Pathways to Impact

Economy
At present there are 1,000s of x-ray radiography machines operating in industry, primarily at Airports and industrial quality inspection. Fast CT machines coupled with automatic threat or defect recognition will replace radiography over the next few years. It is anticipated that components from the three toolkits developed in this project will lead to at least three industrial studies to develop applications specific to industrial needs.

Industrial attendees will continue to be encouraged to assist and participate in the training and science workshops and from their perspective help to define key issues prior to developing any toolkit algorithms. The CCP covers a much broader range of tomography applications and will be open to more diverse industrial users; and consequently the uptake is expected to be far greater than this (see Critical Success Factors). As the CCP continues to develop it will broaden its remit into other tomographic applications (already we have coding collaborations with PET and Neutron Tomography) and this industrial focussed community will grow. Industrial connections have already allowed access to raw and metadata, reconstruction expertise, input through workshops and individual interactions. The following industrial companies and national organisations have all agreed to continue or become members of the network; Nikon Metrology, FEI, LaVision, Zeiss, Bruker, Deben, Simpleware, Tessella, BSI Group and the Natural History Museum.

Knowledge
This Tomographic Imaging CCP will benefit directly:

- ESRF and Diamond Light Source x-ray imaging users: The community is growing and it is estimated it involve 200 academic users per annum over many subjects (see below)
- ISIS Neutron and Muon spallation users, which will grow to dozens of academic users over the next few years, on the IMAT beamline that is becomes commissioned; these users will use tomography for experimental guidance as well as direct insight.
- Those with access to laboratory x-ray facilities: this is harder community to numerate since the number of laboratory facilities is increasing rapidly and it is estimated at a conservative there are 50 imaging instruments in the UK at present. Nikon Metrology's factory in Stains alone is now manufacturing three to four laboratory based facilities a month (Sep 2014).

Figures for the University of Manchester's Henry Moseley x-ray Imaging facility alone run at over 300 experiments per year with about 1 industrial user per week.

The research disciplines that will benefit include:

- materials scientists (foams, Li batteries, fuel cells, composites, metals microstructure, creep, fatigue, ceramic laminates, nuclear graphite, etc)
- biomaterials scientists (ingress of tissue into artificial bone, skin, cartilage, etc)
- physicists (imaging nanodevices, solar cells, nanotubes, etc)
- medics (cancer, etc)
- dental scientists (teeth, cement)
- mechanical engineers (structures, collapse, cracking, etc)
- chemical engineers (gels, aerated materials)

As well as traditional pathways to impact we will continue to fund, staff exchanges and international fellowship visits to encourage knowledge transfer.

- life scientists (systems; viruses, spores, cryo-imaging – to localise proteins and organelles within cells and tissues)
- geologists (oil extraction, rock, CO_2 sequestration, fracking)
- aerospace engineers (thermal barrier coatings, composites, etc)
- palaeontologists (fossils, artefacts)
- civil engineers (concrete, soils, sediments, intumescents)
- cultural heritage (pots, artefacts, art)
- food technology (bread, chocolate)
- x-ray instrument developers

One of the key pathways to impact so far has been the software show-and-tell sessions, the annual symposiums, workshops, and training exercises. These enable knowledge transfer to the academic community and industry and vice versa. A key further industrial impact has been the presence of a CCPi sponsored stand at KTN Materials and TSB Intelligent Imaging Programme events.

EPSRC Software as an Infrastructure strategy
Not only does this CCPi assist and aid some of the major national facilities but it also utilises related infrastructures including compute clusters within STFC and in the regions. There have been initial software development training to

the community, and following the quote “Better Software Better Research” we have members who are fellows (currently Mark Basham) within the SSI (Software sustainability Institute); and members within the CCP_FORGE in STFC.

In the first phase we have taken opportunities to increase skills by collaborating and sharing expertise including, coding a new multi-grid methods exploited with developers in the CCP_ASEArch (Evgueni Ovtchinnikov) and a case study with the Harwell Imaging Partnership (Martin Turner). We are also aware and have been in consultation regarding overlaps regarding Tomographic algorithms with proposed and current CCPs including; CCP_PET/MR (Kris Thielemans), CCP_VISUK (Min Chen), and CCP_EM (Martyn Winn, funded by MRC). Internationally this networking has been expanded in the first phase to become a member with the Europe (COST action) and recently been invited to link with the US Argon National Labs (Advanced Photon Source).

Society
With ‘Beyond 3D’ the project will also focus benefit in the area of Medical Imaging; including image guided radiation therapy (IGRT) equipment as improved image quality will be essential to support dynamic tumour targeting, treatment intervention and adaptation. A pathway to impact in this area will be the production of 3 highlights videos each year to be made available to the Network community to communicate the benefits of the project to stakeholders, to inspire young people in STEM subjects and to raise awareness of the general public. The Working Group expansion already includes applications from the STFC Outreach Fellow and Royal Microscopic Society.

People
We have a strong record of developing young researchers. For example, 12 of Prof. Withers students have gone on to lectureships/Chairs elsewhere and 6 more are now instrument scientists, while at Imperial 6 of Prof. Lee’s are now lecturers or Chairs (e.g. at CMU, Tsinghua, NTU), as well as key industrialists, worldwide. Involvement in a multidisciplinary community is expected to provide an incubator for new scientists and engineers on the Harwell site. Most importantly our training activities have upskilled over 100 PhD students and post-doctoral researchers in quantification and reconstruction algorithms. This will continue to be a large part of the work the CCPi undertakes and costs are included for this.

Finally, visual information can be a great aid to understanding (‘seeing is believing’). This project will deliver results that can be appreciated by the novice as well as the expert. To this end it will have a significant public engagement mission with £3k per year spent on developing touch screen n applications and short animations that showcase the imaging opportunities enabled by this grant for showing to politicians, industrialists, members of the people as well as schoolchildren. These will be made available for all within the network to use. In our first period of funding we were able to real a very large audience from politicians and decision makers (as at the Materials Exhibition at the Reebok, and meetings of Prof Withers with David Willets and George Osborne showcasing the CCPi work our ToScA conference at the Natural History museum through to the general public at the Royal Society Summer Exhibition and Science weeks. Costs are included to facilitate our public engagement activities and our communication tools and media.