

R&D FROM HALTON PERSPECTIVE, FROM MISSION TO SOLUTION

Professor Kim Hagström, DSc

ENABLING WELLBEING IN SUSTAINABLE WAY



NORTHERN STAR AS OUR GUIDING PRINCIPLE

Best-in-class customer experience
through expertise, local presence
and global cooperation



Close to customers globally
with Asia and the Middle East
growing fastest



Unique value to customers through
innovations and increasingly
leveraging digitalization to
create the difference



We enable
safety and
wellbeing in
demanding
built
environments

Strongest sustainability
benefits to customers



Providing “peace of mind”
for customers throughout
the entire lifecycle



Continuously renewing company
and exploring new opportunities
outside present core business



Healthcare



Industrial
Cleanroom



Services

HEALTH AND CLEANROOMS - OUR WAY

CLEAN.

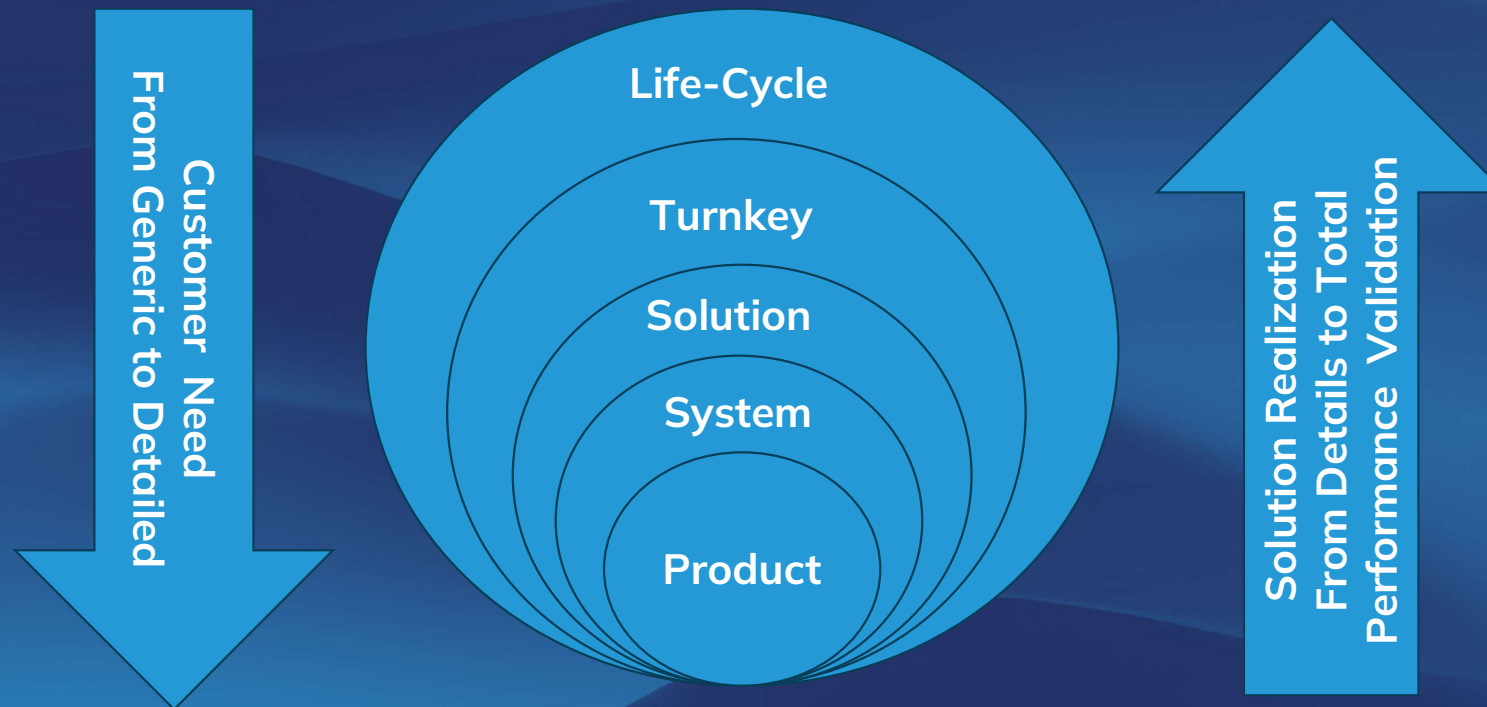
We focus on innovations that enhance the quality and sustainability of the customers' processes.

SAFE.

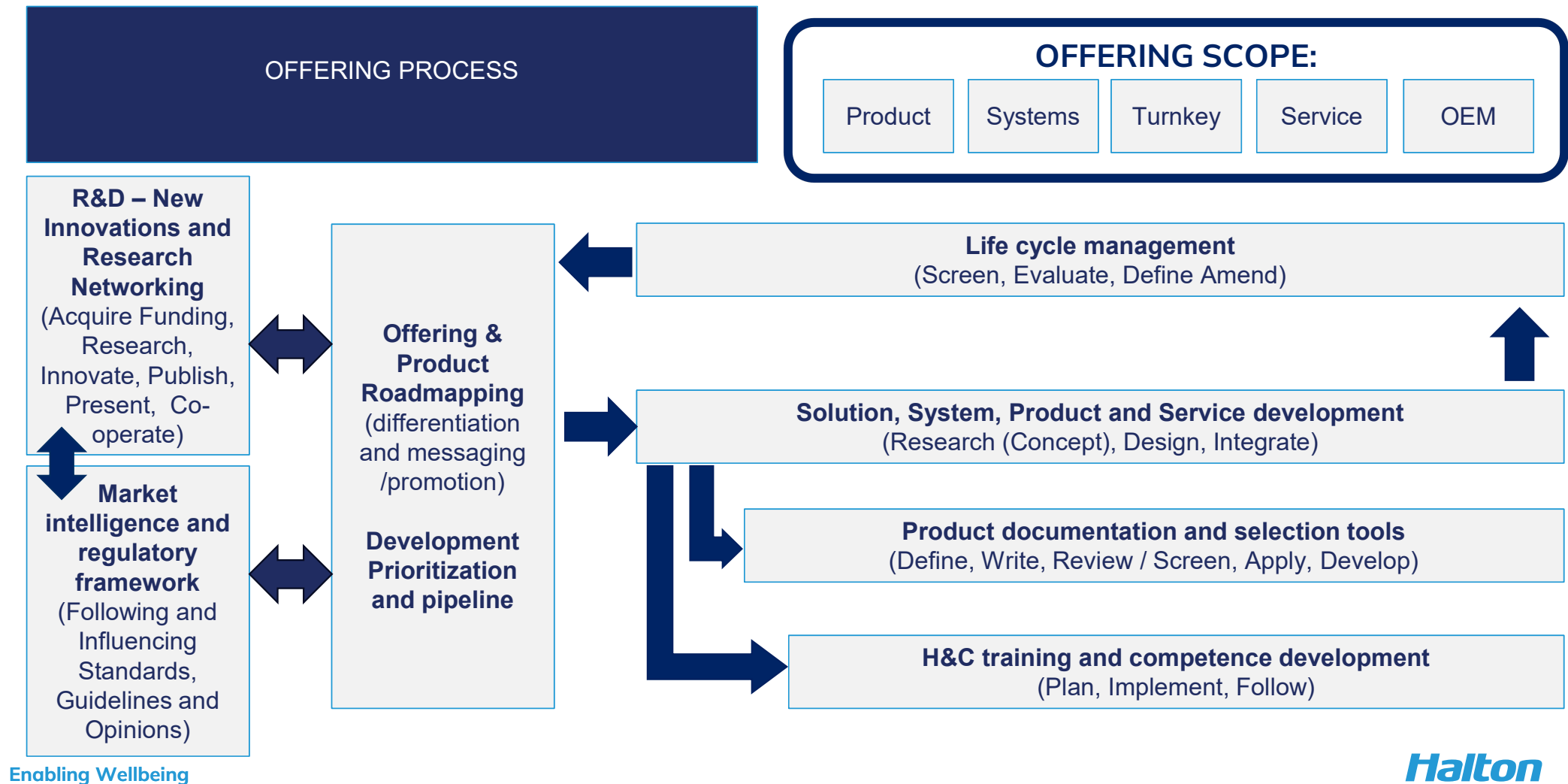
We ensure performance from design to delivery and bring peace of mind to customers. Our focus will shift from individual products to entire systems, turnkey deliveries and life-cycle services.

VERIFIED.

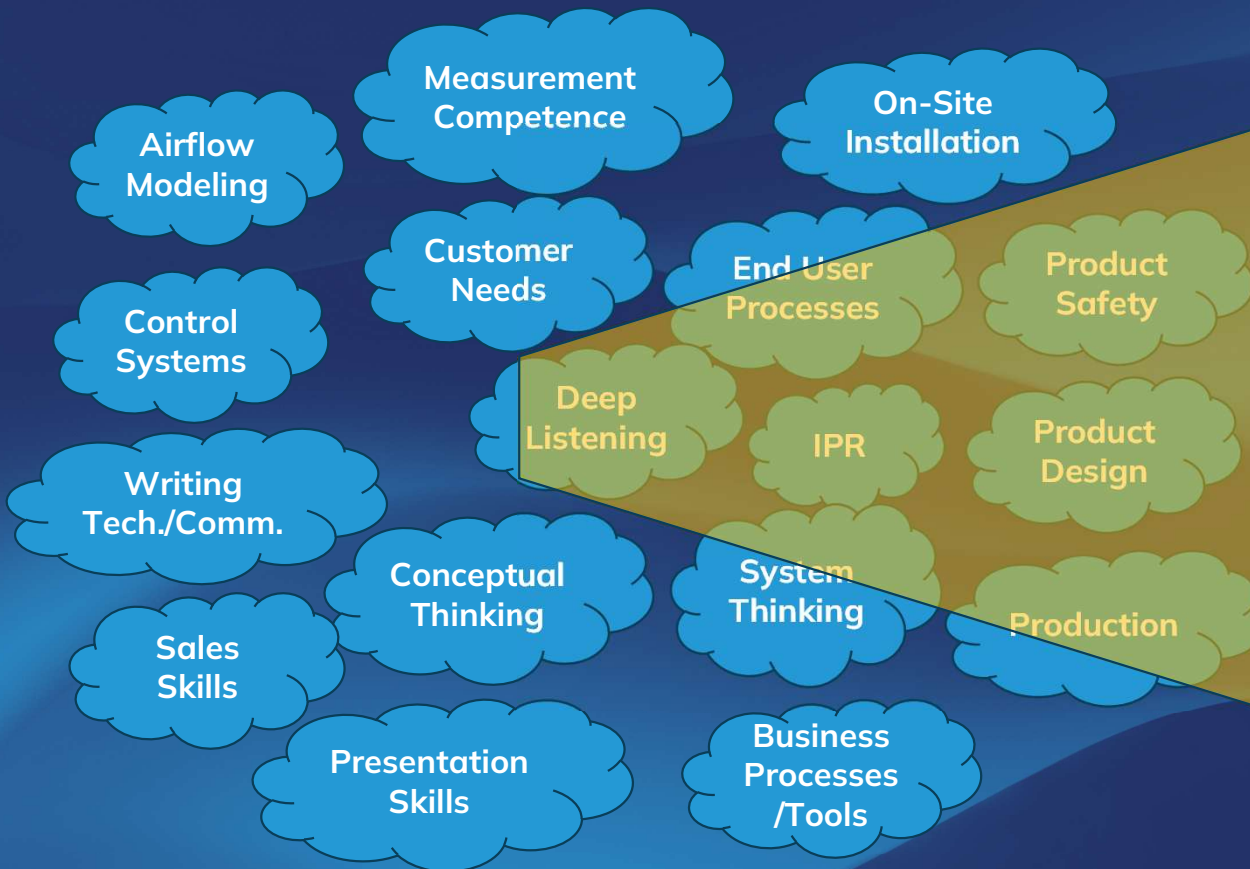
HEALTH AND CLEANROOM OFFERING DEVELOPMENT



Offering process & R&D Activities



R&D COMPETENCE MAP TO SUCCEED



Fully engaging with the speaker

Deep Listening for Better Relationships

Deep listening is not just about hearing words; it's about fully engaging with the speaker—mind, body, and emotions. It involves understanding not just what's being said but why it's being said, creating a space where the speaker feels truly heard and valued. Signs of deep listening include not thinking about your response while the other person is talking, noticing subtle cues like tone and body language, and walking away with a deeper understanding of the speaker's perspective. Deep listening is rare but transformative, and it's at the heart of all healthy relationships.

↳ Rensselaer Polytechnic Institute (RPI) +1



HALTON VITA OR SPACE

**STORY FROM CUSTOMER NEED
TO REALIZATION , VALIDATION
AND COMMERCIAL SUCCESS**

Case Nya Karolinska Operating Rooms



CONSIDERATIONS OF OR VENTILATION

OPERATING ROOM VENTILATION

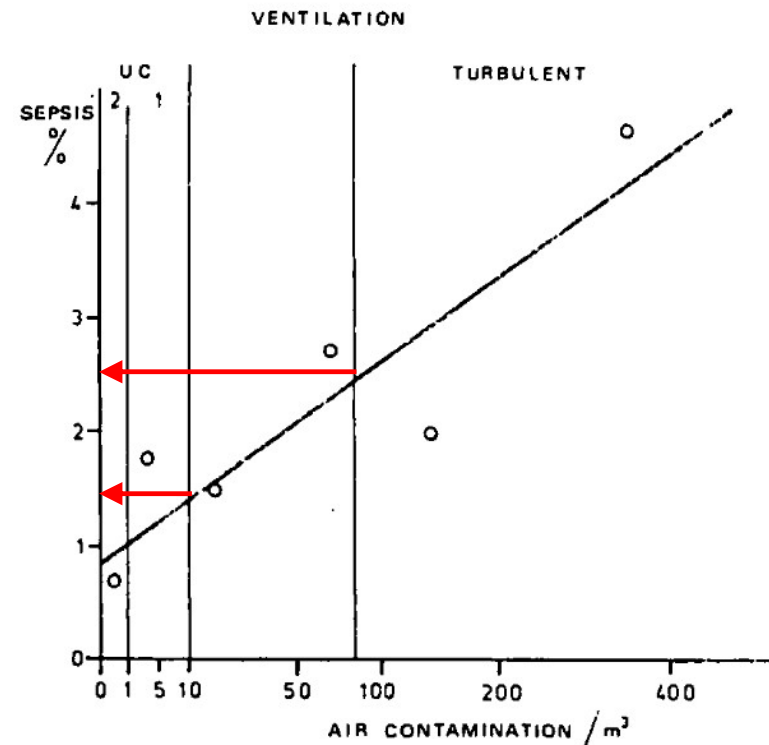
Users Needs and Considerations:

- **Clean operating Environment (low CFU/m³ air)**
- **Occupational health and safety for staff**
 - Typically necessitates also a separate exhaust (anaesthetics and diathermie, e.g. Halton VEX)
- **Comfortable and functional work environment**
 - Thermal comfort, Air Humidity
 - Low sound level to enhance communication
- **Operational flexibility**
 - Not limiting the operational activities/behaviour
 - Enables upgrades of medical installations
- **Operational Efficiency –Recovery Time**
 - Fast Clean-up/Condition change between operations
 - Compensate for Heat generation of medical devices



- **AIR CLEANLINESS VS RISK FOR INFECTION**
VENTILATION IS A MEASURE TO MAINTAIN AIR CLEANLINESS

- Lidwell 1987: Ultraclean air and antibiotics for prevention of postoperative infection.
- Studied on 8052 joint replacement operations (19 hospitals)
- Proven correlation between air contamination level and infection rate in operation.
- Influence of ultra clean air and prophylactic antibiotics acted independently reducing sepsis. Combined effect was better than, if either was used independently.



AIR CLEANLINESS IN OPERATING ROOMS

Factors influencing on the air cleanliness:

- Type of operation
- # of personnel
- Operating clothing
- Operating personnel's activity
- Material emissions
- Door discipline
- Cleanliness of surrounding rooms
- Ventilation system performance
 - Filtration
 - Room pressurization
- Room tightness

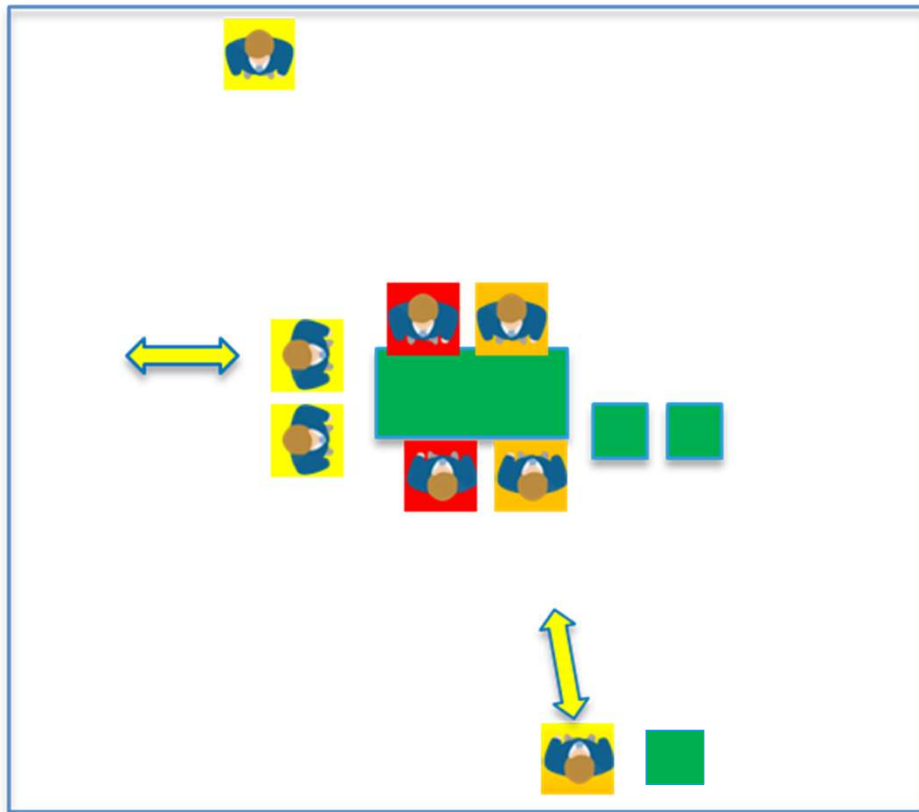


PEOPLE AS A SOURCE OF CONTAMINATION

Activity	Snap smock (particles/min)	Membrane coverall (particles/min)
Sitting or standing still	100,000	10
Light movement: head, leg, arm	500,000	50
Heavy movement: head, leg, arm, foot	1,000,000	100
Change position: sitting down, rising up	2,500,000	250
Walking 0.9 m/s	5,000,000	500

OPERATING PERSONNEL ACTIVITY

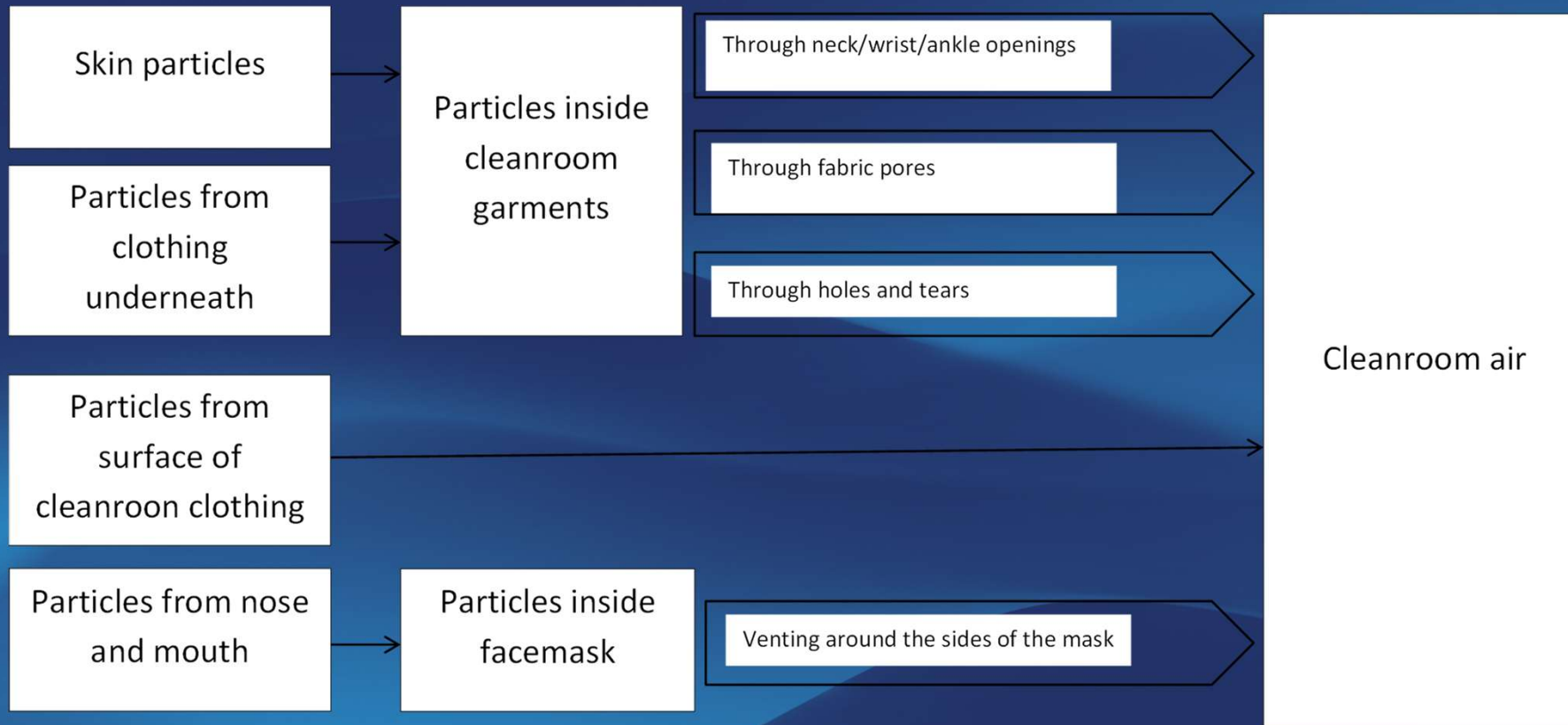
PERSONS CLOSE TO PATIENT/INSTRUMENTS ARE MOST ACTIVE



1. Displace the contaminated air away from sources/Critical areas
2. Dilute the contamination to be able to use the whole room
3. Prevent Ingress of contamination back to critical areas

- Critical Areas
- Person, Heavy Movement
- Person, Light Movement
- Standstill/Visiting Persons

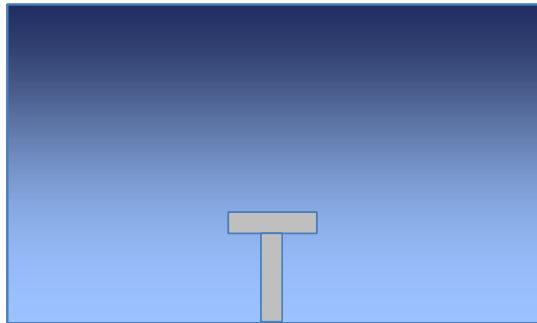
THE SPREADING OF CONTAMINATION



TWO MAIN AIRFLOW CONCEPTS (AS IDENTIFIED BY R3 NORDIC GUIDELINE)

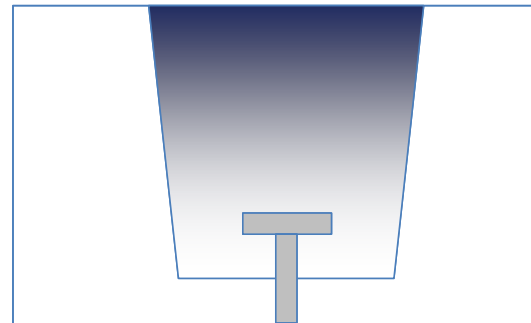
Dilution Mixing System

Performance criteria apply to the complete room



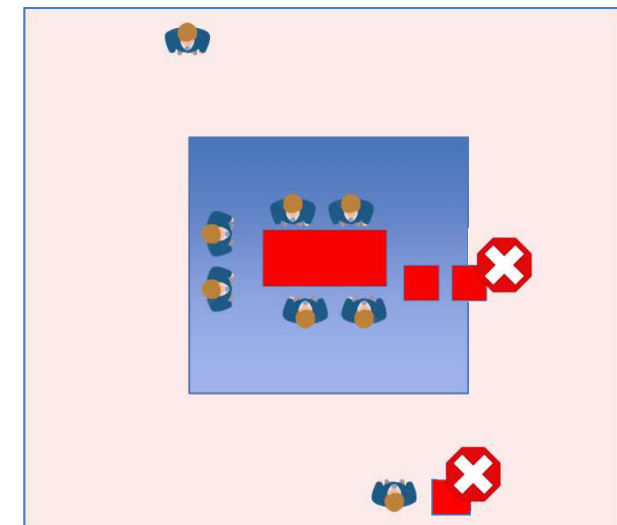
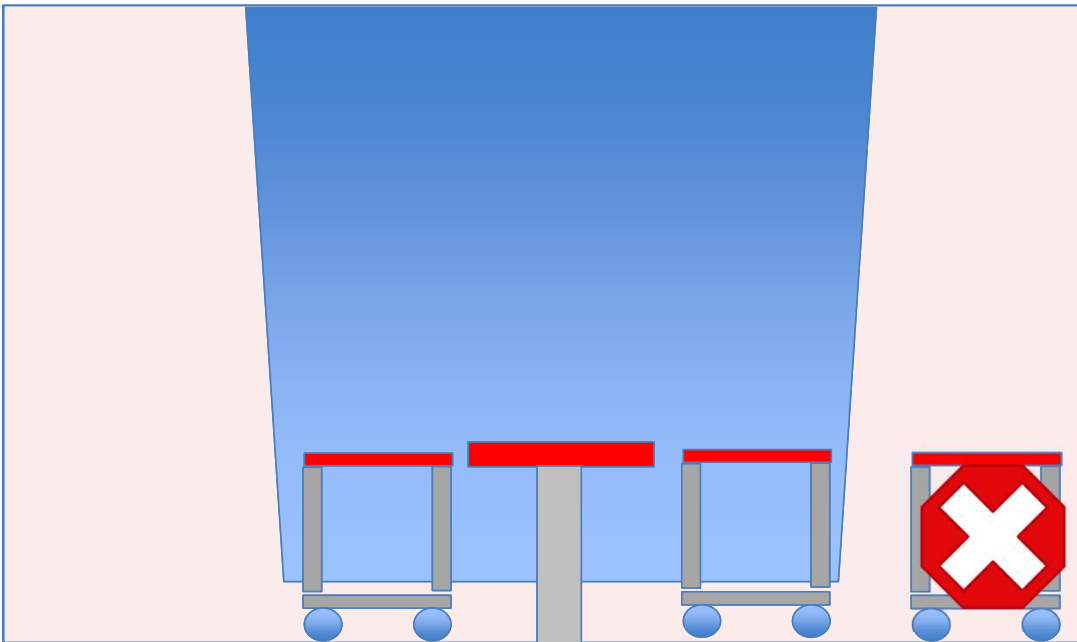
Protected Zone

Performance criteria apply to the specific area of interest (additionally general cleanliness criteria)



DESIGN FOR ZONING

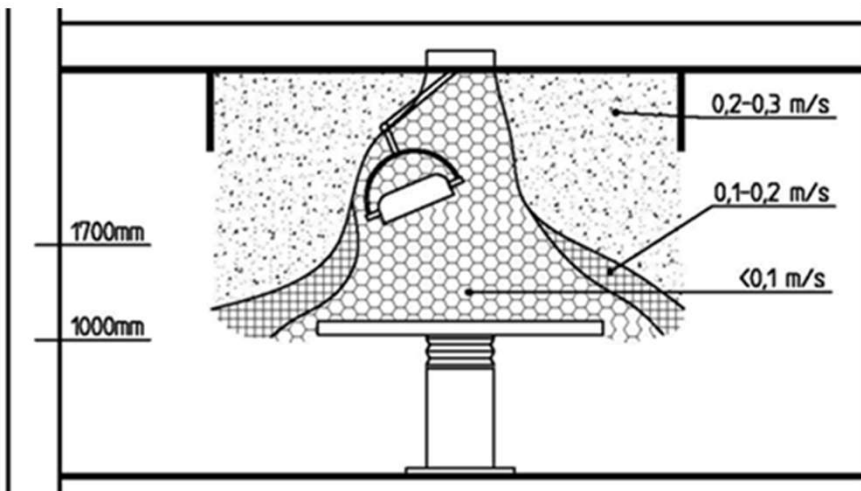
PROTECTED ZONE SHALL INCLUDE ALL CRITICAL AREAS



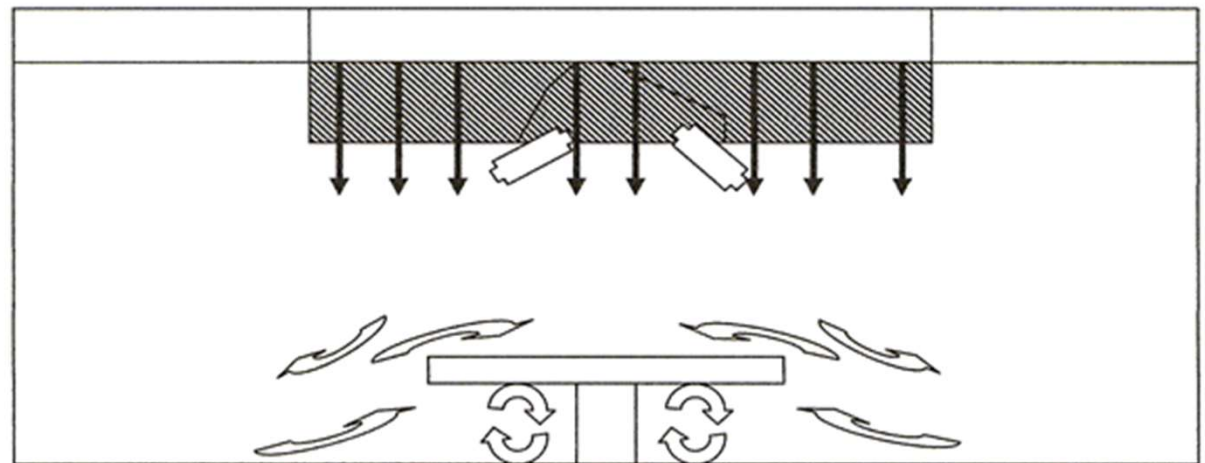
- Critical Area
 - Protected Zone
 - Uncontrolled Zone

UNIDIRECTIONAL AIR FLOW SYSTEM – OBSERVATIONS OF OPERATIONAL PERFORMANCE

Air velocities in the area between air supply and operation table.



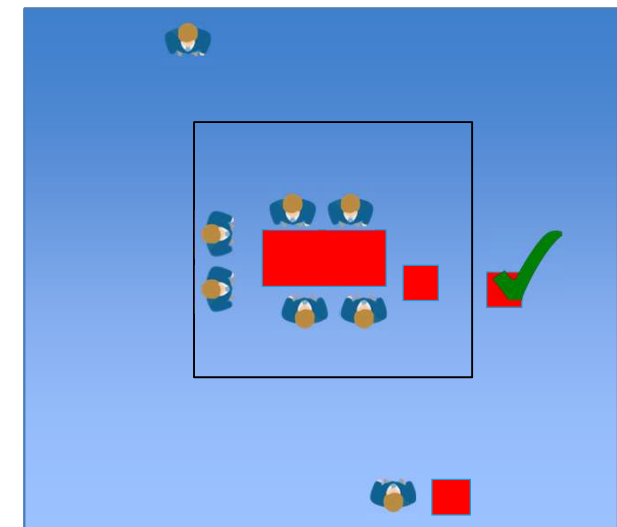
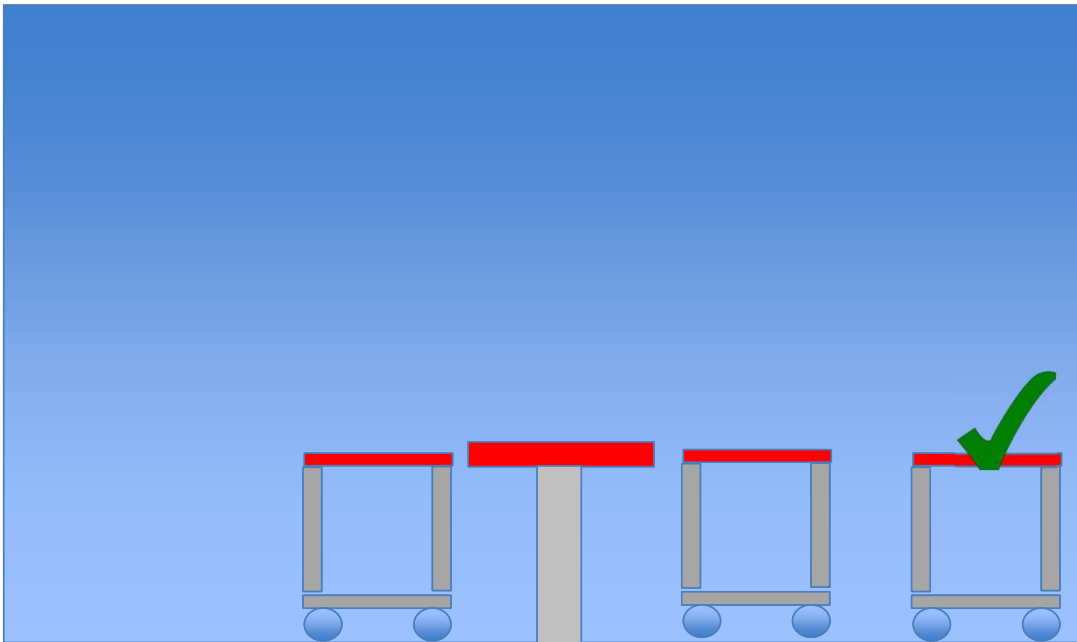
Field measurements by Nordenadler
Operationsrum A (0,27 m/s)



Turbulent, mixed conditions on OR-table During Operation, even when unidirectional flow in use as Obstacles (OR-lamp, etc.) and the activity of the OR staff have a significant impact on air movement.

DESIGN FOR DILUTION

THE WHOLE ROOM SHALL MEET THE DEMAND FOR CRITICAL AREAS



- Critical Area
- Protected Zone

ACTIVITIES OF TODAY – THE WHOLE ROOM IS IN USE



- Instrument tables everywhere in room
- Lack of space around patient
- Sterile packages prepared in whole room
- Different surgeries required in same room
- Medical equipment need more space
- What will be 10-20 years in future?



Nya Karolinska Hospital (NKS) Design Challenges and Targets

- Flexibility; Clinical activities = ?
 - Flexibility; Equipment in the OR's = ?
 - Economy; energy efficiency
 - Environment; draught, noise level(<35dB(A)), etc.
 - 5 CFU / m³
-
- Controlled Dilution principle was chosen
 - Skanska chose Halton as their partner to develop new solution

HALTON VITA OR SPACE 5

VALIDATION AND VERIFICATION OF THE PERFORMANCE FOR NYA KAROLINSKA

VALIDATION AND VERIFICATION IN DIFFERENT STAGES

1. Design (Pre)validation – In Operation (PQ)

- Is the designed ventilation system capable of providing required conditions **in operation** specified by the user (**maximum load**)?

2. On site Verification

- Does the system meet the conditions of the validation as delivered? (IQ, OQ)
- Are the conditions and functionalities met in the final operation (PQ)?

4. Life-cycle Qualification

- Does the system and its maintenance provide consistent function (Simplified IQ, OQ)?
- Are the user operations according to specification (PQ)?
 - Alterations / Undesired behaviour?

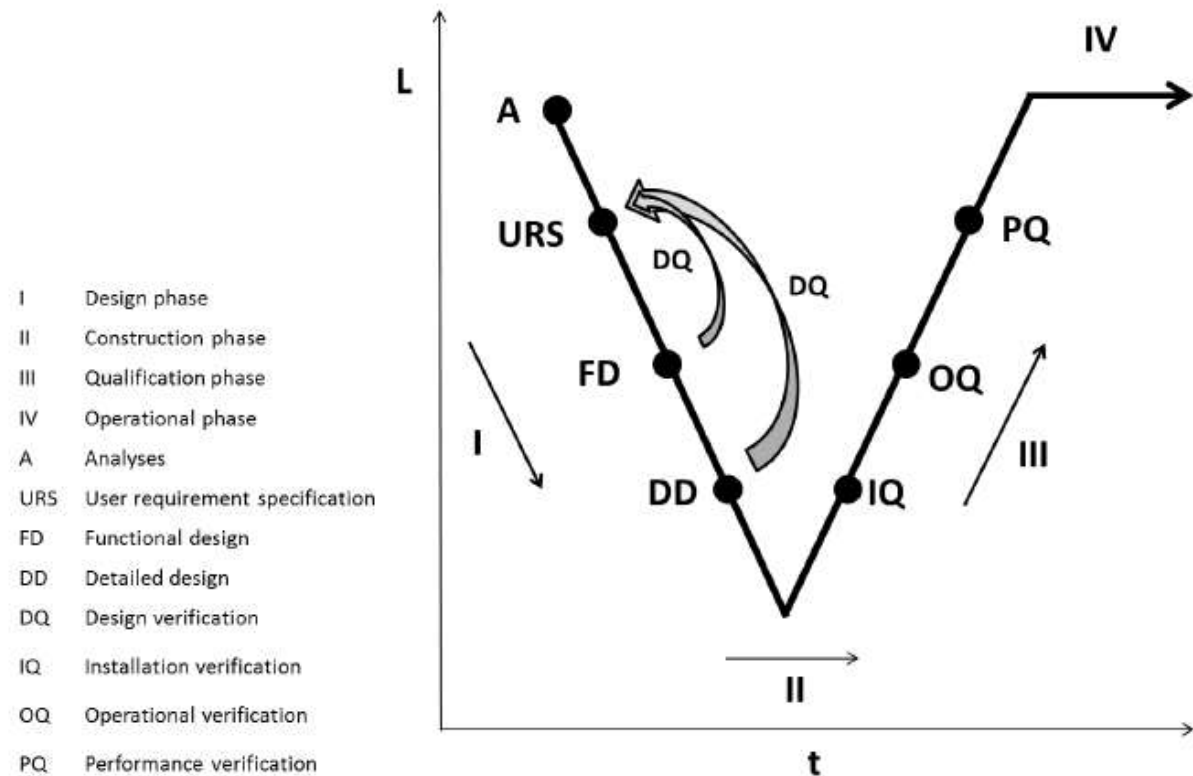


Figure 1. Graphic representation of the process (table 1).

DESIGN (PRE)VALIDATION

PREVALIDATION BY MEANS OF SIMULATED OPERATION

- Question: Is the designed ventilation system capable of providing required conditions in operation specified by the user?
- TARGET: Assess the microbial cleanness and thermal comfort in real operating conditions.
 - Real people with OR clothing
 - Simulated realistic equipment load and layout
 - Managed operating process by OR Staff

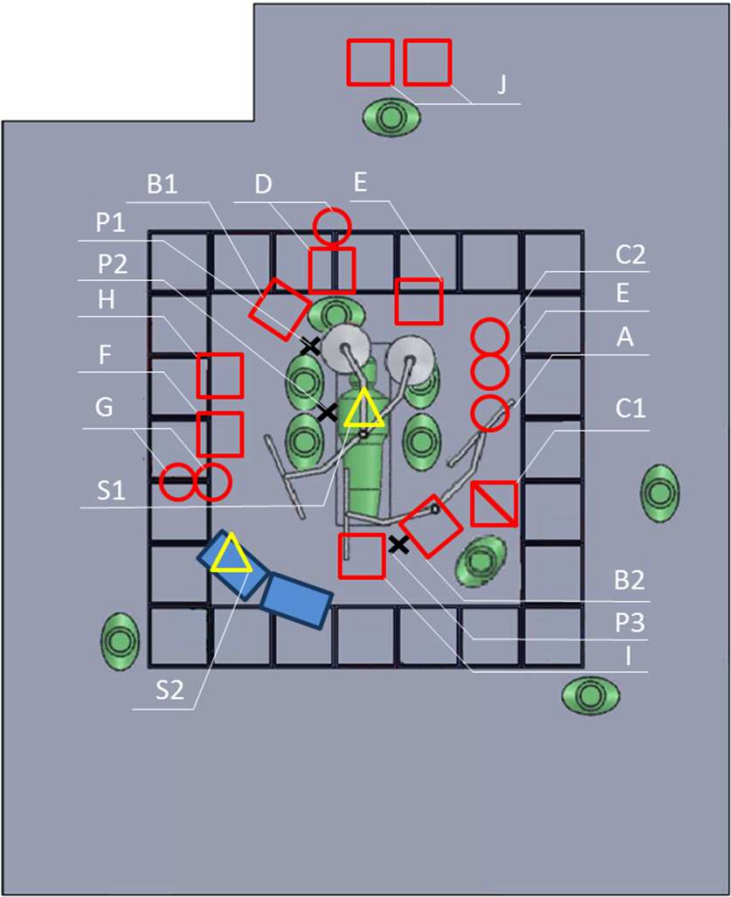
During the functional tests microbiological measurements, air temperature and air velocity measurements were carried out

- Enabling assessment of performance with maximum loading at the most critical areas



CASE 1, NKS, LAYOUT 1 AND 2

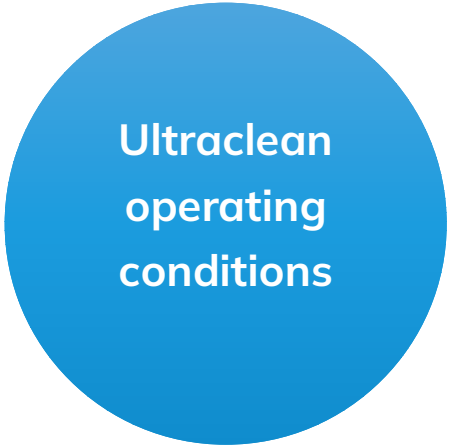
GROUP	Heat source	measured power [W]
A	D 2x100 W, 1X60 W	200
B1		250
B2		400
C1	K 3X75 W	495
	K 3X100 W	
C2	D 3X60 W	159
D	D 1X100 W, 2X60 W	496
	K 3X100 W	
E	D 3X60 W	453
	K 3X100 W	
F	K 3X75 W	152
G	D 3X75 W	400
	D 2X100 W, 1X60 W	
H	K 2X75W	101
I	K 2X100 W, 1X60 W	238
J	K 2X100 W, 1X60 W	401
	K 2X100 W, 1X60 W	
SUM [W]		3745
General lights [W]		1200
OR lamps [W]		215
Screens [W]		300
TOTAL [W]		5460



MEASURING DEVICES	
GROUP	DEVICE
S1	Sartorius MD 8
S2	Andersen HK-10
P1	Air velocity
P2	Air velocity
P3	Air velocity

NKSVALIDATION RESULTS, AIR CLEANLINESS

HALTON VITA OR SPACE 5



Ultraclean
operating
conditions

Requirement	In operation ^(*)	Measured
Microbial cleanliness	< 5 CFU/m3	<< 5 CFU/m3

Requirement	At rest ^(*)	Measured
cleanliness	ISO 5	<< ISO 5
Recovery time	<10 min	< 7 min

NKS VALIDATION, THERMAL CONDITIONS

HALTON VITA OR SPACE 5

Air velocity

- Three sensors were used on heights 1,1 m, 1,5 m and 1,8 m
- Air velocity levels were around 0,3 m/s when used airflows were 2,2 m³/s and 1,6 m³/s

Perceived Thermal comfort

- People perceived the thermal environment satisfactory during each operation despite the different airflow rate or loading used
- Comments from the participants:
 - *Room conditions was OK, no draft, low sound level, altogether very positive experience*
 - *Even standing close to heat sources I felt comfortable*
 - *This solution seems to be really good*
 - *I felt comfortable, no draft*
 - *Compared to rooms with laminar ceiling this was much more comfortable*
 - *When sitting just next to the wall, I could feel air movement, but not much*

ON-SITE VERIFICATION

NKS ON-SITE 3RD PARTY VERIFICATION (PQ)

Conducted as a Simulated Operation at the finished Operation room with Halton Vita OR Space On-Site by Nya Karolinska Hospital and MyAir Qualification company without any involvement by Halton

Results:

- Average 1,5 CFU
- Maximum individual reading 4 CFU

The validation results were presented at Hospital days (Sjukhusdagarna) organized by international R3Nordic organization in Stockholm 02.06.2016.

The results confirm the the Pre-Qualification data gained from Simulated operations at Halton Laboratory.



LIFE-CYCLE VERIFICATION

NKS, LIVE OPERATION PERFORMANCE VERIFICATION

From:
Sent: den 8 december 2017 08:34
To:
Subject: CFU/m³-measurements at New Karolinska
Hospital Sweden

Hej Bengt,

Here are the results from OR NKS.

At Thorax Surgery we measured live in 4 operations
- measurements were all under 5 CFU/m³ (0,5-2,0
CFU/m³)

At Childrens Surgery we measured live in 2 operations
- measurements were all under 5 CFU/m³ (2,0 and 2,8).

The number of persons in the room were between 6-10.
Clothing System, Olefin.

More measurements will take place soon I hope. But the
indication is that with Olefin Clothing System we are
below 5 CFU/m³ - as planned.

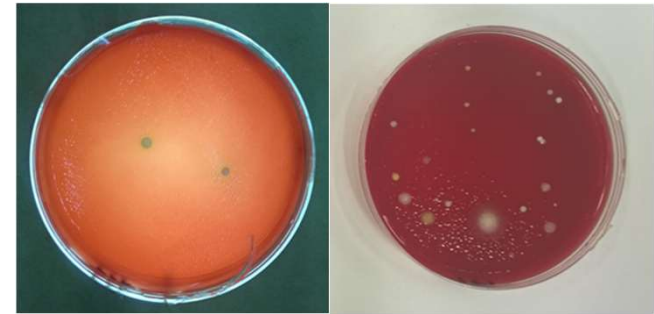
BR NN

Karolinska Universitetssjukhuset, S3:06 Solna
171 76 STOCKHOLM
Telefon: +46 700856833

MICROBIAL MEASUREMENTS IN OPERATION (LIFE-CYCLE)

Periodic Quality monitoring metric for the medical operations - rather than for ventilation

May be conducted by Hospital itself or as a 3rd party service



Limitations/ Challenges:

- The most critical areas are hard to reach during live-operation, especially the wound area
- Not representative of the worst case scenario:
 - Access to measurement (see above)
 - The loads are most often less than the maximum (e.g. # of people)



Facing Challenges of Reduction of Patient Radiation Dose, Excellent Image Quality and Air Cleanliness in a Hybrid Cardiac Catheterization Laboratory

Ludo VEREECKEN^{1*}, MSc, Kim HAGSTRÖM², DSc, Frédéric VAN
HEUVERSWYN¹, MD, Pascal DE WAEGEMAEKER¹, MSc, Pekka
KANERVA², PhD, Ismo GRÖNVALL², BSc, Sander RAMIOUL³, BSc

¹Ghent University Hospital, Ghent, Belgium, ²Halton Oy, Helsinki, Finland
(³Leuven, Belgium)



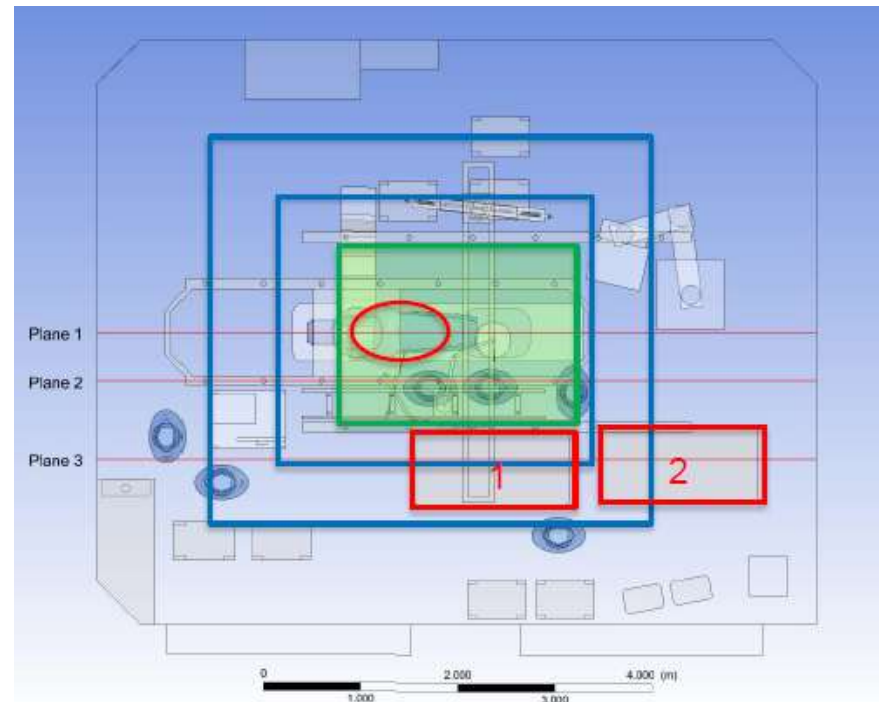
ASSUMPTIONS OF LAF NOT FULFILLED IN HYBRID OR





COMPARISON OF LAF AND HALTON VITA OR SPACE

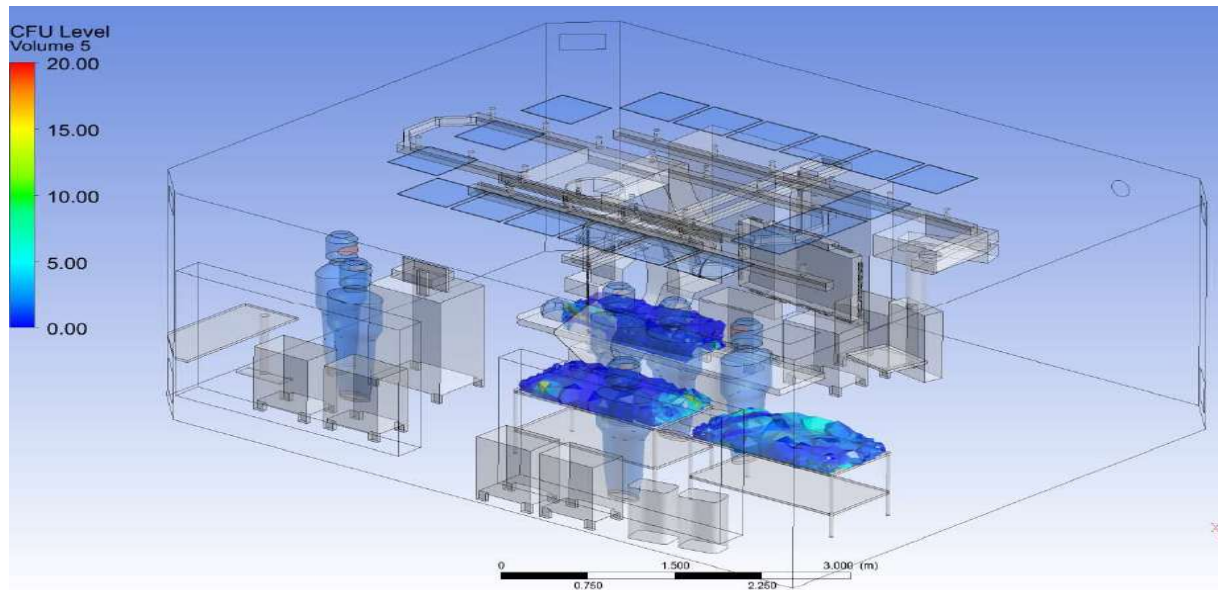
- Green rectangle LAF 1,8 x 2,4 m
- Blue Ring: nozzles in Vita solution
- Critical zones – Red Areas
 - Wound Area
 - Instrument table 1 and 2
- The LAF corresponding to the same air flow (about 5000 m³/h)





RESULTS HALTON VITA OR SPACE

- Microbial Cleanliness critical areas
- Fulfills the requirements of $< 10 \text{ CFU/m}^3$



CFU	Vita OR Space	Laminar
OR Table	<1	<1
Instr Table 1	<1	12
Instr Table 2	2	19

Hybrid OR, Specific Challenges

- Often designed for specific operations
- Installation; Integration of Imaging, Medical and Ventilation
- Influence of Installations and Operation Layout on Ventilation Performance
 - Obstruction caused by installations
 - High capacity heat sources
 - Location of Instrument tables
 - Medical personnel positions in relation to critical areas
- Some of them Large rooms and extensive # of personnel

Hybrid OR, Design Process

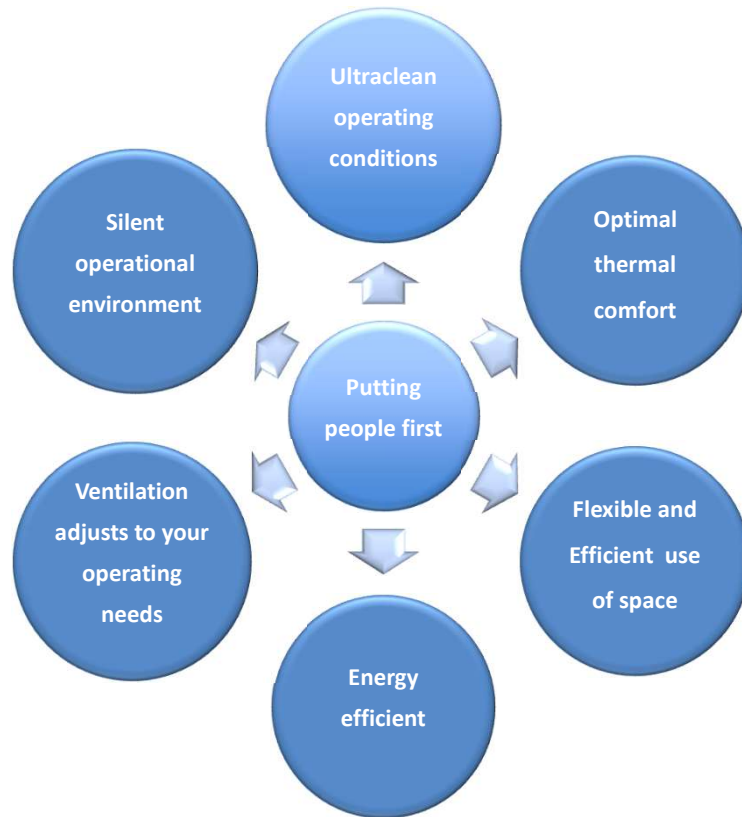
1. Data collection and design of system capacity
2. Collaborative design for optimal installation layout
3. Design optimization of Air flow pattern and adjustments using CFD
 - Air flow pattern
 - Comfort conditions
 - Optimization of cleanness in critical positions of operation and instruments
4. Implementation according to specific design and verification

HALTON VITA OR SPACE

**CONTROLLED DILUTION
CLEANLINESS IN THE WHOLE ROOM**

Halton Vita OR Space 5 for ultraclean air

Benefits:

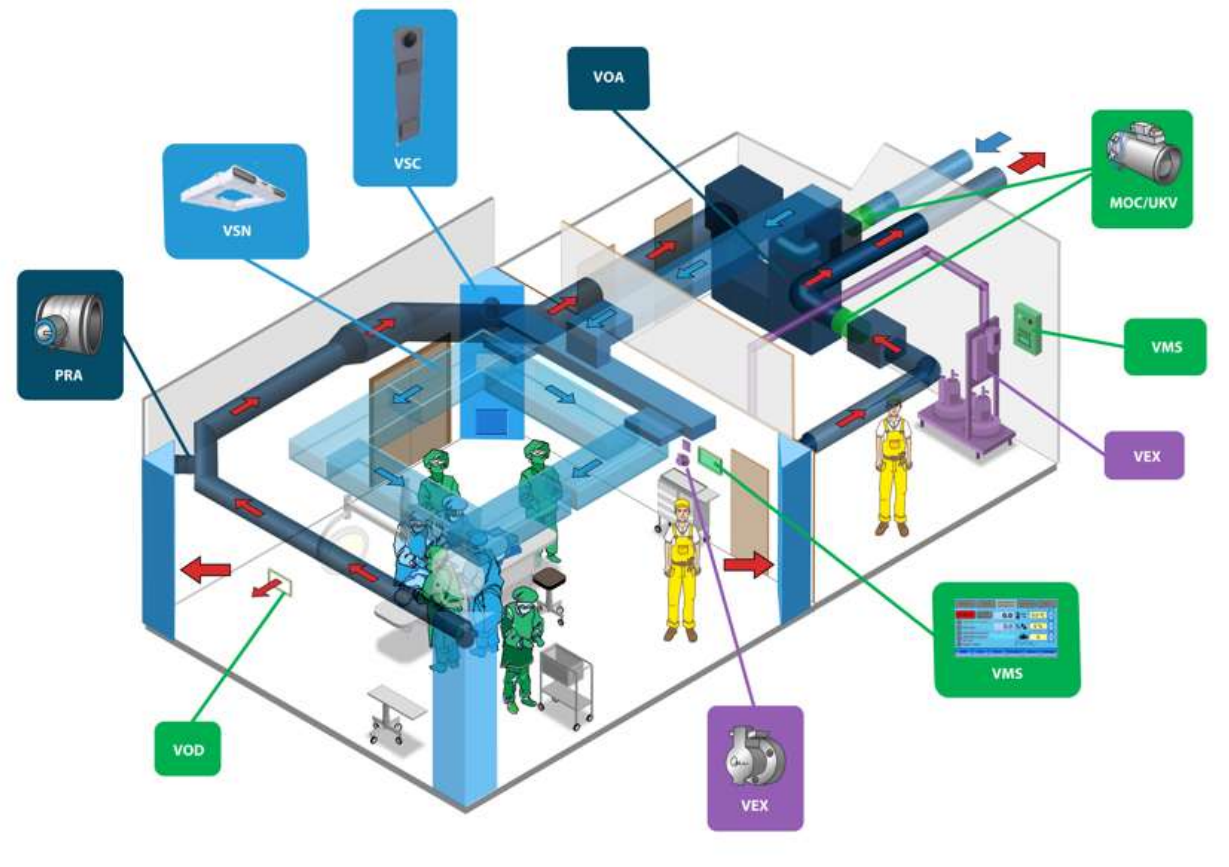


Hybrid OR, UZ Gent

Halton Vita OR Space solution Today 1/2

Halton Vita OR Space solution includes following products:

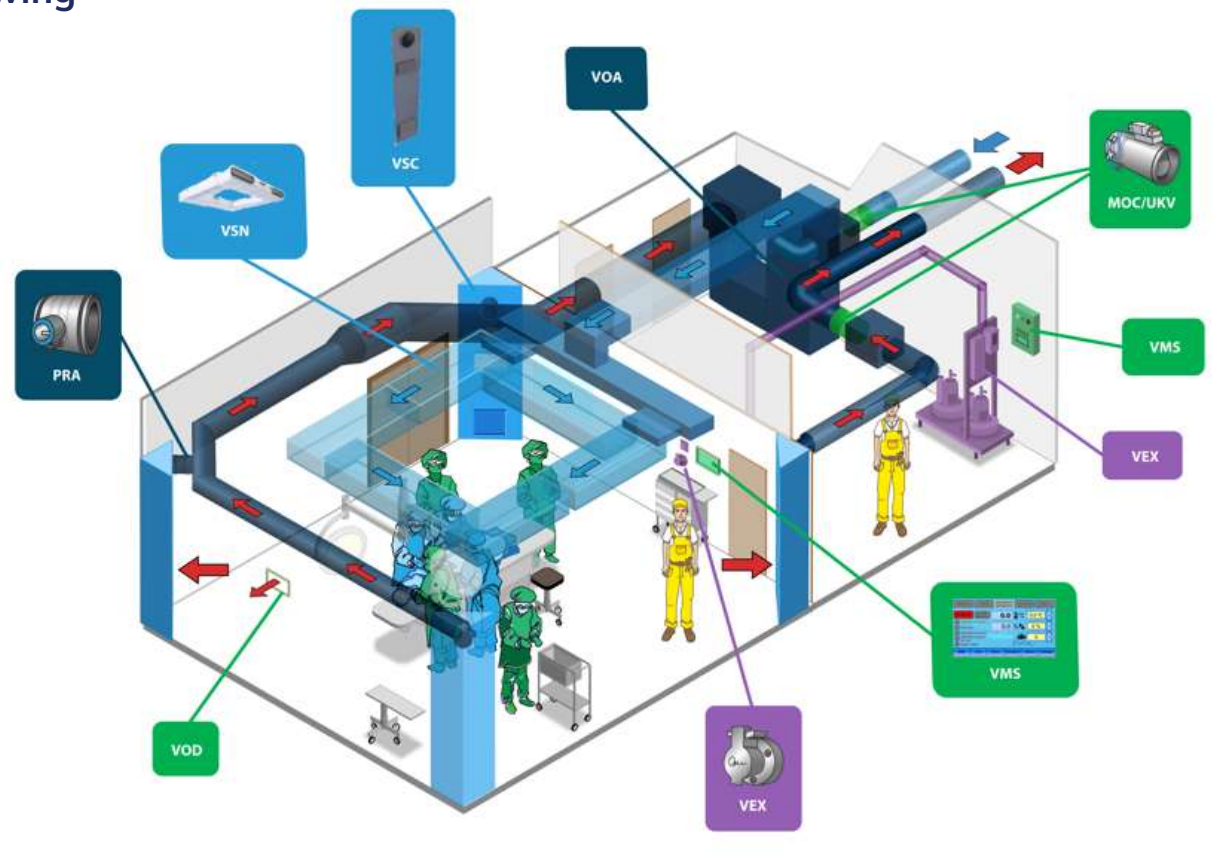
- Halton Vita VSN/VSR supply air units
- Integrated General/ Blue disinfecting Lights
- Halton Vita VSC exhaust air units
- Halton Vita VOA recirculation air handling unit
- Halton MOC/UKV VAV dampers
- Halton PRA manual dampers
- Halton Vita VOD overflow damper
- Halton Vita VMS ventilation control system
- Halton Vita VEX gas and smoke extraction solution



Halton Vita OR Space solution Today 2/2

Halton Vita OR Space solution includes following services:

- Design support
- Pre-verification
 - CFD simulations
 - Simulated operation
 - Body-Box testing
- Commissioning
 - Installation check
 - Throw pattern adjustment
 - Functional testing
- Validation measurements
 - Room air leakage
 - HEPA filters leakage test
 - Room air cleanliness test
 - Pressure measurements
 - Microbial air cleanliness test
- User training
- Life-cycle services
 - Yearly verification and validation services
- OR Upgrade contracting
 - Performance update
 - Sustainable control update



THANK YOU!