UNH Biomedical Engineering Lab

"Development of Interoperability Standards for Medical Devices Used in Operating Rooms"

CiA JTF Meeting – September 26-27, 2006

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Who We Are…

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UNH

- **Dr. John LaCourse**
  - Principal Investigator
- **Frank Hludik**
  - Engineering Supervisor
- **Jon Waters**
  - B.S. in Computer Engineering, Alumnus
- **Jeff Ojala**
  - Pursuing a B.S. in Computer Engineering with a Minor in Materials Science

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- **William Seitz**
  - President
- **Joshua Pearl**
  - Development Engineer, Alumnus

Use Case

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- **Problem**: An invasive blood pressure monitor will display an inaccurate blood pressure if the height of the patient's heart changes relative to the height of the transducer
- **Present Solution**: The care giver would approximately measure the change in heart height, manually calculate a value based on a known formula, and add or subtract that value from the blood pressure monitor's displayed value; or manually adjust the height of the transducer relative to the change in the patient's heart height
- **Proposed Solution:** Provide the height of the patient's heart as the result of repositioning a hospital bed and the blood pressure monitor's displayed value at all times across a computer network, and automatically adjust the blood pressure monitor to the correct value using the same linear adjustment from the present solution

Project Goal

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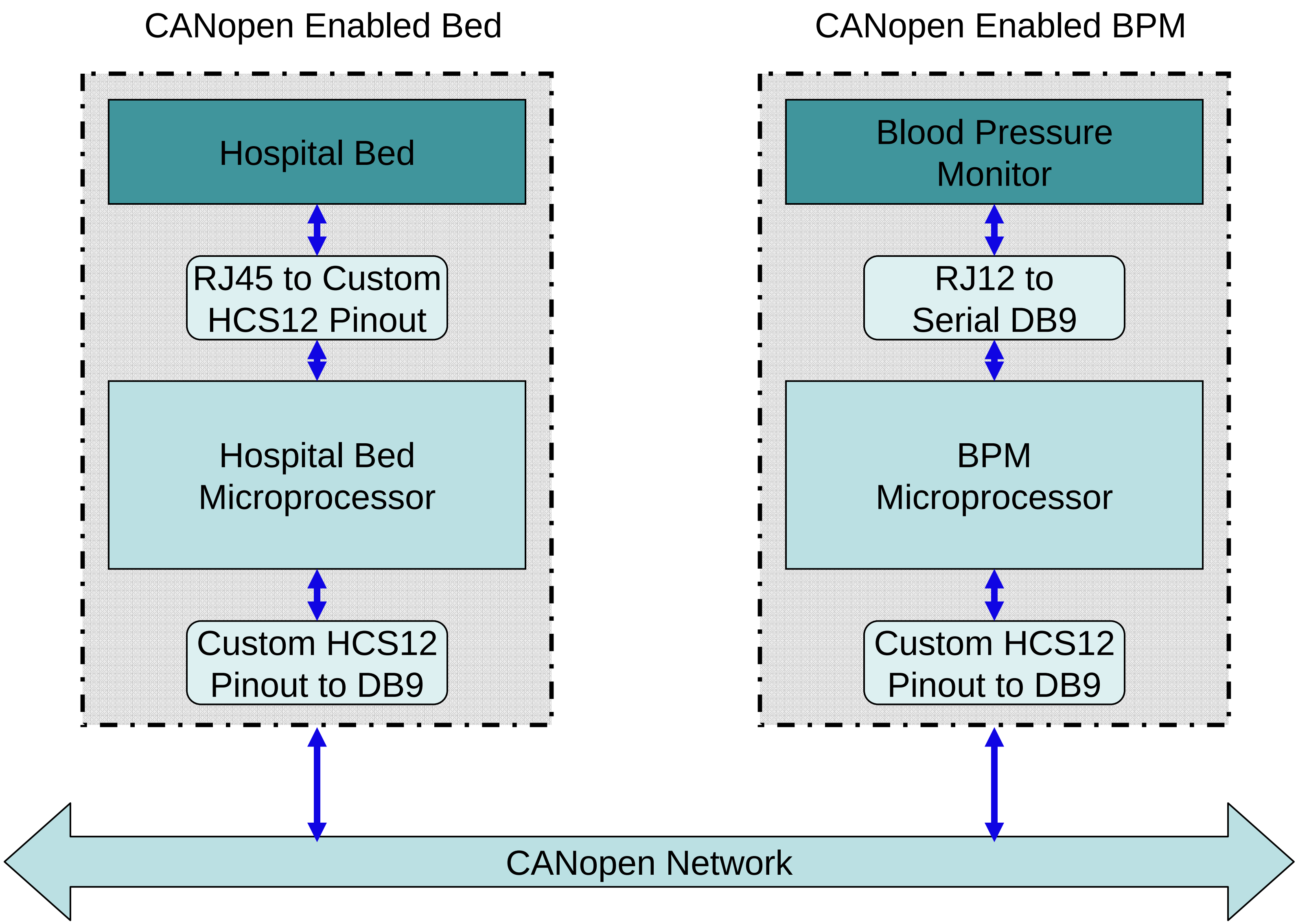
- Develop and demonstrate a working model of our proposed solution
- Inspire a need for interoperability between various medical devices commonly used within a hospital/operating room
- Develop a communication protocol that will serve as open Medical Device Plug and Play (MD PnP) standards for future use cases

System Diagram



Background

- Familiarity with CAN Data Link Layer
- Familiarity with CAN Physical Layer
- Familiarity with CANopen Application Layer
- Familiarity with CAN and CANopen Analyzing Tools
- Implemented CANopen Protocol Stack on HCS12 Microprocessor

Hospital Bed – Overview

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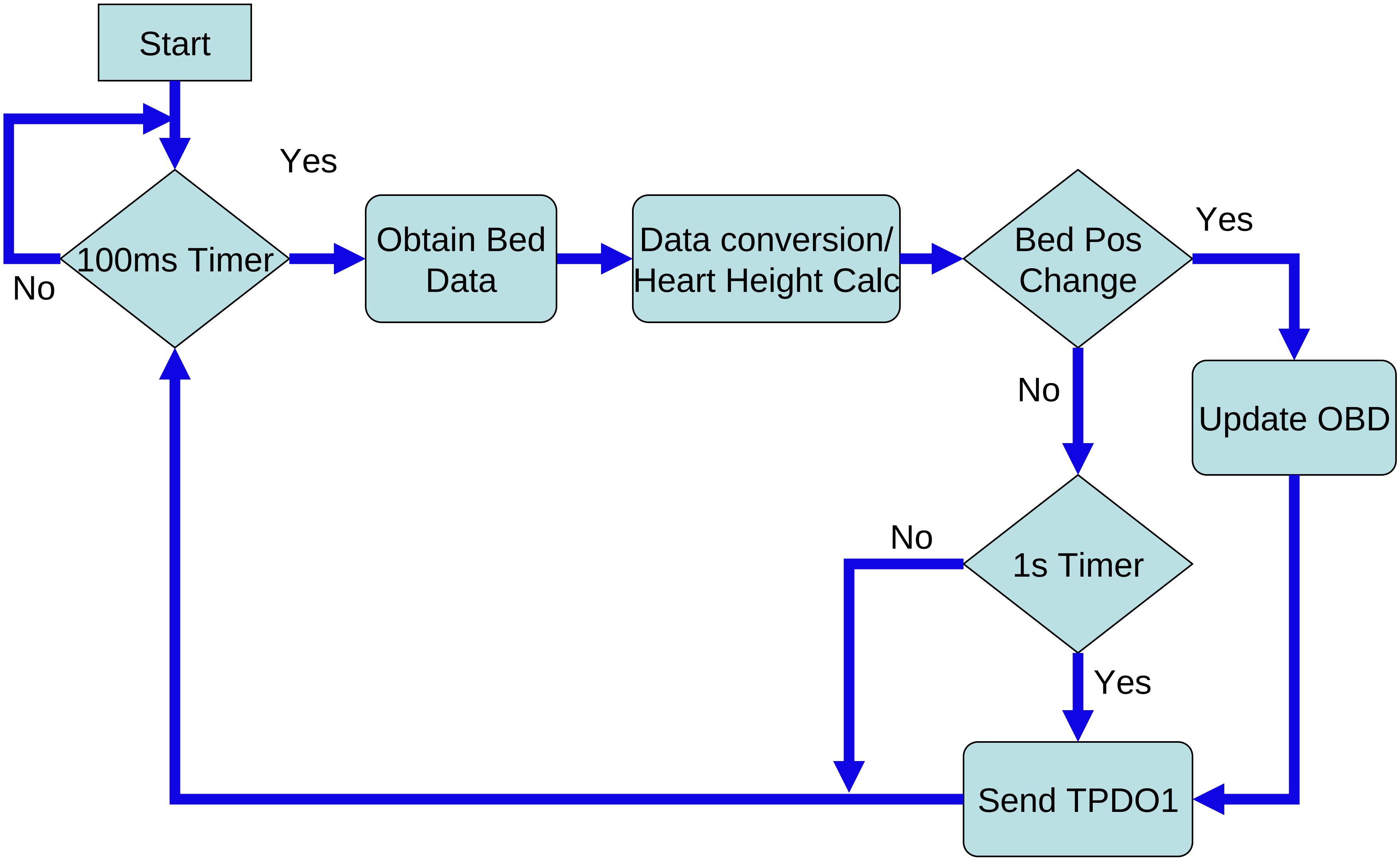
- Constructed custom cables to connect HCS12 microcontroller to CANopen Network
- Implemented Hospital Bed Object Dictionary in CANopen protocol stack
- Developed microprocessor application that gets information from the hospital bed to calculate the patient’s heart height and transmits the information across the CANopen Network

Hospital Bed – Flow Chart



Hospital Bed – Communication

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- The HCS12 microprocessor acts as the internal CANopen interface for the hospital bed
- Application calculates heart height, bed heights, bed angles, patient positions and sends this information periodically across the CANopen Network
- Bed's interfacing microprocessor acts as the master on the CANopen Network
  - Self starting
  - Responsible for starting new nodes that exist on the CANopen Network at the time of boot up or any time a new node comes on line

Hospital Bed – Communication

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- **Transmit Process Data Object One (TPDO1)***
  - Transmitted from the hospital bed's CANopen interface (i.e. the HCS12 microprocessor)
  - Provides
    - Geometric hospital bed position data
    - The internally calculated heart height
    - Patient position flags
  - Transmission Frequency
    - Once a second if no bed movement
    - Ten times a second if bed is in motion

* as defined in CiA WDP440

Hospital Bed – TPDO1 Mapping

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Entry No	Application Object			
0	Number of Entries = 5			
	Index	Sub-Index	Description	Length/Bit
1	6011	01	Bed Height	16
2	6011	02	Heart Height	16
3	6010	01	HOB Angle	8
4	6010	02	Bed Title Angle	8
5	6012	00	POS Flag	8

Index	Sub-Index	Application Object Value
6010	01	HOB Angle
6010	02	Bed Tilt Angle
6011	01	Bed Height
6011	02	Heart Height
6012	00	POS Flag

TPDO1	Byte1	Byte2	Byte1	Byte2	Byte1	Byte1	Byte1
	Bed Height		Heart Height		HOB	Bed Tilt	POS Flag

Hospital Bed – Heart Height Calculation

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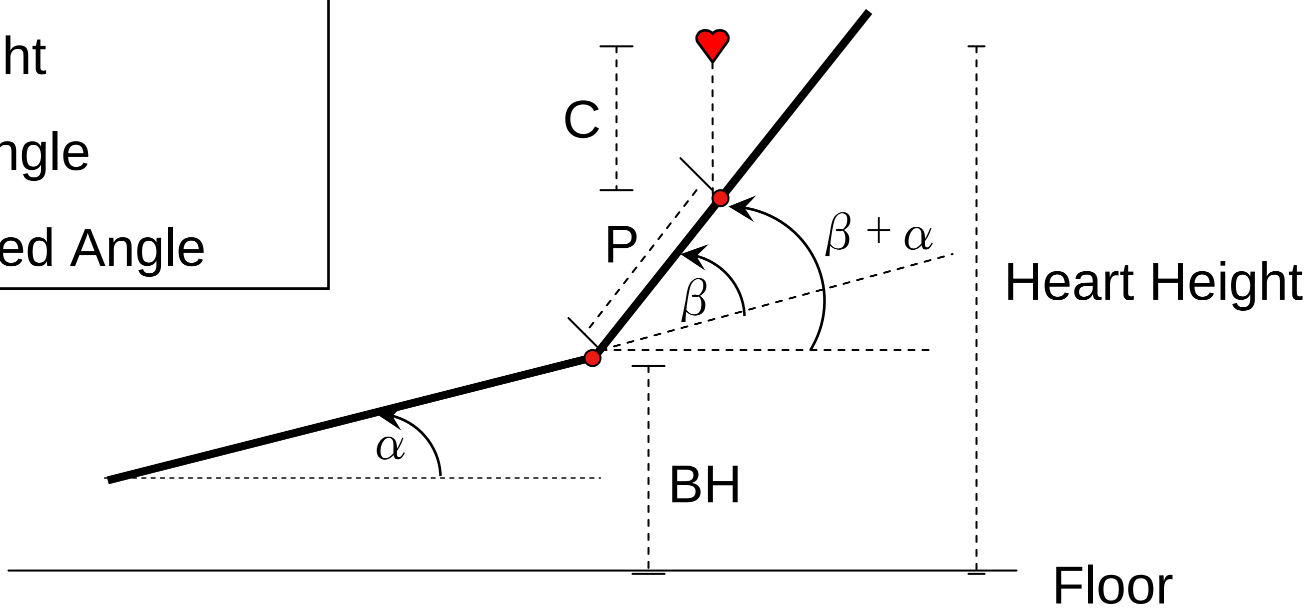
C = Heart Constant

P = Distance from hip point

BH = Bed Height

α = Bed Tilt Angle

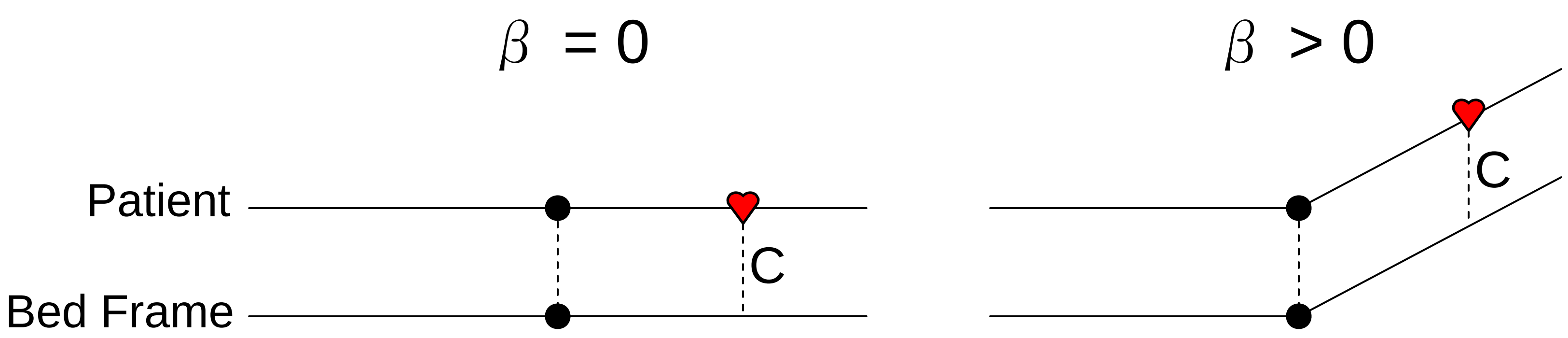
β = Head of Bed Angle



Heart Height = Sin($\beta + \alpha$)*P + BH + C

Hospital Bed – Parallelogram Argument for Heart Constant

- We used a parallelogram assumption to model the difference between the pivot point of the patient and that of the bed when the head of bed angle increases or decreases in order to locate the position of the heart relative to the bed frame



Hospital Bed – Patient Position Flags

- Helps medical blood pressure records be more accurate
- Allows health care providers to make more confident and accurate blood pressure measurements
- Implemented motion flags, other patient position flags not implemented yet

Name	Definition
valid	0 = patient position flags are invalid; 1 = patient position flags are valid
ps	0 = patient is not on its side; 1 = patient is on its side
pb	0 = patient is in bed; 1 = patient is out-off bed
psu	0 = patient is not sitting-up; 1 = patient is sitting-up
bhm	0 = bed height is not in motion; 1 = bed height is in motion
tbm	0 = tilt of bed is not in motion; 1 = tilt of bed is in motion
hbm	0 = head of bed is not in motion; 1 = head of bed is in motion

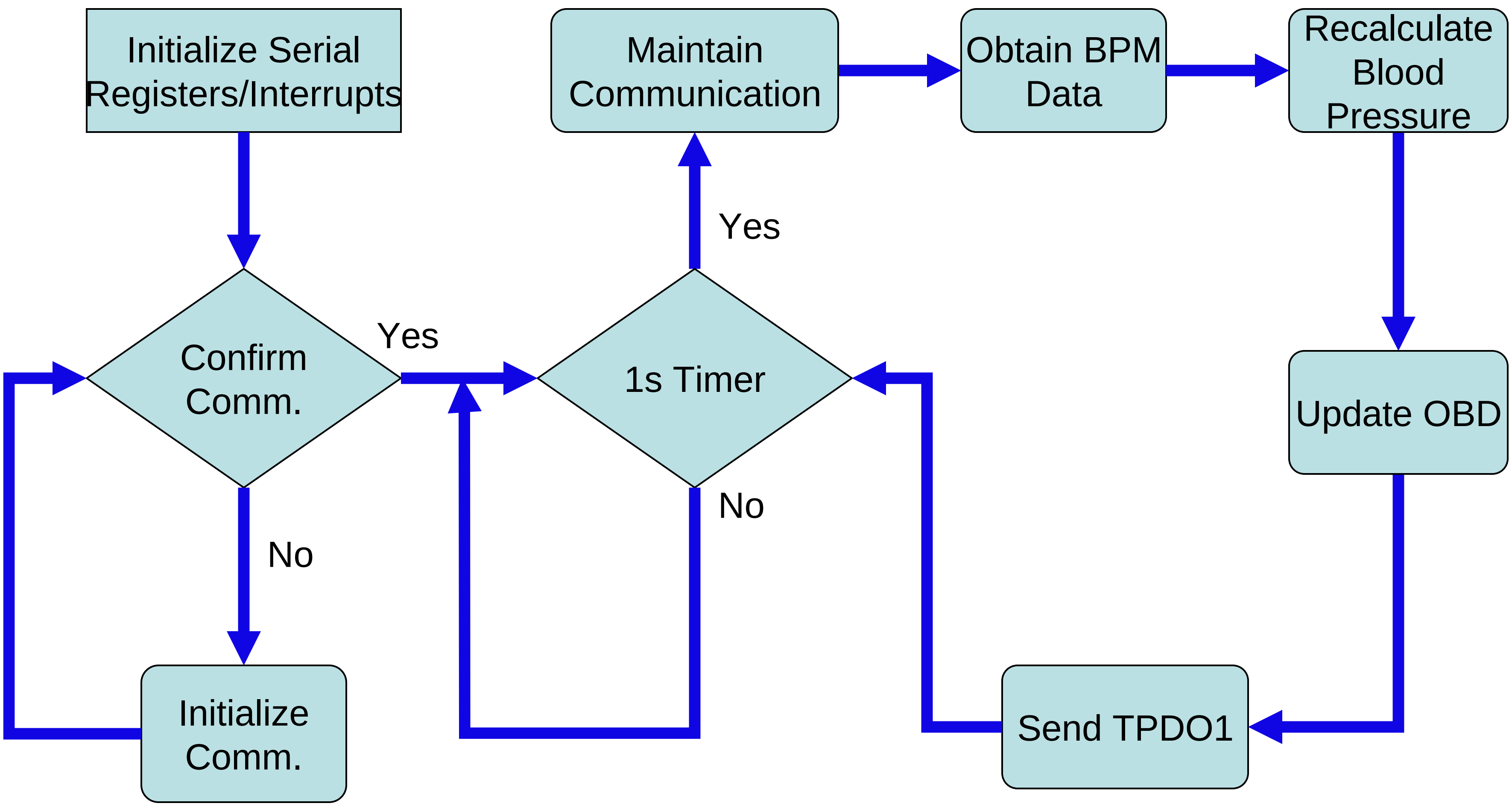
Hospital Bed – Recap

- HCS12 is used to translate data from the hospital bed into the appropriate Work Draft Proposal 440 (WDP440) format and make necessary heart height calculations
- TPDO1 acts as the internal interface of the hospital bed to send out all of the translated information received from the hospital bed to the CANopen Network

Blood Pressure Monitor – Overview

- Constructed custom cable to connect HCS12 microcontroller to CANopen Network
- Constructed custom cable to connect HCS12 microcontroller to Blood Pressure Monitor (BPM)
- Implemented BPM Object Dictionary in CANopen protocol stack
- Developed microprocessor application that recalculates blood pressure value based on patient’s heart height

Blood Pressure Monitor – Flow Chart



Blood Pressure Monitor – Communication

- BPM Receive Process Data Object One (RPDO1) is mapped to receive the Hospital Bed TPDO1
- HCS12 communicates with the BPM and acts as the internal CANopen interface
- During the zeroing process the BPM acquires the patient's current heart height to establish a calibration reference point (i.e. the zeroed heart height)
- During runtime the BPM recalculates the blood pressure based upon the real-time blood pressure value and the difference between the real-time heart height and the zeroed heart height

Blood Pressure Monitor – Correction Procedure

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- For every 1 centimeter a patient's heart height is above the height of the BPM transducer, the blood pressure value will be higher than the patient's actual blood pressure by 0.74 mmHg

- For every 1 centimeter a patient's heart height is below the height of the BPM transducer, the blood pressure value will be lower than the patient's actual blood pressure by 0.74 mmHg

Adjusted blood pressure = Measured blood pressure
+/- 0.74mmHg*(zeroed heart height – current heart height)

Blood Pressure Monitor – Communication

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- **Transmit Process Data Object One (TPDO1)***
  - Transmitted from the BPM's CANopen interface (i.e. the HCS12 microprocessor)
  - Provides
    - BPM systolic blood pressure
    - BPM diastolic blood pressure
    - Adjusted systolic blood pressure
    - Adjusted diastolic blood pressure
  - Transmission Frequency
    - Once a second

* as defined in CiA WDP440

Blood Pressure Monitor – TPDO1 Mapping

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Entry No	Application Object			
0	Number of Entries = 4			
	Index	Sub-Index	Description	Length/Bit
1	6030	01	Systolic BP	16
2	6030	02	Diastolic BP	16
3	6030	03	Adj Systolic BP	16
4	6030	04	Adj Diastolic BP	16

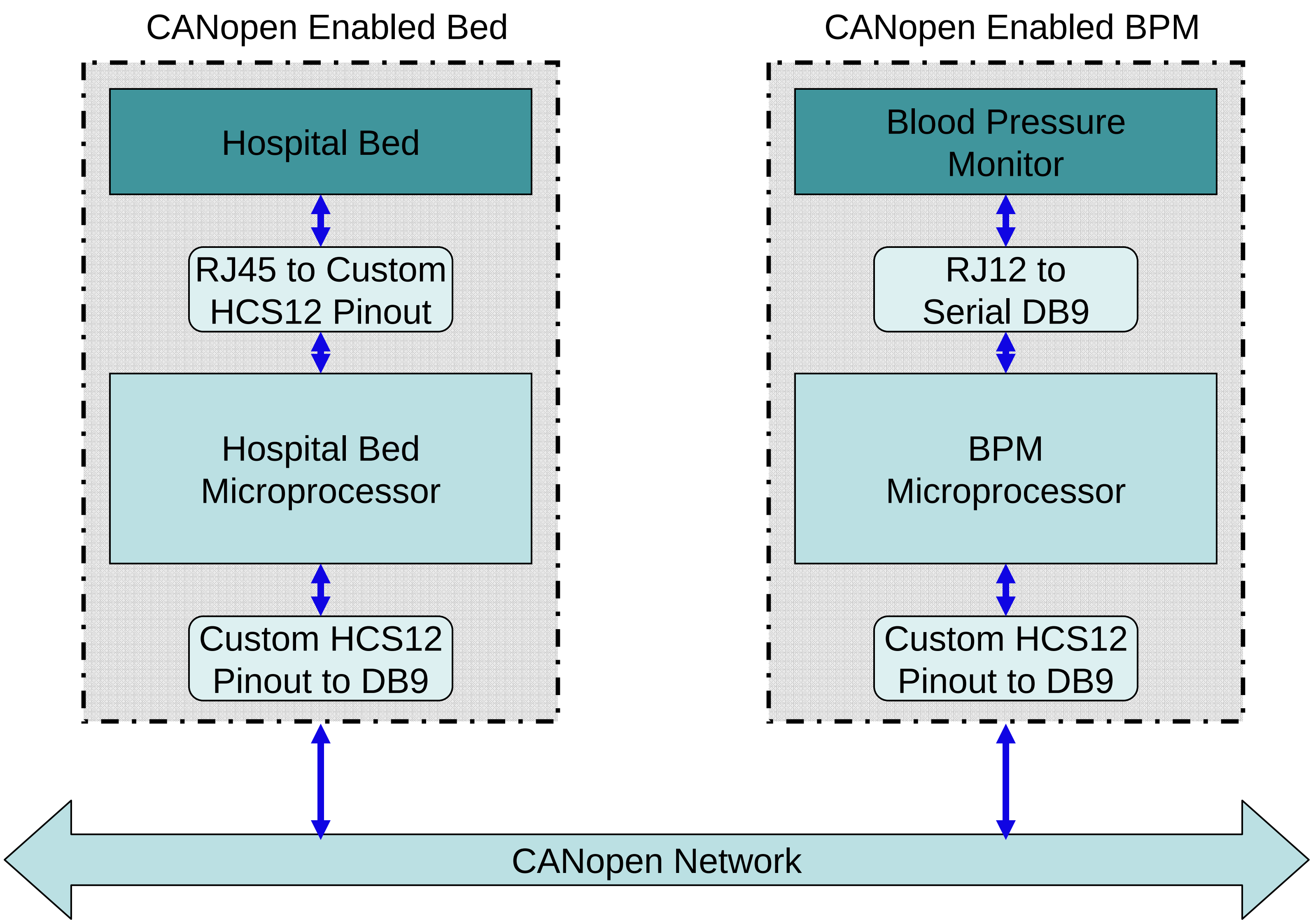
Index	Sub-Index	Application Object Value
6030	01	Systolic BP
6030	02	Diastolic BP
6030	01	Adj Systolic BP
6030	02	Adj Diastolic BP

Byte1	Byte2	Byte1	Byte2	Byte1	Byte2	Byte1	Byte2
Systolic BP		Diastolic BP		Adj Systolic BP		Adj Diastolic BP	

Blood Pressure Monitor – Recap

- The BPM's RPDO1 is linked to the Hospital Bed's TPDO1 to receive patient heart height values
- HCS12 used as the BPM's internal CANopen interface and to calculate the adjusted blood pressure values
- The BPM's TPDO1 used to send out all blood pressure values to the CANopen Network

System Diagram



Work to Complete Contract

- Further development of the CiA WDP440
- Complete implementation of patient position flags
- Further testing of plug-and-play capabilities
- Calibration and validation of blood pressure measurements
- Calibration and validation of heart height measurements
- Final written report

Future Work

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- Implementation of other hospital beds and blood pressure monitors
- Implementation of other devices (ventilators, ECG, electrosurgical etc.)
- Medical information transferring (eg. medical files)

Thank You
Hill-Rom & Welch-Allyn

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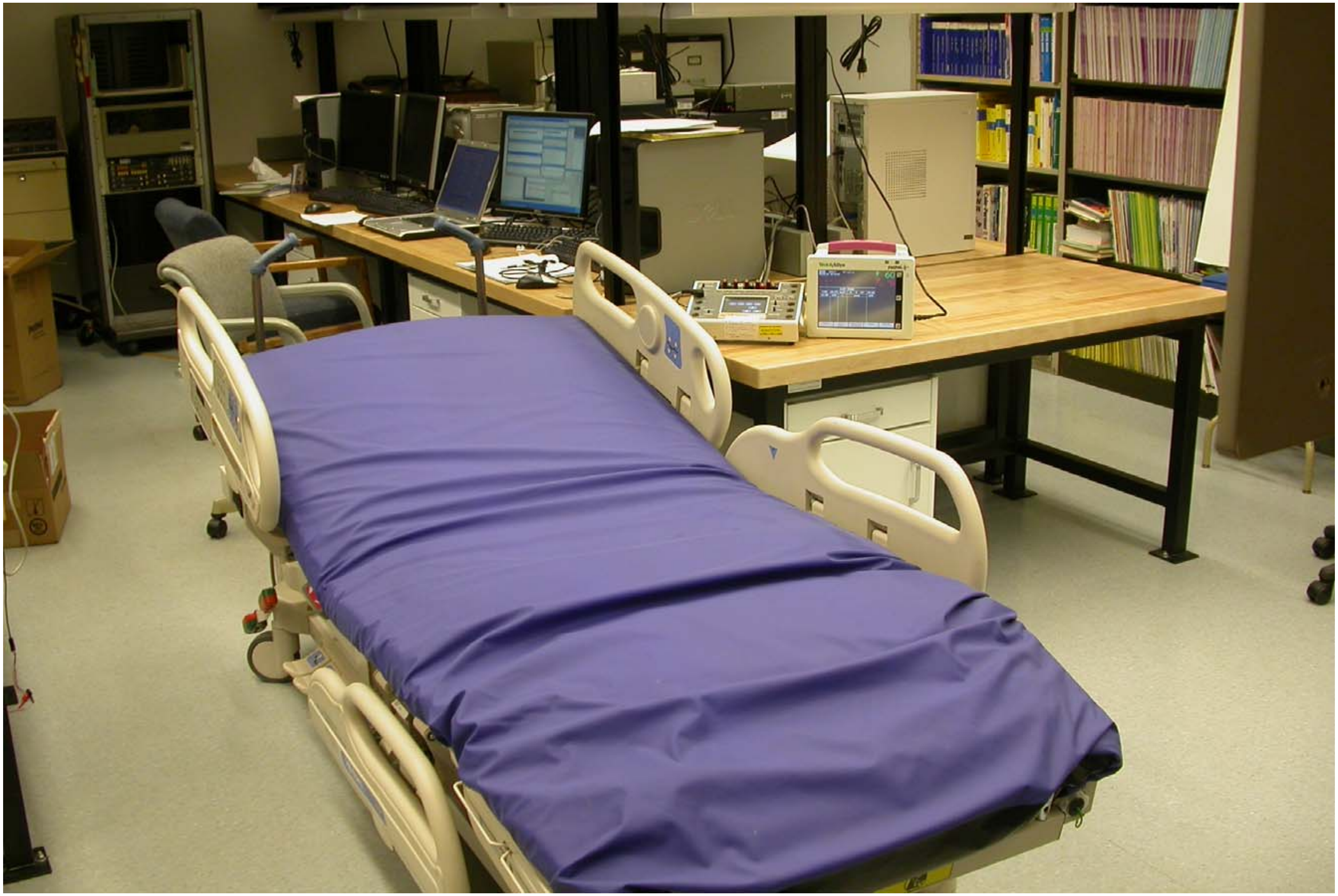
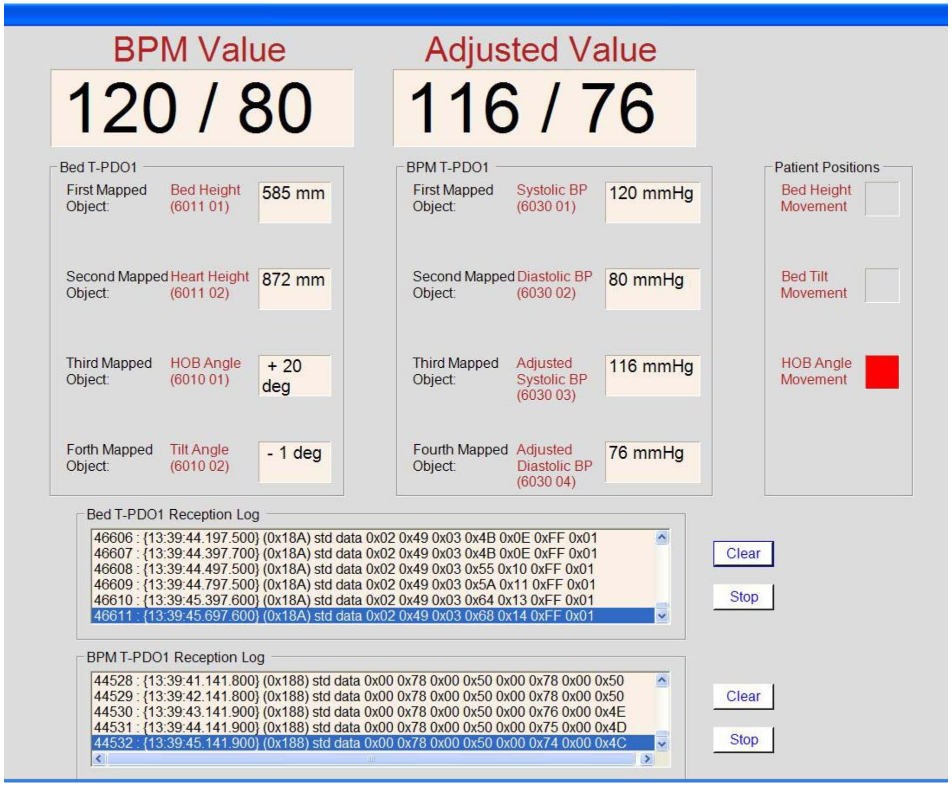


Project Demonstration

- Developed a Windows based C# program that acquires the following information directly from the CANopen network:
  - Hospital Bed's TPDO1 in real-time
  - BPM's TPDO1 in real-time
  - BPM's displayed blood pressure
  - BPM's adjusted blood pressure



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