

# Let's Talk Informatics

## **An Innovative Approach and Technology Solution to Manage Clinical Alarms in the New Single Family Room NICU at the IWK Health Centre**

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April 26<sup>th</sup>, 2018

Bethune Ballroom, Halifax, Nova Scotia

Please be advised that we are currently in a controlled vendor environment for the One Person One Record project.

Please refrain from questions or discussion related to the One Person One Record project.

# Informatics...

utilizes health information and health care technology to enable patients to receive best treatment and best outcome possible.

# Clinical Informatics...

is the application of informatics and information technology to deliver health care.

AMIA. (2017, January 13). Retrieved from <https://www.amia.org/applications-infomatics/clinical-informatics>

# Objectives

At the conclusion of this activity, participants will be able to...

- Identify what knowledge and skills health care providers will need to use information now and in the future.
- Prepare health care providers by introducing them to concepts and local experiences in Informatics.
- Acquire knowledge to remain current with new trends, terminology , studies, data and breaking news.
- Cooperate with a network of colleagues establishing connections and leaders that will provide assistance and advice for business issues, as well as for best-practice and knowledge sharing.

# Session Objectives

- Describe the NICU Care Environment
- Describe Alarm Burden & Alarm Fatigue
- Describe the Technology Solution
- Describe the Role of Clinical Informatics
- Describe the NICU Alarm Management Project
  - Project Organization
  - Phases of Implementation
  - Strategies for Reducing Alarm Burden
  - Strategies for Communication of Alarms

# Conflict of Interest Declaration

- We do not have an affiliation (financial or otherwise) with a pharmaceutical, medical device, health care informatics organization, or other for-profit funder of this program.

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# NICU Patient Population

- Neonatal period:
  - Birth to 44 wks PMA
- Age at birth varies:
  - Term: 37+0 to 41+6 wks
  - Preterm: as low as 22 wks
  - Post-term: 42+0 wks and up
- Birth weight varies:
  - 400 to 5000 grams
- Variety of medical issues:
  - Medical and surgical
  - Congenital and acquired
- Most vulnerable time in a child's life



<https://www.vyaire.com/us/our-products/respiratory-care/mechanical-ventilation/neonatal-ventilation-solutions/3100a-high-frequency-oscillatory-ventilator>



<http://www.dailymail.co.uk/health/article-3236619/Tiny-baby-girl-born-just-one-week-abortion-limit-thriving-despite-doctors-warning-parents-1-chance-surviving-let-go.html>

# Balancing Hypoxia & Hyperoxia

- Preterm infants prone to episodes of hypoxia
- Liberal oxygen use in 1930-50s
  - ↓ mortality & CP but ↑ blindness & lung injury
- Restrictive oxygen practices in 1960-70s
  - ↓ blindness but ↑ mortality & CP
- Evolution of routine monitoring in 1980-90s to target oxygen therapy saturation
  - Defining an optimal saturation range challenging
  - 85-89%: ↑ mortality    91-95%: ↑ blindness

# Challenges Maintaining Stability

- Hard to keep preterm infants within saturation targets
  - Typically within target range less than 50% of the time
- Few interventions shown to achieve better compliance with saturation targets
  - Reduced patient to nurse staffing ratios
  - Automated oxygen titration
- Even with dedicated 1:1 oxygenation titration staff or automated control compliance may be less than 65%

Van Zanten HA, Tan RNGB, van den Hoogen A, Lopriore E, te Pas AB. *Compliance in oxygen saturation targeting in preterm infants: a systematic review.* Eur J Pediatr. 2015;174:1561-1572. DOI: 10.1007/s00431-015-2643-0.

Wilinska M, Bachman T, Swietlinski J, Jakiel G. *Quicker response results in better SpO2 control – a comparison of 3 FiO2-titration strategies in ventilated preterm infants.* Ann Agric Environ Med. 2015;22(4):708-12. DOI: 10.5604/12321966.1185781.

# Alarm Burden & Alarm Fatigue

- Local audit of IWK NICU on May 12, 2017:
  - On average, 88 alarms per patient per 12-hr nursing shift
  - 61% of alarms resulted in no action
- High alarm burden leads to alarm fatigue
  - Associated with decreased response time
  - May result in care providers ignoring alarms
- Calls for hospitals to recognize the potential hazards of alarms and improve alarm management
  - 2012-2018: Named a top health technology hazard by ECRI
  - 2013: National Patient Safety Goal of The Joint Commission

# Environment & Parental Presence

- Gradual recognition that environment can have noxious effects on developing neonate
  - Physiological stress from excess noise, light, handling
- Increasing care complexity & changing societal expectations led to shift to patient-centered care
  - For NICUs, shift to family-centered care
- Increasing evidence of benefits parental presence and involvement in neonatal care, esp. skin-to-skin care
  - Better growth, decreased pain responses, reduced stay
  - Improved bonding, better neurodevelopment



# Evolution of NICU Care & Design



[https://commons.wikimedia.org/wiki/File:Kapiolani\\_Neonatal\\_ICU.jpg](https://commons.wikimedia.org/wiki/File:Kapiolani_Neonatal_ICU.jpg)



<https://www.pinterest.ca/pin/408912841160005476/>

# Problem: How Do We Keep Patients Safe?

Open Bay

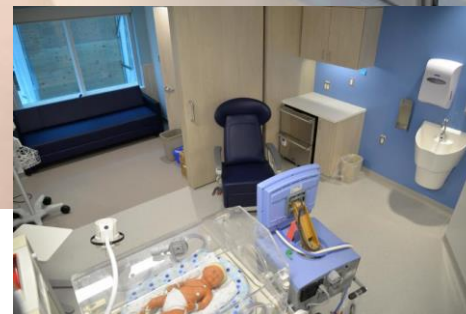
Single Family Room



IWK photo



IWK photo



IWK photo

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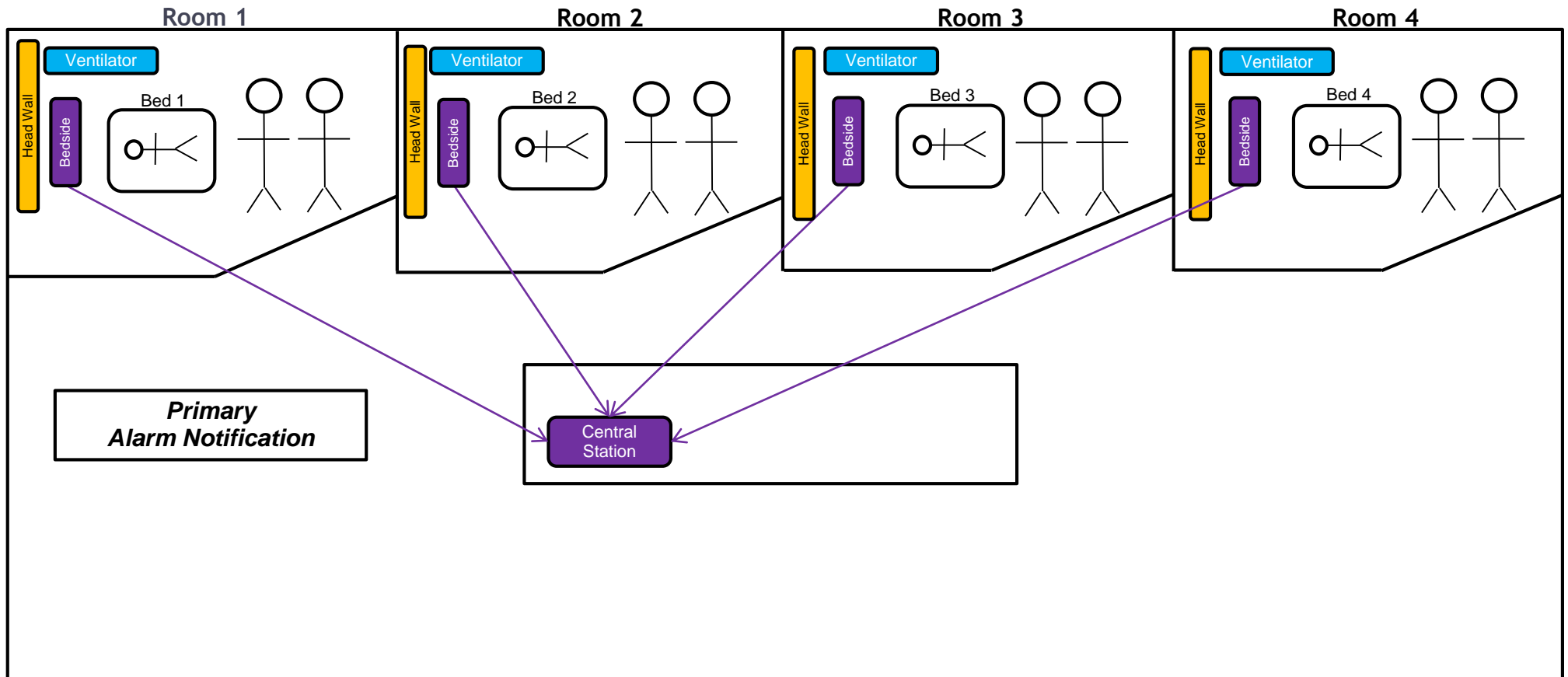
**So...**

***How Did We Solve This Problem?***

# NICU Project | Alarm Environment

Patient Monitors

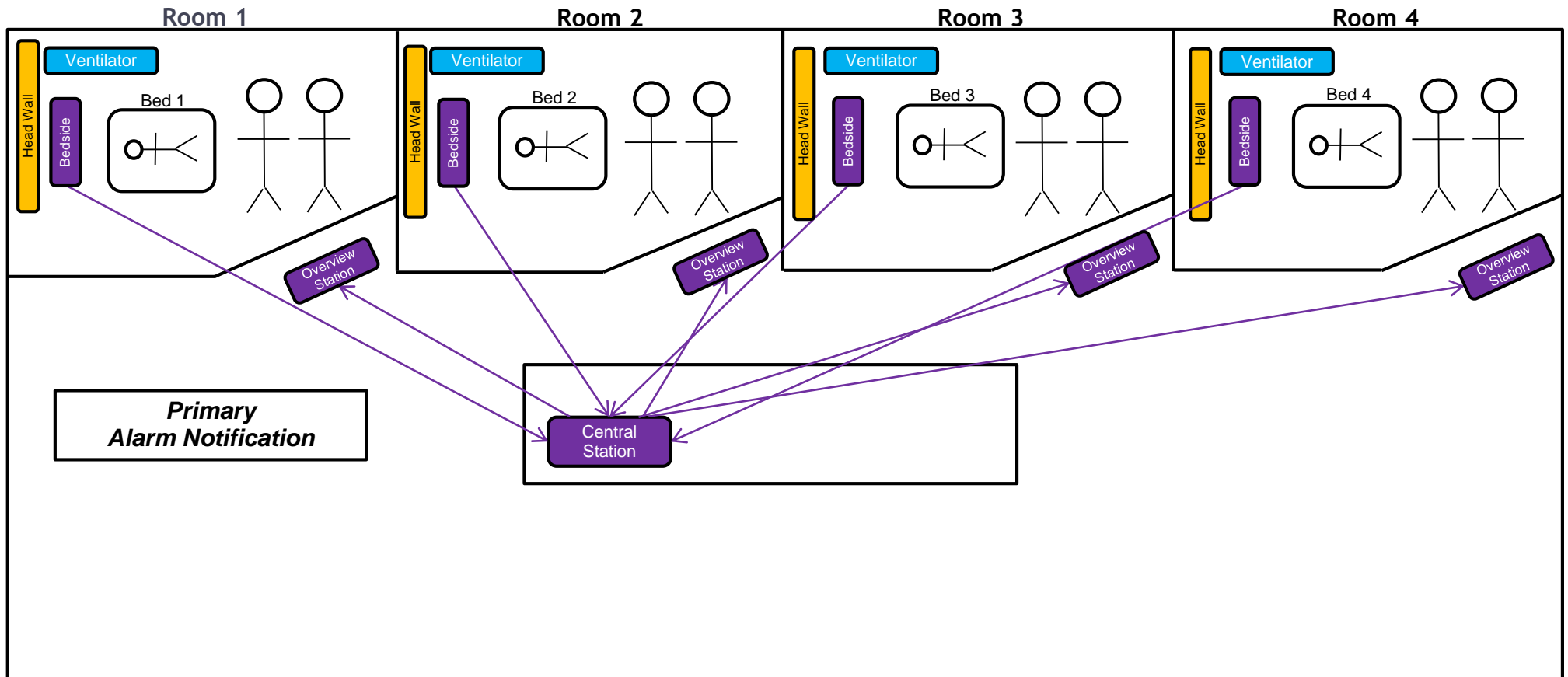
Ventilators



# NICU Project | Alarm Environment

Patient Monitors

Ventilators

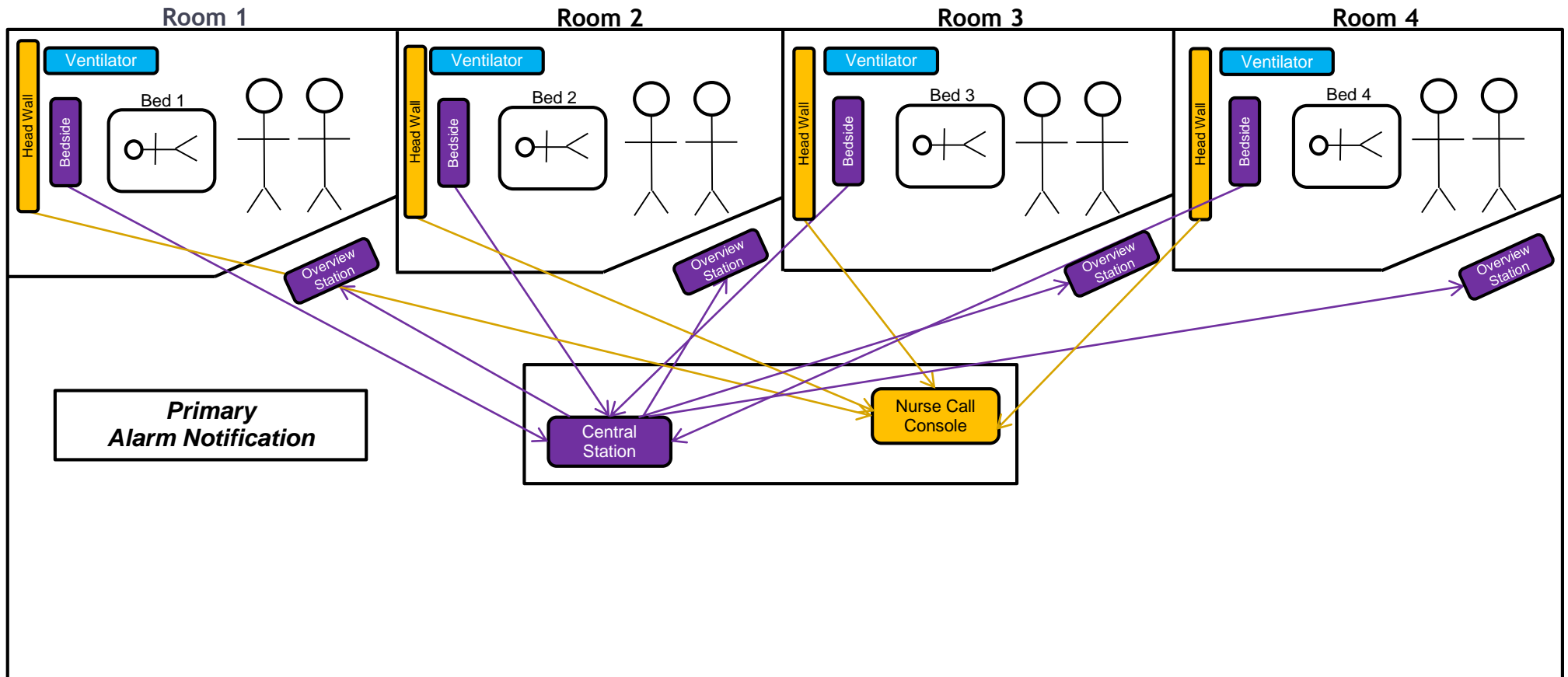


# NICU Project | Alarm Environment

Patient Monitors

Ventilators

Nurse Call



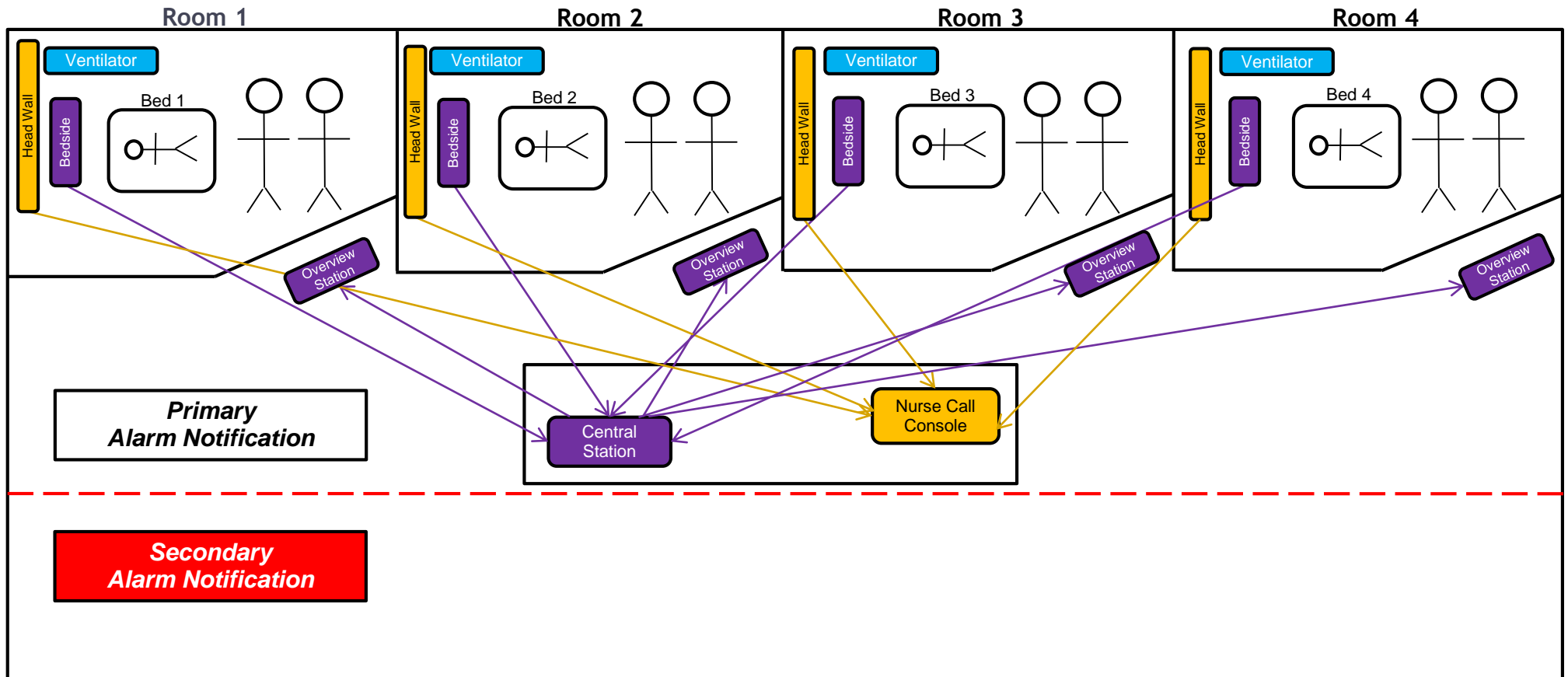
# NICU Project | Alarm Environment

Patient Monitors

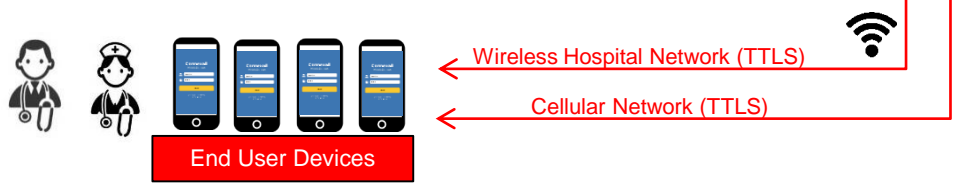
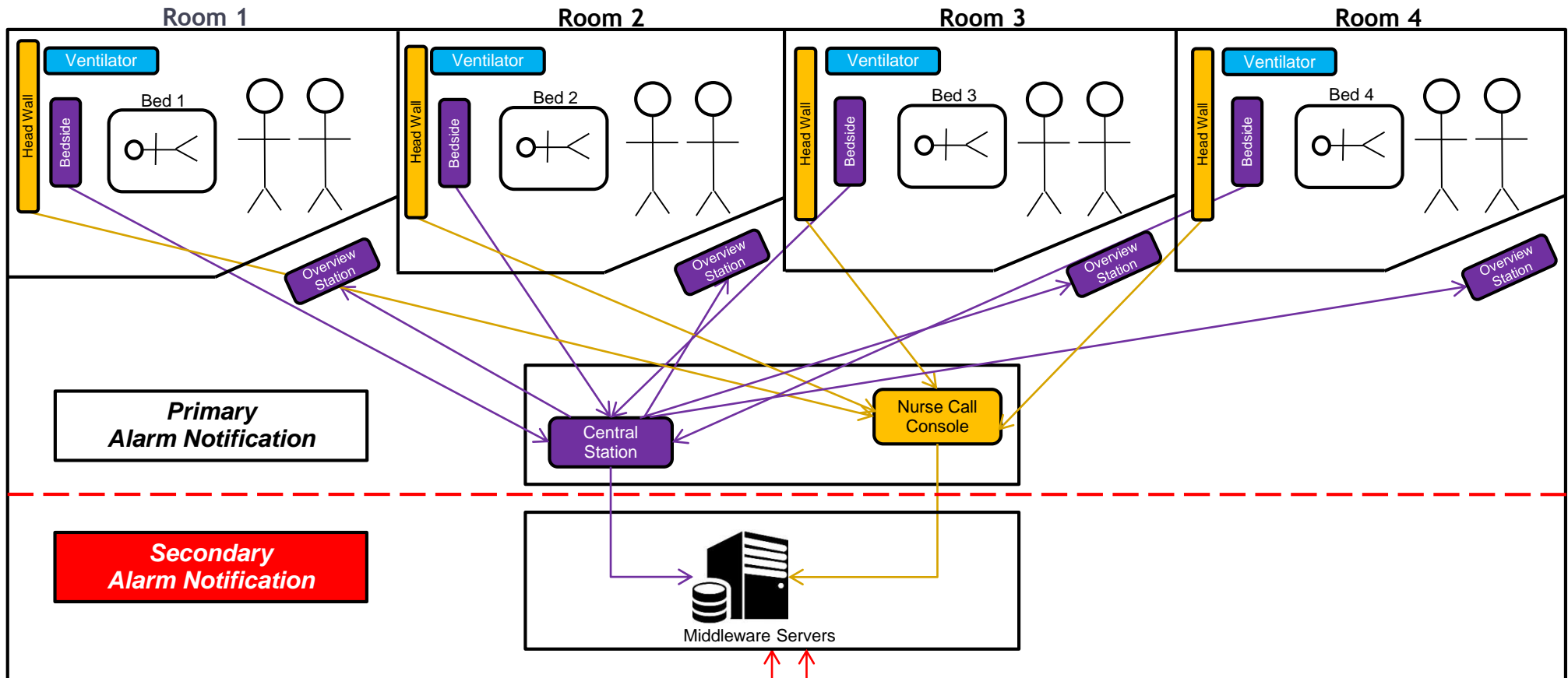
Ventilators

Nurse Call

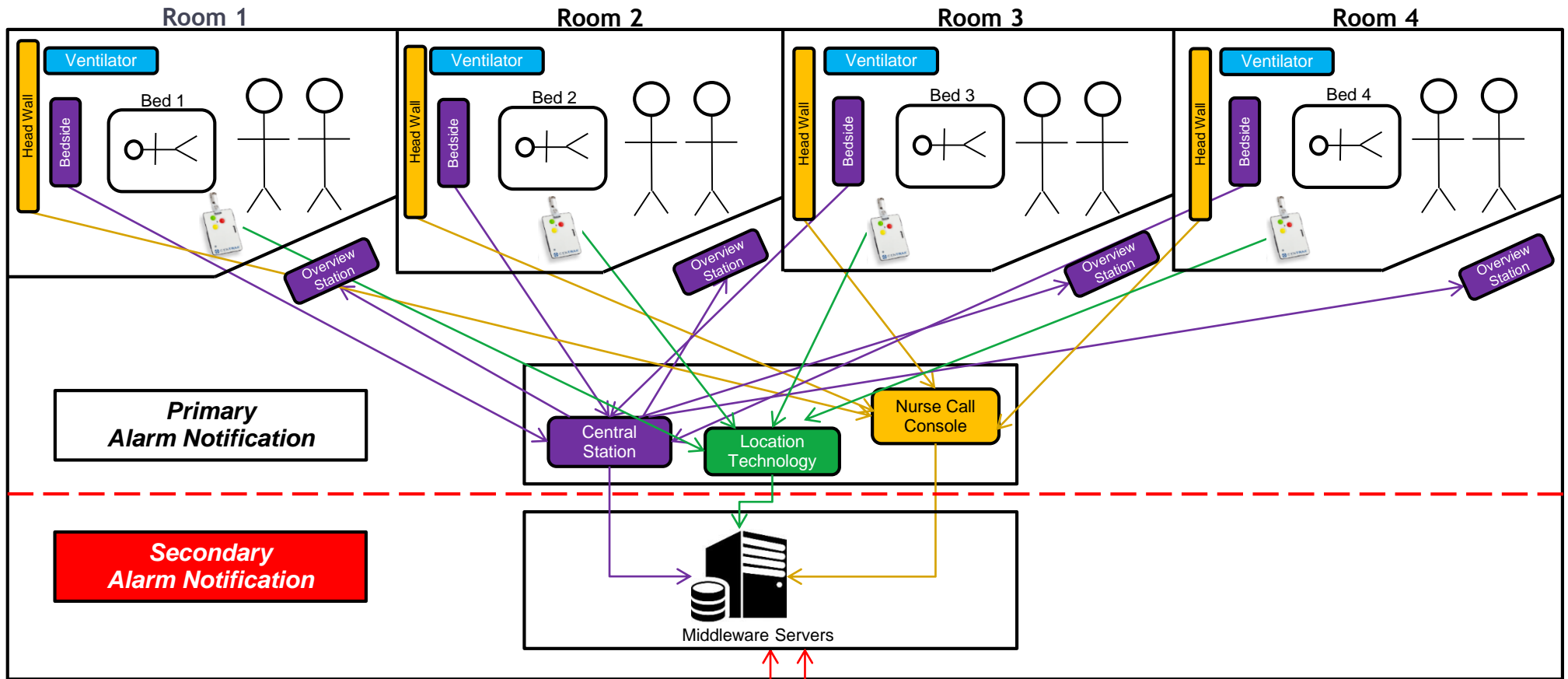
End User Devices



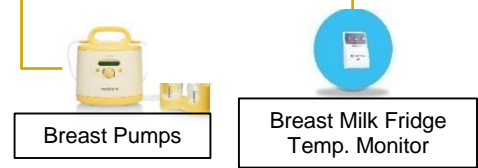
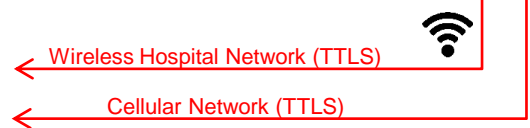
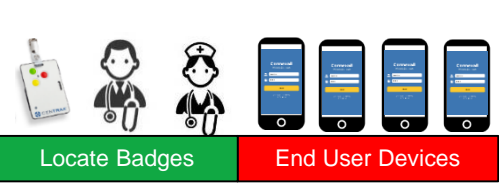
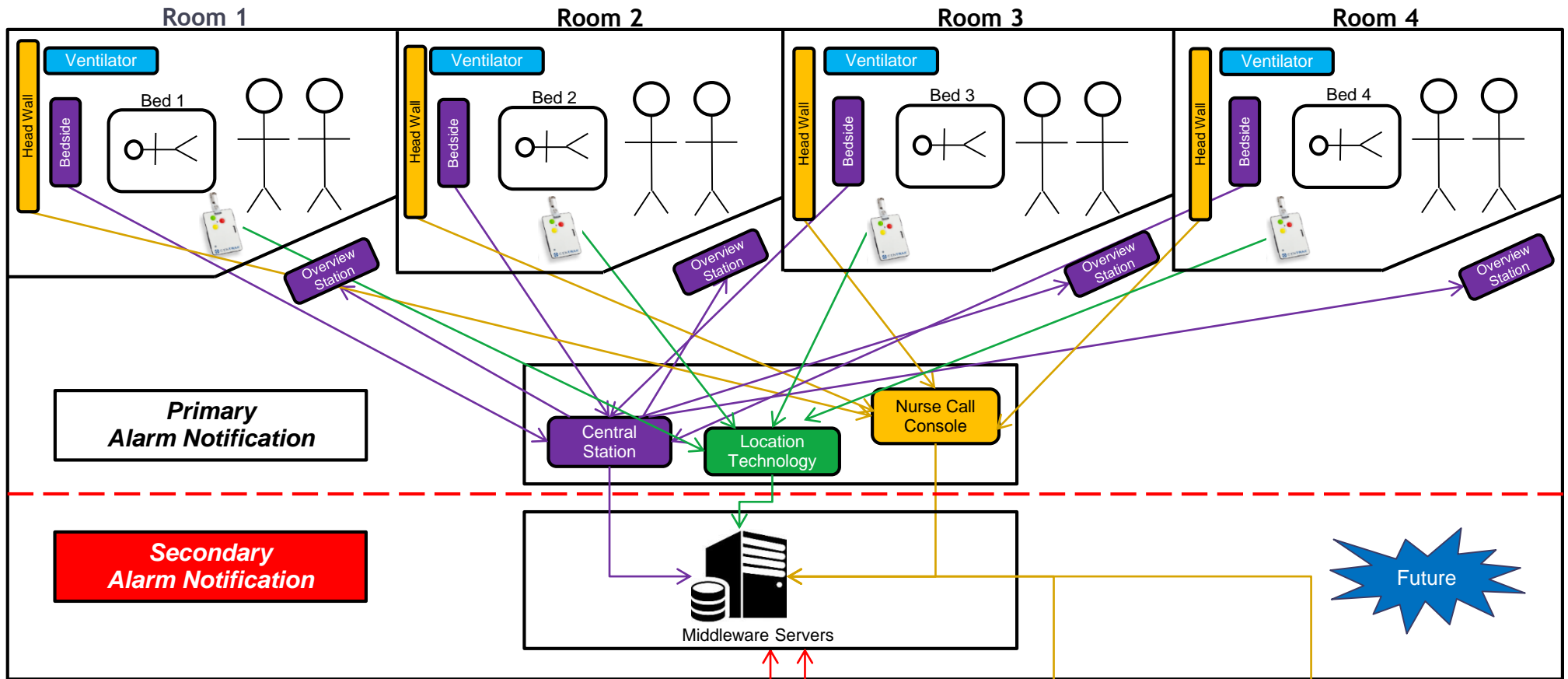
# NICU Project | Alarm Environment



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# NICU Project | Alarm Environment

Patient Monitors

Ventilators

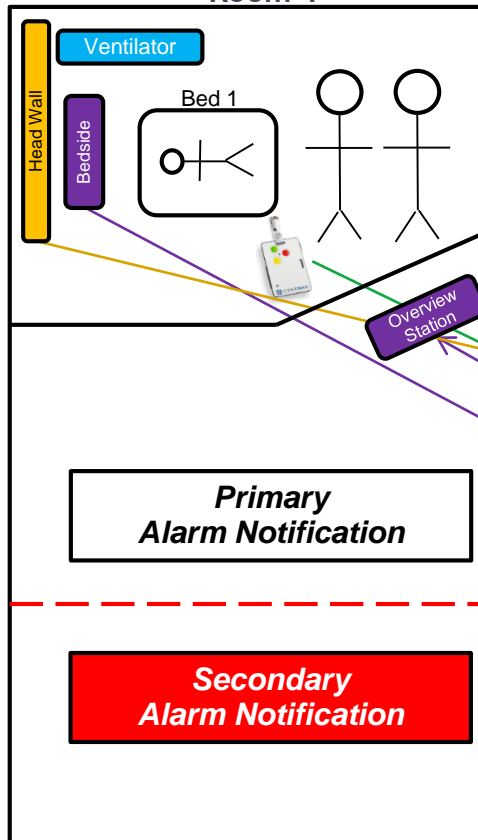
Nurse Call

End User Devices

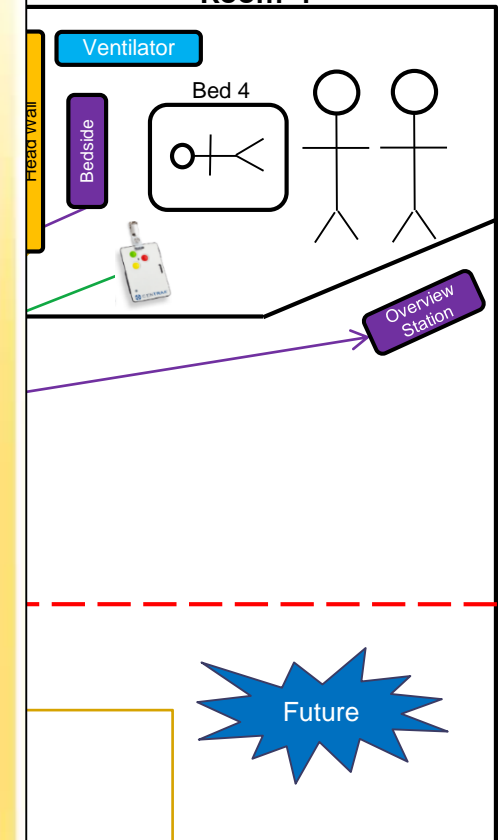
Middleware

Location Technology

Room 1



Room 4



<https://sites.psu.edu/isd4/2016/09/29/week-5-blog-summation-integrating-technology/>



Locate Badges

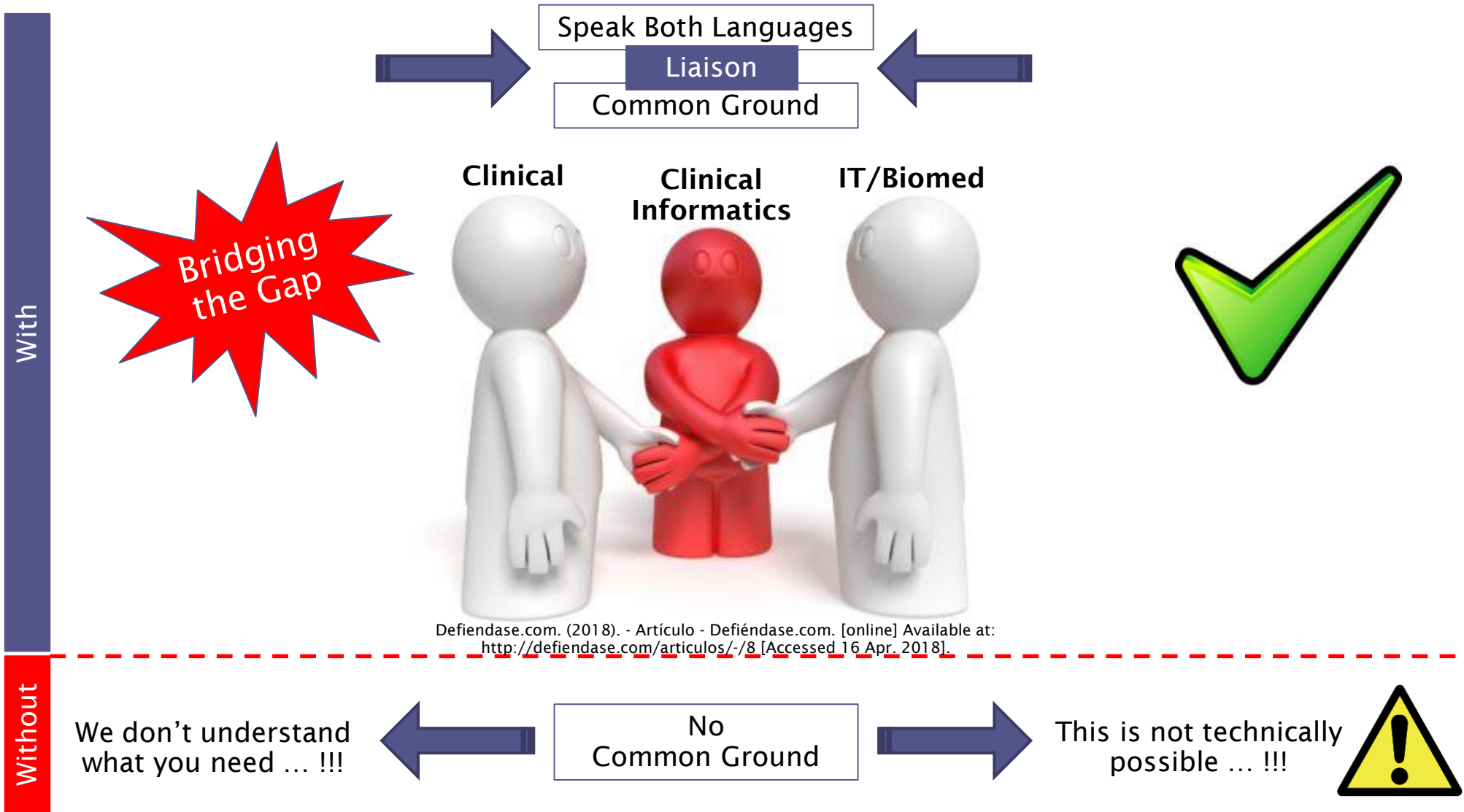
End User Devices



***So...***

***How Did We Reach This **Solution?*****

# Clinical Informatics Role...



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# Multi-Disciplinary Teams

## *Strategic Direction*

No	Steering Committee
1	Manager   Biomedical Eng.
2	Nurse Call Project Manager   Biomedical Eng.
3	Technologist   Biomedical Eng.
4	NICU   Clinical Lead
5	PICU   Clinical Lead
6	Patient Safety Consultant
7	NICU   Redevelopment Project Manager
8	IT Director   IWK Health Centre
9	Provincial IT   Government NS IM/IT
10	Clinical Alarm Project Coordinator   Clinical Informatics

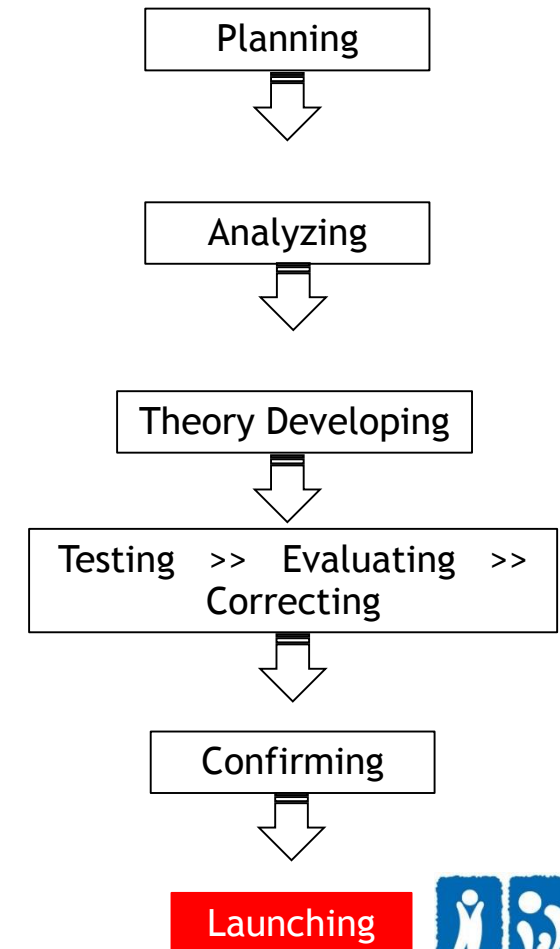
## *Clinical/Technical Guidance*

No	Task Force
1	Neonatologist
2	NICU   Clinical Lead
3	PICU   Clinical Lead
4	NICU   Nurse Champion
5	Respiratory Therapist Champion
6	Manager   Biomedical Engineering
7	Technologist   Biomedical Engineering
8	Patient Safety Consultant
9	Provincial IT   Government NS IM/IT
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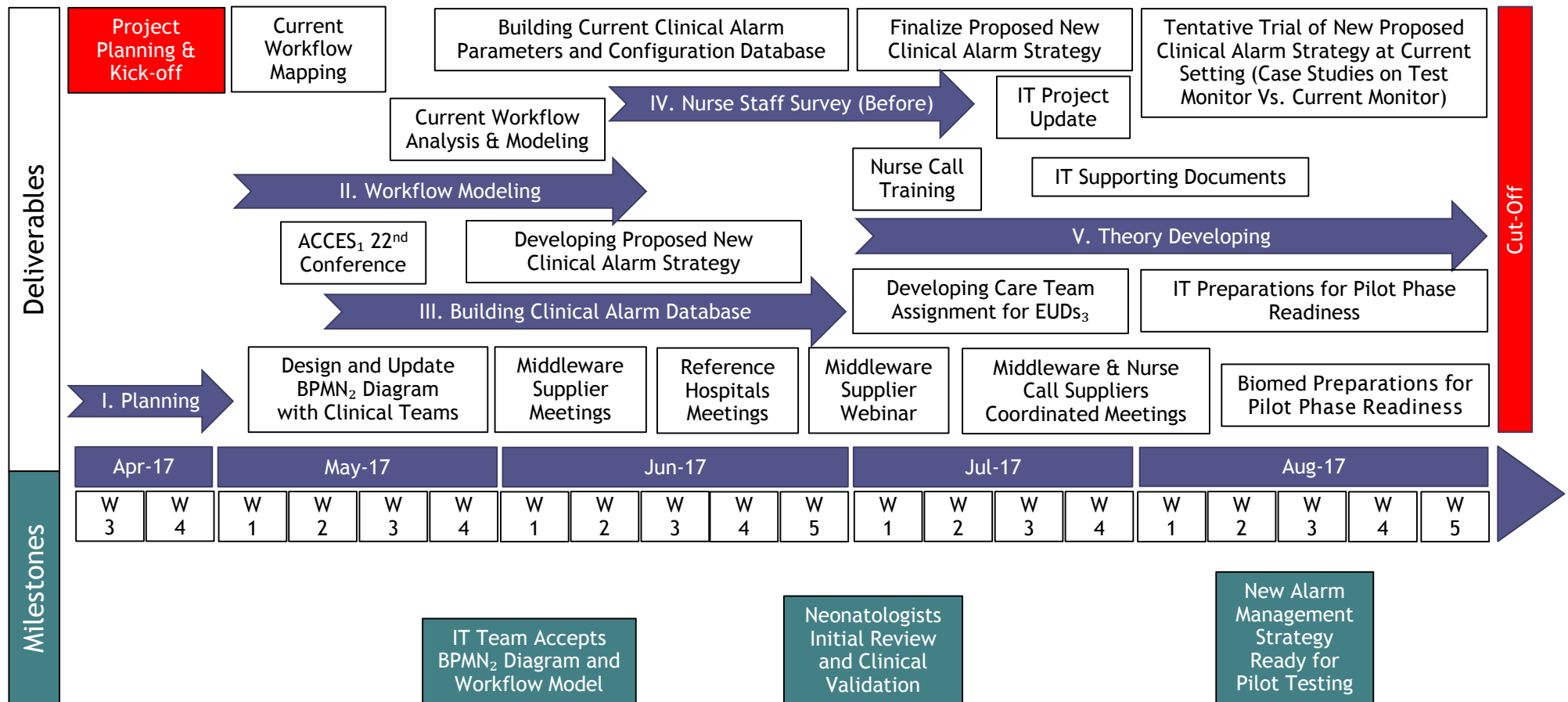


# Time Constrained Project (1 Year)

Phase	Description	Time Frame	Status
I	• Project Planning & Kick-Off	Apr-17	Done
II	• Workflow Modeling	May & Jun-17	Done
III	• Building Clinical Alarm Database	May & Jun-17	Done
IV	• NICU Nurse Staff Survey (Engagement & Satisfaction Levels)	Jun & Jul-17	Done
V	• Developing New Clinical Alarm Strategy • Developing Best Practice for Care Team Assignments to End User Devices	Jul & Aug-17	Done
VI	• Pilot Testing	Sep to Nov-17	Done
VII	• Initial Implementation - Open Bay Setting: a. Test vs. Current Monitor Configuration b. Without End User Devices c. With End User Devices	Dec-17 to Mar-18	Done
VIII	• Final Implementation - Single Family Room Setting • Parent Satisfaction Survey	Apr-18 & On	Ongoing



# Road Map... Phase I to V



ACCES<sub>1</sub>: Atlantic Canada Clinical Engineering Society  
 BPMN<sub>2</sub>: Business Process Model Notation  
 EUDs<sub>3</sub>: End User Devices

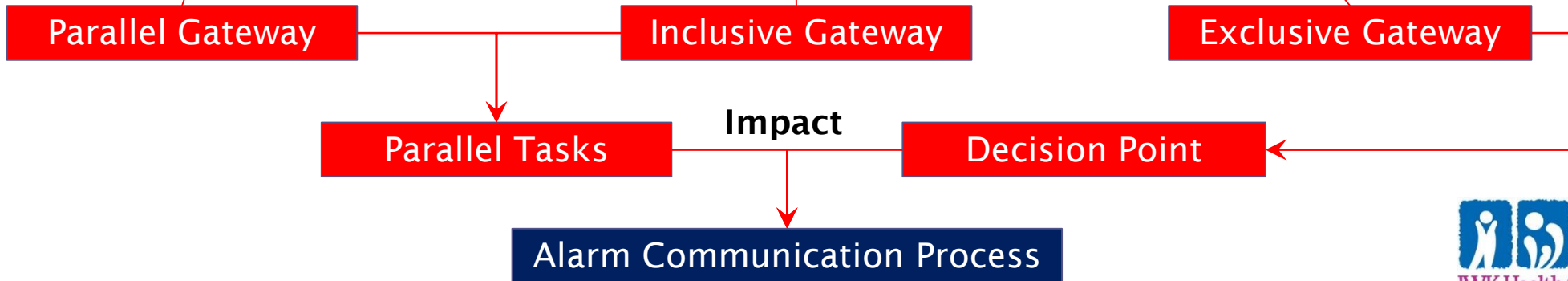
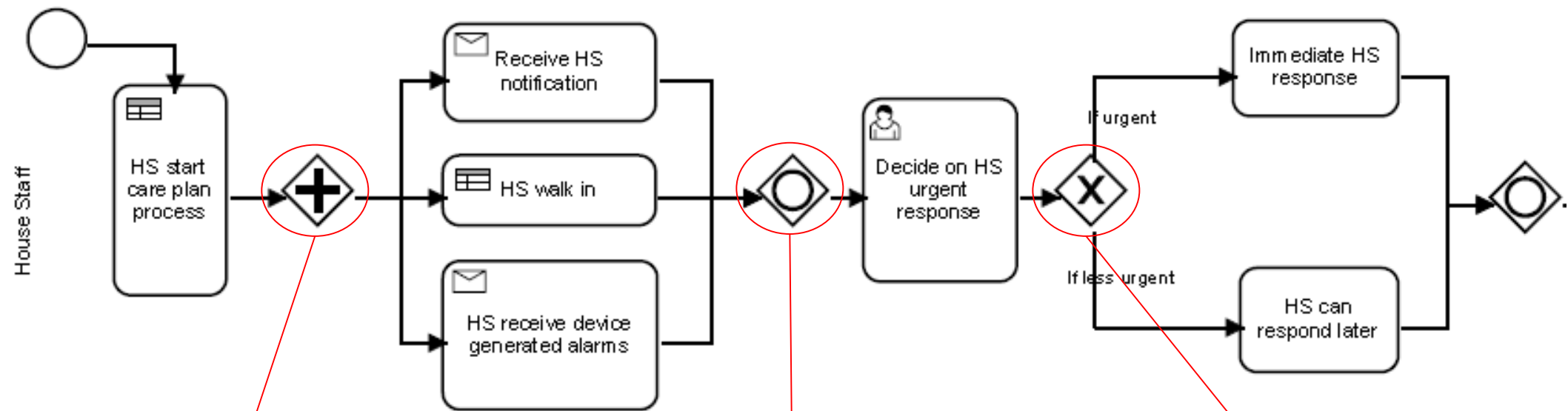
□ Deliverables    ■ Milestones    ■ Cut-Off Dates

## *Phase II...*

*How Did We Model The Workflow?*



# BPMN<sub>1</sub> Diagram | Physicians Lane



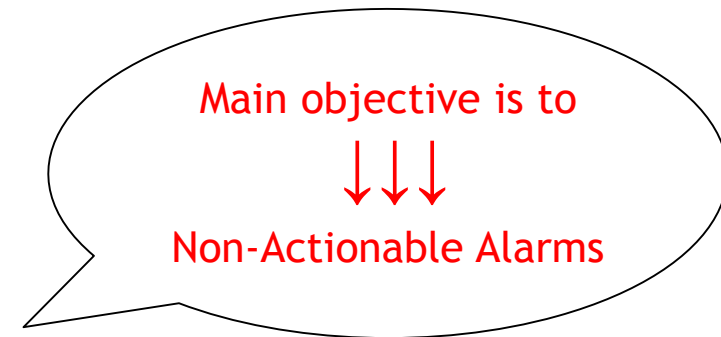
*Phase V...*

*How Did We Reduce Alarm Burden?*

# Strategies to Reduce Alarm Fatigue

- ECRI<sub>1</sub> Recommendations

- Changing the status or priority level of particular alarms
- Selecting alarm limits wisely
- Avoiding "over-monitoring"
- Instituting modest delays
- Paying special attention to leads-off (or other sensor-off) alarms and artifact-induced false or nuisance alarms



ECRI Institute. (2018). Log In. [online] Available at:  
<https://www.ecri.org/components/HDJournal/Pages/Strategies-for-Reducing-theAlarm-Load.aspx> [Accessed 14 Feb. 2018].

# Avoid Over-Monitoring

Before	Device	Parameters	Priority	Color	Tone	Frequency	Sound Pitch
	Patient Monitor	13	High	Red	Single	1/ 1 sec	High
		24	Med	Yellow	Single	1/ 2 sec	Med
		3	Low	Blue	Single	1/ 3 sec	Low
		1	Low	Red Banner (Admit patient)	NA	NA	NA
		1	All	All (Chicklets)	NA	NA	NA

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After	Device	Parameters	Priority	Color	Tone	Frequency	Sound Pitch
	Patient Monitor	8	High	Red	Single	1/ 1 sec	High
		4	Med	Yellow	Single	1/ 2 sec	Med
		3	Low	Blue	Single	1/ 3 sec	Low
		1	Low	Red Banner (Admit patient)	NA	NA	NA
		1	All	All (Chicklets)	NA	NA	NA

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# Alarm Limits per Patient Population

## NICU Patient Profiles

1. Standard NICU
2. <36 weeks + O<sub>2</sub>
3. ≥ 36 weeks + O<sub>2</sub>
4. Sat + BP
5. SigLungDis
6. CHD
7. Hypothermia
8. PPHN
9. Privacy



Select Patient Profile

# Alarm Limits & Delays

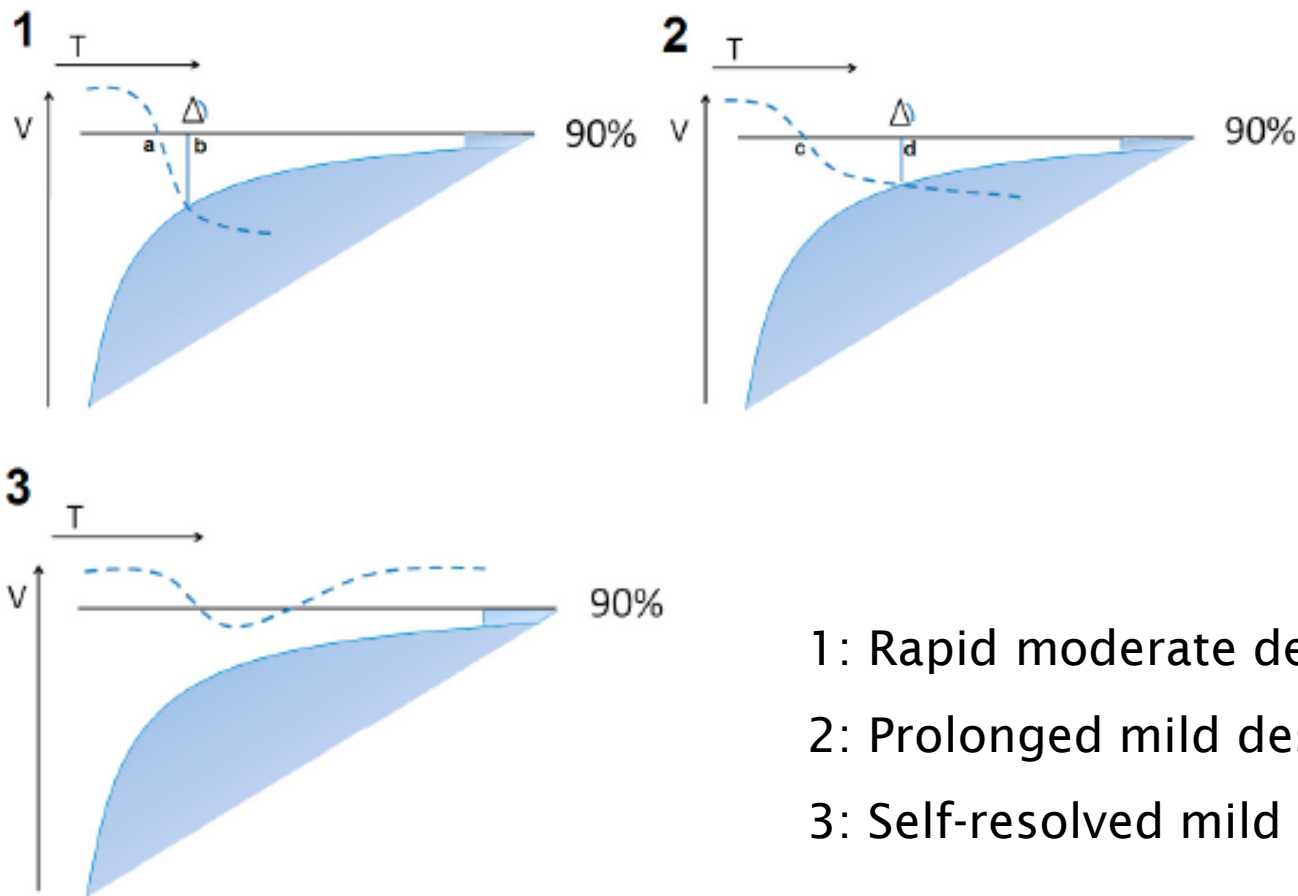
<36 W + O<sub>2</sub>

Parameter	Lower Limit	Upper Limit	System Delay		Smart Delay		Averaging Time
			Y/N	Time	Y/N	Time	
High Sat		94%	N		Y	L	20 s
Low Sat	86%		N		Y	L	20 s
Desat	75%		Y	10 s	N		20 s

SigLungDis

Parameter	Lower Limit	Upper Limit	System Delay		Smart Delay		Averaging Time
			Y/N	Time	Y/N	Time	
High Sat		97%	N		Y	L	20 s
Low Sat	80%		N		Y	L	20 s
Desat	70%		Y	10 s	N		20 s

# SpO<sub>2</sub> Smart Alarm Delay



- 1: Rapid moderate desaturation
- 2: Prolonged mild desaturation
- 3: Self-resolved mild desaturation

# Impact on Alarm Burden

## Before

(2 random days cumulative data)

Unit	Numer of Patients	Alarms			
		Type	Count	Avg/Pt /Day	Avg/Pt /Hour
Total NICU	74	Red	1,021	14	1
		Yellow	9,922	134	6
		Blue	198	3	0
		Total	11,141	151	6

## After

(2 random days cumulative data)

Unit	Numer of Patients	Alarms			
		Type	Count	Avg/Pt /Day	Avg/Pt /Hour
Total NICU	68	Red	1,401	21	1
		Yellow	3,555	52	2
		Blue	586	9	0
		Total	5,542	82	3

Δ

## Delta Gain

Unit	Alarms		
	Type	Variance	Δ Gain %
Total NICU	Red	380	49%
	Yellow	-6,367	-61%
	Blue	388	222%
	Total	-5,599	-46%

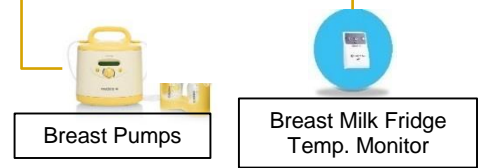
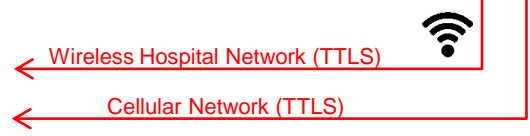
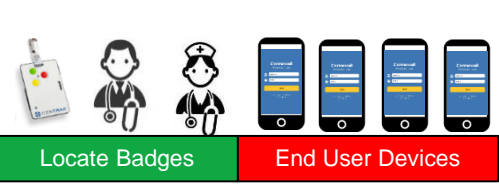
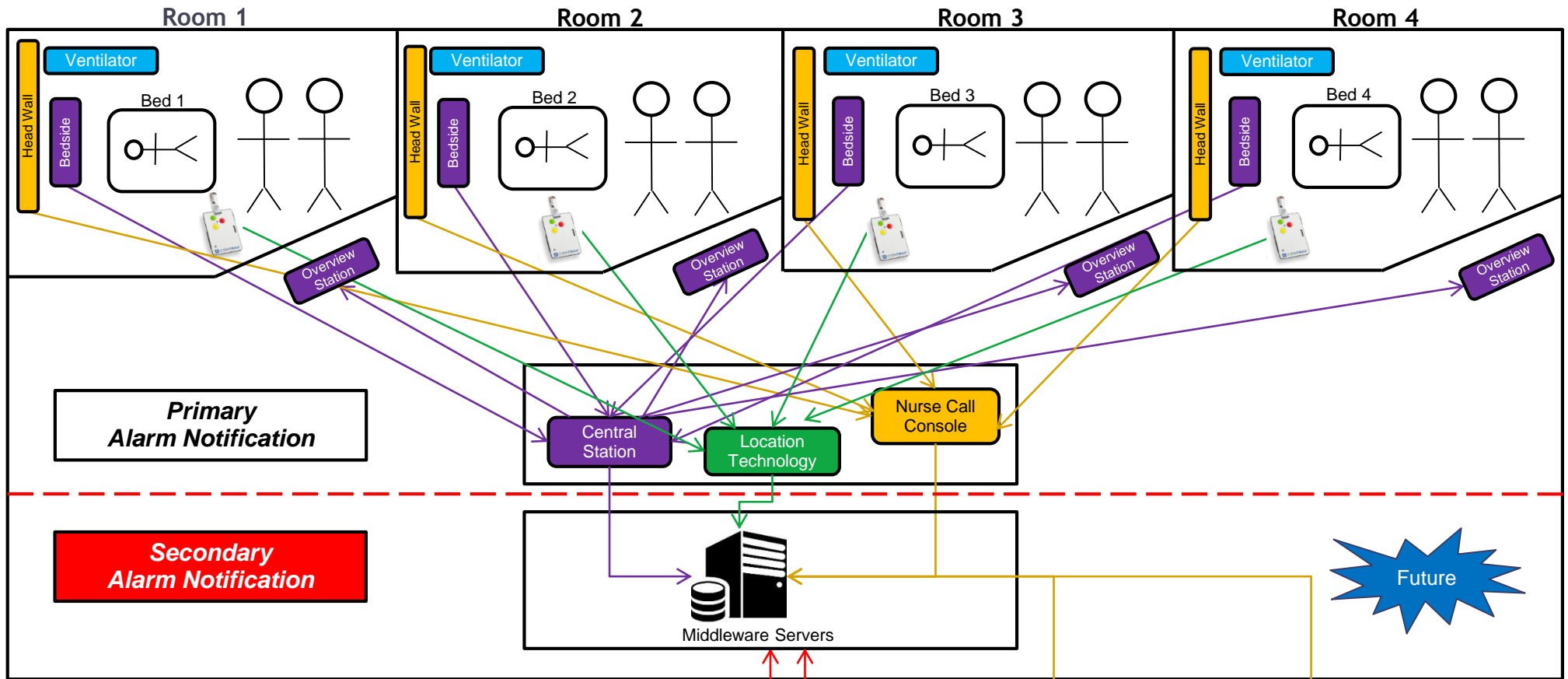
- Overall Δ gain:            -46%            Significant decrease            >>>            Significantly less alarm load            ✓
- Red alarms:                    ↑            Reasonable increase            >>>            Favourable            ✓
- Yellow alarms:                ↓↓↓            Significant decrease            >>>            Favourable            ✓
- Blue alarms:                    ↔            Technical            >>>            Needed further work            ⚠



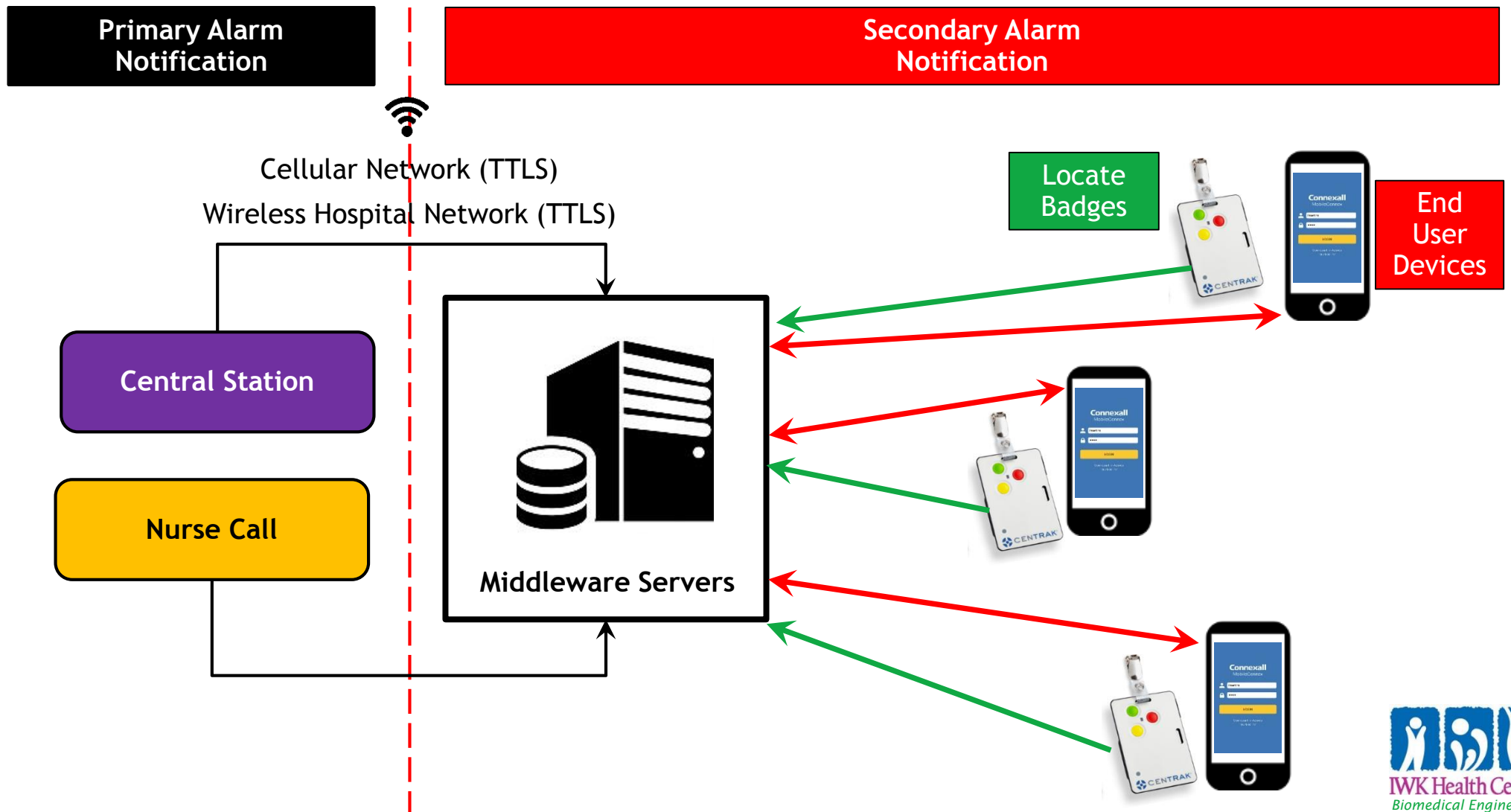
*Phase V...*

*How Did We Communicate Alarms?*

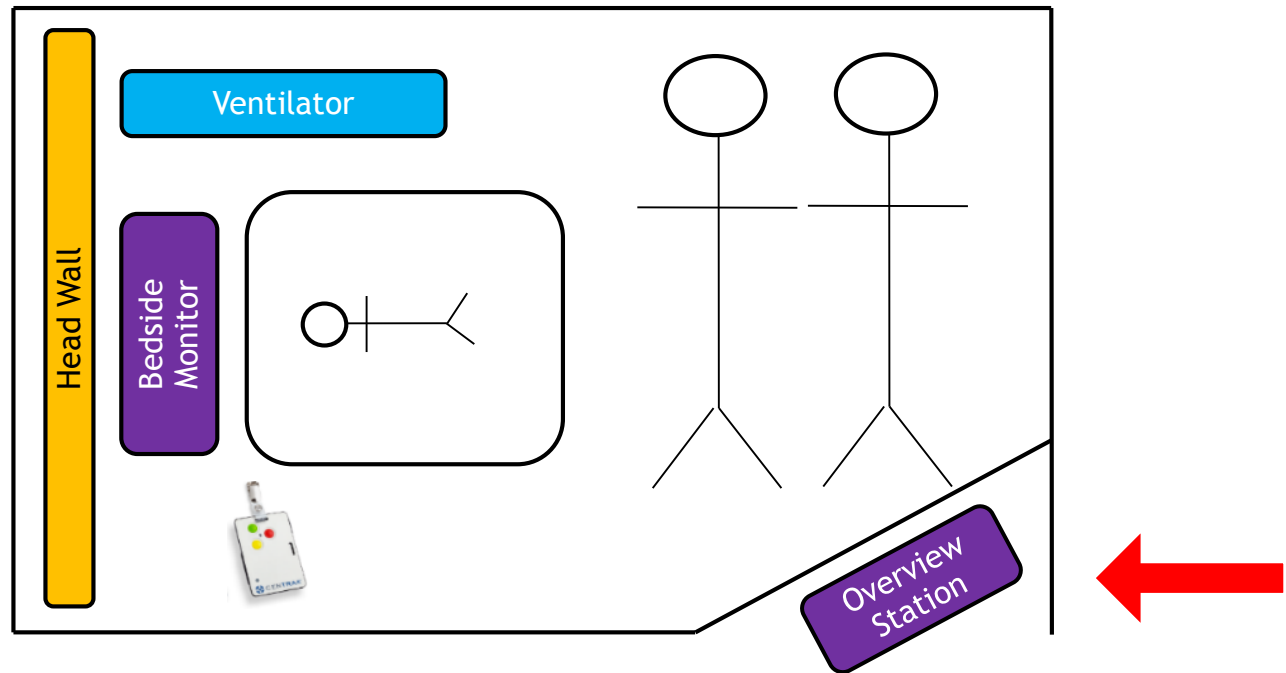
# NICU Project | Alarm Environment



# Alarm Communication Platform



# Overview Stations (Virtual Open Bay)



# Overview Stations (Virtual Open Bay)



IWK photo

# Alarm Escalation Process & Assignments

## Bedside Monitors

Description Label	Colors	Primary Escalation (Primary Nurse)			Secondary Escalation (Buddy Nurse)			Tertiary Escalation (Everyone)		
		Response Time Allocated (s)	Primary Retry Attempts	Primary Retry Interval (s)	Response Time Allocated (s)	Secondary Retry Attempts	Secondary Retry Interval (s)	Response Time Allocated (s)	Backup Retry Attempts	Backup Retry Interval (s)
BRADY	Red	60	1	30	60	1	30	∞	999	30
TACHY	Red	60	1	30	60	1	30	∞	999	30
DESAT	Red	60	1	30	60	1	30	∞	999	30
HIGH SAT	Yellow	360	2	120	360	2	120	∞	999	120
LOW SAT	Yellow	180	2	60	180	2	60	∞	999	60
LEADS OFF	Blue	360	2	120	360	2	120	∞	999	120
NO CENTRAL MONITOR	Blue	360	2	120	360	2	120	∞	999	120



# Alarm Escalation Process & Assignments

## Nurse Call

Description Label	Colors	Primary Escalation			Secondary Escalation			Tertiary Escalation		
		Role Notified	Primary Retry Attempts	Primary Retry Interval (s)	Role Notified	Secondary Retry Attempts	Secondary Retry Interval (s)	Role Notified	Backup Retry Attempts	Backup Retry Interval (s)
CARE TEAM	Red	HS/RT/CN/ PN	1440	2	-	-	-	-	-	-
RESPIRATORY (RT Required (Non-Emergent))	Yellow	RT	2	300	S RT	999	300	B RT	999	300
NEEDS CLEANING (Room Turnover)	Yellow	UA	999	1200	-	-	-	-	-	-
BATH	Red	PN	1	30	SN	1	30	NT	999	30
CALL CORD DISCONNECT	Red	PN	1	30	SN	1	30	NT	999	30
NORMAL	Yellow	PN	999	300	-	-	-	-	-	-
SHOWER	Red	PN	1	30	SN	1	30	NT	999	30

HS (House Staff)  
S RT (Secondary RT)

RT (Respiratory Therapist)  
B RT (Backup RT)

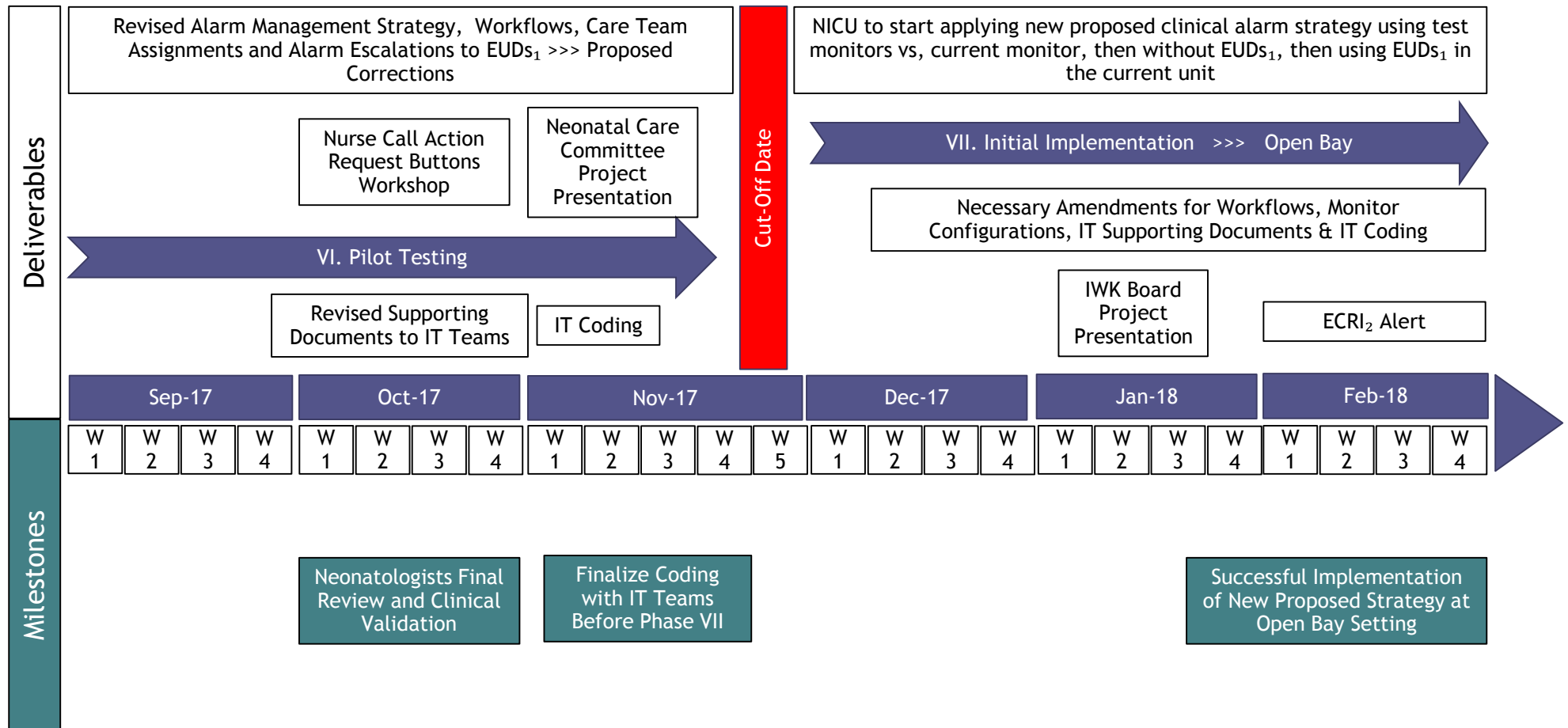
CN (Charge Nurse)  
NT (Neighborhood Team)

PN (Primary Nurse)

UA (Unit Aid)

SN (Secondary Nurse)

# Road Map... Phase VI & VII



EUDs<sub>1</sub>: End User Devices  
 ECRI<sub>2</sub>: Emergency Care Research Institute

□ Deliverables    ■ Milestones    ■ Cut-Off Dates



*Phase VI...*

*How Did We Manage The  
Simulation Phase?*

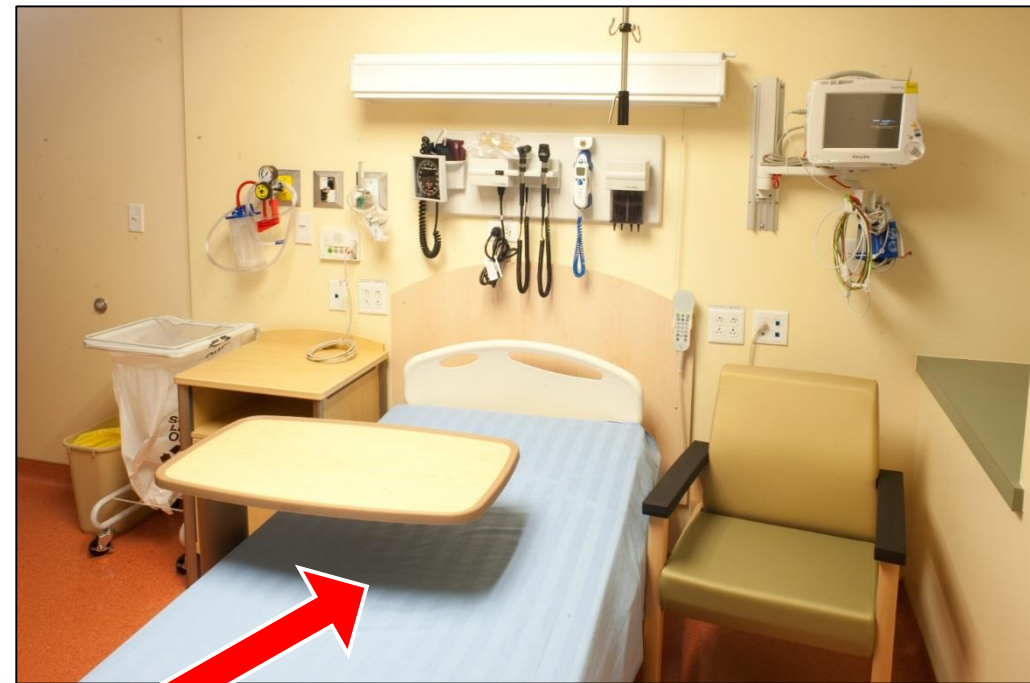


# IWK Test Environment



IWK photo

Patient Rooms (10)



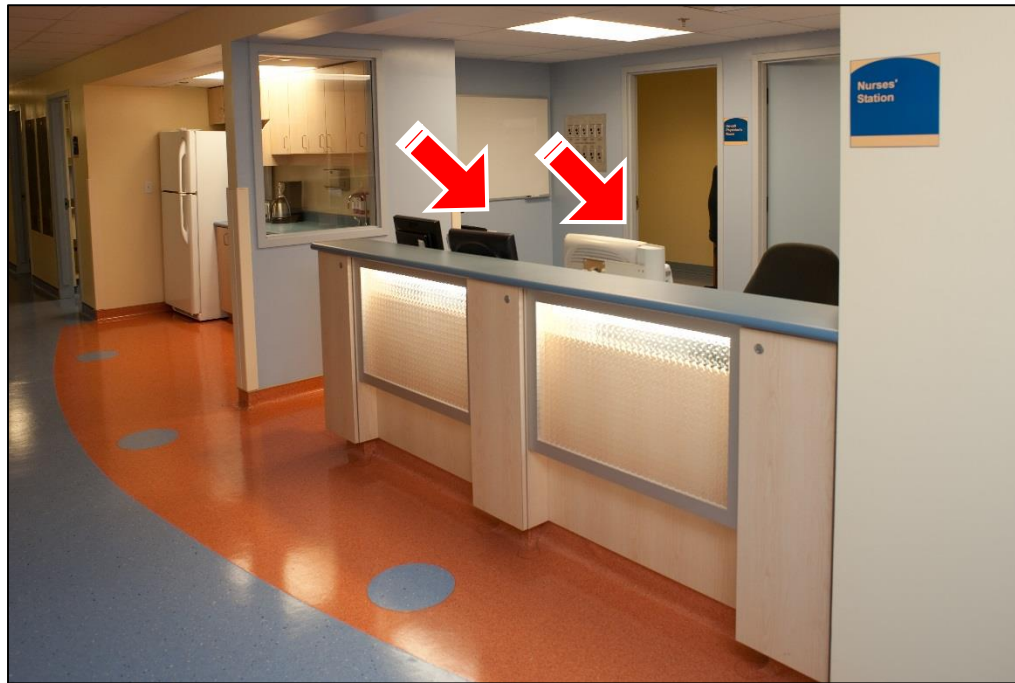
IWK photo

Patient Simulators (3)



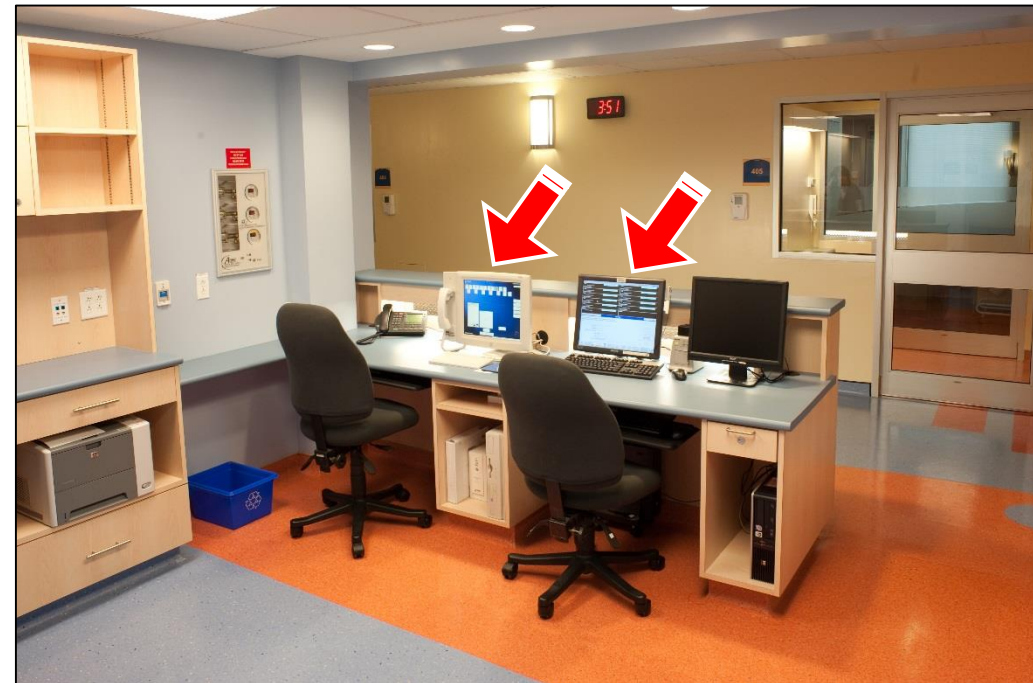
# IWK Test Environment

Nurses' Station (Outside)



IWK photo

Nurses' Station (Inside)



IWK photo


Central Monitor + Nurse Call Console

## *Phase VII...*

*Why Did We Include an Initial  
Implementation Phase?*



# Initial Implementation Phase

- 
- Limitations of the test environment (no real patients)
  - Nurse Staff Survey (**Before**) Results
    - High level of anxiety among nurses about the move to the single family rooms
    - Nurses were questioning the efficacy of the technology
  - Step-wise approach to endorse the new strategy in the Open Bay Setting
    - Phase VIIa >>> **Test vs. Current** Monitor Config.
    - Phase VIIb >>> **Without** End User Devices
    - Phase VIIc >>> **With** End User Devices



# Monitor Configuration

Current Monitor

Test Monitor

High Sat\*\*

Low Sat\*\*

Desat\*\*\*

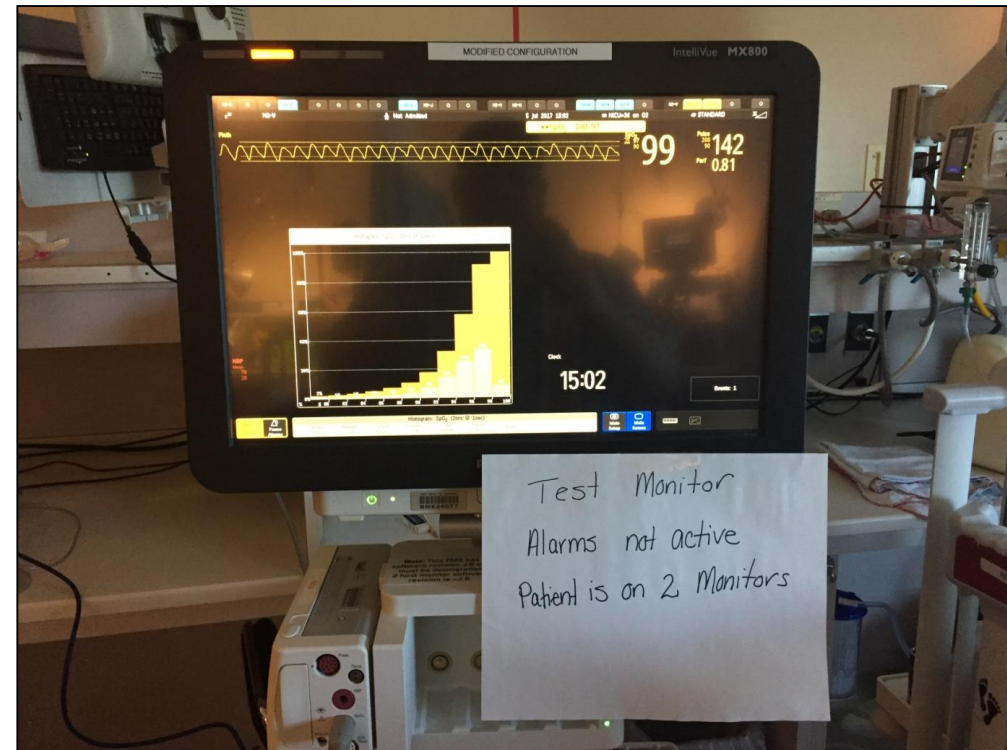
High Sat\*\*

Low Sat\*\*

Desat\*\*\*



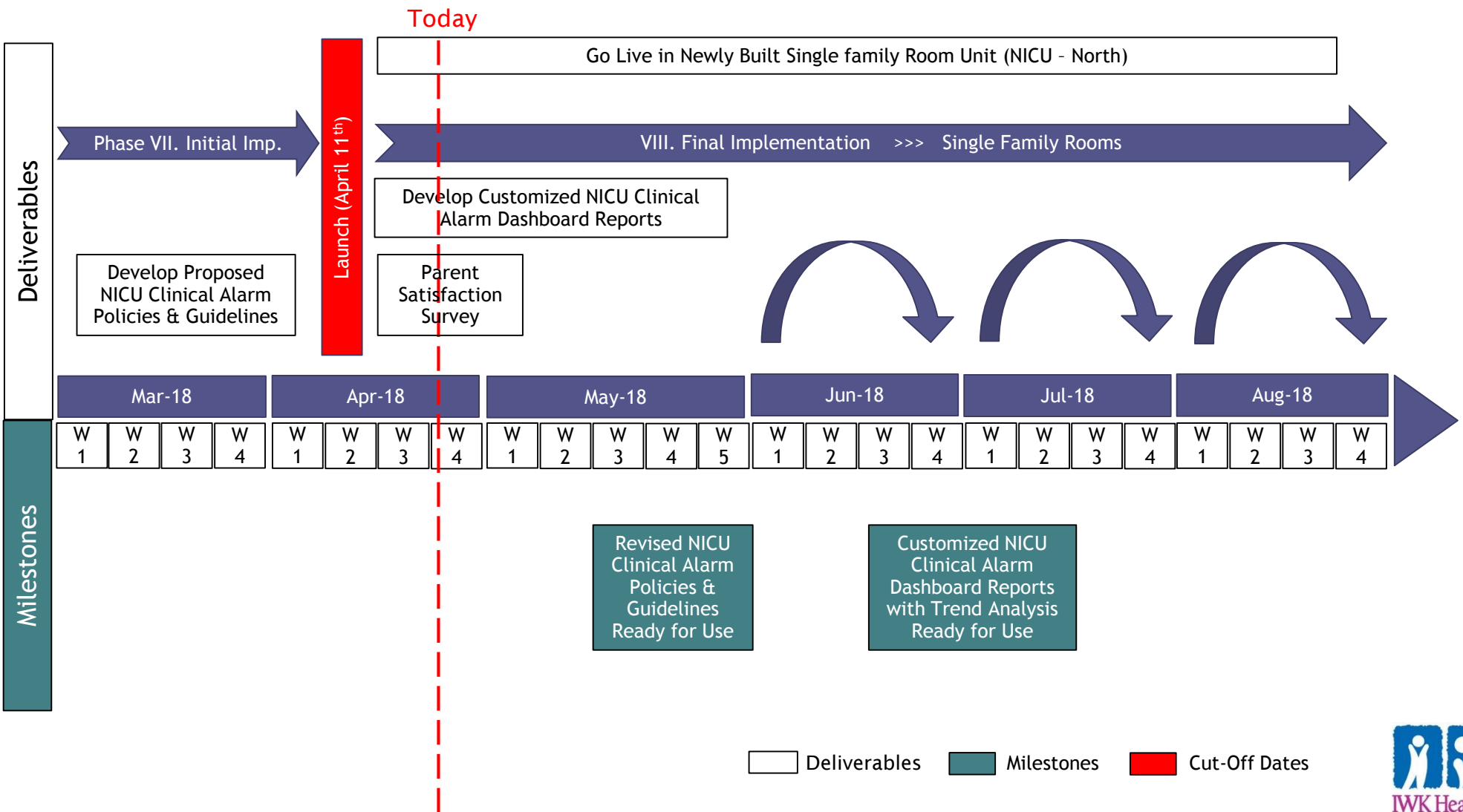
IWK photo



IWK photo

Test Monitor  
Alarms not active  
Patient is on 2 Monitors

# Road Map... Phase VIII (Launch)



# Critical Success Factors

- Reducing Alarm Burden
  - Alarm Configuration Per Patient Population
- Multiple Sources of Alarm Notification (Primary & Secondary )
  - Overview Stations (Virtual Open Bay)
  - End User Devices
- Multi-Disciplinary Teams
  - Right Expertise
  - High Engagement Level
  - Frequent Communication
- Managing Change
  - Simulation Phase (Pilot Testing)
  - Initial Implementation Phase



# Ongoing & Future Work

- Customized Clinical Alarm Dashboard Reports
- Greater Leveraging of Location Awareness Technology
  - Cancellation of secondary alarm notifications while the clinician is inside the same patient room
  - Asset tracking
- Nurse Staff Survey
  - Engagement & Satisfaction Levels
- Parent Satisfaction Survey
  - Open Bay Setting vs. Single Family Room Setting
- NICU South Redevelopment Project
- PICU Redevelopment Project

# Discussion...

## Speakers Contact Info

For *Biomedical Engineering Questions*, please contact David Hancock at:  
[David.Hancock@iwk.nshealth.ca](mailto:David.Hancock@iwk.nshealth.ca)

For *Clinical Questions*, please contact C. David Simpson at:  
[CDavid.Simpson@iwk.nshealth.ca](mailto:CDavid.Simpson@iwk.nshealth.ca)

For *Clinical Informatics & NICU Alarm Management Project Questions*, please contact Marwan Abouelela at:  
[Marwan.Abouelela@iwk.nshealth.ca](mailto:Marwan.Abouelela@iwk.nshealth.ca)



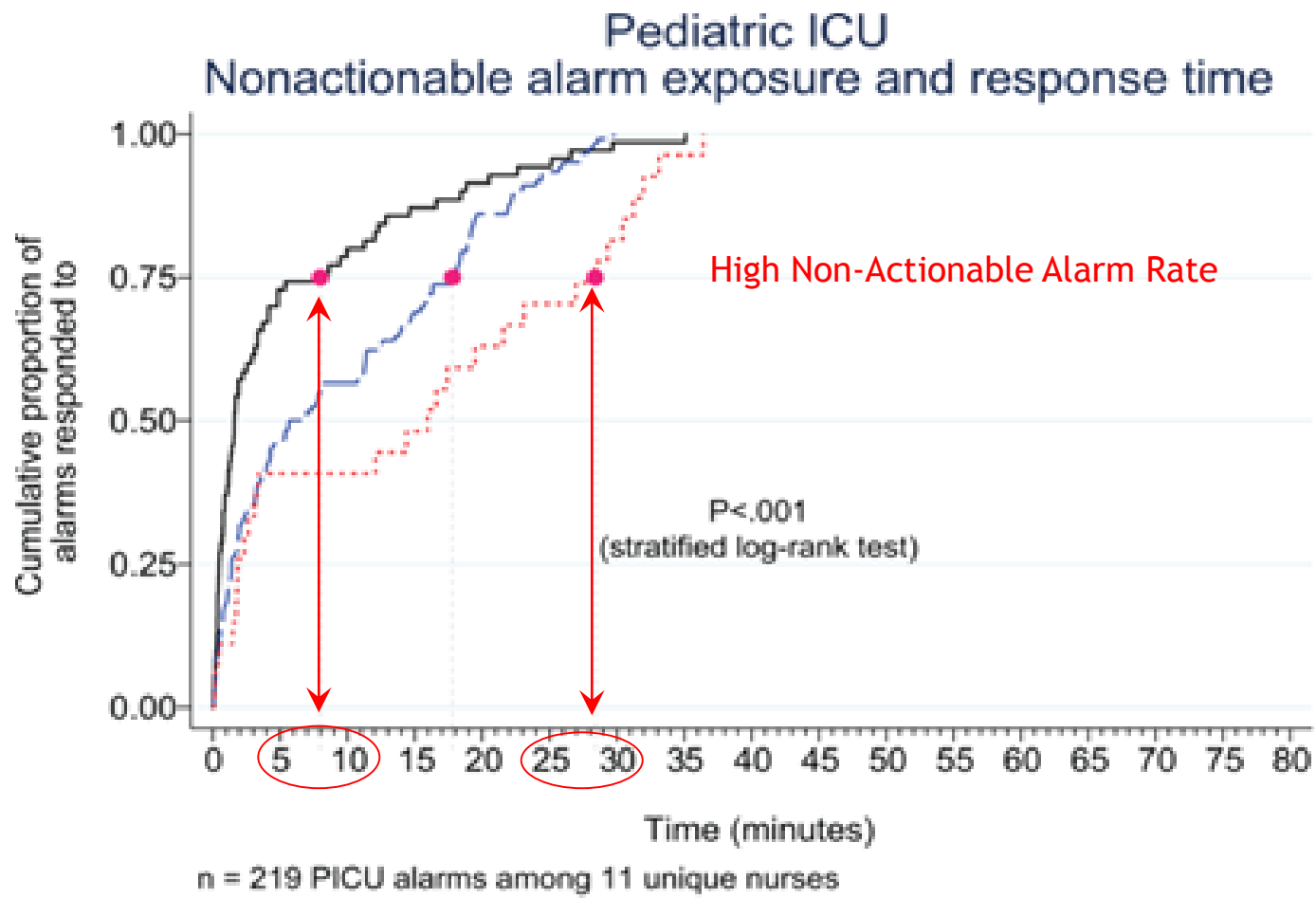
Let's Talk Informatics has been certified for continuing education credits by;

- College of Family Physicians of Canada and the Nova Scotia Chapter for 1 Mainpro+ credit.
- Digital Health Canada for 1CE hour for each presentation attended. Attendees can track their continuing education hours through the HIMSS online tracking certification application, which is linked to their HIMSS account.

*Thank you for attending this event.*

*Additional Slides Not Included  
in The Presentation*

# Decreased Response time



Bonafide, C., Lin, R., Zander, M., Graham, C., Paine, C., Rock, W., Rich, A., Roberts, K., Fortino, M., Nadkarni, V., Localio, A. and Keren, R. (2015). Association between exposure to nonactionable physiologic monitor alarms and response time in a children's hospital. *Journal of Hospital Medicine*, 10(6), pp.345-351.



Patient Simulator 1

Patient Simulator 2

Patient Simulator 3



Head Wall

Ventilator

Bedside



Head Wall

Ventilator

Bedside



Head Wall

Ventilator

Bedside



Overview Station

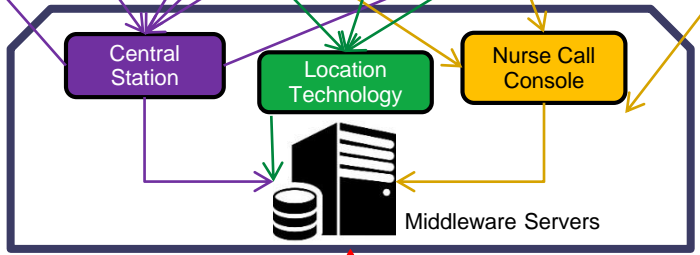
Overview Station

Overview Station

Room 1 Room 2 Room 3 Room 4 Room 5 Room 6 Room 7 Room 8 Room 9 Room 10

Primary Alarm Notification

Secondary Alarm Notification



IWK Test Environment



Wireless Hospital Network (TTLS)

Cellular Network (TTLS)