



European Society for Computing and Technology in Anaesthesia and Intensive Care



16th Annual Meeting, Sep 7<sup>th</sup> – 10<sup>th</sup> 2005, Aalborg, Denmark

## SmartCare™

### Optimizing Workflow Processes in Critical Care through Automation

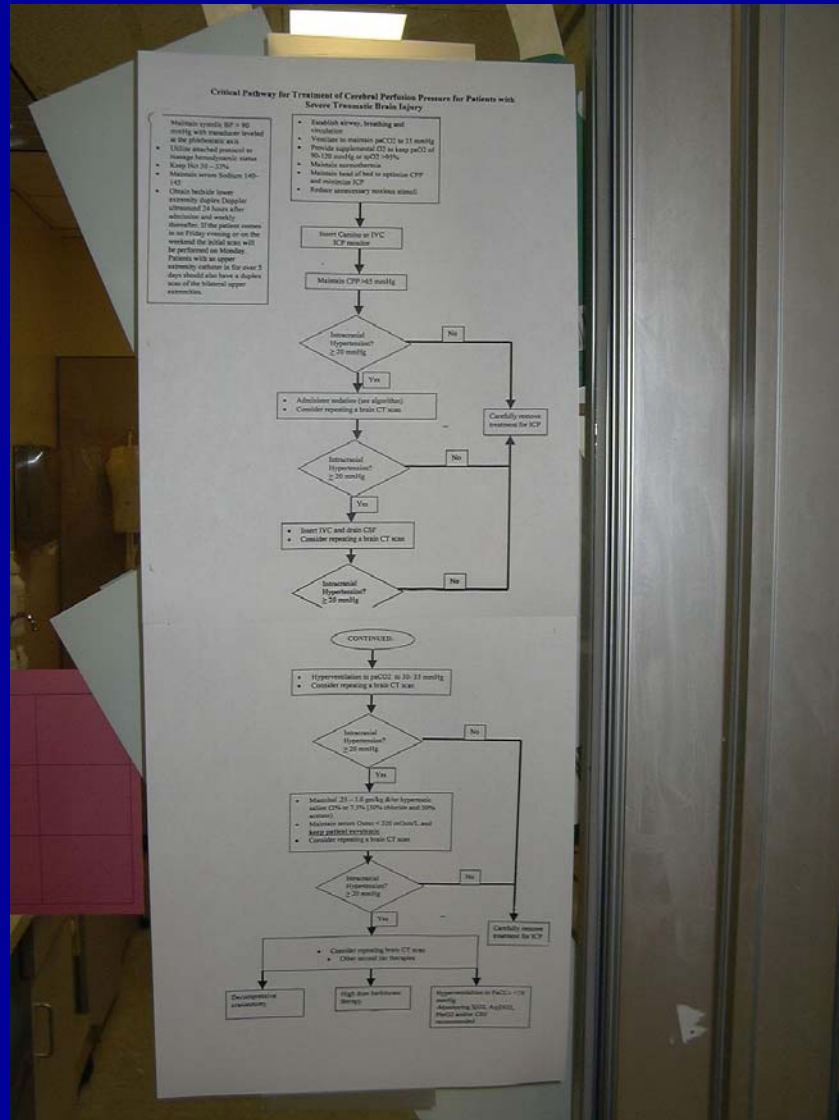
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# Guideline-Based Care



## Clinical Guideline

... systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances.

[www.iom.edu](http://www.iom.edu)

## But:

Clinical Guidelines are difficult to apply at the bedside in everyday life.

## Guideline-Based Care Benefits

- Standardization of Health Care Processes
- Improvement of Therapeutic Quality
- Reduction of Device induced Complications
- Reduction of Hospital Stay
- Reduction of Mortality Rate
- Allevation of Burdens on Clinical Staff
- Control & Reduction of Therapeutic Costs

Ely et al., N Engl J Med, 335:1864-1869, 1996

Marelich et al., Chest, 118:459 - 467, 2000

Burns et al., Crit Care Med, Vol. 31, No. 12, 2003

# Applying Clinical Guidelines

## History

### 1. Therapist-driven Guideline Execution

LDS (Morris, East)

### 2. Clinical Decision Support Systems

ESTER [Hernandez 89], VIE-VENT [Miksch 97], INVENT [Rees 99], ...

### 3. Guideline Development Frameworks \*

Arden, GLIF, PROforma, Asbru, EON, ..., Solvatio, IlogRules, Huggin Expert

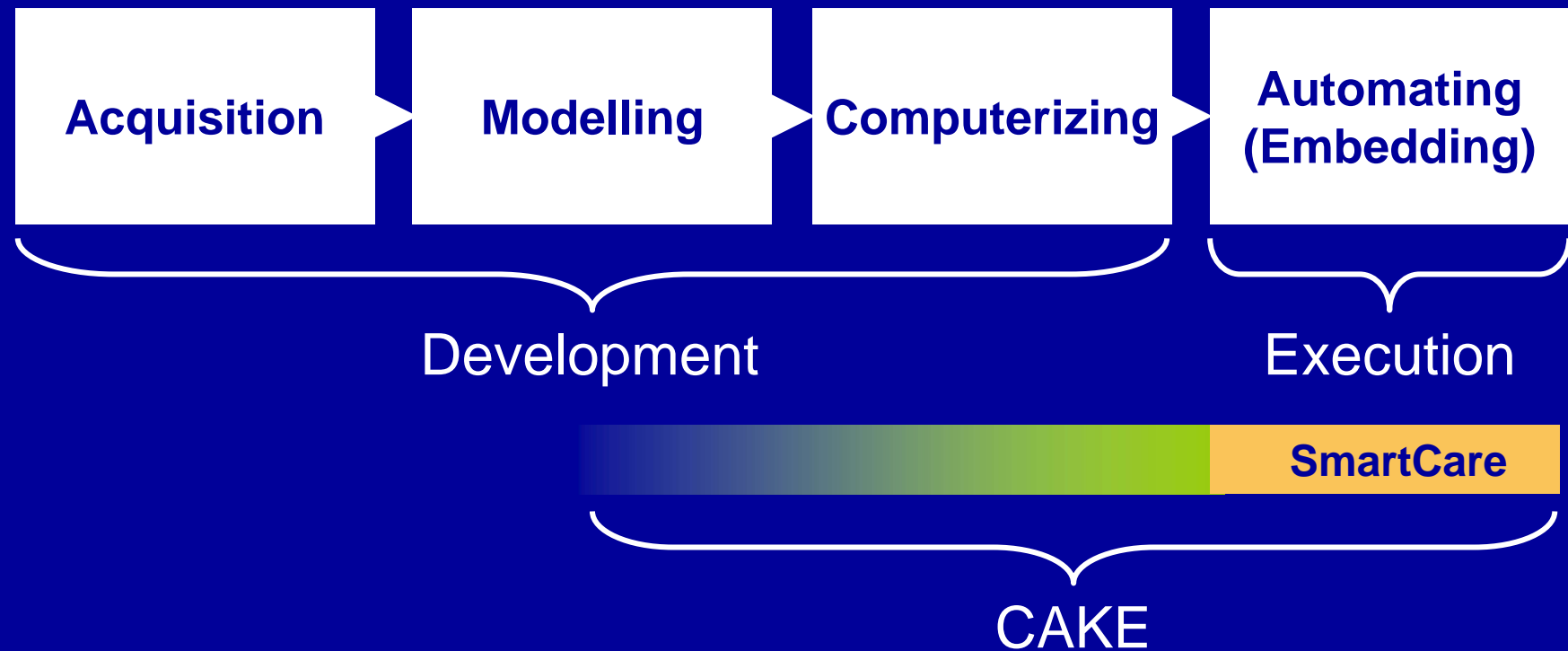
### 4. Automated, Closed-Loop Guideline Execution

NéoGanesh [Dojat 97] → SmartCare™/PS

*\* de Clercq, Blom, et al.: Approaches for creating Computer-Interpretable Guidelines that facilitate Decision Support Artificial Intelligence in Medicine (2004) 31, 1—27*

# Applying Clinical Guidelines

Example: Smart Care<sup>®</sup>

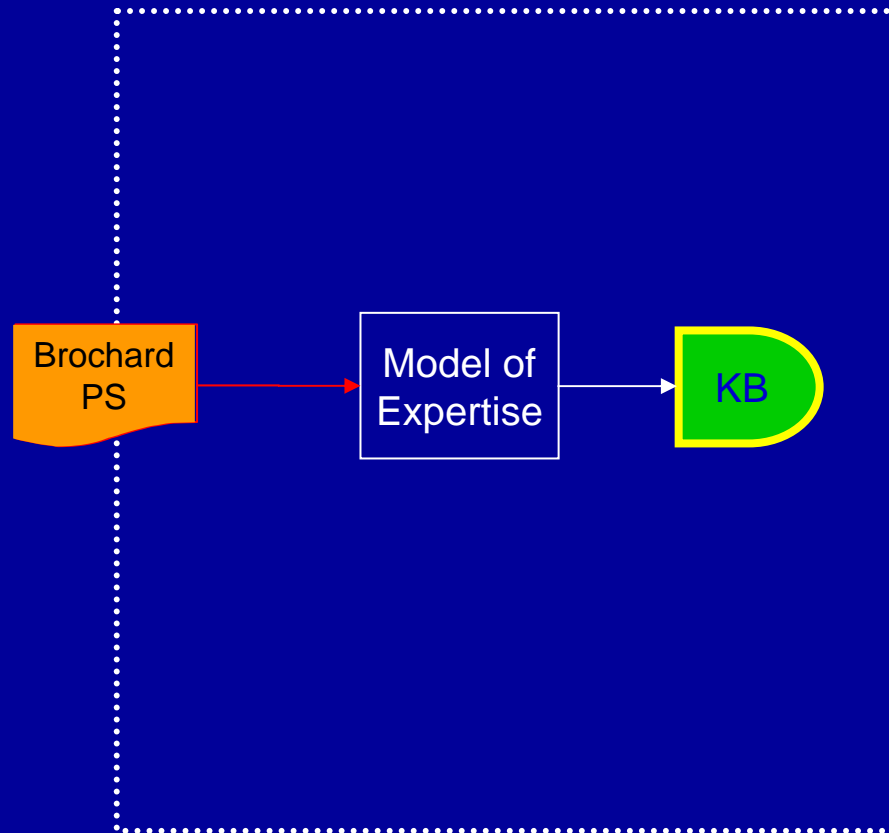


- Framework for Computerizing CGs
- Engine for automated Execution of CGs

# Smart Care® Commercial Implementation

Construction

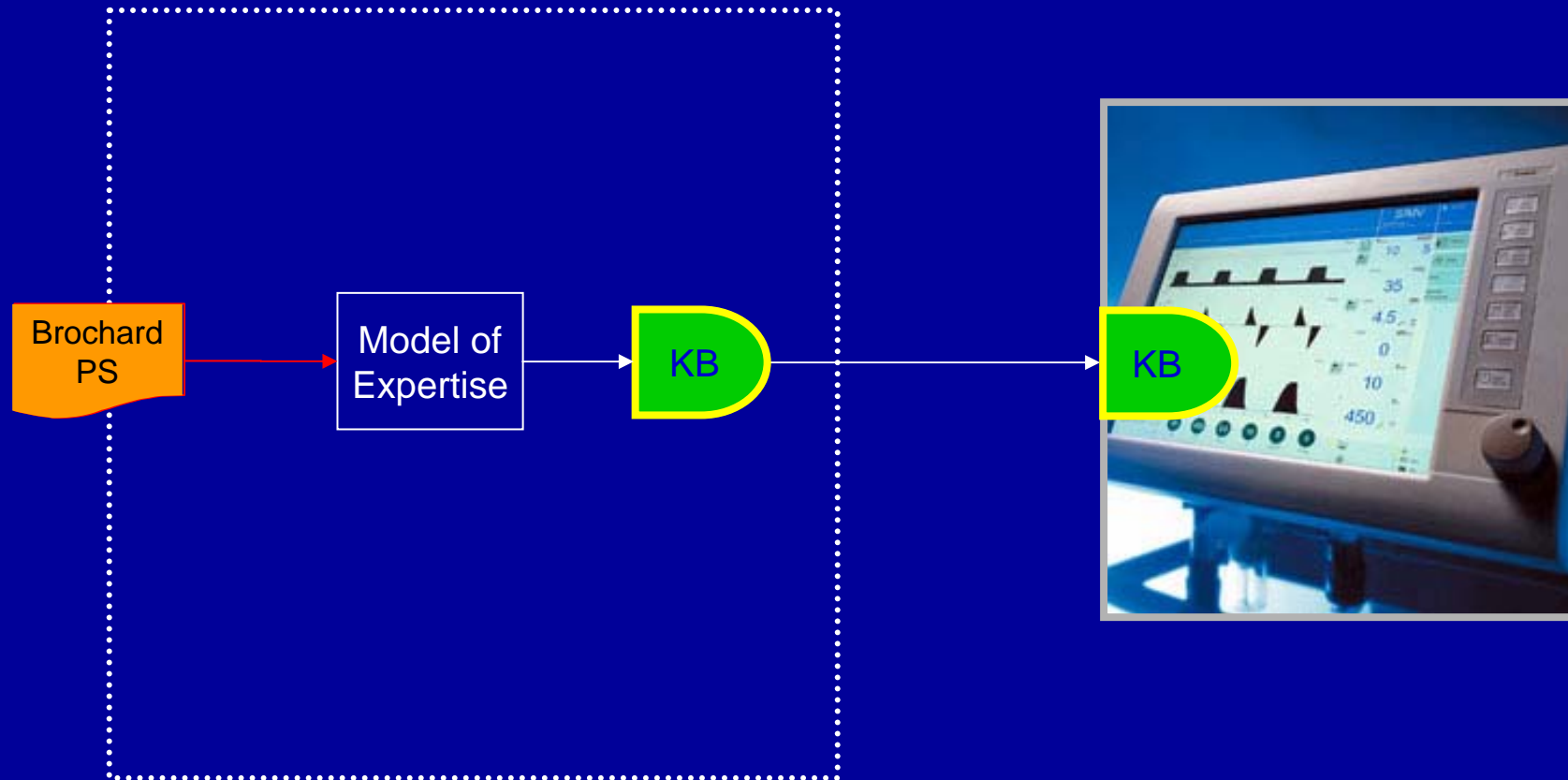
Operation



# Smart Care® Commercial Implementation

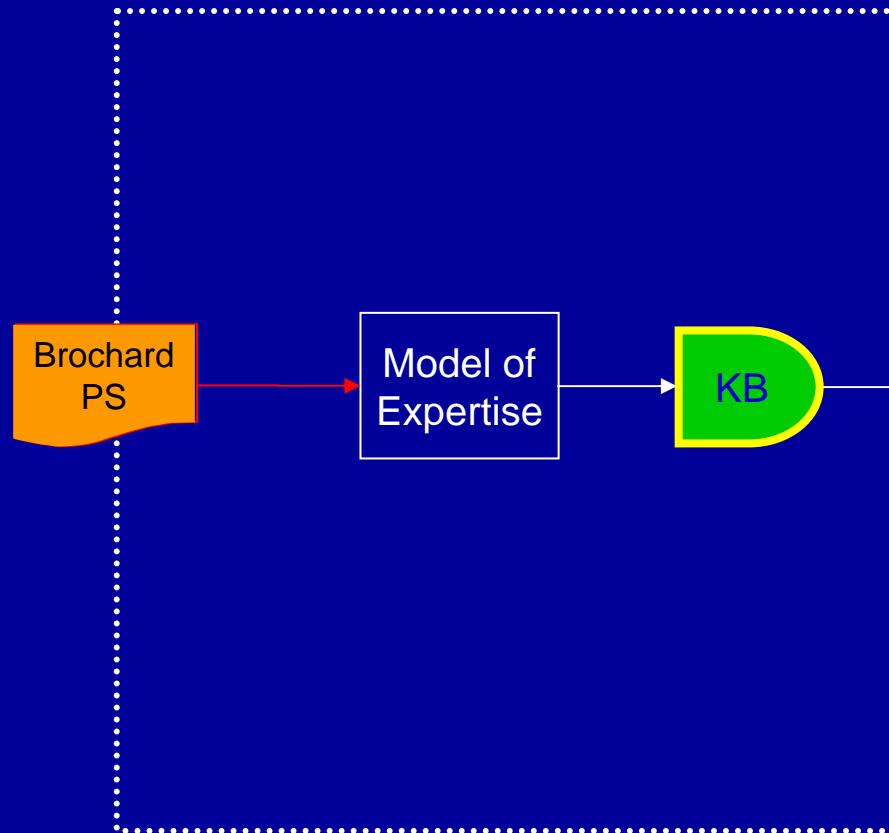
Construction

Operation

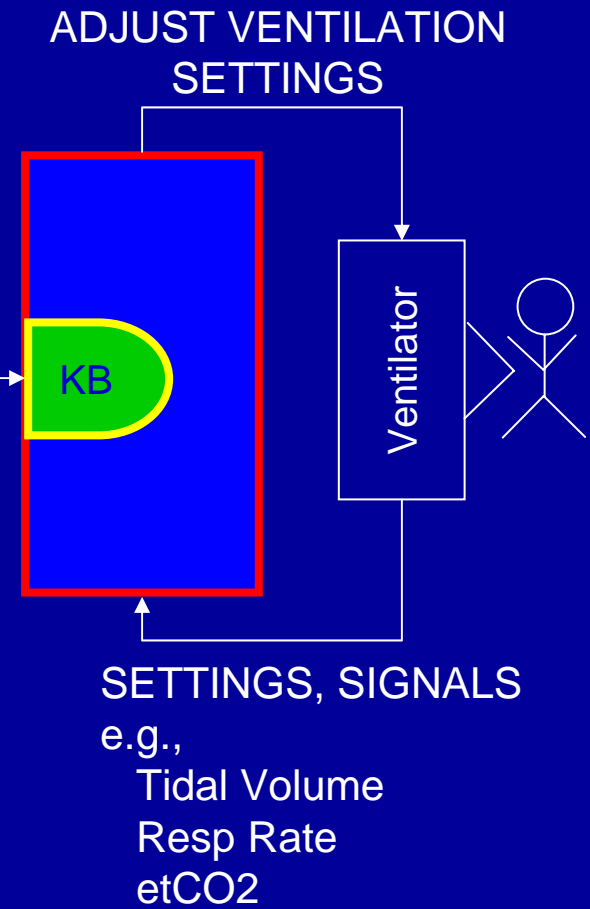


# Smart Care® Commercial Implementation

## Construction

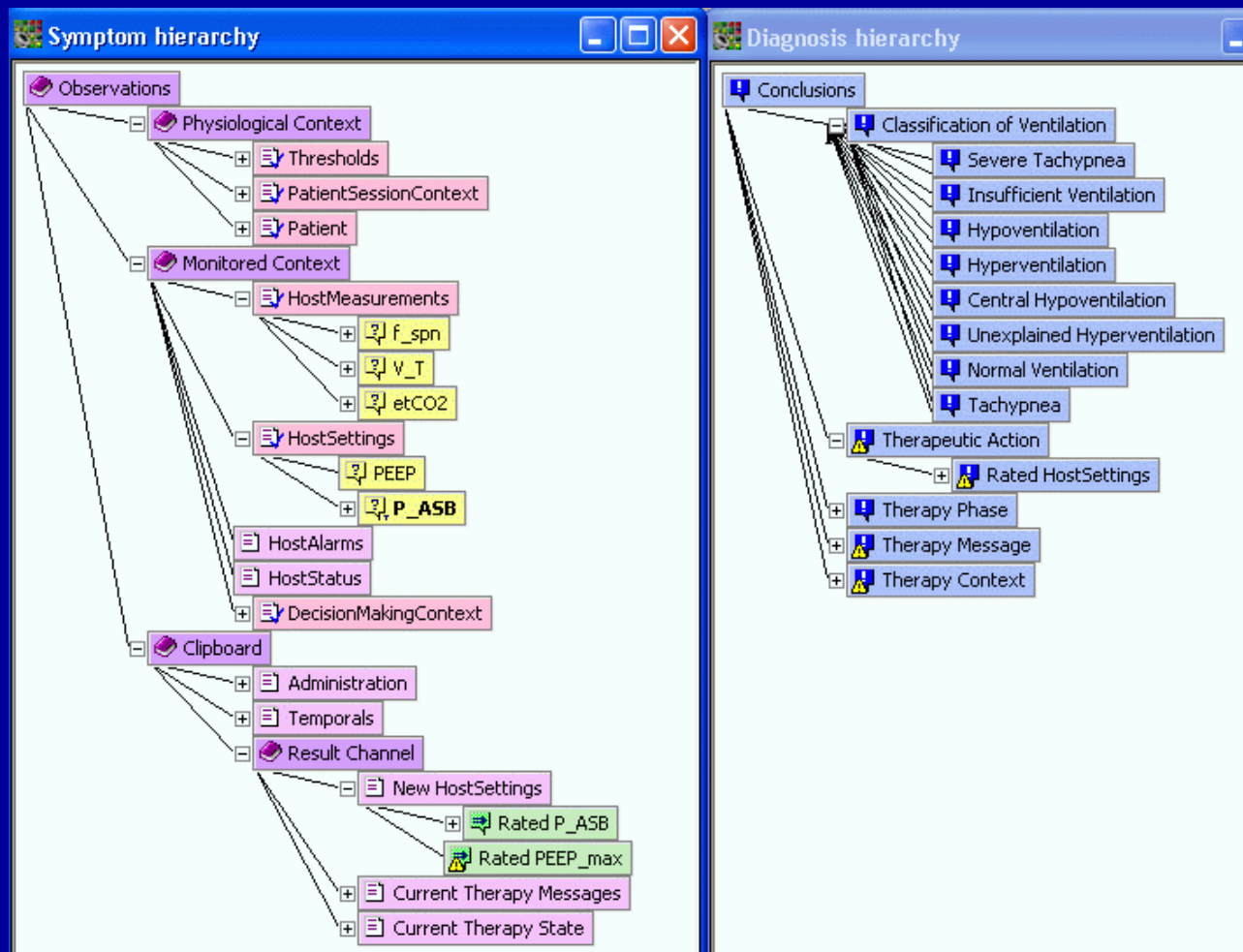


## Operation



# Smart Care® Clinical Guideline Representation

*Evolving Ontology for Critical Care*



# Smart Care®

## Clinical Guideline Representation

Derivation of "Rated P\_ASB"

**Common rules for deriving**

( P\_ASB [ Now ] - Stepwidth )  
IF P\_ASB = KNOWN [ Now ]  
AND Stepwidth = KNOWN  
AND Regular Adjustment = ESTABLISHED  
EXCEPTION: IF Acute Adjustment = ESTABLISHED  
OR Instability Handling = ESTABLISHED

( P\_ASB [ Now ] - Stepwidth )  
IF P\_ASB = KNOWN [ Now ]  
AND Stepwidth = KNOWN  
AND Tolerate Instability during Postponed Maintain = ESTABLISHED  
EXCEPTION: IF Acute Adjustment = ESTABLISHED

VALUE ( P\_ASB\_low )  
IF P\_ASB\_low = KNOWN  
AND Tolerate Instability during Observation = ESTABLISHED  
OR Tolerate Instability during Normal Maintain = ESTABLISHED  
EXCEPTION: IF Acute Adjustment = ESTABLISHED

VALUE ( P\_ASB [ Now ] )  
IF P\_ASB = KNOWN [ Now ]  
EXCEPTION: IF Acute Adjustment = ESTABLISHED  
OR Instability Handling = ESTABLISHED  
OR Regular Adjustment = ESTABLISHED

( P\_ASB [ Now ] - 2 )  
IF P\_ASB = KNOWN [ Now ]  
AND Tolerate Instability during Perturbed Maintain = ESTABLISHED  
EXCEPTION: IF Acute Adjustment = ESTABLISHED

VALUE ( P\_ASB [ Begin of Instability ] )  
IF P\_ASB = KNOWN [ Begin of Instability ]  
AND Tolerate Instability during Adaptation = ESTABLISHED  
EXCEPTION: IF Acute Adjustment = ESTABLISHED

Form Delete New rule Close

# Smart Care® Implementation



## Data ✕

Values
Logbook
Trends

Time	f <sub>spn</sub> bpm	V <sub>T</sub> L	etCO <sub>2</sub> mmHg	Phase	Diagnosis	P <sub>AsB</sub> mbar
11.02. 14:08	18	.804	22	Adapting	Normal Ventilation	20
11.02. 14:10	15	.897	23	Adapting	Normal Ventilation	20
11.02. 14:12	14	.853	24	Adapting	Hyperventilation	20 -> 16
11.02. 14:14	21	.662	23	Adapting	Normal Ventilation	16
11.02. 14:16	26	.640	23	Adapting	Normal Ventilation	16
11.02. 14:18	23	.638	23	Adapting	Normal Ventilation	16
11.02. 14:20	21	.646	24	Adapting	Normal Ventilation	16
11.02. 14:22	29	.591	22	Adapting	Normal Ventilation	16
11.02. 14:24	33	.597	21	Adapting	Tachypnea	16 -> 18

Context 11.02.03 14:08

PEEP	7	mbar
Night Rest active	Yes	
Suction	No	
Suspended Control	0	sec

Messages

Aborted by user

⏪
⏩
⏴
⏵

Basic
SmartCare

# Smart Care® Implementation



SC: Consider separation !

Alarm  
Info

CPAP  
ASB

Adult

Patient can probably be separated from ventilator

SmartCare



# Smart Care® Evaluation

## Five University Medico-Surgical ICUs:

- Créteil - Dr F. Lellouche, Pr L. Brochard, S.Taillé
- Barcelona - Pr J. Mancebo
- Geneva - Dr Ph. Jolliet, Pr J.C. Chevrolat
- Brussels, St Luc - J. Roesler, Pr Reynaert
- Paris - Dr F. Schortgen, Dr L. Bouadma

## Methods

- 145 patients in early weaning stage
- 74 patients: Smart Care Weaning
- 71 patients: Local Weaning Protocol

## Summary Results

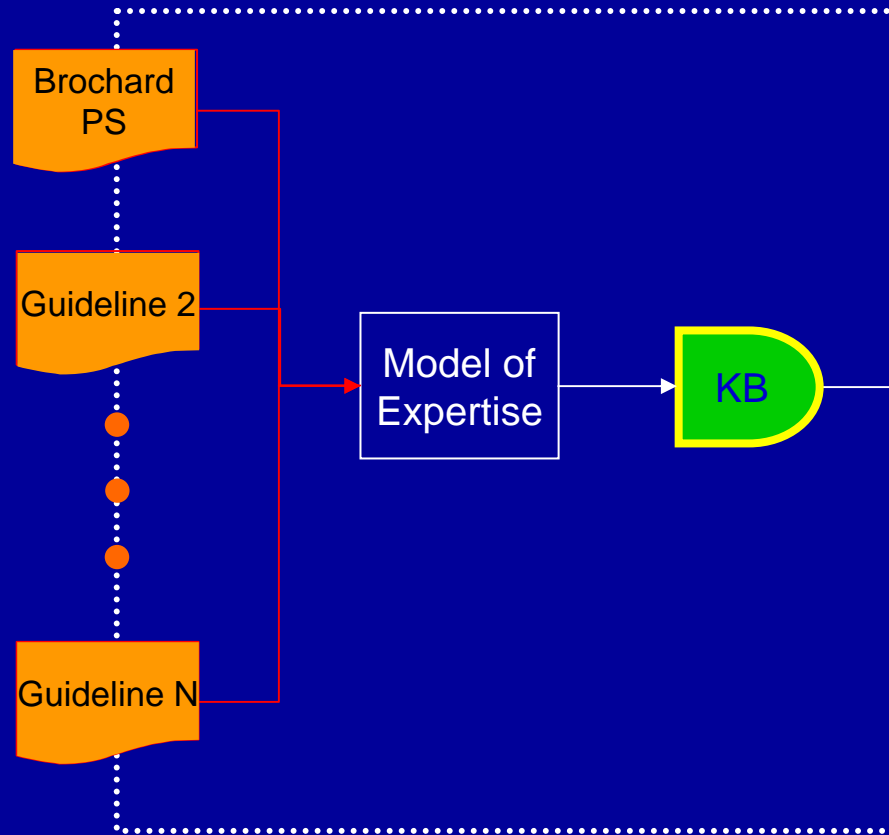
	Standard	SmartCare	
<b>Weaning Duration</b>	4	2	days
<b>Duration Ventilation</b>	9	6	days
<b>ICU Stay</b>	17	12	days
<b>Need for noninvasive Vent.</b>	36	19	%

(all differences:  $p \leq 0.02$ )

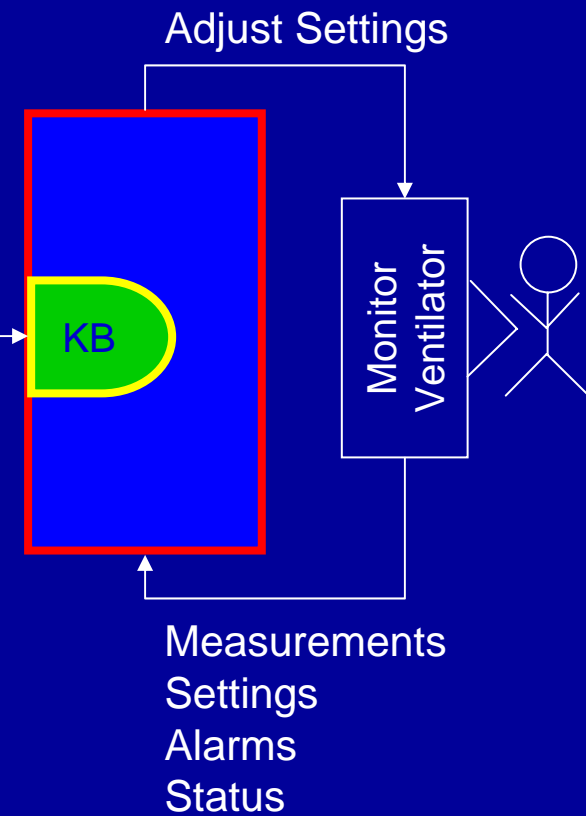
# Smart Care®

To be continued...

## Construction



## Operation



## Summary

- Automated Control of Medical Devices
- Generic Engine for multiple CG Execution
- System & Domain Independent
- Computer Aided Knowledge-Engineering
- Software-Engineering
- Clinical Evaluation

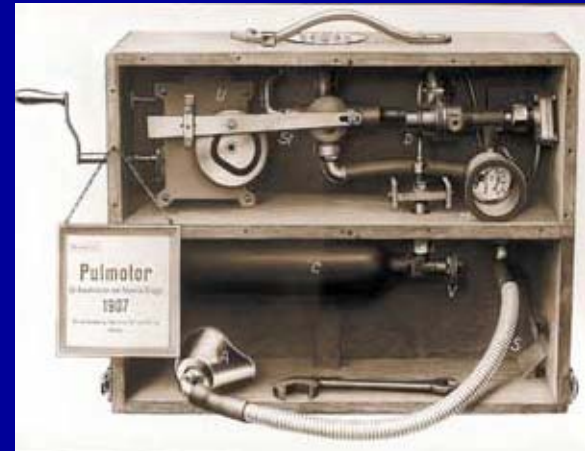
# Challenges

- Clinical Guideline
  - Acquisition (appropriate, applicable)
  - Validation (Clinical Study)
  - User Acceptance
- Knowledge Engineering
- Resource Restrictions for Embedded Systems
- Cross-Development: Host ↔ Target
- Quality Management, Regulatory Affairs

Bellows, Hand-bags



Respiratory Rate, Tidal Volume



Therapeutic Goals





## Therapeutic Goals

