

Assignment 01
Introduction to Industry 4.0

**Laser Technology Centre at Bangor University and Industry
4.0**

Submitted to:
Dr. Mahesh Kannath

by:
Yasir Joya
(Bangor University)

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Abstract:

The need for high efficiency, short lead times and high profitability has sparked efforts globally to invent systems with increased functionality, added value, automation and self-diagnostics to warrant standardised manufacturing operations. Since its inception, Industry 4.0. technologies have taken a paradigm shift emerging as next evolution of smart manufacturing and digital technologies connecting billions of people. This report presents an academic case study where expanded capability of the department be put to maximum benefit by allowing industry 4.0 standards for establishing advanced laser technology centre. The issues with the existing labs space and infrastructure are also highlighted and solutions are proposed to implement advanced protocols and central control through sensors and devices to maintain safe and efficient operation standards.

Introduction:

This report includes description of the key processes and typical challenges encountered by the users of the engineering labs containing sophisticated research equipment. School of Computer Science and Electronic Engineering (CSEE) at Bangor University (BU) houses a range of lasers systems, specialised optics and photonics equipment and advanced electronic instruments. In the past several years, more lasers and expensive kits for high power photonics applications were acquired for research. However, dedicated lab for safe keeping of the equipment and optimum operation became a challenge owing to limited space remaining in the building. Involvement of new research facility i.e. digital signal processing (DSP) centre, and nuclear futures Institute (NFI) at BU are great addition to the school strength though, complicated the things and need for a centralised control of lab facilities and space conservation was discussed.

Facility upgradation of the research equipment demonstrates the capability of the school, which has been expanding rapidly in recent years, thanks to the generous investment by the Welsh Government, benefitting collaborations with the local manufacturing sector. These developments have soured potential issues in operating advanced equipment installed in existing labs most of which are outdated and lack standards of safety required for modern academic infrastructure. The use of the advanced lasers, optical and electronic equipment to its full potential is a challenge and long-term use may lead to potential problems such as inconsistency of data and reliability issues. Full-scale use of these research facilities is vital to fulfil the department mission and creating an impact on the economic growth of industrial sector pan Wales. Major reforms in buildings structure, size and research infrastructure is essential to realise this aim. The objective of this report is to carefully assess those challenges and propose plausible solutions to improve the delivery of outcomes and increase collaborations between the academic and industrial sector through proactive involvement of a central laser processing and fabrication facility. In addition to the 09 laser systems at CSEE, there are multiple characterization machines including high-resolution laser confocal microscope and 3D optical microscope, range of spectrometers and clean room equipment which are in high demand for research and study.

The school has assigned a technician for supporting these labs and maintain, this incurs long delays if something goes out of order suffering the research output by students and staff. The need for a centralised control of the lab equipment for track and trace of issues and for efficient operation of labs is highly desired. The existing space to accommodate all research facilities has been diminishing as two individual schools (Computer Science, and Electronic Engineering) share the same building and have their experimental facilities distributed through multiple rooms and variable labs. Procurement and installation of new laser systems has been affected, for example, a new high power ultrafast laser system (£150k) was procured recently through a funded project. However, during installation it was realised the allocated lab space was unsuitable due to ingress of humidity and temperature variations in the space. The laser was confined to remaining lab rooms already housing 08 laser systems along with peripheral equipment, which may induce electromagnetic interference to the laser products.

This report aims to iterate possible solutions via potential involvement of industrial internet of things (IIoT) through industry 4.0 technologies. The term IIoT is nothing new, it has been impacting our lifestyle from how we exercise to how our cars operate for a decade (Boggess, 2020). Industry 4.0 is the next evolution of smart manufacturing and digital technologies in the era of fourth industrial revolution. This is enabled through involvement of robotics, sensors and devices and integration with the laser systems to control various operations. This will ensure instruments perform smoothly as issues with machines can be detected at entry point and solved quickly before turning into a major accident. We need to think how these industry 4.0 technologies may be integrated to realise this model and make working space safer and productive for all.

Implementation Methodology:

As discussed earlier, establishing a dedicated laser engineering centre at the University/school is essential to integrate the engineering equipment, systems and devices under one roof, increase visibility, enhance the efficiency of machines bringing more productivity to operations. This solution will also benefit the teaching programs, scholarly research output, collaborations and creating jobs. Following steps may be followed to implement this proposal.

- 1) Selection and identification of lasers, instruments for a job
- 2) Introduce latest technologies and tools to improve process efficiency, enhance output
- 3) Integrate sensors and devices to monitor systems health, such as humidity and temperature sensors to control ambient conditions recommended for a particular machine
- 4) Sensors to detect the laser on/off status and display outside the room.
- 5) Control system of an industry 4.0 standard showing all laser systems, peripheral equipment status and maintenance requirements
- 6) Display screen to show the live monitoring of the devices for accessibility and real-world system diagnostics and troubleshooting
- 7) Provision of dedicated trained staff (technician, engineers) to oversee the engineering operations, machine calibration, laser safety training instructors for the centre

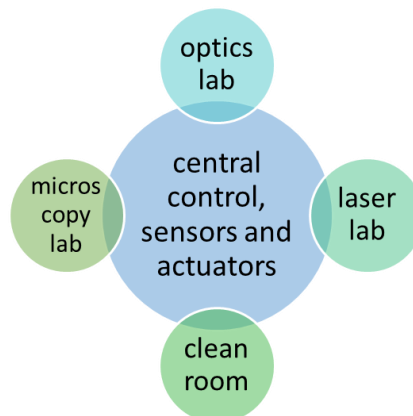


Figure 1. Schematic chart showing the relationship between various labs and central controls

Some of the advantages anticipated by implementing this model are as follows:

- 1) Establishing state-of-the-art laser tech centre in the region, allow training facility for human resource generation and creating jobs for manufacturing sector
- 2) Outlook of the school will improve, increasing visibility and marketability of resources
- 3) Student intake will increase, especially with protected characteristics to join for study and research

- 4) Industrial outreach will improve, yielding more collaborations, enterprises will be attracted the centre for working on solutions with academics
- 5) School will benefit through the upgraded facility, which will be reflected in REF reports, contributing to improve ranking of the university
- 6) Research output will be increased, through more efficient use of lasers and associated equipment, shorter lead times by track and trace through regular monitoring

The present proposal for transforming the existing laboratories with robust inhouse IIoT system is backed by the model of industry 4.0. technologies to implement the solution. This is a smart manufacturing environment where technological advances are enabled by integrated operation (Trott, 2021). Similarly connecting the sophisticated machines, laser systems, optical devices and instruments to a central server accessible by the manufacturer will enable live monitoring, diagnostics, timely maintenance to serve the customer demand (Fig.1). The modern laser systems are being designed with advanced software and digital automation (Andrew Stadler, 2009) for this reason with remote connectivity option to the manufacturer lab for diagnostics, calibration and service through effective feedback mechanism. This is enabled by the developments in cloud computing and IIoT technology for gathering, storing, and analysing huge quantities of data at economic costs (Gilchrist, 2016).

At the same time, improving the energy efficiency of buildings and offices, partly to this move, will contribute energy savings, reducing CO2 emissions contributing to the net zero goal by UK govt (GOV.UK, 2020). One of the strategies to implement this plan is to improving building management through control systems with potential to improve building energy efficiency. For this purpose, installing sensors/actuators on thermal radiators or air conditioning may require comprehensive labour, however latest advancements in EM technology and the IoT especially, use of smart sensors and devices with wireless functions, will significantly reduce the disruption cost helping to make smart buildings a reality. The smart lab concept integrates sensors and cameras for detection of fire, smoke and capability to trigger alarms and countermeasures in a real-world scenario guiding the public to safe exit from the premises (Gilchrist, 2016). Intelligent use of these sensors and devices will also help to reduce accidents and undesired process disruption. An example of implementing efforts to cutting emissions and meeting future sustainability goals is reflected in BU's strategy recently (strategy, 2022) among other institutes in the UK. This is the moment to start focusing on labs upgradation feeding into the design of a laser technology centre at the institute.

Conclusions:

- The smart office/labs are efficient solutions to introduce advanced manufacturing solutions where space limitations .
- The use of industry 4.0 technologies for laser systems can be deployed in standard lab space to perform system checks, functions and parameters of the lasers
- Industry 4.0 technologies allow laser systems to be integrated with sensors (optical/IR) for proximity testing, focus and power adjustments without manual adjustments of the optics.
- Remote control access of the sensors to the external server will allow early diagnosis and timely troubleshooting where required.

Recommendations:

- Development, health review of labs infrastructure at the school to inform upgradation
- Integrated system for labs protocols and safety documents for public accessibility
- Online booking systems and live monitoring of availability for a machine, EDI
- Appointment for dedicated staff for laser technology centre
- Allocation of new dedicated space for installation of new equipment

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