London South Bank University

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I-STUTE Project
- WP2.3 Data Centre Cooling

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Topics to be considered

1. Progress on project tasks

2. Development of data centre test facility
   - Overall aims
   - Main features
   - Options for air flow management
   - Equipment needed
   - Instrumentation and sensors
   - Evaluation of recovered heat

3. Planned experiments for data centre test facility

4. Future work

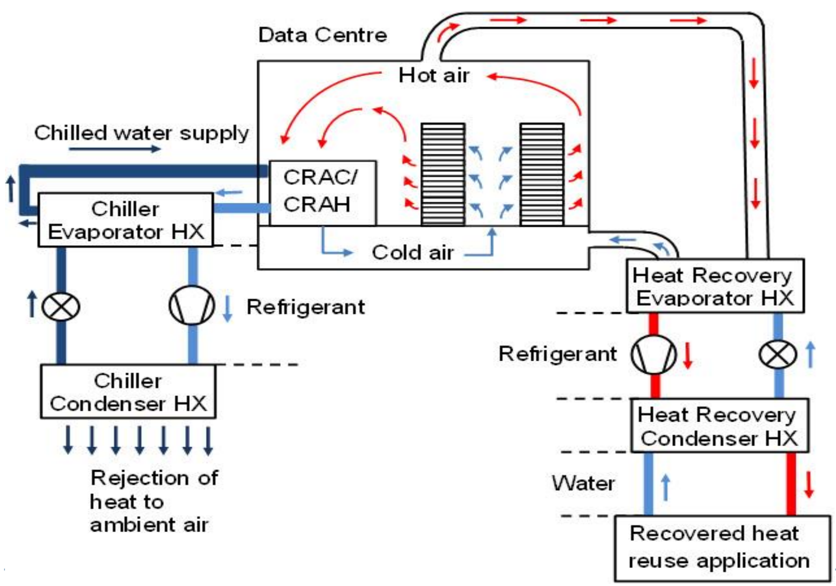
Project Progress

Task	Duration	Status
Working with Robert Tozer to finalise roadmap report	May-June 2015	New section on use of heat pumps for upgrading waste heat incorporated. RT is applying alternative method for classifying cooling technologies
Publish journal paper on waste heat recovery from data centres	May-June 2015	Paper submitted to ATE. Reviewers comments currently being addressed.
Design and construction of data centre test facility	May-Dec 2015	Currently underway. Progress to be reported below.

Development of data centre test facility

Overall aims:

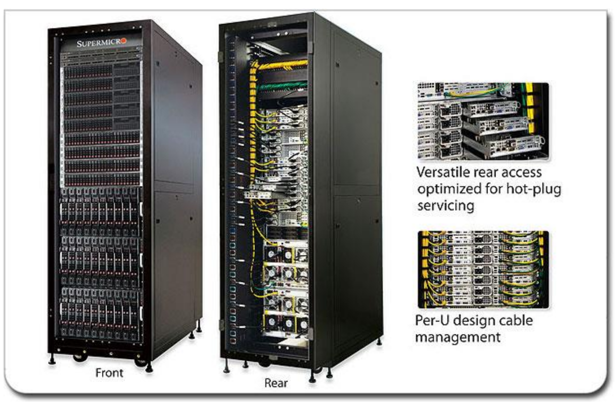
1. Construct a test facility to simulate a conventional server rack producing 5-10 kW of heat
2. Apply a range of thermal management approaches i.e. cooling methods and waste heat recovery approaches
3. Evaluate the quantity and quality of waste heat recovered in each case
4. Estimate the potential energy, carbon and cost savings available

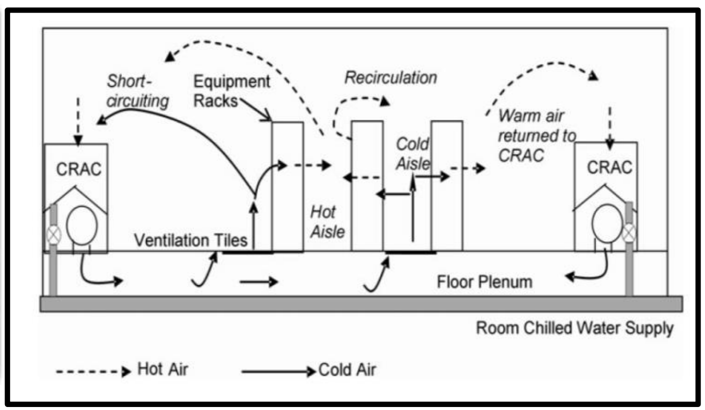


Schematic of remote air cooled data centre with waste heat recovery

Typical conventional data centre – main features

1. 42U racks – dimensions 0.6 m (w) x 1.07 m (d) x 2.0 m (h)
2. 42 x 1U servers or a combination of 1U up to 7U servers
3. Remote air cooling using CRAC/DX or CRAH/chilled water system
4. Reject waste heat directly to air or via chilled water to air
5. Hot aisle/cold aisle arrangement
6. Raised floor/plenum for delivery of cold air
7. May use cold air or hot air containment
8. CRAC condenser may be inside or outside data centre room

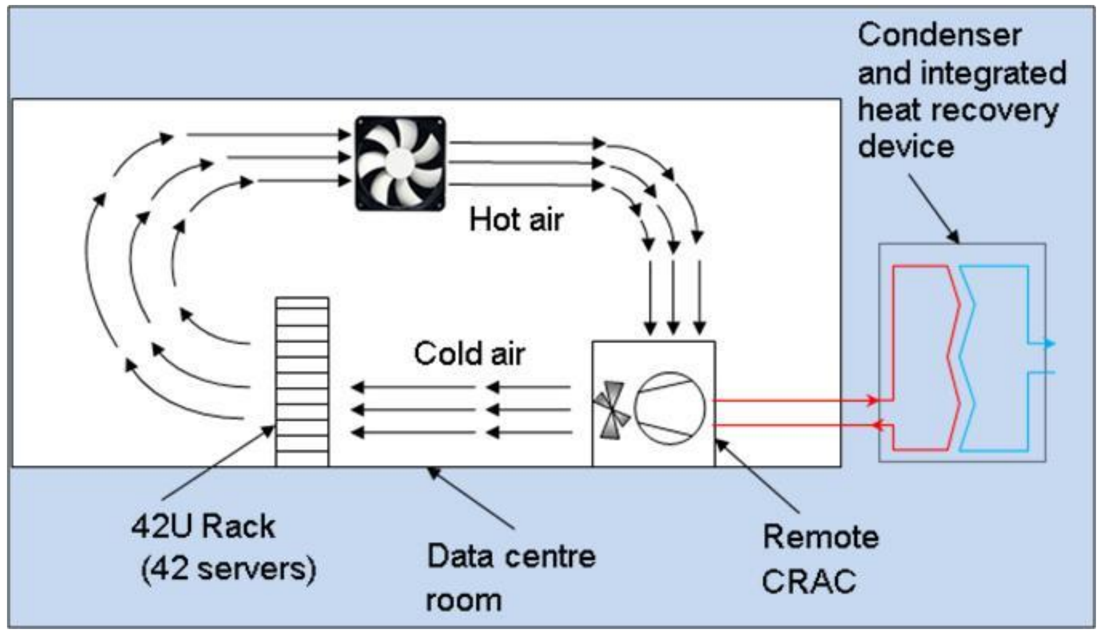




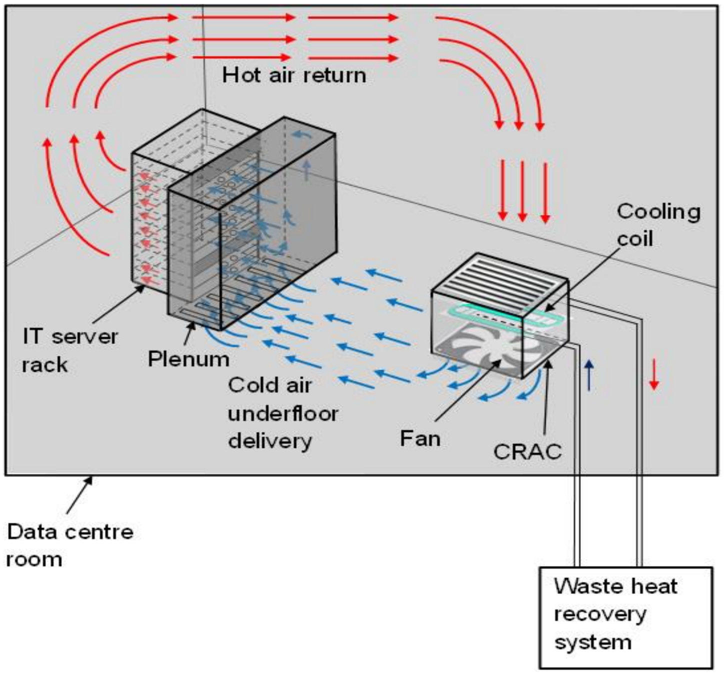
Development of data centre test facility

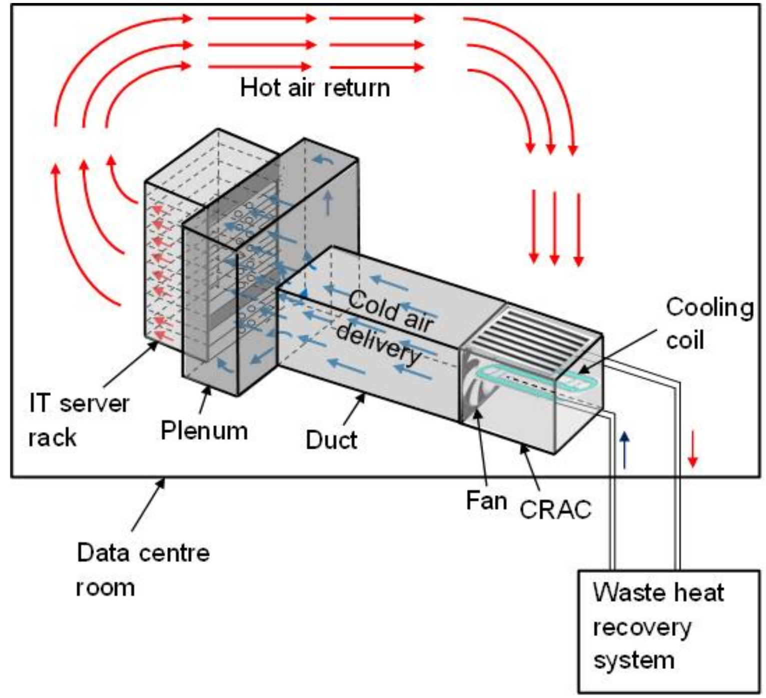
Planned LSBU test facility:

1. Single 42U (42 x 1U) IT server rack in a room of dimensions 3.8 x 6.4 x 2.7 m
2. Remote air cooled using CRAC/DX system
3. Waste heat recovery system using water cooled CRAC condenser to collect rejected heat
4. Upgrade of waste heat removed by CRAC to produce water at 70°C
5. Cold air or hot air containment



Options for air flow management I

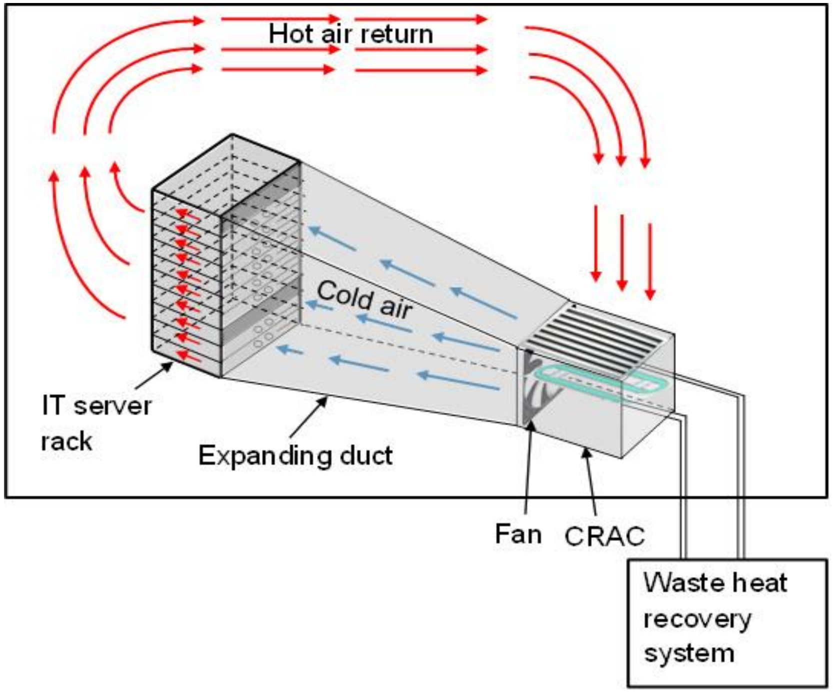


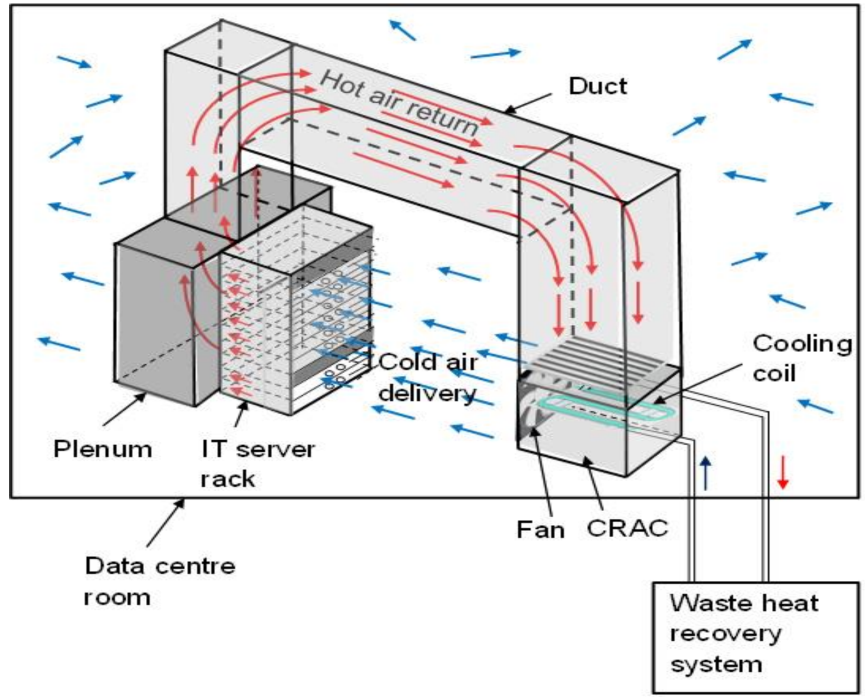


- Underfloor (plenum) cold air supply
- Cold air containment (using 2nd plenum)

- Cold air supply above floor
- Cold air containment using duct and plenum

Options for air flow management 2

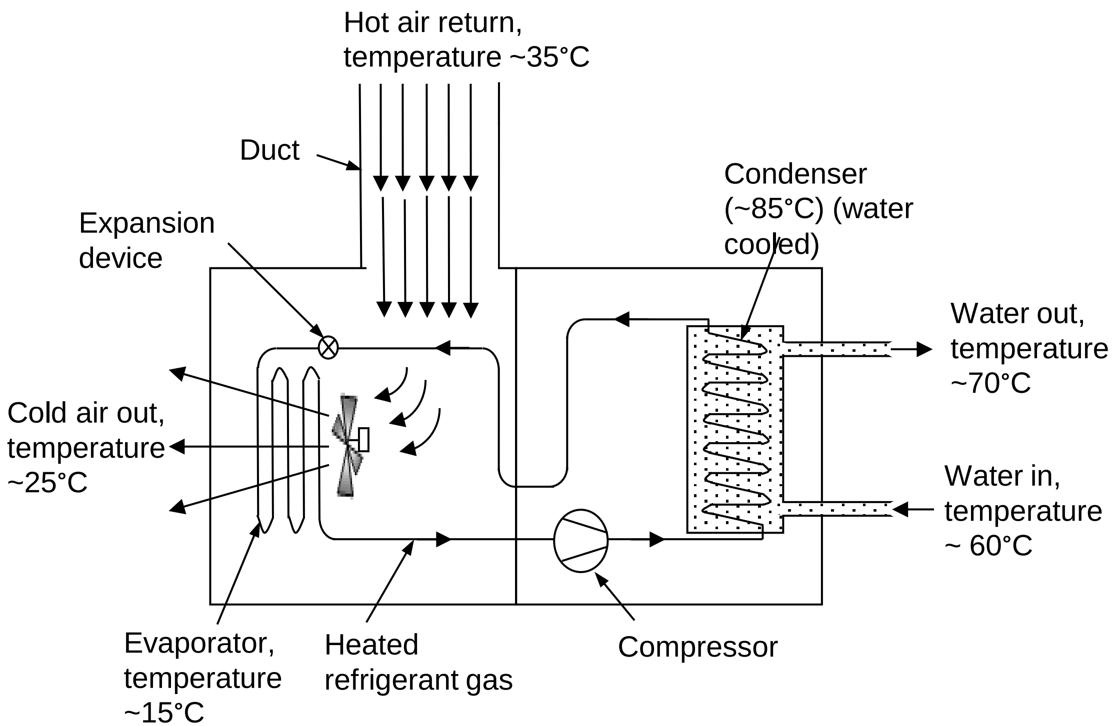




- Cold air supply above floor
- Cold air containment using expanding duct

- Cold air supply above floor (uncontained)
- Hot air containment using plenum and duct

Details of CRAC/heat recovery unit



- Typical hot air return temperature 30-35°C
- Server supply air temperature 20-25°C
- CRAC/heat pump will be used to boost temperatures to 85°C and then transfer to water
- Water supply/return temperatures 60/70°C or 50/70°C
- Use R134a
- Suitable components identified

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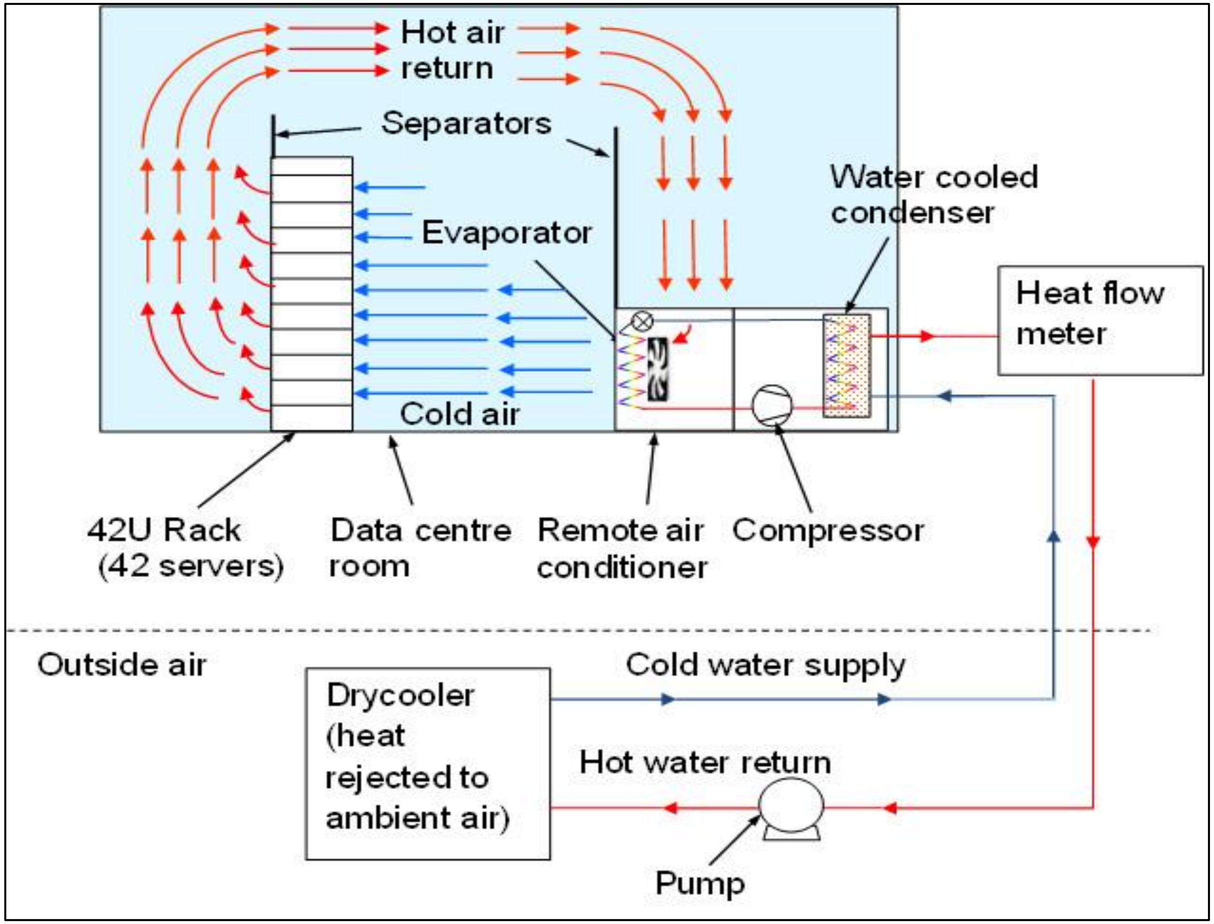
Overall design for test facility



- Water will be pumped to a dry cooler outside the laboratory
- Heat will be rejected to ambient air
- However, heat carried in water could be reused
- Heat flow meter will be used to quantify the recovered heat

(Note: initially cold air containment will be used in data centre room)

Data centre test facility – equipment needed

Equipment needed	Source identified
Data centre room (minimum height 2.7 m)	LSBU environmental chamber
42U IT server	Recycled server(s) from co-location operator
CRAC compressor	Bitzer
CRAC water cooled condenser	Swep
CRAC evaporator	Lu-ve
Control instrumentation	TBC
Water pump	TBC
Dry cooler	TBC

Data centre test facility – instrumentation and sensors

Ultrasonic heat flow meter

Electricity power meter

Sensor locations:

1. Temperatures of air at inlet, outlet and inside of server rack for top, middle and bottom servers
2. Humidity measurement at inlet to IT server rack and within data centre room
3. Air off temperature for evaporator and hot air return temperature at inlet to CRAC
4. Air temperatures at a range of locations within data centre room
5. Temperature of water at inlet and outlet of heat pump condenser
6. Ultrasonic heat flow meter used to measure heat flow out of heat recovery condenser and heat flow into condenser (difference = heat recovered)
7. Electricity power meter used to monitor power draw by IT servers (IT load)
8. Electricity use by CRAC compressor, evaporator fan and water pump also monitored
9. Pressure sensors used to determine pressure in cold air duct and in room

Evaluation of recovered heat

- The effectiveness of energy recovery from the data centre may be characterised as:

Energy Reuse Effectiveness (ERE):

$$\text{ERE} = \frac{\text{Total energy (CRAC/Heatpump + Fans + Water pump + IT server input - Reused (recovered) heat}}{\text{IT server input energy}}$$

or Energy Reuse Factor (ERF):

$$\text{ERF} = \frac{\text{Reused (recovered) heat energy}}{\text{Total energy}}$$

- The overall power usage effectiveness of the data centre (PUE) may be determined as:

$$\text{PUE} = \frac{\text{Total energy}\left(\text{CRAC/Heatpump} + \text{Fans} + \text{Water pump} + \text{IT server input}\right)}{\text{IT server input energy}}$$

- Other measurements of temperatures, humidity, heat energy and flow rates will provide further characterisation of the system

Planned experiments for data centre test facility

It is proposed that the test rig will be used to evaluate:

1. IT input loads e.g. 5% of maximum power capacity, up to 100%
2. CRAC cold air temperatures (and flow rates) and hence IT server rack inlet temperatures e.g. 15 to 27°C
3. Duct fan speed and hot air return temperature
4. CRAC evaporator temperature e.g. 5-17°C
5. CRAC condenser temperature e.g. 60-90°C
6. CRAC condenser water inlet/outlet temperature and flow rate (i.e. heat recovery conditions) – to be determined.

Future work

Activities	Duration	Deliverables	Due date
Publish roadmap report	May- June 2015	Roadmap report	1st Aug 2015
Design data centre/ heat recovery test facility	May-July 2015	Completed plan	1st Aug 2015
Assemble equipment and install/ connect	Aug-Sep 2015	Completed facility	1st Oct 2015
Install monitoring instrumentation and sensors	Oct 2015	Completed monitoring system	1st Nov 2015
Commission and test	Nov-Dec 2015	Operational facility Report on test facility construction	1st Dec 2015 1st Feb 2016