Science & Technology Facilities Council

PRIORITY PROJECTS: Outline Summaries

01 A Correlative Imaging Platform at Harwell

Correlative imaging will unleash an imaging revolution, probing *in situ* the atomic and molecular mechanisms in many areas. Five specific activities funded through this project are i) develop an SEM and TEM for *in situ* correlative high-resolution light and electron microscopy ii) collaboration with Diamond on *in situ* correlative light and x-ray microscopy iii) development of enabling technologies iv) development of open software and hardware platforms for acquisition, handling, and analysis of large volumes of complex image data and v) support of activities promoting cross-campus collaboration in correlative imaging.

02 HiLUX (Ultrafast Structure and Dynamics in the RCaH)

This project is an instrument development programme for Ultra and Artemis (The HiLUX Project) which combines the expertise and capabilities of the two facilities to create a unique centre for ultrafast vibrational, electronic and XUV spectroscopy and imaging. The overarching scientific objectives are to correlate the ultrafast dynamic interactions between electrons and nuclei and the role this has in relation to structure and dynamics in chemistry, physics and biology at the quantum level.

03 Advanced Technology Programme for Next Generation Laser Facilities

Major advances in CLF's high power lasers have always necessarily been preceded by technology development programmes. From the original Vulcan 100 TW project, the Gemini system, the Vulcan 2020 to the current EPAC (and the EUXFEL HiBEF where CLF & its Community have a major role). This proposal seeks to invest in the development of a range of new technologies that will be necessary for the next generation of our high power laser facilities.

04 Vulcan 2020: The Science of Extremes

The Vulcan 2020 project will deliver a globally unique capability to the high energy density (HED) science community – a scientific area of extreme national importance. This investment in the Vulcan laser facility will make it the most powerful and flexible laser in the world enhancing its capability and capacity. It will upgrade the existing *Vulcan* infrastructure; no other facility offers a combination of 20 Petawatt laser power and 10 kJ of laser energy in a single system.

05 Diamond-II

Diamond has developed a plan to implement MBA technology that is unique in the world, offering not only dramatic gains in brightness and coherence but also additional sites to install new photon sources based on insertion devices. This project will enable Diamond-II to accommodate high-performance beamlines that are currently based on bending magnets and it will also offer additional sites for new beamlines, offering greater capacity and flexibility to accommodate new scientific drivers and communities well into the future.

06 HTMXbridge - Bridging high throughput MX to Diamond-II

In readiness for the Diamond II upgrade dark period, this project is to design, construct, commission and operate, a structural biology beamline, HTMXbridge, at another low emittance synchrotron to perform ultra-high throughput macromolecular crystallography (MX) providing much needed replacement capacity to the (predominantly UK) structural biology community.

07 Optics Fabrication Facility

To set up a state-of-the-art Optics Fabrication Facility at Diamond/ RAL site, primarily for multilayer optics fabrication. This would be a first of its kind facility in the UK, delivering a wide range of new optics for the Diamond Light Source, the ISIS neutron facility, and possibly for future Free Electron Laser applications. Access to new technology is critical to support world class science at large scale facilities through the delivery of state of the art instrumentation.

08 ISIS-II Feasibility, Design Studies and R&D

The objective of the project is to carry out the feasibility and design studies, and associated R&D, to enable a fully informed decision on the optimal proton driver and target system architecture to build a MW-class short pulse neutron and muon facility at ISIS – 'ISIS-II'. This is in line with the recommendations of the 2017 STFC
Accelerator Strategic Review.

09 Endeavour

The ISIS programme impacts across the research landscape from curiosity driven basic research to applied research with immediate and sensitive industrial relevance. To maintain and enhance this activity, it is vital that ISIS develops its instrumentation capability to meet the basic and applied research challenges of the coming decade and beyond. Without such development none of the 'ISIS as the core' scenarios for UK neutron/muon provision2over the next ten years will be achievable. Endeavour is a portfolio of neutron and muon instruments optimised to deliver significant and transformative impact in four challenge areas: i) Materials of the future ii) Smart, flexible and clean energy technologies and iii) Advanced Manufacturing and iv) Biosciences and Healthcare.

10 Industry/university/facility studentship programme

This project comprises an industry/university/facility co-funded PhD studentship programme aimed at maintaining/building expertise in effective exploitation of the UK national facilities (ISIS, Diamond, Central Laser Facility) at the Harwell Campus, and spreading that expertise out to industry. Individual studentships would be awarded annually through a peer review process, with 50% co-funding from industry/university being expected.

11 I-SEC

This project is for International Stress Engineering Centre (I-SEC), a new collaborative global centre of excellence for stress engineering research, measurement and training at the Harwell Campus. It will offer unique residual stress measurement facilities and deliver transformative research and training to meet UK industry 4.0 needs over the next 25 years. It will protect and enhance the UK's pre-eminent global position in this strategic research space by creating a critical mass of research expertise through partnering. I-SEC will incorporate access to the existing Engin-X and IMAT beamlines and contain a new neutron beamline, ε-map, which will create a step change in UK research capability.

12 National Thin Film and Characterisation Centre

To set up a National Thin Film Deposition and Characterisation Centre at the STFC Daresbury Laboratory which will be capable of synthesising and characterising application oriented thin films. The centre will facilitate knowledge transfer and networking between academia and industry and provide infrastructure to scale up R&D, enabling technology transfer to UK industry. The main purpose of the centre would provide access to state of the art equipment and expertise, whether at Daresbury or through partner institutions. A national centre will enable the training of technicians and scientists with specific skills to support UK industry and R&D.

13 Quantum Computing Innovation Centre

The project will create a Centre of Excellence to develop tools, algorithms and applications software to accelerate the practical application of quantum computing (QC). This initiative will make the UK a leader in this emerging field, as well as providing access to a state of the art QC facility to the academic and commercial community.

14 RAL AI Institute

The project is to create an Artificial Intelligence (AI) Institute with the objective of exploiting particle physics information to develop Machine Learning (ML) techniques and realisations. The development of Artificial Intelligence is one of the Government's top strategic industrial development priorities. It will directly address one of the grand challenges named in the Industrial Strategy white paper, namely "putting the UK at the forefront of the artificial intelligence and data revolution".

15 Computational Science for Facilities

The growth in data volumes and complexity from the UK's national experimental facilities (ISIS, CLF, Diamond), and the increasing demand for computational modelling and simulation together, mean an investment in scientific computing is urgently needed. This project seeks funding to establish a programme of software development, scientific collaboration and support, and training in computational modelling and simulation to support the STFC Facilities.

16 High Altitude Platform

The UK lacks a means of independently deploying high-altitude platforms (HAPs) for terrestrial, solar or astronomical observations or telecommunications. It is dependent on other leading European nations, and the USA, to deploy its high altitude instrumentation and this severely limits the available observation time and constrains advances in technical development and demonstration. This project is for the provision of a national HAP facility to mitigate this strategic limitation.

17 UKSpace Industrial Research Programme - R2A

The UK space sector's community of researchers, agencies and industrial collaborators want to strengthen their world-leading excellence and impact from academic knowledge in its application in a space environment, adding to its significant international role with space fairing nations and subscription to the European Space Agency (ESA). This project is a flagship programme to radically change the availability of opportunities for UK led research to be quickly applied in a space context and deliver impact at global scale or where it is most needed.

18 Space Weather Instruments and Modelling

To create a programme of modelling and ground-based instrument development to support UK space weather prediction efforts by establishing a Centre of Excellence (CofE) within RAL Space that will work collaboratively with the UK Met Office and the UK academic community to promote the transition of instruments and models from research to operations (R2O). The CofE would work with UKMO requirements for better space weather information and techniques by collaborating with researchers to make datasets and models available to satisfy this need.

19 STRIKE: STFC Telecommunications Research and Innovation Knowledge Exchange

This project is to establish *STRIKE*, with a key objective of exploring 5G terrestrial and Earth-space telecommunication applications via activities in i) 5G satellite Technology Development ii) Integration 5G test and monitoring applications and iii) Coordination and Knowledge Exchange. It will utilise the world leading scientific expertise present within the Chilbolton Facility for Atmospheric and Radio Research (CFARR) for the benefit of the future 5th Generation (5G) telecommunication ecosystem.

20 Detector Systems Centre

To establish a national focus for the development of next generation instrumentation systems for the STFC programme and maximise their impact in the wider UKRI and government landscape. Within the Harwell site, the Centre would combine the microelectronics support team that currently provides Europe-wide microelectronics training with instrumentation development teams, dynamic laboratories, testing facilities and computing infrastructure. It would also build on STFC's recent investment in clean rooms, test facilities and design expertise and host internal STFC and external staff to enable our UK teams to excel.

21 Gravitational-wave optical transient observatory: GOTO

This project would produce a cost-effective, sensitive optical facility using an array of autonomous robotic telescopes optimized for searching the large sky areas provided by GW detectors in order to locate their electromagnetic counterparts. GOTO would be a pivotal facility in the emerging field of gravitational wave astrophysics and transform our search capability.

22 The Simons Observatory: UK Telescope Array

This proposal is for a future UK Cosmic Microwave Background (CMB) Polarization Telescope. It will operate as an integral part of the wider US-led Simons Observatory (first light expected in ~2021), which will consist of multiple telescopes sited in the Atacama desert in northern Chile. A major contribution to the observatory is the cornerstone of the UK CMB community's future roadmap. The objectives are i) more precise measurements of secondary effects on the CMB (weak gravitational lensing, Sunyaev-Zel'dovich effects) and ii) more precise measurements of CMB polarisation.

23 Next generation ultra-sensitive receiver systems for ALMA

This project would develop next-generation mm-wave receiver systems with substantially improved sensitivity and enhanced spectral detection bandwidth, with an architecture allowing them to be configured as focal plane imaging arrays. This revolutionary approach, that utilises UK heritage in developing state-of-the-art low noise amplifier technology, would substantially increase the effectiveness of ALMA as a national community facility and simultaneously advance the considerable related technical expertise and skills that exists within UK universities and STFC.

24 New Robotic Telescope

A proposal for the New generation Robotic Telescope on La Palma to maintain and grow traditional UK strengths in time-domain and solar-system physics and support STFC investment in facilities such as LSST, aLIGO, CTA & PLATO. The NRT addresses Science Roadmap Challenges: A:3. Dark matter and dark energy; B:1. Extrasolar planetary systems; B:2 Dynamic influence of the Sun on Solar System bodies; D:1. Extreme physics; D:2. High energy particles and gravitational waves; D:3. Ultra-compact objects, extreme gravity and the impact on environment.

25 The Receiver Factory: SKA band 5 receivers for MeerKAT, AVN and eMERLIN

This project will set up a novel manufacturing facility to produce and install 80 SKA Band 5 receivers (covering 4.6 – 15.3 GHz) onto the MeerKAT, African VLBI Network (AVN) and e-MERLIN telescopes. These receivers will bring immense scientific capabilities and benefits: opening up a waveband in an area where the UK has huge scientific and technical expertise and allowing the UK to capitalise on its leadership within the SKA.

26 Laboratory Analysis for Research into Extraterrestrial Samples: LARES

To establish a networked UK centre for space sample analysis and curation, with the potential to be the world's leading facility in this emerging field. In the next few years it is expected that a range of space missions will return samples from comets, the Moon and Mars providing unique insights to the origin of our solar system and life. This centre will confirm the UK as the place to analyse, disseminate and curate these unique collections working with European, US, Japanese and Chinese agencies and will offer considerable PE & educational opportunities for STFC science.

27 Solar-C EUVST

A timely opportunity for the UK to play a leading role in the next Japanese Solar mission (which builds on the success of Hinode and compliments US/ESA developments) Solar-C-EUVST is a single instrument mission designed to provide conclusive answers to long-standing questions regarding the interplay of magnetic fields and plasma responsible for creating and driving solar activity. This project will provide opportunities for tech and industry engagement, PE and international partnering based upon current UK excellence in solar science.

28 SULIS: Solar cUbesats for Linked Imaging Spectropolarimetry

The UK has established itself as a leader in CubeSat technology, in both RIs and universities. The next stage is to enable science from coordinated suites of CubeSats – enhancing the research potential of this very cost effective tool. SULIS will be three CubeSat pairs that will fly in formation, one pair ahead and one pair behind Earth, whilst the third pair is in Earth polar orbit. It will be the first to directly measure the magnetic field of the extended solar corona, with the ability to create 3D reconstructions – with potential to understand how solar activity develops and leads to effects on the Earth – a solar physics input to the studies of Space Weather.

29 Main Belt Comet Low-Speed Impact Lander

A timely opportunity to engage with a planned Chinese mission (Zheng He) to a main belt comet (MBC) with the aim of better understanding the origin of the Earth's oceans and to test models of solar system formation. It would build upon the success of the Rosetta mission which had huge potential for PE and education. The development of a low-speed impact probe containing a mass spectrometer, together with a descent/sub-surface imager, an accelerometer and temperature probes would both build on current expertise, offer industrial engagement and potential for interdisciplinary research – notably in areas of miniaturisation and operation in extreme environments.

30 Solar Atmospheric Modelling Suite

The suite of new STFC-supported, facilities (SKA, Solar Orbiter, DKIST) likely to be on line in the next few years will require equally far reaching tools to allow their data to be fully exploited, based upon a sound theoretical basis. This facility will foster a coordinated programme of software development and validation with potential to be the world's leading resource for solar atmospheric theory. It will utilise developments in HPC and e-infrastructure, have potential for interdisciplinary research with those working on the Earth's climate and Space Weather.

31 Einstein Telescope

This project is for UK participation in the Einstein Telescope (ET), a proposed third-generation gravitational wave (GW) observatory in Europe and is one of ASPERA's "Magnificent Seven" research infrastructures. Conceived of as a set of underground interferometers whose arms form an equilateral triangle, ET will have 10 times the distance reach of Advanced LIGO across a broad frequency band, and be sensitive to GW frequencies as low as $\sim$1 Hz. This will constitute a facility with infrastructure capable of delivering science over several decades.

32 UK AION for the exploration of Ultra-Light Dark Matter and Mid Frequency Gravitional Waves

This proposal is to establish a world-class UK facility/centre and corresponding experiments that enables the exploitation of the very interesting mid-frequency band using quantum sensor technology. It would make the UK a leader in the exploitation of the enormous physics potential of this frequency band with many groundbreaking discovery options. These include the timely opening and exploration of a new territory in dark sector physics for ultra-light dark matter and probing the critical frequency band in the gravitational wave spectrum that is otherwise not covered by existing and future detectors, complementing LISA and LIGO. The centre would also facilitate the development of quantum sensor technology in general.

33 HAWC and SGSO: all sky Gamma ray Survey Observatory above 10 TeV

This project is to enable upgrade the High-Altitude Water Cherenkov Gamma-ray Observatory (HAWC), that is both complementary to CTA and an excellent instrument for the synoptic survey of all northern hemisphere diffuse and point gamma-ray sources. The second part of this project is for investment in the Southern Gamma-ray Survey Observatory (SGSO). Currently, there is no equivalent of HAWC or the Large High-Altitude Air Shower Observatory (LHAASO) in the southern hemisphere, meaning that continuous monitoring of the southern VHE gamma-ray sky is not possible above about 100 GeV.

34 TERAS: TEchnologies for RAre event Searches

This project brings together the direct dark matter and neutrinoless double beta decay (NDBD)

communities to develop a new and ambitious world-leading low-background technology development and radio-assay facility for future rare event searches. A significant part of this project also includes turning the Boulby underground laboratory into a unique facility offering a full set of technologies for radiopurity screening, sample preparation, precision high purity cleaning and ultra-low background detector development.

35 IceCube-Gen2

This proposal is to enable UK involvement in the IceCube upgrade project. The NSF have recently funded a seven-string upgrade of IceCube. These strings will be installed in a low-energy (PINGU-like) configuration. This upgrade also allows the drilling infrastructure to be refurbished, as a first step towards a massive high-energy upgrade of IceCube that will increase the detector volume by a factor of 10, significantly increasing the sensitivity of IceCube to astrophysical neutrinos.

36 The Electron-Ion Collider (EIC)

The most recent Nuclear Science Advisory Committee (NSAC) Long Range Plan, published in 2015, identified a future Electron-Ion Collider (EIC) as the highest priority new nuclear physics project in the United States. The EIC project will be the world's first doubly-polarised electron-nucleon/light-ion collider and the world's first electron-heavy-ion collider. The new facility is expected to commence operations around 2030.

37 EPIC: Exploiting potential of ISOLDE at CERN

This project will transform the capacity and capability of the ISOLDE facility at CERN to deliver radioactive ion beams to the UK and wider international community of scientists, impacting the fields of nuclear physics, astrophysics, atomic physics, materials science and fundamental physics. The project will maximise the benefit associated with the UK's CERN subscription and the upgrade of the CERN accelerator chain as part of the HL LHC project.

38 AGATA: Europe's Gamma-ray Spectrometer

AGATA is a continually evolving international detector facility and is planned for completion of the full 4π, 180-detector array by 2030. We have identified an opportunity to contribute at the very highest level to the current and planned phases of AGATA through developing a long-term solution for the electronics and data acquisition for the full 180- detector array. Such a solution does not yet exist and we envisage will provide bespoke electronics directly onto the detector unit, with the aim of providing a full 180-detector solution which also delivers improvements in performance, reliability and portability for the AGATA array.

39 DRACULA

In consultation with the NSCL Laboratory Director, we have identified a niche area for UK leadership at FRIB – **DRACULA** (**D**irect **R**eaction **A**rray for the **C**ore **U**nderstanding of **L**ight-nuclei and **A**strophysics). Here, we propose to develop a new, multi-configuration charged-particle detection system to be used in conjunction with the world-leading GRETA 4π coverage γ-ray tracking array and S800 magnetic spectrometer. Furthermore, we will provide critical upgrades to the existing A1900 analysis beam line and S800 focal plane, addressing an imperative need for the entire FRIB programme and thereby, dramatically increase the overall capacity of the facility.

40 UK Particle Physics Technology Centre

This project is to encompass a wide variety of detector R&D activities in one centre and contain a fund to be used for R&D around all UK institutes. The key deliverables will be i) a detector R&D research programme ii) a centre for Doctorial Training and iii) to establish a focal point for industrial engagement with UK particle physics.

41 Hyper-Kamiokande

The Hyper-Kamiokande (Hyper-K) experiment is the next generation, state-of-the-art flagship neutrino experiment targeting a broad physics program consisting of neutrino oscillations, nucleon decays, and astrophysical neutrinos with unprecedented precision. Hyper-K will be the third-generation underground water Cherenkov detector in Japan following on from Kamiokande and Super-Kamiokande experiments whose discoveries were awarded the 2002 and 2015 Nobel Prizes, respectively. This is project is to support UK activity on the Hyper-K experiment.

42 Precision Physics UK: next generation storage ring EDM and CLFV experiments

This proposal is to establish a significant UK leadership role in several next-generation precision physics experiments (PPUK) that will have improved sensitivities to EDMs and rare charged lepton flavour violating (CLFV) decays. It will involve a set of precision experiments that will look for deviations from Standard Model predictions.

43 Software Institute – *submitted as part of e-Infrastructure proposal.*

44 UK Novel Accelerator project

Co-ordinated programme of research for novel acceleration techniques. In particular, this project proposes a target area dedicated to novel acceleration work with provision for wakefield and ion acceleration on the GEMINI laser facility at the Rutherford-Appleton Laboratory; development of targetry and diagnostics to enable high-rep rate laser ion acceleration, new dedicated high-power laser beamlines on the SCAPA laser centre at the University of Strathclyde; and a beamline for testing plasma and dielectric structures on the CLARA electron beam facility at Daresbury Laboratory.

45 CLARA

Research and test accelerator for science and technologies underpinning a future UK FEL user facility. This project has three key objectives i) to pave the way for the UK to host ambitious next generation X-ray FEL light source user facility ii) to be the European test bed for accelerator R&D and iiI) to enable the UK academic, industrial and health sectors to develop new accelerator based technologies, treatments and frontier research.

46 CERN Future Collider projects

Accelerator R&D to support the development of future colliders for high-energy physics. Two options are currently under discussion as part of the refresh of the European Strategy for Particle Physics, a circular proton-proton collider and a linear electron-positron collider.

47 AWAKE RUN 2

In order to be able to apply the AWAKE scheme to applications for high energy physics, the AWAKE collaboration is developing a Run 2 programme (2021–24) in which electrons will be accelerated to higher energies, whilst preserving emittance and demonstrating that this is a scalable process. This project will be the next stage of UK participation in AWAKE (wake-field acceleration) experiment at CERN.

48 ExaPath: Exascale Pathfinder for Research and Infrastructures

The creation of a Centre of Excellence for per-exascale data driven computational research and innovation. The Centre will include a cloud based supercomputer with 55 Pflops and a team of research software engineer fellows. Building on DiRAC and IRIS, this project covers aspects of 'huge data' to provide a pathway to exascale specific architecture for STFC science.

49 College of Research Software and Infrastruture Engineers

To create a college of Research Software Engineers and Research Infrastructure engineers/technicians that are a coherent group across STFC and the universities that it supports. Aimed at creating a pool of RS and RI engineers/technicians that could be seconded to national facilities and science programme activities to carry out defined tasks, to enhance skills and career paths

50 The DiRAC 3 HPC Facility

This project is to provide the essential HPC facility that STFC theory communities need to maintain their world-leading position. This major hardware upgrade will provide the PPAN Theory community with internationally competitive computing resources to support their scientific leadership beyond 2020.

51 Data Wrangling, Curation, Discovery and Analysis Service

Cool storage is essential for AI and stepping stone for adding HTC value and it could potentially have commercial exploitation route. This project would give the opportunity to lead in this area, building on experience of CEDA and JASMIN and using FAIR principles to create a standards space.

52 e-Infrastructure for Programmes and Facilities 2019-2025

To tackle the diffuse problem associated with the upcoming large science projects and provide the necessary support to make an efficient and effective service to all the STFC science areas. This project focusses on the people element, which is a crucial aspect.