Site Selection for Mission Critical Facilities

White Paper 81

Revision 2

by Wendy Torell

> Executive summary

When selecting a new site or evaluating an existing site, there are many risks and benefits that must be considered in order to optimize availability and reduce cost. Geographic and regional, local and site-related, and building risks need to be understood and mitigated to lessen the downtime effects on your business. Meanwhile, site selection can offer financial benefits when a data center considers climate, electricity rates, and incentives. In this paper guidelines are established for selecting a new site or assessing an existing one.

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Introduction

Site selection of a data center facility includes many factors, from facility considerations to business & IT considerations. This paper discusses site selection from the facility perspective. In building a new data center or evaluating an existing one, it is important to understand the data center's environment including the threats that it poses and the advantages that it offers.

- **Availability risks** – how they could impact business continuity, and how best to mitigate them.
- **Financial benefits** – how they could reduce costs, and how to make the most of them.

For any given site, there are dozens of risks that need to be considered. These can be broken into three categories:

- Geographical risks are major availability threats including natural disasters as well as man-made hazards.
- Local risks are risks that result from the municipal infrastructure, the local environment, local regulations, and employees.
- Building risks are risks driven by building characteristics and constraints such as age of the building, types of loads running, and the type and quality of the facility.

When critical business processes do not remain operational, it can have a significant negative impact on the success of the company. It is important to remember that it is often significantly less expensive to invest in mitigating a risk of downtime, than to recover from the event after it occurs. If the impact of the event is understood, an educated decision can be made regarding whether or not to take the appropriate preventative measures. Preventative measures might include re-designing a building, making structural changes, or buying certain types of insurance.

Link to resource
White Paper 5
A Practical Guide to Disaster Avoidance in Mission-Critical Facilities

A disaster preparedness plan should be written and then regularly reviewed with employees. This plan should consist of preparation & prevention, detection & incident classification, response & mitigation, and recovery. To learn about best practices of disaster preparedness, see White Paper 5, *A Practical Guide to Disaster Avoidance in Mission-Critical Facilities.*

Site considerations should go beyond availability, as there are financial benefits that can certainly be expected from a successful site selection, such as free cooling hours, reduced electricity rates and tax preferences.

Geographical risks

The ideal time to consider geographic and regional risks is when selecting a new site for a business, not after a major disruption has occurred. The most common geographic and regional risks to consider are weather-related, including distinctive events such as tornadoes, earthquakes, floods, hurricanes, snowstorms, and lightning.

If a new site is not in the business plan, it is still extremely valuable to perform a risk analysis on the existing site, so to understand how to mitigate these geographic and regional risks. Geographic risks can never be eliminated, but being familiar with the area's natural threats can help keep one informed about precautions to take in the event of an emergency.

Every site should consider the following general mitigation techniques to anticipate any emergency:

1. Create emergency communication plans.
2. Install a generator for emergency power in the event of an extended outage. Make sure you have several days' worth of fuel on hand.
3. Add redundant utility feeds and/or carrier lines to help reduce the likelihood of the power going down. Redundant communication lines should be mandatory for those sites whose business relies on availability.
4. Be sure that the building is built at least to code and ideally higher than to code. That is probably the first basic defense against such storms. It is recommended that the building meets similar standards required of fire and police stations, hospitals, and large gathering places.
5. Store food and water on site for a minimal staff for a week.
6. Have computer data backed up off site.

Floods are caused when heavy rain falls, thunderstorms, or snow thaws create an overflow of water from rivers and other bodies of water. There are both regional floods and localized floods. Regional floods are caused by events such as hurricanes and overflowing rivers. Localized floods are caused by events such as thundershowers and plugged drains. Most floods occur over a span of several days. Flash floods, however, can develop within minutes and are caused by dam failures or large storms occurring over a short period of time. Floods and flash floods occur within all 50 states. Communities particularly at risk are those located in low-lying areas, near water, or downstream from a dam. According to the Federal Emergency Management Agency (FEMA), approximately 90% of all natural disasters in this country involve flooding.

The typical advance warning on a flood is several days. When a flood occurs, catastrophic damage and disruption to data centers can occur. Both regional and localized floods can destroy buildings and equipment, cause water damage to structure and contents, result in power failures, damage roadways, and cause human injury or death. The following can be done to mitigate the risk of damage and downtime during a flood:

1. Choose a site away from a flood plain if possible. Ideally, the site should be at least 100 feet above the maximum projected flood elevation level. It is suggested that the building and other business-critical areas be above the 100-year flood plain.
2. Flood proof the facility.
    a. Reinforce walls to endure water pressure.
    b. Build floodwalls outside the building.
    c. Install watertight doors and permanent pumps.
3. Buy flood insurance to protect items within the building, and more specifically, in the data center.
4. Elevate machinery and utility systems to reduce the likelihood of water damage.
5. Use dry flood-proofing techniques to protect buildings in flood hazard areas. This technique can be seen in **Figure 1**.
6. Build with flood-resistant materials. **Figure 2** illustrates sample flood-resistant materials.

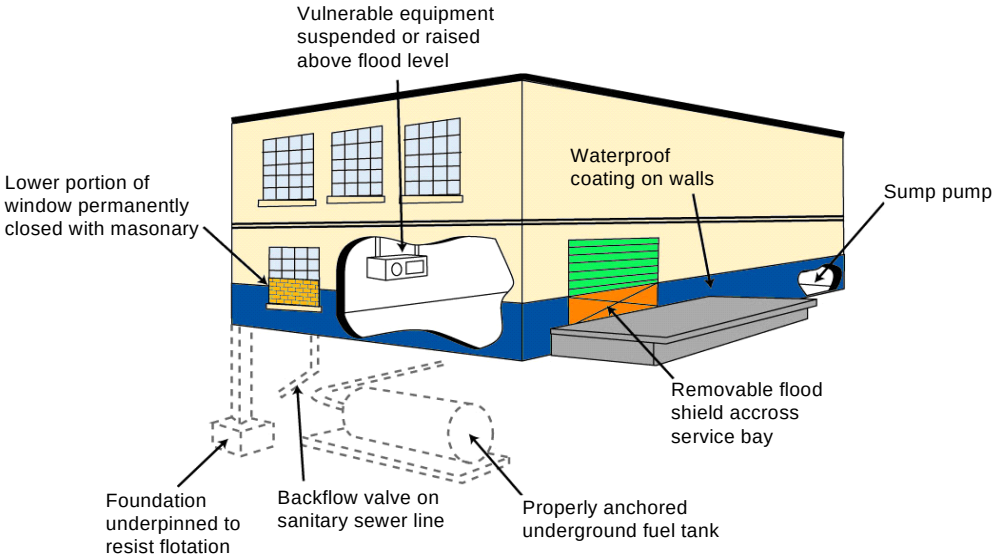


Figure 1

Dry flood proofing

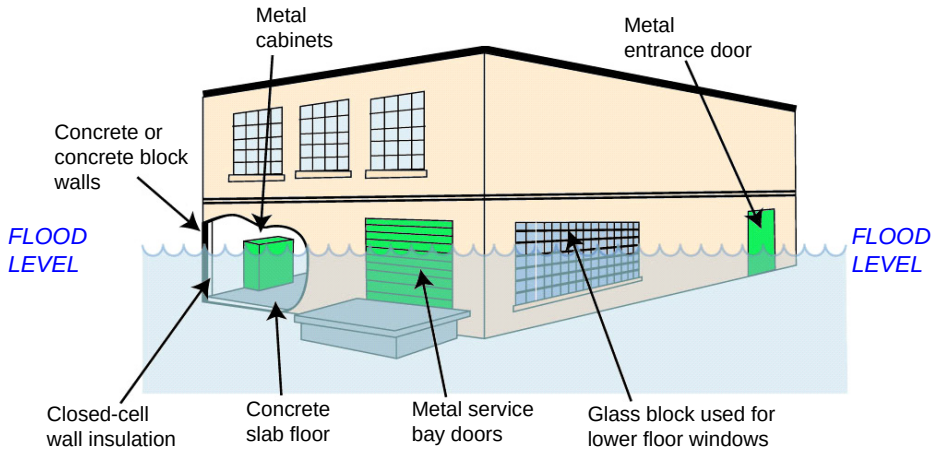


Figure 2

Flood-resistant materials

Tornadoes strike with incredible velocity. Wind speeds from tornadoes can approach 300 miles per hour. Although tornadoes occur in many parts of the world, they are most frequently in the United States east of the Rocky Mountains during the spring and summer months. In the Great Lakes area, they occur most frequently in late summer and early fall. The duration of tornadoes is typically very brief, although intense.

Typical advance warning of a tornado is a few hours; however, the warning may not be site-specific. When a tornado hits, data centers can expect disruption and minor to severe infrastructure damage. Loss of local utility and communications, especially if not buried, can also be expected. It is also likely that roads will be blocked as a result of tornadoes.

The following can be done to mitigate the risk of damage and downtime during a tornado:

1. Secure loose materials, reinforce entries, and remove large objects surrounding the building.
2. Install permanent storm shutters (aluminum or steel) to prevent wind from entering the building. If wind were to enter the building, the likelihood of severe structural damage increases and the contents of the building will be exposed to the elements. These shutters can be seen in **Figure 3**. If possible, design a new data center with no windows or eliminate windows in existing data center.

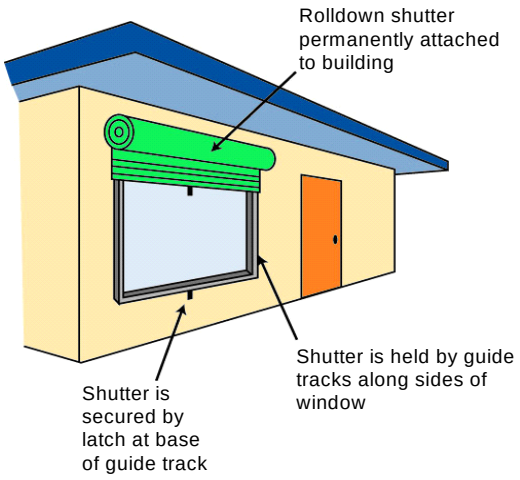


Figure 3

Permanent storm shutters

3. Metal siding and roofing in high-wind areas should be securely attached to the frame of the building so that wind cannot work its way underneath.
4. Securely attach composition shingles to avoid them being damaged or torn away by high winds. **Figure 4** illustrates how to securely attach the shingles.

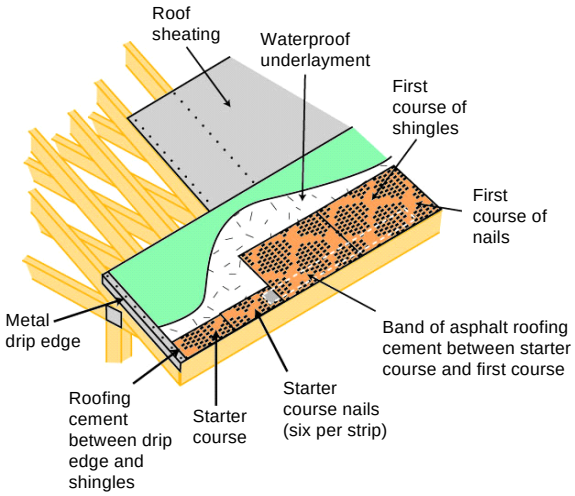


Figure 4

Secured composition shingles

5. Consider disconnecting from the utility power and running loads from the generator. This can isolate the facility from the power-quality events caused by tornado winds and damage.
6. Protect items that are outside the building such as cooling towers, water tanks, storage areas, and condenser farms. They are all exposed to projectile damage.

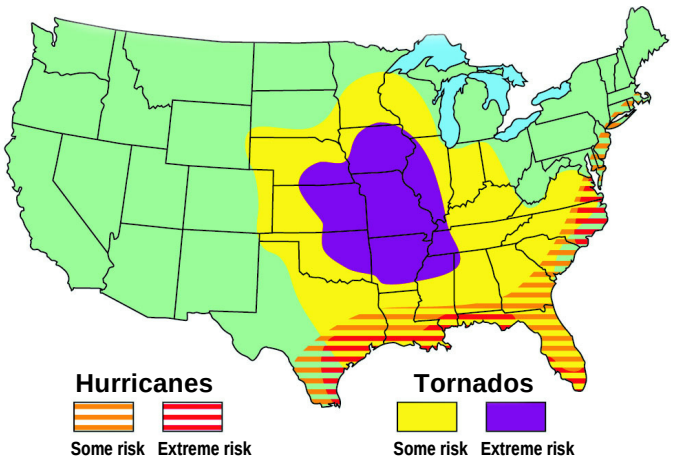
Hurricanes occur primarily along the East coast, particularly in the southeastern-most United States and the Caribbean, but they can occur anywhere from Maine to Texas. The duration of the storm can range from hours to a few days. **Figure 5** illustrates the hurricanes and tornadoes that hit the US.

Significant advance warning usually is provided when a hurricane is near. If the business is in or near the hurricane storm path, one can expect disruption and minor to severe infrastructure damage. Data centers and infrastructure may be damaged or destroyed by high winds and high waves. Debris can break windows and doors, allowing high winds and rain inside

the facility. Trees and power lines topple and weak elements of buildings fail. Loss of local utility, communications, and transportation is likely and could persist for extended periods.

Figure 5

Tornadoes and hurricanes risk locations – source: ComputerSite Engineering



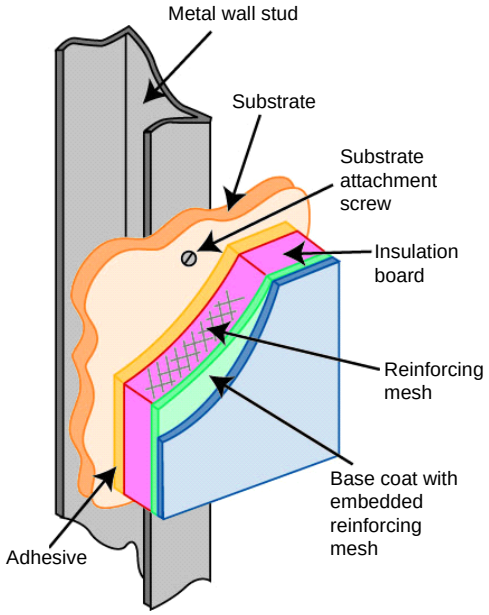
Source: ComputerSite Engineering

The following can be done to mitigate the risk of damage and downtime during a hurricane:

1. Ensure that building and any exterior equipment can easily endure conditions that could be expected during a hurricane in your area, such as very high winds and rainfall.
2. Secure loose materials, reinforce entries, and remove large objects surrounding the building.
3. Remove all unsecured items from or near the data center premises.
4. Make sure composition roof shingles are securely attached, or they can be damaged or torn away by high winds.
5. Inspect and maintain all building walls, including Exterior Insulation Finishing System (EIFS) walls. These walls can be weakened by moisture that becomes trapped behind them. Once an EIFS wall has been weakened, it is more likely to be torn off or penetrated by high winds. An EIFS is illustrated in **Figure 6**.
6. Ensure proper drainage for high rain. Flooding can occur as a result of hurricanes.

Figure 6

EIFS wall



Earthquakes occur most frequently west of the Rocky Mountains, although historically the most violent earthquakes have occurred in the central US. All 50 states are vulnerable to earthquakes, with 41 states or territories at moderate to high risk, according to FEMA. **Figure 7** illustrates the seismic activity in the US.

To reduce the risk of an earthquake, a site with a low seismic risk should be selected. Ideally, the site should be located in a seismic zone 0. Any site located in zone 3 or higher is less favorable; however, today site-specific dangers can be designed around using base isolation and other techniques.

There is no warning to an earthquake, so they can be particularly difficult to prepare for. One can expect catastrophic damage and disruption to data centers near the epicenter and infrastructure damage to data centers farther away. Highways and bridges may be damaged or destroyed preventing the movement of fuel and other operating supplies required for continued operation. This damage can also lead to loss of electricity and communications.

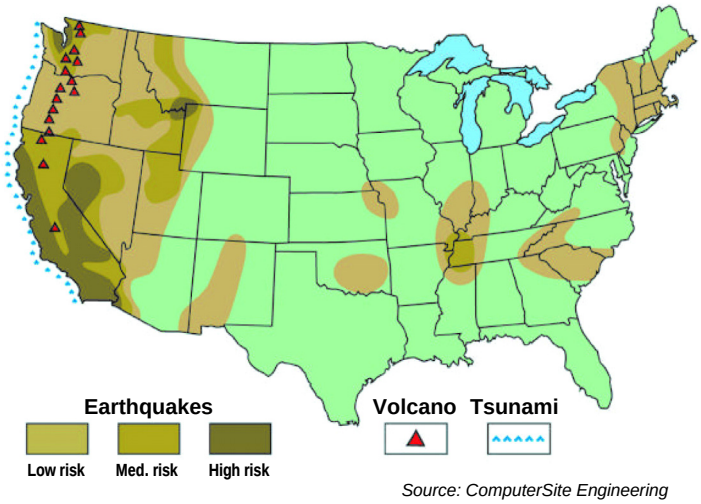


Figure 7

Seismic activity

Source: ComputerSite Engineering

The following can be done to mitigate the risk of damage and downtime during an earthquake:

1. Upgrade facilities to withstand shaking from an earthquake or high winds.
2. Secure light fixtures, cable trays, bookcases, file cabinets, computer racks, and desktop items that could fall or shake loose in an emergency. An example of how to secure equipment is shown in **Figure 8**.
3. Move heavy or breakable objects to low shelves.
4. Restrain computing equipment in a loosely coupled way. This prevents it from falling over. Do not rigidly anchor computing equipment to buildings, as resonant frequency of the building can do major damage to the equipment.
5. Anchor large equipment such as chillers and engines properly. It is recommended to anchor equipment directly to the floor or another suitable part of the building as opposed to mounting equipment on vibration isolators. **Figure 9** illustrates the anchoring technique.
6. Install floors with seismic anchoring. Without this, floors can collapse resulting in not only a temporary outage but also in a significant amount of destroyed equipment.
7. For facilities in higher earthquake zones, consider base-isolation techniques to minimize building risk. Seismic base isolation is a system of protecting buildings from earthquake damage by using “bearings” or supports, typically made of layered rubber and steel pads, to separate buildings from the ground on which they sit. The bearings allow a building to move freely on shaking ground. Blizzards include a combination of gusting winds, low temperatures, and large amounts of snow.

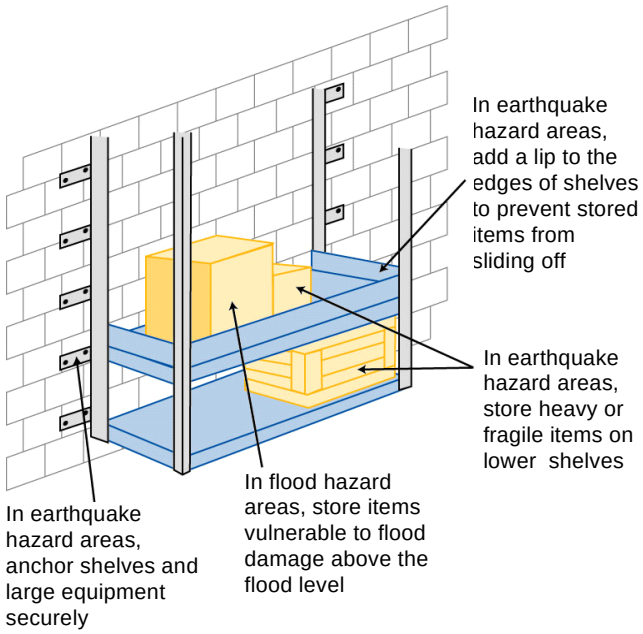


Figure 8

Secured equipment

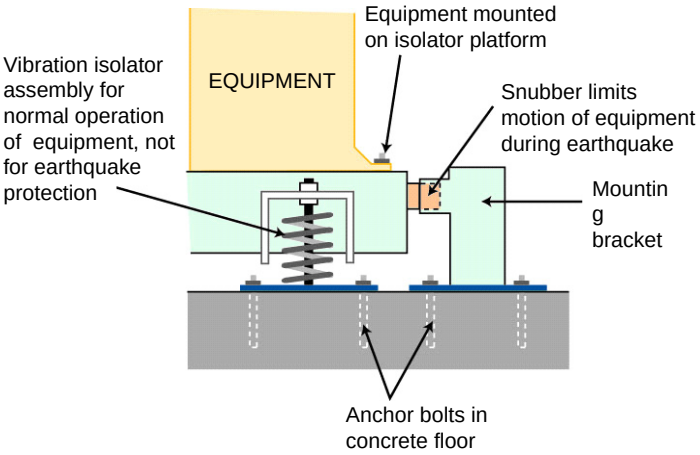


Figure 9

Anchored equipment

Blizzards are most commonly found along the Mid-Atlantic coast to New England and in the Midwest and Alaska. Storms also occur between the Rockies and the West coast. Blizzards typically span the months of November through March. **Figure 10** illustrates the snowfall accumulation by state. Typically, several days' warning is provided. One can expect some disruption or failure if the outside equipment is not designed to survive severe ice and snow accumulation. Snow and/or ice can collapse power and telephone lines, knocking out services for hours or even days. Data center employees may be unable to get to work due to icy conditions or unplowed roadways. Buildings may also collapse under the enormous weight of snow. In particular, roofs are often flat, resulting in snow buildup. Snow removal is often needed.

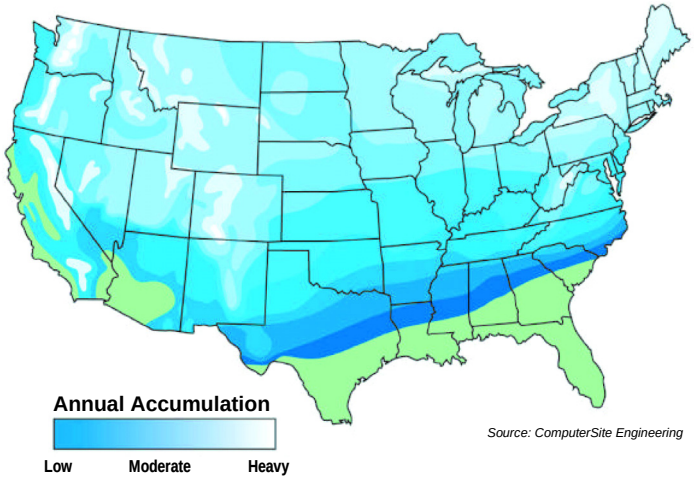


Figure 10

Snowfall map

The following can be done to mitigate the risk of damage and downtime during a blizzard:

1. Consider the installation of storm shutters for all exterior windows and doors.
2. Be sure that the generators are enclosed properly under such conditions.

Lightning strikes typically occur during thunderstorms and can occur anywhere in the United States. The duration of the event is brief but may recur daily. The frequency of thunderstorms by state is illustrated in **Figure 11**.

Lightning strikes can cause disruptions within a data center if proper surge protection is not used. Expect frequent momentary public utility disruptions from lightning strikes hitting the electric power transmission grid. Lightning can cause power outages and fires, or may damage office wiring and computers.

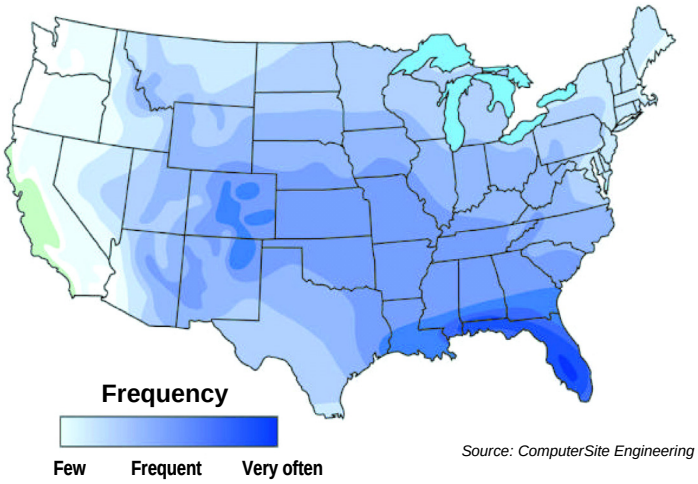


Figure 11

Thunderstorms

The following can be done to mitigate the risk of damage and downtime during a thunderstorm with lightning:

1. Lightning detectors, available at differing costs and technologies, sometimes are useful to provide early warning.
2. Have lightning rods installed with a well-designed grounding system.

3. Employ multiple down conductors, structural steel/rebar/metal stud walls, wire mesh, and HALO rings into the shielding design.
4. Bond all buried and overhead building entry penetrations such as utility pipes, service ducts, AC power, data & signal lines, and metallic conduits to the Faraday Cage or to an equivalent ground electrode system at the building entry. Bond interior electrical-equipment grounding wires via the shortest route to the ground electrode reference grid. Measure all bonds for effectiveness and resistance level.
5. Employ a buried ground ring and/or Ufer ground where practical. Use thermal welds on all below-ground connections. Assure that buried grounds are directed away from exterior assets.
6. Install CE-listed surge protection devices on all appropriate circuits, outlets, and panels.
7. Provide dielectric isolation or high-resistance isolation between critical interior assets and nearby metallics and other conductive pathways.
8. Run on generators to prevent surges coming in over power lines.

Other less frequent natural disasters are also possible and should be investigated for your area, including volcanic eruptions, tidal waves, mudslides, forest fires, dust storms and drought. It is important to understand the risk of these events occurring in the potential site and mitigate the risks when possible.

Local risks

In addition to geography, there are many other factors to consider when selecting a site. Local and site-related characteristics could significantly drive the availability of the business, including characteristics about the site, its community, and potential man-made risks. These factors can be categorized as follows:

- Utility power, water and back-up fuel
- Local infrastructure, neighbors and environment
- Local regulation and labor market

Utility power, utility water and back-up fuel

Utility power service (capacity and quality) can vary significantly from one location to the next. While evaluating an area, it is important to make sure that utility feeders in the area can provide sufficient capacity, not only for current needs but also for future growth. It is also important to consider power quality, as these are potential availability risks. To learn more about power problems see White Paper 18, *The Seven Types of Power Problems*.

Link to resource
White Paper 18
The Seven Types of Power Problems.

Cities are heavily populated, which means larger consumption of power and typically less abundant capacity but more overloads than suburban or rural areas. Rural areas, although very scarcely populated, can experience worse power quality than suburban areas. When a power defect occurs, response time from the power company can be longer because of the distance between it and the customer.

Power grid redundancy is another factor to consider. First, the power access can come from multiple grids. With the deregulation of power distribution market, there are often several power distributors providing utility services in one area. Large-scale data centers can leverage it to get utility service from different providers, which can improve the availability of utility power. Second, some utility feeders might be more fault-tolerant than others due to the automatic dispatching configurations in the transmission lines. When an outage takes place, the downtime will be less on those with highly-resilient upstream substations.

Generally speaking, the closer a data center is to the substation, the less likely it is to experience power events. When the utility power is routed above ground, it is exposed to the environment and therefore can result in power events caused by human error, animals on lines, and weather. Underground wiring is significantly more stable because these risks don't exist. When it does fail, however, it typically takes longer to repair. Additionally, ground impedance factors should also be considered. Grounding is the foundation of the electrical system, and both soil types and humidity will affect the design of a proper grounding system.

Water supply is as critical as utility power in a data center. First, it is important to identify the capacity of the public water supply system. Many data centers consume significant volumes of water per day depending on the cooling architecture. The use of water-cooled chillers and cooling towers has capital and operational cost benefits in data centers of large scale, but also evaporates thousands of tons of water per day. The capacity of water supply is a key factor to the selection of heat rejection approaches, which, if overlooked, might lead to project delays from the re-work of designs and costs exceeding budget. Not only is water supply important but also water continuity, since these cooling systems as well as fire suppression systems need to be available 24 x 7 x 365. For a high availability facility, having water storage on site to support continuous cooling and the fire sprinkler systems should be considered.

When a power outage occurs, generator systems take the responsibility to support all loads including IT loads, cooling, lighting, etc. The running of generators requires fuel like diesel, petrol or natural gas. Usually, a data center keeps enough fuel storage on site to last between a few hours and a few days. In the case of a major outage, a date center might need to refill its fuel storage; therefore, a data center should be located in a convenient distance to fuel providers.

Local infrastructure, neighbors and environment

Data centers should be situated for convenient access for both personnel and equipment, and also have multiple access routes in the event one is obstructed by natural disaster or human activities. It should also be in the coverage of public services and transports, such as in a short driving distance from fuel station, fire station, police station, local airport, railway station, high way exit and etc. This information helps in planning construction and emergency preparation. There are other helpful ancillary resources in the local communities, such as ATM, Post office, hospitals and etc.

Understanding who the neighbors to the site are can help you calculate the potential for man-made risks. Some examples of high-risk neighbors are airports, prisons, military camp, chemical storage, freeways, rail lines, natural gas and other pipelines, electrical transmission and distribution lines, and radio emission. Data centers should establish enough clearance from these high risk neighbors to avoid downtime. It is also important to consider the volume and type of construction that is going on in the neighborhood of a data center. There are several reasons that downtime increases when neighborhood construction exists.

1. Sags can be caused due to overloading the power lines.
2. The availability of local infrastructure are subject to construction accidents, which can take down power lines or water piping, or block road access completely.
3. Construction near local public services sometimes results in scheduled shutdowns in the area.

Air quality is worse in cities and suburban industrial areas than rural areas. Traffic, factories, power plants, and waste management facilities can degrade the perimeter air quality of a data center. Air pollution can cause contamination issues in data centers and extra cost to purify. This is a concern, especially for those using fresh air free cooling. For instance, the

sulfides and chlorides in the air can be harmful to PCBs in IT equipment. Some particulates in the air can decrease the heat exchange efficiency if glazing on the coils of cooling systems occurs, or lead to short circuits and hardware failures in the electronic equipment. Therefore, attention should be paid to avoid building data centers near power plants, waste management plants and other air pollution source.

Local regulations and labor market

A data center project needs to comply with a variety of regulations, many of which involve acquiring approvals from the local council or other administrative agencies. These regulations include safety regulations, such as electrical code, local building code, fire code, and environmental regulations in regard to power and water consumption, energy efficiency, air and noise dispersion, and carbon emission. For instance, it usually takes quite a period of time to get the permission to add more utility feeders, especially for large data centers. This period varies from six months to two years which can cause significant delays and budget overruns, if not planned well.

The location of a data center determines its talent pool. Populated cities can provide a large number of qualified employees, engineers and managers, but there is a higher cost to retain the employees. Rural areas, on the other hand, have limited talent pools, leading to understaffing or less qualified staff. In addition, vendors who provide power and cooling equipment may also suffer from lack of staff in rural areas which could cause delays of service, or result in the data center owner having to retain more in-house facility engineers. The location also determines whether a data center is staffed by union or non-union employees in some countries, which can significantly impact installation and maintenance costs.

Building risks

The building itself will have a huge impact on the availability of the business. This includes factors such as complying with electrical laws and standards, age of the building, types of loads running, and the type and quality of the facility.

A building built to code will protect the life-safety of its occupants, not necessarily offer high performance. When looking at a new facility, consider the insurance rating of a building. This rating is a key to its structural soundness.

Buildings are required to comply with electric safety codes (National Electric Code in the U.S.). There is also an IEEE performance wiring standard that considers sensitive electric loads such as computing devices. IEEE standards lay out the recommended practice for powering sensitive electronic devices like computing equipment. Often times, older buildings only comply with the safety codes. When looking at a new facility, or evaluating an existing one, be sure that at a minimum it complies with IEEE standards.

Older buildings typically experience more power problems than younger ones. This is typically because building wiring standards have improved over time and new ones have been put in place. Older standards often resulted in grounding and bonding problems, and buildings that comply with these older standards are not required to comply with new standards. The number of problems due to wiring increases over time due to failed or degraded components.

Having heavy equipment running in your facility can cause sags within the building and for surrounding miles due to the high power draw. Heavy equipment can be defined as any electric device that has a large motor. Some examples are elevators, industrial machinery, and cleaning equipment.

Location of a data center *within* a building is also important. For instance, it is not recommended to have the data center located under a kitchen or in a basement.

If the data center is in a shared facility, it is important to consider all the other applications within the building. Companies located in multi-tenant sites must also assess those threats posed by their neighbors. A neighbor's fire or security break can quickly become your problem. If the building offers a service level agreement, its important to make sure the agreement is in line with the business's objectives and the infrastructure fault tolerance it demands.

Financial considerations

There are other key factors that should be considered when choosing a site that have financial implication to the business. These include the following:

- Energy cost
- Tax preference and incentives

Energy cost

Energy efficiency and the electricity rate have a significant impact on profitability and cash flow, especially in places where carbon tax has been introduced. The annual energy cost of a data center can be estimated using the following formula:

Annual Energy Cost = IT load × **Annual PUE** × **Electricity rate**× 8760 hrs

Geographic climates can have a significant impact on the annual PUE of a data center. Cold and dry weather can decrease the energy consumed on heat rejection. The thermal characteristics of condenser coils or cooling towers improve along with the drop of outdoor temperature and humidity. The use of an economizer mode (aka free cooling) in a cooling plant can lead to significant energy savings. When the outdoor temperature is low enough to cool the data center, compressors or chillers can be turned off. The number of hours in a year that a data center can operate in free cooling varies from hundreds to thousands. Selecting a site with a cold and/or dry climate will extend the economizer hours. To learn more about free cooling see white paper 132, *Economizer Modes of Data Center Cooling Systems*.

Link to resource
White Paper 132
Economizer Modes of Data Center Cooling Systems

Electricity rates vary by regions across the country, as well as by areas between industrial and commercial estates.[1] For instance, coal, nuclear and water power are less expensive resources to generate electricity than gas, solar, and wind in most states. But, carbon tax can be a variable to the potential cost, if applied, in the future. In addition, electricity is generally priced more affordable in industrial estates than in commercial estates, even within the same region. These advantages can be converted into real money if taken into consideration.

Tax preference and incentives

Tax preference or other incentives are sometimes offered in exchange for investment and jobs. It is worthwhile to initiate negotiations with local governments or economic development agencies during the site selection process.

1. U.S. Energy Information Administration (EIA), "July 2012 Monthly Energy Review", http://www.eia.gov/totalenergy/data/monthly/#prices

Conclusion

When going through the process of selecting a new site for a data center or evaluating an existing site, it is important to understand all potential risks associated with that site, and then to mitigate those risks. Factors relating to the geography, the site, the building, and the economy can cause downtime. Although the costs to mitigate risks may seem expensive, it is important to consider the alternative – the cost of recovering from a potentially long-term interruption in business. When a thorough site selection review process becomes part of a data center project, the business can expect both downtime risk reduction and cost savings.

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Resources

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White Paper 5

The Seven Types of Power Problems
White Paper 18

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White Paper 132

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