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# Capstone Phases 1-3

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# Data Center Phase 1 Design Plan

## Mission statement

To empower World Kinect Corporation's aviation division with a highly secure, scalable and energy efficient data center. We will deliver energy efficiency, environmental responsibility, and sustainable practices, to ensure long-term operational success and support critical aviation services globally.

## Design Footprint

Our design footprint is centered on creating a green, modular data center optimized for aerospace operations. The design integrates the following core elements:

- **Space Allocation & Infrastructure Layout:**
  A modular design that allows for scalable expansion is planned. We have allocated specific zones for server racks, cooling systems, and power distribution.
  Solid-back racks with integrated chimney structures facilitate effective hot/cold aisle separation and airflow management.
  *Example for **SmartRack** shows a modular rack. The modular design allows for rapid deployment of additional capacity with minimal downtime.*

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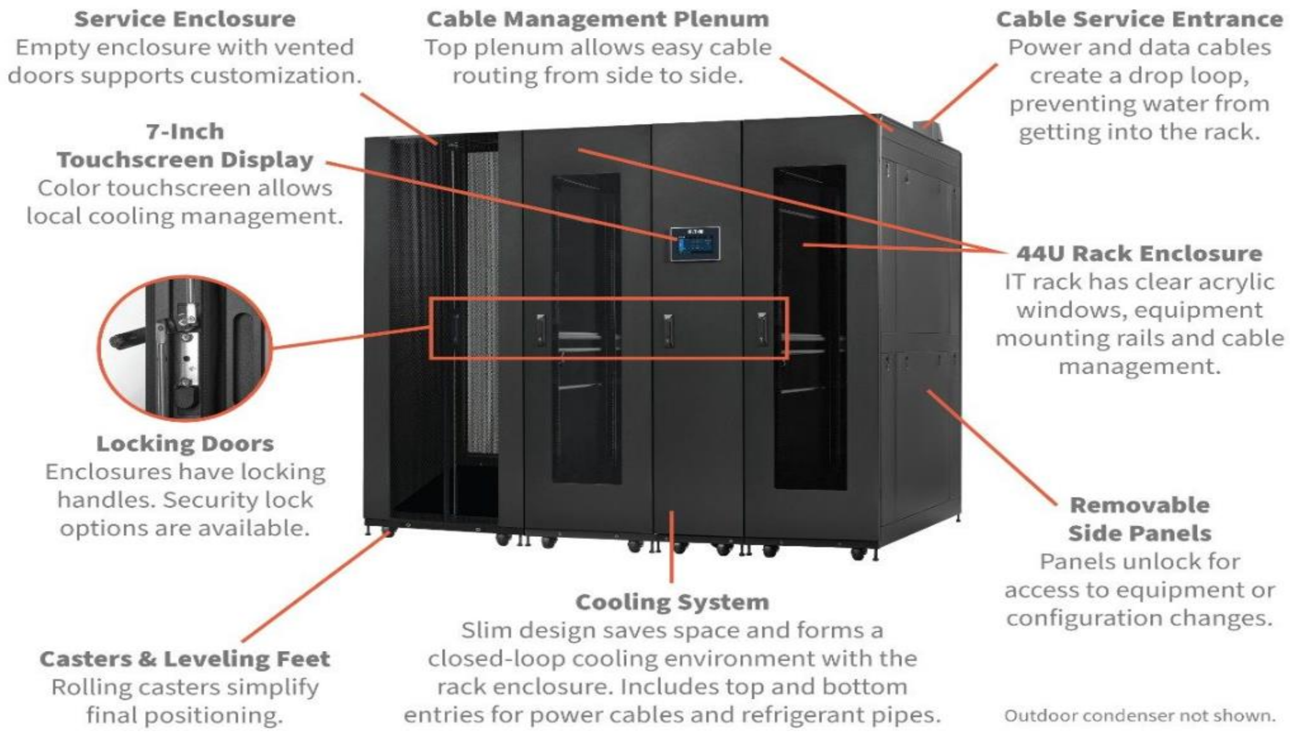


Each module incorporates standardized power, cooling, and network infrastructure, enabling seamless integration and scalability. During expansions, redundant systems and careful planning will limit disruptions to WKC's operations.

- **Cooling System & Energy Efficiency:**
  A closed-loop, chilled water-cooling system is integrated into the design. This system leverages waste heat recovery, using on-site solar power combined with battery storage. Computational Fluid Dynamics (CFD) simulations inform the "hot air containment" strategy, ensuring optimal routing of warm air back to the Air Handler Unit (AHU) for re-cooling.
  *See the attached diagram "Closed-Loop Cooling Design" for a visual representation of our approach.*

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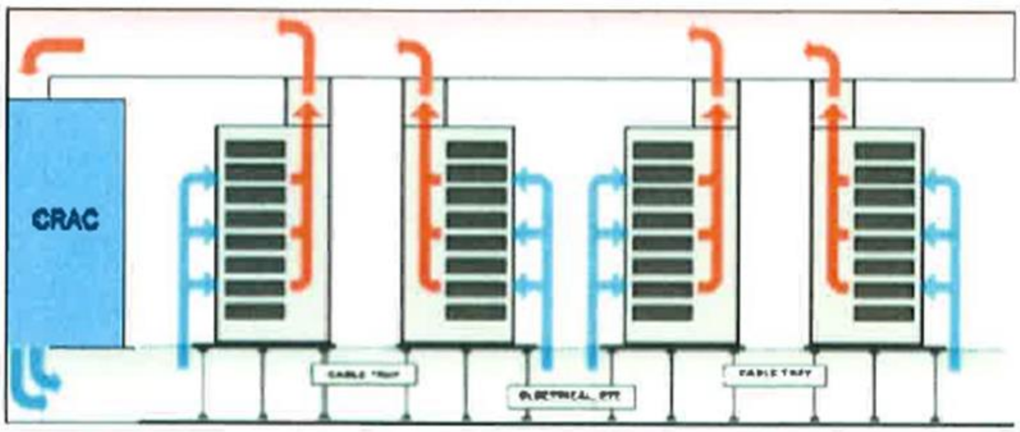
A Closed looped cooling design (pictured below) separates cool air distribution and warm air return paths, which are isolated from the open room air. CFD (Computational Fluid Dynamics) were used to analyze the airflows. This "hot air containment" is important as it allows us to control the warm airflow path and funnel it back into the AHU (Air Handler Unit). The AHU contains heat exchanger coils which use chiller water to cool the warm supply air and distribute it back out into the Data Center. Racks with solid backs and chimneys will be installed to isolate hot and cold air.




- **Sustainable Construction & Materials:**
  We are incorporating eco-friendly materials such as Cross-Laminated Timber (CLT), recycled steel, and recycled concrete. These choices reduce our carbon footprint and support rapid, sustainable construction.
  *For further details, consult "Building Sustainable Data Centers: Innovations in Construction and Energy Use."*
- **Human & Smart Tech Integration:**
  The design includes an onsite team supported by AI-powered predictive analytics and a digital twin platform. These technologies enable real-time monitoring, predictive maintenance, and continuous optimization of energy and performance.
- **Aerospace Integration:**
  The building architecture draws inspiration from aerodynamic design principles. Additionally, provisions for edge computing and high-bandwidth connectivity ensure seamless communication for aerospace operations. Below are a few architectural designs.

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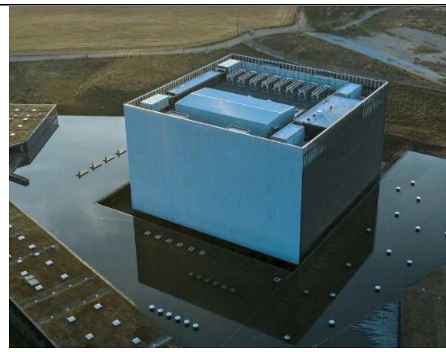
|  |  |  |
| Harbin Data Center - One of the largest data centers globally.<br><br>https://www.webopedia.com/technology/10-biggest-data-centers-in-the-world/ | Portugal's Covilhã Data Center - Mountain Air Keeps One of Europe's Largest Data Centers Cool. Designed to keep the servers running efficiently even during heat waves.<br>https://www.bloomberg.com/news/features/2018-12-04/the-covilh-data-center-s-moat-and-mesh-like-facade-keeps-it-cool | NextDC Merlot Datacenter - An increasing number of urban/suburban data centers are paying attention to façades, landscaping, and tastefully imbuing the design with local and regional flavor.<br><br>https://www.hdrinc.com/portfolio/merlot-2-data-center |

## Capacity

Our capacity planning has been developed based on both current requirements and anticipated future growth, ensuring that the data center is robust and adaptable. The datacenter will have a total power capacity of 20MW – 40MW, primarily sourced from renewable on-site solar installations and generators and battery storage will provide redundant backup power.

- **Server & Rack Capacity:**
  The data center is designed to house **500 – 1,000 racks**. Approximately 50–70% of these racks will support high-performance computing (HPC) with custom servers optimized for GPU-heavy aerospace simulations, while 30–50% will serve general-purpose tasks like management, storage, and backup. Each rack can house up to 44U of rack mounted equipment Each module will have dedicated power distribution unit (PDUs). Power will also be redundant in each rack with 2 ***mounted PDUs*** with their own dedicated outlet on different circuits.
- **Power Capacity:** 20MW – 40MW in total. At least 20kW per rack, including cooling. For custom servers that provide more demanding workloads up to 30kW per rack.
- **Storage Capacity:**
  The design accommodates **50–100 PB** of storage, leveraging high-speed SSD-backed storage arrays for rapid data processing and analytics.

- **Efficiency Metrics:**
  We aim for a Power Usage Effectiveness (PUE) of **1.05 or lower** by employing liquid cooling, and AI-based workload optimization to minimize energy wastage. Also, free cooling based on our location (Washington state) due to its cool climate.
- **Applications & Workload:**
  The center will support aerospace simulations (fluid dynamics, aerodynamics), AI-driven safety modeling, and real-time analytics, ensuring that both core HPC tasks and operational management are optimally supported.

## Site Location

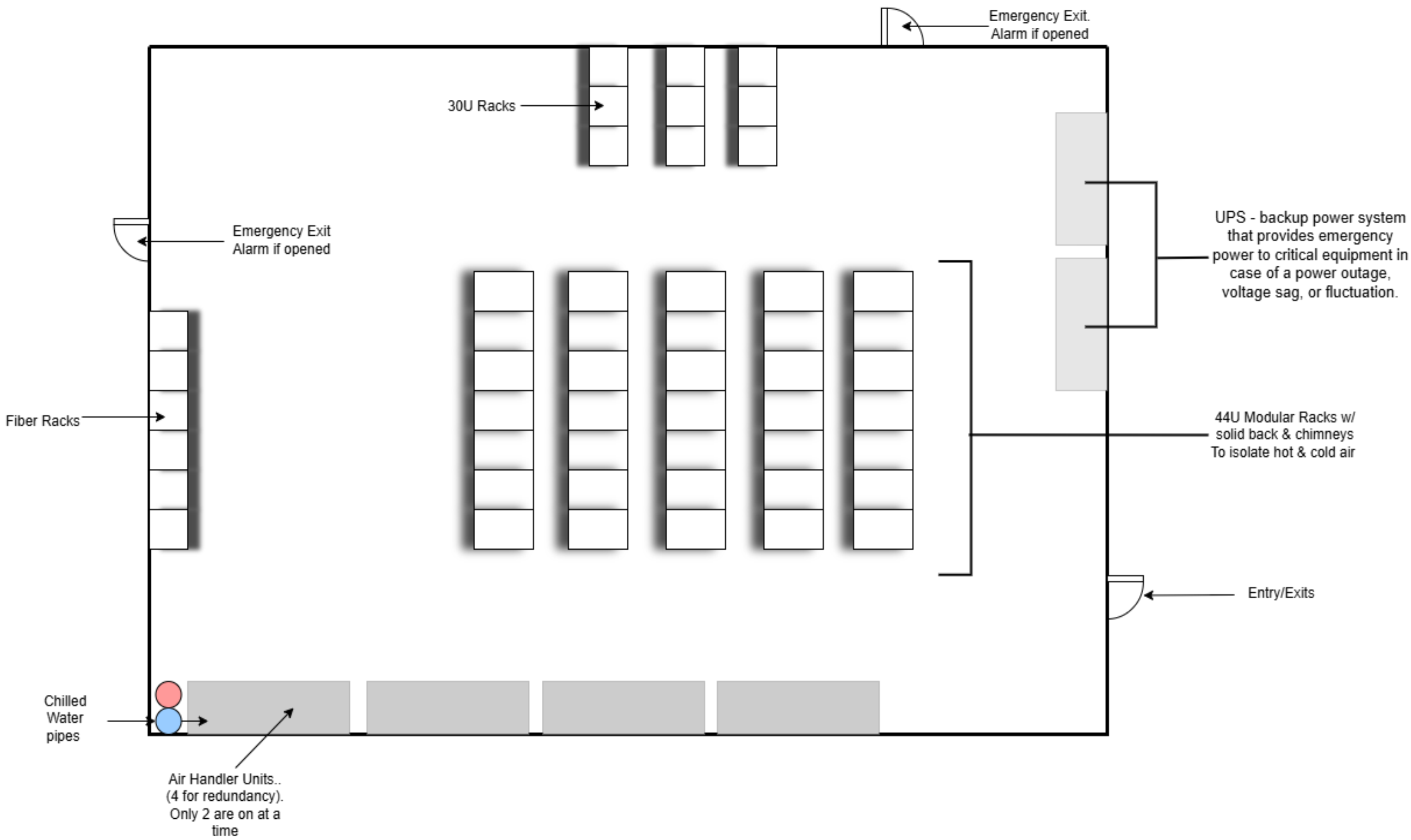
**Chosen Location: Washington State**

After evaluating various geographic options using our weighted decision matrix, Washington state has emerged as the ideal location for the data center. Key factors influencing this decision include:

- **Abundant Renewable Energy:**
  Washington is renowned for its extensive hydroelectric power generation. This aligns perfectly with our goal of maximizing renewable energy use and maintaining a low carbon footprint.
- **Favorable Climate for Free Cooling:**
  The region's moderate climate minimizes the need for artificial cooling. This natural advantage improves energy efficiency and contributes significantly to achieving our target PUE of 1.05 or lower.
- **Lower Operational Costs:**
  With lower energy costs and strong infrastructure support, Washington offers an attractive balance between upfront investment and long-term operational savings.
- **Robust Infrastructure & Connectivity:**
  The state's well-established fiber-optic networks and connectivity to major tech hubs ensure reliable, high-speed data transmission—essential for both core aerospace applications and general data center operations.
- **Risk Mitigation:**
  Washington state exhibits a lower incidence of extreme weather events compared to other regions, reducing operational risk and supporting continuous uptime.
- **Decision-Making Approach:**
  A weighted decision matrix was used to evaluate factors such as renewable energy access, sustainability initiatives, cost-effectiveness, network connectivity, tax incentives, and risk mitigation. Washington state emerged as the optimal choice across these criteria.
- **Tax Considerations:** According to the Department of Commerce (2018), the lack of tax incentives in certain urban areas of Washington places them at a disadvantage compared to other regions. "Urban Washington counties that do not have access to sales and use tax

exemptions for data centers are at a competitive disadvantage to other urban data center markets such as Portland that either do not have sales tax or that offer tax incentives that abate the sales tax" (p. 26). This suggests that without similar incentives, Washington may struggle to attract new data center investments compared to its tax-friendly competitors.

**Preliminary Physical Diagram:**




Dimensions are not exact. The layout is expected to change, and more information needs to be added. Such as power and cable management. Does not account for security measures yet or staff. ***Made with draw.io.***

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# Infrastructure

## Flooring

**Hard floors** offer greater structural reliability, ease of maintenance, and flexibility for modern cooling strategies such as hot aisle containment and overhead cooling systems. This approach not only enhances operational uptime but also simplifies cable management through dedicated overhead solutions.

- **Efficiency**: Ideal for liquid immersion cooling, in-row cooling, and hot aisle containment. Eliminates underfloor airflow loss.
- **Structural Benefits**: Higher weight-bearing capacity to support heavy racks and equipment. Lower upfront and long-term costs with no need for raised platforms.
- **Materials:** Conductive Solid Vinyl Tile - Easier to install than other floor material types. Provides some static protection (though not as much as rubber). Can be laid over existing flooring, reducing labor costs.

## IT equipment

**Racks**

- Deploy high-density 42U racks to maximize vertical space efficiency
- Implement hot aisle/cold aisle containment with solid-back racks and chimney structures
- High-Density Configurations to Accommodate HPC workloads and modular scalability.
- Seismic-Rated Racks to ensure stability in case of environmental disturbances.
- Use racks with integrated cable management and smart PDUs for real-time power monitoring
- **Hot-Swap Capabilities:** Design racks with hot-swappable modules that allow for easy insertion or removal of systems without shutting down the entire rack.

**Switches**

- Cisco Nexus 9300 Switch Series
    - Commonly used in spine-leaf data center architectures due to its high performance, scalability, and low latency.

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**Servers**

- For HPC workloads: Deploy Dell PowerEdge servers with AMD EPYC CPUs for 35% lower power draw
- For general-purpose computing: Utilize blade servers for density and energy efficiency
- Implement server virtualization using VMware vSphere to increase utilization and reduce physical server count by 10:1


**Storage**

- Primary storage: Pure Storage FlashBlade all-flash arrays for high performance and 50% less energy consumption than HDDs
- Secondary storage: Implement software-defined storage for scalability and easier management
- **RAID & Redundancy**: RAID 10 for performance and redundancy in critical systems. Erasure coding for fault tolerance in object storage.
- **Archival needs:** Deploy object storage solutions for large datasets and long-term retention

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**Networking Hardware**

- **Core network:** Implement high-speed 400G spine-leaf architecture
- **Edge network:** Deploy redundant top-of-rack switches for each rack
- **Load balancing:** Implement F5 BIG-IP appliances for traffic distribution and application delivery

**Redundancy Considerations**

- Implement N+1 redundancy for all critical systems
- Use redundant network connections with automatic failover mechanisms
- Deploy clustered servers and RAID storage configurations for data protection

**Scalability**

- Choose modular equipment that allows for easy expansion from 500 to 1000 racks
- Implement scalable spine-leaf network topology to accommodate future growth
- Use software-defined solutions (SDN, SDS) for easier upgrades and capacity expansion

**Energy Efficiency**

- Select ENERGY STAR certified equipment where possible
- Implement intelligent power management features across all IT equipment
- Use liquid cooling solutions for HPC racks to reduce overall cooling energy consumption

## Power & Energy efficiency

**Power Usage Effectiveness (PUE) Optimization**

- **Data Center Infrastructure Management (DCIM):** Tracks energy consumption at the rack and module levels.
  - **Tailored Metrics:** Baseline PUE metrics for HPC and general-purpose workloads to pinpoint inefficiencies allowing us to identify and address inefficiencies specific to each type of application.
  - **Software:** DcTrack & PowerIQ by Sunbird

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## Efficient Cooling Systems

- **Free Cooling:** Leverages Washington State's cool climate to reduce mechanical cooling demands.
- **Water-Side Economizer:**
    - Provides consistent cooling, ideal for high-density environments.
    - Integrates with chilled water loops for heat reuse.
    - Higher water consumption and maintenance requirements.
- **Closed-Loop Chilled Water Cooling:** AI-driven cooling adjustments with waste heat recovery.
- **Hot/Cold Aisle Containment:** Solid-back racks with chimney structures prevent hot and cold air mixing.
- **Liquid Cooling Solutions:** Direct-to-chip cooling for HPC racks, reducing overall cooling energy consumption.
- **Advanced Airflow Management:** CFD analysis ensures optimized airflow and minimal cooling overhead.

## Renewable Energy Integration

**Hydroelectric Power:** Primary renewable energy source given Washington State's abundant hydropower resources.

## Energy-Efficient IT Hardware

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- **Low-Power CPUs & Efficient Power Supplies:** Optimized for HPC workloads.
- **Virtualization:** Maximizes resource utilization, reducing the number of physical servers.
- **Advanced Cooling Components:** Hardware with high thermal tolerance reduces cooling demand.

**UPS and Power Distribution Optimization**

- **Dedicated PDUs:** Each module has PDUs with dual-circuit redundancy.
- **Smart Power Strips & PDUs:** Real-time monitoring to prevent phantom loads and optimize distribution.
- **Customizable Load Management:** Supports 20kW-30kW per rack.
- **High-Efficiency UPS Systems:** ENERGY STAR-certified, reducing energy losses by 30-55%.
- **Redundant Small-Scale UPS Modules:** Improves efficiency, as demonstrated in Exelon's data center upgrades.
- **AI-Driven Power Adjustments:** Monitors workload intensity and optimizes resource allocation in real time.

**Heat Reuse Systems**

- **Heat Recovery:** Captures waste heat from servers for building heating or industrial applications.
- **Energy Cascading:** Directs excess heat to neighboring facilities, contributing to broader district heating systems.

  Considerations:
- Heat reuse systems depend on local demand and infrastructure compatibility.

**Additional Energy Efficiency Measures**

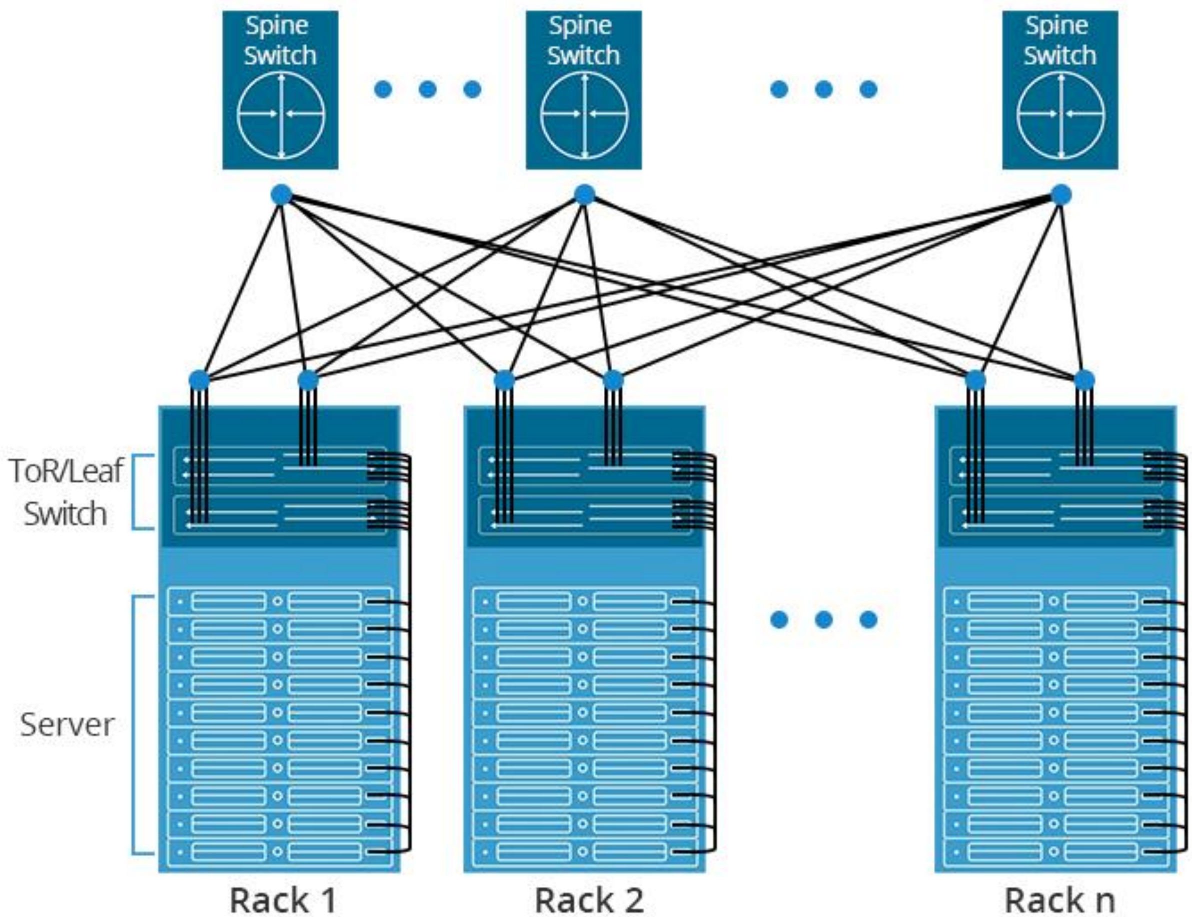
- **LED Lighting:** Motion-activated, low-wattage LED lighting reduces unnecessary power usage.
- **Insulated Doors & Air Seals:** Minimize thermal leakage, maintaining cooling efficiency.
- **Fire Suppression Systems:** Non-conductive, energy-efficient solutions to protect critical infrastructure.
- **Cable Management & Power Routing:** Organized power cabling reduces resistance and maintains efficiency.
- **Adopted Standards:** Pursue ENERGY STAR, LEED, or ISO 50001 to benchmark and validate efficiency improvements.
- **Regular Audits:** Continuous audits help in identifying improvement areas and maintaining standards.

## Network Cabling

- **Spine-Leaf Architecture**:
  - Two-tier network with spine and leaf switches.

        - Place Spine switches in a dedicated rack at the end of the row.
        - Every Leaf switch in each rack connects to all Spine switches for redundancy and load balancing.
        - Spine switches do not connect to each other—only to Leaf switches.
        - Place one Leaf switch per rack at the top of the rack.
        - Leaf switches connect to servers, storage, and other network devices in their rack.
    - Fiber optic cabling between layers for high-bandwidth, low-latency connections.

The leaf switches are not connected to each other and spine switches only connect to the leaf switches (and an upstream core device).



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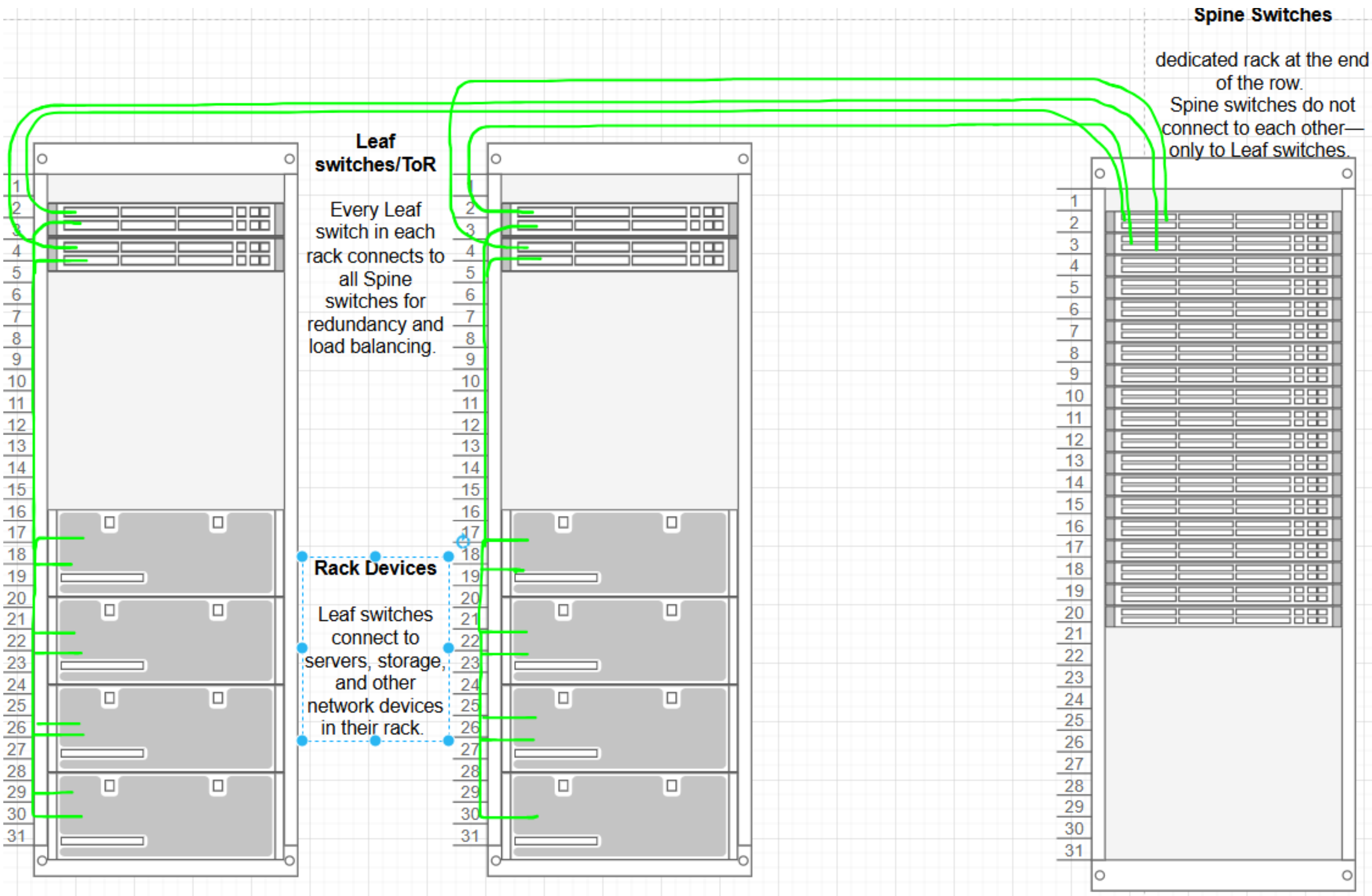


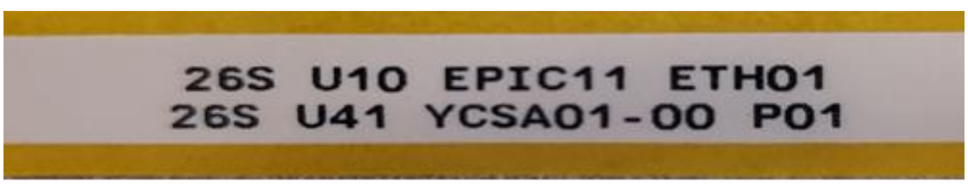

- **Cable Pathways**:
  - Overhead perforated trays for horizontal cabling. Trays shall have a maximum depth of 6".
  - No underfloor routing to maintain airflow.
  - Cabling should be run along different routes for redundancy
  - **Optimal Cable Runs:** Adhering to industry-recommended cable lengths (e.g., keeping copper runs within 100 meters) helps maintain signal integrity and performance. Avoiding excessive cable lengths also promotes better airflow.
- **Cable Length Management**:
  - Pre-Terminated Cabling Systems:
    - Ideal for scalability and quick upgrades.
    - Reduces labor costs and on-site termination errors.
    - Pre-cut and labeled cables for optimal organization and airflow.

- **Separation of Cabling Types**

- Use separate trays for copper and fiber. Improves administration, minimize damage to smaller diameter cables.
- Retainer clips for power cords to prevent power cords form becoming loose and disconnecting.
- Velcro ties instead of zip ties to allow adjustments and avoid damaging cables. Also allows grouping a like cables together for a cleaner look.
- Bundle cables loosely to avoid excessive heat buildup.

<u>Color coded cables</u>
Power: Black/Green
Fiber: Aqua
Ethernet: Blue/Black (10 gigs)
LAN: Orange

- **Cable Labeling & Documentation**
  - **Standardized Labeling**:
    - Labels on both ends of cables before routing.
    - Placed 3-6 inches from cable ends.
    - Machine-printed labels for visibility.
  - **Example Label ID Format**:
    - [ 03G/U23/SomeServer/ETH01 ] - [ 03G/U48/SomeSwitch/P08 ]
    - Includes **Device Name, Rack #, RU #, and Port #**.




  - **Documentation & Monitoring**:
    - Update digital twin application immediately after changes.
    - Maintain historical records for audits and troubleshooting.

**Compliance and Quality Assurance:**
Our cabling design aligns with key standards such as TIA/EIA-942, ANSI/BICSI-002, and ISO/IEC 11801. Adhering to these guidelines ensures that our infrastructure is reliable, scalable, and ready for long-term success.

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# Staging

**Equipment & Network Staging**

- Staging Area:
    - Dedicated room with 2-3 test racks mirroring production racks.
    - Desktop PC for configuration and testing.
    - Equipped with appropriate power and cooling standards.
- Pre-Configuration:
    - Structured cabling (fiber & copper) in overhead pathways.
    - Pre-configured VLANs, routing, and security settings for quick deployment.
- Testing Procedures:
    - Pre-startup checks: Verify connections, settings, and configurations.
    - Basic network troubleshooting: Ping, traceroute, and network discovery.
    - Performance testing: Simulating real-world traffic loads.

**Software & Application Staging**

- Replication & Security:
    - Identical software versions and configurations in both staging and production.
    - Secure staging with mirrored production security policies.
    - Apply critical security patches before deployment.
- Testing & Validation:
    - Performance, scalability, and security testing.
    - Use virtualized environments for additional validation.
    - Deployment pipeline consistency across staging and production.

**Data Migration Staging**

- Preparation:
    - Data Cleaning: Remove redundant or corrupt data.
    - Data Transformation: Convert formats for compatibility.
    - Compression: Optimize for faster transfer speeds.
- Testing:
    - Pilot migrations to identify potential issues.
    - Load testing to evaluate system performance under strain.
- Data Validation:
    - Integrity checks using checksum comparisons (MD5, SHA-256).
    - Accuracy testing to confirm migrated data matches the source.
    - User Acceptance Testing (UAT) to ensure application functionality.

**Disaster Recovery Staging**

- Setup & Preparation:
    - Secondary DR site with at least 40% of primary data center capacity.
    - Replication mechanisms like VMware Site Recovery Manager.
    - Redundant power and cooling at DR site.
- Testing:
    - Regular disaster recovery drills for failure simulations.

- Failover process validation to prevent downtime and data loss.

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W25 CTS4935.0M1: NST CAPSTONE

# Phase 3: Hazards & Standards

## HVAC & Environmental Controls

We mitigate operational risks through comprehensive hazard assessments and environmental planning. Key implementations include:

- **Adaptive HVAC**: Hybrid chilled water systems using variable speed drives and phase change materials to modulate temperature and humidity. Clean HVAC ducts regularly; replace filters on schedule.
- **Air Quality Controls**: HEPA filtration, VOC-free materials, and UV sterilization systems ensure optimal air purity. Maintain positive air pressure and seal external openings to keep contaminants out.
- **Redundancy Planning**: Full N+1 power and cooling redundancy with real-time environmental IoT monitoring.

Location selection accounts for seismic stability, flood plains, and proximity to law enforcement. Renewable energy sources and water-efficient cooling systems using recycled or non-potable water are integrated to support sustainability mandates.

## Avoiding Hazards & Challenges

**Electrical Hazards**

- **Arc Flash:** High-density 20–30kW racks pose risks. Implement grounding with static-dissipative flooring.
- **Load Balance:** Monthly circuit breaker validation prevents overloads and overheating.
- **UPS Failures**: Regular testing and redundancy planning mitigate downtime from UPS malfunction.

**Fire Hazards**

- **Liquid Cooling Risks:** Monitor direct-to-chip systems for leaks using IoT sensors.
- **Fire Suppression:** Use FM-200 or NOVEC clean agents—avoid water-based systems.
- **Combustibles:** Ban flammable materials in server areas.

**Physical Security Hazards**

- Secure spine and leaf switches with badge access; log entry events.
- Use locking front and rear rack doors.
- Apply surveillance, visitor management, and access tracking.

**Environmental Hazards**

- **Dust & Static**: Use ESD flooring and sealed cabling pathways.
- **Air Pollution**: Washington-specific air quality rules require emissions management. Use gas-phase filtration for generator exhaust.
- **Natural Disasters**:
  - Earthquakes: Use Erico Caddy CRB braces to secure racks.
  - Wildfires: Camfil CityCarb filters protect against smoke particulates.

**Human Error**

- **Network Risks:** Misconfigured STP, VLANs, or loops can cause outages—enforce planning reviews.
- **Cable Mislabeling:** Strict documentation and QA reduce confusion during staging.
- **Containment Disruption:** Train staff to avoid bypassing airflow systems.

## IDAC Standards & Frameworks

To ensure operational safety and compliance in our data center, the infrastructure will incorporate both traditional and emerging standards. We align our architectural approach with IDCA's Infinity Paradigm, which supports application-centric performance, modular design, and sustainability over rigid tier-based structures.

Our systems will adhere to:

- **ISO/IEC 22237** for comprehensive infrastructure lifecycle management
- **ASHRAE 90.4** for HVAC energy efficiency
- **ISO 14644** for cleanroom-level air filtration, safeguarding sensitive electronics
- **SSAE 16 / ISAE 3402** for auditing and compliance
- **EPI-DCOS and TIMS** for operations and tiered maintenance

Security operations will rely on zero-trust principles, layered access control (including biometric and role-based authentication), and continuous monitoring via AI-driven tools such as Splunk or Elastic. Systems will also be segmented for microservice architecture, limiting attack surfaces.

We reference **Uptime Institute's tier model** to benchmark uptime and redundancy expectations:

- **Tier I:** Basic setup (no redundancy) – 99.671% uptime
- **Tier II:** Redundant components – 99.741% uptime
- **Tier III:** Concurrently maintainable – 99.982% uptime
- **Tier IV:** Fully fault-tolerant – 99.995% uptime

Our planned infrastructure aligns with **Tier III** minimum standards, scaling toward **Tier IV** as operational needs grow.

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The International Data Center Authority (IDCA) provides a comprehensive framework for grading and certifying data centers to ensure scalability, reliability, efficiency, and security in digital ecosystems.

1. Grade Levels (G0–G4):

- G0: Zero risk or failure potential, ideal for mission-critical applications where zero tolerance for downtime is essential.
- G1: Above-average achievement with low levels of risk, insecurities, inefficiencies, vulnerabilities, and chances of failure. Ideal for **e**nterprise-class workloads requiring high availability and reliability.
- G2: Average exposure to risks, insecurities, inefficiencies, vulnerabilities, and chances of failure. Ideal for general-purpose data centers and small to midsize business applications.
- G3: Below-average achievement with increased exposure to risks, insecurities, inefficiencies, vulnerabilities, and chances of failure. Ideal for test and development environments or temporary infrastructure setups.
- G4: Allows for the highest risk tolerance, suitable for non-critical workloads, archival storage, or systems where high risk is acceptable.

These grades benchmark applications, IT systems, cloud infrastructure, and physical data centers. Here's an assessment of our data center design mapped to the IDCA Grade Levels (G0-G4):

- Flooring Materials: Conductive Solid Vinyl Tile
    - ***Grade Level: G1.*** Solid vinyl tiles with conductive properties provide some static protection but might fall short of the comprehensive grounding and static control required for G0 environments. Solid vinyl tile offers above-average protection compared to standard flooring.
- Power & Energy Efficiency
    - PUE Optimization: DCIM, Tailored Metrics
    - Efficient Cooling Systems: Free Cooling, Water-Side Economizer, Closed-Loop Chilled Water Cooling, Hot/Cold Aisle Containment, Liquid Cooling, Advanced Airflow Management
    - Renewable Energy Integration: Hydroelectric Power
    - Energy-Efficient IT Hardware: Low-Power CPUs & Efficient Power Supplies, Virtualization, Advanced Cooling Components
    - UPS and Power Distribution Optimization: Dedicated PDUs, Smart Power Strips & PDUs, Customizable Load Management, High-Efficiency UPS Systems, Redundant Small-Scale UPS Modules, AI-Driven Power Adjustments
    - Additional Energy Efficiency Measures: LED Lighting, Insulated Doors & Air Seals, Fire Suppression Systems, Cable Management & Power Routing
        - ***Grade Level: G0.*** The redundancy in power, focus on renewable energy, and advanced cooling and management systems point to a design aimed at minimizing risk and maximizing efficiency.
- Network Cabling
    - Spine-Leaf Architecture: Two-tier network with spine and leaf switches
    - Cable Pathways: Overhead perforated trays
    - Cable Length Management: Pre-Terminated Cabling Systems, Separation of Cabling Types, Color coded cables

    - Cable Labeling & Documentation: Standardized Labeling, Documentation & Monitoring
        - ***Grade Level: G1.*** While a spine-leaf architecture is highly scalable and resilient, the overhead cable trays and documentation processes don't fully eliminate physical security and human error risks.
- Staging
    - Equipment & Network Staging
    - Software & Application Staging
    - Data Migration Staging
    - Disaster Recovery Staging
        - ***Grade Level: G2.*** A well-defined staging plan is essential; the lack of any explicit discussion of edge case and black swan scenarios could result in average exposure to risks.

**Overall**

Our design targets Tier III reliability and a high degree of operational efficiency. The data center design is designed to operate at G0 and G1.

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# Breakdown of Work

**Phase 1 – Initial Design Plan**
Both team members contributed equally to the development of the Phase 1 mission statement, site selection, and design concept. Research, discussion, and planning were shared evenly throughout this phase.

**Phase 2 – Infrastructure Development**
This phase was largely drafted by Tashundre Gilmore, with supporting notes and input provided by Alex Kramer. While the document writing was led by Tashundre, the planning and research involved collaboration from both team members.

**Phase 3 – Hazards and Standards**
Both team members contributed to Phase 3 in a balanced way, working together to research hazards, compliance standards, and mitigation strategies. The final write-up reflects ideas and input from both sides.

**Presentation Development**
The PowerPoint was a joint effort: Tashundre initiated the presentation and handled several layout and formatting revisions, while Alex added new content slides and took the lead on narration. The final voiceover recording was completed by Alex to present the team’s work.