Medical Diagnosis – but not as we know it!

A space-ship style sick bay, bristling with futuristic instrumentation – some of which is unique in the world – has been deployed at a hospital A & E unit thanks to collaborative work by a University team.

“We are replacing doctors’ eyes with state-of-the-art imaging systems, replacing the nose with breath analysis, and the “feel of the pulse” with monitoring of blood flow using ultra sound technology and measurement of blood oxygen levels.”

Professor Mark Sims, Space Research Centre

Capnometer, NO analyzer and spirometer: Measures exhaled carbon dioxide, nitric oxide and breath flow and volume to assess lung function.

Multi-spectral imager: Measures patient’s colour changes. Quicker but less spectrally detailed than hyper-spectral imager.

High-definition infra-red imager: Measures temperature distribution and changes which can be a sign of problems.

LCD monitors: Show imaging data.
Thoracic electrical bioimpedence monitor: Shows how well heart and circulation are working.

Transcutaneous oximetry monitor: Measures oxygen and carbon dioxide in blood.

Gas sampling instrument: Breath analysis mouthpiece and tubing linking to the spirometer, mass spectrometer and NO Analyzer.

Mass spectrometer for breath analysis: Looks at volatile organic compounds that relate to body’s metabolism and bacterial infection.

Propac monitor: Standard NHS machine that measures pulse, blood pressure and electrical activity of heart.

Near infrared spectroscopy monitor: Measures oxygen in body.

Supra-thoracic Doppler: Ultrasound, measuring heart function.

Hyper-spectral imager: Picks up detailed changes in colour (spectrum of reflected light) of patient that for example could mean liver or kidney problems.

Thoracic electrical bioimpedence monitor: Shows how well heart and circulation are working.
Imagine being able to help detect and diagnose a disease simply by sight, or smell or feel. No incisions, blood tests or invasive probing – and the potential to speed up diagnosis.

Implausible though it may sound – it is now becoming a reality at the Leicester Royal Infirmary Accident and Emergency Unit – thanks to the University of Leicester.

Our experts from a range of departments have teamed-up to use technologies utilised in space missions and other applications – and applied them for medical advancement here in Leicester.

We are using three different types of cutting-edge technology in combination and have surrounded a normal hospital bed with an unprecedented array of technology to examine patients:

- One group of instruments (developed in the University’s Chemistry Department) analyses a patient’s breath.
- A second uses imaging systems and technologies based upon those developed to explore the universe – to hunt for signs of disease via the surface of the human body.
- The third uses a suite of monitors to look inside the body and measure blood-flow and oxygenation in real-time.

The technologies employed in the new Leicester Diagnostics Development Unit have never previously all been used in an integrated manner and with such a large pool of patients.

This initiative has brought together teams from space research, emergency medicine and atmospheric chemistry groups, working with colleagues in Cardiovascular Sciences, Infection, Immunity and Inflammation, Physics and Astronomy, Engineering, IT Services and the UHL NHS Trust to create the Unit.

Some of the advanced technology and science behind the unit was developed at the University of Leicester. Explaining how the project came about, Professor Mark Sims, from the Space Research Centre, said: “We are developing a device called the Life Marker Chip for the ExoMars space mission. It will look for organic molecules in samples from below the surface of Mars, helping to answer a question that has been fascinating mankind for many years – is there Life today or was there Life in the past on that planet?

“Developing it has involved both space technology and biology. The project therefore brought us into contact with health organisations and associated technology and helped lead to this initiative.”

Appropriately for something that comes from outer space, the technology might also be a first step towards ultimately developing in the in the long term (5-10 years+) devices akin to the ‘tricorders’ from Star Trek – used by medics in the sci-fi series to diagnose illness simply by waving it near a patient, said Professor Sims, who works alongside Tim Coats, Professor of Emergency Medicine at the University and head of accident and emergency at the Royal Infirmary.

Professor Sims said: “We are replacing doctors’ eyes with state-of-the-art...
imaging systems, replacing the nose with breath analysis, and the “feel of the pulse” with monitoring of blood flow using ultra sound technology and measurement of blood oxygen levels.

“In the old days, it used to be said that a consultant could walk down a hospital ward and smell various diseases as well as telling a patient’s health by looking at them and feeling their pulse. What we are doing is a high tech version of that in order to help doctors to diagnose disease.”

The Diagnostics Development Unit has identified over 40 possible applications to date.

Professor Sims explains that human breath contains a range of by-products (so-called volatile organic compounds) from bodily processes. Identified by a novel instrument called a real-time mass spectrometer, they can provide clues to a wide range of diseases. He says: “An obvious example is ketones, which we detect in the breath of diabetics during hypoglycaemia. But there are also chemicals that can or could be used to indicate conditions such as asthma, sepsis, liver disease, heart disease, and several types of cancer.”

As described by Paul Monks, Professor of Physical Chemistry: “While gases in the breath are the main focus, the same technology can also be used to analyse urine and faeces and there is a project currently being undertaken on C.Difficile”.

One potential especially interesting target is sepsis because it is hard to detect at an early stage, is a considerable burden on the NHS and is expected to exhibit a number of different effects on the body that can be detected by the combined instrumentation.

Space technology is behind the imaging equipment used to gather information from patients, using visible light wavelengths as well as invisible infra-red light.

It includes a thermal imager to see patients’ surface and core temperatures by imaging appropriate targets on the body. Comparing the two temperatures can reveal disease because one response to illness is to withdraw blood from peripheral parts of the body.

Other devices (multi-spectral and hyper-spectral imagers) can in principle detect subtle changes in skin colour. Liver disease is associated with yellowing of the skin and it is possible that this equipment could detect it before it is readily visible to the human eye. Imaging technology can also see veins close to the surface of the skin inside the body and detect whether the blood contains enough oxygen or is oxygen-poor and whether circulation in the extremities is shutting down due to medical shock etc. Also early stage bruising and skin cancers should be detectable.

According to Professor Coats, early disease detection often leads to better outcomes. This technology could make for quicker and more patient-specific diagnoses.

The researchers are using a £500,000 infrastructure grant (from Higher Education Funding Council along with a contribution from the University) to equip the Unit.