Data Centre Design and Operational Best Practices

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i3 Solutions Group

ABB
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## Causes of Failure in Data Centres

<table>
<thead>
<tr>
<th>FAILURE</th>
<th>WHO?</th>
<th>WHAT?</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Design</td>
<td>Consulting Engineer</td>
<td>Human</td>
</tr>
<tr>
<td>Commissioning or Test Deficiency</td>
<td>Commissioning Engineer</td>
<td>Human</td>
</tr>
<tr>
<td>Equipment Design</td>
<td>OEM</td>
<td>Human</td>
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<tr>
<td>Equipment Failure</td>
<td>No one</td>
<td>Machine</td>
</tr>
<tr>
<td>Operator Error</td>
<td>Ops</td>
<td>Human</td>
</tr>
<tr>
<td>Installation Error</td>
<td>Contractor</td>
<td>Human</td>
</tr>
<tr>
<td>Maintenance Oversight</td>
<td>Ops</td>
<td>Human</td>
</tr>
<tr>
<td>Natural Disaster</td>
<td>Act of God</td>
<td>Various</td>
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</table>
High Profile Data Center Outage

- Hot summer day, utility power outage, data center at full load 7.2MW
- Four 2.5 MW generators installed (N+1 configured)
- One generator fails to start (now N configured)
- Running on 3 generators
- 30 minutes later another generator fails (now N-1 configured)
- Now 5MW capacity supporting a 7.2MW load
- Remaining generators overload ≈ 60 seconds
- Cooling plant has no power
- IT equipment begins shutting down (over-temperature)
- DC data centre runs on UPS for another 30mins (2N 15mins each side)
- Total data center failure 30 minutes later
- Utility restored after 6 hours
- Data Center fully restored after 8 hours later

  **Numerous senior managers fired**
  **Worldwide enquiry launched**
  **Litigation and financial penalties**
  **Highly publicized therefore reputational damage**

Why did they have to lose the whole data centre? Why couldn’t the data centre load be reduced from 7.2MW to 5MW? There was enough time.
Data Centre Outage – Root Cause

- Data centre operations under pressure to keep costs to a minimum
- FM tendered and outsourced to the lowest of three bidders
- FM team were technically skilled but did not receive adequate transitional training from previous contractor or DC owner
- Incident occurs 3 months after new FM contractor appointment
- DC owner decided to scale back maintenance from pro-active to reactive
- Pneumatics systems not fully maintained or regularly tested
- On the day the Gen No1 failed to start due to a blown seal in the Pneumatic System 1
- Ops didn’t know how to manually re-route the pneumatic system to start Gen 1
- Data centre failure was inevitable
- Huge negative impact on the DC owner
- Data centre CIO tasks us with an independent ‘no-holds barred’ review

What was the root cause, who was responsible and why?
Depth of experience is a combination of relevant working experience, education (cognitive knowledge), skills (psychomotor) and effective learning, teamwork, awareness, knowledge sharing, communication etc.
Why is 100% Uptime Impossible

All mechanical, electrical and electronic components are characterised by a Mean Time Between Failure, typically shaped like a bathtub.

**The Bathtub Curve**

- **Burn In Period**
- **End of Life Period**

**Time**

**Failure Rate**

**Constant Failure Rate $\lambda$**
Operational Best Practices

- Plan for Failure
- Manage Capacity
- Standard, Maintenance and Emergency Operating Procedures
- Label Everything
- Staff Levels
- Training
- Record Management
- Communications
Human Error

- There is no such thing as 100% uptime
- Analyses of space, nuclear, aviation, chemical and other industries and reports that 80% of all failures are down to human error
- This correlates with the uptime institute's reports of approximately 70% of data centre failures attributed to human error
- Human failure rate is explained by the Universal Learning Curve which is an exponential curve that varies in terms of organizational experience and operators' depth of experience.
- Gradually we all become complacent and therefore it is better to plan for an inevitable rare failure (100,000 to 200,000 hours accumulated experience), than to assume / believe that the failure will never happen.
Work in the Data Centre

- All operations need peer review, rehearsals and full switching plans
- Also need approval of the business or customers to carry out the work
  - Program of work to be carried out
  - Time frame
  - Risk review
  - Roll Back plans i.e. when to Roll Back of program to stay within operational widows
- Switching plans
  - Switching schedule of all steps
  - Tags fixed to each breaker/switch with breaker/switch reference number and switching plan step number
Operating Procedures (SOPs and MOPs)

- **Standard SOPs (Standard Operational Procedures)**
  - Procedure will generally have prior planning and approval required before operating and implementing and may cover multiple devices and equipment.
  - e.g. Software upgrades such as UPS firmware promotion.

- **Planned MOPs (Maintenance Operating Procedures)**
  - As the SOP but written specifically to cover a maintenance activity.
  - e.g. Put UPS into bypass for inverter maintenance.
  - Permit to work.
  - Also included would be electrical Single Line Diagram and switching tags.
Emergency Operating Procedures (EOPs)

- Absolute minimum procedure required to safely and reliably operate the equipment in a fast response incident
- Example EOP to open and close an ACB (Air Circuit Breaker) rated at 4000A

World Data Centers Engineering Operations
Emergency Operations Procedure

WDC EOP (E) 009 - Reset of tripped incoming VCB (Vacuum Circuit Breaker)

Procedure:
1. Obtain permission from Datacentre Manager before attempting to reset the VCB.
2. Unlock the VCB panel and ensure it is locked securely.
3. Check that the VCB is clear of any obstructions and is not overheated.
4. Unlock the VCB contactor to ensure the High-Low Circuit is opened.
5. Remove the trip and reset the VCB in the LOCA.
6. On the control panel, ensure that the system is in the desired state.
7. Prevent the switch to be opened, and ensure the circuit breaker is open.
8. On the main circuit breaker, ensure the circuit is in the desired state.
9. Verify that the circuit breaker is in the desired state.
10. Ensure that the circuit breaker is in the desired state.
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17. Ensure that the circuit breaker is in the desired state.

Notes:
1. If the incoming VCB (VCC) is tripped, the Datacentre system would have automatically switched to the VCC.
2. Before you attempt to reset the VCB, ensure that it has not been tripped on an earth fault, which can be identified by the Earth fault alarm.
3. Once the VCB is reset, the Datacentre system will switch to the VCC, and the building will be back in normal operation.
Data Centre Infrastructure Management

- Capacity planning, forecasting, simulation, analytics
- Optimization, operational BI, load management
- Data management, integration and reporting
- Environmental monitoring and reporting
- IT Services and Systems Management, VM Mgmt
- Power management, power capping
- Cooling control, BMS, alarms etc.
- Asset, configuration and change management
- Building Life, Safety, Security
- Power, energy measuring, modeling
- Data collection, meters, sensors
Data Centre Design Begins with Understanding...

**Business Processes:**
- **Application Chain:**
- **IT Infrastructure:**
- **MEP Infrastructure:**

**Functional elements**
- **Applications, Application Management**
- **Compute, Network, Storage, VMs and Ancillaries**
- **Power, Cooling and Ancillaries**
Design Best Practice

- How is application resilience implemented (onsite clusters, async/sync mirroring)
- How is technology infrastructure resilience implemented (network/compute/storage)
- What SLAs are required of the data centre
- Unless we can answer these questions everything else in M&E design is guesswork
- Then how skilled are the operations team in implementing EOPs
- Now we can start the M&E and building design:
  - How big, what capacity, what density, growth plan, how many dc modules
  - Watts per square meter vs. kW per rack
  - Business SLAs determine the design
  - Design determines the budget
  - Business TCO balance and CSR drives PUE

All this before we’ve decided what to build and where to build it!!
Cost Optimization Requires Reliability and Availability Analysis

Adding redundant components improves availability and is expensive.

Adding too much redundancy eventually causes availability to reduce due to complexity.

Where are you on the curve?
## Reliability Modelling

### Using Probabilistic Risk Assessment

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<th>Gen</th>
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<th>ASTS</th>
<th>Dual Cord</th>
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Why do Reliability Modelling?

- Quantifies the risk of failure
- Identifies vulnerabilities
- Alignment of business mission and performance
- Create action plan for site hardening
- Performance benchmarking
- Support business case expenditure

What is involved?

- Step 1: Develop Resiliency Metrics and Quantify Reliability Expectations
- Step 2: Develop RBD Model and Evaluate Redundancy
- Step 3: Perform Reliability Modelling
- Step 4: Upgrade/Alteration Recommendations and Performance Benchmark Findings
Results

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Reliability Data Sources

- The reliability data sources used are from IEEE Standard 493-1997 Gold Book and Reliability Analysis Center NPRD-95
- Use of manufacturers data is avoided due to the impartial figures quoted
Now are we Ready to Decide

- Design topology (concurrently maintainable, fault tolerant, hybrid etc.)
- Module sizes (250kW, 500kW, 1000kW etc., 200sqm, 400sqm, 600sqm etc.)
- Module types (fixed or mixed density, CRAU, In Rack, In Row etc.)
- Type, size and configuration of cooling (Water or air cooled chiller, economizers, DX)
- Type, size and configuration of power (block redundant, distributed redundant, 2N etc.)
- Type of UPS (fuel cell, rotary, static)
- Raised floor or no raised floor
- AC or DC power
- Reserves (power, water and gas)
- Density (3, 5, 7, 10, 15, 20, 25, 30 kW per rack etc.)
- Single or hybrid tier system
- DCIM, BMS, SCADA control
Common Design Errors

- Design with the operator in mind – avoid multiple bypasses and other complex operations
- The most unreliable component in the data centre is always batteries
- Followed by anything that has mechanical moving parts (chillers, pumps, relays etc.)
- Anything more than 5 minutes of battery autonomy is a waste
- Hot & Cold aisles are wasteful without containment or precision airflow
- Data centres comprises business service lines of varying priority, design accordingly
- Mirrored tier data centres are orders of magnitude more reliable than a single data centers
- When looking at PUE, consider partial load, it's more important than full load
- Tier 4 can be justified where the frequency of generator ops is high due to a weak utility
- The tier system is a guide, nothing more
- The key data centre design standard is now ANSI – BICSI 002 2011
- Cooling economizers do not provide good ROI in the tropics (Sensible PUE target 1.4)
- There are new cooling technologies that will radically improve tropical PUE to around 1.15
- Dynamic workload allocation will force data centres to be more responsive to applications.
Key Design Rules

- Understand the IT strategy, engage with your IT group, understand their constraints
- Don’t add unnecessary redundant paths - complexity causes errors
- MEP, IT infrastructure and application chains are aligned
- The design is scalable, businesses need to be agile, so does the DC
- The design is flexible, experience shows the future isn’t always predictable
- Design for operations, remember the easier it is to operate, the better it is
- Don’t overprovision – it’s easy to do, it’s wrong, don’t do it
- The business SLA requirements are met, all DC stakeholders need to be aligned
IT Stack Alignment

- C-Level prioritize service lines (highest to lowest)
- Identify application dependencies
- Map applications to physical devices – dedicated and virtualized
- Configure VMs based upon C-Level category priorities
- Avoid mixed priorities on VMs where possible
- Locate VMs and dedicated platforms physically based on priority levels
- Configure Cooling to service line priorities
- Configure Power to service line priorities
Locate Common Priorities Together
Dedicated Servers and VMs

Increasing Priority (P1 highest)

A Side

B Side
Data Centre: Prioritized Cooling
Data Centre: Prioritized Power
Thank You

Ed Ansett
Managing Partner
i3 Solutions Group