February 19th, 2007

Mr. Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440/305 Functional Specification for Theater Ushering System

Dear Mr. One,

Please find the attached document, *Functional Specification for Theater Ushering System*, outlining the functional requirements for our prototype device. Our project is to build a simple ushering system for movie entertainment industry usage. The system is aimed to provide convenience and other fun features for moviegoers.

The purpose of this functional specification is to outline the functional requirements of the system at each stage of development. The document lists the specification of the prototype system, scheduled for demonstration during April 2007 and additional specifications for subsequent production system.

U-Nexus Inc consists of four senior-level undergraduate students in the electronics option. Team members consist of Danny Chan, Gordon Lee, Bo Wang and Eric Wang. Please do not hesitate to contact us if you have any concerns, we can be reached at ensc-unexus@sfu.ca.

Best Regards,

Eric Wang

Eric Wang
CEO
U-Nexus Inc

Enclosure: *Functional Specifications for Theater Ushering System*

ENSC 305/440 Functional Specification:

Theater Ushering System

Project Team:	Danny Chan Gordon Lee Bo Wang Eric Wang
Contact Person:	Eric Wang ensc-unexus@sfu.ca
Submitted to:	Mr. Lakshman One – ENSC 440 Mr. Steve Whitmore – ENSC 305
Issued date:	February 19th, 2007
Revision:	1.0

Executive Summary

U-Nexus Inc is currently in the process of developing a system capable of changing the movie going experience forever. The system is called *Theater Ushering System* and is targeted specifically for the movie entertainment industry. As its name suggests, it acts as a seating usher by providing moviegoers with location on seating priori to their entrance of a movie screen. The system is also capable of other features such as displaying advertisements or movie trailers. With additional add-ons, interactive features such as opinion polling and trivia games can be incorporated as well. The goal of the system is to enhance and promote movie experience to a new level.

The system is split into three phases, where we will present a working prototype in first phase, engineering prototype in the second phase and manufacturing model in the last phase. A working prototype will be used to demonstrate usability with limited features and will be crude in terms of aesthetic. Engineering prototype will have all features completed and the system running on embedded system. The manufacturing model will then have all components from engineering prototype, except all components will be safely enclosed with wiring path properly shown. Phase one will be targeted for completion for April 2007, and will have the following features

1. System will be able to monitor status of seats and display them via display panel
2. System will communicate seating information wirelessly using low power design
3. System display will be able to run advertisements, trailers and seating information simultaneously

The two subsequent phases are scheduled depending on feature implementation progress. The remainder of this document is dedicated to the detailed discussion of functional specifications for each design phase.

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1. Introduction

The Theater Ushering System is a device specifically designed for movie theater industry, used to provide convenience and interaction to moviegoers. The first major task of the systems is to provide seating information on display panel prior to entrance of a movie screen. Moviegoers can gather location of vacant seats before entrance, thus save the daunting tasks of seat finding. The second major task is for the system display panel to have additional features such as movie trailers and advertisements capabilities. The system uses wireless communication protocols for transmitting seating information to the display panel, thus minimizing the changes introduced to the infrastructure.

The project will be divided up into phases, where a working prototype will be completed during mid April 2007. Engineering prototype with embedded system is targeted for August 2007 and the manufacturing model is targeted for February of 2008.

1.1. Scope

The scope of this document will be the description of the functional requirements to the Theater Ushering System. Note that the functional requirements discussed in this document are for the working prototype scheduled to complete during April 2007. Further models such as engineering and production models are expected to retain majority of the specifications of the prototype; however, we cannot guarantee the completeness of this documentation. Due to possible changes, we will frequently revise this document to reflect the changes accordingly.

1.2. Acronyms

FAQ	-	Frequently Asked Questions
TUS	-	Theater Ushering System
SSM	-	Seating Status Monitor
SST	-	Seating Status Transmitter
RF	-	Radio Frequency
MCU	-	Microcontroller unit
DU	-	Display Unit
AU	-	Acquisition Unit
MPEG	-	Motion Picture Expert Group
QT	-	QuickTime
WMV	-	Window Media Video
RM	-	Real Media
JPEG	-	Joint Photographic Expert Group
GIF	-	Graphic Interchange Format
PNG	-	Portable Network Graphics
IR	-	Infrared

Txt	-	Text File
VGA	-	Video Graphics Array
DVI	-	Digital Visual Interface
S-Video	-	Separated Video
MAC	-	Medium Access Control
PHY	-	Physical Layer
LR-WPAN	-	Low-Rate Wireless Personal Area Networks

1.3. Referenced Documents

Referenced documents can be found in project file of U-Nexus Website.

[1] Proposal for Theater Ushering System

[2] IEEE 802.11.4-2003 Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)

[3] Wireless Communication Protocol Method Evaluation

[4] Seat Occupancy Detection Methods Evaluation

1.4. Intended Audience

This document is intended for design engineers, product managers, marketing specialists and lawyers.

- Design engineers can use this document as a guideline during development.
- Product managers can use this document as an overview of the project to better estimate development time and milestones.
- Marketing specialists can use this document to present to potential customers and develop promotional materials.
- Lawyers can use this document as reference in case if there is a dispute presents.

1.5. Conventions

The following convention will be used throughout this document to denote functional requirements:

R[#] Description to Functional Requirement (X)

Where X denotes the numerical value, 1, 2, or 3 according to the description below

(1) A functional requirement for phase 1: working prototype

(2) A functional requirement for phase 2: engineering prototype

(3) A functional requirement for phase 3: production prototype

2. System Overview

2.1. Simplified System Overview

In this section, we discuss the key components required by the *Theater Ushering System*. Figure 2.1 shows the major blocks in a system block diagram. The Seating Status Transmitter (SST) is responsible for data acquisition used to gather the current status of seats around the theater. After acquisition, information is then transmitted to the Seating Status Monitor (SSM). Upon receiving the seating information, SSM will perform the necessary processing and present the seating information to the audience via a large screen display. So the general flow of the system is data acquisition, data transmission, data receiving, data processing and lastly, data output [1].

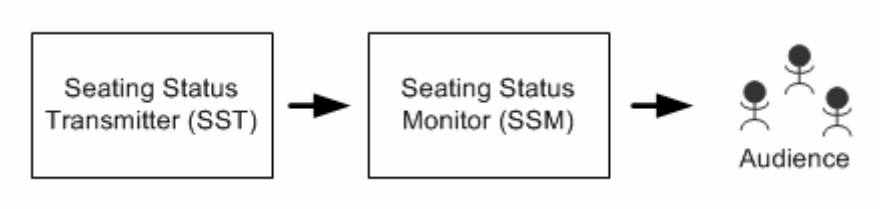

Figure 2. 1.1: Simplified System Block Diagram

2.2. Detailed System Overview

Figure 2.2.1 shows the detailed system block diagram of the Theater Ushering System. Seating Status Transmitter (SST) is further divide into two subsystems, known as Acquisition Unit, and Beacon. In short, Acquisition Unit (AU) utilizes the proximity sensor to monitor the seat's occupancy information, and Beacon is the wireless transceiver device for data delivering.

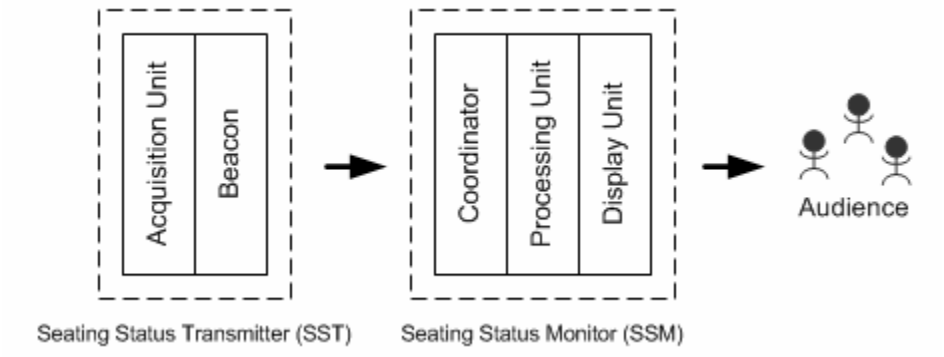

Figure 2. 2.1: Detailed System Block Diagram

Similarly, Seating Status Monitor (SSM) is further divide into Coordinator, Processing Unit and Display Unit. In short, Coordinator is the wireless transceiver device for communicating with Beacon. Processing Unit processes the seat's occupancy information and advertisements for display unit. Display Unit presents such information to the audiences.

In summary, SST obtains the seat's occupancy information through Acquisition Unit and transfers such information via Beacon to the SSM's wireless transceiver. After SSM received such information via the Coordinator, it then processes the seat's occupancy information and the preloaded advertisements for displaying to the audiences.

In the reset of this section, we give more in depth descriptions and summarize the duties for each individual component in the Theater Ushering System.

2.2.1. Acquisition Unit

Acquisition unit interfaces with about 8-16 proximity sensors to obtain the relevant seat's occupancy information. This unit shall be capable of processing the proximity sensor information and transfer such information to the SST's wireless transceiver also know as Beacon.

2.2.2. Beacon

Beacon is a wireless transceiver which compliant with the IEEE 802.15.4 telecommunication protocol [2]. Its duty is to process the seat's occupancy information obtained from the Acquisition Unit, and packaging such information so that it's compliant with the IEEE 802.15.4 protocol for delivering to the SSM's wireless transceiver or namely Coordinator.

2.2.3. Coordinator

Coordinator is also a wireless transceiver which compliant with the IEEE 802.15.4 telecommunication protocol [2]. Its duties are initiating the handshaking procedure with all the Beacon stations, scheduling the wireless communication, and maintaining the wireless traffic control in a TUS. Simultaneously, it delivers the seat's occupancy information obtained from the Beacon to the Processing Unit through the RS232 communication protocol.

2.2.4. Processing Unit

In the working prototype stage, Processing Unit is a personal laptop computer. Its duties include communicating with the Coordinator to obtain the seat's occupancy information, processing the seat's information for display unit, scheduling the advertisements, and providing input for setup/maintenance on the TUS.

2.2.5. Display Unit

Lastly, the Display Unit obtains the seat's information or advertisements from the Processing Unit through VGA, DVI, S-Video, or Component Video for displaying to the audience.

Due to time limitation, our working prototype uses the laptop computer as both the processing unit and the display unit. However, one can always build an embedded system to replace the computer. This is scheduled in the engineering prototype.

2.3. Overall System Overview

Previously in the Figure 2.1.1, we presented the simplified TUS system which only capable of handling 8-16 seats due to the fact that an Acquisition Unit only interface with 8-16 proximity sensors. However in real world scenario, typical movie theatres have more than 150 seats. In additional, the number seats per screen are subject to the design of the individual infrastructure. To overcome these difficulties, we will expand our simplified design mode and make use of the wireless advantage. As the result, the overall TUS design model has many sets of SSTs communicating wirelessly with single SSM at scheduled time interval as shown in the Figure 2.3.1. The single SSM will process the information, and then display seating information to the audiences at the entrance. This design solution overcomes the difficulty with number of seats required by different size of movie threat and as a bonus it allows ease of deployment.

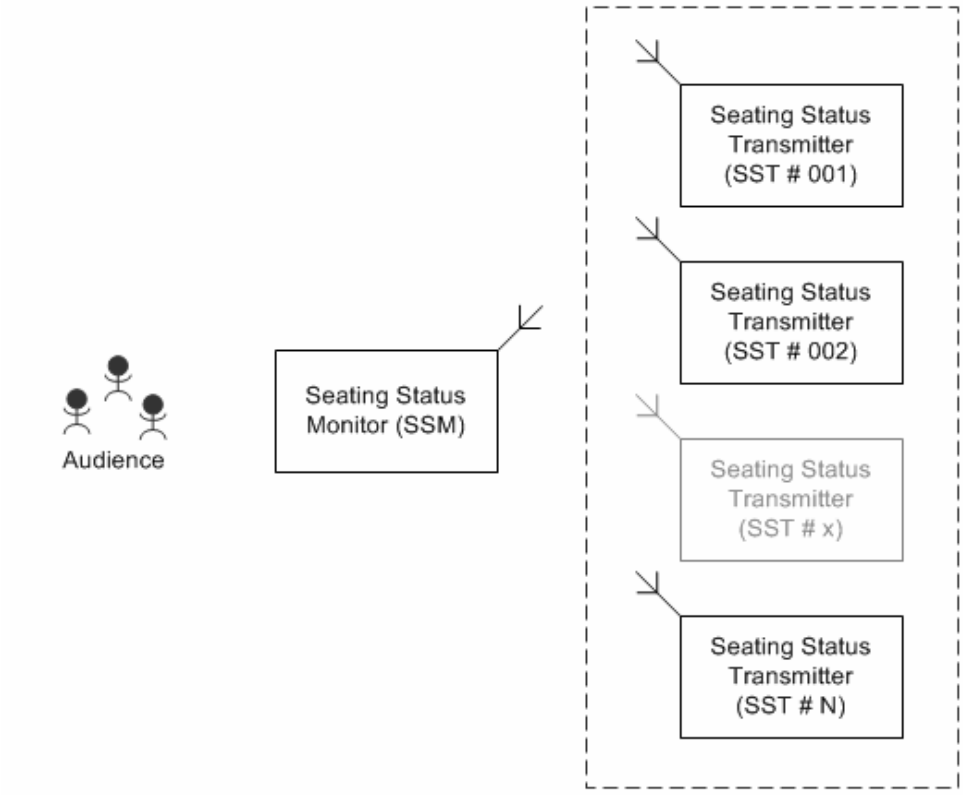

Figure 2. 3.1: TUS Design Model

In our working prototype type demo, we are targeting to have a single SSM wireless communicating with 2 to 3 SST managing about 16-24 seat's occupancy.

3. System Requirements

In this section, we describe the functional requirements necessary for the Theater Ushering System (TUS). We present the list of requirements by each component of the system discussed in Figure 2.2.1, previously. The system will operate in two modes, online or offline mode. In offline mode, an operator will be able to setup the system according to their own preference. In the online mode, the system is running according to the predefined preference, thus no operator is required.

3.1. General Requirements

This section describes the typical accepted working environment for the TUS. Since the TUS is built upon computers, we will assume that the system operates in typical indoor environment.

R[1] TUS will require an operator in the offline mode for setup/maintenance. (1)

R[2] TUS shall operate in ambient temperature range of 0°C to 40°C. (1)

R[3] TUS shall be able to operate at low lighting situation. (1)

R[4] SSM and SST both shall have proper internal heat dissipation, such that the operating temperature will not exceed 40°C. (1)

3.2. Performance Requirements

This section describes the operating performance of TUS and the usability of the system in general, for example, the refresh rate of seating information.

R[5] TUS must update seating status within 2 seconds on the Display Unit. (1)

R[6] TUS must be capable of display up to a resolution of 1280 x 1024 pixels. (2)

3.3. Wireless Communication Requirements

In this section, the wireless communication requirements are defined based on the IEEE 802.15.4 which is a telecommunication protocol specified for low rate wireless private area network [2].

R[7] TUS shall operate on one of the 16 channels in the 2450MHz band. (1)

R[8] Each movie screen shall have only one TUS. (1)

R[9] TUS consists of only one SSM and multiple SST. (1)

R[10] TUS shall not interfere with other neighbor wireless devices which operate at same frequency. (2)

R[11] Neighbor TUS shall operate at different frequency to avoid interference. (2)

R[12] SSM shall be able to form network with SSTs in the same movie screen. (2)

R[13] SSM and SST must locate within 30 meter at most to maintain proper operation. (1)

R[14] Packet delivery/transfer between SSM and SST must be guaranteed to ensure accuracy of seating information. (1)

R[15] All the wireless communication must be validated by with error checking. (1)

3.4. Safety Requirements

We present a list of safety features regarding the TUS in this section. We focus on wireless transmission safety issues and TUS physical unit safety issues specifically.

R[16] Wireless transmission conforms to IEEE 802.15.4 safety features. (1)

R[17] Wireless transmission conforms to the IEEE 802.15.4 security encryption. (1)

R[18] System shall be FCC, UL, CSA and CE certified in North America. (3)

R[19] The coordinator, beacon, and AU shall be water proof. (3)

3.5. Final Product Installation Requirements

This section describes the requirements for the final product deployment.

R[20] Seating sensor must be durable and long life. (3)

R[21] There must be NO exposed wires on each any component after installation. (3)

R[22] Installation must not require dissembling seats. (1)

R[23] Installation must not require theater renovations. (1)

4. Seating Status Monitor (SSM) Requirements

SSM is the unit responsible for receiving and processing seating information. After processing, the seating status will be displayed on its display unit. In this section, we present the requirements and the various operation modes that the system must have to ensure usability.

For SSM overview and system components please refer to section 2 of this document.

4.1. General Requirements

In this section, we describe the general input requirements for the SSM unit.

R[24] SSM shall be able to display texts according to entries in the corresponding TXT file. (1)

R[25] SSM shall be able to accept mouse and keyboard for input purpose. (2)

4.2. Physical Requirements

In this section, we describe the location and power requirement of SSM.

R[26] SSM shall be placed at the entrance of each movie theater. (1)

R[27] SSM shall be capable of operating from standard 110V AC outlets. (1)

4.3. Display Unit Requirements

At the working prototype development stage, display unit will be a 17 inches laptop display. One can also upgrade the display unit to desirable size with VGA or DVI connectivity.

R[28] DU shall be able to display resolutions up to 1280 x 1024 pixels at 16 bit color. (1)

R[29] DU shall be mounted on the wall with appropriate support. (3)

R[30] DU is a 17 inches flat panel screen by default. (1)

R[31] DU sizes can be upgradeable according to preference. (1)

R[32] DU shall be capable of displaying seating status and the advertisement. (1)

R[33] DU shall be able to accept VGA, DIV, S-Video, and Component Video. (1)

4.4. Processing Unit Requirements

At the working prototype development stage, processing unit will be a personal computer. It should cable of performing following requirements. In the further development the processing unit can be upgrade from personal computer to an embedded system to achieve the efficiency, and ease of installation.

R[34] Processing Unit shall be capable of handling 3D computation. (2)

R[35] Processing Unit shall be capable displaying high definition videos. (2)

R[36] Processing Unit shall be capable outputting the video through VGA, DVI, S-Video, or Component Video. (1)

R[37] Processing Unit shall be capable of accepting input command from mouse and keyboard. (1)

R[38] Processing Unit shall be capable of communicating via the RS232 protocol. (1)

R[39] Processing Unit shall be capable of communicating with the coordinator to requests for current seating status and control signals (i.e. to put entire network in sleep mode) (1)

4.5. Wireless Communication (Coordinator) Requirements

Coordinator is the wireless transceiver in the SSM component. Its wireless capabilities are compliant to the IEEE 802.15.4 standard [2]. In this section we describe the operational requirements needed.

R[40] The dimension of the Coordinator shall not exceed 10cm by 10cm. (1)

R[41] Coordinator shall be able to determine and select unused frequency band. (1)

R[42] Coordinator shall query and maintain a list of live Beacons. (1)

R[43] Coordinator shall be able to broadcast that all Beacons can receive. (1)

R[44] Coordinator shall also be able to communicate to a specific Beacon. (1)

R[45] Coordinator shall perform and initialize the network scheduling. (1)

R[46] Coordinator shall be able to add or delete Beacons. (1)

R[47] Coordinator shall be cable to communicating with the Processing Unit to transfer relevant seating information. (1)

4.6. Safety Requirements

In this section we describe the safety requirements for SSM unit such as enclosures.

R[48] Electrical wiring of SSM shall be enclosed. (2)

R[49] SSM shall be sealed in enclosure to prevent unauthorized tampering. (3)

5. Seating Status Transmitter (SST) Requirements

SST is the unit responsible for detecting whether or not the seats are occupied. In this section we present the requirements needed for SST, from its object detecting sensors to the wireless data transmission components.

For SST overview and detailed system components, refer to section 2 of this document.

5.1. General Requirements

This section describes the general operating requirements of the SST such as power requirement and interface requirements.

R[50] SST shall be battery powered. (1)

R[51] SST shall be able to put into sleep mode by SSM wirelessly. (2)

R[52] SST can be woken up by SSM wirelessly. (2)

R[53] AU shall transmit the seating status information to beacon via RS232. (1)

5.2. Physical Requirements

This section describes the physical requirement and features for each SST unit.

R[54] SST shall have power-on indicator. (1)

R[55] Seat status shall be indicated by LED. (1)

5.3. Performance Requirements

This section describes the performance requirement for SST in terms of wireless reliability and battery life.

R[56] SST shall operate at ultra low power consumption deemed by the 802.15.4 protocol. (1)

R[57] The battery life of the SST shall be in minimum of 2 months. (1)

5.3. Acquisition Unit Requirements

This section describes the requirements of acquisition unit and beacons. Proximity sensors requirements are also discussed below. For system structure details, please refer to section 2 for further information.

R[58] The dimension of the AU shall not exceed 5cm by 5cm. (1)

R[59] AU shall be enclosed and hidden from moviegoer to prevent tampering/ injury. (1)

R[60] AU shall be capable of communicating binary data with the Beacon. (1)

R[61] Proximity sensor shall be enclosed and hidden from moviegoer to prevent tampering/ injury. (1)

R[62] Proximity sensor shall trigger as long as any object is in its path thus deeming the seat as occupied. (1)

R[63] Proximity sensor shall be placed under the seat to ensure accurate result. (1)

R[64] Proximity sensor will trigger if any object is in the proximity of 10 cm for duration of 2 seconds. (1)

R[65] Proximity sensor signal duration less than 2 sec shall be treated as a false signal, and discarded. (1)

5.5. Wireless Communication (Beacon) Requirements

Beacon is the wireless transceiver in the SST component. Its wireless capabilities are compliant to the IEEE 802.15.4 standard [2]. In this section we discuss beacon requirements in details. Requirements covered are such as dimension, communication interface, and networking basics.

R[66] The dimension of the Beacon shall not exceed 10cm by 10cm. (1)

R[67] Upon power on, Beacon shall first register with Coordinator. (1)

R[68] Beacon shall be able to join different network provided by other coordinator. (1)

R[69] Beacon can only register with one coordinator at a time. (1)

R[70] Beacon shall reject the packet if it is not from the same network. (1)

R[71] Beacon can only communicate with coordinator and not other beacons. (1)

R[72] Beacon shall only transmit signal on the designated time slot scheduled by the coordinator. (1)

R[73] Beacon shall transmit the seating information to the Coordinator. (1)

R[74] Beacon shall be cable of accepting binary data from the AU. (1)

5.6. Safety Requirements

In this section we discuss the safety requirements of SST such as its physical placement, and enclosures.

R[75] SST is located in round enclosure to protect moviegoers from injury. (2)

R[76] SST is located in area which does not obstruct pathway. (3)

R[77] Electrical wiring of SST shall be enclosed and fixed under the seats. (2)

R[78] SST shall be made waterproof to prevent damage from spilled liquid. (3)

6. System Operation Requirements

In this section we present the operational and software requirements needed for TUS. We discuss in terms of software or the material that will be presented to the audiences.

6.1. Seating Information Display Requirements

In this section we present the requirements for the display unit such as color coding/landmarks to help moviegoers identify seating availability.

R[79] Landmarks shall be placed in the seating information screen to aid navigation. (1)

R[80] Seating layout shall be displayed by white line and black background by default. (1)

R[81] Occupied seats shall be displayed in red. (1)

R[82] Empty seats shall be displayed in green. (1)

6.2. Advertisement Requirements

In this section, we present the requirements for acceptable input file format for advertisements. Advertisements are either in movie format or still image format. We must be able to support multiple formats in order to ensure ease of usability on the operator.

R[83] Accepted advertisement image format are JPEG, GIF, and PNG. (1)

R[84] Accepted advertisement video format are MPEG, QT, WMV, and RM. (2)

R[85] Advertisement files must be placed in the predefined folder. (1)

R[86] Advertisements in the predefined folder will automatically cycle through in predefined duration. (1)

R[87] Advertisements will be played in a continuous loop during the normal mode. (1)

6.3. Normal Mode Requirements

Normal mode will be operating only at selected times. In this section, we discuss conditions and operating behavior of the normal mode.

R[88] DU shall display the seating occupancy information 20 minutes before/after the scheduled movie time. (1)

R[89] DU shall display advertisements at all time. (1)

6.4. Setup Mode Requirements

Setup mode is required for operator to enter preferences of the normal mode. In this section, we discuss the requirements for the setup mode.

R[90] SSM shall enable operators to configure the seating location according to the physical infrastructure. (2)

R[91] SSM shall enable operators to enter the movie schedule. (1)

R[92] SSM shall enable operator to select advertisement files. (1)

R[93] SSM shall enable operators to adjust seating layout preference. (2)

6.5. Diagnostic Mode Requirements

Diagnostic mode is used to test if the connected SSTs are functional. In this section we present the requirements of diagnostic mode and its behavior.

R[94] Coordinator shall query all Beacons to check if they are still operational. (2)

R[95] Operational Beacons will flash green on the display. (2)

R[96] Non-operational Beacons will flash red on the display. (2)

7. Documentation & User Training

Even though the system does not require direct intervention with moviegoers, an operator is still required to setup and maintain the system. This section describes the requirements in user manual in order to reduce complication to the operator.

R[97] On-site consultation regarding implementation will be provided. (3)

R[98] Assistance in deployment will be provided upon request. (3)

R[99] User manual shall be provided in English and French. (3)

R[100] User manual shall focus on setup required by the operator. (3)

R[101] User manual shall be written assuming minimal knowledge on electronic devices. (3)

R[102] User manual shall contain feature explanation, operating modes, and FAQ. (3)

R[103] User manual shall contain troubleshooting guide and general help section. (3)

R[104] All documentation clearly displays company contact information. (1)

8. Conclusion

Functional specifications for the Theater Ushering System has been outlined and discussed. These specifications have been carefully planned to ensure that our system will meet the operational performance previously defined. This document will be regularly updated to ensure accurate information. Working prototype is targeted for demonstration in April 2007, and upon completion, we will evaluate if additional features needs to be implemented.