Unit-level environment template (REF5b)

REF2021

Institution: University of Chester	

Unit of Assessment: 11 Computer Science and Informatics	

1. Unit context and structure, research and impact strategy

Context

REF2014 was the first time the University of Chester made a return to Computer Science and Informatics, and coordinated computer science research activities were just beginning at that time. We are, therefore, one of the youngest Units in the UK to become research active in this area and this statement is based on progress in the first seven years. 7.6 FTEs are included in the return, and one research assistant and three other colleagues who have moved on to new positions are also referenced in this environment statement:

Name	Status
Nick J. Avis (0.6 FTE)	Professor
John M. Counsell	Professor
Thaddeus Eze	Senior Lecturer
Nigel W. John	Professor
Yousaf Khalid	Lecturer
Helen Southall	Senior Lecturer
Lee Speakman	Senior Lecturer
Richard Stocker	Senior Lecturer
Thomas Day	Research Assistant
Serban R. Pop	Industry
Panagiotis Ritsos	Senior Lecturer, Bangor University
Neil Vaughan	Associate Professor, University of Essex

The Faculty of Science and Engineering was founded in 2013 at Thornton Science Park, a unique location where industry, academia and commerce are co-located for mutual benefit. It brings computer science together with a variety of engineering disciplines, as well as mathematics and physical sciences. The science park hosts 38 companies working in the strategic areas of Energy, Automotive, Environment, Medical and Advanced Manufacturing. It also at the centre of the Cheshire Science Corridor's Enterprise Zone and is a key player in the Northern Powerhouse initiative.

The Faculty is contributing to the University's strategic aim to further develop its Science, Technology, Engineering and Mathematics (STEM) provision, broaden the curriculum and extend the range of its activities into engineering and the physical sciences. Key to its success was the award of a HEFCE/STEM Capital grant of £7.1M, of which approximately £1.2M was used, together with the acquisition of legacy equipment from Shell Research Ltd (the former operators of the site), to equip laboratories with near state-of-the-art and industry standard facilities. Development of the science park has subsequently benefitted from European, local enterprise and other funding to a total of >£30M. Computer Science is an integral part of the Faculty's activities and is fully aligned with the strategic areas of the science park.

The University of Chester Corporate Plan – Vision 2015-2020 – expresses an explicit commitment to supporting an expanding and innovative University research environment that ensures high quality research and innovative practices that help influence the development and improvement of society. The strategy of our Computer Science Unit is fully aligned with this aspiration, as is evidenced by the outputs from the activities described below.

1.2 Structure

An ongoing effort has been made since 2015 to provide an effective research structure for computer science. Research is focussed into four main themes: Medical Visualization and Computational Modelling are the primary areas, with developing activities in Cybersecurity and User Experience

Design. The themes benefit from the proximity of companies on the science park for collaboration and industrial participation, and from the cross-fertilization of ideas and expertise from the associated multidisciplinary colleagues within the Faculty and wider University. A Director of Research provides oversight across these different themes, and progress and plans are discussed with all staff at departmental meetings held across the academic year. The Director of Research is also a member of the Faculty Research Committee and the University's Research and Knowledge Transfer Committee.

The Department of Computer Science was a separate department at the University between 2014 and 2019. In 2019 it merged with the Department of Electronics and Electrical Engineering to provide a greater critical mass of established researchers and to encourage more cross-disciplinary work. The new department remains a core component of the Faculty of Science and Engineering.

1.3 Research and Impact Strategy

The primary aim reported in REF 2014 was to develop a research centre with critical mass, and with at least two areas of computer science research focus with recognised outputs of international excellence. This would also leverage the world-leading facilities at the Thornton Science Park to develop strong interactions with industrial and commercial users. This has been achieved, supported by the investment made in hiring research active staff and installing new facilities for computer science topics, including a research laboratory for virtual and augmented reality, and a User Experience Lab. We now have four active research streams as we continue to develop an applied research focus with staff who demonstrate enthusiasm and vitality.

The research and impact strategy of the Unit is closely aligned with all four of the Core Themes listed in the Institutional-Level Environment Statement and is focussed on building strength and depth within our research whilst reflecting the institutional values. We recognise that the Unit is relatively small, and therefore strategic aims will be achieved through collaboration and interdisciplinary working across the University, and externally both nationally and internationally. Research informed teaching is a natural output from all of our activities.

i. Medical Simulation and Visualization (John, Day, Vaughan, Ritsos, Pop)

John and Ritsos were recruited in 2015 from Bangor University, together with Pop who came from Oxford Brookes University after previously being at Bangor. They came with established track records to fast track development of this research theme at Chester. From 2017-2020, the Unit was reinforced with Vaughan, a Research Fellow of the Royal Academy of Engineering. Day completed a PhD at Chester before being appointed as a Research Assistant in the Unit. The focus has been on investigating novel uses of virtual and augmented reality with application in a variety of healthcare scenarios. We have been funded by Innovate UK on a collaborative project with industry and the NHS to use virtual reality (VR) for the cognitive rehabilitation of stroke survivors. During the REF2021 assessment period, eighteen publications in leading international journals (including three IEEE Transactions papers) have been produced, and fourteen publications in refereed conference proceedings. A review paper in Computer Graphics Forum on "Appearance Modelling of Living Human Tissues" has been acknowledged by the publisher as being in the top 10% of most downloaded papers from the journal between January 2018 and December 2019 and so generating immediate impact. Our work with paramedics was also highlighted by Universities UK's MadeAtUni campaign to celebrate the projects that bring to life the impact of universities on families, communities and wider society. We were selected as one of the *Nation's Lifesavers* whose work is saving lives and making a life-changing difference to our health and wellbeing. Also, of note is that Vaughan won the 2019 Digital Innovator of the Year Award at the annual Healthcare Education and Training Awards, run by Health Education England. Our ongoing strategy is to develop practical solutions based on computer graphics and haptics related research that benefit both healthcare providers and patients.

ii. Computational Modelling (Counsell, Khalid, Pop, Ritsos, John, Avis)

Counsell and Khalid are leading research into modelling and designing software tools for Smart Multi-vector Energy Systems that have been applied on a global scale. This includes fundamental

scientific research in modelling the physics of heat, power and nonlinear control algorithms that has been published in learned society journals and conferences and applied to industrial case studies in partnership with leading international companies. Past EPSRC and InnovateUK grants have involved collaboration with University of Liverpool and Newcastle University, and recent collaboration with the University of Durham has resulted in an EPSRC grant to model and simulate a hybrid thermochemical-compression seasonal solar energy storage and heat pump system for homes and local energy systems using heat networks. The research will involve the use of inverse dynamics algorithms for high-speed computational modelling and visualization of the systems' multiple energy vectors such as thermal comfort, power utilisation, heat utilisation, CO_2 emissions, primary energy factors etc. Furthermore, the research uses a Meta-modelling approach to structure object-oriented approaches to energy system modelling, drawing on Counsell's research dating back to the mid 1990s.

Data Analytics and its application to Big Data is a fast-growing area of research worldwide. Ritsos and John have developed a new framework that enables immersive visual analytics experiences. Avis has also contributed the computational analysis of social media data to detect tension within on-line communities.

Pop has been engaged in computational modelling in collaboration with the University of Liverpool, and he developed a model of drug transport from silicone oil across the outer blood–retinal barrier. Such work is contributing to the creation of new drug delivery systems. Pop has also been engaged in an international collaboration with Babeş-Bolyai University in Romania to model thermophoretic transport of small particles through the convection in a differentially heated square cavity with a wavy wall.

We have satisfied a REF2014 goal by achieving outputs of international excellence in computational modelling, including three publications in IEEE journals as well as other high impact journals. Our ongoing strategy is to continue to impact on Smart Energy Systems and to integrate this work with the developing research on visual analytics.

iii. Cybersecurity (Eze, Speakman, Avis)

Speakman was recruited from GCHQ and Eze accepted his first academic post at Chester following a successful PhD at the University of Greenwich. Our research interests are in software and system protection methods, including in hypervisors & virtualisation, containers, firmware exploitation, low-level system and firmware monitors, and underpinning intelligent or autonomic Intrusion Detection Systems (IDSs), behavioural models, as well as Malware Analyses and Penetration Testing, Trustworthy Autonomic Systems, Trusted Autonomic Architectures, and Autonomic Interoperability. We work cross-faculty to bring in the wider areas of cyber security in law, psychology, sociology, business and management, and other aspects, in a dynamic and pervasively connected world. Our ongoing strategy is focussed on three research topics, each supported by a PhD student. The first explores the challenges of existing intrusion detection and protection systems (IDPS) and is building a trustworthy AI-based IDPS that addresses known issues such as false positives/negatives. The second focuses on using techniques such as control flow integrity to address control flow hijacking vulnerabilities in software. The third seeks to develop automation solutions in malware analysis that are capable of addressing some anti-forensic methods like obfuscation techniques used by malware developers. We will publish in these areas and seek at least two successful grant applications in the next REF period.

iv. User Experience Design (Southall, Stocker, John)

Currently, there are many approaches to software design which facilitate user involvement and adequate software testing (including user-centred, lean, and agile approaches) but more recently, we've seen contemporary problem-solving techniques emerge such as the 5-day design sprint, which can be used to galvanise software teams and create more effective software products. However, the original 5-day duration remains a barrier to adoption for organisations, and there is a need to compress and refine this process to offer a more manageable and less intimidating schedule, especially for less complex problems. To address this barrier, we have been looking at ways to condense the process and apply a shortened version to software development projects and tested

out the methodology in organisations such as the BBC. Current applications in virtual heritage and serious games design are being developed. We have also been involved in collaborations with Liverpool University addressing the reliability of autonomous systems for Astronaut-Rover teams using the formal verification of models in the Brahms multi-agent modelling language. Our ongoing strategy is to design standards-based digital solutions through human-centred design and multidisciplinary approaches to software development. These will have immediate impact in many different commercial and academic settings.

1.4 Future Plans and Aspirations

The university's 'Citizen Student' strategy seeks to equip its staff and students with the skills and knowledge to be 'confident world citizens'. Through its vision for 'teaching-led research', the institution aims to ensure that research is embedded in all aspects of University life, and that all students are encouraged to engage in research activities and develop research skills. Alongside this, and in support of the research agenda for the next five years, the University will establish named research clusters with which staff and students will identify. Computer science research will be an important element in these new clusters.

Throughout this REF period, research activities have been based at Thornton Science Park but by summer 2021 some activities will also take part at Exton Park in the middle of Chester. This move will additionally provide the opportunity to establish more multi-disciplinary research collaborations within the University. For example, we are now starting to engage in a new Health and Well Being research cluster that will be the catalyst for interdisciplinary research initiatives. It also provides a programme of cross-Faculty monthly seminars that offers a forum for collaboration. Also, links are growing with the Department of History and Archaeology, and a joint internal grant award has been won to create a package of computing resources to be marketed to the Museum, Heritage and Education sectors, with further joint grant submissions being made to the AHRC.

The overall future strategic aim within Computer Science is to build on and strengthen its core activities in applied research through collaboration within and beyond Chester with ambitious partnerships forged with world leading organisations. We will strive for international impact in the area of cybersecurity with close collaborations with UK police forces. Our first journal publications in user experience design for serious games and virtual heritage applications will also be a goal for these developing areas of research at Chester. Finally, we will consolidate our track record in both Medical Simulation and Computational Modelling and target a significant increase in grant awards on collaborative projects with the NHS and industrial organisations totalling at least £3 million. We have established a thriving research community during this REF period and will continue to support and develop our existing staff and PGR activities.

2. People

The unit is relatively small and therefore staff are recruited to strengthen and consolidate current areas of strategic importance. Most of the 7.6 FTEs in this return have either joined the University or become independent researchers since 2014. The four FTEs returned in REF 2014 have changed roles (**Avis** was Pro Vice Chancellor for Research at the University), retired or moved to new employment. The emphasis is on alignment with Unit priorities as outlined above, and with the strategy of the Faculty of Science and Engineering. Staff are cross-disciplinary and come from a variety of backgrounds thus enriching the experience and diversity of the Unit. Staff development is partly through self-development, for example all staff have participated in conferences during this REF period. Some staff are active in journal/grant reviewing and editorship (see section 4.2), and early career researchers are encouraged and supported to take on these responsibilities. Membership of professional organisations is also encouraged and we currently support the IEEE, IET and the Eurographics Association. Staff also make use of the University's comprehensive professional development schemes, including supervision of PGR students and in grant writing and management. Time is made available via the Workload Allocation Management System for these activities, and their value to the Institution is recognised. The introduction of peer mentoring has given staff the opportunity to develop their own skills whilst supporting and nurturing those of their colleagues. Career progress of research-active staff is considered as part of the annual Personal Development Review (PDR) process. The Unit and its contributing departments are keen to

recognise and reward excellence in all fields of academic endeavour, including research. Consequently, promotion is based on both research record and contribution to the wider University community. Eze was promoted to Senior Lecturer in 2018.

In 2018, an annual Research and Knowledge Transfer Festival was established at the University. This encourages researchers from all departments to collaborate and exchange ideas whilst participating in a ten-day programme of events that covers promotion of research activities, support with research applications, and provision of insight from eminent external keynote speakers. As a part of the festival, the Unit staff have delivered sessions that include Building a Departmental Research Culture, and How Serious Games and Virtual Reality Can Strengthen Your Research.

The University's REF code of practice has been followed to identify staff and outputs. Selection of outputs has been primarily based on self-assessment of quality by their authors. To enable statistically significant monitoring against equality and diversity objectives, the data for Computer Science and Informatics is combined for analysis with other cognate units.

2.1 Well-Being and Diversity
The well-being and development of its staff is central to the Mission, Vision and Foundational Values of the University. The Faculty and the Unit encourage and promote equality and diversity. We are proud that the University has successfully renewed its Athena Swan Bronze award, holds the HR Excellence in Research award, and in 2014 was one of only 5 HEIs to be awarded the Gender Charter Mark Bronze award. We have adopted a policy whereby all staff recruitment interview panels have at least one female member, where possible. Multi-faith spaces, quiet rooms and quiet gardens are available at the Thornton and other University sites, as are gender-neutral toilets and parent-and-baby rooms.

The Thornton Science Park offers good access to people with disabilities. Reserved car parking spaces are close to the entrance of most buildings and there is also a wheelchair accessible minibus that operates a shuttle service between the different University sites. Many doors into buildings will open at the touch of a button located at wheelchair height, and there are lifts in the buildings where access is needed to a second floor. We have also incorporated some aspects of supporting disabilities into our research, and have developed a virtual environment that allows people to practice driving a powered wheelchair. Across the University, disabled staff are invited to join the Disabled Staff Support Group. This group discusses and finds possible solutions to the various issues relating to disability and making a positive impact to the working lives of disabled staff. For example, they have put together a set of leaflets on a number of disabilities which contain support information for managers and staff, addressing autism, dyslexia, epilepsy, hearing impairment, Meniere's disease, mobility, and visual impairment. There is a dedicated quiet room at Thornton Science Park designed specifically for people with Asperger's syndrome and other autism spectrum disorders. The University also employs a dedicated Assistive Technologist who provides support on the use of assistive technology. We have been awarded the Disability Two Ticks Symbol by Jobcentre Plus, which acknowledges those employers who make certain commitments regarding the recruitment, training, retention, consultation and awareness of disabled people and disability in general.

The University prides itself on its inclusive policies. It has established a support network for staff who identify as Lesbian, Gay, Bisexual or Trans, and holds the Navajo Merseyside and Cheshire LGBTIQA Charter Mark, an indication of good practice, commitment and knowledge of the specific needs, issues and barriers experienced by this community.

The University holds an annual Diversity Festival that is also open to members of the public, and provides a focus through which the University actively promotes, challenges and develops an understanding of equality, diversity and multiculturalism. Throughout the year staff can participate on several different equality and diversity discussion boards. The University's Equality Forum takes place on a quarterly basis and all staff are welcome to attend.

13% of staff included in the Computer Science and Informatics Unit are female (22% of eligible staff are female across the faculty), and 26% identify as BAME (27% of eligible staff are in this category

within the faculty). No staff in the return have reported a disability. We are conscious of the need to attract more diverse staff into the unit and the above listed initiatives will help to achieve this. We also draw attention to the impact of our part time doctoral programme on widening participation and supporting a diverse student population.

2.2 PGR Community

The Unit hosts a small but active PGR community. These students are supported by a first and second supervisor, with the Faculty Senior PGR tutor (was **John**, 2016-19) maintaining oversight of their well-being and progress. All PGR students are subject to a rigorous supervision and monitoring regime which includes 6-monthly progress reviews, and an MPhil to PhD progression review at 12-18 months. We are striving to attract a higher proportion of female participants in our postgraduate research (and undergraduate) student body. This is supported through a continuing series of public lectures by well-known female science representatives, for example celebrating International Women's Day, our traditional Christmas lecture series, the RAF, and school events. These events are organised by the faculty's OFFA-funded STEM Outreach Coordinator.

PGR students participate in the annual Institutional PGR Conference and also the Research Festival. All Thornton-based PGR students take part in an active seminar series and are required to present their work at the end of the project (for MRes and PhD), and on transfer from MPhil to PhD registration. The seminar series also includes presentations from more senior members of staff, and external speakers including those from commercial companies based on the Science Park.

During this REF-period, the Unit has awarded five students with their PhD degrees, and a further six students are currently working towards this outcome. The PhD graduates have taken up posts in industry (e.g. BBC) or are now in research assistant posts (at Chester, York and Bangor). In the REF 2014 submission there were zero research degrees awarded and so we have made good progress in providing research opportunities for students. Further steps to increase the PGR population include Faculty fee-waiver arrangements.

31% of the outputs included in this return have involved work carried out by PGR students. One output is the result of an undergraduate project.

3. Income, infrastructure and facilities

<u>Income Summary</u>

John Counsell	RISE	Innovate UK	£90,403
John Counsell	Heat-STRESS	EPSRC	£201,167
Neil Vaughan	Research Fellowship	Royal Academy Engineering	£29,769
Nigel John	VIRTUE	Innovate UK	£157,665
Nigel John	ParaVR	Welsh Ambulance Service	£6,250
			£485,253

This is a significant improvement from REF 2014 where the total research income reported was negligible (£4,742).

<u>Infrastructure and Facilities</u>
The Unit is well equipped to support research in the areas of strategic focus. Specialised facilities are briefly summarised below:

Virtual Reality Laboratory (Holodeck):
- Including the latest head mounted displays, stereoscopic displays, haptics hardware, tracking technologies, and other specialised equipment (such as a powered wheelchair).

User Experience Lab

- This an ideation and problem-solving space, which enables effective and efficient multidisciplinary collaboration. Typically, users work in teams of between 5-7 working on solving business problems using technological solutions, through 'lean' human-centred approaches to software development.

DOMESTIC: Domestic Energy Systems & Technologies Incubator

A Test Facility for the demonstration of domestic technologies and design methodologies:

- Indoor Air quality experimentation
- Metering, monitoring, modelling
- Intelligent Control and integration of heating systems
- Application to Micro Building design Concept e.g. net zero office

Informatics Centre

- A commercial entity within the department consisting of four software engineers that produce bespoke digital products.

High Performance Computing

- Computational modelling is carried out in part using the University's high-performance computing cluster, which consists of a combined processor power of 312 cores based on Intel Xeon E5 series @ 2.5GHz CPUs with up to 530 GB of memory in total. Cores are divided amongst 17 computer nodes linked via high-speed infiniband interconnects.

These specialist facilities are fundamental to supporting the impact of our research activities, providing suitable environments for the development of case studies, as well as showcasing research outputs to new collaborators and the general public.

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4. Collaboration and contribution to the research base, economy and society

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4.1 Collaborations, Networks and Partnerships

The Unit strongly believes in the power of networks and collaboration to build and strengthen research impact and reach. Our collaborations are cross-disciplinary, multi-national, and focussed around our key themes. We work with Universities, research institutions, local authorities, the National Health Service, the national police force and commercial enterprises to maximise the contribution of our skills and expertise for economic and social good.

4.2 Contributions to the Research Base

Staff within the unit demonstrate commitment to the research base through participation in professional bodies, learned societies, journal editorial board membership, and conference organisation. **John** is a Churchill Fellow, a Fellow of Eurographics and a Fellow of the Learned Society of Wales; **Counsell** is a member of the IET; **Eze** is a member of the IEEE; and **Southall** is a member of the Institute of Physics – emphasising our cross-disciplinary approach. All members of staff exercise good research community citizenship through the peer-review process for a wide range of scientific journals and grant awarding bodies. **John** has been an Associate Editor of the Computer Graphics Forum. Both **Avis** and **John** are members of the EPSRC Peer Review College and **John** is also a member of the Sêr Cymru Prioritisation Panel for research funding issued by the Welsh Government. In this assessment period the Unit has hosted the following national and international conferences related to computer science topics:

- Eurographics workshop on Visual Computing in Medicine and Biology 2015
- Cyberworlds 2017
- IEEE UK & Ireland YP Postgraduate STEM Research Symposium 2018
- European Conference on Cyber Warfare and Security 2020

These have provided staff with both experience of organising the conference and excellent networking opportunities. **John** is also an ACM Distinguished Speaker and is funded by the ACM to act as an international guest speaker.

4.3 Contributions to the Economy

The work on modelling and designing software tools for Smart Multi-vector Energy Systems has to date had a commercial impact in excess of £35 Million within this REF period as a result of collaborations with BRE, Arup, Leep Utilities, URENCO, Eastbourne Homes, EDF Energy, Q-

Sphere, Fujitsu, Advanced Control Partnerships (ACP), AXSYM, M&I Materials, EA Technology and ISIM International. The research is disseminated in an annual workshop – Artificial Intelligent Multivector Energy Systems (AIMES) – to over 100 industrial companies, local authorities and housing associations. This is led by Chester in partnership with Durham University and the University of Manchester.

Recent projects delivered by the Informatics Centre include the intranet for a local hospital, a psychometric assessment system, and a tool for creating digital treasure hunts for businesses, educational institutions, charities, and private events. The Informatics Centre also provides a conduit for our academics to use their expertise on commercial projects.

4.4 Contributions to Society
The Medical Graphics team have strong links with several NHS trusts and aim to deploy their research in hospital environments for the benefit of clinical professionals and their patients. For example, we have been running a trial at the Countess of Chester Hospital NHS Foundation Trust to assess the effectiveness of using virtual reality for the cognitive rehabilitation of stroke survivors. We are also working closely with a specialist Gastrointestinal surgeon on developing new training environments. Another example is our collaboration with the Welsh Ambulance NHS Trust on skills maintenance and training in virtual reality. This has resulted in a tool for CPR training that has been demonstrated at local schools as a part of the national Restart a Heart Day organised by the Resuscitation Council UK.

The department has continuing research collaborations with local police forces (e.g the Cheshire Constabulary). It was conceived to support the ongoing work being conducted within UK Policing in order to inform best practice and identify risks and opportunities to build upon the current strategic response to the cyber threat. The major focus of this research is cyber awareness and education. It seeks to explore and improve the way in which police forces can build their capabilities around cybercrime prevention and investigation by identifying issues which may be acting as a blocker. It also hopes to deliver the required evidence base for cybercrime training for frontline police officers and staff in UK police forces

4.5 Former Staff
The vitality of the Unit is further evidenced by a healthy turnover of staff recruited during this REF period as they progress their careers: Ritsos took up a post as Senior Lecturer at Bangor University (2017), Pop moved back to his native Romania (2019) and now holds a position in industry (Nehemiah Security), and Vaughan has moved to the University of Exeter as an Associate Professor of AI and Data Science (2020).