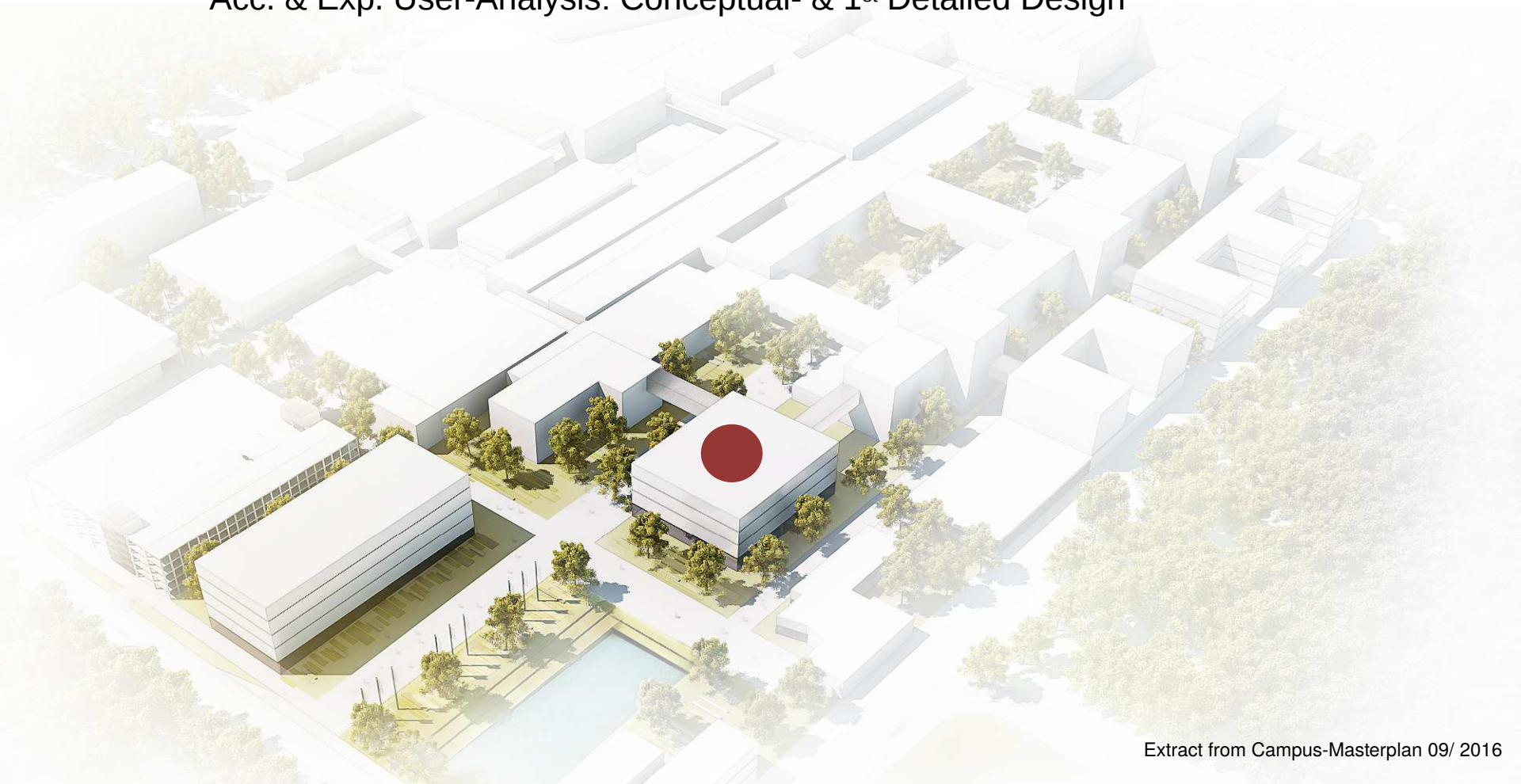
FCC – FAIR Control Centre

Acc. & Exp. User-Analysis: Conceptual- & 1st Detailed Design



Extract from Campus-Masterplan 09/ 2016

Ralph J. Steinhagen for the FC²WG & FCC-WG, based on previous work and input from: Ch. Arzinger-Mayer, R. Bär (CSCO), K. Berkl, A. Bloch-Späth, A. Fischer, H. Kollmus, I. Lehmann, J. Lindenberg, C. Omet, D. Ondreka, S. Reimann (deputy, OP-GL), U. Scheeler, C. Schröder, P. Schütt, M. Schwickert, P. Spiller (SIS100/SIS18), G. Stephan (CE), D. Severin (Exp.-Coordinator), K.-H. Trumm, R. Vincelli (CSCO-IN), M. Vossberg, Operators, and informal discussions within the accelerator and experiment communities.

special thanks: R. Giachino, M. Lamont, D. Manglunki, R. Steerenberg (CERN)

FAIR Control Centre
Primary Goals

A) provide sufficient room for the operation of the existing and enlarged GSI/FAIR facility

B) Ergonomics: Main Control Room should not “get in the way of it’s primary function”: support of operators, accelerator experts, and accelerator-kin experiments during commissioning, operation, and further exploitation of the facility, notably a human-centred-design to

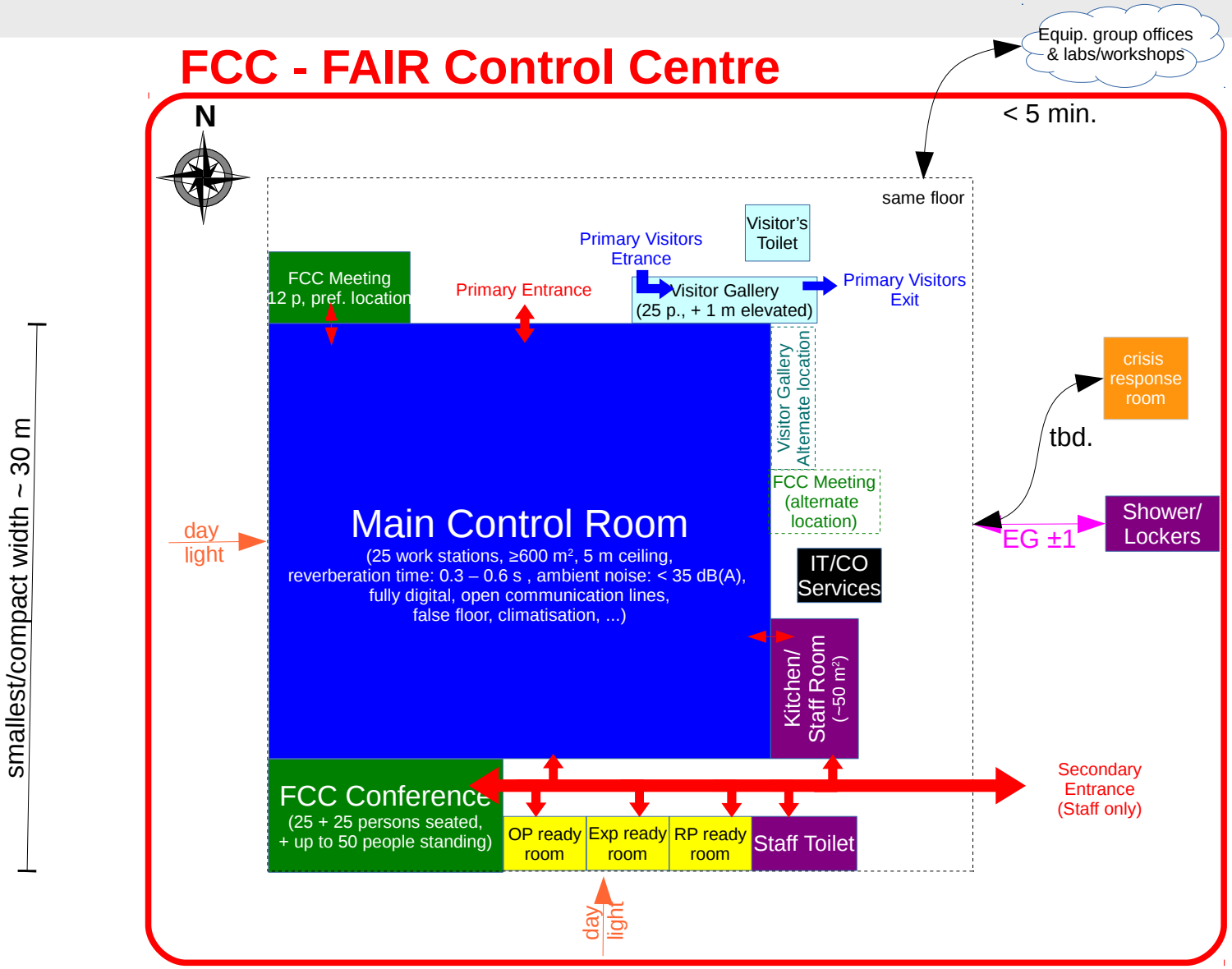
- provide sufficient workstations and spaces for routine and peak operational periods
- provide comprehensive status visualisation and control of the facility and individual accelerators, without unnecessarily straining operation crews (→ ‘minimisation of wastes’)
- follow best practises to optimise efficiency, minimise overhead and error sources w.r.t. daily operation, interactions and communication between OP, accelerator experts, and equipment groups (→ ‘poka yoke’)

C) Secondary:

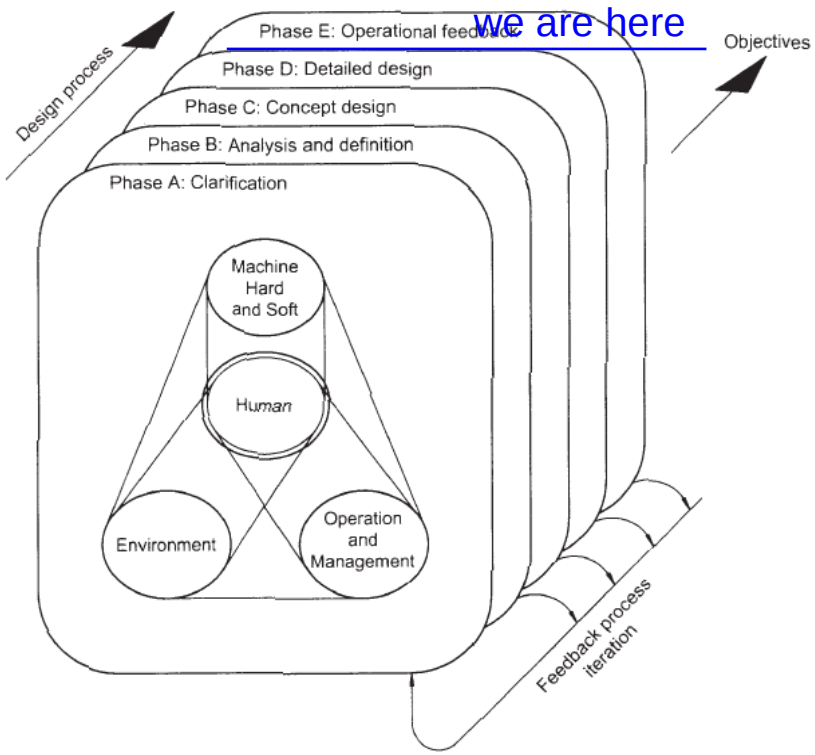
- Representation: design should reflect (to a healthy amount) the level of excellence put into the design of FAIR’s accelerator- and experimental infrastructure
- should provide additional badly needed space for experiment operation, meeting & conference rooms, as well as offices

FCC ... more than a 'Main Control-Room'

additional required facilities



FAIR Control Centre
‘Human/Operator Centred Design’



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FAIR	**Detailed Specification**	Template Number: Q-FO-QM-0005	Page 1 of 22

Document Title:	**Detailed Specification for the FAIR Control Centre in view of Commissioning, Operation, and operational Exploitation of the FAIR Accelerator Facility**
Description:	Functional requirements, ergonomics, and detailed design of the FAIR Control Centre (FCC) covering: FCC Main Control Room (MCR), MCR-related meeting and conference rooms, visitor’s gallery, and ancillary infrastructure.
Division/Organization:	FAIR/GSI
Field of application:	FAIR Project, existing GSI accelerator facility
Version	V 0.1

Abstract

This document describes the user-level functional requirements, ergonomics considerations, and derived detailed design of the FAIR Control Centre (FCC) from an accelerator commissioning, operation, and operational exploitation point of view, including experiments that are tightly intertwined with accelerator operation. This specification builds upon best practises and operational experiences with similar, existing accelerator infrastructures at GSI, CERN and other large international laboratories, and summarises the present user-community understanding, discussions and ergonomics in view of the future operation of FAIR. This document extends, combines, and supersedes previous FAIR specifications F-DS-C-21e and F-DS-C-22e.

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Based on DIN EN ISO 11064: “Ergonomic design of control centres”
and similar CERN Control Centre (CCC) and external (petro-chemical) industry experiences

Fixed-Display & Workstation Layout

tentative distribution of ~25 consoles...

Proposed BPC-Paradigm Sceme:

- 12 – Skeleton-crew (24h/7 OP)
  - 6 parallel BPCs/operators
  - 3 – Cryogenics (non-multiplexed)
  - 3 – Technical Infrastructure (non-m.)
- 5 – Island/Bay #1 – *reconfigurable usage*
  - storage ring/accelerator-kin experiments
  - machine developments
  - Hardware (HWC) &
    Beam (Re-)Commissioning (BC)
- 5 – Island/Bay #2 – *reconfigurable usage*

Classic scheme (deprecated):

- 5 – primary beam accelerators (UNILAC → SIS18 → SIS100)
- 3 – ESR, CRYRING, CR
- 2 – HESR
- 2 – SuperFRS
- 3 – Cryogenics
- 3 – Technical Infrastructure
- 5 – accelerator-kin experiments
- 2 – generic short-term debugging consoles (+ shift leaders)

Simple reference/comparison with existing GSI Main-Control-Room:

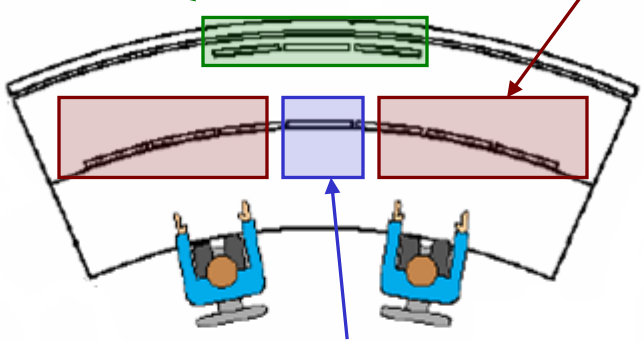
- 330 m^2 & ~ 12 consoles (work-stations) for the operation of 3 accelerators
  (N.B. includes Storage-Ring experiments &accelerator-kin experiments are performed from neighbouring counting rooms)
- Future: move from 3 → 9 acclerators + more experiments

Workstation Layout
CERN reference concept

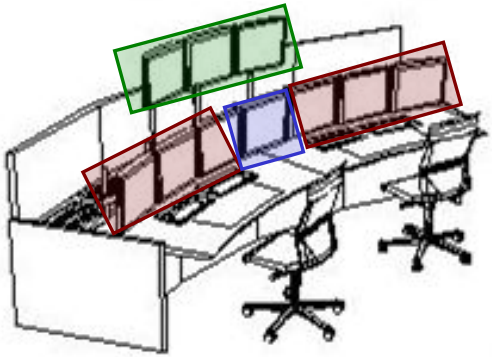
3 fixed displays split between 2 workspaces

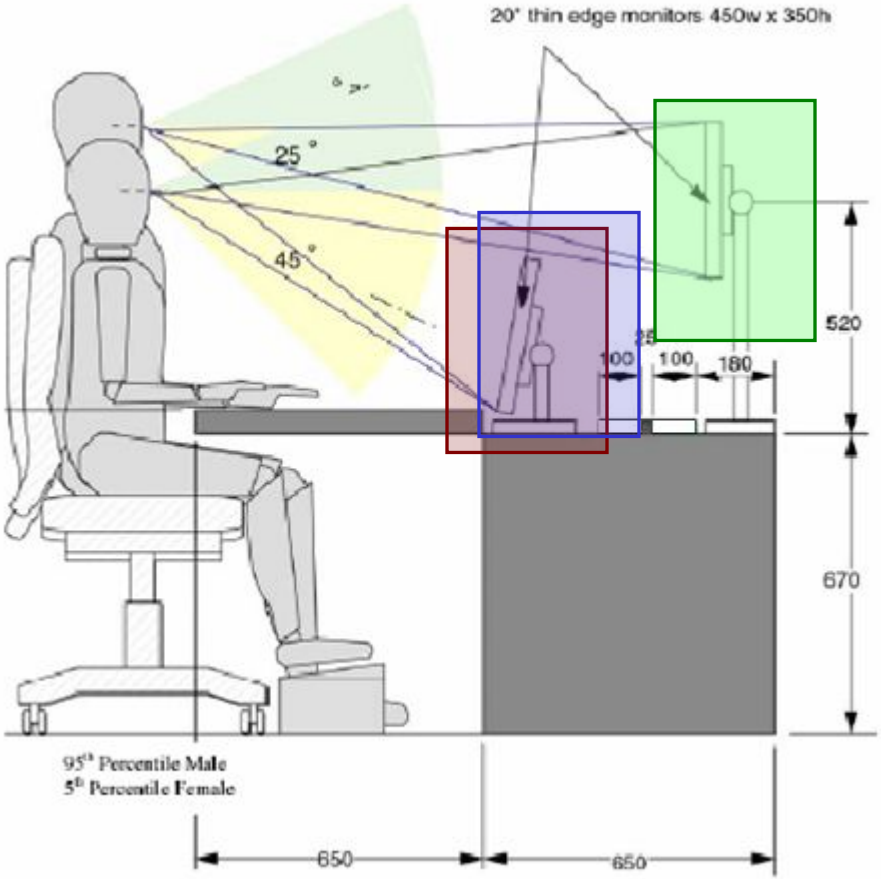
CERN experience→ FAIR:
independent fixed displays for each workspace

3 flat screens per workspace
1 keyboard 1 mouse



1 additional admin PC

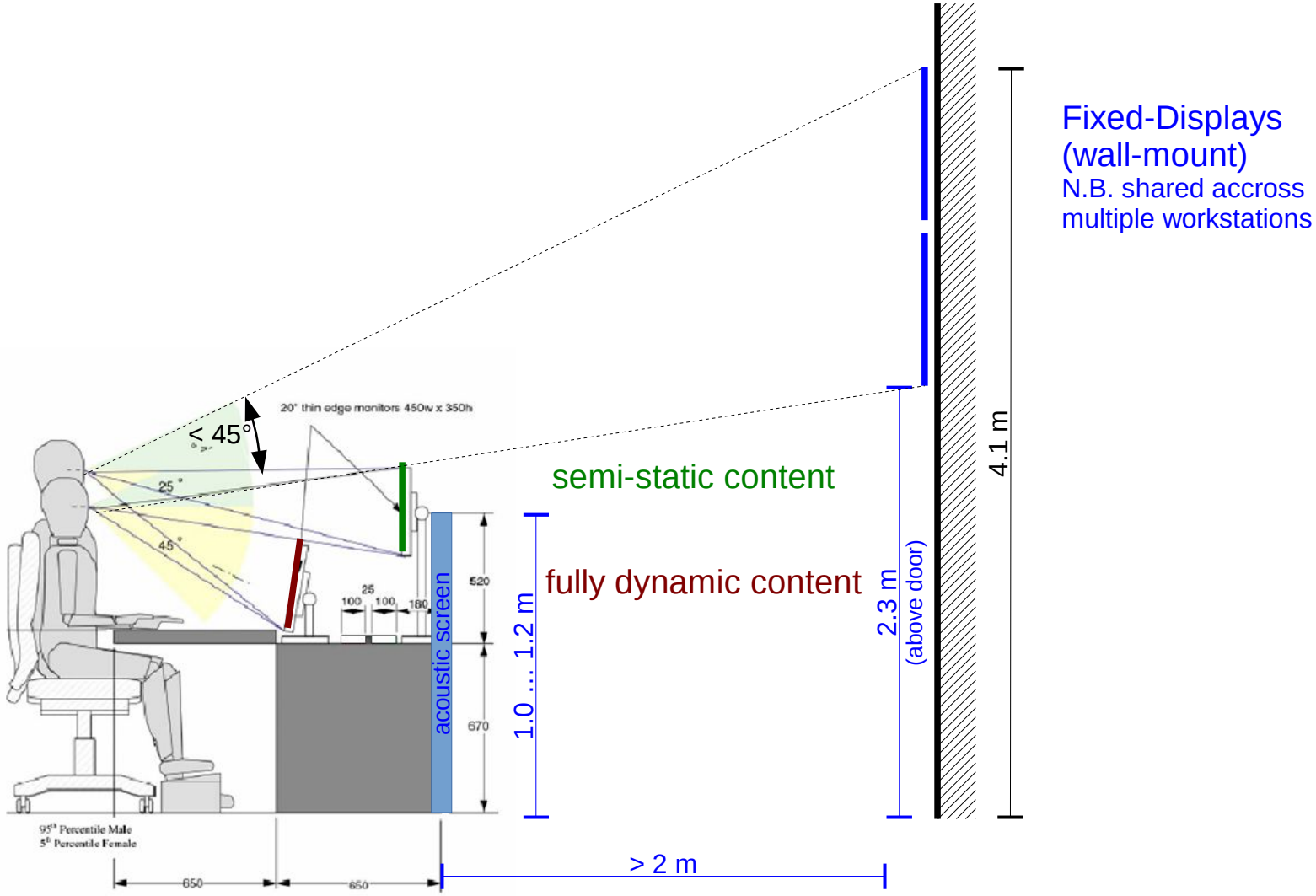




Courtesy D. Manglunki (CERN)

FCC Fixed-Display & Workstation Layout

FCC reference concept



FCC Fixed-Display & Workstation Layout

Future HW Technology to be watched ...

Technology option:
Transparent OLED display for semi-static content (second row of monitors) ???

- Improves more direct communication
- Back-to-Back sharing of relevant contexts
- Good for visitor concept
- costs, presently: ~1500 EUR vs. 600 EUR (expected to decrease in coming years)

Technology option:
LED Signage Displays (wall-mount fixed-displays) ???

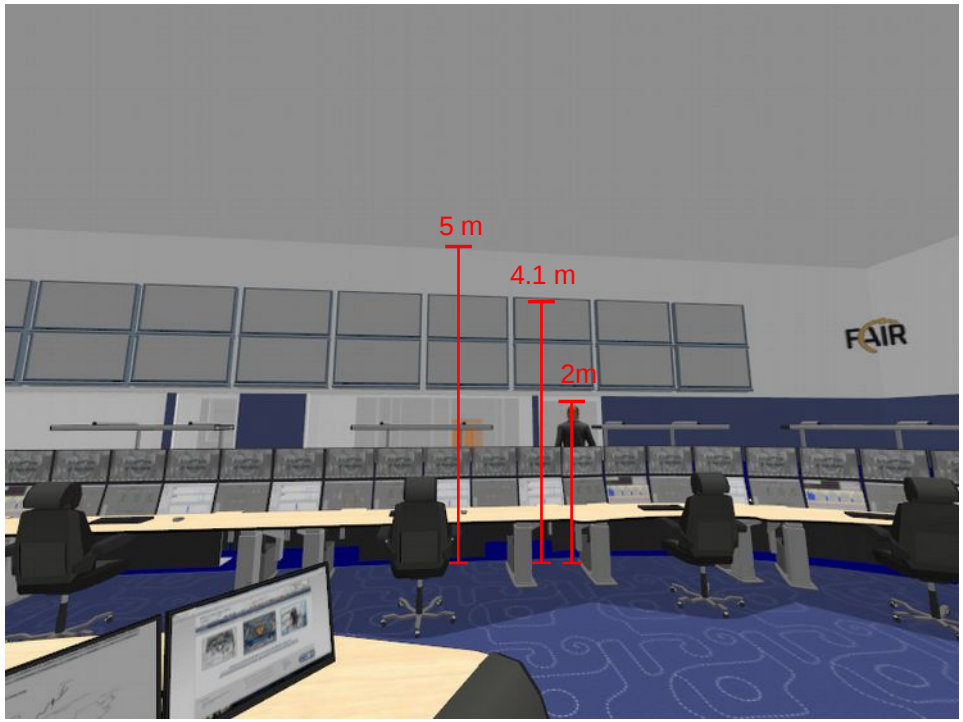
- Better wall surface usage & design
- Designed for 24h/7 usage (most monitors aren't)
- first cost indication: ~ neutral over 10 yrs (N.B. service contract)
- new technology → less experience

image material courtesy Samsung

FCC Main Control Room Height
5 m ceilling height

5m ceilling height required for:

- Minimisation of parking garage (low-ceilling) effect (aka. Human-Factors-Engineering or 'Ergonomics')
- Ventilation – minimise of air speed/draft
- Acoustics: higher volume → lower sound pressure/less standing wave issues ($p \sim 1/r^2$)
- Indirect lighting concept → minimisation of glare effects on monitors
- Shared wall fixed-display concept



Lower ceilling heights not advisable on technical and acc. operation ground. Also: '5 m' identical to existing MCR and compatible to 'GSI Level 0' ceilling heights.

FCC Main Control Room
Light & Privacy Requirements

- compliant with national regulations
  - brightness: 500 lux on work surfaces, up to 1000 lux fully dimmable (N.B. also compensation for aging of LED lights)
  - experiences at CERN/GSI: no direct spot light (↔ reflections on screen)
- at least 6 independently controllable sectors in FCC MCR
- Proposal of usage of Smart Glass (easier maintenance/better reliability):
  - inside windows (meeting/conference rooms/visitor‘s gallery): transparent → milky
  - outside windows: controllable transmission (replaces blinds)
- For illustration purposes only (many different vendors available):

image material courtesy InvisiShade

FCC Primary-User Concept
Main Control Room

Primary Goals:
- establish functional relationships between MCR & ancillary rooms
- validate/check w.r.t. FAIR Commissioning & Control concept
- validate/check whether input for building planner is feasible and consistend with DIN/ISO norms

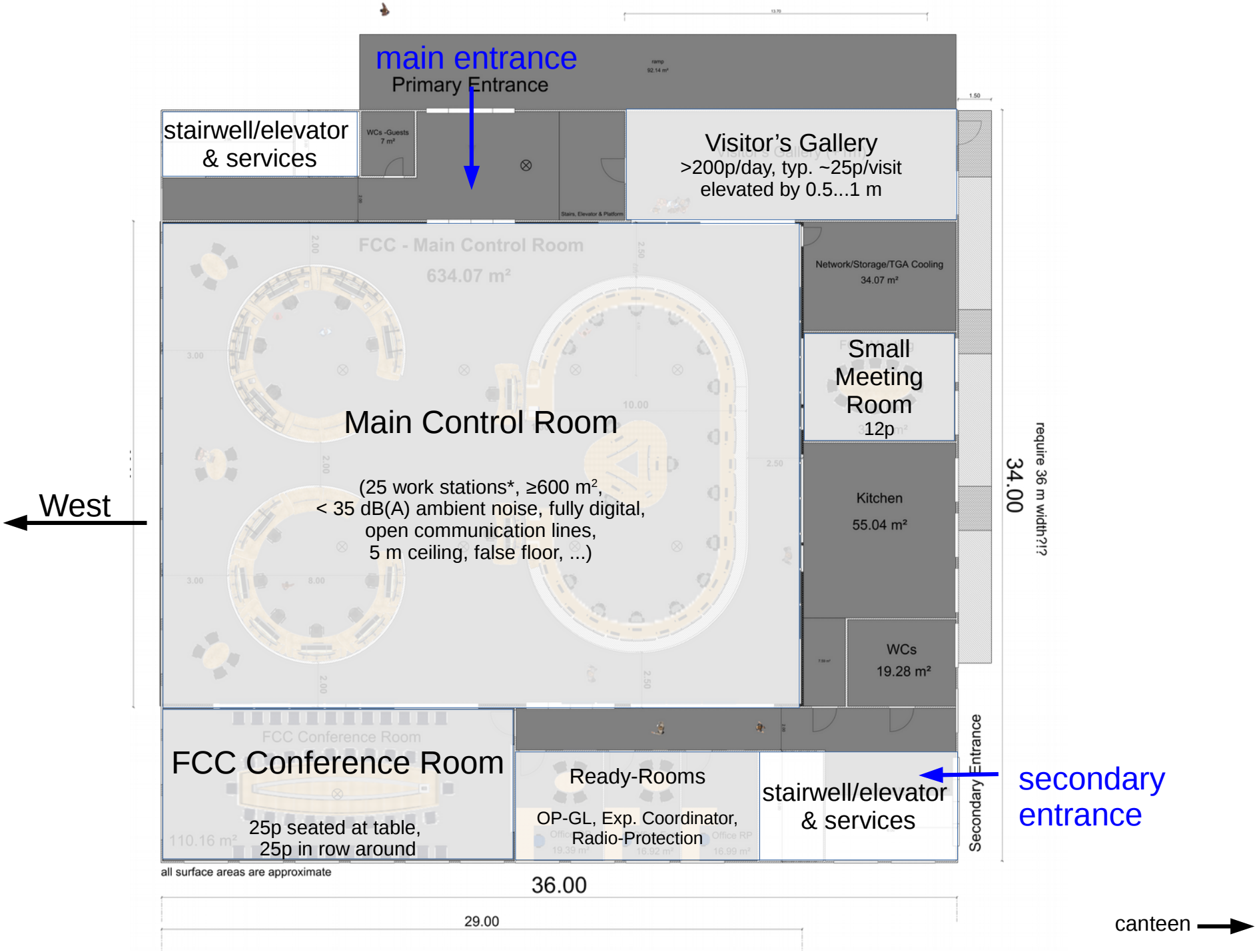
N.B. surface numbers are approximate and may change due to civil construction constraints

Outer hull measurements, colour, design, etc. may change

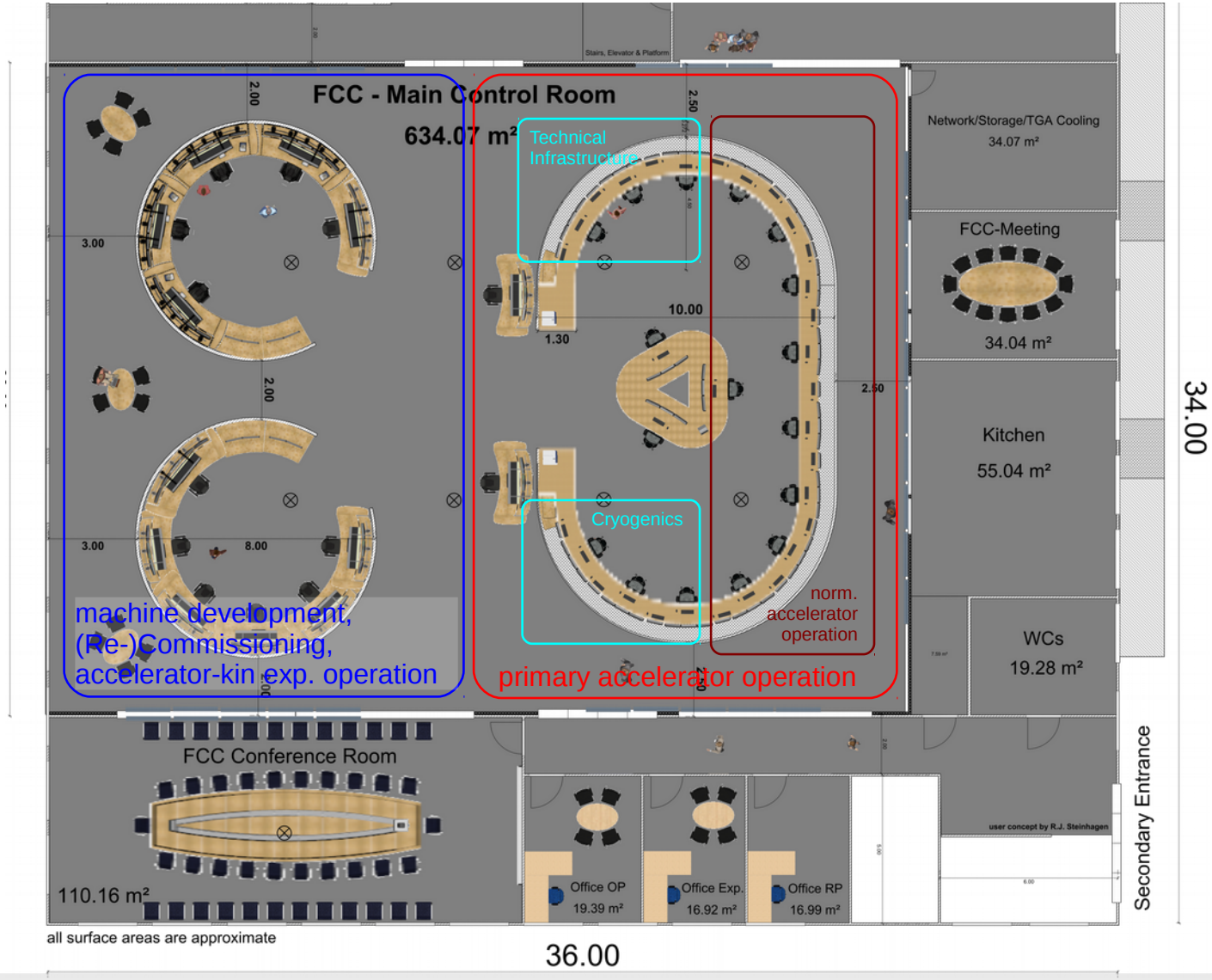
…

Lower floor: showers, changing rooms, lockers, CSCO-IN infrastructure, building infrastructure, ...

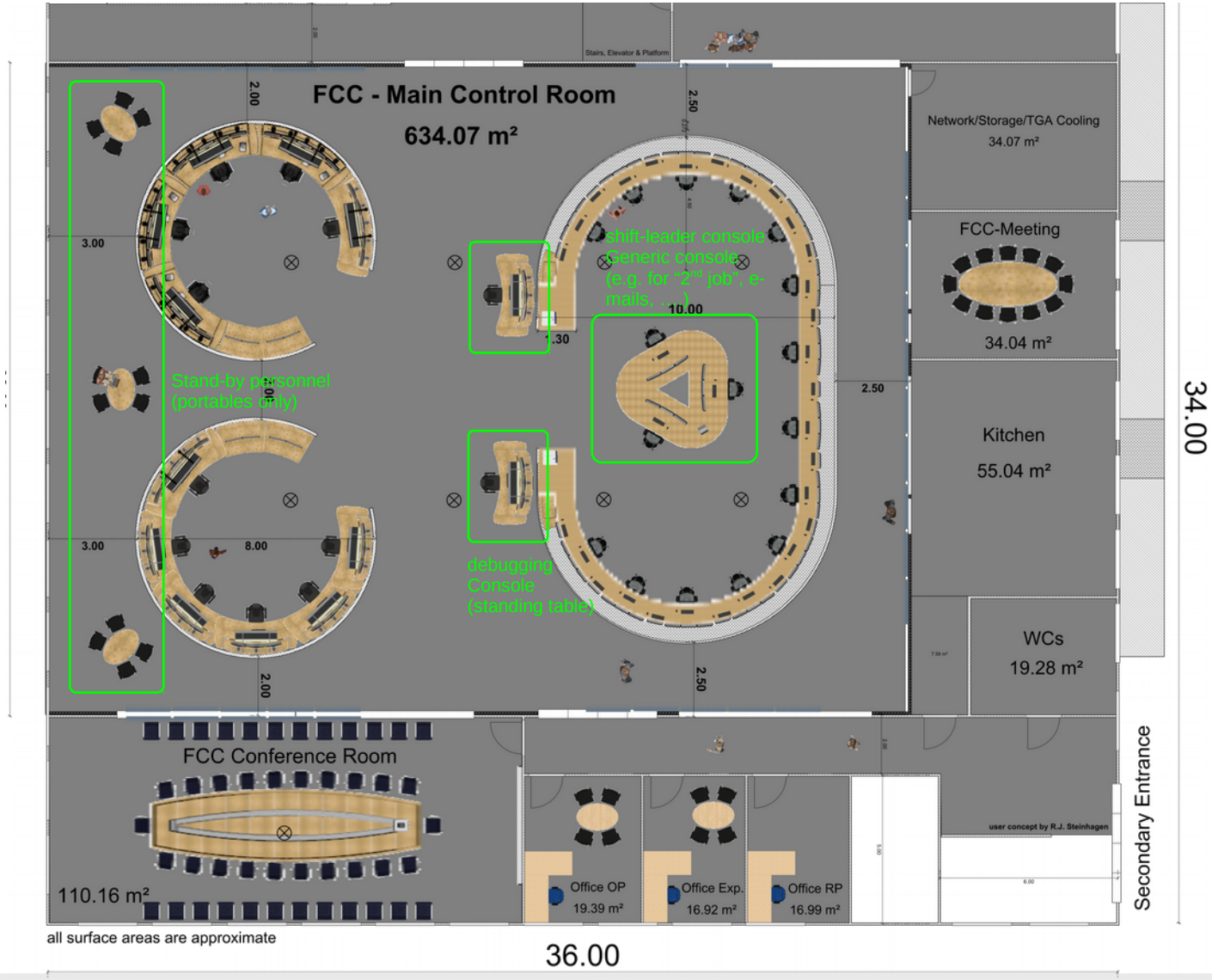
R. J. Steinhagen


main entrance
Primary Entrance
stairwell/elevator & services
WCs -Guests 7 m²
Visitor's Gallery
>200p/day, typ. ~25p/visit
elevated by 0.5...1 m
FCC - Main Control Room
634.07 m²
Network/Storage/TGA Cooling
34.07 m²
Small Meeting Room
12p
Main Control Room
(25 work stations*, ≥600 m²,
< 35 dB(A) ambient noise, fully digital,
open communication lines,
5 m ceiling, false floor, ...)
Kitchen
55.04 m²
WCs
19.28 m²
West
34.00
require 36 m width?!?
FCC Conference Room
FCC Conference Room
25p seated at table,
25p in row around
110.16 m²
Ready-Rooms
OP-GL, Exp. Coordinator,
Radio-Protection
stairwell/elevator & services
Secondary Entrance
secondary entrance
all surface areas are approximate
36.00
29.00
canteen

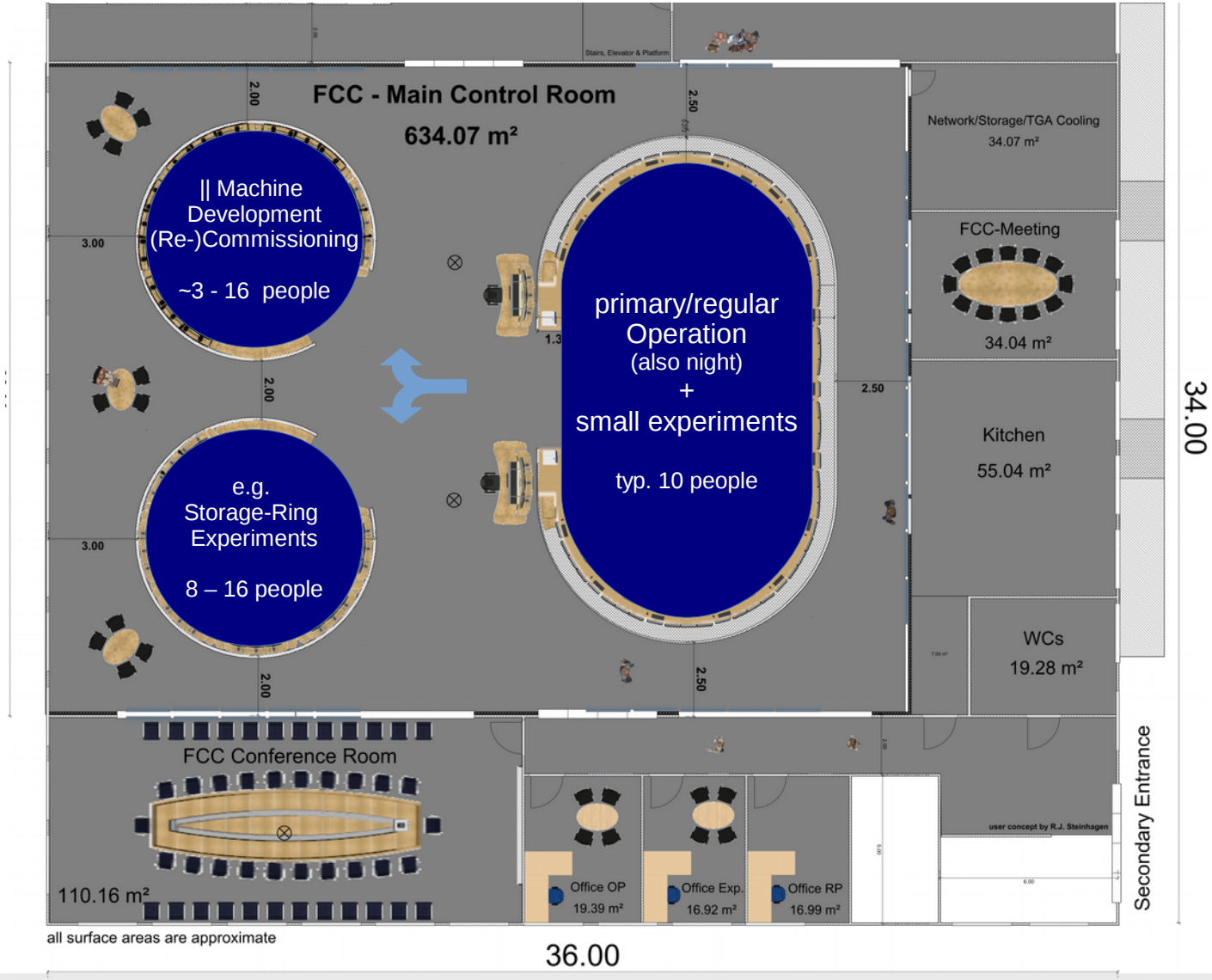
FCC Primary-User Concept
Main Control Room – Functional Organisation



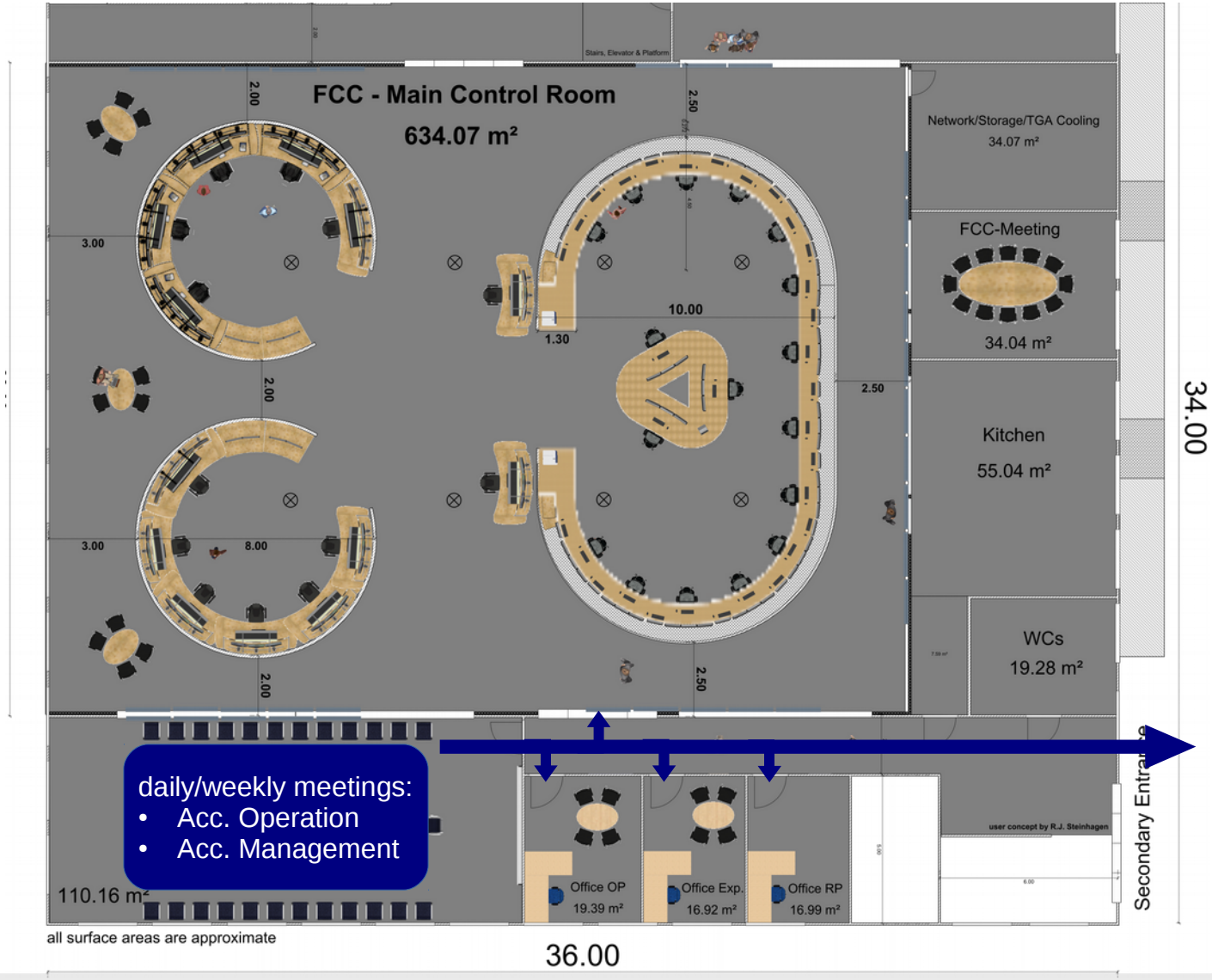
FCC Primary-User Concept
Main Control Room – Functional Organisation



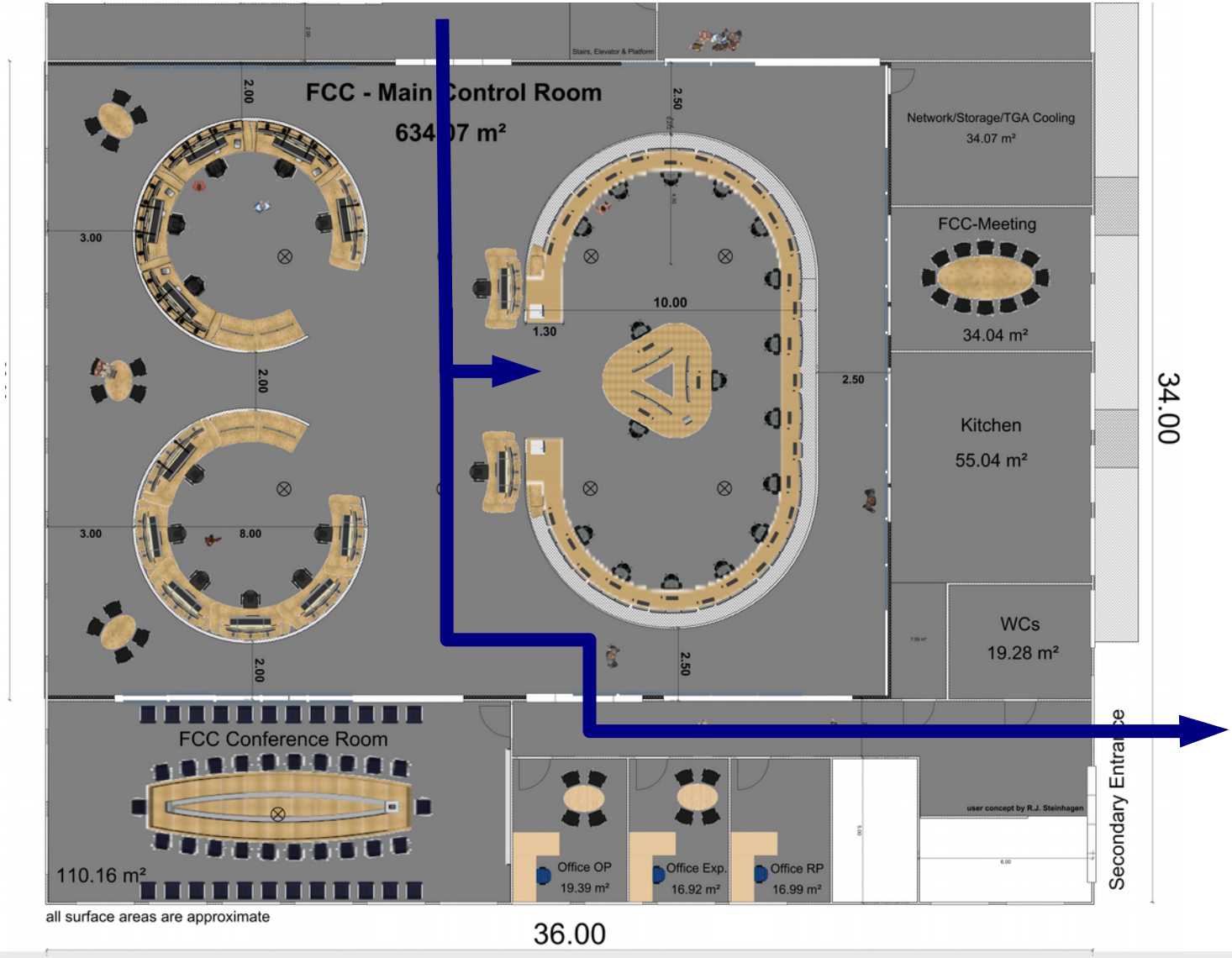
FCC Primary-User Concept
Main Control Room – Functional Organisation



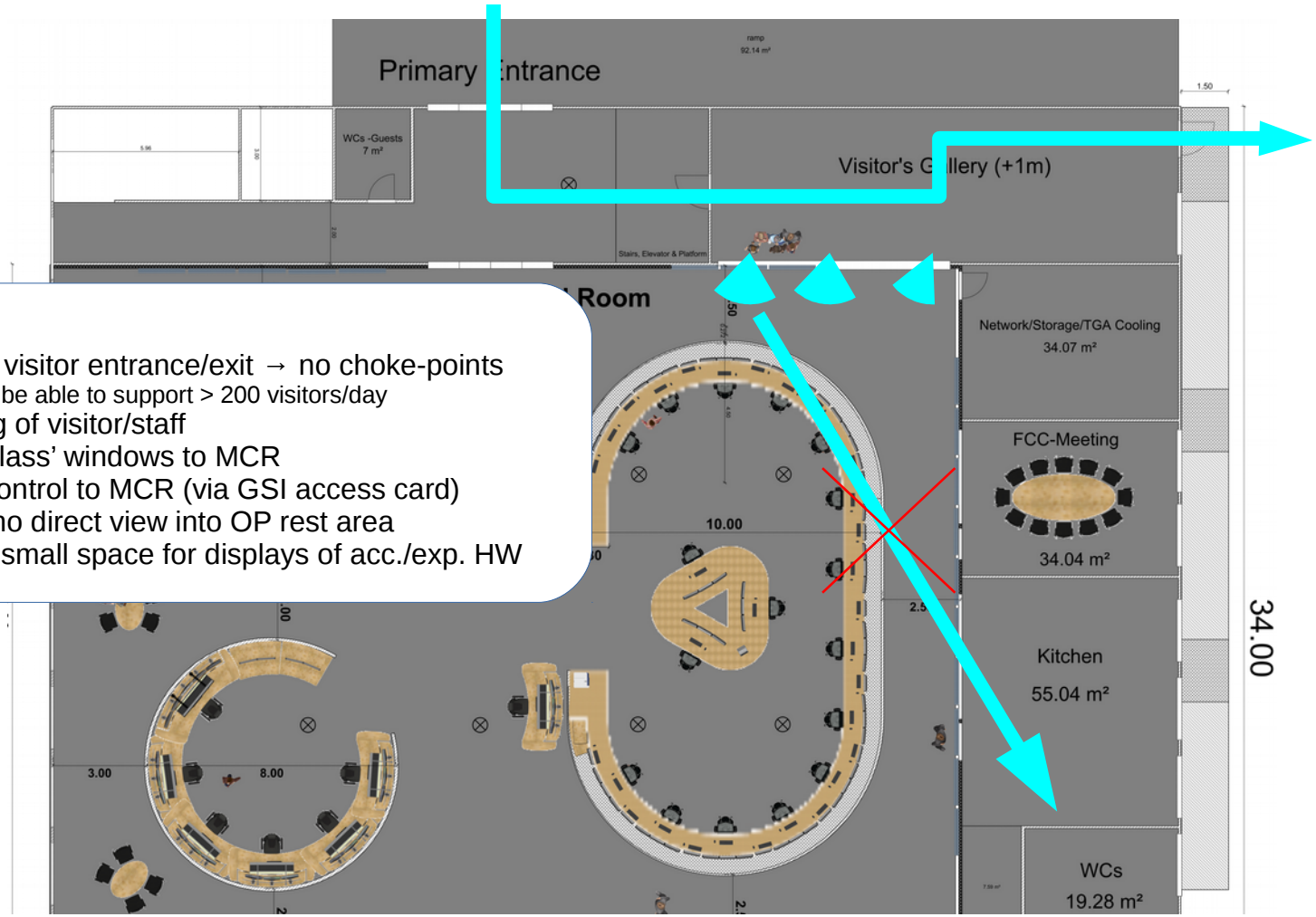
FCC Primary-User Concept
Conference Room Organisation



FCC Primary-User Concept
Main Control Room – Morning Route



FCC Primary-User Concept
Main Control Room – Visitors' Route

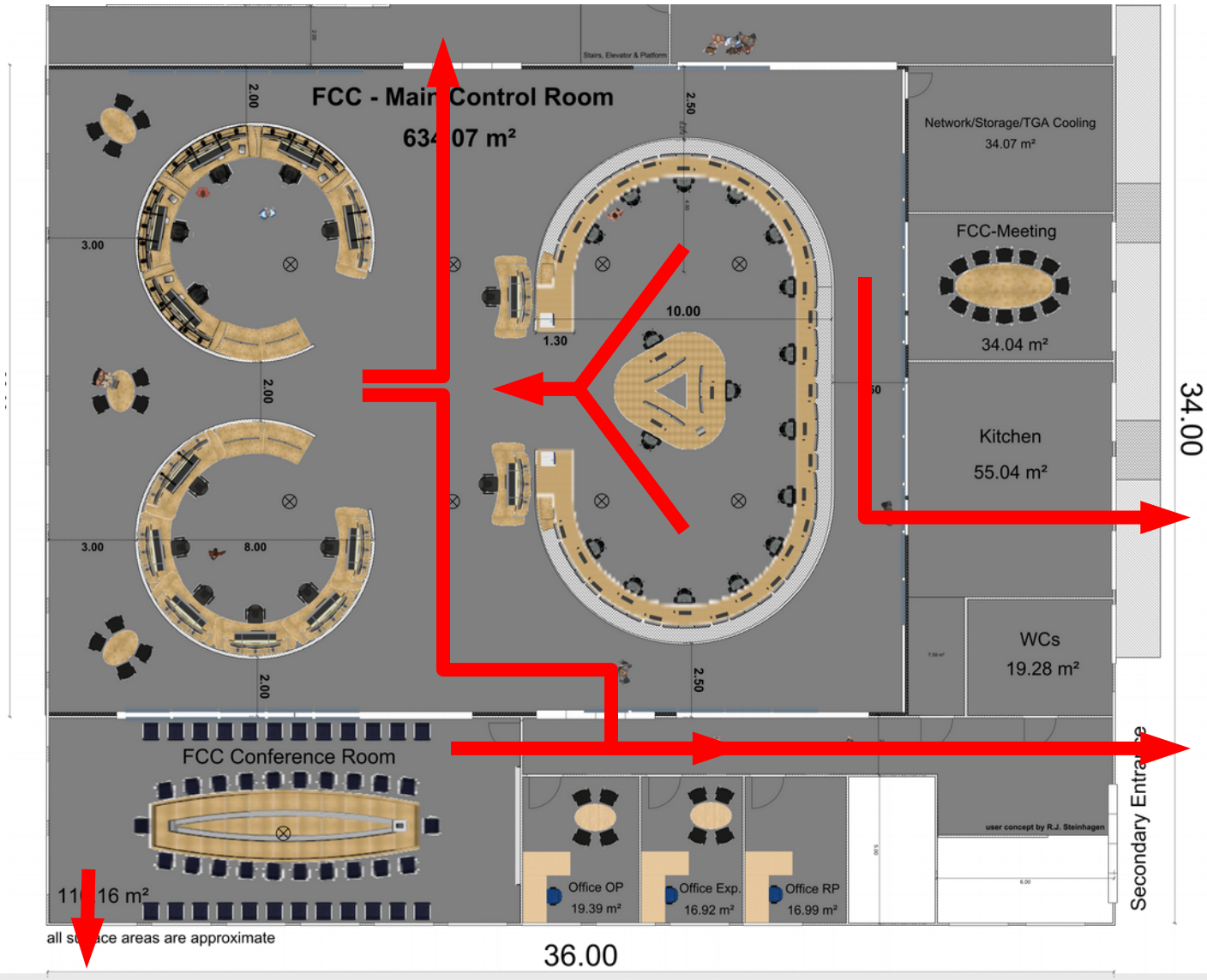


to note:

- separate visitor entrance/exit → no choke-points
  - should be able to support > 200 visitors/day
- no mixing of visitor/staff
- 'Smart-Glass' windows to MCR
- access control to MCR (via GSI access card)
- privacy: no direct view into OP rest area
- optional: small space for displays of acc./exp. HW

FCC Primary-User Concept

Main Control Room – Possible Evacuation Routes

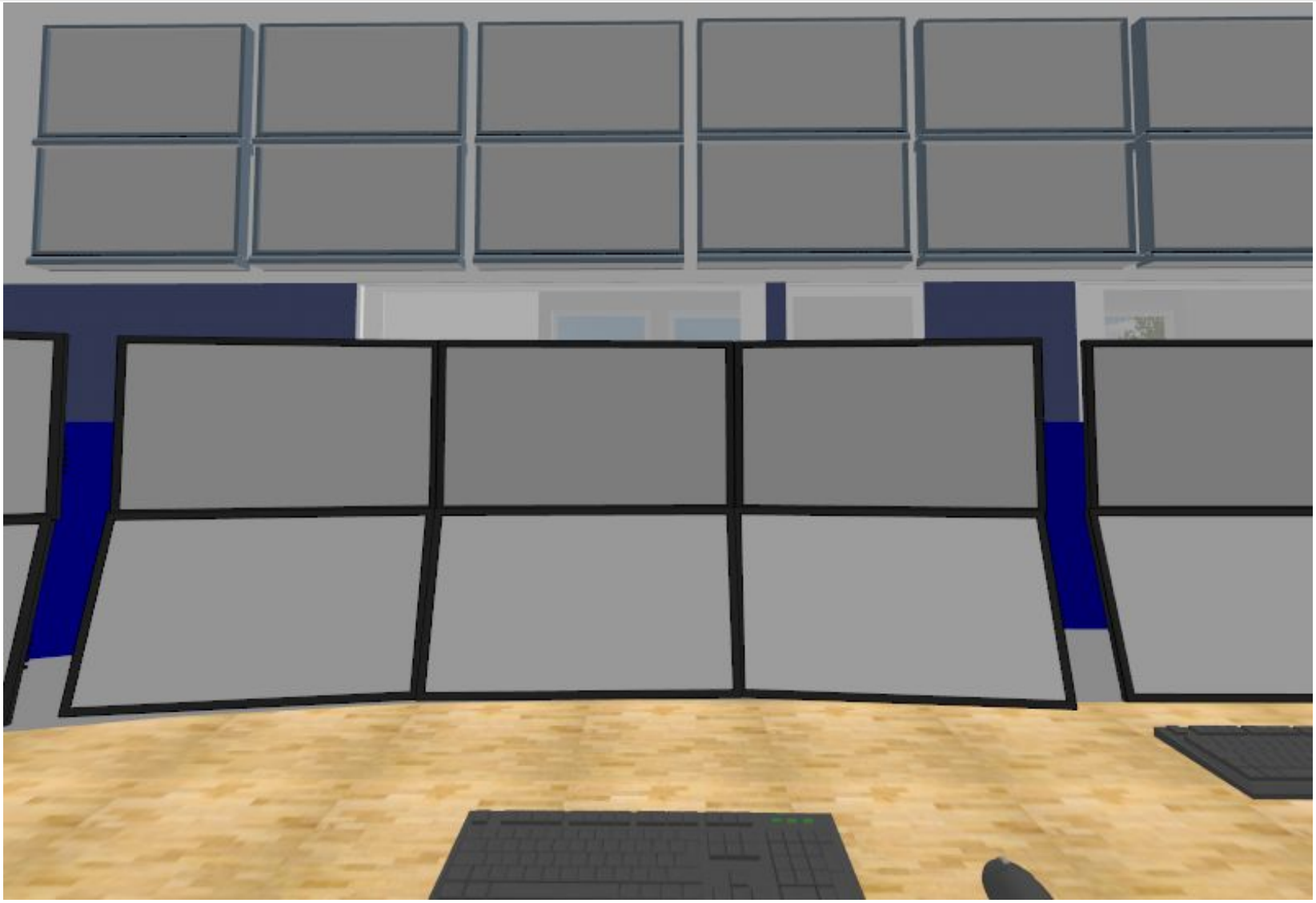


FCC Primary-User Concept

Main Control Room – Interior View (100° view angle)

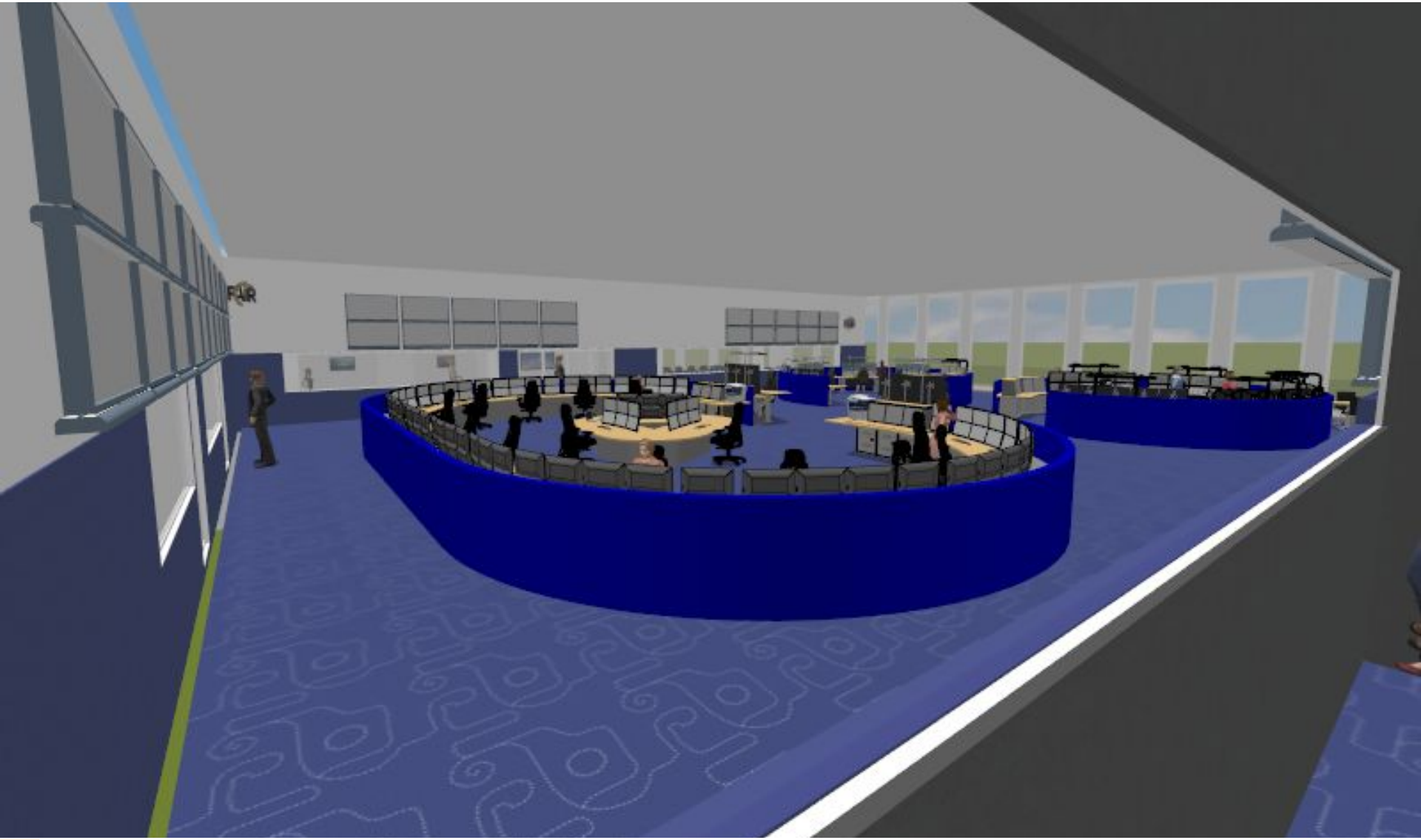
FCC Primary-User Concept

Worstation View (100° horizontal view angle)



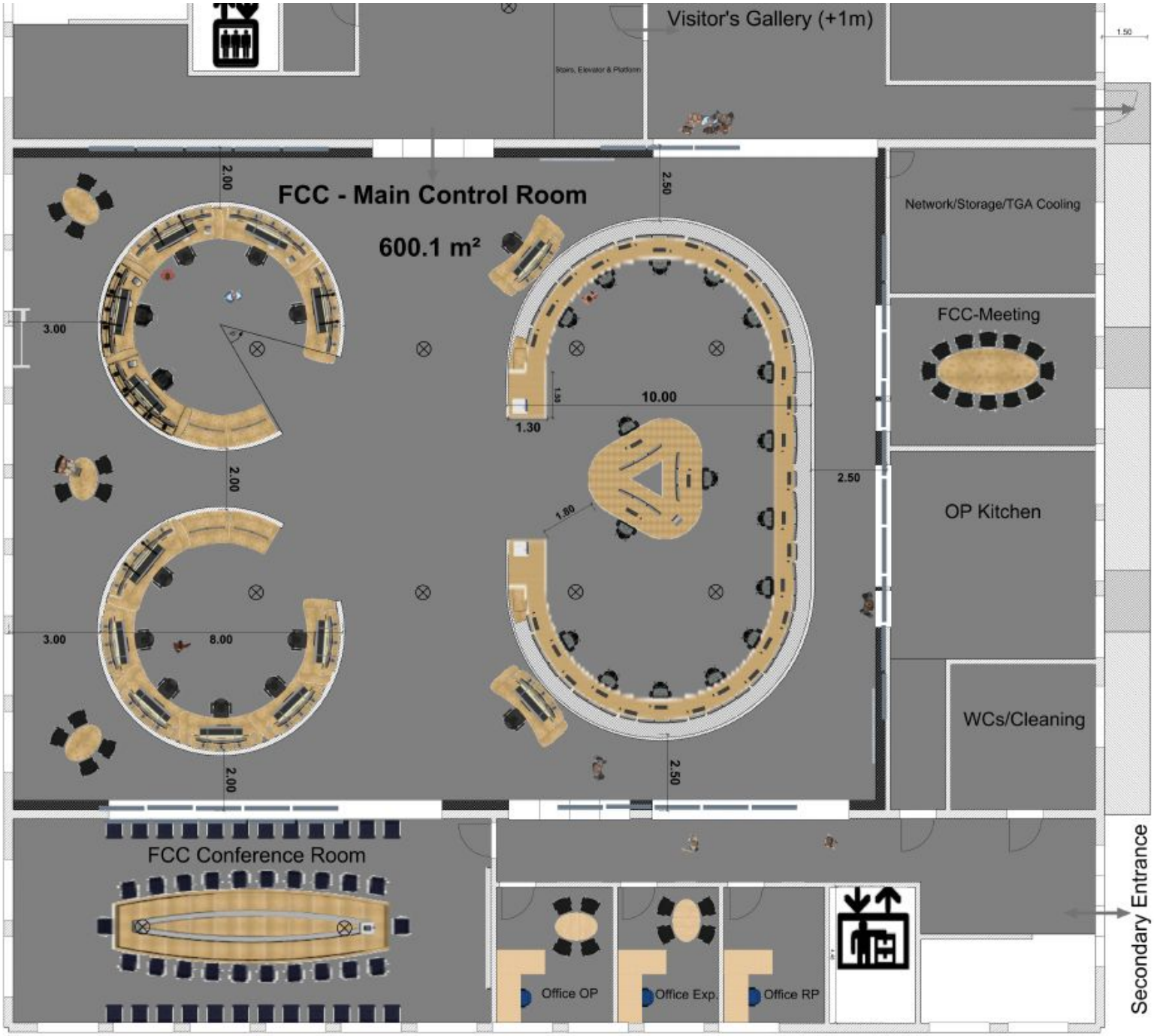
FCC Primary-User Concept
Main Control Room – Visitor View #1

FCC Primary-User Concept
Main Control Room – Visitor View #2



FCC Primary-User Concept

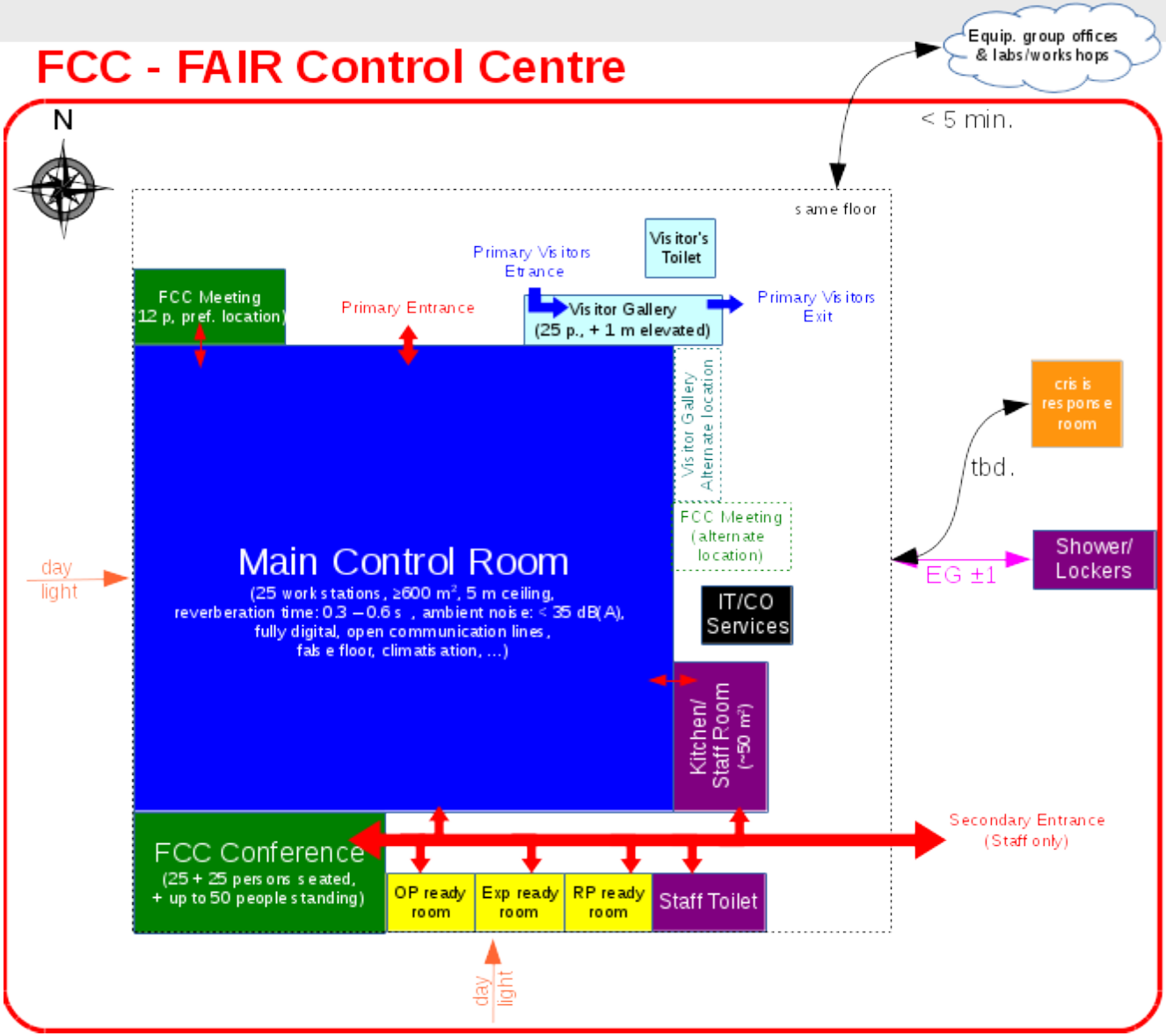
Conference Room (aka. Beschleunigerbesprechungszimmer)



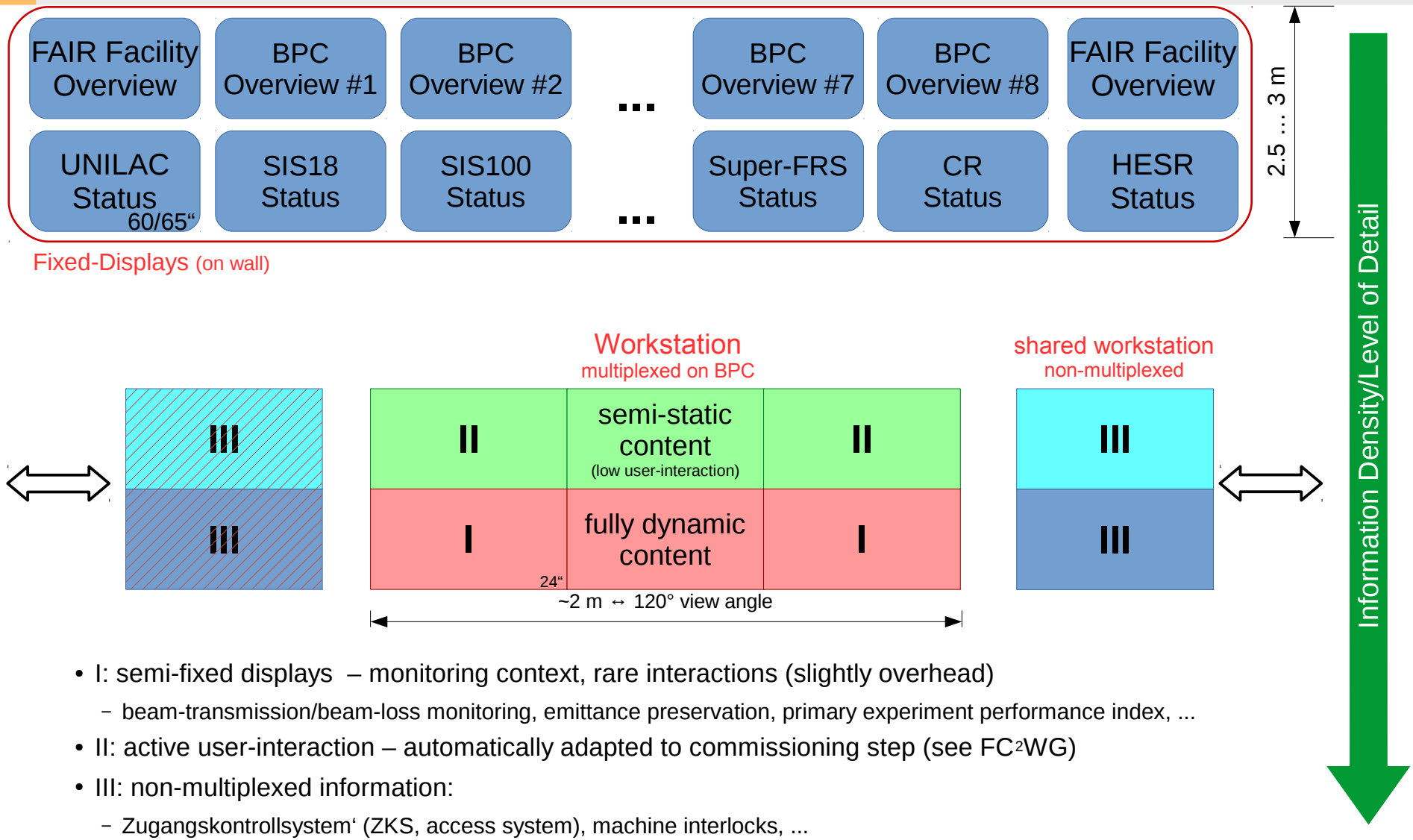
all surface areas are approximate

Appendix

FCC ... more than a 'Main Control-Room'
additional required facilities

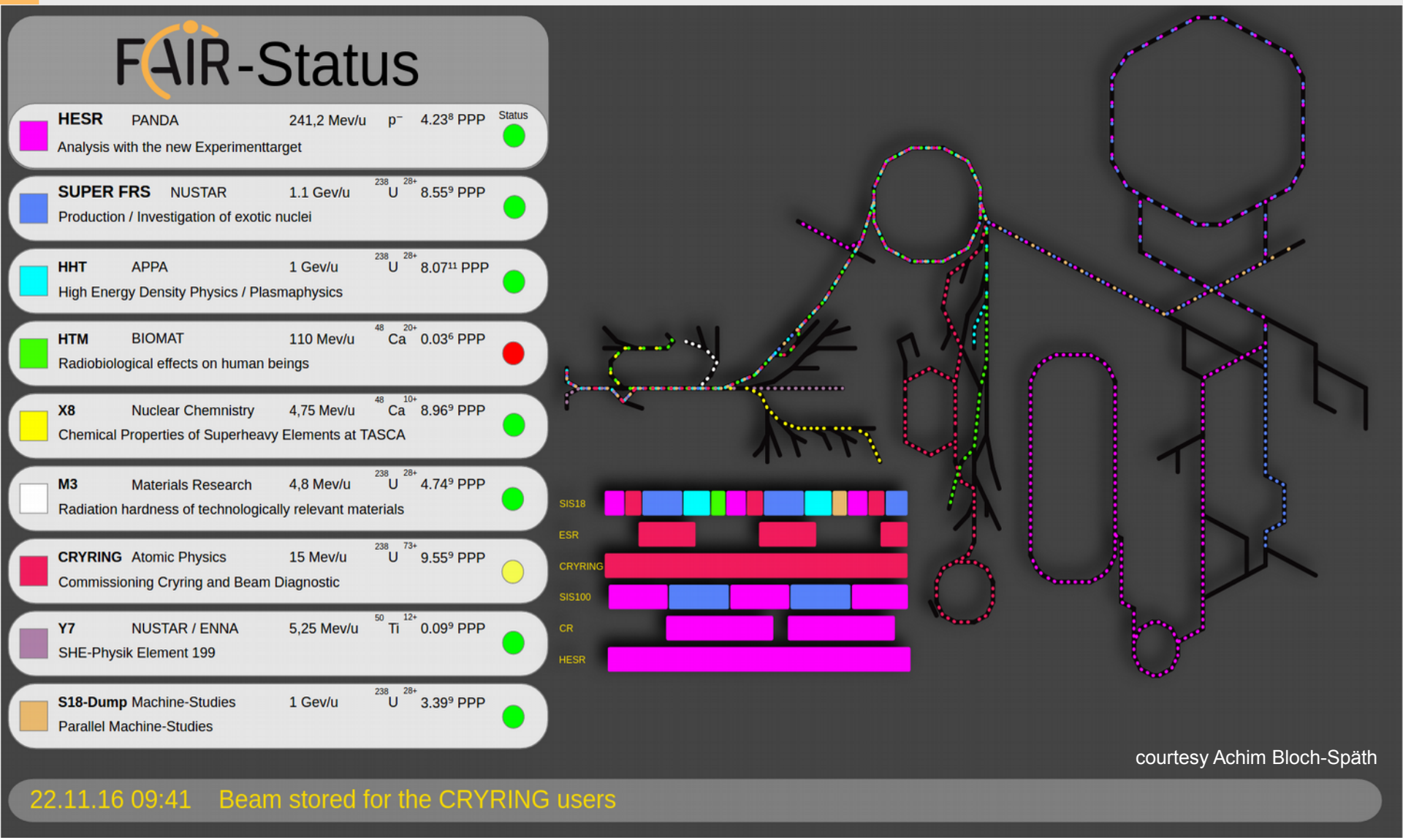


FCC Fixed-Display & Workstation Layout
Information Density Hierarchy



- I: semi-fixed displays – monitoring context, rare interactions (slightly overhead)
  - beam-transmission/beam-loss monitoring, emittance preservation, primary experiment performance index, ...
- II: active user-interaction – automatically adapted to commissioning step (see FC²WG)
- III: non-multiplexed information:
  - Zugangskontrollsystem‘ (ZKS, access system), machine interlocks, ...

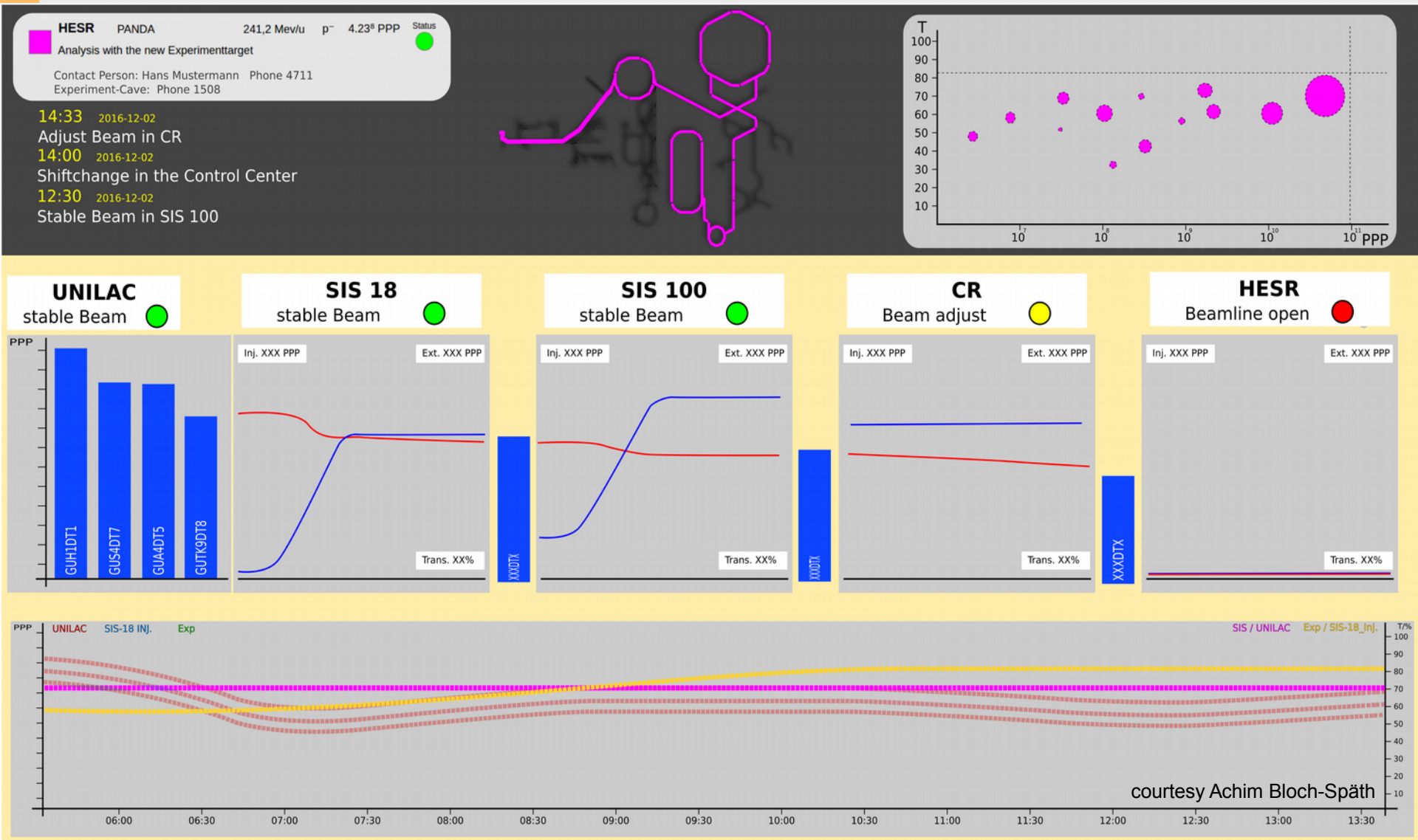
Example: FAIR Facility Overview
Global Operator View – Proof-of-Concept



courtesy Achim Bloch-Späth

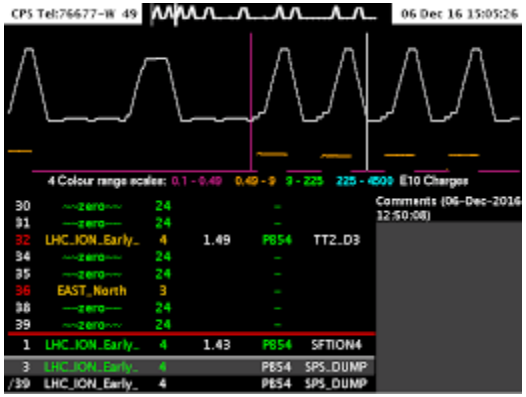
FAIR Beam Production Chain Overview

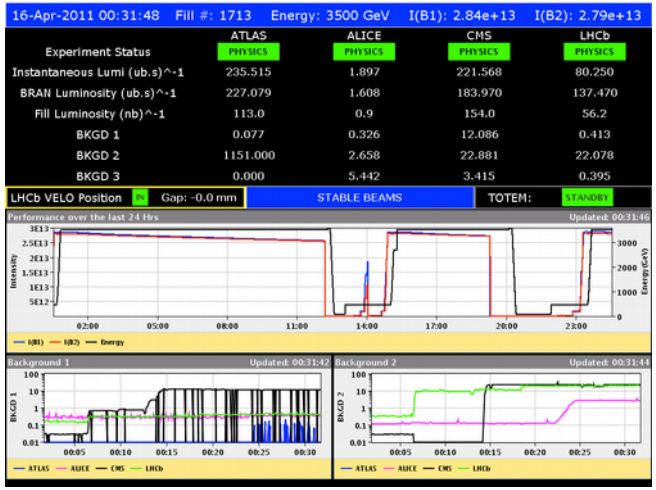
BPC-specific view – Proof-of-Concept

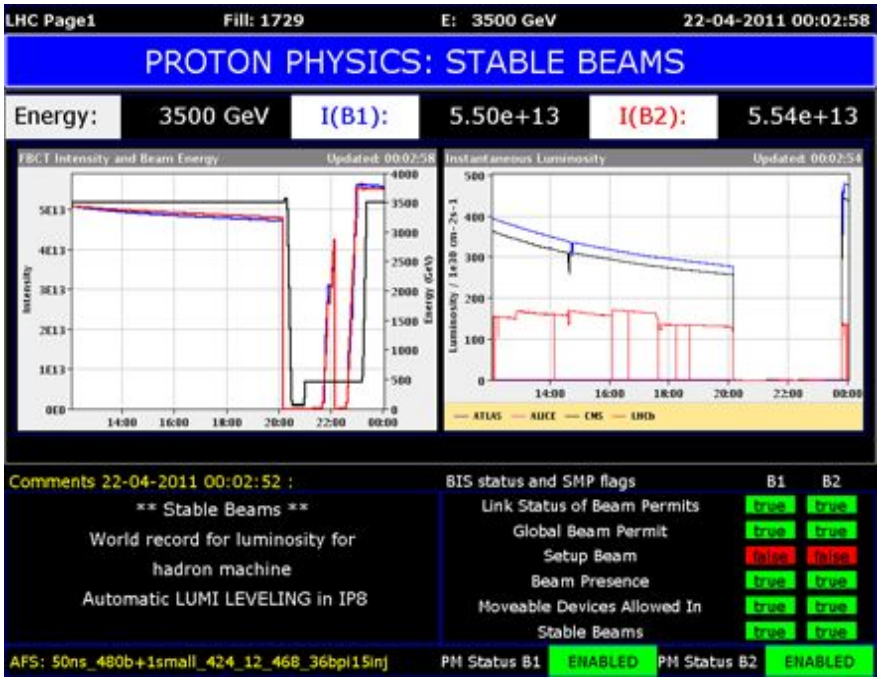


FAIR Accelerator & Experiment Overview

Examples from CERN

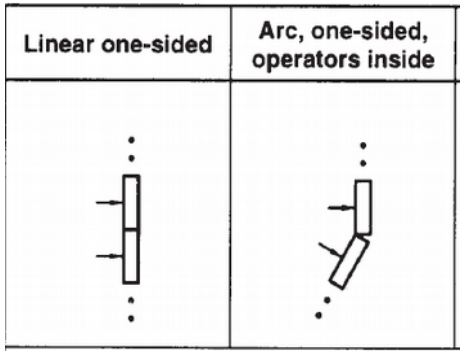






Preferred FCC Workstation Layout

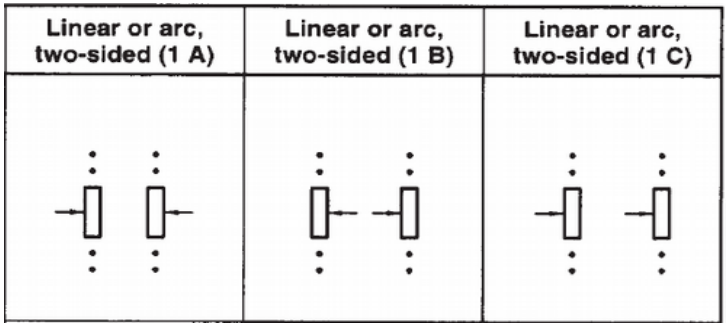
categorisation according to DIN EN ISO 11064



OK!

- sharing off-workstation display
- sharing of workstation equipment
- minimises noise interference
- teamwork support/egality
- verbal communication within island
- direct eye contact across island and to read-rooms (kitchen/FCC meeting

Well established acrooss accelerator facilities modern concept → the new standard

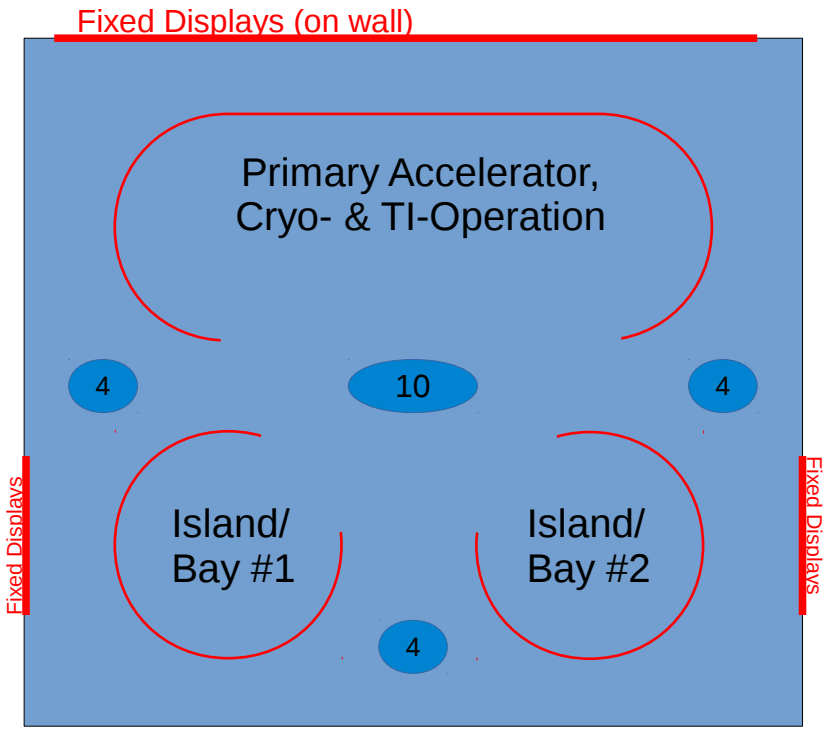


- sharing off-workstation display
- sharing of workstation equipment
- minimises noise interference
- teamwork support/egality
- verbal communication within island

veto-ed concepts from accelerator OP point of view, except across acc./exp. islands

FCC Workstation Layout
General Concept

Central meeting table:
- shift hand-over
- small ad hoc meetings
  (→ + small meeting room)
- social functions



permanent usage
24h/7 during OP year
(includes all accelerators, technical infrastructure needed for acc. operation)

reconfigurable usage
- storage ring experiments
- machine developments
- experiments tightly intertwined with acc.
- Hardware and Beam (Re-) Commissioning

? ... m

12 Workspaces for short-notice stand-by personnel
(|| R&D, acc. exp. Students, ..)
(table with data / power connections)

experiment control-room:
L1 trigger adjuments, data-preanalysis, commissioning, ...

FCC Main Control Room
Acoustic Targets – MCR & FCC Conference Rooms

$$t_{rev} \approx 0.16 \cdot \frac{V}{\sum_i S_i a_i}$$

V: volume of room,
Si: area, and
ai: absorption coefficient of each individual surface.

N.B. p~1/r2 → -6 dBA for doubling the distance to the source

- reverberation time t_{rev} < 0.6 (decay time for 60 dB attenuation)
- ambient noise: < 35 dBA including all nominal room equipment[1]
  - foresee ~80-100 high-performance PCs with GPUs in MCR
  - FCC conference room: high-lumen video projector & video conferencing system
  - ventilation system should be inaudible i.e. noise level in any one-third octave band should not be more than 3 dB greater than noise level adjacent bands
- workstation cabinets, carpet, wall & ceiling require sound absorbing properties (see ISO 354):
  - carpet tiles: Impact sound insulation (ISO 140-8): 40 dB – 1000 Hz (ΔLw:27dB)
    - individual carpet tiles must provide possibiliy to add floor tanks for mains, Ethernet connection, and routing of cables to tables. The tanks should be reconfigurable both in place and function.
  - cabinet must not have hard vertical concave surfaces
  - wall absorbent should be continuous and any wall fittings cover the absorbent or battens inserted into the absorbent to provide a fixing for any fittings
  - more durable surfaces below 700 mm from the floor possible if it is deemed that the chosen finish is too vulnerable to damage
- Ceiling should provide possibility for speaker and sound monitoring equipment (noise conditioning/masking system & audio announcements/alarms)

FCC Main Control Room
Acoustic Targets – Screens

- Additional acoustic screen/workstation rear panels to improve privacy
  - ideal height 1.5 m but 1.2 m preferred/accepted by user for FCC
  - improve privacy in large MCR while providing visual contact for seated position
  - direct/open communication via central corridor and above screens
  - aids isolation of noise from workstation computer
  - target similar sound absorption performance as for walls
- CCC experience/calculations suggested following typical numbers (ISO 354)[1]:
  - reference calculation in appendix

Hz	125	250	500	1k	2k	4k
Ceiling	0.85	0.90	0.95	0.95	0.95	0.95
Wall	0.10	0.29	0.79	0.98	0.98	0.98
Carpet	0.02	0.05	0.11	0.28	0.33	0.41

- Negative impact of windows on noise performance should be checked: quick in-house FEA simulation (e.g. via I-Simpa, or similar tool)

[1]data courtesy D. Manglunki (CERN), M. Clark (CCD), "CERN Common Control Centre – Acustic Specification", 2004

FCC Main Control Room
Console Requirements I/II

1) The console modules shall be assembled in (see drawing for details)

   a) Two open circular shapes with 4 m radius, including 5 standard console modules. The other arc-ends being each terminated by a straight section containing a cabinet and shelf. An opening angle of 45° should be envisaged.

   b) Two half-circles with 5 m radius, including five standard console modules, joined by a straight section with five standard consoles. The other arc-ends being each terminated by a 1.5 m long straight section containing a cabinet and shelf.

   c) Two standing tables implementing the standard console layout, same table surface, being motorised and height-adjustable.

2) The wiring of the PCs to the floor (mains, Ethernet network) shall be hidden in the footing. The wiring of the PCs to the flat displays shall use an internal routing system. Where wireless equipment cannot be used for computer keyboards and mice the wiring shall be hidden.

3) The table shall have a minimum depth of 65 cm, to accommodate an A4 binder in front of the keyboards below the control displays.

4) The upper surface of the table shall be 72 cm above the floor level, leaving at least 67 cm below for the operator's legs.

5) The footing of the table shall allow the operators to roll their chairs along the console consisting of several modules without encountering any obstacle for their legs and feet.

6) The distance between each of the control displays (first row of displays) and the operator's eyes shall be horizontally adjustable from 50 cm to 70 cm without restraining the useable area on the table.

7) The control displays and the fixed displays shall be fully viewable both from a sitting and a standing position in front of the console.

8) The rim of the highest 24" display shall be at a maximum height of 155 cm; no accessory or part of the console shall be higher than the rim of the highest display.

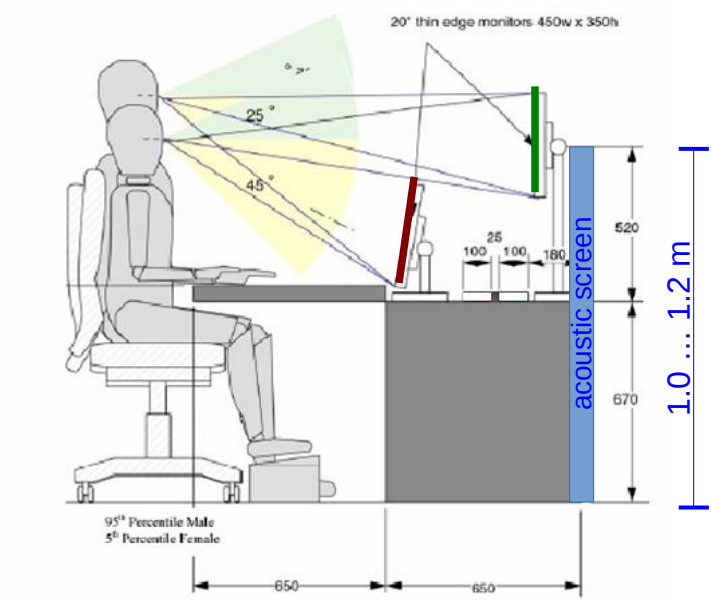
FCC Main Control Room
Console Requirements II/II

9) 120 cm high self-standing anti-noise panels will be located 10 to 20 cm behind the console.

10) In the level above the control displays either fixed displays or additional control displays can be installed therefore the supports of these displays shall allow positioning, so that both types of displays can be installed.

11) The enclosure for the PCs shall allow for natural cooling. Cooling of the room will be provided from the ceiling only. The openings of this cabinet shall allow for an easy replacement or connection of the PCs even in the case of several console modules joined together; it shall not intrude into the 65 cm depth under the table for the legs of the operators. The structure shall be compatible with the use of wireless devices with emitters located inside the structure.

12) The design of the console modules and the way they will be assembled shall allow rearranging of the layout of the control room within one day, i.e. disconnect, move console modules and change the assembly into consoles.



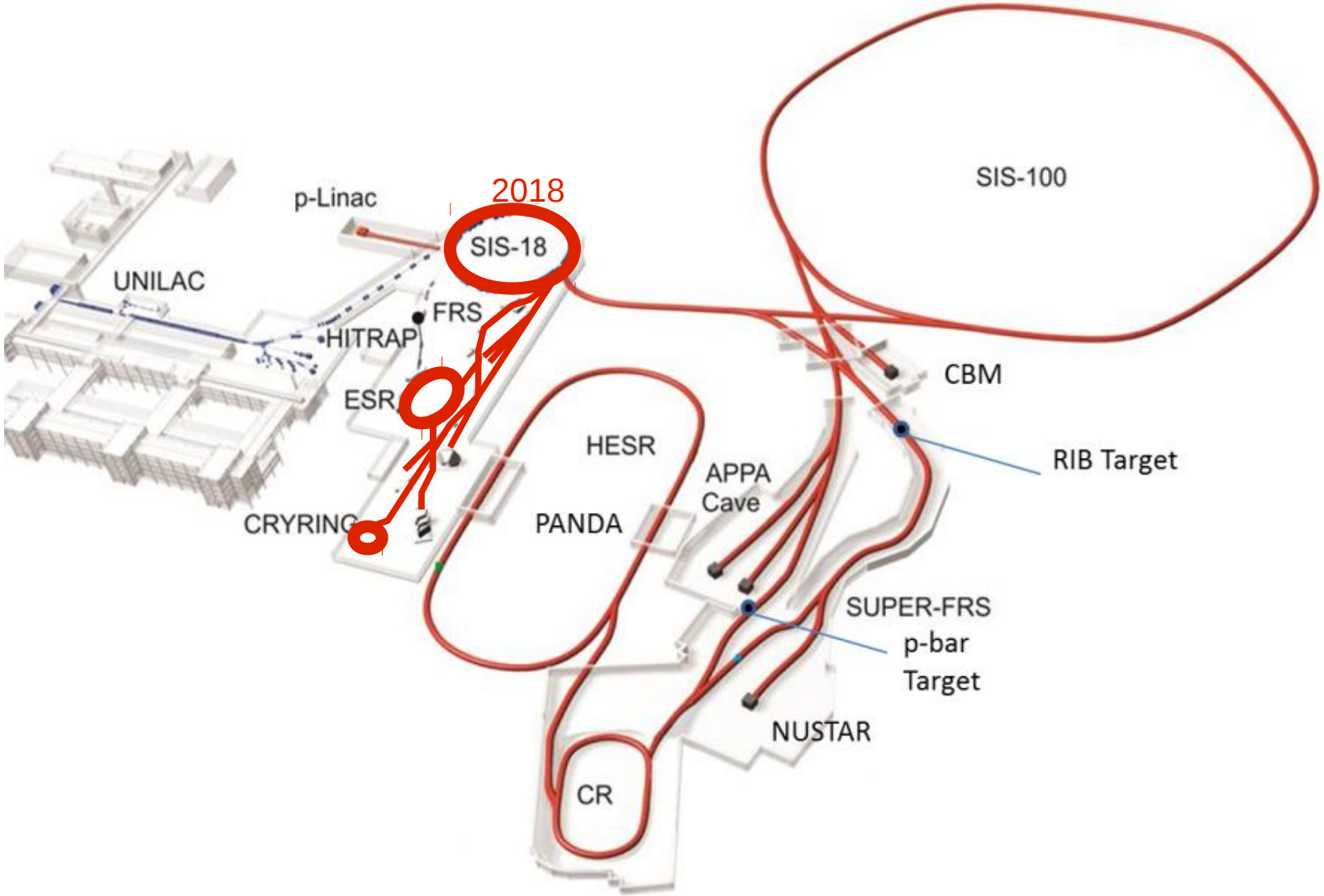
FCC Main Control Room
Additional Table Infrastructure

- One table will be located in the vicinity of the operation consoles mentioned in ‘1.b)’. This will be used either for three fixed PCs dedicated to administrative tasks and/or portable PCs temporarily brought into the FCC by equipment specialists or machine physicists. These tables shall provide enough space for 6 persons to work simultaneously. The tables shall comprise the housing for the fixed computers, as well as the space for the screens. The wiring for the PCs, shall be integrated in the footing of the tables. Mains and Ethernet sockets should be available in the table surface.

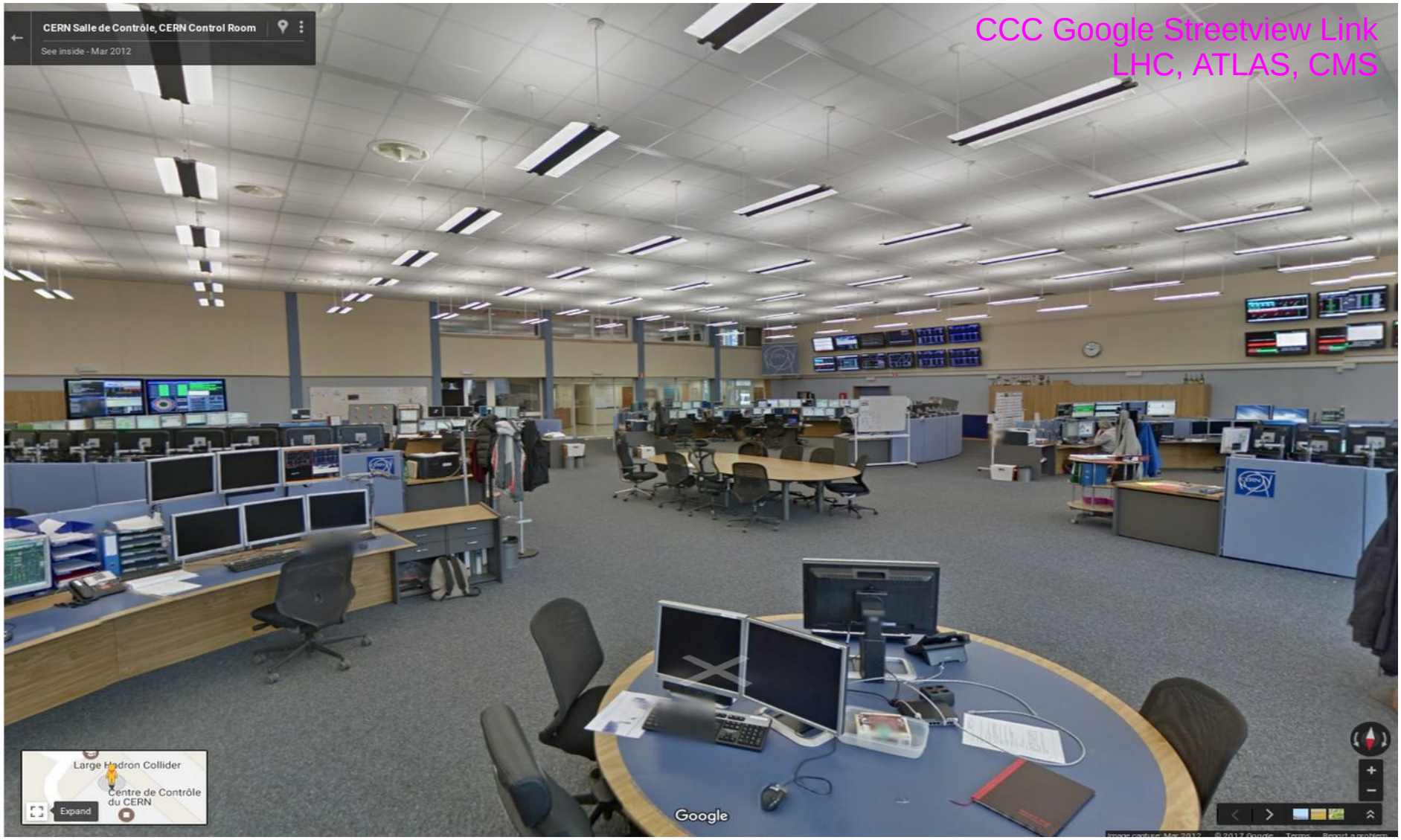
- The additional office FCC MCR, FCC Conference Room, and FCC Meeting Room furniture items shall be manufactured of the same materials, colours and style used for the consoles. Mains and Ethernet sockets, as well as panels to control the video equipment should be available in the table surface.

- Required table surface infrastructure (to be checked by CSCO-IN & IT):
  - Table & FCC MCR furniture: 6 power socket (CEE 7/3), 3x2 CAT-6e Sockets + 2 spare sockets
  - FCC Meeting Room table: 12 power sockets (CEE 7/3), 6x2 CAT-6e Sockets, at the front of the table: 2 spare video/audio sockets, spare slot for video-conferencing control equipment, ...
  - FCC Conference Room table: 25 power sockets (CEE 7/3), 12x2 CAT-6e Sockets, at the front of the table: 1x2 CAT-6e Sockets, 2 spare video/audio sockets, spare slot for video-conferencing control equipment, ...

“alt-HKR” & Accelerator Controls Retrofitting
GSI → FAIR Transition in 2018



For reference:
CERN Control Centre (CCC)



Reverberation times for reference:
CERN Control Centre (CCC)

Volume of control room 3312.5m³									
Schedule of absorption coefficients (a) for each material in octave bands (Hz)									
		Area (m2)	**(Hz)**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Floor	Carpet	629		0.02	0.05	0.11	0.28	0.33	0.41
	Computer Floor	629		0.25	0.21	0.41	0.15	0.18	0.17
Ceiling	Tiles	509		0.85	0.9	0.95	0.95	0.95	0.95
	Diffusers	129		0.6	0.6	0.6	0.6	0.6	0.6
Walls	Blockwork	127.77		0.02	0.02	0.02	0.02	0.02	0.02
	Absorber + 75 mm Gap	83.7		0.3	0.8	0.95	0.95	0.95	0.95
	Absorber + 25 mm Gap	187.20		0.15	0.6	0.95	0.95	0.95	0.95
	Absorber (no gap)	184.78		0.1	0.5	0.85	0.95	0.95	0.95
	Window	108.6		0.15	0.05	0.03	0.03	0.02	0.02
Furniture	Screens (each)	36		0.5	0.4	0.45	0.45	0.6	0.7
Sa for each area of specified material in octave bands (Hz) where S = area and a = absorption coefficient									
		Area (m2)	**(Hz)**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Floor	Carpet	629		12.58	31.45	69.19	176.12	207.57	257.89
	Computer Floor	629		157.25	132.09	257.89	94.35	113.22	106.93
Ceiling	Tiles	509		432.65	458.10	483.55	483.55	483.55	483.55
	Diffusers	129		77.40	77.40	77.40	77.40	77.40	77.40
Walls	Blockwork	127.77		2.56	2.56	2.56	2.56	2.56	2.56
	Absorber + 75 mm Gap	83.7		25.11	66.96	79.52	79.52	79.52	79.52
	Absorber + Gap	187.20		28.08	112.32	177.84	177.84	177.84	177.84
	Absorber	184.78		18.48	92.39	157.06	175.54	175.54	175.54
	Window	108.6		16.29	5.43	3.26	3.26	2.17	2.17
Furniture	Screens (each)	36		18.00	14.40	16.20	16.20	21.60	25.20
	A			788.39	993.10	1324.46	1286.33	1340.96	1388.59
Reverberation Time (s)				**0.67**	**0.53**	**0.40**	**0.41**	**0.40**	**0.38**