

Safe evacuation of different groups of (vulnerable) hospital patients

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Graduation presentation





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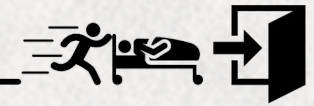
CONTEXT



Impact & damage

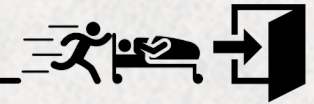
- Hospitals are **complex buildings** with several high risks
- Dependent patients who **need assistance** during evacuation
- **1000 fires** in Dutch health care premises each year
- Major causes are **faulty or misuse equipment**, arson and smoking





Current regulations

- Based on **old principles** of health care
- Based on larger patient rooms
- Corridors only used as **traffic space**
- Horizontal evacuation only required in one direction



Changing design trends

- Shifting towards
“Healing Environment”

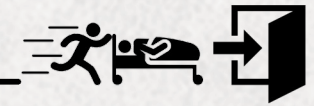
- Smaller individual patients rooms



- Corridors which serve as **living room**

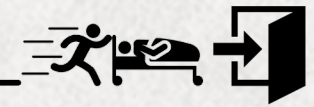
- Increase of fire risks and fire load which leads to lower **ASET**
(Available Safe Egress Time)





Changing use

- **Limited staff** available due budget restrictions
- Patient population is changing, increase of **complex patients** on all wards
- **More equipment** must be disconnected
- Increase of **RSET**
(Required Safe Egress Time)



Fire test in patient room

RESEARCH QUESTION



What design guidelines can be derived for a fire safety concept in hospitals that matches new design trends, actual use and corresponding egress times of vulnerable patients?

RESEARCH



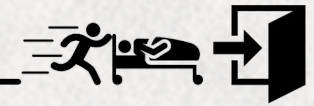
OBJECTIVES

Existing research

- Overview of available data on egress time of different groups of vulnerable people

Missing:

- No data available for the actual disconnecting and evacuation times for specific patients
- Designs focussed on the required safe egress time of a ward and the actual risks



Specific parts of evacuation



Arrival speed

Leaving room

Evacuation speed

Passing fire door

Descending stairs



Average uncoupling & disconnecting times



Basic patient

Standard patient

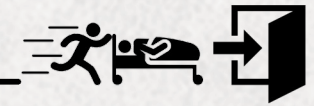
Dialysis

Recovery

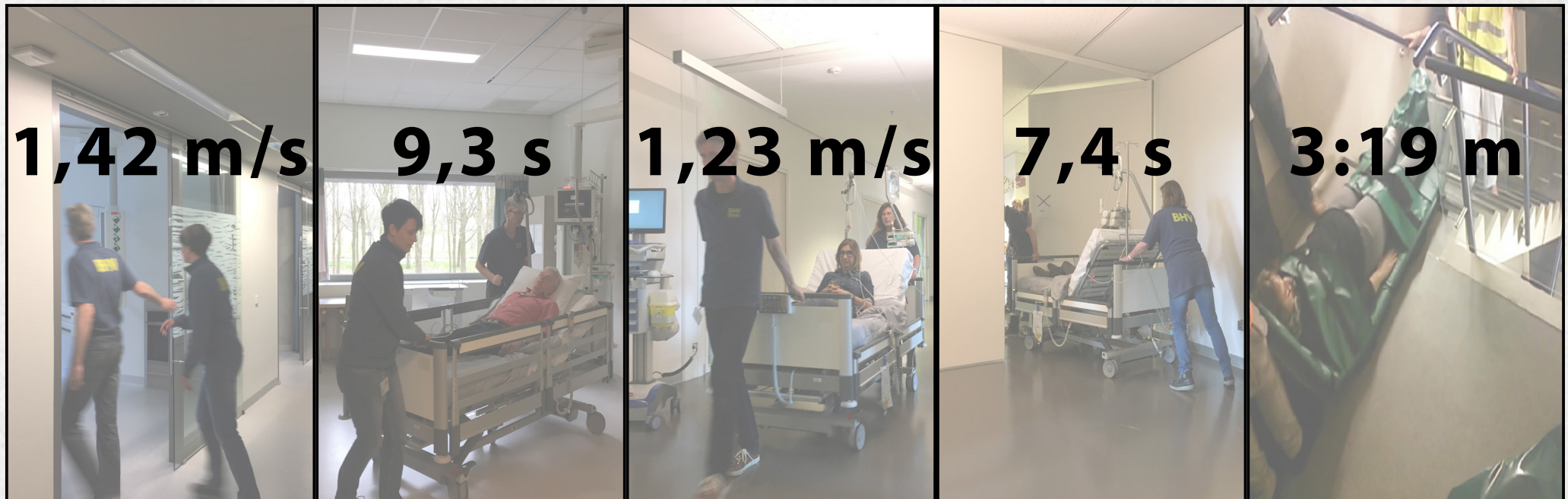
Heart monitoring

Incubator

Intensive care



Specific parts of evacuation



Arrival speed

Leaving room

Evacuation speed

Passing fire door

Descending stairs



Specific parts of evacuation



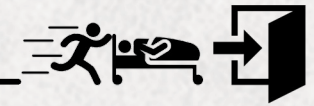
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Average uncoupling & disconnecting times



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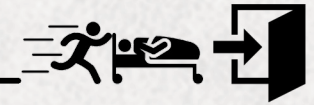
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Average uncoupling & disconnecting times



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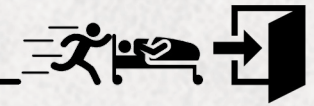
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Average uncoupling & disconnecting times



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Standard patient

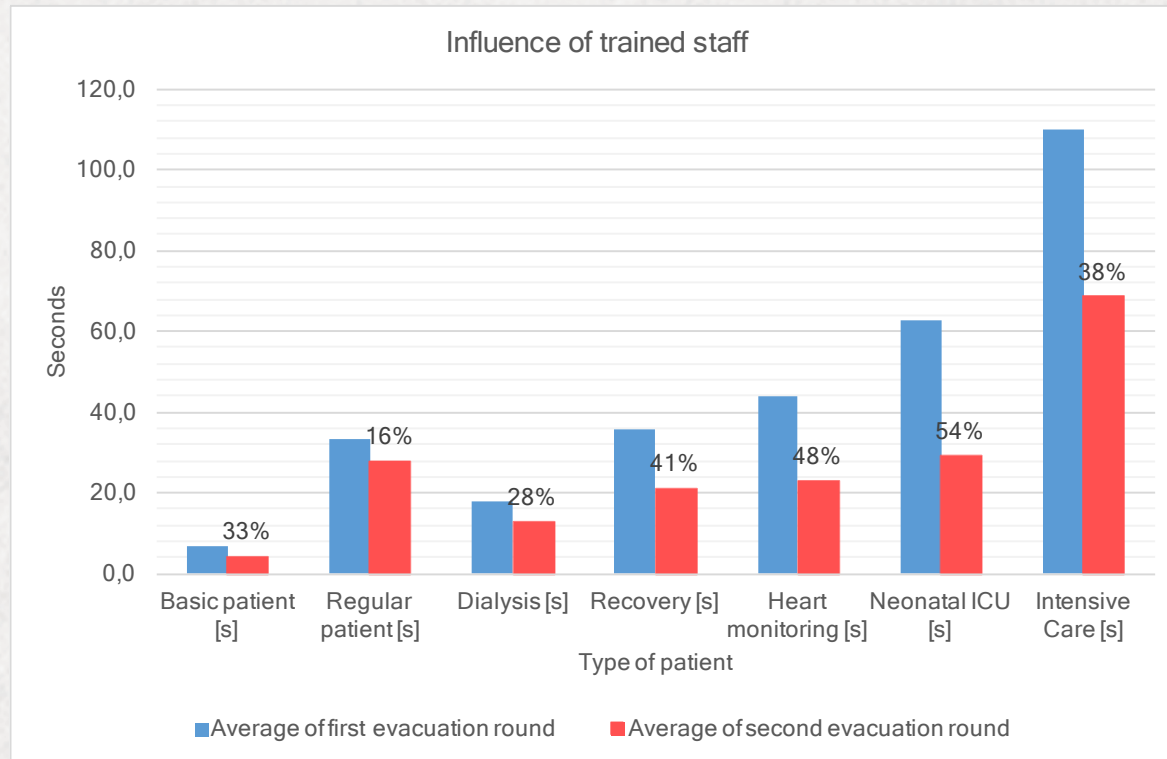
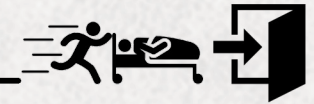
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Intensive care



Influence of trained staff in uncoupling specific patients

Influence of trained staff

- Improvement of evacuation times during experiments
- Time necessary for coordination and discussion
- Doors remain open

DESIGN TOOL



ARCHITECTURAL ELEMENTS



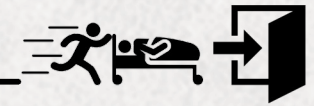
PRESENCE OF STAFF



TRAINING



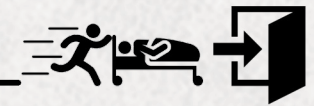
Design approach developed



Fill in design tool

- Safe design in 9 steps
- Data applied
- Comparable results



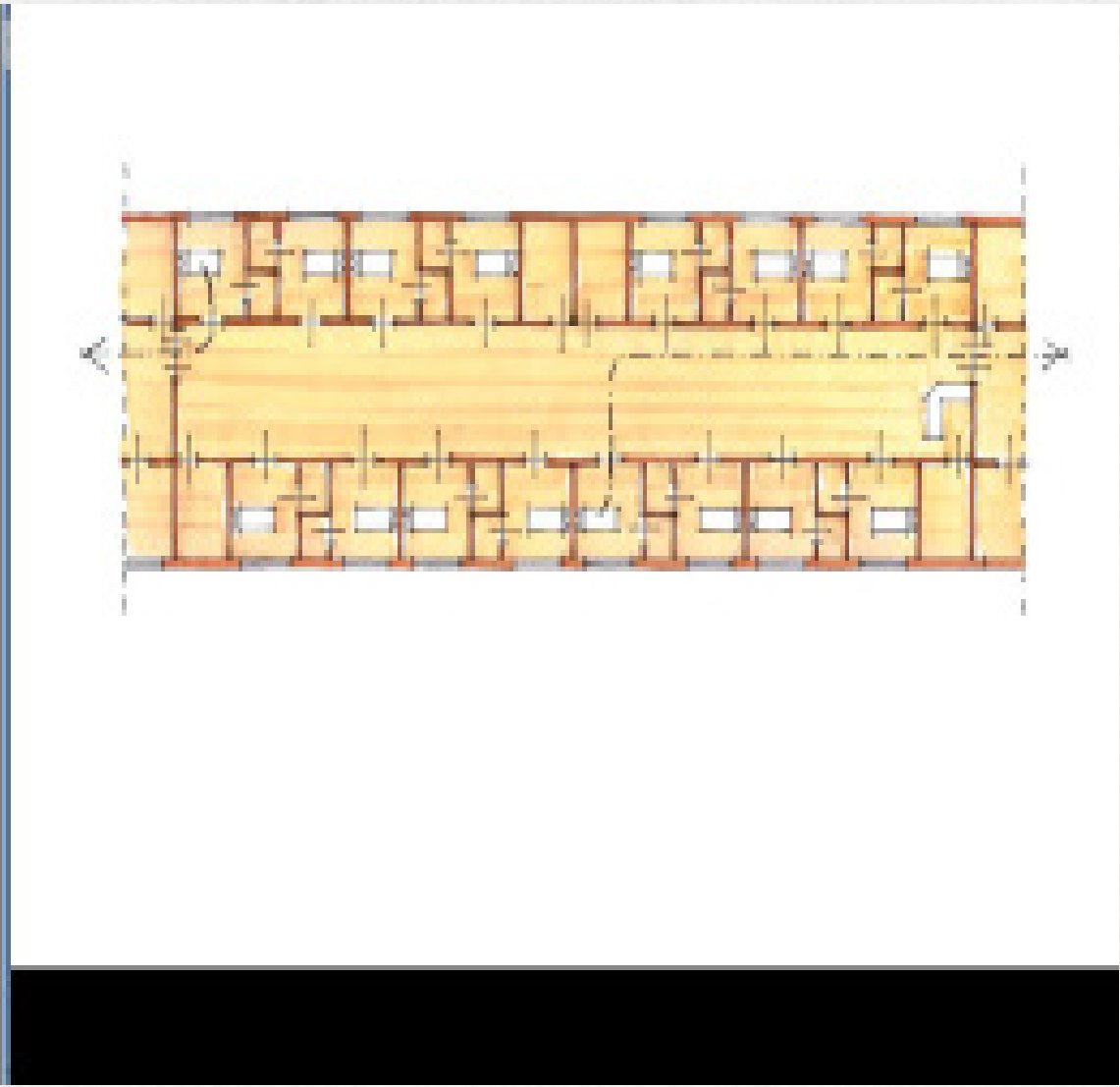


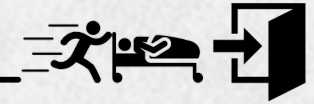
Patient room A	50	5	0
Patient room B	50	0	4
Patient room C	24	0	2
Patient room D	20	0	1
Nurses room	15	1	0
Door-closets	150	1	0
Fire compartment (m ²)	400		30
*Fire compartment maximum 300 m ²			

Design options

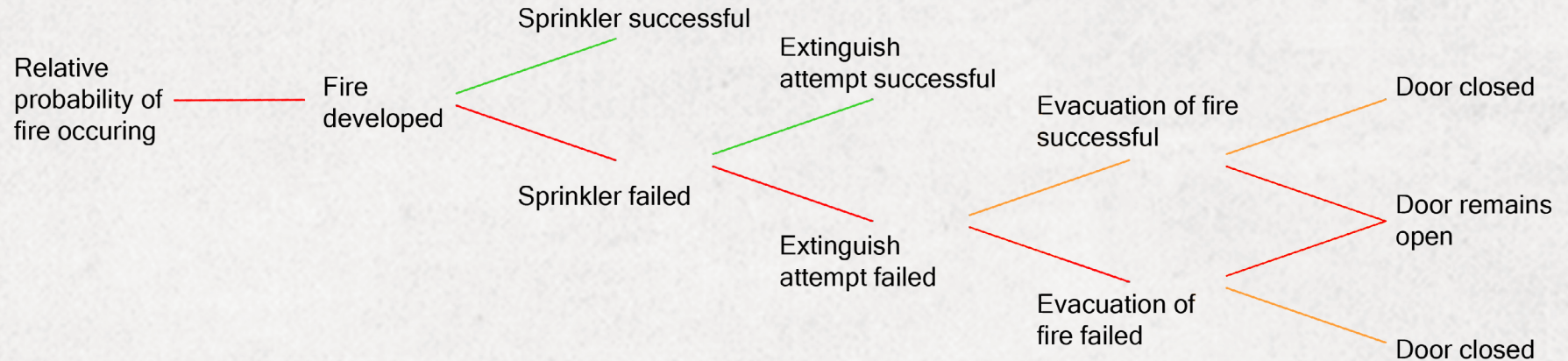
Self-closing doors patient rooms	No
Staircase	No
Smoke-protected corridors	No
Smoke-protected patient rooms	No

Type of ward	Standard patient
Shortest evacuation length	10 m
Longest evacuation length	30 m
Additional evacuation length	0 m
First arrival length	0 m
Shortest arrival length	10 m
Longest arrival length	30 m





Calculations



Probability calculations

$$\text{Average RSET of ward} = \frac{\text{Response time [s]} + \text{Extinguish attempt [s]} + (\text{Evacuation time per patient [s]} \times \text{Number of patients})}{\text{Staff present} + (\text{extra staff - arrival time [s]}) + (\text{extra staff - arrival time [s]}) + \dots}$$

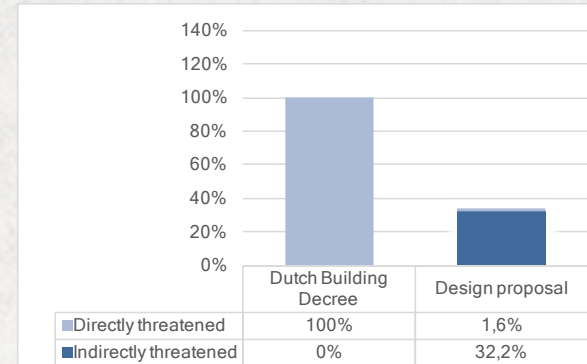
Egress time calculations



Results

Relative risk

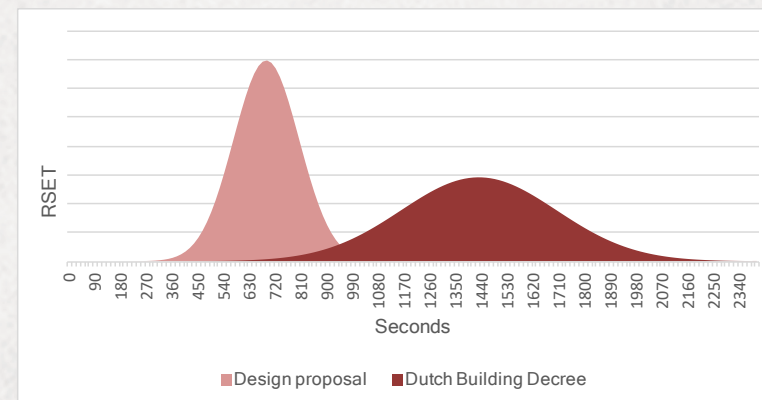
- Calculated risk for new design
- Calculated risk for layout based on current regulations
- Risk in % to compare new design



Relative risk on casualties

Required Safe Egress Time

- Calculated RSET for new design
- Calculated RSET for layout based on current regulations
- Equal times for comparison
- RSET in seconds

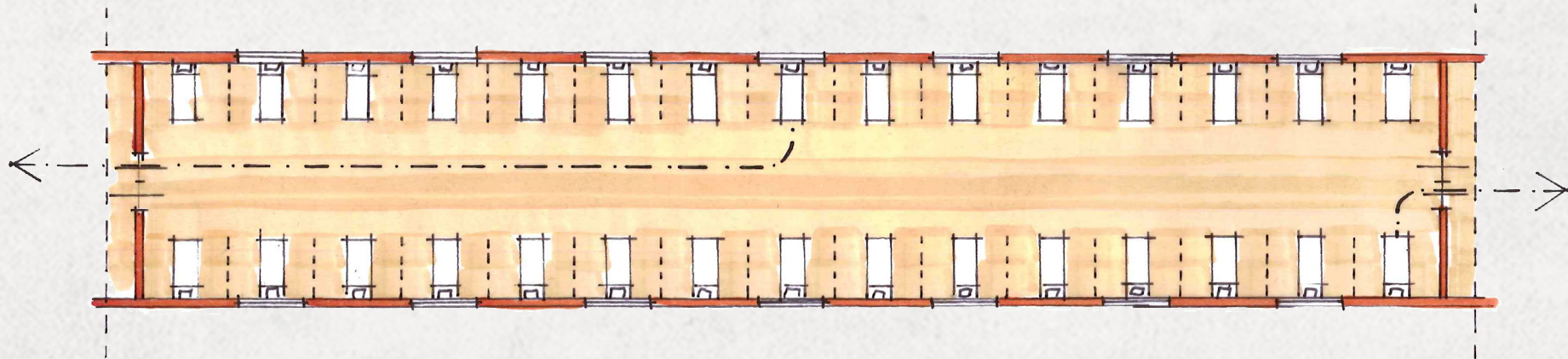


Calculated RSET

CASE STUDIES



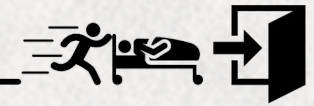
Dialysis & Intensive Care



Basic layout based on current regulations

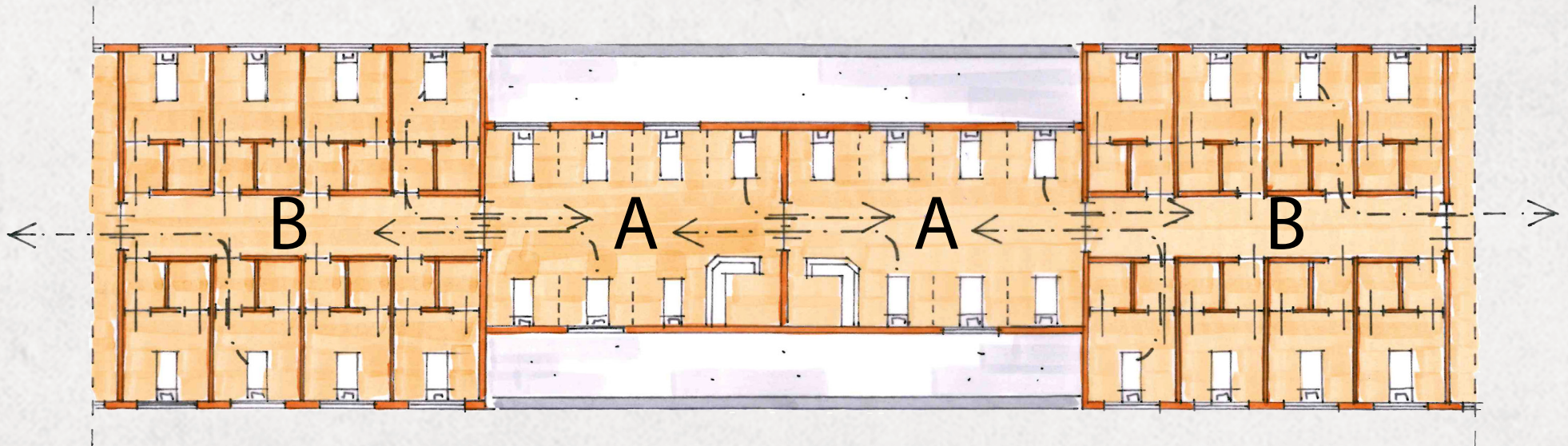
Current regulations

- Fire compartment of 500 m²
- No separations if permanent surveillance

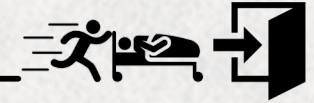


DESIGN: CASE STUDIES

Intensive Care



New layout for Intensive Care, split up in 4 compartments



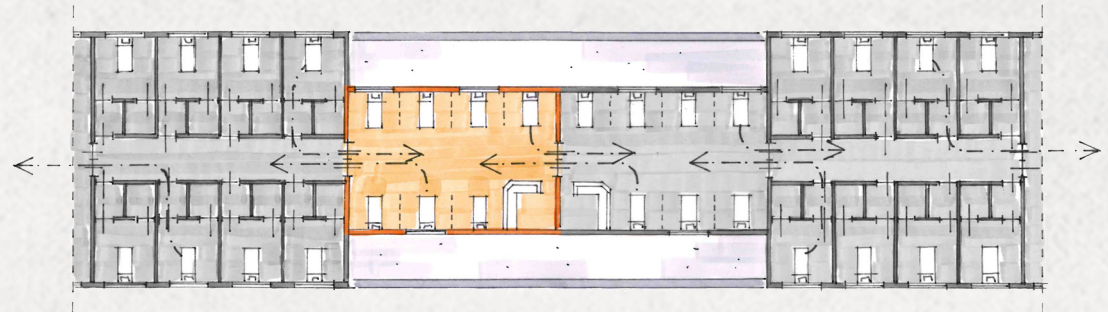
Intensive Care

- Split up in 4 compartments
- 4 staff members direct present

Compartment A

Open compartment with 7 patients

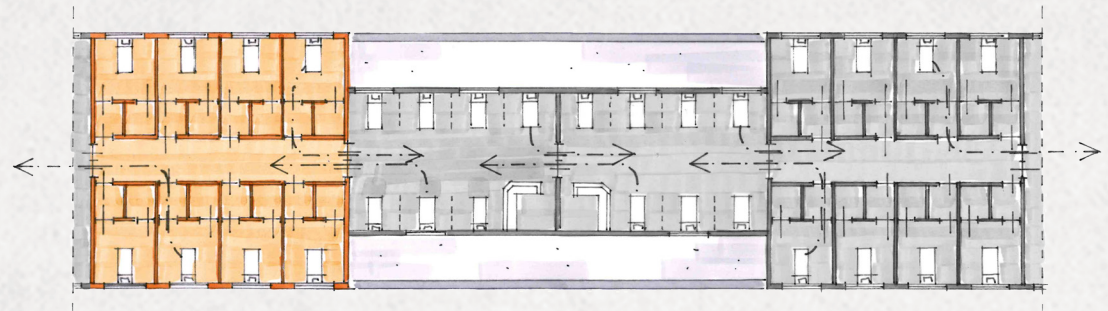
- Actual risks 8,6% directly threatned
- RSET 09:49[mm:ss]

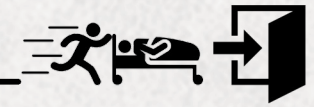


Compartment B

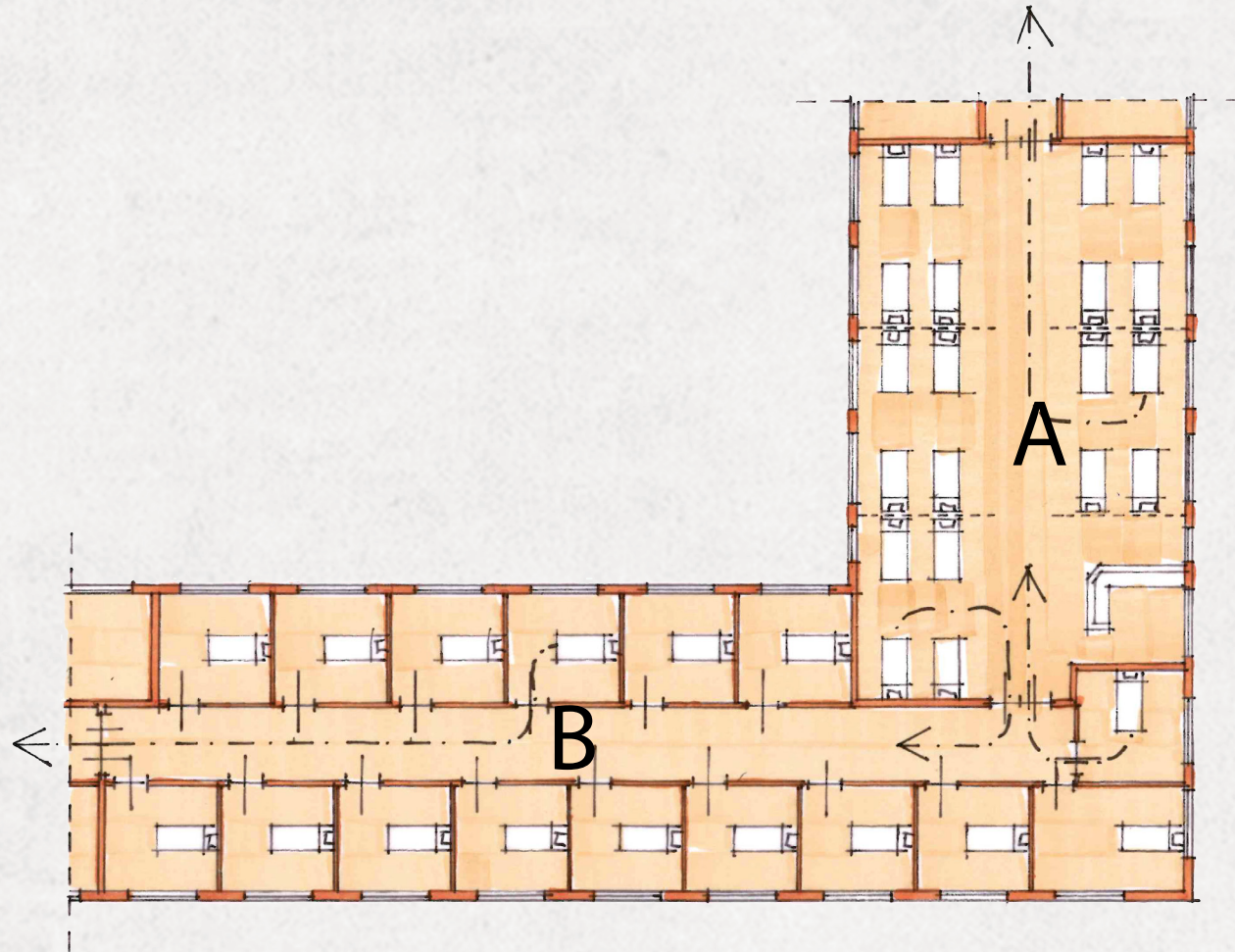
Single patient rooms with 8 patients

- Actual risks 6,6% directly threatned
 13,8% indirectly threatned
- RSET 11:13 [mm:ss]





Dialysis



*New layout for Dialysis,
split up in 2 compartments*



Dialysis

- Split up in 2 compartments
- 4 staff members present

Compartment A

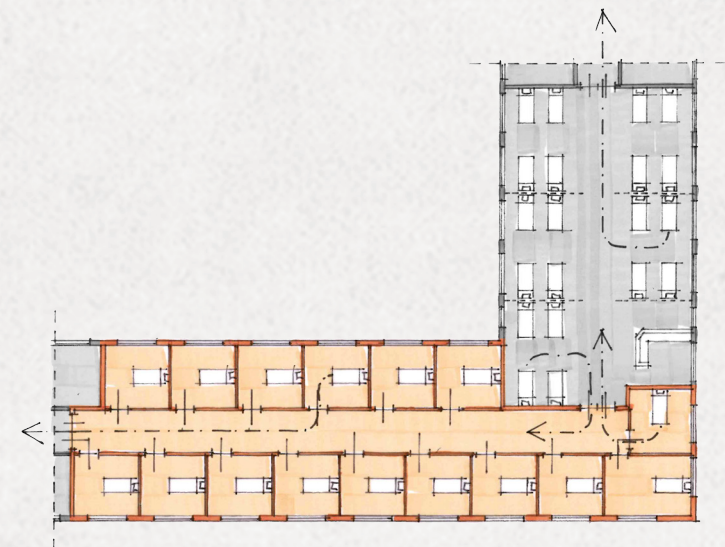
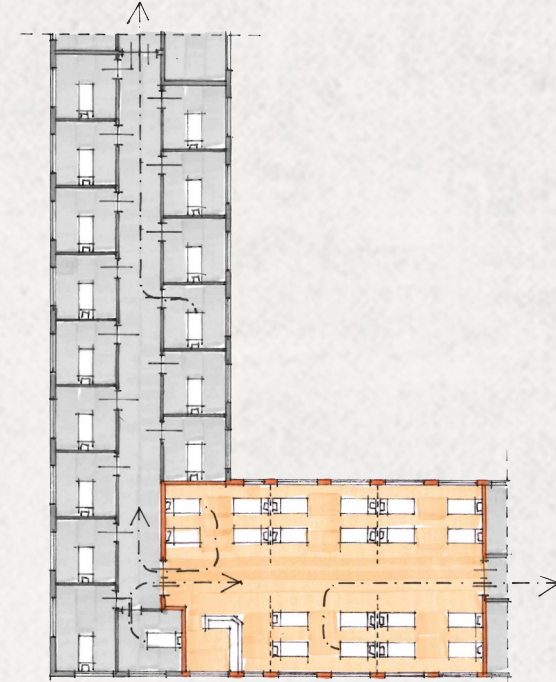
Open compartment with 20 patients

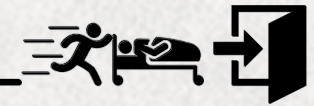
- Actual risks 34,9% of directly threatned
- RSET 09:23 [mm:ss]

Compartment B

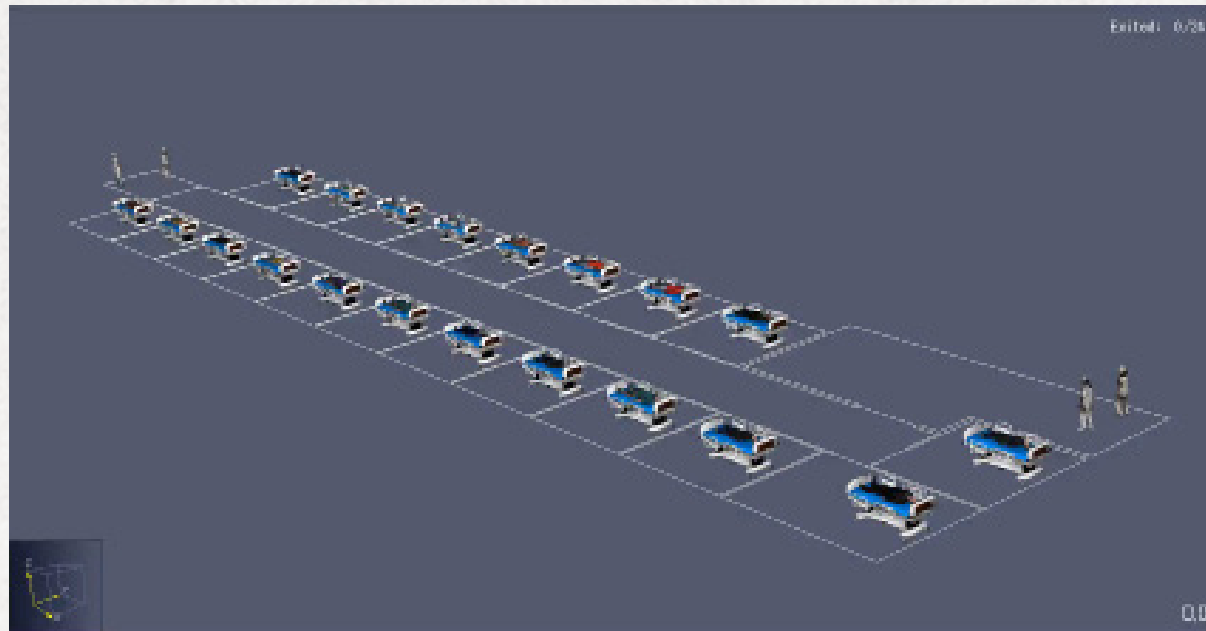
Single patient rooms with 16 patients

- Actual risks 10,8% directly threatned
 34,0% indirectly threatned
- RSET 08:09 [mm:ss]

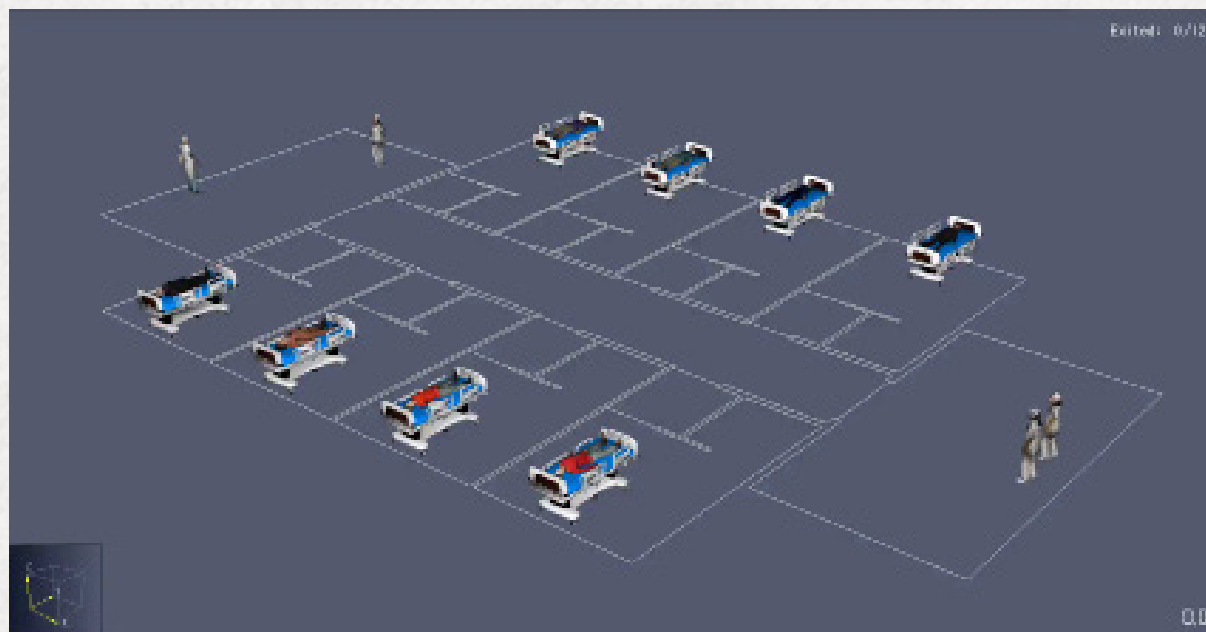


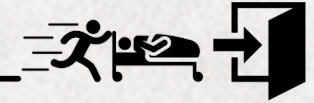


Dialysis



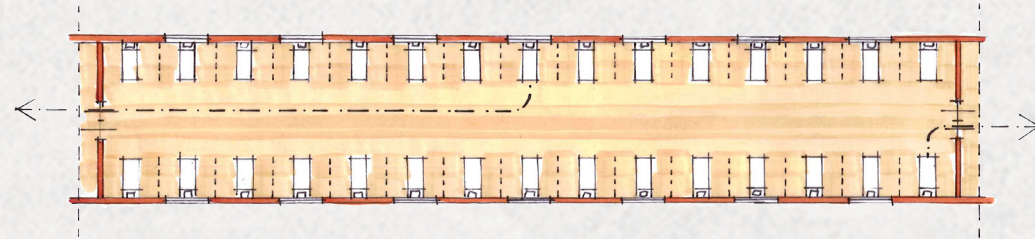
Intensive Care



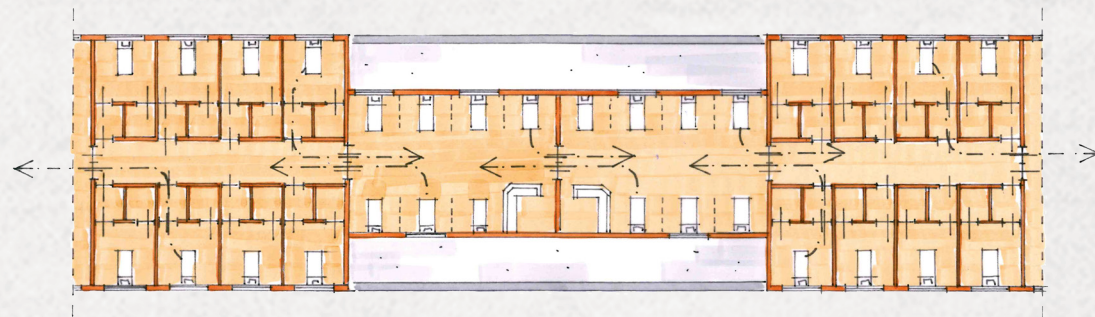


Conclusion

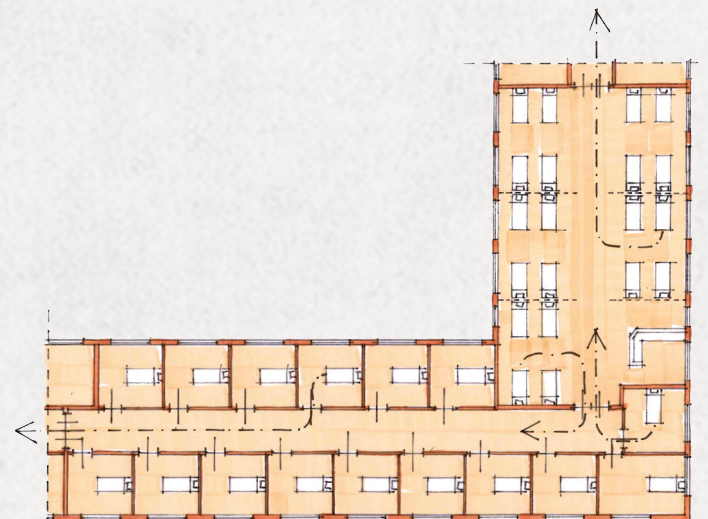
- New layouts based on equal risks and equal required egress times
- Different designs necessary for specific wards
- Current regulations outdated
- Focus on egress time instead of square meters



Basic layout based on current regulations



New layout for Intensive Care, split up in 4 compartments



New layout for Dialysis, split up in 2 compartments

CONCLUSION



CONCLUSION

Literature

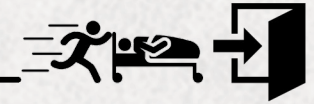
- Regulations are outdated
- Problems occurred during fires

Experiments

- Behaviour of staff
- Large diveristy in uncoupling times

Design

- Combination of solutions
- Presence of staff
- Focus on required egress time and risks instead of square meters



RECOMMENDATIONS

Research

- Gathering more data about specific egress times
- Probabilities of problems occurred during fires
- More specific data about causes of fire

Design

- Equal risks and egress times for specific wards
- More elaborated link between ASET & RSET
- Designs should be focussed on simple performable evacuations
- Reconsideration of limit values

“Customised designs for specific wards are required to ensure equal risks per patient in hospitals.”

“Adaptable design solutions for a state of the art fire safety concept that matches new design trends, actual use and corresponding egress times for different groups of (vulnerable) patients.”

Thank you!

