Objective of this talk

Many facilities in the world are built to premium standards however not every institution can afford this. Our methodology and approach has always been to support the client to attain the best possible facility within the constraints of the funds available.

In this talk, I will be discussing localised methods of achieving the optimum environment for the animals used in research as well as show an example of a facility we recently completed successfully.

Agenda

- Design Considerations
  - For an Animal Facility
  - Construction
    - Materials and Details
  - Architectural
    - Planning & Layout
  - Audit
    - Physical Environment
  - Example Projects
    - NIH Invivo – Malaysia
    - NTU LKC CSB – Singapore
  - Project References
Design Team

- Typically consists of:
  - Facility Management
  - Veterinary staff
  - Scientists / users
  - Architects / engineers (M&E, P&S, C&S)
  - Specialists Consultants (AAALAC, Biosafety)
  - Local Authorities – NEA, Local Power

- Ensure that references are relevant – check experience of team
- Good idea to visit similar facilities in other countries to see design problems / issues and materials used to get ideas

Areas for Consideration

- Animal holding / breeding rooms
- Animal receiving / Quarantine rooms
- Procedure / Surgery / Necropsy rooms / Behavioral Studies
- Laboratories – in vivo, in vitro, diagnostic procedures
- Imaging rooms – requires shielding? X-ray / MRI?
- Washing area (clean and dirty cage wash)
- Equipment Storage / Sterile Store
- Reception areas for personnel (changing rooms) and animals (loading bays)
- Storage for animal feed, bedding, chemicals / biologicals and waste
- Pharmacy – drug dispensing
- Waste disposal room / Cold room
- Bio-containment / Bio-exclusion?
- Administrative offices including animal care staff shower/change room, break area/small meeting room
- Technical areas- HVAC / service space
- Security features – Card-key systems, surveillance, alarms etc
### Procedural Considerations

- Small animals and/or large animals (rodents, rabbits, large animals, aquatic...)
- Animal health status (intact, immuno-deficient, immuno-compromized)
- Special types of research, specific management needs (barrier, containment)
- Species with specialised environmental requirements
- Non-Human Primates – yes/no – will animals be held in quarantine?
- Work with pathogens or hazardous agents (human or animal) yes/no
- Separate building or integrated into research building
- All in-vivo laboratories included within the facility or not – this will depend on your activities
- In-house breeding? (stringent barrier requirements)
- Single corridor or Clean and Dirty corridors?
- Feed/Bedding
  - Autoclaved / irradiated vs. non-autoclaved / non-irradiated
- Water
  - Filtered vs. reverse osmosis vs. UV treatment vs. acidification vs. autoclaved

### Identifying Use

- Type of research activities:
  - Development (toxicology, product testing etc)
  - Discovery (basic research, applied research)
  - Infectious, hazardous agents
  - Imaging/radiation
  - Breeding?
  - Regulatory control – GLP or non-GLP?

- Species used:
  - Mammals: rodents, lagomorphs, large animals (dogs, etc.)
  - Non-human primates
  - Aquatic species: marine, fresh water, amphibians
Considerations - Standards

- Identify which standard the facility will be built to:
  - Local standards, the "Guide" [NRC 2011], EU, GLP regulations, AAALAC international's expectation etc.
  - Local regulations ie, Malaysia Animal Welfare Act etc
  - Space requirements for animals differ between guidelines
  - Room dimensions will then need to be modified
  - Consider changes in legislation in future

Space Planning

- Capacity – present and future – based on average number of housing units per day that is balanced against the total number of animals that can be expected to be housed in the course of any given research period
- Long term and short term requirement
- Future prediction of animal use – facilities that are not currently using them may require large or small species in future
- The animal facility should be designed with high degree of flexibility and expansion possibilities. This is particularly the case when designing for discovery research
- Through-put calculations for washers and sterilizers and other equipments to identify bottle-necks and future expansion
- Procedure rooms vs animal holding rooms
Barriers

- All facilities require some degree of barrier, to separate functions, reduce cross-contamination and provide a stable environment that ensure reproducible research
- Barriers are important to reduce / eliminate pathogens from the facility
- Barriers are also important to prevent Laboratory Acquired Allergies (LAA's) and reduce biological, chemical and physical hazards
- Barriers are important to separate species and manage noise
- Rodent barriers – for escapee rodents
- Barriers can be maintained through a good combination of facility design, PPE and procedures
- Wet shower or Air shower? Typically depends on function – wet shower for breeding facilities, air shower for research facilities and not necessary for conventional facilities.
- Typically air showers can be replaced with air-locks
- Air shower limitation - cycle length, position of nozzles, number of people in shower etc.
- Procedures are also important!

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Building

Conventional
- Longer Construction
- Cheaper
- Less control of the quality
- High maintenance

Modular
- Fast erection of building
- Quality is consistent
- Tested and validated in the factory
- Flexible for expansion
- Lower maintenance
Walls

Brick/Concrete
- Material: Brick / Concrete
- Finishes: PU paint layer / water proof paint
- Insulation: Brick / Concrete
- Reliance on local labour quality

Sandwich panels
- Material: Stainless steel, mild steel, GI steel
- Finishes: Stainless Steel, Powder Coated
- Insulation: PU, Mineral Wool, Honeycomb Alu,
- Tested and validated in the factory

Dry-wall
- Material: Calcium Silicate, Gypsum board, single/double layer
- Finishes: PU paint layer / water proof paint
- Insulation: Mineral Wool
- Reliance on local labour quality

Wall Mounting / Penetration

Surface mounted or flush with wall?
- Facilitate ease of disinfection / decontamination
- Minimise accidental damage from cage racks / trolleys
- Fully sealed or leave a gap big enough for a mop!

Wall/Ceiling Penetration
- Maintain critical pressure regime
- Ensure no leak between hot zone and outside
- Examples of media air-tight gaskets
### Flooring material

**Vinyl**
- Material: 2 to 3mm Vinyl Flooring
- Finishes: Anti-slip R9 or R10. Deeply embedded inlaid carborundum particles
- Insulation: Foam backing, Glassfibre grid, anti-static.

**Epoxy**
- Material: polymer materials liquids that are converted to solid polymers by a chemical reaction combining resins and hardeners
- Finishes: Self levelling or Surface painted, polymer, rough finish, non-slip, matt finish, hardness?

**Tiles/Stone**
- Material: Tiles/Stone
- Finishes: Insulation:
- Reliance on local labour quality

### Ceiling

**Modular Metal Ceiling**
- Material: Stainless steel / GI Steel
- Finishes: Powder coated
- Insulation: Mineral Wool / none
- Removable and modular

**Sandwich panels**
- Material: Stainless steel, mild steel, GI steel
- Finishes: Stainless Steel, Powder Coated
- Insulation: PU, Mineral Wool, Honeycomb Alu,
- Walkable ceiling with load at 200kg / m2

**Dry-Ceiling**
- Material: Calcium Silicate, Gypsum board, single/double layer
- Finishes: PU paint layer / water proof paint
- Reliance on local labour quality
- Non trafficable
- Manhole required for access
Doors Types

Stainless steel doors
- Material: Stainless steel / GI Steel / Wood Core
- Finishes: Powder coated
- Insulation: Wood Core
- Very heavy

Sandwich panel doors
- Material: Stainless steel, mild steel, GI steel
- Finishes: Stainless Steel, Powder Coated
- Insulation: PU, Mineral Wool, Honeycomb Alu

HPL - Laminate doors
- Material: Wood Core
- Finishes: Laminate finish

Aluminum doors
- Material: Aluminium
- Finishes: powder coated

Doors & Corridors - features

- Hermetic vs Sealed doors - doors may not need to be fully sealed.
- For pest prevention, all doors leading to outside must fit well. Rodent barrier also.
- Doors to be large enough for equipments. Approx 1m clear width.
- Wash and Decontamination proof. Chemically resistant to VHP for example.
- Bumper guards, kickplates to protect doors and frames.
- Red tinted glass do not transmit specific wavelengths that rodents have a limited ability to detect red portions of the spectrum, but facilitate human viewing
- Loud sudden sounds can disturb animals – soft closer and seals are good options.
- Ideally doors should open into animal/procedure rooms, not into corridors. However, local fire safety code will need to be consulted with.
- Clean / Dirty or Single Corridor? Clean / Dirty corridor is ideal, but requires a lot of space...
- Adequate space for transporting equipment / animals
- Bumper guards to protect walls / doors in high traffic areas
- Inter-locking doors for air-locks.
Drains

Required?
- Small animal rooms typically not required – may be installed and sealed for future use.
- Ensure U shape trap to prevent odours / insects coming up!
- Large animals – scupper drains are required – size will depend on number of animals / species housed
- Scupper drains need to be covered with grate

HVAC System

Heating Ventilation and Air Conditioning (HVAC)
- Redundancy option, N+1 or 1+1.
- Ductwork integrity (PPVC / GI / Stainless steel) – minimal leakage, heat and chemical resistance
- Air pressure differential – Clean vs Dirty areas, cascading pressure regime, airlocks
- AHU Zoning
- Room controls: RH 30 to 70%, Temperature 22 to 24 deg +/- 1 deg, ACH 10 to 15
- Additional exhaust requirements for equipments
- Back up power supply
- Install 250 micron filters over supply diffusers?
- Monitoring and datalogging of environmental parameters – BMS, LMS or manual – alarm system required
- Building Exhaust – filtered? High Plume? Stack height?
Other Considerations

- Fire Alarm – audible alarm or silent visual alarm? Certain sound spectrum?
- Smoke Extraction System (air-balancing during testing)
- Emergency lighting on E-source or battery
- Loading bay with lifts for heavy equipment
- Security - Need to ensure adequate number of cameras to monitor activities, especially BSL3 areas, entry / exit doors etc.
- Overrides for interlocking doors in case of emergency

Utility Provisions

- Automatic Watering System – RO / Acidified / filtered
  - Needs early planning – piping, drains need to be constructed early on
- Steam – Clean steam or black steam
  - This will affect the decisions when selecting equipment.
- Power – How much power do you require for each equipment?
  - Without sufficient power allocation, you will not be able to run the facility.
  - Do you need a back up power supply (Genset)
- Gas – Medical Gas, Oxygen, Nitrogen, Carbon Dioxide
  - This needs to be designed up front due to piping.
- Exhaust – Equipment requirements.
  - Equipment requirements - IVCs, Sterilizers, Washers, Decon Chambers etc all require exhaust.
- Heat loading of equipments
- Drainage – Washing, Equipments
- Chemical or heat treatment of biological waste / discharge water?
Large Capital Equipments

Large equipment needs to be identified early
- Autoclaves (Steam Sterilisers)
  - Total capacity - cycle time, chamber size
  - Redundancy (breakdowns / servicing)
  - Utilities required – power, steam, compressed air
  - Floor strength / ceiling height (pit mounted?)
- Cage Wash Area
  - Typical work flow
  - Type and number of items to be washed
  - Cabinet washers
  - Rack washer
  - Tunnel washer
  - Size of room – longer area required for tunnel washers
- Bedding Dispenser – Clean Side / Dirty Side
  - Requires advanced planning in order to plan vacuum lines to prevent blockage

Decontamination or Fumigation

- Decontamination Systems
  - Vaporized Hydrogen Peroxide (VHP)
  - Formaldehyde
  - Chlorine Dioxide Spray / Fogging
  - Peracetic Acid Spray / Fogging
- Materials compatibility
  - Some materials may not be compatible with commonly used fumigants and disinfectants - walls, floors, ceiling, work surfaces, equipment, exhaust ducts (venting)
- Installation
  - Fixed installation of spray nozzles / ports
  - Machine placed inside room or outside and gas / vapour forced into room
Specialized Facilities - Containment

- The ABSL-3 Laboratory is designed to contain agents that may cause serious or lethal disease as a result of contact or inhalation.
- All procedures involving infectious materials are conducted within biological safety cabinets or other physical containment devices (e.g. glove box).
- Primary Containment – Containment at Cage Level.
- Secondary Containment – Containment at Room Level.
- "Proper" decontamination, personnel and materials, all waste before exit.

ABSL-3 equipments required:
- Bio-seal Sterilizer
- Incinerator
- BSC’s
- Animal Caging System (fully ducted)
- Separate / dedicated HVAC system (BIBO etc.)

Specialized Facilities - Aquatic Facilities

- Water requirements
- Drainage requirements
- Rooms need to be fully washable / waterproof
- Waterproof sockets / lights
- Large number of water / electric points
Specialized Facilities - Imaging Facilities

- Consider how animals move between holding areas and imaging areas to prevent cross contamination
- Need to understand traffic patterns (for personnel and animals), storage administrative and personnel areas, showers etc.
  - Support areas - animal holding, procedure rooms, cage wash and storage
  - Euthanasia
  - Power requirements, gases etc.
  - Lead lining / faraday cage
  - Anaesthetic machines
  - Containment and decontamination
- Do animals return to animal holding rooms after use?
- Is imaging facility inside animal facility?
- Who else uses the imaging facilities?

Conclusion

- The objectives of the facility need to be defined early on – e.g. Breeding, research, GLP, containment, type of animals
- Equipment lists need to be put together early in the planning stages, following discussions with PI’s, managers and other stakeholders
- Large, complex equipment needs to be identified early on so that provision can be made in the design. Ensure equipment suppliers are on hand to provide specific information about their products to ensure smooth integration with design
- Architects, Engineers, Planners, Consultants and Users all need to work together to define what is required and to optimize the design as well as expansion plans
- Construction of the facility needs to be closely supervised to ensure any problems are dealt with quickly.
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Traffic flow options

- Animal holding rooms
- Labs
- Diets & bedding reception
- Diets & bedding storage
- Storage
- Waste storage
- Personnel changing rooms
- Quarantine
- Animal reception
- Washing & Sterilization
- Traffic flow options
Audit – Physical Environment

- The audit consists of a review of the building, construction, fit out and equipment only often by a qualified 3rd party company. i.e. a validation company with animal facility experience

- The audit will not consider soft items, such as SOP’s, training, IACUC and other operational factors outside the scope of construction
Sample Report

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I. Overview of Audit and Scope

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   1. Monitoring Care & Use of Animals
   2. Accreditation and Reporting Requirements
   3. Animal Care Personnel
   4. Animal Care Practices
   5. Occupational Health & Safety of Personnel
   6. Medical Evaluation & Prevention Medicine for Personnel

B. ANIMAL ENVIRONMENT HOUSING & MANAGEMENT
   1. Physical Environment
   2. Temperature, Humidity, and Ventilation
   3. Housing Practices
   4. Social Environment & Rehabilitation
   5. Parasite Prevention & Control

C. VETERINARY MEDICAL CARE
   1. Attending Veterinarian
   2. Emergency & Wound Care
   3. Population Management
   4. Animal Procurement & Transportation
   5. Nutrition
   6. Pathology, Parasitology, & Anesthesia
   7. Radiology

III. Conclusion

IV. Proposed Schedule for AAALAC Accreditation (appendix)

Sample Room Datasheet

<table>
<thead>
<tr>
<th>ROOM REQUIREMENT</th>
<th>Code</th>
<th>Description</th>
<th>Quantity</th>
<th>Area (sq m)</th>
<th>Housing Capacity</th>
<th>Comments</th>
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<td>1</td>
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<td>Room 1</td>
<td>2</td>
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### Sample Utility Requirement Matrix

<table>
<thead>
<tr>
<th>S/N</th>
<th>Description</th>
<th>Level</th>
<th>Location</th>
<th>Requirement</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cage and Rack Washer</td>
<td>3</td>
<td>Isolation Cage Room, non-SPF, position</td>
<td>Duct Size [in x mm]</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Cabinet Washer</td>
<td>3</td>
<td>Isolation Cage Room, non-SPF, position</td>
<td>180mm x 400</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Quarantine, terminate 2,4m from</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Holding Room 1, terminate 2</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Holding Room 2, terminate 2</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Holding Room 3, terminate 2</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Holding Room 4, terminate 2</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Holding Room 5, terminate 2</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Air Handling Unit</td>
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<td>Holding Room 6, terminate 2</td>
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<td>10</td>
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<td>Holding Room 7, terminate 2</td>
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<td>11</td>
<td>Air Handling Unit</td>
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<td>Holding Room 8, terminate 2</td>
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<td>12</td>
<td>Air Handling Unit</td>
<td>1</td>
<td>Holding Room 9, terminate 2</td>
<td>Diameter 50</td>
<td>2</td>
</tr>
</tbody>
</table>

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**ITS GROUP**

www.its-asia.com
Sample of an Ideal Animal Facility

- 4000 m² – 50,000 animals
- Separate dirty and clean corridor
- Separate entrance for people, animals and supplies
  - Animal entry connected to quarantine room,
  - Quarantine room connected to holding rooms and procedure room
  - Human entrance fitted with change rooms and air shower
  - Feed and bedding entrance connected to dirty corridor and to sterilizer
- Isolated Animal Suites
  - Holding rooms, procedure rooms and air locks in each suite.
  - Clean and dirty corridor connected to each suite
- Wash area centrally located
  - Waste storage connected to dirty corridor
  - Sterile room connected to clean corridor and clean storage room
- Mechanical rooms are externally located
  - Access for servicing
- Expansion space allocated
  - For future expansion of the facility