LumiNotify

Automated Light Intensity Measurement for Visual Notification Appliances

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

FM Approvals

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Company Overview:

FM Global is a leading property insurer of the world's largest businesses, providing more than one-third of FORTUNE 1000-size companies with engineering-based risk management and property insurance solutions. FM Global helps clients maintain continuity in their business operations by drawing upon state-of-the-art loss-prevention engineering and research; risk management skills and support services; tailored risk transfer capabilities; and superior financial strength. FM Approvals is a wholly owned subsidiary of FM Global. FM Approvals is an international leader in third-party testing and certification services. The company tests property loss prevention products and services—for use in commercial and industrial facilities—to verify they meet rigorous loss prevention standards of quality, technical integrity and performance.

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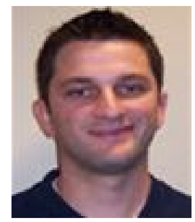

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Project Motivation:

Visual Notification Appliances (commonly referred to as "strobes") are used as part of a fire alarm system to alert building occupants when to evacuate the building. FM Approvals tests and certifies visual Notification Appliances to two standards: FM3155 and EN 54-23. Both standards require the measurement of light intensity output on-axis and also measurement of the spatial distribution of light intensity off-axis. This is done by mounting the strobe onto a fixture that spaces the device the required 10 feet from the light intensity meter.

To adjust the individual angular settings of the measurement fixture manually, and take a light intensity reading at each setting, is a very time consuming activity. The motivation of the project is to motorize the respective angular settings and automate the light measurement, thereby saving test time on each project.

Anticipated Best Outcome:

A measurement fixture with the following features:

- Fully motorized α and β turntables, meeting the angular accuracy requirements
- 3 axis linear adjustment to correctly position the Unit Under Test (UUT).
- Control sequencing of the α and β angles, and light intensity measurement collection at each angular combination.
- Data output in a .XLS or .CSV file.
- Preprogrammed with common test scenarios with user configurability for custom test scenarios.

Project Details:

The fixture consists of two graduated turntables. The lower one permits angular rotation of the device relative to the meter in the horizontal plane (referred to as α angle in EN 54-23). The second turntable, mounted on top of the lower one allows angular rotation of the strobe device around its axis (referred to as β angle in EN 54-23).

In preparing for EN 54-23 accreditation, the β angle turntable was motorized with an off the shelf stepper motor and controller combination. This allows specific angular displacements to be dialed in via the controller, and the device is indexed as required. This is much quicker and more accurate than turning the turntable by hand and reading the graduations.

However, an off the shelf motorized solution was not found for the α angle turntable, as a more powerful motor would be required. Manual setting of this angle is still required.

The vision for the Capstone project is:

1. To motorize and control the α angle turntable.

2. To automate the light intensity measurements. This would entail indexing to the required α angle and β angle, initiate the light intensity measurement, record the reading, index to the next angular combination, record the reading and so on until all the required measurements are taken.

The project could build upon what has been developed to date, or be an original solution.

The smallest α angle and β angle increment is 5O and angular setting accuracy is ±0.5O.

Configurability and Data Collection:
It is anticipated that the overall sequencing and data collection will be accomplished using a PC. There would be selections to sequence the common measurement requirements (e.g. EN 54-23 Tables A.2 through A.4) and have flexibility to program custom angular combinations.

The output would be an array of light intensity measurements, which could take the form of a spreadsheet or CSV file.

The normal output of the strobe device is a light flash (of 1-2 ms duration for Xenon tube devices), at approximately 1-2 flashes per second. It should be noted that the light intensity meter integrates the light output of 10 flashes, so there may be the need for a photo sensor to facilitate counting the flashes.

Existing System:
The existing system, in addition to the α angle and β angle turntables, features 3 axes of linear adjustment to position the unit under test so that the light element is directly over the fulcrum of the α angle turntable and centered on the axis of the light intensity meter. This is accomplished using 3 orthogonal translating slide tables (see Figure 1 for definition of x, y and z axes). There will be no requirement to motorize the linear adjustments, as these are set once for each UUT and will remain set for the duration of the testing.

Photographs of the existing positioning system are shown in Figures 1, 2 and 3.

Existing Equipment:

- Light Meter (radiometer): International Light Technologies model ILT1700, using the SED033/Y/W light sensor.
- β Angle Turntable: Thorlabs Inc model NR360S Nano Rotator Stage.
- β Angle Turntable Stepper Motor Driver: Thorlabs Inc model BSC202 Two Channel APT Benchtop Stepper Motor Controller (note: this has the capability to drive 2 Thorlab stepper motors, but only one is presently used).

The fixturing and linear translation devices are all Thorlabs stock items.

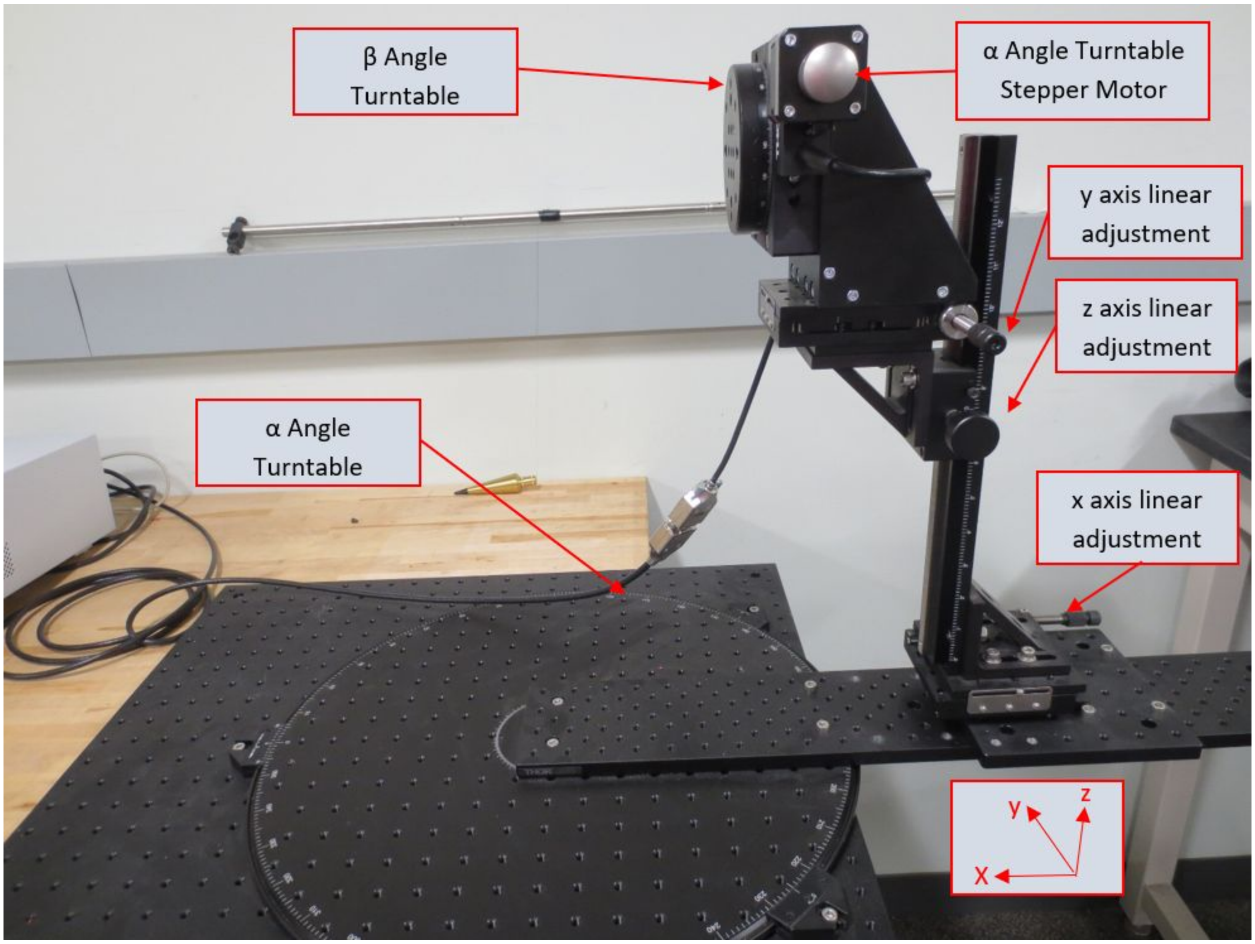

Figure 1 - Side View of UUT positioning fixture

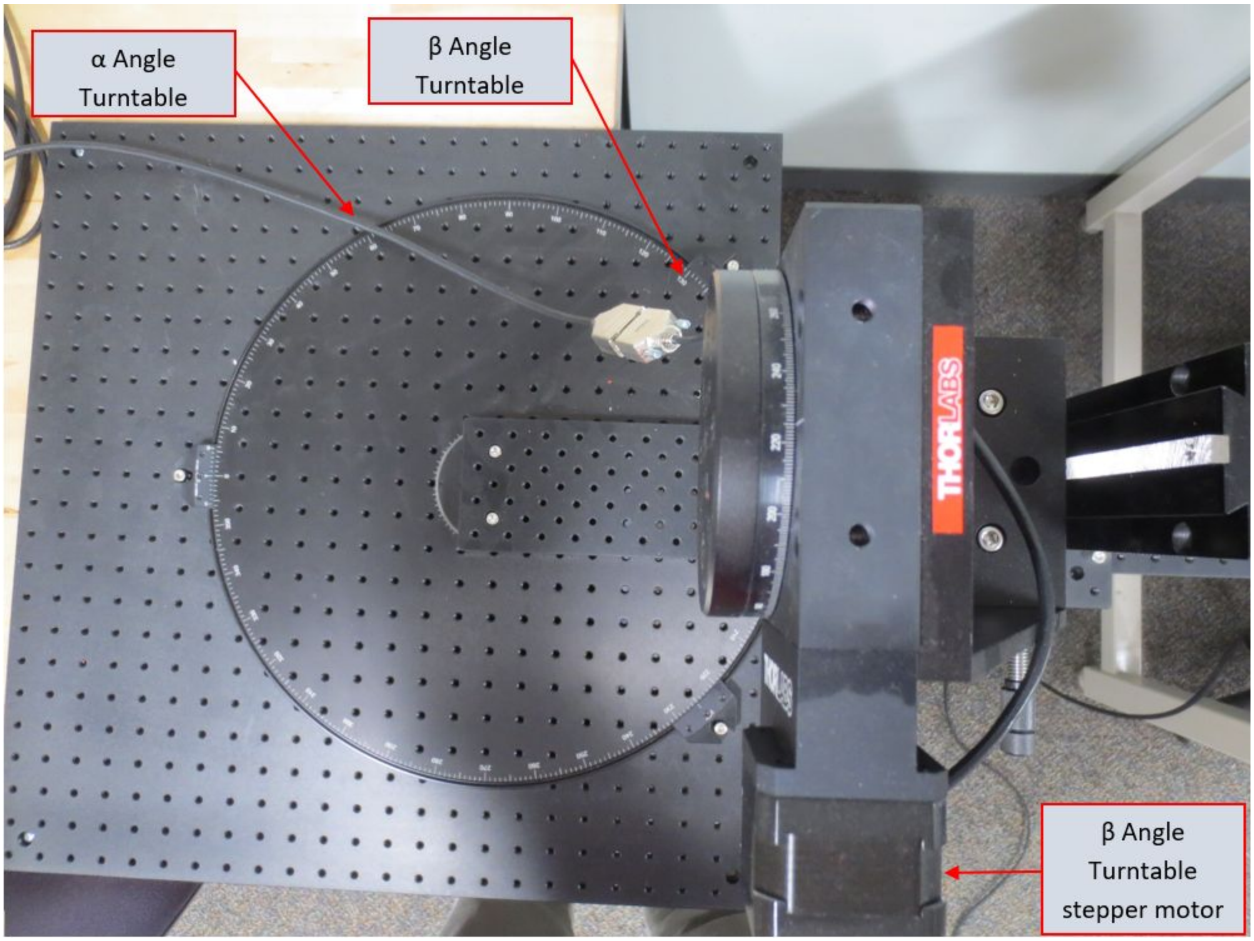

Figure 2- Plan view of UUT positioning fixture

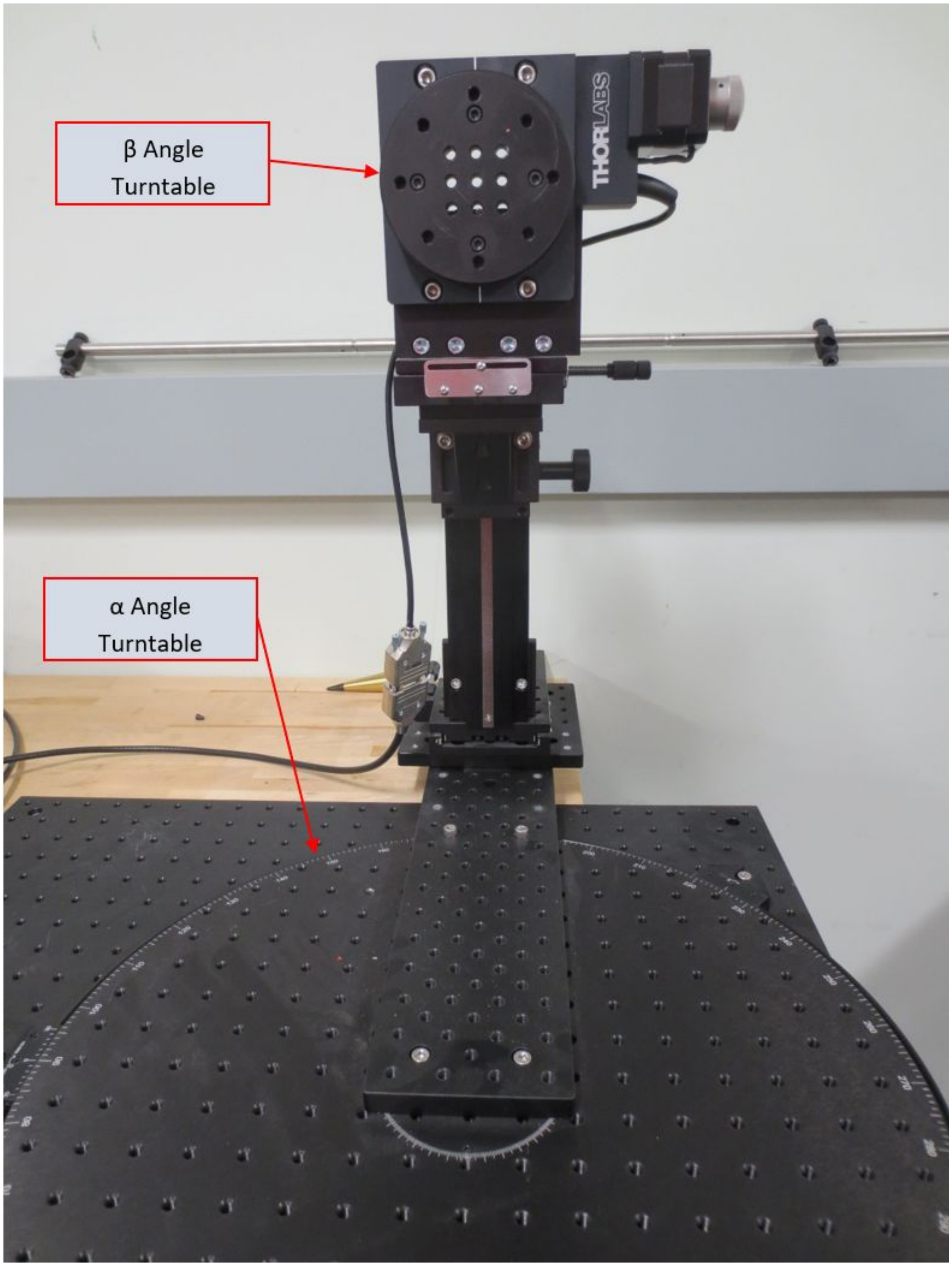

Figure 3 - View looking directly at the UUT mounting face (α angle set to 90 deg)

Overall system concept:

The Anticipated Best Outcome will permit the following test sequence for the testing of visual notification appliances (with reference to Figure 4):

1. The UUT (Unit Under Test) is mounted to the face of the β turntable, so that the light element is directly on the axis of rotation of the turntable.

2. Using the x, y and z axes linear translators, the UUT is positioned in space so that the light element is directly over the axis of rotation of the α turntable and is on the axis of the light meter.

3. Using the PC, the test sequence is selected from a menu of test options. The test options will be preset to sequence through the angular test requirements of EN 54-23, Tables A.2, A.3 and A.4 (6 sequences in total) and FM 3155 (one sequence). Alternatively, another option will allow the user to select a custom sequence of α and β test angles.

4. Once the test sequence is selected the option to initiate will be presented. When selected, the test sequence will begin: at each α and β test angles, the UUT is powered and the light output from 10 flashes is measured by the light meter and the resulting reading is retrieved from the meter by the PC and logged. In this concept, the flash count is sensed by a photocell, but other solutions may be possible.

5. The UUT is depowered and transitioned to the next test angle (in this concept, power to the UUT is turned on and off in sequence, but other solutions may be possible e.g. a controlled shutter in front of the light meter).

6. At the conclusion of the test sequence, the results of the test are presented as an array of α and β test angles with the corresponding light measurement. This will be available as a .CSV or .XLS file.

Note: with an assumed light measurement of 10 flashes and with an allowance of 1-2 seconds to reposition the UUT, the time to perform the maximum test sequence (EN 54-23 Table A.4 for C devices) would be in the region of 3 hours.

Block Diagram:

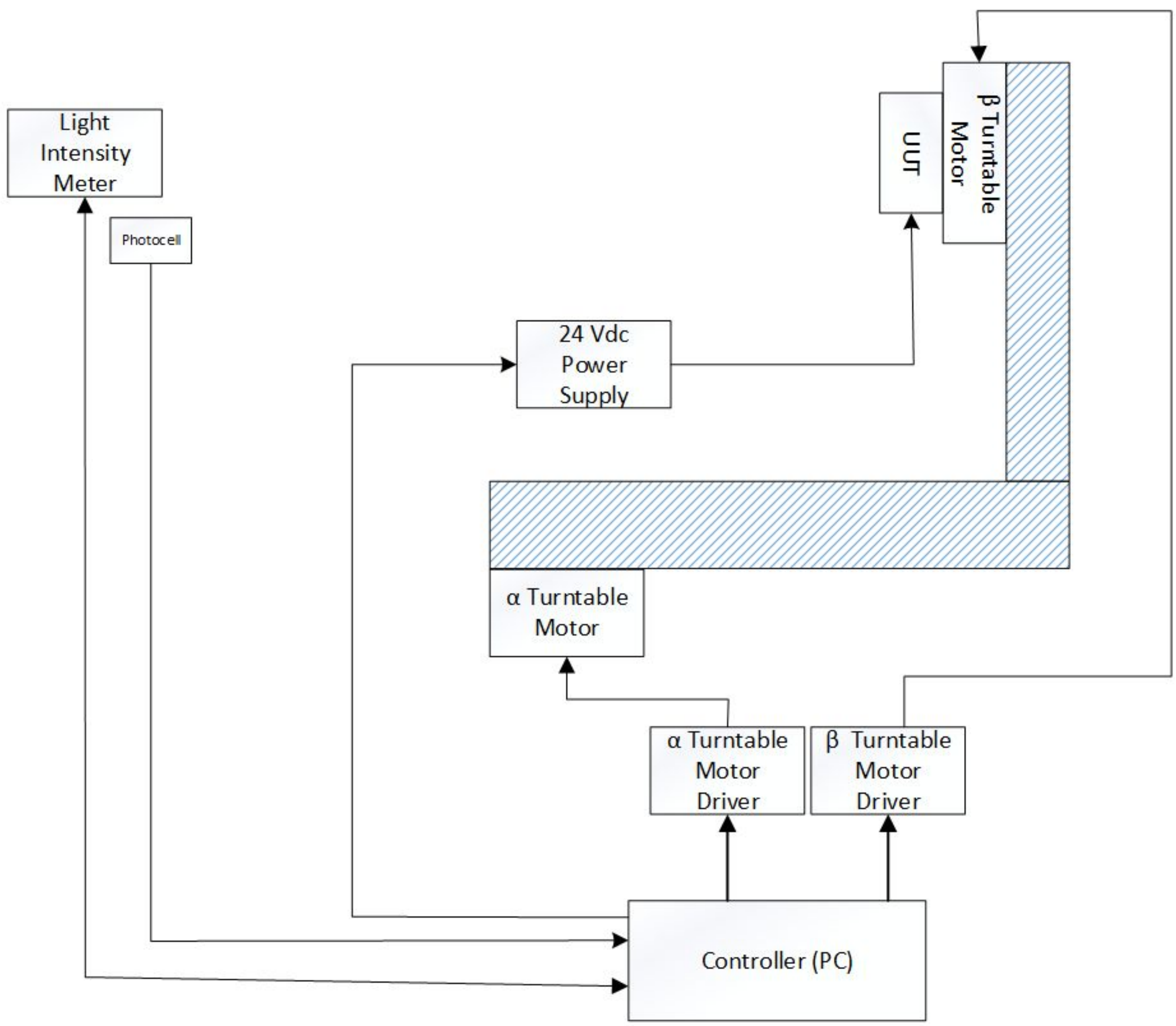

Figure 4 - UUT Positioning System Block Diagram

Hardware/Electrical Tasks

- Selection of rotary fixtures with adequate motor capability.
- Sizing /selection / design of the motor drivers.
- Selection of instrumentation with adequate interface capability to facilitate PC control.

Firmware/Software/Computer Tasks

- Sequencing / data collection software.
- Depending upon the final concept, the following items will be controlled / sequenced:
  - Power to the UUT
  - α and β test angle motors
  - Initiate light meter and retrieve the result
  - Count the flashes
  - Compile the results
- User configuration software.

Composition of Team:

1 Computer Engineer and 1 CPE/ELE Double Major.

Skills Required:

Electrical Engineering Skills Required:

- Motion control basics
- Sizing motor / driver and mechanical interface
- Circuit design (minimal)

Computer Engineering Skills Required:

- GUI Application Development
- Experience with embedded systems/actuators
- Experience with low level programming languages like C
- LabView experience is welcome, but not required

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact:

The Best Outcome will save on test time significantly. All FM Approvals test and certification projects are estimated based upon time, so a reduction in test time will result in a more competitive proposal to our customers and will shorten the total project duration.

The estimated savings are $10 – 20k per year*.

**Based upon an assumed 10 manual measurements per hour, medium sized project, 2 to 3 projects per year.*

Broader Implications of the Best Outcome on the Company's Industry:

There may be opportunities to invest in more automation for other product testing. Automation of the measurement process parallels all industries shifting from those requiring skilled laborers to a perfect or near-perfect computer system. This allows for greater specialization of employees, increases production rate, and allows companies to leverage resource on advancing their technologies and pursuing larger challenges.