ENGR 1120 Spring 2019
Project 5
Grand Challenge: Advance Health Informatics

Excerpt from “Grand Challenges for Engineering”, National Academy of Engineering, 2008

> “No aspect of human life has escaped the impact of the Information Age, and perhaps in no area of life is information more critical than in health and medicine. As computers have become available for all aspects of human endeavors, there is now a consensus that a systematic approach to health informatics — the acquisition, management, and use of information in health — can greatly enhance the quality and efficiency of medical care and the response to widespread public health emergencies.
>
> Health and biomedical informatics encompass issues from the personal to global, ranging from thorough medical records for individual patients to sharing data about disease outbreaks among governments and international health organizations. Maintaining a healthy population in the 21st century will require systems engineering approaches to redesign care practices and integrate local, regional, national, and global health informatics networks.
>
> Basic medical informatics systems have been widely developed for maintaining patient records in doctor’s offices, clinics, and individual hospitals, and in many instances systems have been developed for sharing that information among multiple hospitals and agencies. But much remains to be done to make such information systems maximally useful, to ensure confidentiality, and to guard against the potential for misuse, for example by medical insurers or employers.”

WHAT IS HEALTHCARE INFORMATICS?
Healthcare informatics utilizes computer hardware, specialized software, and communication devices to form complex computer networks to collect, analyze, and transmit medical processes. The tools for creating health information systems are not limited just to information technology. These systems should also allow for the assimilation of clinical directives, understanding of formal medical jargon, storage of data, and transmission of clear communication. Medical informatics can be applied in all types of health environments, including primary care, general practice, hospital care, and rehabilitation. It is also inclusive of many of the specialties within the healthcare field.

PROJECT PROPOSAL
A Division of Harris Corporation called “Healthcare Solutions” Jim Traficant, Harris VP and Senior Executive of Healthcare Solutions has a division called “Enterprise Intelligence for Healthcare.”

> Healthcare transformation is in the data. Insurers, hospitals, and physicians deliver optimal care and save lives when accurate and meaningful patient information is readily available at the time they need it most—now. Harris is bringing a real-time enterprise view to healthcare for actionable intelligence at the point of care. From the radiologist, to the oncologist, to the pathologist, to the surgeon, to the patient’s home, we are ensuring all patient data fully integrates across the enterprise and is delivered with security and privacy when and where it’s needed. Enterprise Intelligence empowers healthcare delivery with integrated information and work-flows at the point of care, creating a collaborative enterprise for patient care. Critical medical information delivered on demand across the chain of healthcare providers will transform healthcare and save lives by establishing continuity of care, better quality care at reduced cost, and confident decision making.

One key aspect to make “Enterprise Intelligence” become a reality is the ability to transform vast quantities of existing patient paper-records into an electronic format. Therefore, Mr. Traficant has an interest in evaluating the feasibility of using record retrieving robots to facilitate a hospitals ability to make archived medical records that currently exist on paper, electronic. He envisions a single (or multiple) robot(s) could be deployed at an archived medical records facility (something similar to a warehouse) to collect medical records that are distributed throughout a facility and bring them back to a central location for scanning. In the event there are multiple robots deployed at the same facility, he envisions they (the robots) would be intelligent enough to operate in a cooperative manner. In the archive facility, medical records are typically stored in boxes by "case type" (e.g., heart cases, bone cases, skin cases, tec.) and by year rather than by individual patient name and in alphabetical order.

Mr. Traficant, and his HealthCare Solutions team at Harris Corporation, has drafted some very general attributes for a record retrieving robot. These include the ability to:

1. Operate autonomously in a timely fashion.
2. Navigate indoors without the aid of GPS (Global Positioning Satellites) or other more traditional forms of indoor navigational aids (e.g. lines).
3. Use barcode scanning techniques to quickly ascertain the contents of a file box.
4. Transport a file box back to a copy center (i.e. retrieve the box of medical records and return it to the central processing facility for scanning).
5. Avoid collisions with humans and other objects in its path (including another robot).

Mr. Traficant has contacted Ms. Walmack, CTO (Chief Technology Officer) at the company for which you work and has asked her to develop a prototype robotic system, which has the characteristics outlined above. As Ms. Walmack talks with Mr. Traficant, she begins breaking down the request into more manageable pieces in order to understand more precisely what he is asking her company to do and how the prototype will be evaluated. Her notes include:

1. Make a robot that will self-navigate in a hypothetical facility (i.e., no physical walls) that is approximately ten feet by nine feet. The facility has five horizontal aisles and three vertical isles, each being one-foot wide, in which maneuver. The records are stored on four rows of shelving, with each shelf holding up-to six boxes that are accessible from one aisle and a different set of six boxes on an adjacent aisle (i.e., while a shelving unit may hold a maximum of six boxes, there may be some boxes missing). Therefore, boxes should **NOT** be used as navigational aids. The center of each potential storage box location will nominally be on 6.1[9] inch centers beginning approximately 2 inches (i.e., half a box width) from the end of the shelving unit[10]. There are to be a total of eight shelves in the facility, each being 3 feet long and one foot wide. A rough sketch of the facility is provided below (where the units are inches):

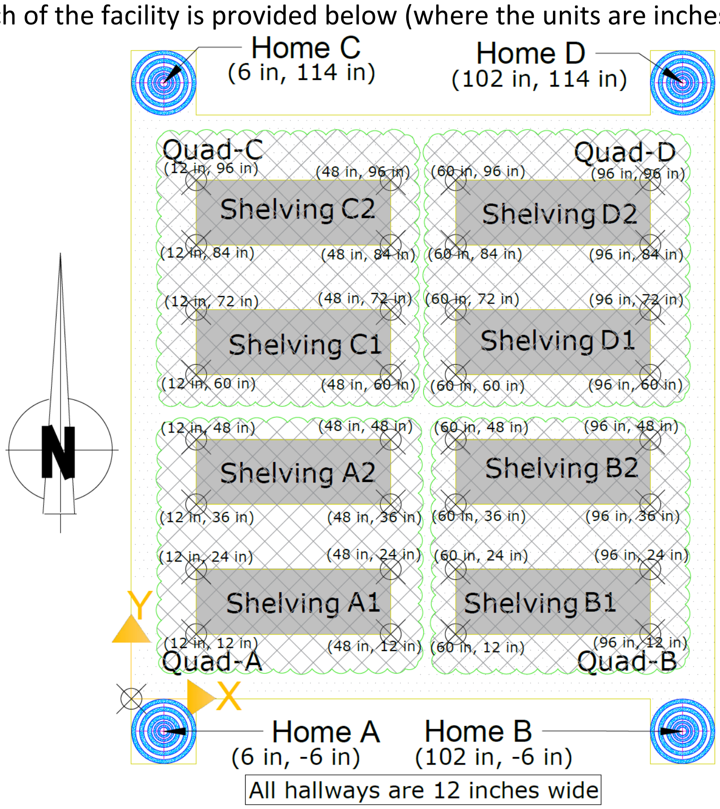


Figure 1. Schematic of the hypothetical facility[7]

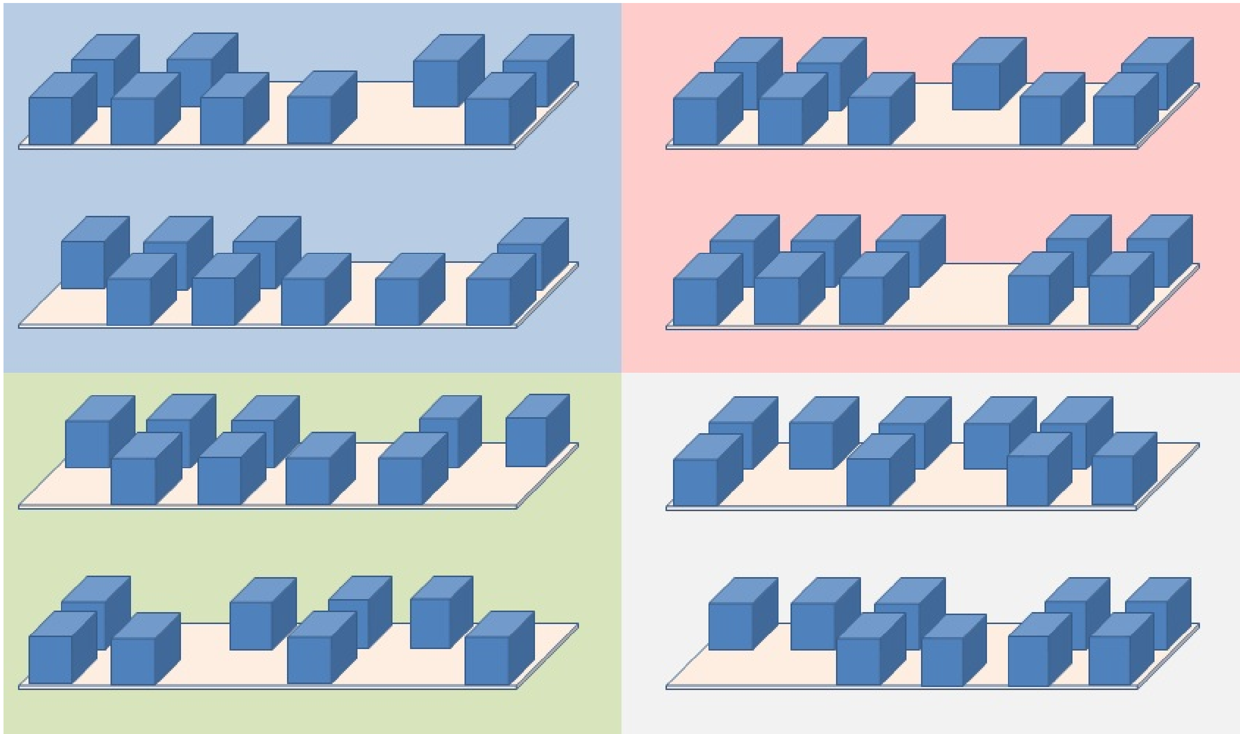


Figure 2. A pictorial representation of box locations on the shelving units for each Quad A-D. Note: this is a simply a sample representation. The number of boxes, and their location, will be determined on the day of the demonstration. All boxes sit on the floor.[5]

2. The robot instructions **must** be programmed using one of the following languages:
   a. LabView
   b. Python
   c. MATLAB
   d. *NEW*: Lego Mindstorms EV3 may be used (use at your own risk and with the knowledge that you may have difficulty completing all of the required project elements with this software package. Therefore it is not recommended, but allowed).[1]
3. The robot will be provided the following input information prior to beginning its task:
   a. The initial search zone (A, B, C, or D), corresponding to the robot's starting "home" location. Your robot will be instructed as to what the starting search zone will be according to the following mapping (the robot must capable of searching all four zones):
      i. Starting Zone is A: search zone A followed by B followed by C followed by D.
      ii. Starting Zone is B: search zone B followed by C followed by D followed by A.
      iii. Starting Zone is C: search zone C followed by D followed by A followed by B.
      iv. Starting Zone is A: search zone D followed by A followed by B followed by C.
   b. When a robot departs it's home location it should always follow the prescribed path: zones A and D, the robot should make an right turn into the hallway and immediately begin searching the shelving unit to its left; zones B and C, the robot should make an left turn into the hallway and immediately begin searching the shelving unit to its right.
   c. The coordinates of home (to match the search zone).
   d. Box Type (to retrieve, i.e., 1, 2, 3 or 4) and the corresponding robot ID.
4. The robot will start at a random, but specified, HOME location. Teams will **NOT** have the option of selecting a preferred home location.

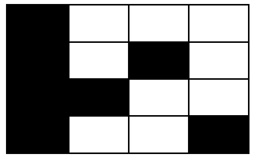
5. When a robot departs its home location, it should always follow a prescribed path. In zones A and D, the robot should make a right turn into the hallway and immediately begin searching the shelving unit to its left. In zones B and C, the robot should make a left turn into the hallway and immediately begin searching the shelving unit to its right.
6. The robot must navigate autonomously down the aisles without physical navigation aids (e.g., walls, lines, markers, etc) as well as know where in the facility it is currently located.
7. [2,3]Your robot **MUST** be capable of using IGPS (Indoor Global Positioning System) for which you are given a limited number of opportunities to use without penalty (3 times). Use of the IGPS beyond that which is provided will cost you demonstration points. The more times you use the IGPS the more points it may cost per use. The IGPS system uses fixed locations that enable your robot to triangulate to its current location. To invoke the IGPS, your robot will have to stop and be prepared to receive three distance measurements (in inches):
    a. How your robot will receive information depends on the software package used to program your robot:
        i. Python: pass user data to the EV3 brick using a remote terminal window (SSH terminal).
        ii. MATLAB: pass user data to the EV3 brick using the MATLAB command window.
        iii. Lego Mindstorms EV3: pass data to the EV3 brick via Bluetooth from another EV3 brick. At the time of your demonstration you will be asked to pair your brick with an 1120 course brick. When you command your robot to receive IGPS data, it will be sent data via Bluetooth from the paired 1120 course brick.
    b. Data will be provided in the following order (in inches).
        i. Radial distance (in inches) from Tower A: coordinates (6, -6)
        ii. Radial distance (in inches) from Tower C: coordinates (6, 114)
        iii. Radial distance (in inches) from Tower D: coordinates (102, 114)

    After receiving the set of distances, your robot should play the sound ‘click’ 1 time and display radial distance A, followed by radial distance C, followed by radial distance D on your robot’s LCD. After displaying these distances, the robot should display the computed X coordinate followed by Y coordinate to the LCD display.

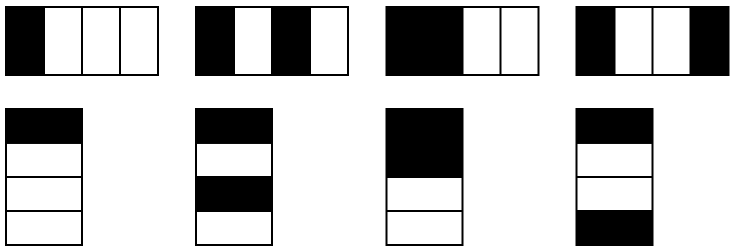
8. The robot should be capable of autonomously retrieving one or more boxes (your call) and returning them to its home location and unload load it (or them) for processing. Whenever the robot returns to home, and after it has unloaded all of the boxes it is carrying, you will have the ***option*** to align and/or reposition the robot on its HOME coordinate location. The timing of when the ***optional*** alignment and/or repositioning takes place will be at your discretion as long as: 1) it occurs **AFTER** all boxes being transported are unloaded; and 2) the ***optional*** alignment and/or repositioning is/are not used to reduce the total number of movements the robot would normally need to perform in preparation to re-enter the storage facility (e.g., a) the robot is off its HOME coordinate location by (+1, -1) inches relative and is 20 degrees out of alignment with the hallway entry – moving the robot to its HOME coordinate and aligning it with the hallway entry would be considered *acceptable*; b) the robot enters HOME facing in a particular direction – picking the robot up and manually rotating 180 degrees so it is facing in the opposite direction, as well as moving the robot to its HOME coordinate would be considered *unacceptable*).

9. Box specification given to third party vendor:
    a. Dimension : Height: 6 $^5/_8$ in.; Width: 4 $^3/_8$ in.; Depth: 6 $^3/_8$ in, all dimensions are ± $^1/_8$ in.[4.8]
    b. Lifting Handle: A rigid handle approximately ½ inch wide is located approximately ½ inch above the box, centered and spanning the box width.
    c. Weight: < 200 grams.
    d. Other Features: A small magnet glued on the inside center face of the box.

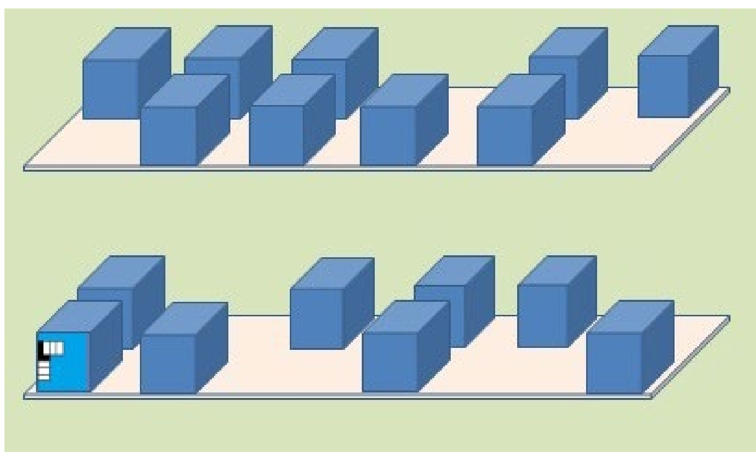
10. Box identification will be performed using a crude barcode scanning technique.



Each box will have both a horizontal and vertical barcode. Your robot needs to scan either horizontal or vertical barcode, but not both. The horizontal barcode is one inch tall and has 4 – 0.5 inch segments; the vertical barcode is two inches tall and has 4 – 0.5 inch segments as shown below.



Box type 1 Box type 2 Box type 3 Box type 4



The horizontal barcode should always be scanned from left to right and the vertical barcode scanned from top to bottom. The horizontal barcode will be positioned on the left edge of box with its vertical center located approximately 4.5 inches from the bottom of the box. The vertical barcode will be positioned directly below the horizontal barcode and its left side running down the left edge of box.

11. The robot should be smart enough to avoid collisions with humans and other objects in its path (including another robot) by navigating around them and without crashing into walls or shelving units.

Request For Additional Information (RFAI)

Teams will have the opportunity to ask questions about required functions in order to better understand the problem. Questions will be answered and presented in a Frequently Asked Question section of the Project 5 folder.

Use of Advanced Manufacturing techniques

1. You will have access to the rapid prototyping facility to manufacture unique parts for your design. There will be two manufacturing windows: the first one will be around spring break and the second approximately two weeks before the end of the semester.
2. You are only allowed to use parts from the kit you are issued or parts that you manufacture by rapid prototyping. You are NOT allowed to add parts or sensors from another kit or from personal storage.

3. The 1819 Makerspace will be available for your team to fabricate components for the mousetrap vehicle using small hand tools. The Makerspace operates on a first-come-first served bases. You are limited to having one person represent your team in the space. Training is required:
   Steps to become a member of the Ground Floor Makerspace:
   a. Enroll as a new member of the makerspace using the instructions below:
      Ground Floor New Member Instructions:
      https://uc.box.com/s/2vq60lh00jejp5w1xmpe589tqmxhlk20
   b. Register for an Orientation!

PROJECT DELIVERABLES

1. Each team is required to document their entire design process in an "Electronic" Design Notebook that is in the form of a single PDF document. The Design Notebook should be used to chronicle their design process (e.g., project management, meeting agendas and minutes, design concepts, brainstorming ideas, decision matrices, QFDs, flowcharts, test cases). Electronic Design Notebook practices that you **must follow** are as follows:
   a. You must always have a **single** "stand alone" PDF document available during any/all classes on a flash drive for the teaching team to view upon request (i.e., typically during class, sub-tasks or demonstrations);
   b. The design notebook may **not** contain *hot links* to external references. Use of *hot links* that allow you to navigate within your document are permissible;
   c. Meeting minutes must be "electronically" signed by each meeting participant. The "electronic" signature of each meeting participant signifies his/her participation;
   d. Pagination of each page within the Design Notebook is required;
   e. You can create your design notebook using Word®, or any other suitable software tool, that will allow you to capture the information. Whatever tool(s) you select to create your design notebook in, you must ultimately produce a PDF version (as a single file) for the teaching team to view upon request (i.e., i.e., typically during class, sub- tasks or demonstrations). To create a PDF version in Word®, all you need to do is select "Save As" and "Save As Type: PDF" for your design notebook to be created as a single "stand alone" PDF document.
   f. Failure to have a Design Notebook will impact your overall project grade. Ultimately, such information will be useful as you prepare to write your Project Report.

2. There will be an initial *Design Specification Review* on **February 14, 2019 by 5 p.m.** The *Design Specification Review* should be created in PowerPoint and include, but is not limited to:
   a. a brief description of the major sub-components, in the form of a functional block diagram, of your robot, which includes both explanation of each sub-component's function and features. *Please remember, this is **not** a description of your solution*.
   b. a detailed list of metrics (something measurable) that will be used to assess the function and features of each sub-component of the system. Think about using a HOQ approach to convert needs into requirements. *Please remember, this is **not** a description how you intended to solve the problem, but rather how you will evaluate the effectiveness of ideas towards a solution*.
   c. project management information, such as Work-Breakdown structure and Gant chart, indicating your initial conception of a project schedule.

   The Design Specification Review will be submitted electronically using the file name `Proj5_DSR1_19spr_`*`Team_XXX`*`.pptx`, where *XXX* is your team number.

3. Periodically throughout the semester you will be asked to demonstrate basic capabilities of your robot. These sub-tasks will generally be announced one-week in advance and will be held in the evening. Project 5, Subtask 1 is tentatively scheduled for **February 18, 2019** between 6 p.m.-10 p.m.

4. A prototype demonstration of your robot design will be held the **April 22, 2019**, in the evening (between 5 p.m.-10 p.m.).

5. A 8-10 minute oral presentation by your team during the **April 24, 2019** (for MW classes) and **April 25, 2019** (for TR classes) in your normal class. Details about the presentation will be posted in the Project 5 poster.
6. Submit electronically the following documents no later than **April 26, 2019 by 11:59 p.m.**
   6.1. [6]Your "Electronic" Design Notebook. The notebook should be assembled in to a single file named `Proj5_DN.19spr_Team_XXX.pdf`. **Design Notebook's submitted using any other name will be discarded**.
   6.2. Your Final Report. The report is an internal report (i.e., intended to be used by individuals within the company). The report should be named `Proj5_FR.19spr_Team_XXX.pdf`. **Final Report's submitted using any other name will be discarded**.

   The Final Report must include the following sections:

   a. *Memorandum* – A memo written to Ms. Walmack, the CTO of your company, from your team that summarizes your sub-component design and provides a clear rationale as its selection. You must support your design decisions with facts and convincing evidence. The memo is limited to 1-page.
   b. *Executive Summary* –one page summary highlighting the problem you solved, unique features of your robot, and a factual description of it's performance.
   c. *Introduction* – maximum one-page that describes the problem being solved and the overall goals of the project. The introduction should offer immediate context for the reader by establishing why the problem being studied is important and by describing the nature and scope of the problem. The introduction represents a transition toward the main body of the report. It should take an uninformed reader from a level of zero-knowledge to a level in which the reader is able to understand the problem being solved, potential limitations of the work, and the organization of the document as a whole.
   d. *Design considerations* – maximum 3 pages that detail the design process you used to achieve the final demonstration design (both hardware and software). This section should include a description of the preliminary designs that were considered, their positive and negative attributes, and the reasons why they were eventually discarded. We will specifically be looking for brainstorming ideas, decision matrices, morphological charts, QFDs, flowcharts, test data, sensor characterization, etc. This section should also include a description of your final robot, as well as any unique features it may have and why they are unique. Include whatever sketches or drawings you deem necessary, but note that figures do not count toward the total page count.
   e. *Results and Discussion* – maximum two pages that describe how your robot performed compared to how you thought it would perform. If it failed to operate as you designed it, then you should explain why you think it failed or the factors that contributed to the failure. If the robot performed as designed, then you should explain why it worked as designed. Include whatever data is relevant. As described above, figures and/or tables do not constitute any part of the page count.
   f. *Conclusions & Recommendations* – maximum one page that summarize your findings and make recommendations on how your team could improve your robot now that you have been through the process one time.
   g. *Team Reflection* – One page reflection of your teaming experience. This should include positive aspects of your team interactions, things your team needs to work on to improve your performance and specific recommendations on changes (additions/deletions) to your team Code of Cooperation at both the individual and team levels.
   h. *APPENDIX A* – Reporting of Personnel Cost. The appendix should report the total personnel cost to develop the prototype robotic system. This should be presented by listing each individual team member (with a brief discuss of their role), their hours contributed and their associated personnel cost. The total hours and personnel cost associated with the project should then be presented. Use the below formula to compute the personnel cost.

Personnel Cost = PH(1+.78)*Rate

- Where PH is the Personnel Hours (i.e., the time (in hours) your team has charged to the project to develop your prototype robot).
- Rate is the rate of pay for each team member (assumed to be $40 per hour) involved in the design.

The formula includes fringe and benefits plus overhead.

At the bottom of the Personnel Cost Report, each team member should electronically sign the report to indicate their agreement with the information being presented.

i. ***FORMAT*** - The written report will be submitted using the following format: a) top and bottom page margins - 1 inch, left and right margins - 1.25 inches; b) spacing – single; c) font 12 point Times New Roman ; and d) all figures should be standard graphic images. A cover sheet is allowed.

MODIFICATIONS

1. Lego Mindstorms EV3 added as a option (not recommended)

2. Original list had an item 7) that was removed. The remaining items were renumbered.

3. Details about the IGPS have been revised.

4. Box depth added.

5. Note added to Figure 2 title.

6. Design Notebook submission requirement added.

7. Figure 1 replaced. Dimensions now shown in inches and coordinates of shelving units added.

8. Supplier updated box dimension specification with more specificity.

9. Updated centerline distance for box locations: was 6.4 inches and changed to 6.1 inches.

10. Added detail.