Report on the Laboratory Design Charrette for the Maison de Sciences de la Vie on 6 March 2009

Context: The new campus of the University of Luxembourg (UL) in the North of the Cité des Sciences in Belval will comprise a complex of laboratory buildings, which will house research in health and environmental sciences and fundamental biology, chemistry and physics. This complex is designated Maison des Sciences de la Vie, and will, in the first phase of development of the Cité, offer a usable surface of about 21 000 m², of which just under 10 000 m² will be laboratories. Teams of architects and engineers are selected based on a competition on ideas for integration of these buildings in the existing urban plan taking into account the overall function and character of the Cité. Winning teams were announced on 16 March 2009. This approach allows for greater collaboration of users and other interested parties in the early building design, in contrast to past competitions in which building projects were subject of the selection.

Objective: The objective of the Charrette was to jointly define the requisites for the architectural programming for the Maison des Sciences de la Vie by integrating the perspectives of biology researchers from the UL and the CRP Gabriel Lippmann, UL maintenance services, and officials in Luxembourg involved in judging health, safety, and environmental impacts of buildings, and in the administration of public buildings, architects, and engineers. Two key concerns relating to sustainability of laboratory design were usage flexibility over time and energy-saving measures. (For a complete list of participants see Annex I, and for the agenda of the meeting see Annex II).

Main outcomes: The group decided to start from the premise that laboratory form should follow function, and that people's needs should be considered first. The connection between well-being and productivity can be considered a prime basis for the social, economic and environmental aspects of sustainable development. Accordingly, this report describes resulting recommendations on user requisites, preferences, and areas for setting building performance goals. Recommendations are intended as guidance to the architects and engineers working on the Maison des Sciences de la Vie, and, some will also be applicable to other laboratory buildings in the Cité. The recommendations are organised under five headings which are described in more detail below:

1. Research needs and user comfort
2. Maintenance and servicing
3. Flexible use over time
4. Environmental impacts
5. Planning and commissioning

1. Research needs and user comfort

Requisites and preferences: Current research in the University Life Sciences group investigates cell signalling processes, including inflammatory processes and neurodegenerative diseases.

Technical requisites and infrastructure requirements are:

- office or writing spaces,
- cell culture rooms,
- a microscopy facility,
- an animal facility,
- cold rooms and cryogeny (N2),
- a centrifuge room and spaces for other noisy equipment,
- a high-through-put sequencing facility,
- fume hoods (few/low-density), and
- a P3 confinement laboratory for viral infections.

Areas with certain functions should be grouped where possible, to facilitate their use, but also to remove noisy equipment, and to place in close proximity spaces with similar temperature tolerances (It is common practice to position freezers outside of laboratories) (see also section 4. on environmental impacts subsection – energy.). Users should be closely involved in discussions on grouping functional areas, or perhaps even be able to draft he 'Plan d'Aménagement' of a basic floor plan themselves before the end of the APS stage of project design.

Similarly, discussions on the centralisation versus distribution of buildings service functions should involve users. Centralisation of the IT facility is desirable as it facilitates cooling, expansion, and optimal use, and facilities keeping the cooling system state of the art.

The following requisites shall be thoroughly evaluated during the building's design development phase:

To ensure health and safety and user friendliness:

- Maximize day-lighting.
- Avoid of UV protected glass or any intentional screening, as reducing the sun light's spectrum that reaches people can lead over long term to discomfort and impact the human circadian rhythm.
- Provide for user control of any air conditioning system where one is necessary.
- Locate fume hoods to ensure containment is not compromised by air turbulences from doorways and egress/ingress pathways.
- Restrict mechanical ventilation and cooling to specific activities that require it in as localised a manner as possible For example, in animal facilities, cages should be individually ventilated. Cooling should in general be targeted at the large appliances that need it, rather designed for whole rooms.
- Locate liquid nitrogen in containers that can be filled from the outside of the building and accessed within the building for use.
- Avoid transport of hazardous waste through public areas within and between buildings should be developed.
- Consider access control of laboratory buildings, and use of cards to signal the presence of persons within buildings and specific building areas.
- Evaluate card control inside of laboratories, in which case each door would need to be cabled, and consider coupling such a system with Prof. Thomas Engel's research on intelligent buildings and building systems that talk to each other in a demonstration project.
- Include Luxembourg's legal requisites on health and safety early on in the planning process and distinguish between codes (need to have) and standards (nice to have) and produce systematic needs vs. wish lists to help better understand trade-offs. (For legal requisites please see Annex III kindly provided by the public inspection agency in charge of worker health and safety ITM).

To complement social needs:

- Foster interaction between research groups.
- Optimize walking distances to execute related tasks within a research project.
- Locate office spaces not too far away from the laboratories.
- Provide convenient access to other technology platforms on campus and optimised walking distances between buildings.
- Include a centralised purchasing system.
- Prioritize spaces for social interaction.

One option for improved social interaction between groups discussed was to cluster all offices within a wing and make people walk through an atrium to help people meet. Consider creative spaces in hall ways or atriums or couch corners with white boards on walls for drawings and impromptu exchange.

Proposed building performance goals and targets:

- Provide natural light and ventilation during most of the day for 90-100% of the work space,
- Establish an infra-structure to receive a 'best workplace' rating, and
- Consider planning the laboratory for a handicapped person.

Future needs: Whilst it is difficult to anticipate requisites for research in 20 or 30 years time, future trends are that research will become progressively IT-intensive. Access to computers, possibly in a centralised computer room, and modular expandable servers will be key to adapt to changes in needs over time. Build the data centre in an expandable space modularity is key.

2. Maintenance and servicing

A strategy to enhance awareness of users of maintenance services should be conceived, involving plans for more contact and communication between them. In line with above preferences, maintenance activities should be possible without interrupting lab work, to avoid impatience about rather than recognition for support work well done.

Requisites and preferences:

- Design technical spaces with services accessible without entering the laboratory: interstitial spaces or service corridors are desirable, false ceilings should be avoided.
- Gather the same devices in one place to facilitate servicing by external firms (e.g., one hood room per building).
- Monitor the energy consumption of equipment for each laboratory.
- Develop a concept to facilitate waste management.
- Avoid mechanical motorised devices on windows, doors, for heat control or on sashes, as these tend to break down difficult for maintenance and can lead to feeling of disempowerment of the user. An additional option (or main option) for manual control can address this risk.
- Arrange fluids, ducts and valves for easy access and maintenance.
- Install metering and monitoring systems to assess plug loads.
- Consider installing energy meters for every lab.
- Define units that need to be metered for every service utility. If electricity is metered for every room, other services could be metered for larger special units….

3. Flexible use over time

Flexibility in use over time in modern architecture is often achieved through ‘modularity’. Both terms are defined and discussed below. A range of examples from past experience at the University in the type of flexibility that was requested is listed to help architectural planning and design.

Flexibility can be seen to have three dimensions:

(1) adjustability/refurbishment (e.g. shifting an incubator),
(2) adaptability/transformation (e.g. run in a new gas line), and
(3) expandability/extension (e.g. move walls, expand whole module, move fume hood).

Accordingly, modularity should be conceived of at different levels: modules in themselves should be adaptable to varying tasks (e.g. animal housing requires modular spaces adaptable to needs of different species of different sizes), as well as to varying group sizes and hence be moveable, shrinkable or expandable. In practice, self contained units as modules of a particular size that all are equipped with the same functional units are often discarded as impractical. A “one-size-fits-all” mentality often does not hold true. Each lab-space should only include an inventory of devices and services that are appropriate for the anticipated research. This also extends to the issue of “size”; however, labs having a standard module size work when similar research will be performed in multiple locations.

One solution popular in the UK is to plan for standard sizes for office space areas, procedure areas, support areas and each can be moved around. Procedure areas are usually the space where the “hazardous” science occurs, for instance, where the fume hoods are located in a so-called wet lab. In addition, apparatus that is used on a daily basis that contributes to the science that needs to be accessed repeatedly by the user/worker/technician/scientist would also be located in a “Procedure Area.” A “Support Area” definition is more amorphous. In some cases, it simply refers to the office or “write up” area. In other situations, the support area is where devices, usually mechanical, are located. For instance, a vacuum pump would be located in a support area that provides vacuum to a particular lab or group of labs. Gas cylinders could be located in a support area that allows change-out without interrupting the daily operations of a lab. Many other devices could, or even “should”, be located in a support area that have been traditionally located in the lab “procedure” area such as DI water processors (e.g., polishers), infrequently accessed freezers, specialized electrical power conditioning equipment.

Examples of changes in laboratory spaces required over the last five years include

- the need to control humidity or temperature in a room,
- room size or carry capacity for big equipment,
- cooling needs,
- needs for water or gas.

Therefore flexibility is required in terms of extraction of air, supply of gases, weight that can be put on the floor, places where the plug load can be higher. The adaptability of all or most zones from P1 to P4 should also be considered. Murphy's law: you are bound to have to make those changes you never foresaw.

Requisites and preferences:

- Enough space for the duct systems improved flexibility of duct systems if reconfiguration is possible without disturbing the work in the laboratories.

4. Environmental impacts

Requisites and preferences:

- Set verifiable efficiency goals for use of natural resources in participatory processes with users and maintenance and aim for continued reduction of the environmental foot print of the lab.
- Create buildings that teach its users about its environmental impacts that complements user-education campaigns.

Goals and targets could be defined for:

- Energy use (e.g. in kW / m2 -- targets could be adapted to the concept of the 2000 W society.[1] Separate targets could be set of electricity use and heating.
- Consider life cycle analysis building materials.
- Water use (e.g. in litres/person).
- Daylight (e.g. in W/ m2).
- Efficiency of cooling (kW/ton).
- Energy use of fans (kW/m^3).
- Main thermal losses relate to fume hoods, but in this case, there will likely be few fume hoods (Recovery of energy from stacked exhausts rarely makes sense and can be hazardous.)
- The focus should be on reducing air flow: reducing air flows to 0.4 m/s and the sash opening in fume hoods to 30 or 40 cm are options to be considered.
- Calculate air change rate based on lab area.
- Develop a concept for use and reduction of toxic substances and wastes considering latest insights on 'green chemistry'.
- Supplement lab supply air by for cascading conditioned air from offices to labs.
- Set maximum external solar heat load from the sun and consider the use of solar shading devices and window film.
- Develop an overall concept for all heating and cooling and avoid having to do both at the same time, i.e., avoid simultaneous heating and cooling – to develop a concept for overall adoption of best practices and rational use of energy.
- Provide 50-60% of energy from renewable sources is desirable, 10% is required.
- Extracted air from laboratories and fume hoods in particular should be cleaned before diluted into general air shafts for external dispense when manifolding the exhaust from fume hoods. It is impractical to "clean" the effluent from fume hoods for a host of reasons.
- Consider the Labs 21 environmental performance criteria : (see http:// www.labs21century.gov)
- Consider performing an accreditation and plan for it according to Norm ISO/IEC17025para 5.3 mentions environmental conditions that depend on the infrastructure.
- Consider eco certification according to BREEAM (a new chapter on laboratories is being drafted).

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[1] La moyenne globale de la consommation énergétique par personne par an s'élevait à 17500 kWh dans l'année 1995. Cela correspond à une puissance continue de 2000 W. En Europe occidentale, la moyenne actuelle s'élève à 6000 W, aux USA à plus de 12000 W. Pour limiter le changement climatique au niveau mondial, la consommation d'énergies fossiles devrait être réduite à 500 W/personne jusqu'en 2150. Cela correspond environ à une émanation de 1 t de CO_2 par personne par an. Un objectif à moyen terme consiste à atteindre d'ici l'an 2050 une société de consommation de 2000 W. Des résultats récents de la recherche scientifique soutiennent l'idée qu'il est possible de concrétiser cette vision, à condition d'utiliser intelligemment les potentiels d'efficience et de substitution. E. Jochem (Editor) et al. 2004: Steps towards a sustainable development. A White Book for R&D of Energy-Efficient-Technologies; CEPE/ETH Zurich and Novatlantis, Zurich http://www.novatlantis.ch/index.php?id=60&L=1

5. Planning and commissioning

In design it is helpful to combine deliberations on services such as daylight, heating, ventilation and air conditioning, and list all other services required (gases, water, expected plug loads, N2 cryogeny, etc)
During lab planning stages, requisites of lab users should be formulated as precisely as possible. This involves to:

- Define sources of heat loads and quantify heat gains.
- Determine devices that can be located outside of lab space but in close proximity to facilitate operational efficiency.
- Evaluate storage needs, and, particularly, ventilated storage cabinets.
- Stipulate and verify space temperature set points and acceptable ranges (spans) for temperature, humidity, and air-flow rates.
- Evaluate and estimate potential, future needs.
- Use CFD modelling to evaluate and plan air flows, including of spills of chemicals contamination and other.
- Establish a commissioning plan at the onset of the project, and provide a list of service utilities including quantities of vacuum, process gasses, specialized water needs. For each service, evaluate the pros and cons for a centralized versus a distributed system.
- Identify applicable rules and regulations (containment of GMOs, or DIN norm on hazardous waste), etc. at the earliest stage and understand how it will affect building design before starting the design.
- Consider building eco-certification up front.

Planning the grouping of functional units within and between buildings with users, taking into account the need to foster inter-disciplinarity and to anticipate interdisciplinary (bio physics, etc.).

Once the building is operational, it is recommended to understand and refine building energy-use profiles diurnally, seasonally, and annually employing an iterative approach. This also allows programming optimal timing of energy intensive activities to avoid concurrent electrical-usage peaks.

6. Conclusion

The overarching goal is to define the disposition – the form and function of the building aiming at user friendliness by asking the question 'how will the building positively influence what will be done in it?'

The design philosophy can be summarised as 'functional grouping', 'grouping loads', 'drive containment down', and never to ventilate a room but just an activity. A move from fume cupboards to glove boxes is anticipated. Thinking in terms of several levels of modularity as described in section 3. on flexible use over time is important, at a highest level of the building – with modules that are expandable and shrinkable.

The meeting the following next four action points were agreed upon:

<u>Organise meetings between architects and researchers:</u> Architects and engineers from the Fonds Belval will arrange individual meetings with researchers to better understand their requisites.

<u>Conduct laboratory design charrettes for each laboratory building.</u> The Fonds Belval is invited to suggest suitable calendar weeks for the UL to organise design charrettes for additional laboratory buildings at optimal time points in the laboratory planning process. Students will be invited to see the process.

<u>Visit current UL biology laboratories:</u> The UL offers to organise a visit to the biology laboratory after an engineering students has systematically analysed current activities in terms of electricity consumption implications and plug loads, combined with a user survey on exactly which machine runs at what times of day and night. The visit will serve as much to understand current activities and requisites as well as current limitations of the infrastructure and which short comings have to be avoided, and what might be carried out in terms of research if a perfect infrastructure would be available.

<u>Set environmental goals and targets:</u> the UL will convene a sub group setting goals and targets for of the areas with a focus on environmental and social requisites, starting from current norms and standards.

Annex I

Agenda and List of Participants

AGENDA

Time	Session
Morning session: introducing the issues	
10.00	Introduction and overview (Ariane König)
10.10	Biology research at the University: plans defining user requisites (Evelyne Friedrich)
10.25	Surface requirements and design tendencies (Michael Scheuern)
10.55	Major design choices in laboratories (Geoffrey Bell) • Services options and day lighting • Heating, ventilation and air-conditioning • Controlling evolving building service functions through-out the construction process
12.15	Lunch
13.30	Combining perspectives on needs, preferences and target setting (ALL)
15.30	Tea break
15.45	Combining perspectives on needs, preferences and target setting ctd (ALL)
16.45	Résumé of the day
17.00	Closure

PARTICIPANTS

NAME	FIRST NAME	ORGANIZATION
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