Mobile Decision Support in Healthcare

Catherine Burns

Advanced Interface Design Lab

Presentation to WIHIR, Sept 15, 2004

Motivating Issues

- Recent awareness of medical error/patient safety (IOM report)
- Incentive to reduce healthcare costs
- Need to improve healthcare accessibility
- Possibilities offered by information technology

- IOM report, 'Keeping Patients Safe: Transforming the Work Environment of Nurses' [3] recommends

- an increase in the development and use of computer-supported clinical decision support systems as a way to improve patient safety

Computerized Decision Support

- Relatively new to healthcare
- Not new to other domains
  - Power plant control
  - Oil refining and production
  - Space exploration
- Safety consciousness, existence of other computerized tools, extensive reach of accidents

Previous Attention

- Anesthesiology
- Neo-natal intensive care
- Hemodynamic monitoring in intensive care

Why Monitoring a Human

- Is a bit like monitoring a power plant
  - Complexity
  - Time lags
  - Many interconnected components
  - Unexpected interactions
  - Prone to unanticipated events
  - Added complexity when something is “broken”
  - Safety of “the plant” is important

Why Monitoring a Human

- Is not at all like monitoring a power plant
  - Incomplete set of sensors
  - Incomplete knowledge of how “the plant” works
  - Multiple complex internal control loops
  - Difficult to isolate compone
  - Intervenes and tries to control itself
  - High degree of variation

What happened in nuclear power

- TMI (1979)
- Partial core meltdown
- Largest nuclear plant accident in US history
- Discovery that displays and controls that were adequate under normal conditions were not good enough in abnormal unexpected situations

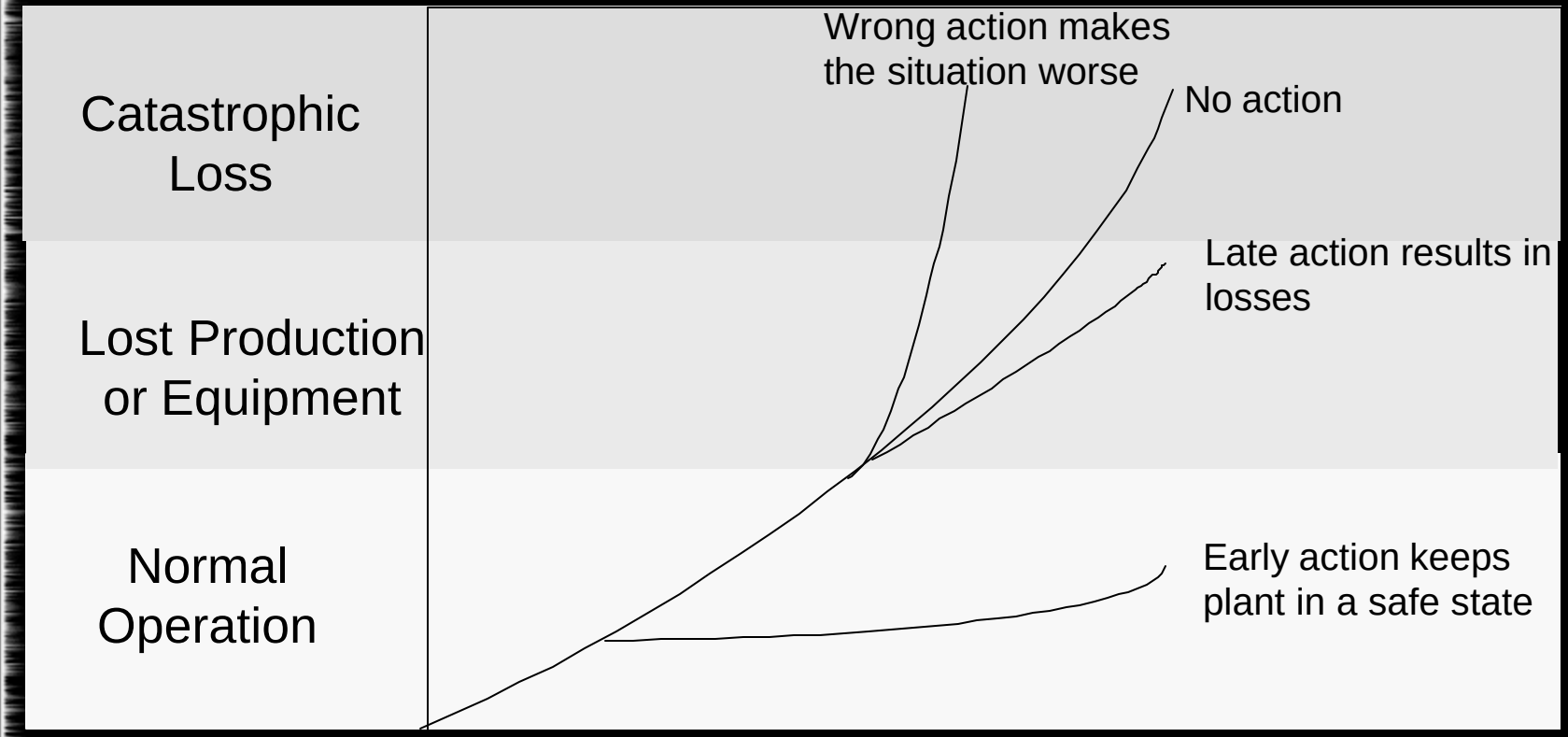
The abnormal unexpected

- Situations can not be anticipated
- Procedures don’t exist
- People must problem solve
- Task analysis is no longer a useful design approach
  - Optimizes normal operation

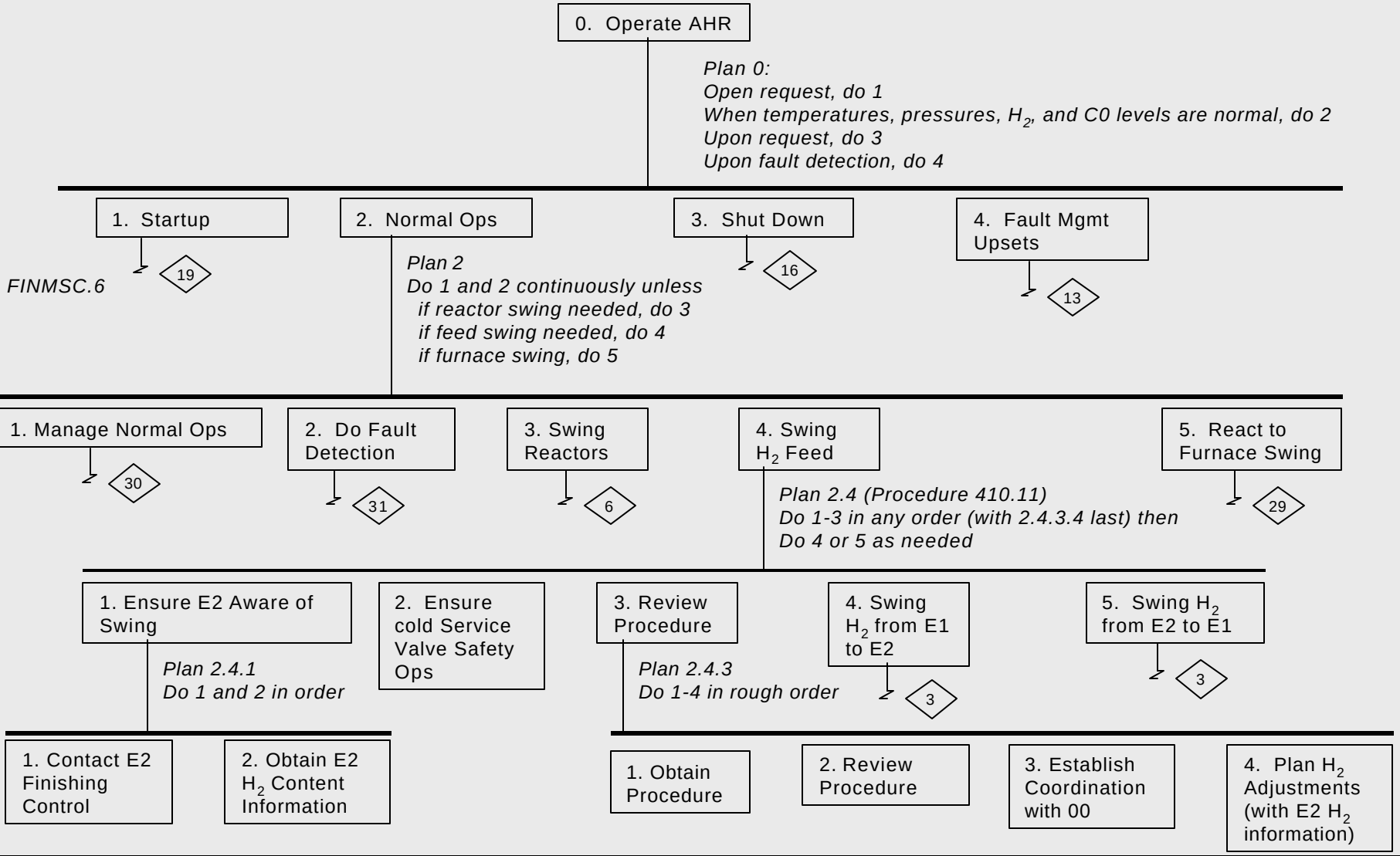
- Often the most dangerous accidents

Abnormal Situation Management

Makes economic sense



Task Analysis Example



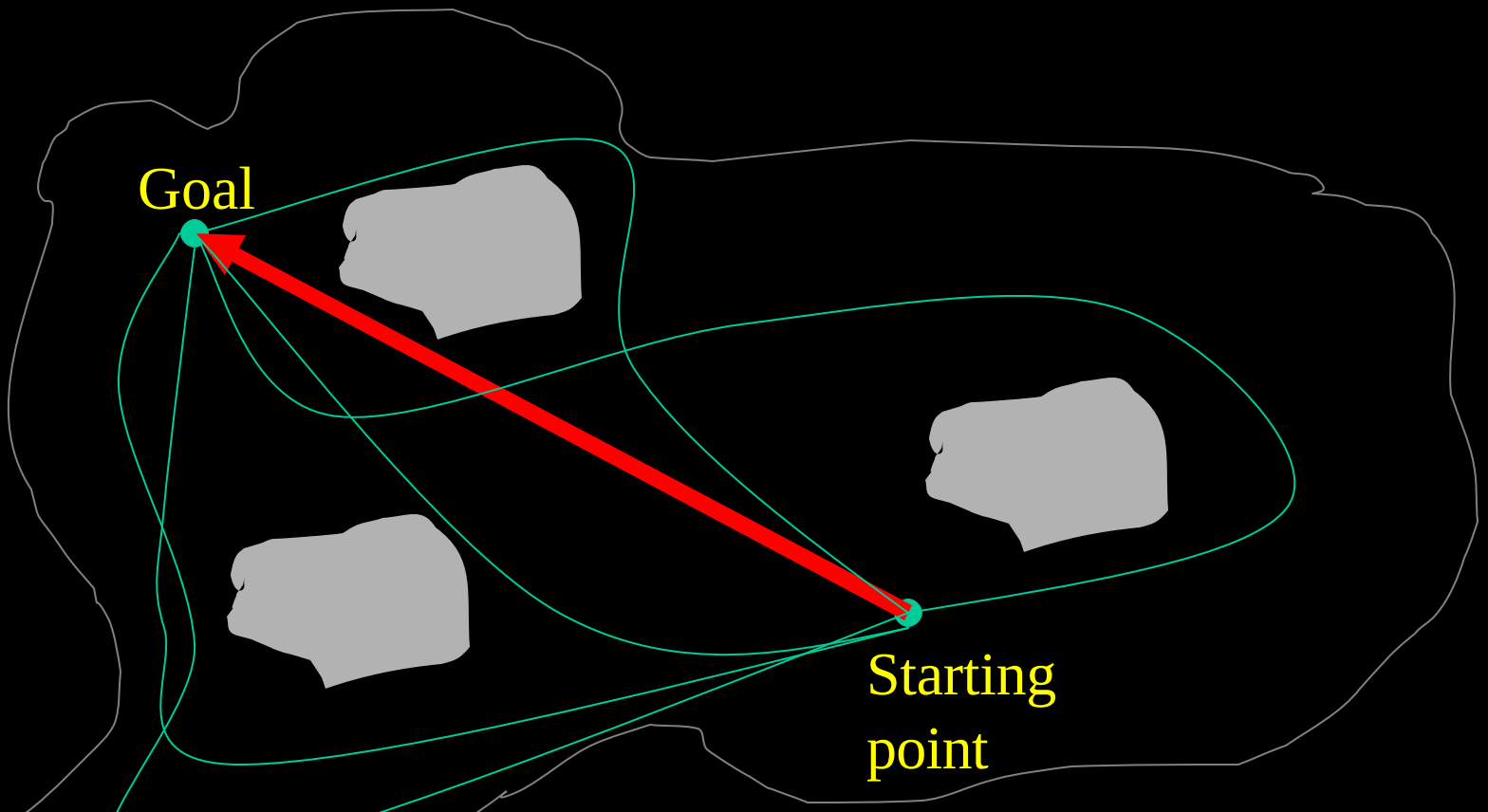
Cognitive Work Analysis

- Response to abnormal situations
- Goal is to support problem solving and diagnosis
- Role is to supplement task analysis as a primary analysis
- Five analyses
  - Work domain analysis
  - Control task analysis
  - Strategies analysis
  - Worker competencies analysis
  - Social-organizational analysis

Work Domain Analysis

- Develop and promote understanding of how the domain works
- Develop accurate mental models in users
- Inform designers of key relationships
- Identify key constraints
- Promote flexible problem solving

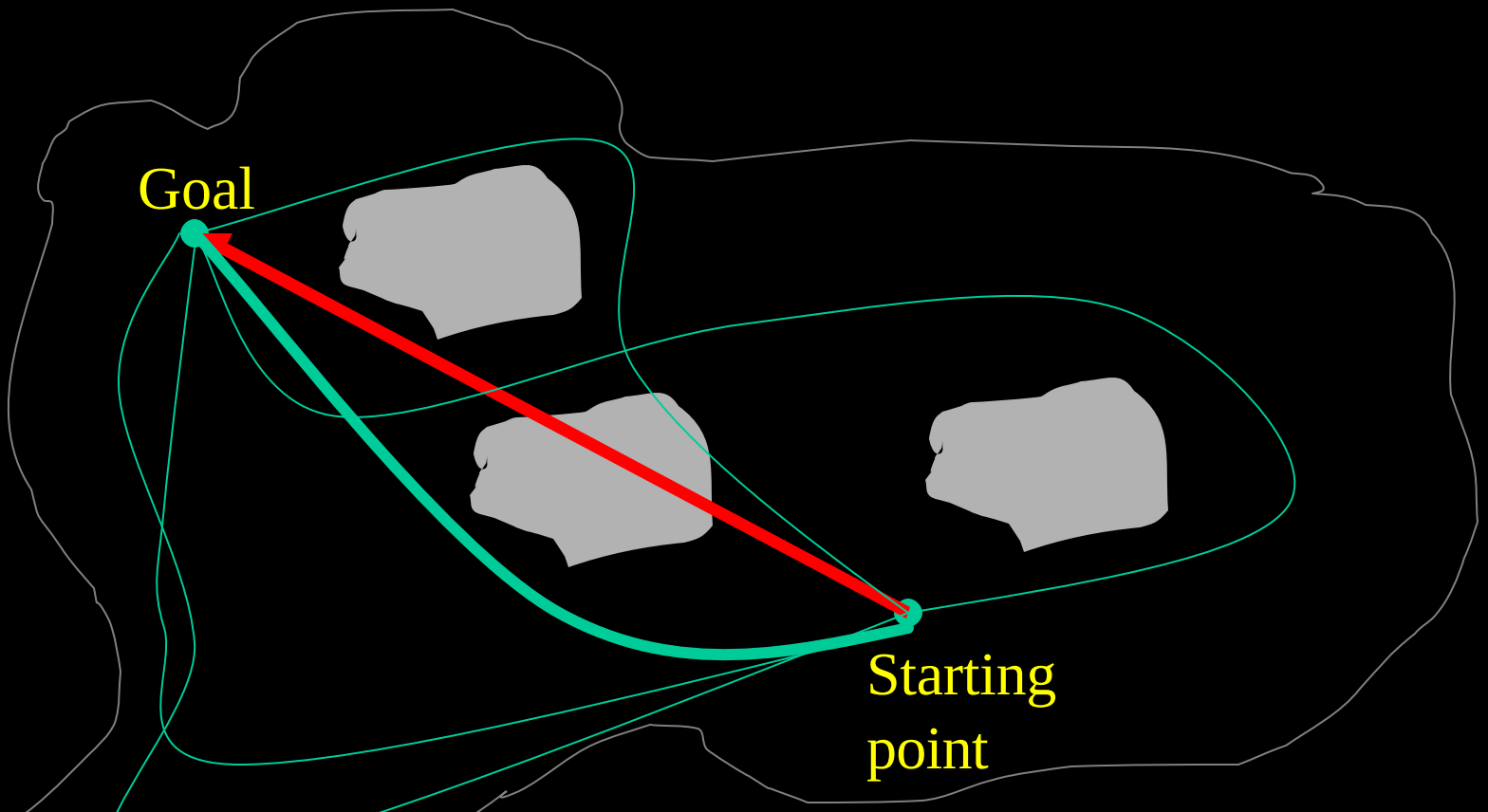
Differences CTA, WDA



More flexible paths

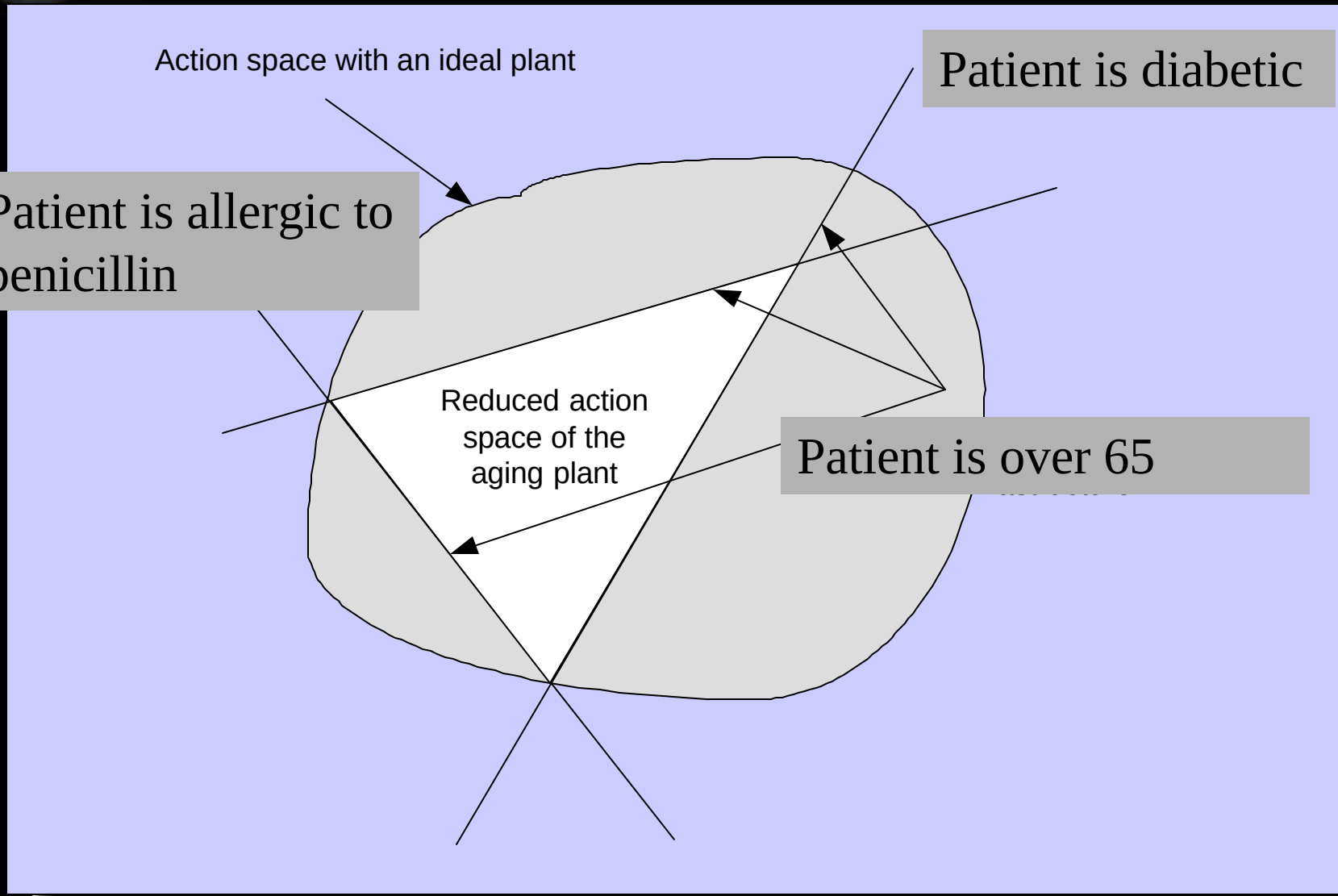
But not necessarily the best way

Differences CTA, WDA

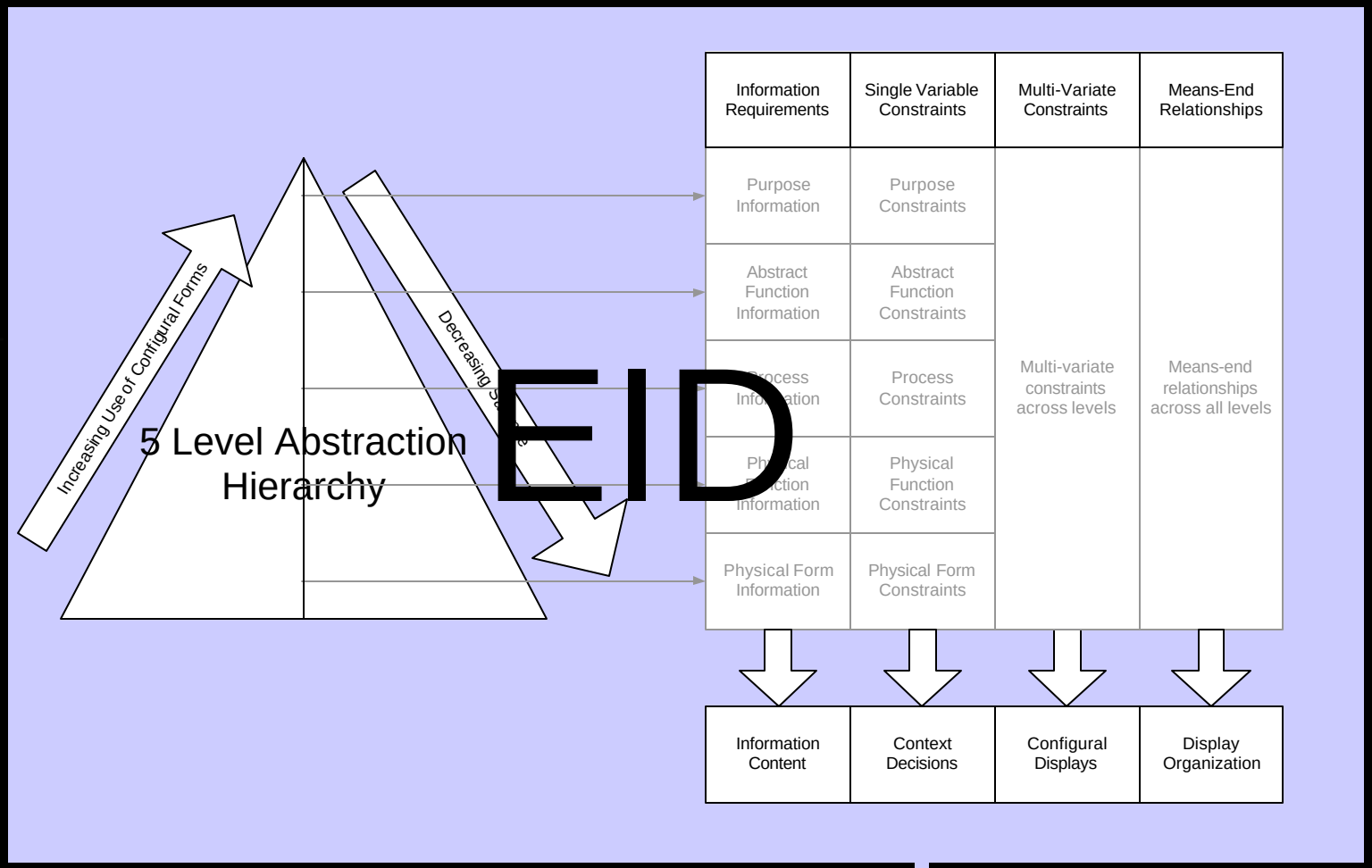


But more robust if things change!

Working in a constraint space

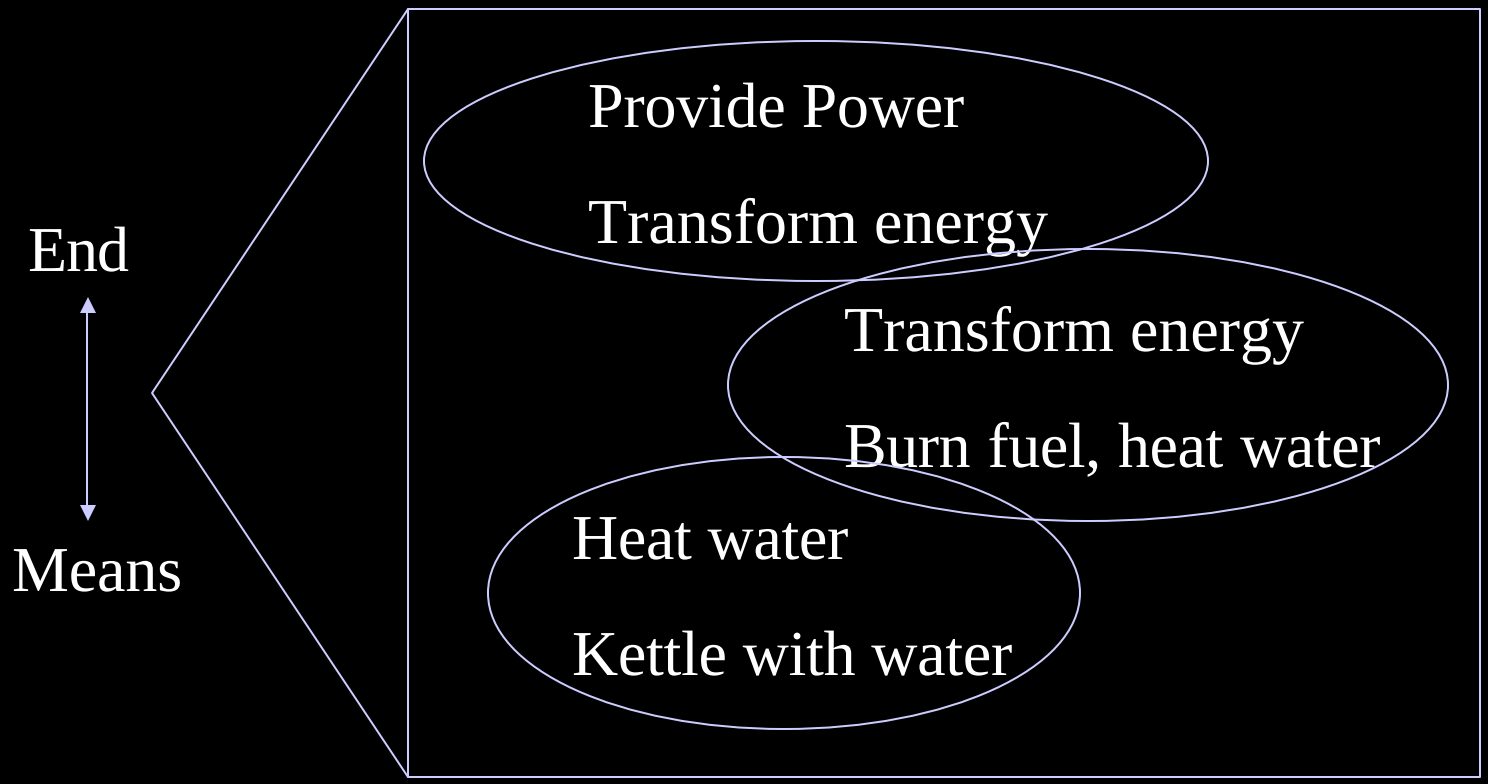


Design Process using WDA

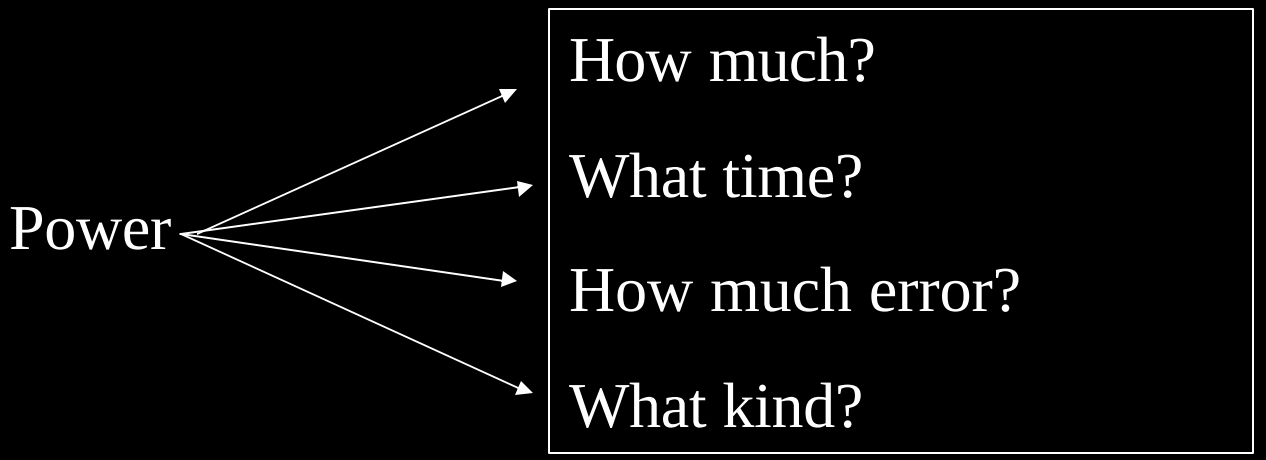


Task Analysis

WDA “unit”


End
Means
Provide Power
Transform energy
Transform energy
Burn fuel, heat water
Heat water
Kettle with water

Expression of Constraints



Example: Diabetes

Project Background

- What is Diabetes?
- Prevalence: Diabetes affects over 19 million people in Canada and the U.S.
- Economic Costs: Estimated at $9 billion/year in Canada and $132 billion/year in the U.S.
- Management of blood sugars affects both daily well-being and long-term health

Sources: Canadian Diabetes Association
American Diabetes Association

Project Motivation

- Difficult to understand how to manage and control the disease
- Management is data intensive
  - Blood Glucose Levels
  - Diet and Exercise
  - Weight
  - Medication
  - Etc …
- Poor mental models

Blood Glucose Level / *Taux de Glycémie*

1999

DATE

MEAL / REPAS

DATE	BEFORE	AFTER	AVANT	APRÉS	BEFORE	AFTER	AVANT	APRÉS	NOTES
Oct 9	9	7		4		8	22		holiday 5.8@8:45p
	16.7		12.0		10.1		3.6		18.9@3:40am skip all am walk 2-3p
	9	3		4		5	22		
	6.4		11.5		*6.4		13.3		DEC appt late dinner
	9	7		4		5	22		1 fruit aft. snack
	17.9		11.5		*5.4		7.1		new meal plan
	BEFORE	AFTER	AVANT	APRÉS	BEFORE	AFTER	AVANT	APRÉS	
	9	5		3		5	22		4.5@4:10pm
	10.6		10.0		*6.9		2.8		bike aft snack
	8	5		1		7	22		9.8@5pm
	10.5		3.6		8.3		3.2		
	8	4		3		2	22		no morn. snack
	8.4		8.4		2.8		10.9		5.6@4:30pm bike 4:40-5:25
	8	1		4		8	22		no morn. snack
	3.0		14.2		11.4		11.9		Curl 8-9:30

Previous work

- Improved glycemic control with electronic diary (mean HbA1C reduction of 0.825%).
- Study by Tsang et al with 19 patients
- Electronic diaries are computerized version of logbooks
- Not decision support tools

Project 3: EID on Mobile Devices

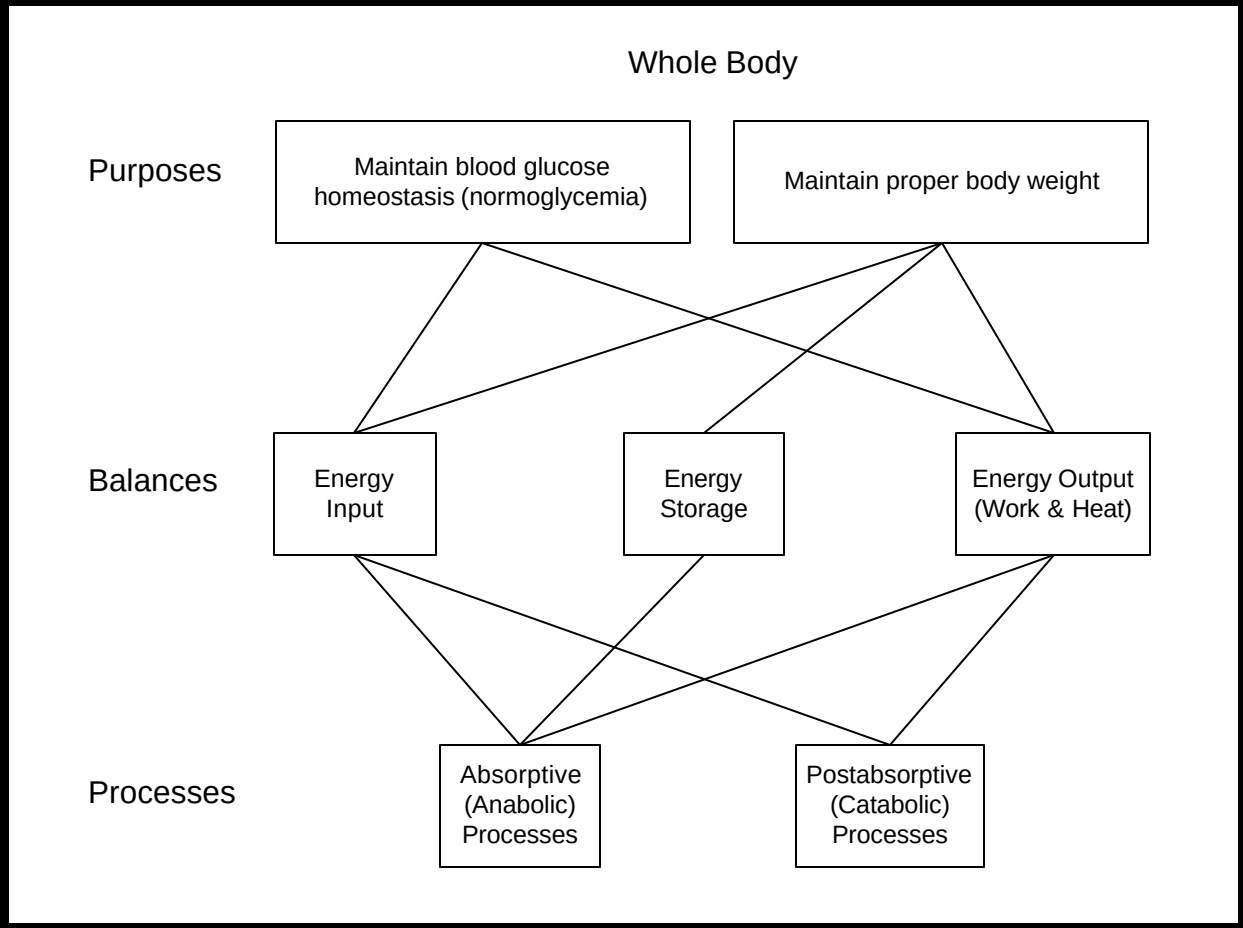
- Context:
  - Blood glucose monitoring by diabetics
  - Improve proactive metabolic control
- Requirements
  - Wireless
  - Secure
  - Mobile
  - Platform independent
  - Widely accessible

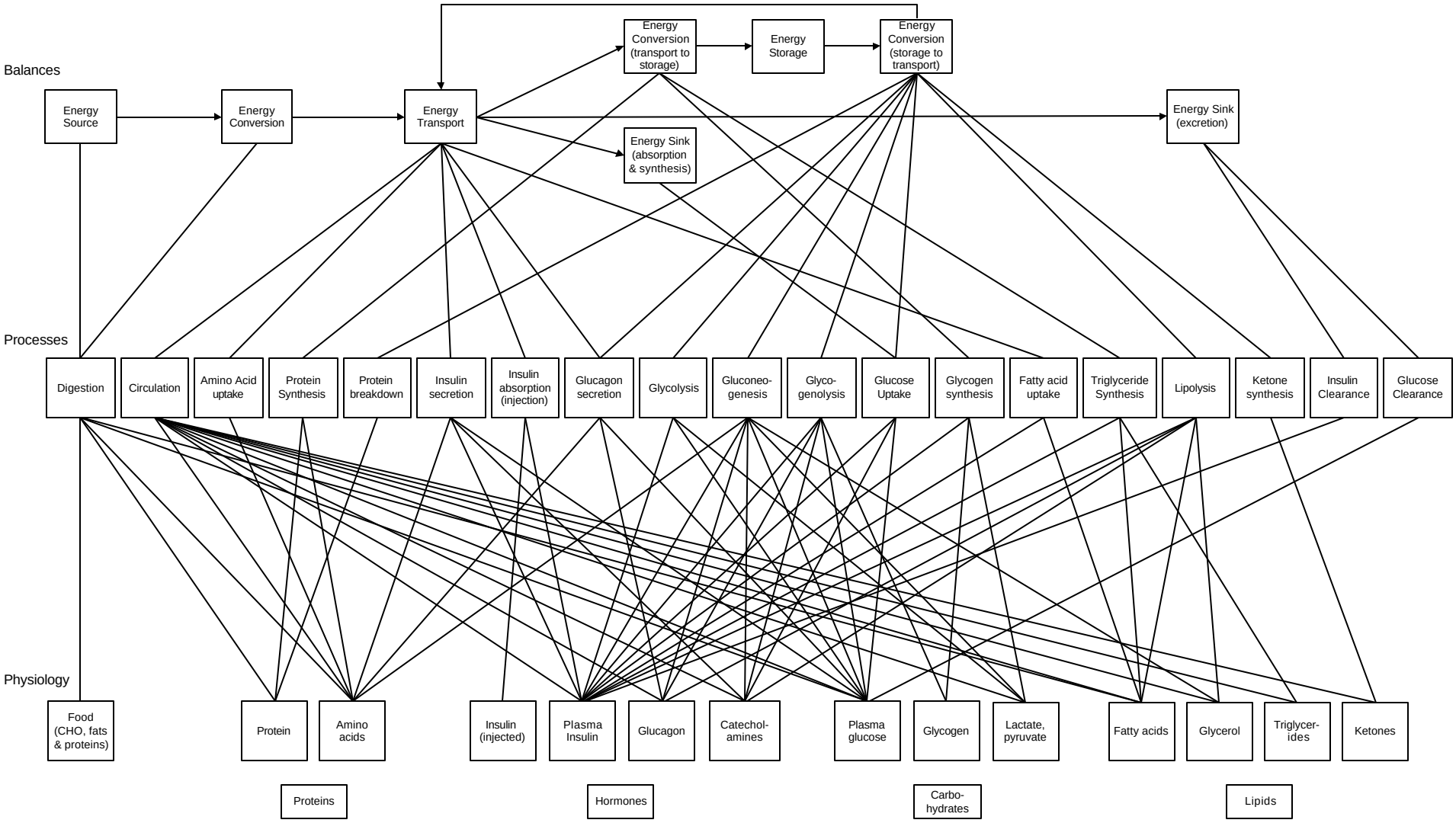
Application Details

- J2ME application
- Intelligent device detection and graphics management
- Runs on any mobile java environment
  - Blackberry
  - Palm
  - Java phone

High-Level Design

- EID Application: Work Domain Analysis (WDA) was used to model constraints and relationships




Balances
Energy Source
Energy Conversion
Energy Transport
Energy Conversion (transport to storage)
Energy Storage
Energy Conversion (storage to transport)
Energy Sink (absorption & synthesis)
Energy Sink (excretion)
Processes
Digestion
Circulation
Amino Acid uptake
Protein Synthesis
Protein breakdown
Insulin secretion
Insulin absorption (injection)
Glucagon secretion
Glycolysis
Gluconeo-genesis
Glyco-genolysis
Glucose Uptake
Glycogen synthesis
Fatty acid uptake
Triglyceride Synthesis
Lipolysis
Ketone synthesis
Insulin Clearance
Glucose Clearance
Physiology
Food (CHO, fats & proteins)
Protein
Amino acids
Insulin (injected)
Plasma Insulin
Glucagon
Catechol-amines
Plasma glucose
Glycogen
Lactate, pyruvate
Fatty acids
Glycerol
Triglycer-ides
Ketones
Proteins
Hormones
Carbo-hydrates
Lipids

Extract Variables

- Some typical
  - Food values
  - Blood glucose reading
- Some calculated
  - Net energy balance for day, week, month
  - Body Mass Index
- Some simulated
  - Plasma insulin level

Content Comparison

- "WDA" Database
- One Touch – comparable patient monitoring device
- Canadian Diabetes Database System – system for health professionals to track their patients
- Diabetes Pilot – personal diabetes tracking system
- Glucom – personal diabetes tracking system

- Looked at
  - Work domain elements
  - Other data (compared across all devices)

Results

	WDA	One Touch	CDDS	Pilot	Glucom
Total Data	245/300 (81.7%)	129/300 (43%)	91/300 (30.3%)	74/300 (24.7%)	25/300 (8.3%)
WD Elements	150/150 (100%)	65/150 (43.3%)	38/150 (25.3%)	59/150 (39.3%)	18/150 (12%)

- Closest database (One Touch) would contain 43.3% of the elements that we needed
- Past research suggests performance with EID is sensitive to sensor levels (Reising and Sanderson)
- WDA does not contain other health information (e.g. other illnesses yet)

Reality of Small Device Graphics

- Screen size is small
  - 3 line cell phone
- Languages are under development
  - No graphic classes
- Processors are limited
  - No floating point processor
- Math functions are limited
  - No trig functions

- Guard every pixel
- Navigation is key
- Cherish every calculation
- Work around, work around, work around…

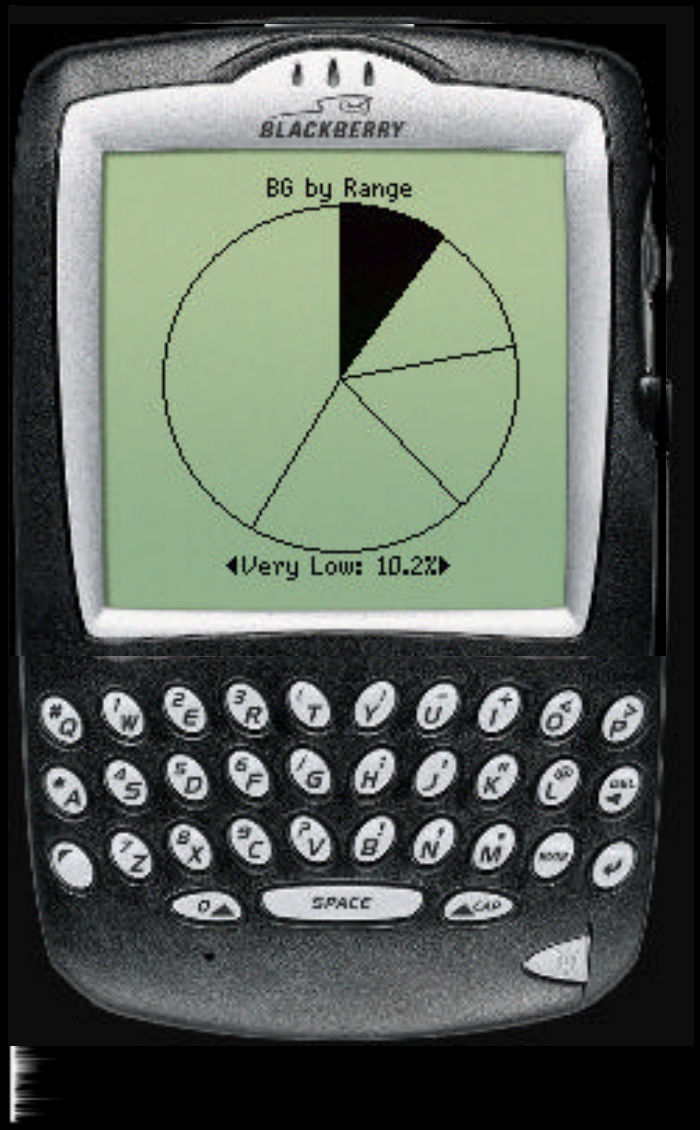
- Sample work arounds
  - Work always in integers (multiply by 100 and then divide)
  - Sine table lookups for functions

Design Approach

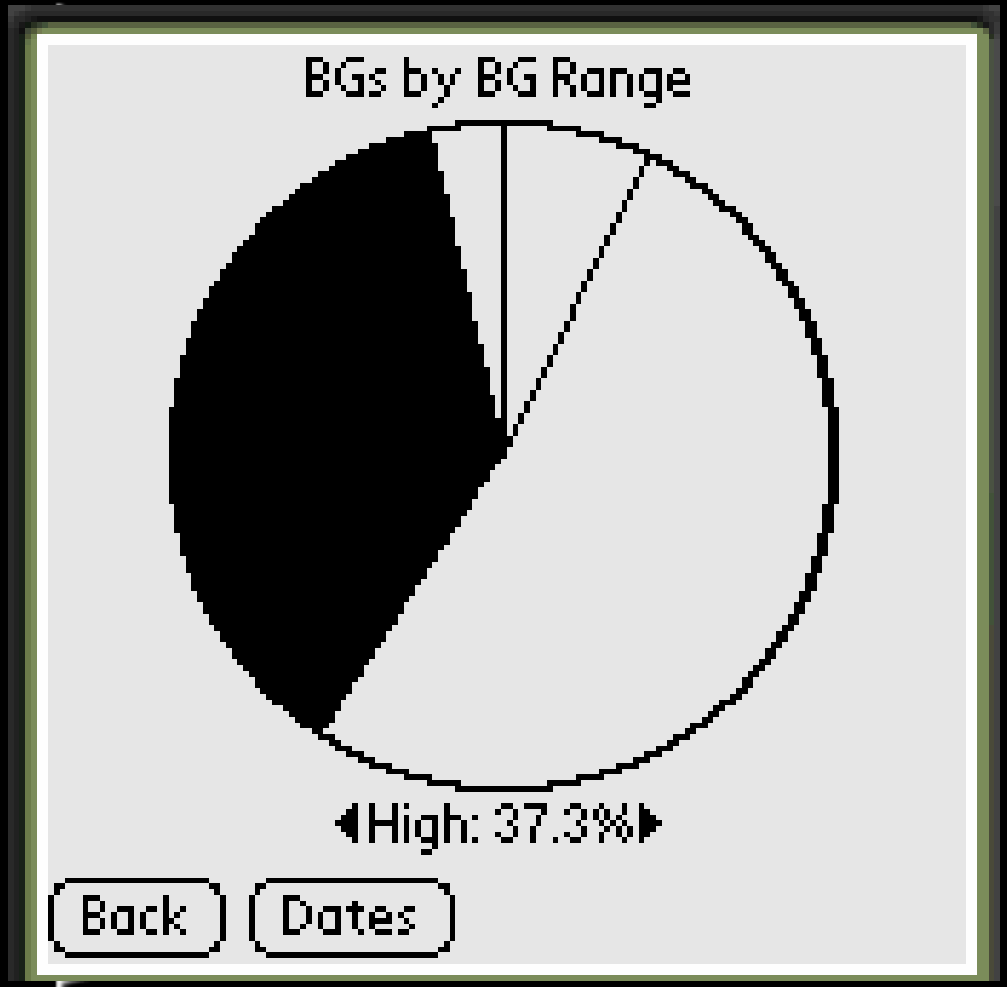
- Attention to most informative part of each display
- Values
- Scales
- Threshold/context markers
- Graphic Title
- Navigation buttons

- Vary as able
  - Color
  - Minor ticks
  - Scale label

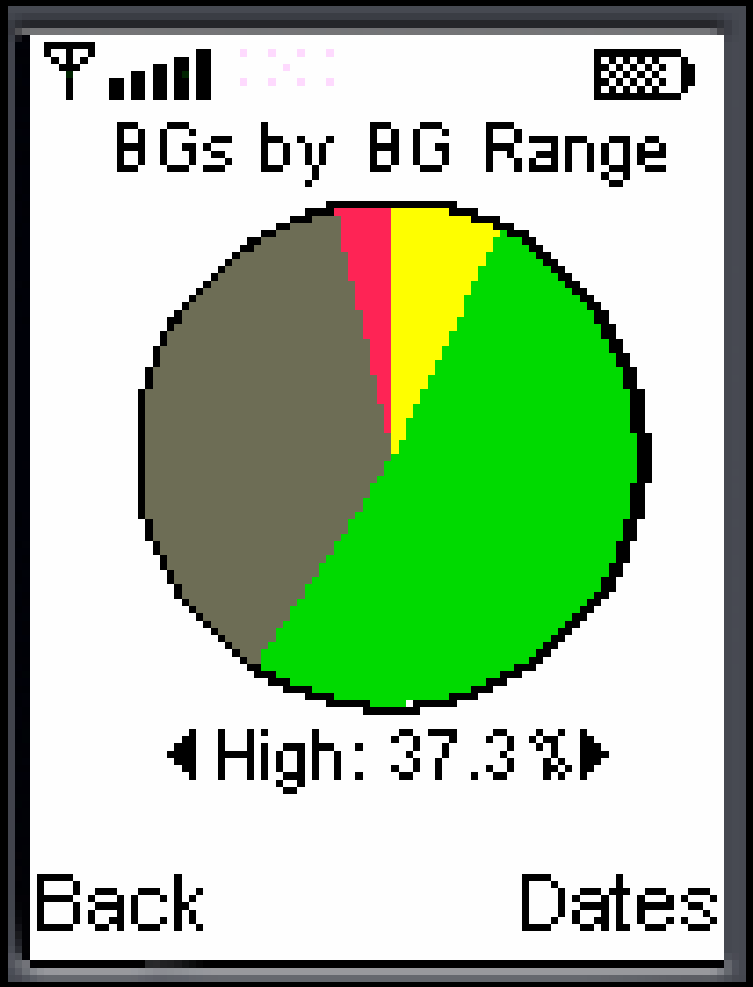
Small EID Displays



Monochrome Palm

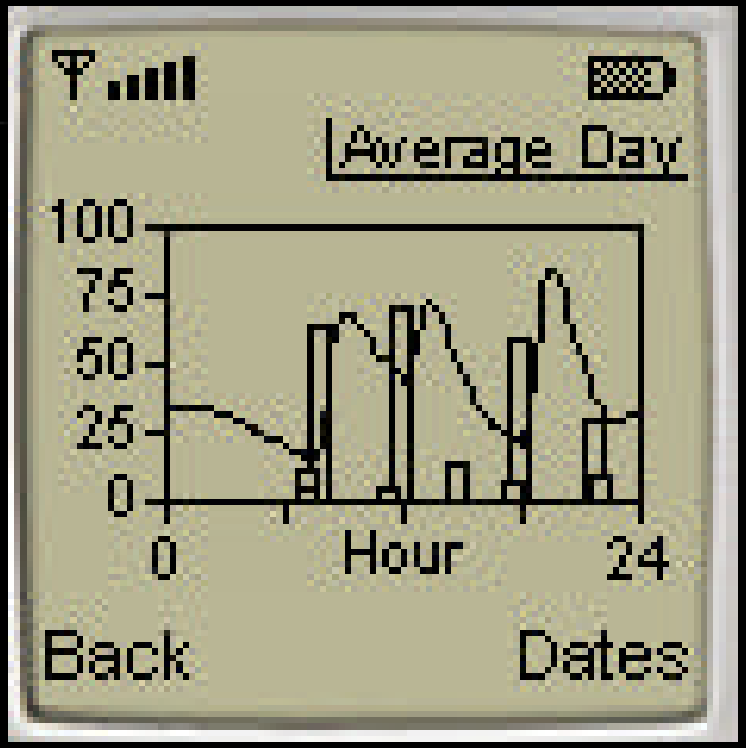


Color Phone

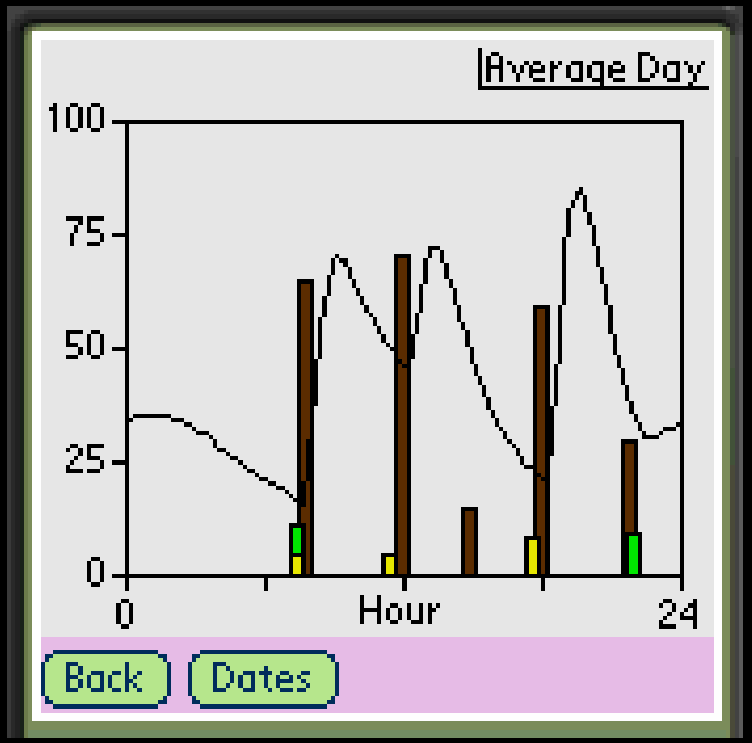


AIDL

Monochrome Phone

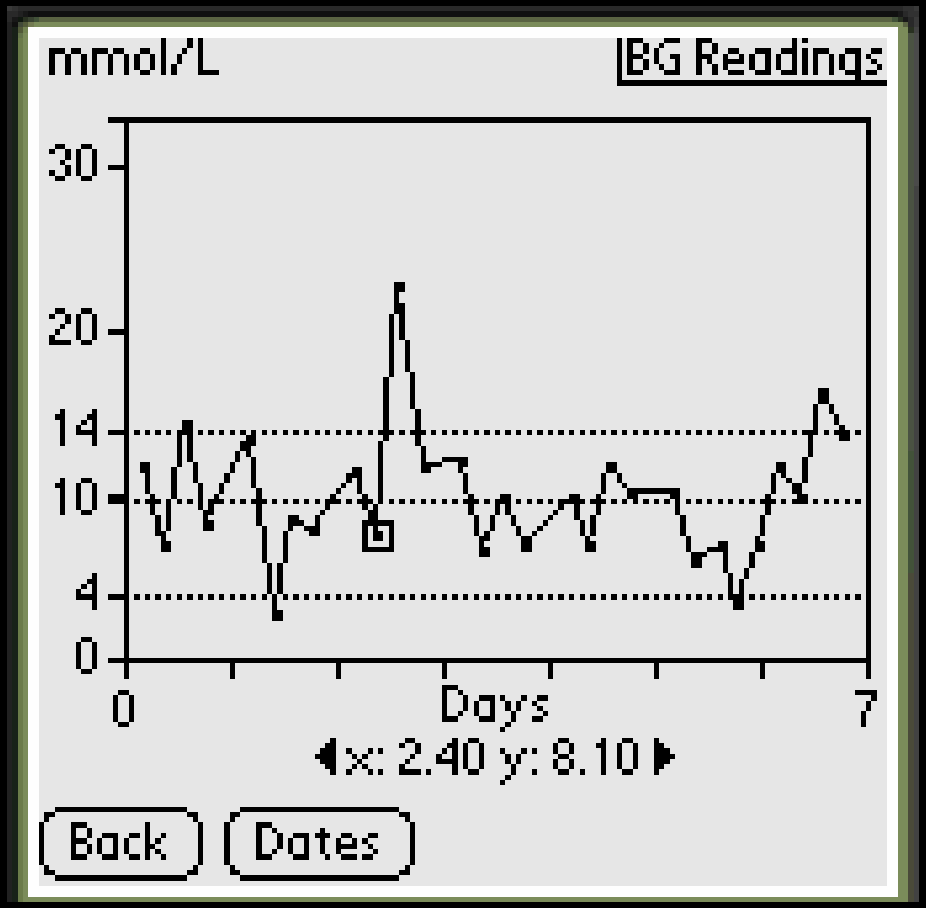


Color Palm

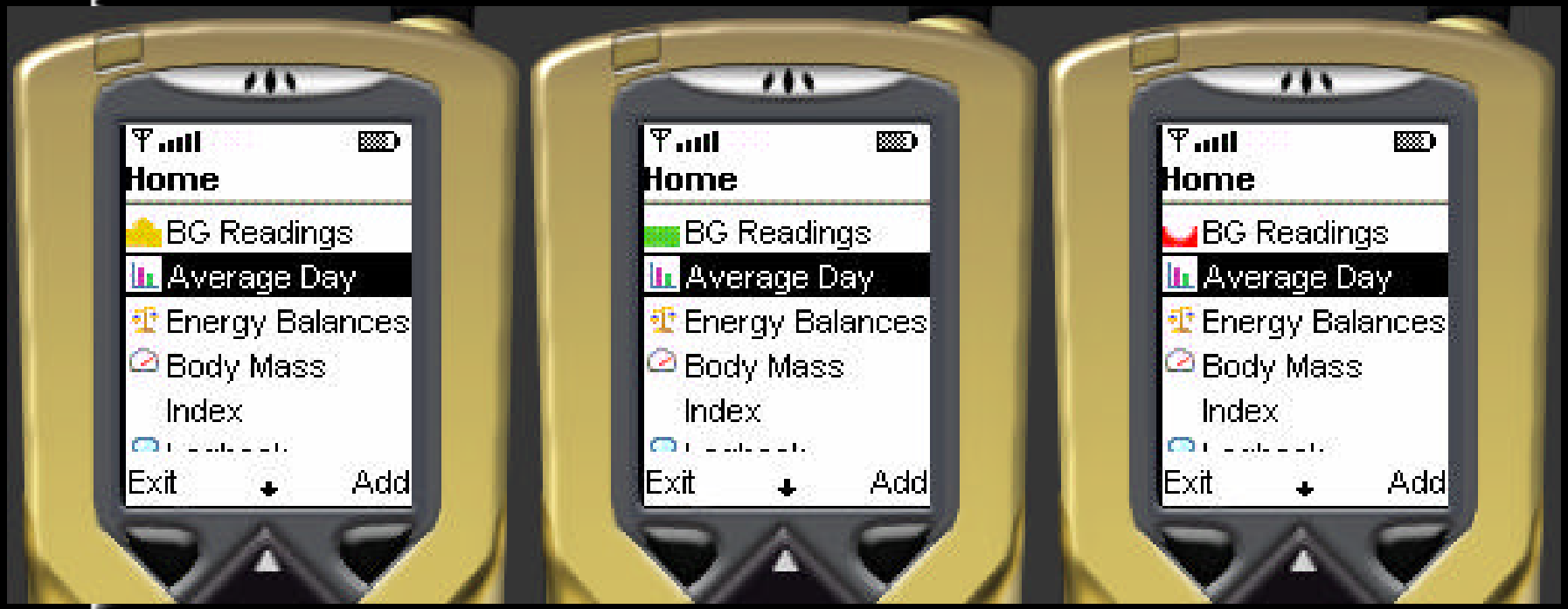


Navigate data

"Point hopper" ™



Example: Icon Design



Future directions

- Continue implementation with security
- Evaluation
- New project developing and evaluating mobile decision support tools for cardiac nurses at the Ottawa Heart Institute

Cardiac Project

- Support for cardiac nurse coordinators
- Evolution from “Decision Trees” to mobile support
- Most human factors work on nursing limited to
  - Time and motion studies
  - Productivity studies
  - Optimizing staffing with patient outcomes

- Hunt et al review of 63 studies of computerized decision support in health care found:
  - # of studies and their quality increasing
  - Definite improvements in drug dosing and preventative care
  - Improvements not yet seen in diagnosis
  - Most reductions in reducing human error
  - Need to correlate with patient outcomes
- Most focused on the doctor not the nurse

One case of a nurse support tool

- Diuretic treatment algorithm for heart failure patients
  - Reduced 30 day readmission rate
  - 50% reduction in heart failure related re-hospitalizations
  - 271 patients over 4 years

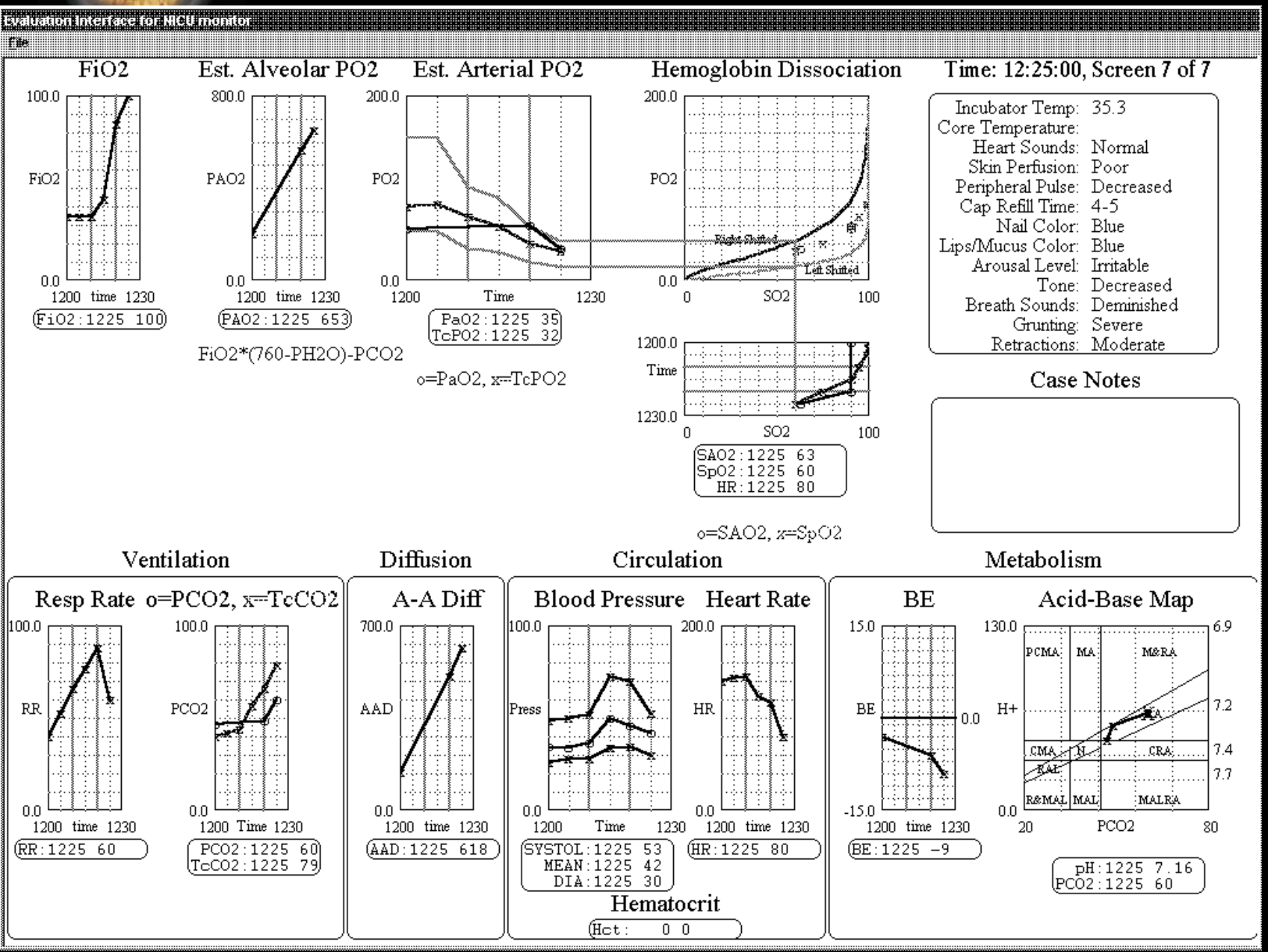
Project Plan

- Contract from Ontario Ministry of Health and Long Term Care
- Partnership with Ottawa Heart Institute
- Team includes cardiologists, senior nurse coordinators
- Now-Winter: Analysis
- Winter to Summer: Design
- Next year: Evaluation with nurse coordinators working at the heart institute

Flashy stuff…

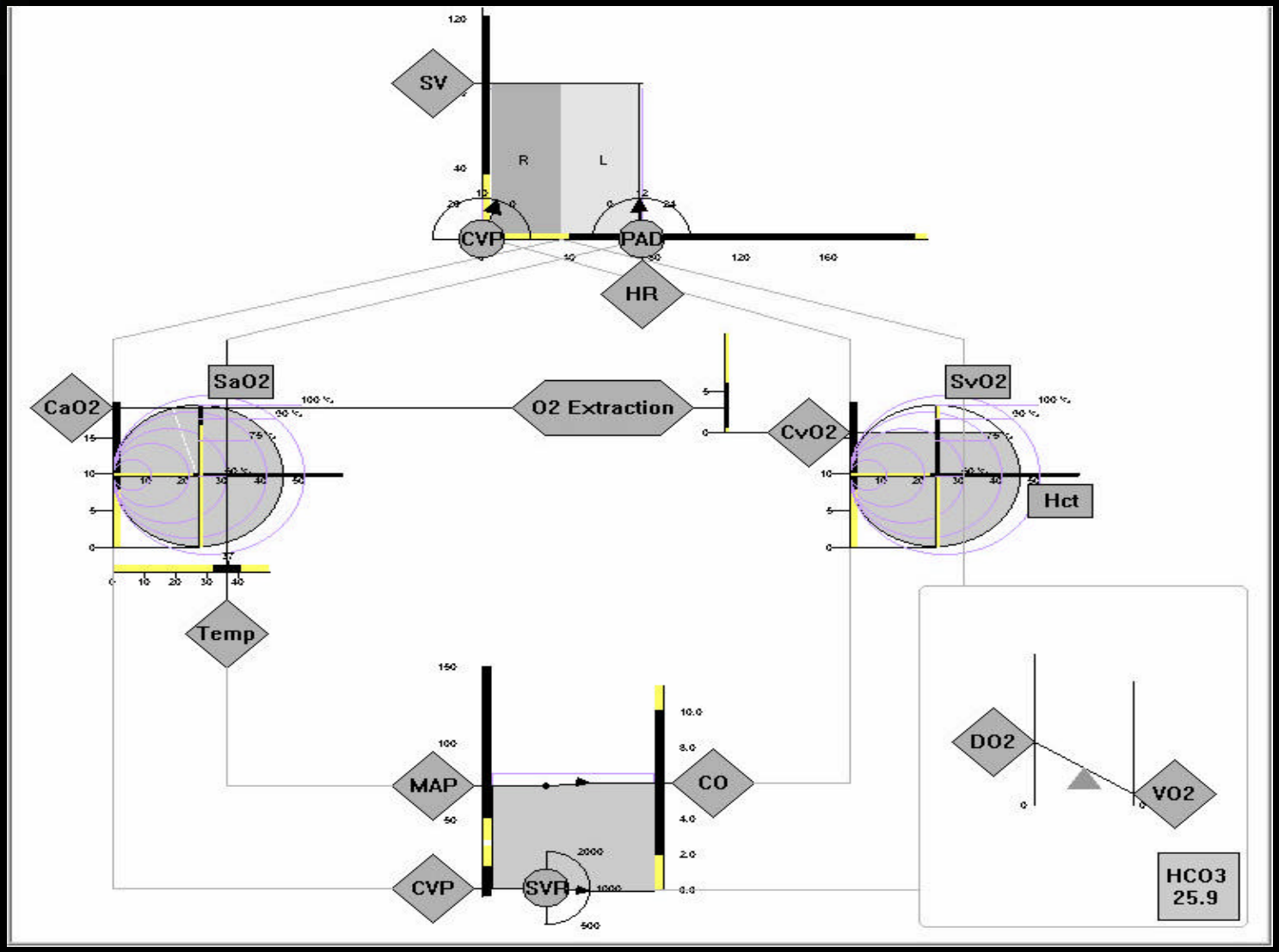
Other EID displays developed for healthcare

Neonatal Monitoring



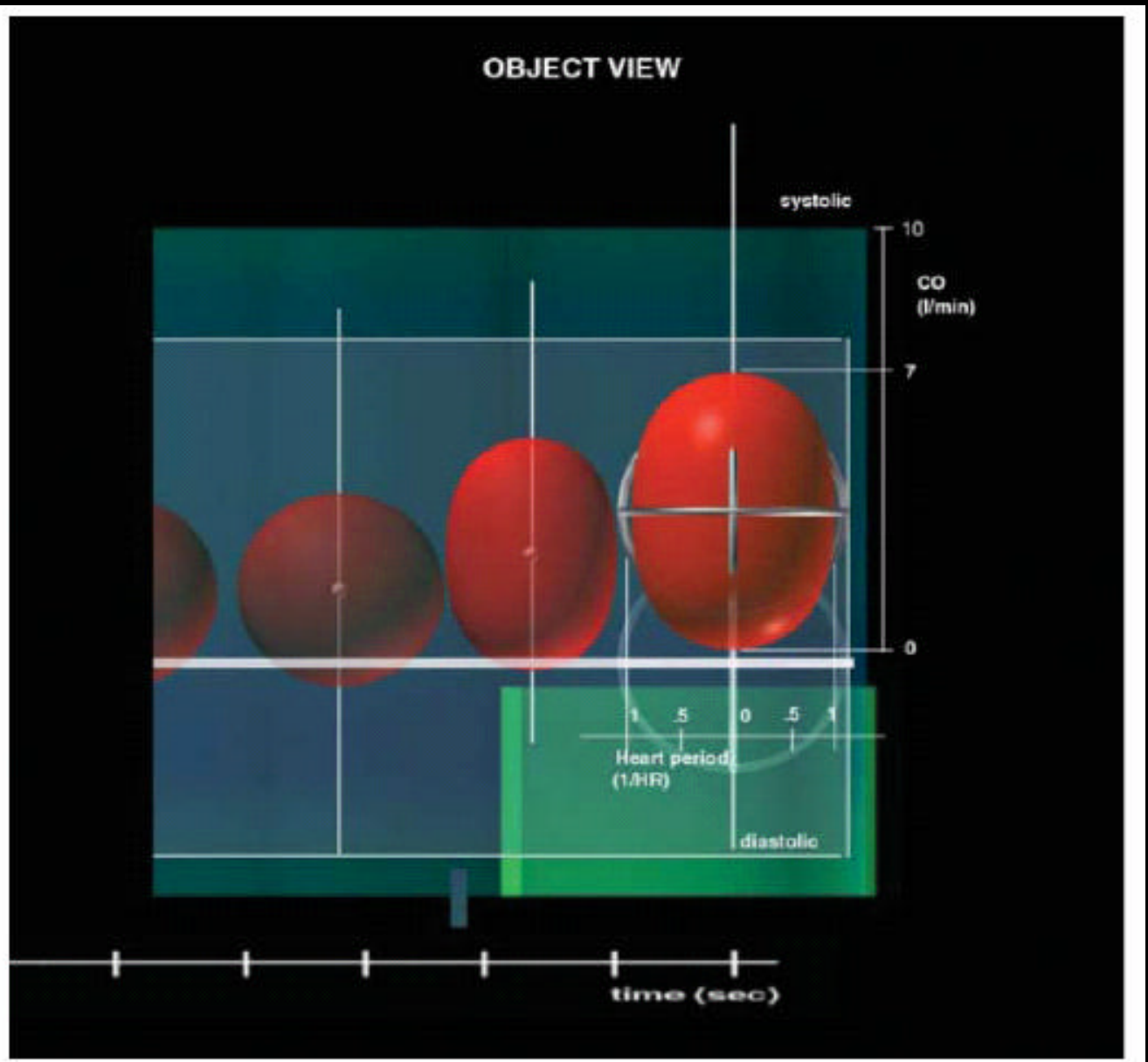
Sharp, 1998

Recognizing Shock under Anesthetic



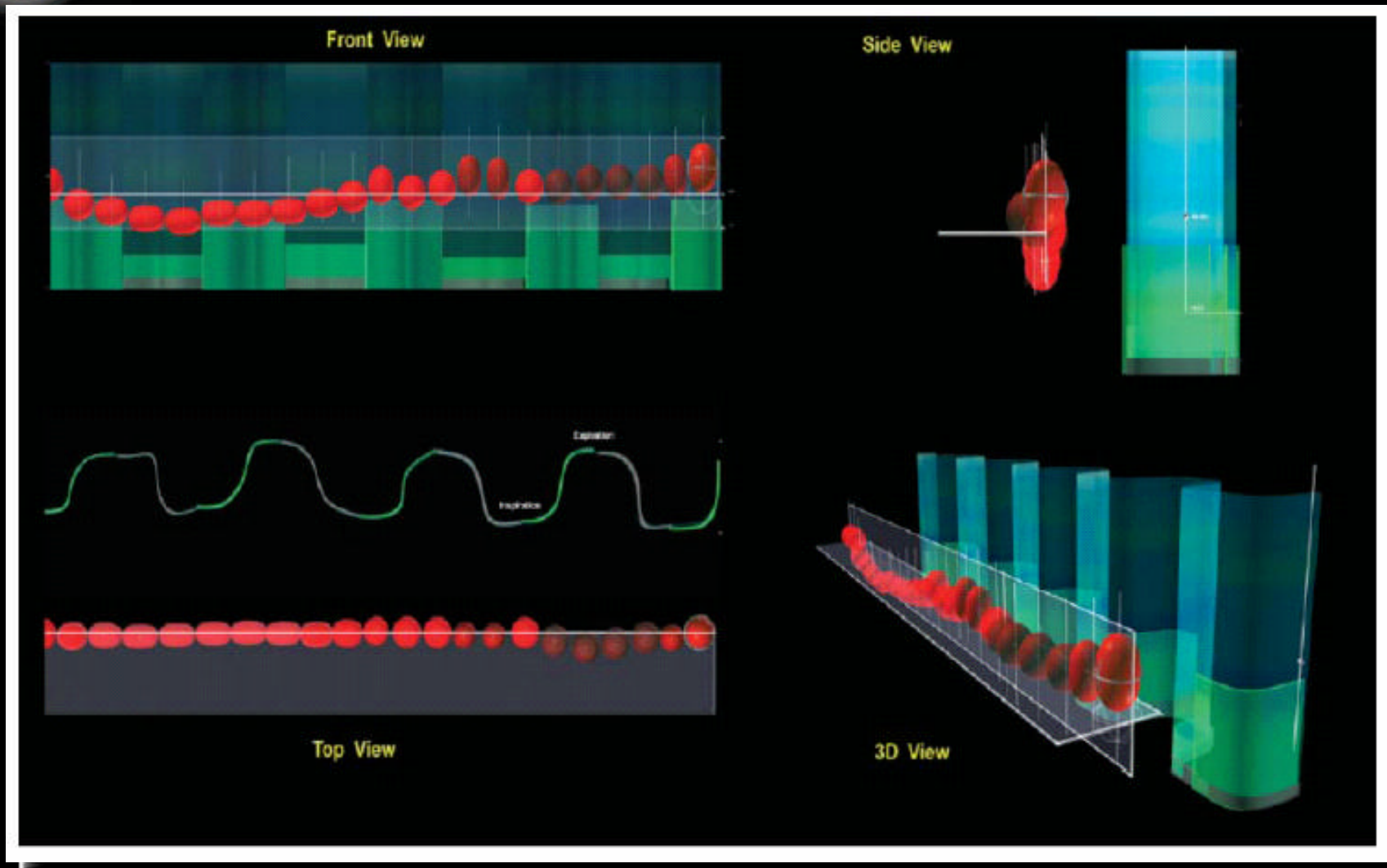
Blike, 2002)

Heart monitoring display



Zhang, 2002)

Integrated display



Zhang, 2002