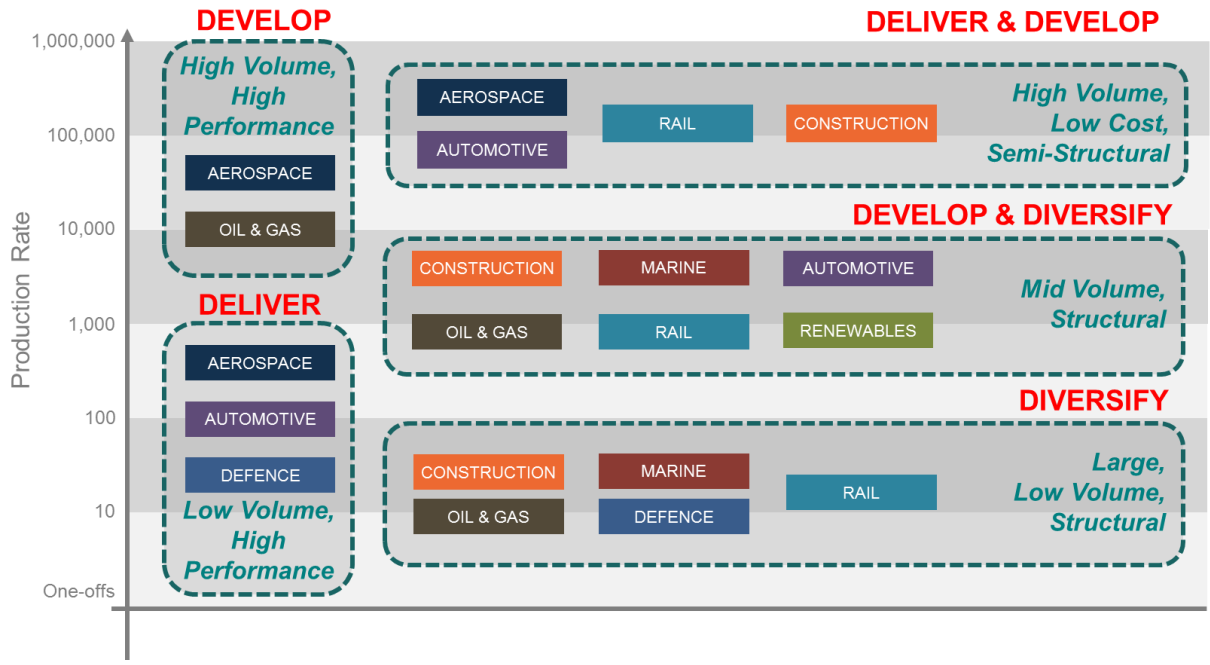
- Facilitation of technology transfer and commercialisation of chemistry-enabled cross-cutting technologies such as functional composites through cross sector communication.

- Work with High Value Manufacturing Catapult (National Composites Centre & CPI) to determine best fit with higher TRL R&D programmes
- NPL and the CLF's Regulations, Codes and Standards Working Group should be involved in the Characterisation theme.
- The CLF Technology Working Group Academic Group should be asked for support in any work to identify chemistry-enabled disruptive technologies for development.
- Supply chain development should recognise the difference in support required by companies of different sizes and at different stages of the supply chain.

## 2. Introduction and Background

The Composites Leadership Forum (CLF) has, for the past two years, been working on a refresh of the 2009 UK Composites Strategy, which will be issued in 2015. This work has included an industry roadmapping process which has shown that in order to facilitate growth in UK capability to deliver future industrial composite requirements, support should be focused on a set of composite manufacturing clusters. The distinguishing characteristics of these clusters are driven by scale factors: product performance, physical size and production rate. The similarities within the clusters are in use of production technologies, supply chain configuration, cost models and skill requirements. Figure 1 shows the manufacturing clusters, their characteristics and the industry sectors in which their market opportunities lie.

*Figure 1: Composite Manufacturing Clusters*




The manufacturing cluster strategy will:

- Enable sectors within each cluster to benefit from knowledge transfer and to develop cross-sector collaborative research and innovation.
- Identify shared investment opportunities within manufacturing clusters.
- Lead to accelerated commercialisation, a more competitive multi-sector supply chain and facilitate the greater application of composite materials.
- Deliver greater impact in shorter timescales from available public funding.

The strategy will also indicate the form of action recommended by the CLF in each of the clusters where:

- “Deliver” indicates support is required to maintain and support growth in sectors which are already using composites.
- “Develop” requires support for technology and supply chain development to capture immediate market opportunities.
- “Diversify” indicates that the UK requires information and development to understand and develop capability to take advantage of opportunities for the use of composites in new applications and sectors.

Detailed analysis has been performed of the challenges and technology requirements within each of these clusters to deliver the required products and ensure the UK wins market

share. This information has provided the overarching principles of the strategy and the delivery mechanisms are currently being determined.

Alongside this, the Chemistry Growth Partnership (CGP) has also developed its strategy, which has three priorities:

- Securing competitive energy and feedstocks.
- Accelerating innovation.
- Rebuilding the UK chemistry supply chains.

The Chemistry Growth Partnership approached the Technology Working Group of the CLF with an offer of support to ensure:

- Communication of drivers and challenges for growth, i.e. where/when new materials are required.
- Alignment of new materials insights with industry growth ambitions.
- Identification of needs where UK Materials Chemistry can enhance the value chain and provide opportunities to accelerate impact.
- Expansion of the Composites UK technology roadmap to include Materials Chemistry contribution to strategy.

Work done by the Knowledge Centre for Materials Chemistry identified areas that the Chemistry Community felt should be areas of focus to facilitate development in the Composites Industry:

- Design, synthesis, and reactivity of matrix resins.
- Surface chemistry, joining and repair.
- Fibres for future needs.
- Formulation and chemical processing.
- Multi-scale modelling and simulation.
- Prototyping for new material technologies.

The Chemistry Growth Partnership and CLF have agreed to work together to understand how areas of focus can be developed into specific programmes of research and development by the Chemistry Community considering the challenges identified, as above, and working collaboratively with the Composites Community. It is believed that through these specific programmes of research, these challenges can be turned into opportunities in terms of innovation and supply chain development for the Chemistry-using Industry.

This report describes a process that was put in place working primarily with chemistry and materials suppliers to identify programmes of chemistry research and recommendations that would support development of the UK Composites Industry.

## 3. The Process Undertaken

Although ultimately the intention was to use a workshop to gather opinions from across the chemistry community, experience indicated that time during a workshop is optimised if a ‘strawman’ is developed beforehand and presented for debate and modification.

The strawman was developed ahead of the workshop through a small number of interviews with a group of industrial representatives from different parts of the chemistry community. The sections below describe this process and the subsequent workshop.

### 3.1. Interviews and Analysis

The interviewees, who were selected to provide a wide-ranging view across the chemistry-using sectors, are identified in Appendix 2 within the ‘Interview’ column. Ahead of the

interviews, a document was prepared to help guide the discussions, which consisted of a table for each Manufacturing Cluster.

Analysis of the Manufacturing Clusters model had allowed identification of the challenges faced by each of them. Each table therefore consisted of cluster requirements along the vertical axis and chemistry areas of focus, as described above, along the top. Some suggestions of solutions to the challenges which had been suggested by the composites community were included to help discussions. The template for this structure is shown in Table 1.

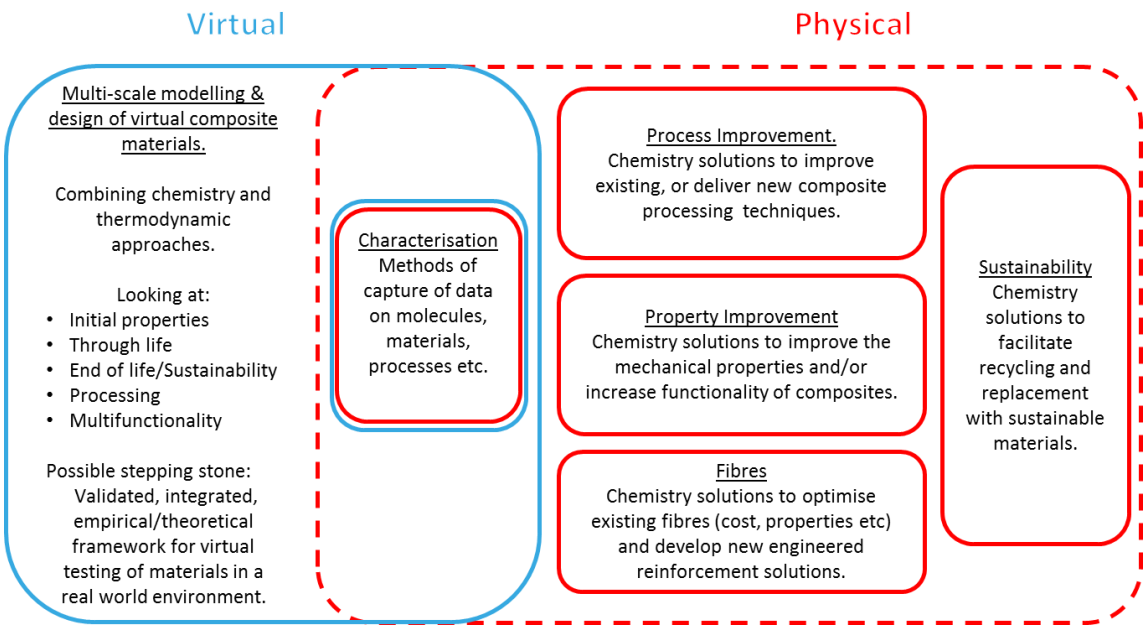
*Table 1: Template structure used for interview process.*

| Challenge | Example solution suggested by composite community | Solutions aligned with chemistry areas of focus | | | | | Other solutions |
|---|---|---|---|---|---|---|---|
| Challenge 1 | | | | | | | |
| Challenge 2 | | | | | | | |
| Challenge 3 | | | | | | | |

During the interviews, participants were asked to either consider the challenges faced and suggest solutions from within the areas of focus, or consider the areas of focus and suggest challenges they might help solve.

Analysis of the responses to the interview identified common themes and a need for a programme of work, as shown in Figure 2, with a virtual stream of work focussed on molecular design of materials and a physical stream, which should progress in parallel and interact and exchange information.

*Figure 2: Programme of work required.*




The virtual stream will ensure the UK can differentiate itself and accelerate innovation by substantially advancing our ability to model material properties and predict performance from nano scale to product level by combining chemistry and thermodynamic approaches. The physical stream will develop technology, provide scientific understanding and integrate the advances in multi-scale modelling and design of composite materials with the issues named above in Figure 2 highlighted under five main themes.

To facilitate presentation at the workshop, one slide for each of the 5 physical and 1 virtual themes was produced. These presented; a brief explanation of the topic, R&D topics to be covered and organisations with specialities or existing programmes in this area. These are shown in Appendix 3.

### 3.2. Workshop

The workshop was held in Birmingham on 28th April 2015. The table in Appendix 2 lists the people invited, with those that attended indicated in the column 'Attended workshop'.

After a presentation on the CLF, the CGP and the process being conducted, attendees were split into two groups and, in two sessions, asked to debate and feedback on:

- The overall programme of work and the streams contained within.
- The individual themes – providing more detail of the work to be included and the organisations that should be involved.

For future audit purposes, the comments made on the day were captured and recorded in an Excel spreadsheet, along with information about who made which comments. The presentations given on the day, plus the comments made (anonymised) were sent out all interested parties listed in Appendix 2 to allow for extra comments to be recorded. Those that provided input are shown in the 'Input after workshop' column in Appendix 2.

## 4. Results of Consultation.

The feedback from the first discussion session on the overall programme of work was positive, with no major alterations to the suggested streams or themes suggested.

The bullet points below list comments made during this discussion:

- The virtual side of the proposed programme is potentially large and with ambitious long term goals dependent on concerted advances in related materials technologies, But this is not necessarily a bad thing – example provided was Materials Genome Initiative (e.g. see https://www.whitehouse.gov/mgi ). The key is to split the project into short and long term goals and ensure maximum synergy with related programmes of work. The short-term goals should provide credibility and delivery to industry, starting with developments building on current state-of-the-art modelling capabilities and current challenges. The longer term goals will deliver ambitious and potentially disruptive technologies and solutions.
- Helpful if a development roadmap can be constructed – a possible future workshop theme with the right stakeholders. This could then be validated/optimised alongside the Physical stream where similar techniques could be employed.
- There were several comments specifically about the data generation aspect of the virtual stream:
    - The process should start with the publically available data for molecular level design – there are data mining facilities (e.g. at Hartree Centre) that could facilitate access to existing databases such as the EPSRC crystallography database.
    - Sharing of data on materials will be required to facilitate the development of next generation computational models and code; for publicly funded research this can be facilitated by using model systems as opposed to commercial materials and formulations
    - Business models for industry collaboration on application of advanced computational modelling are being developed in other industry sectors (e.g. pharmaceutical formulation) and may be relevant here
- There has to be a well thought out link between the physical and virtual streams. Perhaps by working with development roadmaps as described above for the virtual

stream. Also could be a great fit for industry-aligned chemistry labs to provide, such as the Materials Innovation Factory at Liverpool University?

- As well as technology development, there needs to be support for scale-up, materials manufacture and development of the supply chain alongside, otherwise this becomes a barrier to growth. This support needs to recognise that different sizes of companies have different requirements:
    - SMEs need to have the opportunities de-risked somewhat and support to help them manage their time effectively. Initiatives such as the HVM Catapult SME support may be a way to help.
    - Medium size innovator companies bringing new materials innovations to market need introductions to the right people in the OEMs, which generally tends to be people working on future products (R&D) rather than the procurement people.
- Need well defined leadership to drive this forward.
- There needs to be a clear approach with regard to IP to avoid it becoming a barrier. Look to Germany for good examples e.g. SME focus on support for commercialisation of new technology.
- New materials innovations need to consider potential barriers for technology commercialisation with standards, regulatory directives and legislation – e.g. no-one has yet produced graphene at volumes about 1 tonne per year, therefore they have not yet had to comply with REACH. Need to consider scope carefully e.g. just UK or wider EU landscape.
- One area of growing need where the UK once held a leading position is in high performance fibres – specifically in carbon fibre development and manufacture. There is now a gap in UK capability and ideas are in development to address this.
- Much of the development of these ideas has been around industrial requirements. The UK also needs to consider as part of a balanced approach if/how it will identify and support potentially disruptive materials chemistry innovations which deliver ground-breaking solutions that industry currently either cannot imagine or do not know they need and with impacts likely to occur on longer timescales e.g. 15-20 years.
- The HVM Catapult, and particularly the NCC can play a key role in helping to advise chemistry-using companies on real-life materials challenges and the provision of feedback of feedback on new materials options

## 5. Discussion

The discussions held as part of this study have led the author to believe that the virtual stream within this programme of work has the potential to deliver the most ground-breaking change in the interaction between the UK Chemistry and Composite communities. Improved modelling and simulation capability in the chemistry and physics of composites, and the materials of which they comprise, will lead to improved understanding and ability to design and produce to the required initial and through-life properties composites. With innovative integration of such capability with the design and manufacture of composite products, this has the potential to provide the UK with an improved likelihood of achieving a greater share of the potential UK and global market in composites.

Data compiled by the National Composites Centre in a report commissioned by UK Trade & Investment has used discussions with OEMs and the supply chain to predict the future UK market for composites. This has been broken down into three types of opportunities/actions required:

- ‘Deliver’ – industries that understand and use composites, where the market is well understood, but continued development is required to stay ahead of the competition.
- ‘Develop’ – industries where there is a current, and in some cases urgent - usually driven by legislation, need to develop composite know-how and application.

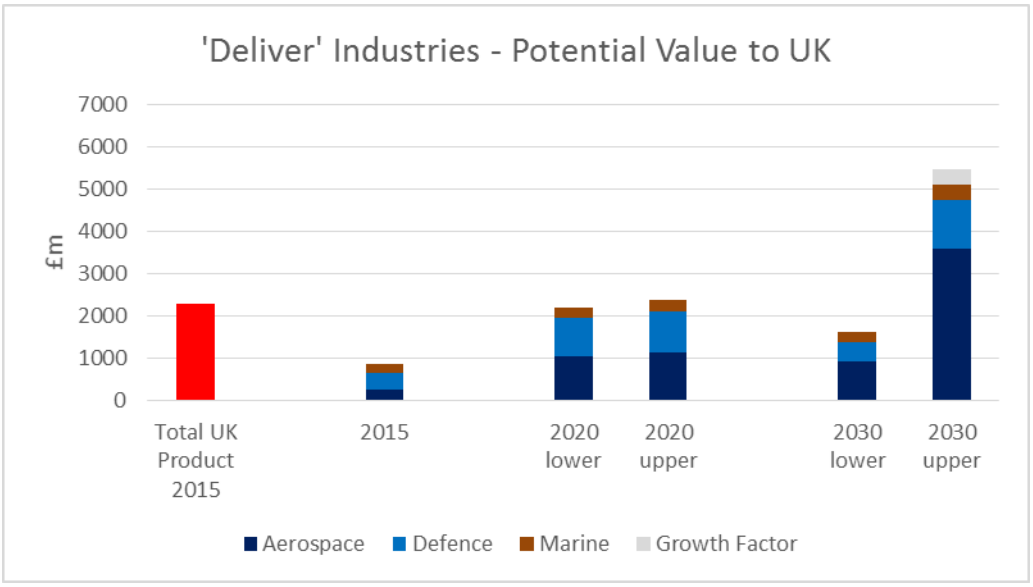
- ‘Diversify’ – industries that current use relatively modest amounts of composites and in which there are currently barriers preventing OEMs and/or the supply chain recognising or planning for potential significant future growth in applications.

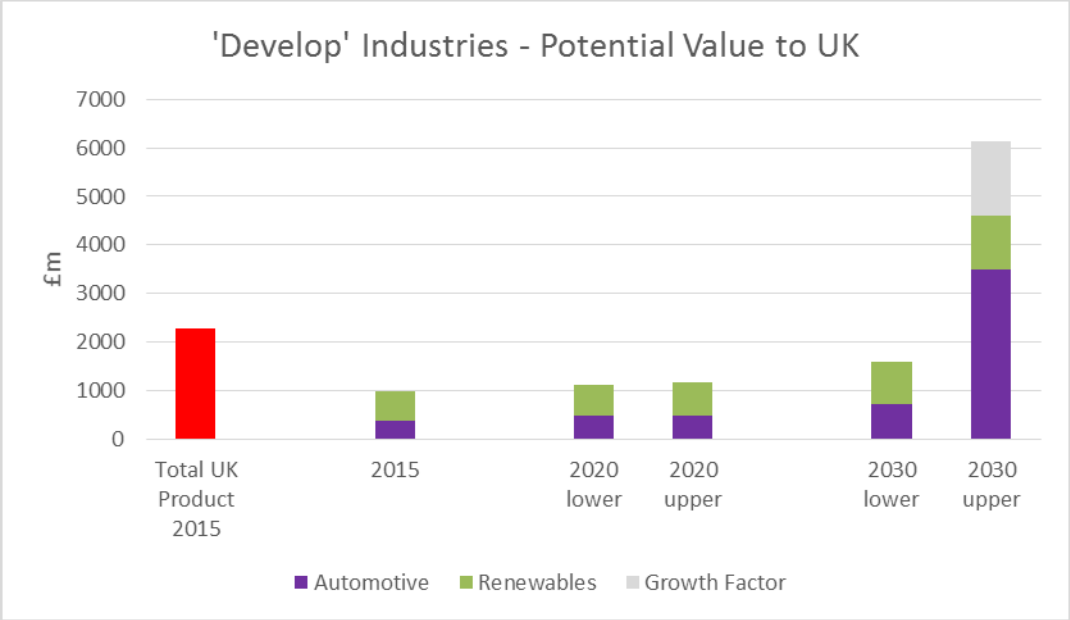
The graphs shown below provide estimates of the potential value to the UK economy of these three types of opportunities and therefore help us evaluate the sale of the potential market that development of this capability could support. In these graphs, the bold colours represent predictions from OEMs and supply chain for the future production of composite products in the UK – lower and upper values are provided. The grey colour represents extra growth factors that, for a variety of reasons, may not be accounted for in OEM and supply chain predictions.

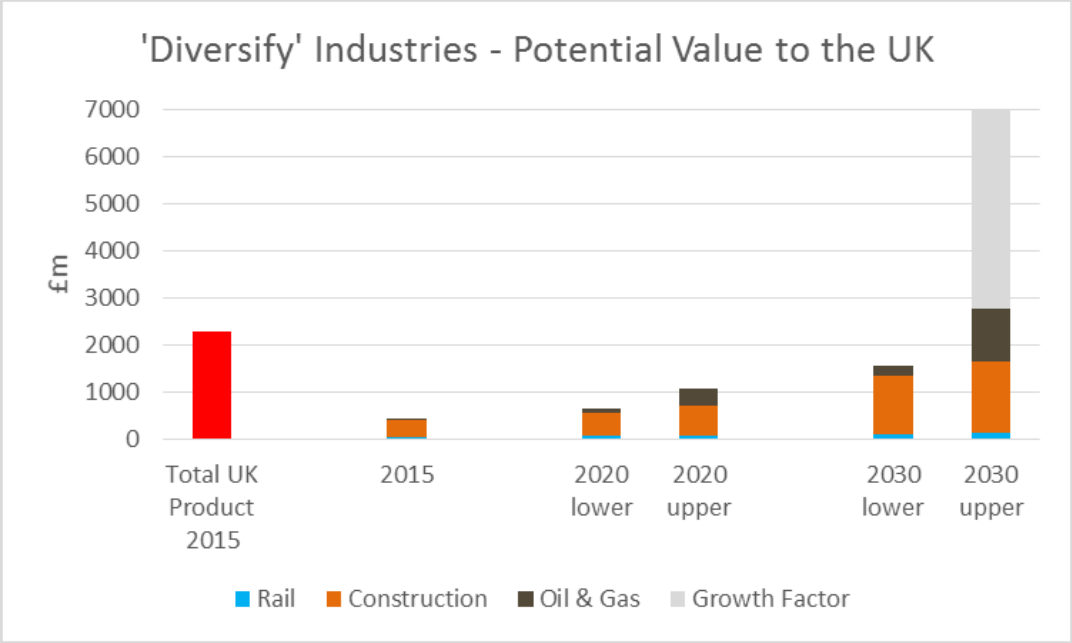
It can be seen that both the Deliver graph and the Develop graph have some uncertainty in future (2030) supply chain predictions (difference between lower and upper estimates, not including the grey ‘growth factor’) because they understand the future market but technology development will be required in order to achieve the full potential market. The proposed virtual know-how development will increase the speed and reduce the cost of technology and process development to help achieve the foreseen market (£5.5bn in the Deliver market and £6.1bn in the Develop market).

In the case of the Diversify graph, the supply chain and OEMs do not yet see the technology developments that could help them overcome existing application barriers, but the large growth factor indicates the potential market should these barriers be overcome. The proposed virtual know-how development will undoubtedly allow new composites to be designed and produced cost effectively that overcome existing barriers and open up the full market, including the growth factor, to reach a total of more than £7bn.

*Figure 3: Graphs showing future production potential for UK composites product as defined in the forthcoming UK Composites Strategy.*






It is clear that the companies that provided input to this process see the need for, and value in, development of a multi-scale quantitative chemical and processing model that facilitates innovation through combination of chemistry (monomer/polymer structure), thermodynamics (morphology and structure) and interfaces (matrix/fibre interactions). This multi-scale modelling approach will provide modelling and simulation solutions for these more complex systems which will accelerate design of composite materials and the components used in them, with the ultimate long-term potential of virtual design covering the value chain from molecules to laminates. Initial quick wins would come from accelerated understanding of materials and the solutions for industrial requirements, through linking of multiscale modelling systems to understanding and predicting mechanical performance. This would provide the UK with leading edge capability in designing for initial and through life properties as well as processing know-how and cost reduction. Longer terms goals would include development of new models that don't currently exist (e.g. high temperature performance) or for new functional systems being developed, such as self-healing structures. Therefore, the

industry has an opportunity to sharpen innovation and improve competitiveness by lowering research and development costs and shorten time to market.

Many companies have indicated either openly, or privately, that they are already working at a small scale on development of various parts of this stream. What was also clear during the discussions was that this ongoing work is not linked into the UK's scientific computing community, including capability and funding in high powered computing and accelerated materials discovery and design. This would be essential if this development is to achieve the world-leading status envisaged.

It is therefore suggested that the first step in exploring how to develop the proposed virtual stream would be for the KTN to facilitate engagement between the chemistry and the scientific computing community to explore their capability and priorities, state-of-the-art applications and how they align with the capability development required within the virtual stream. The Hartree facility was represented, and a very active participant, in the workshop held, and could therefore be a very good entry point to explore who within the computing community should be engaged in this process. If after initial engagement and discussion, it was agreed that there was sufficient alignment, a workshop to bring together the chemistry community together with the computing community, including software developers, to discuss development of a virtual programme to facilitate composite material development, taking into account the comments recorded as part of this process, could be a next step.

Potential issues that must be addressed relatively early on in any relationship and discussion between the chemistry and computing communities include data sharing and ownership of IP. A mechanism must be found that allows collaborative work to develop the UK's capability whilst allowing individual organisations to retain the know-how and IP in their products, infrastructure and software. Existing large-scale collaborations in sectors such as pharma provide examples which may be transferable. Also, there will be open data sources such as publications and other databases which will provide a rich source of information for data integration and discovery purposes.

A point worth mentioning is that engagement with a new community, such as the computing community, also opens up the opportunity of new funding streams (for example within different parts of Innovate UK, Research Council etc.) that are focused on IT applications rather than Industry Sectors or Engineering applications.

The description of the virtual stream as delivering the most 'ground-breaking' potential in the long term does not mean that the physical stream of the proposed programme is of any lesser value, or that it requires any less support. It merely indicates the perception gained from discussions was that there is a clear opportunity to leverage fast advancing capabilities in molecular "bottom-up" material design - and that this gap has yet to be recognised by the supply chain in development of next generation composites.

The types of physical R&D proposed and therefore the support that may be sought are covered by many existing Industry Sector strategies and the support mechanisms being developed for these. Thoughts about how to progress the development identified in the physical themes should therefore always look to ongoing support mechanisms first as this has the added benefit of tying the development into end applications.

With this in mind, many of the R&D topics identified within the Process, Property, Fibre and Sustainability themes are developments currently being called for by the Automotive sector. This is the industry sector which currently has the most urgent need for technology and process development, driven by the need to hit emissions and recycling targets. The need from UK OEMs is currently being analysed by the Automotive Council's Manufacturing Group, which is working with the Composites Leadership Forum to develop a proposal to put

in from of UK Govt and funding bodies for significant funding to develop UK capability in "Affordable composite structures and components". This proposal will take advantage of:

- The fact that after the current APC call, the restrictions on what it can fund will be relaxed to include lightweight structure development.
- OLEV have expressed an interested in funding lightweighting capability in the UK.
- Horizon 2020 is expected to issue a call focused on affordable lightweight automotive components taking into account lifecycle.
- Innovate UK calls for proposals – 'Integrated Delivery Programme 12: Seeding tomorrow's vehicle technologies today' and 'Developing Advanced Lightweight Vehicles'.

Early stage development of this Automotive led proposal indicates that there are indeed common areas between it and the requirements identified in the work of this report. Innovative chemistry input to the affordable composites proposal would help accelerate the UK's position in this capability. It is therefore suggested that the KTN and CGP work with the Automotive Council's Manufacturing Group to ensure that the chemistry requirement and link within the proposal is well defined, that the potential R&D identified within this report is fed into the process – either to participate directly in the development and delivery of the "Affordable composites and structures proposal" or to define a complementary chemistry R&D programme.

In many cases the innovative technology development proposed within the Physical theme of this proposal could have many applications across different industry sectors. One good example of this is further development of highly functional composite materials, such as those with embedded sensors. This offers a great opportunity for multi-sector technology transfer, commercialisation and the associated revenue generation, but it also means that good communication is required to firstly understand all the opportunities for commercialisation and secondly to ensure that the work proposed here is not duplicating work already being taken forwards within an industry sector strategy.

Development and manufacture of Carbon Fibre (and the next generation materials which have the potential to replace current carbon fibre materials) is an area of UK opportunity which is not currently being addressed despite historic strengths. Developments are needed both in the science (TRL 1-3) and materials innovation (TRL 4-6) to help rebuild UK capability. Options include both UK and European funded programmes, and inward investment instruments.

While the virtual and physical streams have so far been considered in isolation, one of the key points for consideration is the interaction between the two. The physical stream in isolation will deliver benefits to the development of the composites sector, but it is with effective linkage between the virtual and physical streams that the UK will benefit most from ground-breaking development. The models developed in the Virtual stream should be made available to support and accelerate work done in the Physical stream and the understanding generated within the Physical stream should inform the direction and focus of the Virtual stream. On a practical level this raises two points:

1. Characterisation of materials will be crucial to the effective linkage of the Physical and Virtual Molecular Design streams. As stated during the workshop, labs such as the Materials Innovation Factory could play a crucial role in delivering the R&D requirements for new chemistries. Development of standards will play a crucial part in this, therefore the CLF's Regulations, Codes and Standards (RCS) Working Group should also provide support to any work conducted. NPL (who provide the Chairman for the RCS Working Group) would also be a natural partner in this work and may be persuade to lead or even

fund a programme of work in this area. Both standards for characterisation and standards for the materials themselves should be considered.

2. Capture and storage of information. Both the High Value Manufacturing Catapult's Large Scale Project (LSP) in Composites and the affordable composites proposal have identified Knowledge Management as one of the key areas of focus. This includes the need for mechanisms to capture materials data and composite know-how. The chemistry work in both the physical and virtual streams should engage with these mechanisms to help accelerate technology transfer and new materials innovation.

Ensuring engagement between the two streams of activity also raises the question of co-ordination of the proposed activities and consideration should be given to where responsibility for this lies. Experience gained through the CLF's development of the UK Composites Strategy has shown that if progress is to be made, responsibility needs to be taken by a group who have the need and the resource to drive the work forward – in this first phase of the work it has been by the KTN, through the KCMC. It may be that responsibility is given to one of the CGP working groups, but it will potentially need to engage with others both within CGP, CLF and other organisations. The actions being taken forward to deliver chemistry capability into the composites community will include development requirements across a variety of topics including technology, supply chain, standards/regulations and skills. The comments included in this report about different support requirements for companies of different sizes should be of particular interest to the groups focused on supply chain development.

Finally, a very valid point was raised during the consultation process about the focus of the discussions being on delivering to current industry requirements and neglecting the possibility of development of disruptive chemistry and chemical processing to provide game changing application/solution. The CLF's Technology Working Group has recognised that this needs to be investigated for the composites community, and the chemistry group would like to engage with such a process when the CLF has established an approach. At this stage, should the KCMC wish to investigate this for chemistry input to the Composites Strategy, they could ask for support from the Academic part of the CLF's Technology Working Group.

## 6. Recommendations

A set of needs and opportunities for chemistry to contribute to the growth of the UK composites industry have been identified. In this context it should be understood that chemistry is taken to imply the full multi-disciplinary capabilities of the chemistry-using industry i.e. alongside materials science, materials and chemical engineering etc. An overview of the resulting research topics is provided in Figure 4.

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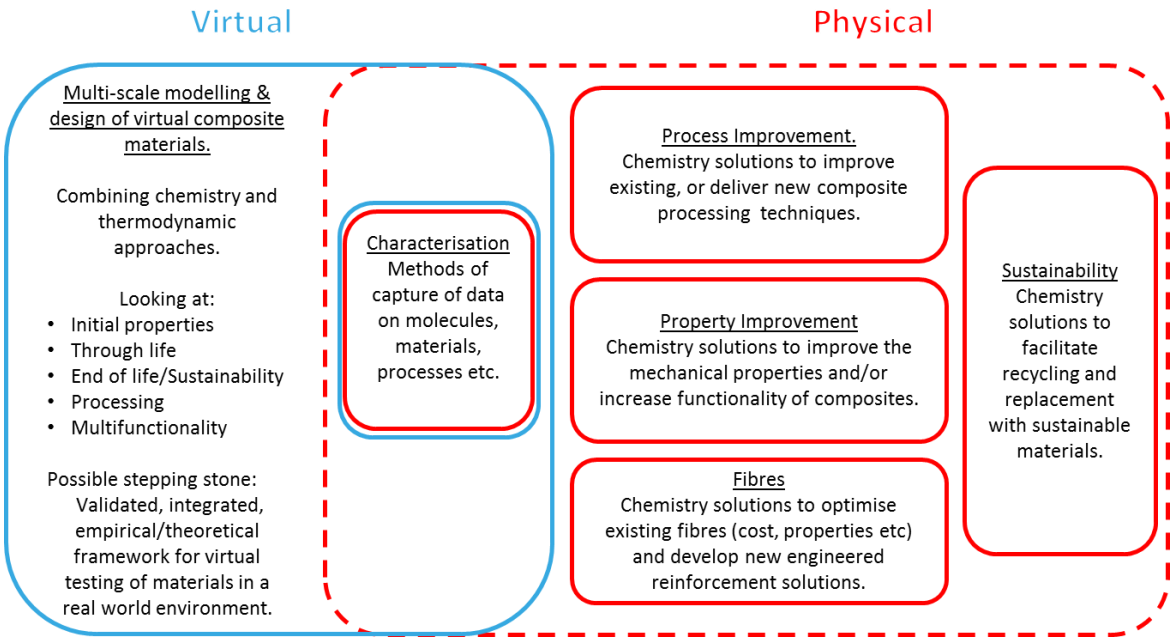
*Figure 4: Proposed programme of work.*




The consultation process previously described allowed capture of detailed recommendations, provided by the chemistry community, on the R&D in the themes within the Virtual and Physical streams that should be taken forward to support the development of the UK Composites industry.

To address these research recommendations, a programme of work should be developed, comprising both cross cutting chemistry themes (e.g. from the virtual stream and fibres), and industry sector aligned themes (e.g. activities to support the automotive sector), with sponsorship from both the UK Composites Leadership Forum and the Chemistry Growth Partnership.

The Materials Chemistry SIG make the following recommendations for the KTN on how this could be taken forward:

- KTN to take responsibility for development of a proposal for the programme of work, recognising that this role requires interaction with and support from other working groups and relevant funding bodies including EPSRC, Innovate UK and the STFC. The first stage of development of this proposal would involve a roadmapping process.
- KTN to facilitate initial engagement, via the Hartree facility, between the chemistry and the scientific computing community to explore their capability and priorities, and how they align with the capability development required within the virtual stream. If there is sufficient alignment and fit with TRL, a workshop to discuss development of a virtual programme to facilitate composite material development could be a next step. It is suggested that one of the key topics to be discussed early on in the formation of this collaboration is the issue of data and IP ownership. ICT funding streams, rather than the usual engineering/manufacturing, may be accessible for any proposed collaborative R&D.
- KTN and CGP work with the Automotive Council's Manufacturing Group to ensure that the chemistry requirement and link within the "Affordable Composite Structures and Components" proposal is well defined, that the potential R&D identified within this report is fed into the process – either to participate directly in the development and delivery of

the “Affordable composites and structures proposal” or to define a complementary chemistry R&D programme.

Additional activities and approaches for consideration:

- Carbon fibre development and manufacture is a key UK industry priority and KTN should support cross-sector collaborative work (eg with HVM Catapult, UKTI) to facilitate development of UK proposals on affordable carbon fibre production for next generation product needs
- The KTN should ensure best-practice good communication with all industry sectors to understand the possibilities for technology transfer and commercialisation of cross-cutting technologies such as functional composites.
- The High Value Manufacturing Catapult’s LSP in Composites is expecting to contain a ‘Knowledge Management’ workstream, which should be involved in any knowledge capture and storage requirements in this programme of work as part of the interaction between the Virtual and Physical streams.
- NPL and the CLF’s Regulations, Codes and Standards Working Group should be involved in the Characterisation theme.
- The CLF Technology Working Group Academic Group should be asked for support in any work to identify disruptive technologies for development.
- Supply chain development as part of this programme should recognise the difference in support required by companies of different sizes and at different stages of the supply chain.

Appendix 1: Glossary of Terms

| | |
|---|---|
| APC | Advanced Propulsion Centre www.apcuk.co.uk |
| CFRP | Carbon Fibre Reinforced Plastic |
| CGP | Chemistry Growth Partnership www.ukchemistrygrowth.com |
| CLF | Composites Leadership Forum www.compositesleadershipforum.com |
| CPI | Centre for Process Innovation www.uk-cpi.com |
| DECC | Department for Energy & Climate Change https://www.gov.uk/government/organisations/department-of-energy-climate-change |
| EPSRC | Engineering & Physical Sciences Research Council www.epsrc.ac.uk |
| FEA | Finite Element Analysis |
| FST | Fire Smoke & Toxicity |
| HVM Catapult | High Value Manufacturing Catapult www.hvm.catapult.org.uk |
| KCMC | Knowledge Centre for Materials Chemistry http://materialschemistry.org.uk |
| KTN | Knowledge Transfer Network https://connect.innovateuk.org/knowledge-transfer-networks |
| LSP | Large Scale Project |
| NCC | National Composites Centre http://nccuk.com/ |
| NDT | Non Destructive Testing |
| NPL | National Physical Laboratory www.npl.co.uk |
| OEM | Original Equipment Manufacturer |
| OLEV | Office for Low Emission Vehicles https://www.gov.uk/government/organisations/office-for-low-emission-vehicles |
| ORE Catapult | Offshore Renewable Energy Catapult https://ore.catapult.org.uk/ |
| PAN | Polyacrylonitrile |
| R&D | Research and Development |
| RCS | Regulations, Codes and Standards |
| REACH | Registration, Evaluation, Authorisation and Restriction of Chemicals |
| SIG and Materials Chemistry SIG | Special Interest Group – the Materials Chemistry Special Interest Group funded by Innovate UK to develop new materials opportunities |
| SIN | Science and Innovation Network https://www.gov.uk/government/world/organisations/uk-science-and-innovation-network |
| SME | Small and Medium-sized Enterprises |
| STFC | Science & Technology Facilities Council http://www.stfc.ac.uk/ |
| UKTI | UK Trade & Investment https://www.gov.uk/government/organisations/uk-trade-investment |