# DEVELOPMENT OF A SIMPLE ROBOT WITH HUMAN-ROBOT INTERACTION (HRI) FEATURES

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Robotics and Automation) (Hons.)

by

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# DECLARATION

I hereby, declare this report entitled “Development of A Simple Robot with Human-Robot Interaction (HRI) Features” is the results of my own research except as cited in the reference.

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| Date | : | …… |

# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.). The member of the supervisory is as follow:

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(Dr. Syamimi Binti Shamsuddin)

# ABSTRAK

Bidang interaksi antara manusia dan robot (HRI) merupakan satu bidang yang menyiasat tentang bagaimana manusia berinteraksi dengan robot. Tujuan utama projek ini dilaksanakan adalah untuk membina sebuah robot yang mempunyai kelebihan berinteraksi dengan manusia, dan melalui kelebihan ini robot dapat membantu menyelesaikan masalah menungu jururawat yang di hadapi oleh pesakit dan pelawat di hospital. Ciri-ciri interaksi pada robot untuk projek ini dibentukkan mengunakan paparan LCD yang disambungkan pada kepala robot dan panggilan robot untuk bantuan menggunakan butang kawalan jauh tanpa wayar. Project ini mengandungi tahap perancangan, mereka bentuk, pembangunan produk dan analisis. Tahap perancang merangkumi kajian literature dan metodologi. Manakala tahap mereka bentuk adalah dalam perisian SolidWorks 2013, Proteus dan Nextion Editor. Satu daripada dua konsep reka bentuk yang dilukis, dipilih untuk tujuan fabrikasi. Kemudiannya, produk yang siap di fabrikasi itu dimasukkan mikrokontrol Arduino Uno. Selepas itu, diteruskan dengan process pengaturcaraan, ujian kebolehpercayaan, dan ujian robot mengikut barisan yang ditetapkan, ujian butang kawalan jauh tanpa wayar dan ujian skrin sentuh LCD. Seterusnya, tahap analisis dijalankan di Pusat Kesihatan Pelajar UTeM untuk meninjai kebolehgunaan robot di situasi yang benar. Ujian dijalankan menggunakan dua sukarelawan di klinik tersebut. Diakhir projek, ujian yang telah dilaksanakan dalam projek ini membuktikan bahawa robot yang dibina dapat berkomunikasi dengan manusia di kawasan hospital.

# ABSTRACT

Human-robot interaction (HRI) is the field investigating on how humans interact with robots. The main purpose of this project is to develop a simple robot with HRI features to solve the waiting problem of hospital patients and visitors to get attention from nurses. Interactive feature of the robot for HRI purpose is a touchscreen mounted on a line-following mobile platform and the robot is called using a wireless remote call button. This project consists of planning, design, product development and analysis stage. Planning stage covers literature review and methodology. Design stage include using mechanical design software; SolidWorks 2013 to design the outlook of the HRI robot, electrical design software; Proteus to design and simulation to check hardware connections and current flow on circuit, for interface designing; Nextion Editor software was used to design and create application for interaction purpose. Two different conceptual designs were produced and finalized to select the best one. The selected design was fabricated. The product then was mounted with Arduino Mega microcontroller. The microcontroller goes through programming phase, where a series of simple reliability tests was conducted; line-following test, wireless remote call button test and touchscreen test. For the analysis stage, a usability test was conducted at Pusat Kesihatan UTeM to carry out observations and distribute survey questions to patient volunteers. Results were analysed and documented. From observations, the tested patients could communicate with the robot and request for services provided by the robot**.** This shows that this simple robot with HRI features was able to interact with patients in hospital environment.

# DEDICATION

Special thanks to my beloved family members, lecturers, seniors and fellow friends who guided and inspired me through my journey in education. Also appreciate their support, motivations and beliefs in me.

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Praise the lord for helping me to complete this final year report successfully in time with great manner even though a lot of obstacle had to be face through the journey in completing this assignment that have been honoured to me in style. Moreover, here I would also like to express my gratitude to my parents who have helped me in many ways such as contributed ideas and money to make sure my final year project flows smoothly without any major problems.

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# INTRODUCTION

## 1.1 Background of Study

The real term of robot comes from a Czech word, robota, meaning "forced labor." In a Czech playwright, robots eventually overthrow their human creators. Actually, robot can be categorized as a machine that accumulates data about its surroundings and utilizations the data taken as a guideline to do work. Be that as it may, robotic engineers would likely not state the VCR or indoor regulator is a robot. As such, robots are doing things more and more. Today's robots are a fusion of numerous sensors and can utilize this data to carry on autonomously. This implies that robot can settling on choices for them in view of data that they get. There is unending assortment in the size, shape and employments of robots. Most robots are utilized as a part of manufacturing plants, while others are profoundly test and utilize computerized reasoning to act increasingly like living animals, ready to act freely in evolving situations. Now, robots perform exactness surgery, space investigation, the ocean and different hazardous zones (Stork, 2012).

The exercises in this guide are intended to help the individuals who see the display recognize:

a) Daily activities that human does which are complex comparing with robots.
b) That they can do a few things that robots unable to do and the other way around, robots can do a few things that they unable to do.
c) There are a wide range of sorts of robots each uniquely designed to do specific undertakings.
d) How robots think, sense, and act.

Comparing with the past years, robots are not a new thing anymore. There are various types of robot with various design and purpose. Even kids nowadays own robot toys such as Cozmo in Figure 1.1. The build of robot is on two specific domains, which is technical intelligence and social intelligence. Technical intelligence types of robots are common in industries for the high precision and effective production. While social intelligence types of robots are commonly used for interaction and entertainment purpose such as rehab, educations and toys (Dautenhahn, 1995).

Figure 1.1: Cozmo uses a set of blocks to play games with humans (Anki Inc., 2016).

Human-robot interaction (HRI) is classified as one of socially interactive robots (Fong et al., 2003). There are loads of research and developments have been done till now on HRI. The purpose of HRI is to require extending aspects of communication and cooperation between robots and between robots and humans. What differs each and every HRI is the working environment, purpose of design, type of functions, and way of communications that the HRI uses to communicate. As we can see here, there are various ways a robot can use to communicate, such as voice recognition, gestures, face detection, and etc. Different HRI has different concept and theme.

On this project, a simple robot with HRI features is about to be developed for a hospital environment. This is because, although robots are highly used in hospitals nowadays, all of them are placed in a safety fence for safety purpose. It is because those

robots are not user-friendly robots. A powerful HRI with human and robots working together as a team is needed (Buchner et al., 2013).

Thus, this is the idea of this project which is to create a HRI robots to communicate with patients and patient's visitors at hospitals. This HRI will be a device to substitute and reduce the workloads of nurses and staff at hospitals.

### 1.1.1 Early History of Robotics and Human-machine Interaction

Early robot usage was remotely worked gadgets with no or low level of autonomy (Figure 1.2). Tesla (1898) exhibited a radio-controlled boat which he portrayed as consolidating "a borrowed mind." By the fact, Tesla controlled the boat remotely. His innovation, which he summed up to various sorts of vehicles, was portrayed in patent 613,809, "Method and Apparatus for Controlling Mechanism of Moving Vessels." Tesla speculated, "you see there the first of a race of robots, mechanical men which will do the laborious work of the human race". He even imagined at least one or more robot operates all the while coordinating 50 or 100 vehicles (Goodrich and Schultz, 2007).

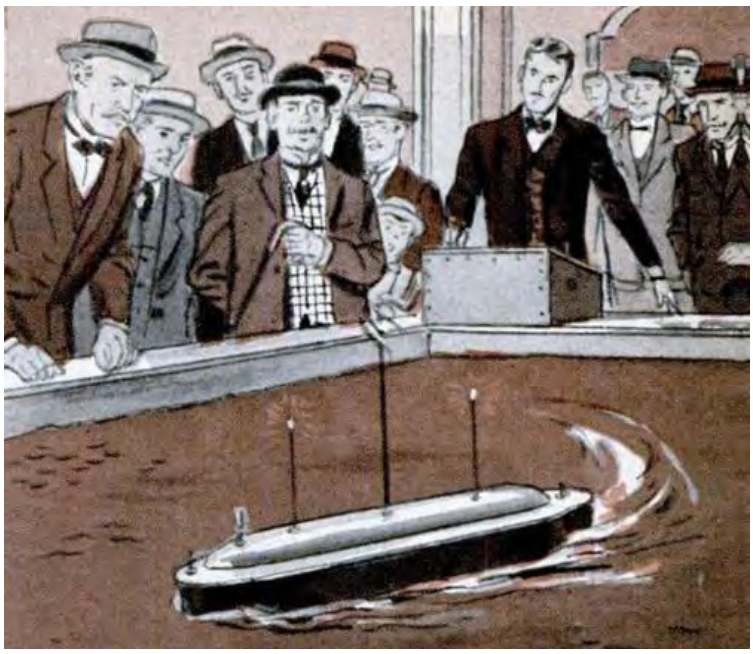

Figure 1.2: Tesla's boat (Turi, 2014).

Different example include: The Naval Research Laboratory's "Electric Dog" robot from 1923, endeavours to remotely pilot planes amid World War II, the making of remotely steered vehicles, and mechanical animals intended to give the presence of life. As innovation developed, the capacities of remotely worked robots have developed (Fong and Thorpe, 2001). A solid evident to prove this is the extremely fruitful utilization of unmanned submerged vehicles that have been utilized to investigate the deep sea to discover lost ships, investigate submerged life, help with underwater development, and study geothermal action (Whitcomb, 2000).

Increasingly advance in robot mechanics, lead the research of artificial intelligence to develop fully autonomous robots. The most commonly referred to case of an early self-governing robot was Shakey the robot, which was equipped for exploring through a block world under painstakingly controlled lighting conditions at the frostily moderate speed of around 2 meters for each hour (Nilsson, 1984).

A leap forward in independent robot innovation happened in the mid-1980s with work in conduct based mechanical autonomy (Arkin, 1998). For sure, it could be contended that this work is an establishment for some current robotics applications. Conduct based mechanical autonomy breaks with the solid sense arrange act circle of a brought together framework, and rather utilizes distributed sense-response loops to produce suitable reactions to external stimuli. The blend of these disseminated reactions produces "emergent" conduct that can deliver exceptionally modern reactions that are strong to changes in nature.

The advancement of strong robot stages and interchanges advances for outrageous situations has been expert by NASA and other global space organizations. Space offices have had a few prominent mechanical activities, outlined with an eye toward securely investigating remote planets and moons. Illustrations incorporate early triumphs of the Soviet Lunokhods (Fong and Thorpe, 2001) and NASA's later accomplishment of investigating the surface of Mars (Leger et al., 2005). Critically, a large portion of the disappointments have been the after effect of programming issues as opposed to mechanical disappointments. Complementing NASA's handled robots have been a few robots created and assessed on earth (Bares and Wettergreen, 1999). Robonaut is a notable

case of effective tele-operation of a humanoid robot (Ambrose et al., 2000), and this work is being reached out at a quick pace to incorporate autonomous development and reasoning.

Rising up out of the early work in apply autonomy, human elements specialists have given extensive regard for two standards for human–robot association: tele-operation and supervisory control. With supervisory control, a human directs the conduct of a self-ruling framework and mediates as a necessary. Early work was typically performed by individuals who were intrigued in apply autonomy as well as manufacturing plant computerization, avionics, and intelligent vehicles. Work in these territories is encapsulated by Sheridan's fundamental commitments (Sheridan, 1992), and other huge commitments from human variables specialists.

Each robot application seems to have some type of communication, even those that may be considered "completely autonomous." The contrast between this kind of "programming based" interactions and modern HRI is that the field right now stresses proficient and dynamic collaborations as opposed to simply occasional connections. Nonetheless, a few scientists are tending to programming based of collaboration by investigating effective programming standards to bolster robot improvement (Horswill, 2000; Yim, 2006).

### 1.1.2 History of Human-robot Interaction (HRI)

Human-robot cooperation (HRI) is the investigation of collaborations amongst people and robots. Robots are simulated specialists with limits of perception and action in the physical world that we call workspace. Their utilization has been summed up in production lines however these days they have a tendency to be found in the most technologically advanced societies in such basic spaces as pursuit and protect, military fight, mine and bomb recognition, logical investigation, law authorization, entertainment and healing center care. The main challenge of HRI is to properly analyse the environment to react accordingly (Breazeal, 2004). For the robot, the environment includes the human. A good interaction involves intention and goal sharing and understanding by both actors (Tomasello et al. 2005).

From the earliest starting point of advancement of a robot, analysts have been concentrating on the likelihood of collaboration between a robot interacting with each other, and the possibility of robots interacting with humans (Fong et al., 2003). Figure 1.3 demonstrates the robotic tortoises worked by Walter in the late 1940s. (Holland, 1997).

Figure 1.3: Robotic tortoises (Walter, 1940).

As the field of artificial life rose, specialists started applying standards, for example, stigmergy to accomplish "group" or "swarm" robot conduct. "Stigmergy" was initially portrayed by Grasse to clarify how social creepy crawly social orders can on the whole deliver complex conduct designs and physical structures, regardless of the possibility that every individual seems to work alone (Bonabeau et al., 1999). At that point Deneubourg and his partners (1991) spearheaded the principal probes stigmergy in stimulated and physical "ant-like robots". From that point forward, various scientists have created robot aggregate and have utilized robots as models for concentrate social insect conduct. (Krieger et al., 2000)

Melhuish et al. (1998) stated that research that up to this point of standards utilization in self-organization and conduct propelled by social insect societies. Such societies are mysterious, homogeneous gatherings in which people don't make a difference. This kind of "social conduct" has ended up being an appealing model for robotics, especially in light of the fact that it empowers gatherings of generally straightforward robots perform troublesome undertakings as in Figure 2.3.

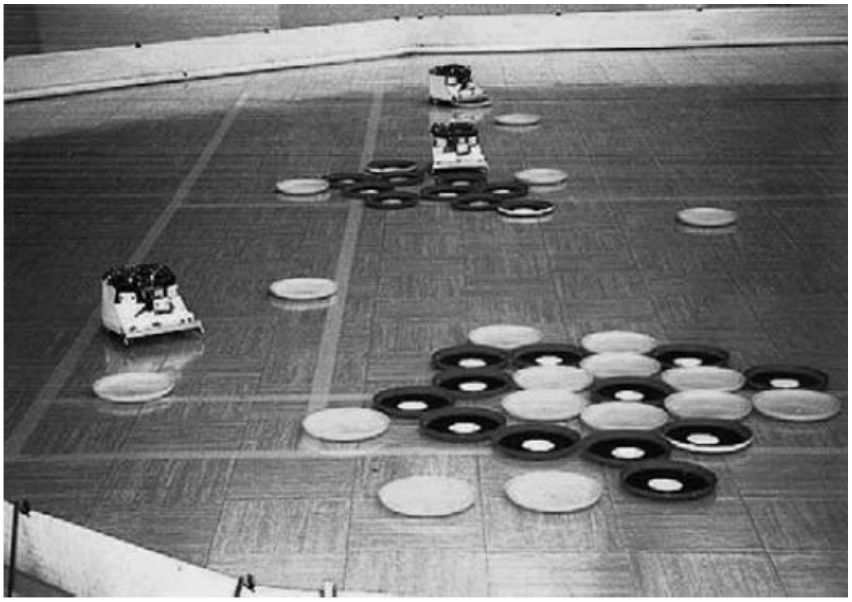

Figure 1.4: U-Bots sorting objects (Melhuish et al., 1998).

Dautenhahn and Billard (1999) suggested the accompanying definition states that “Social robots are embodied agents that are part of a heterogeneous group: a society of robots or humans. They are able to recognize each other and engage in social interactions, they possess histories (perceive and interpret the world in terms of their own experience), and they explicitly communicate with and learn from each other.”

Most research around there has concentrated on the utilization of "benign" social conduct. Breazeal (2003) defines that four classes of social robots regarding how well the robot can bolster the social model that is attributed to it and the unpredictability of the interaction situation that can be upheld as takes after.

## 1.2 Problem Statement

The primary reason for this project is to develop a simple robot with HRI features in a hospital environment at Malaysia. This is because, robots used until now at hospitals at Malaysia are not user-friendly robots and does not have any human-robot interaction features. Moreover, these robots cannot work as a team with humans. When this happens, that is when safety of workers becomes an issues and accidents occurs when dealing with machines. That is why the strong bonds between robots and humans should be created to enhance the performance of work even higher and safety of humans can be concern. In this case, humans that we are talking about are nurses. Nurses at hospitals having problems dealing with patients every day. There are still no development of any robot developments to find solution for this problem in Malaysia. Problems that are faced by both patients and patient's visitors at hospital are:

1) The problem faced by patients at hospitals are when they need to call for nurses for their every need. Nurses are not free and available 24 hours as they also have other works to be done.

2) While the patient's visitors face the problem when they need to for rest rooms or to get drinks. It's because they can't leave the patient alone on the bed.

## 1.3 Objectives

Objectives of this project are listed as below:

1) To design a mobile robot with human-robot interaction (HRI) features and line-following capabilities.

2) To develop and program the robot to interact with patients and visitors at hospital.

## 1.4 Scopes of the Research

The scope of this project is to create a simple robot with human-robot interaction (HRI) features and aimed to patients and visitors at hospitals only. This HRI featured robot is targeted only for a person who able to use their hands on the touch screen. Software used in the development progress of this project includes SolidWorks 2013 for the designing of the prototype, Nextion Editor to design interface on LCD display, Proteus 8.0 Profession for design and simulate circuit and finally Arduino IDE for programming purpose. Materials used for the prototype build is limited to acrylic and wood. Arduino Mega 2560 is the controller selected for the project and hardware to be used are infrared sensor, ultrasonic sensor and LCD monitor. Evaluation and test method used to analyze this final stage of the project was by on questionnaire, survey from patient volunteers done during the usability test. The robot which will built for this project, will be a type of mobile robot with LCD monitor equipped on its head. The robot will use line following sensor for its movement around the fixed hospital environment and the interaction will occur by human touching the monitor on top of the robot head for his required service. Addition features added is wireless remote call button using RF Module. The usability test for the final prototype of the robot will be tested at 'Pusat Kesihatan Pelajar UTeM'.

Table 1.1: Scope overview

| **Project Element** | **Scope Covered** |
|---|---|
| Software | SolidWorks 2013, Arduino IDE, Nextion Editor, Proteus 8.0 Professional |
| Materials | Wood, Acrylic, Screw and Nuts , Washer, |
| Controller | Arduino Mega 2560 |
| Hardware | Infrared sensor, ultrasonic sensor, liquid crystal display (LCD) monitor, RF Module |
| Types of Robot | Mobile robot with fixed LCD monitor on head of the robot. |
| Evaluation/Test method | Questionnaire, Reliability test, Usability test |
| HRI Features | Interactive Touchscreen |
| Algorithm | Line-following |
| Target Application | Hospital care, patients who able to use their hands on the touch screen. |

## 1.5 Importance of Study

This study is important because the HRI robots are still at beginning stage of development in industries. Thus, a study to create HRI robots which can communicate and work together as a team with humans are required specially at hospitals. As developments and technologies are getting advance these years, we must use it correctly by finding solutions to help more people. As this study is to help peoples who are travelling daily to hospitals and having problems to ask help.

## 1.6 Organization of Report

This report consists of five chapters. Chapter 1 introduces the background of study, problem statement, and objectives of the project, scope and limitation of project, importance of study and organization of report. Chapter 2 for the most part talks about the literature review that is linked with this project research. Chapter 3 discusses on the research methodology used to develop prototype of robot with HRI features. Chapter 4 shows the result on final look of the robot and discusses about testing and evaluations done for the robot. Chapter 5 concludes the overall report content and determines whether the objectives are achieved or not.

## 1.7 Project Planning

This is one of the vital tools that can be utilized at whatever point to lead a project. By developing Gantt diagram for PSM I (refer to Figure 1.6) as an early project plan, the progress of project can be monitored by visual chart that creates ease to understand. The estimated time duration for each stage project have been stated in Gantt chart to make the work progress flow clear and can be followed in order to finish the project within the period given.

Table 1.2: Gantt chart

| No | Project Activities | PROJECT PLANNING (GANTT CHART) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSM 1 | | | | | | | | | | | | | | | | | PSM 2 | | | | | | | | | | | | | | | |
| | | E | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1 | PSM title selection | P | | | | | | | | MIDTERM | | | | | | | | HOLIDAY | | | | | | | | MIDTERM | | | | | | | | HOLIDAY |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Submission of problem statement | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Submission of objectives | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Log book writing | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Completing chapter 1 | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Completing chapter 2 | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Completing Chapter 3 | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Poster preparation and presentation | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Complete PSM 1 report submission | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Design and material selection | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Prototype development | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Report writing for PSM II | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Log book submission | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Usability testing | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | Analysis on result and data | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | Presentation preparation | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | PSM 2 presentation | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | PSM II report review | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | Full Report Submission | P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |