Site Selection for Mission Critical Facilities

White Paper 81

Revision 1

by Wendy Torell

Executive summary

When selecting a new site or evaluating an existing site, there are dozens of risk factors that must be considered if optimal availability is to be obtained. Geographic, site-related, building, and economic risks need to be understood and mitigated to lessen the downtime effects on your business. In this paper guidelines are established for selecting a new site or assessing an existing one. Common risks that affect the availability of a business are defined and techniques for minimizing these risks are presented.

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Introduction

In building a new data center or evaluating an existing one, it is important to understand the geographic environment and the threats that it poses. For any given site, there are dozens of risk factors that need to be considered. The key is to understand these risks, how they could impact your business, and how best to mitigate them.

The first step is to identify the critical business processes that must remain operational. Without these critical processes, there would be a significant 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. Although risk mitigation may seem expensive, it is important to consider the alternative – the cost of recovering from a potentially long-term interruption in business.

A disaster recovery plan should be written and then regularly reviewed with employees. This plan must be exercised in the event a disaster occurs. It is important to be clear on the procedure for transferring the operations from the main site to a disaster recovery site, if one exists.

There are several categories of risks that should be considered. Geographical or regional risks are major ones, and these include severe weather events as well as man-made hazards. Site-related risks, building risks, and economic risks, must also be taken into account.

Geographical and regional 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 rainfalls, 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.

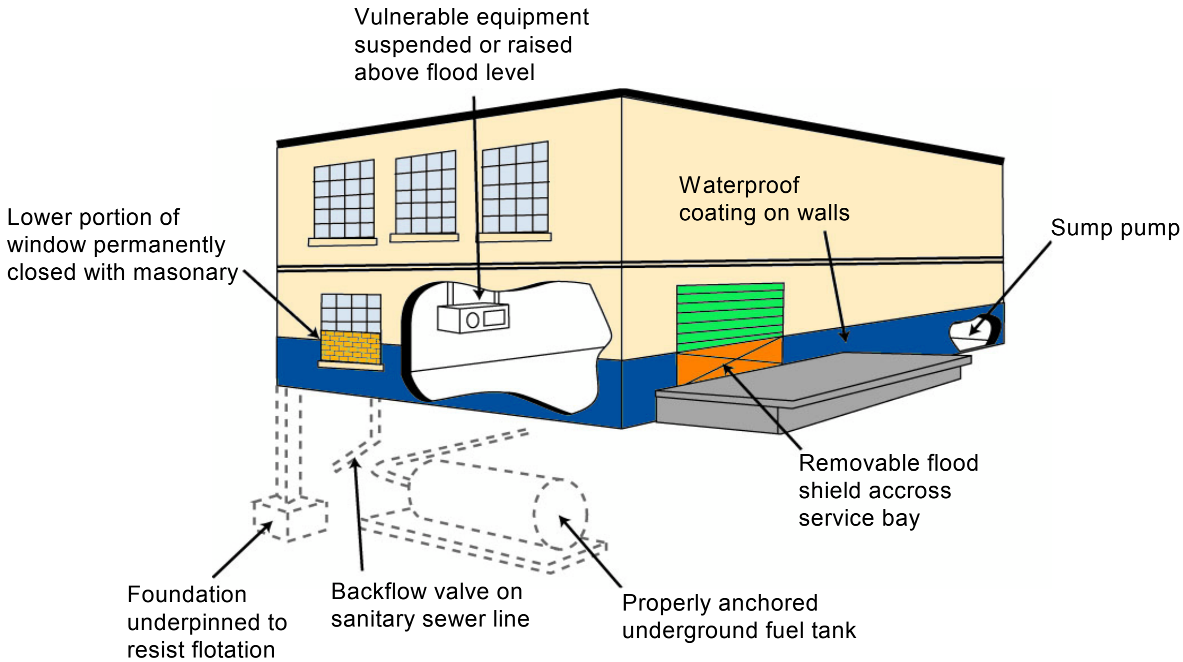


Figure 1

Dry flood proofing

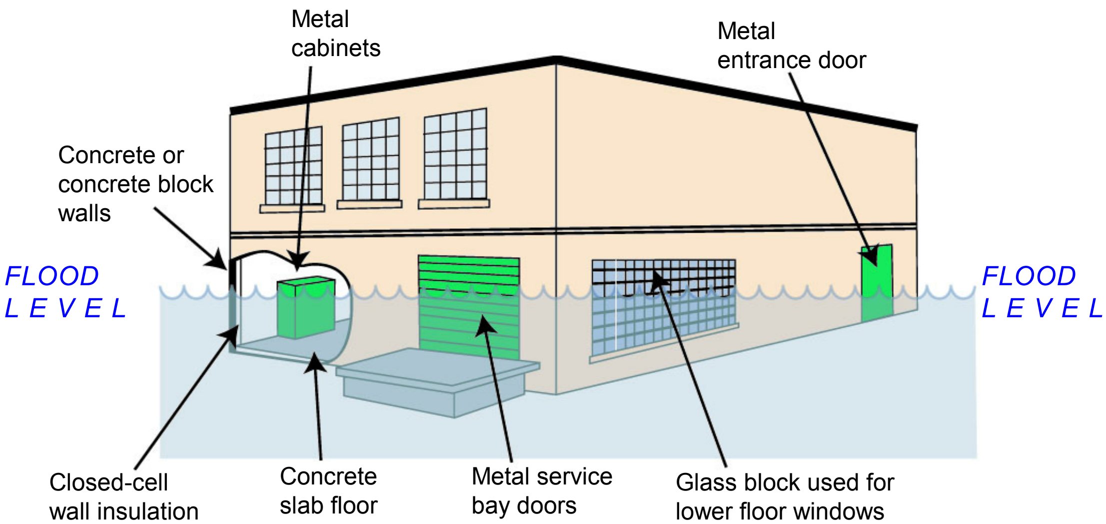


Figure 2

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.

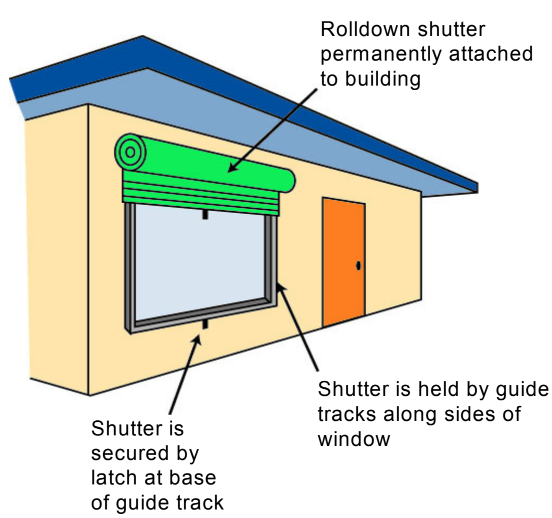


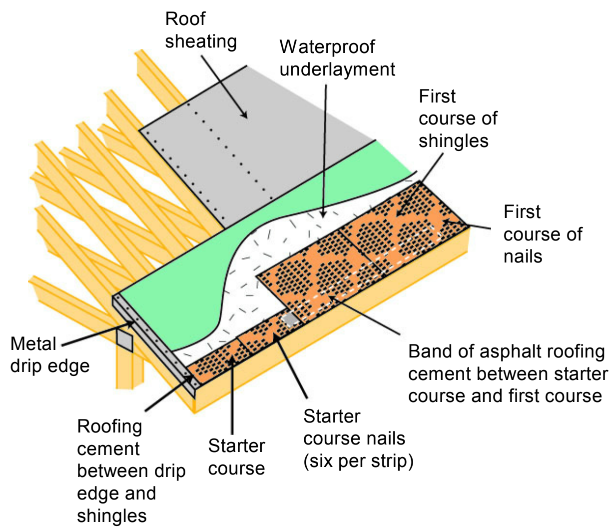
Figure 3

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.
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.

Figure 4

Secured composition shingles

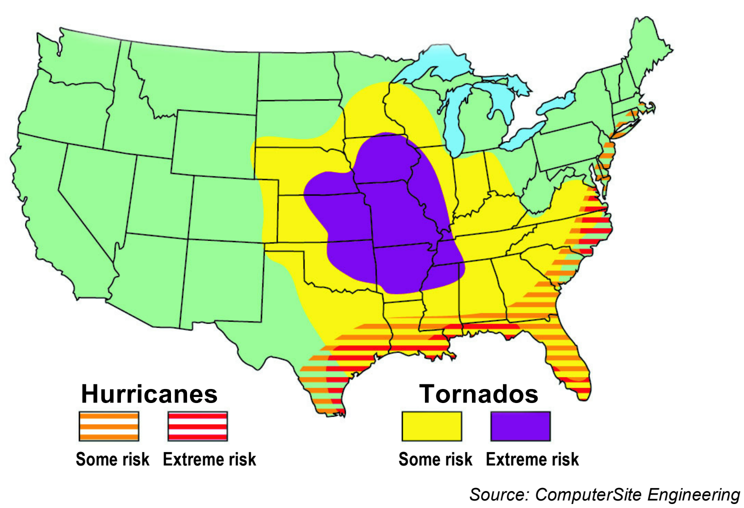


Hurricanes occur primarily along the East coast, particularly in the southeastern-most United States and the Caribbean, but they can occur anywhere from Maine to Texas. The duration of the storm can range from hours to a few days. **Figure 5** illustrates the hurricanes and tornadoes that hit the US.

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

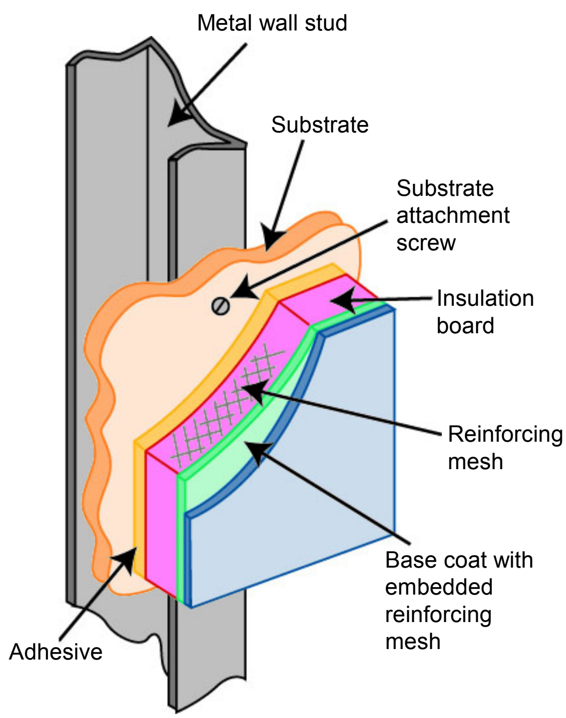


The following can be done to mitigate the risk of damage and downtime during a hurricane:

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



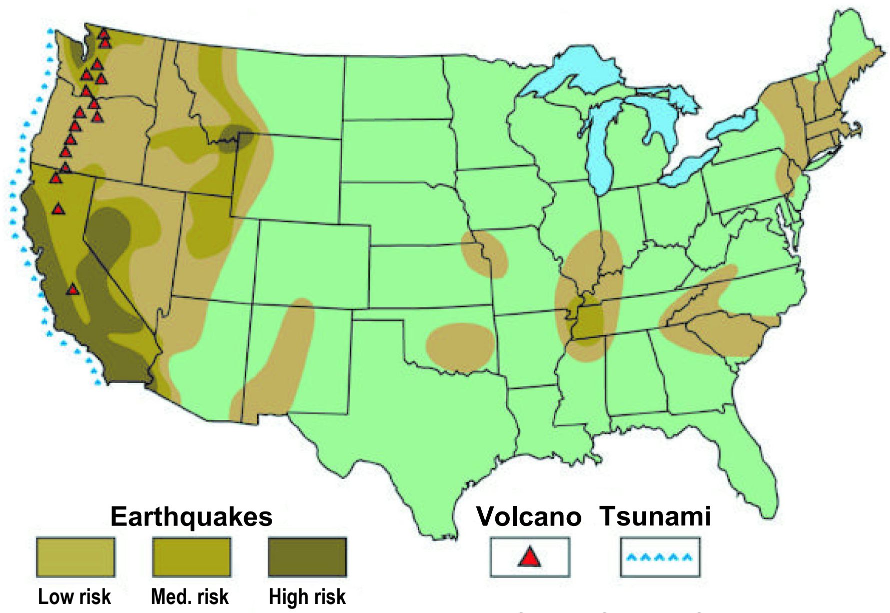
Earthquakes occur most frequently west of the Rocky Mountains, although historically the most violent earthquakes have occurred in the central US. All 50 states are vulnerable to earthquakes, with 41 states or territories at moderate to high risk, according to FEMA. **Figure 7** illustrates the seismic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

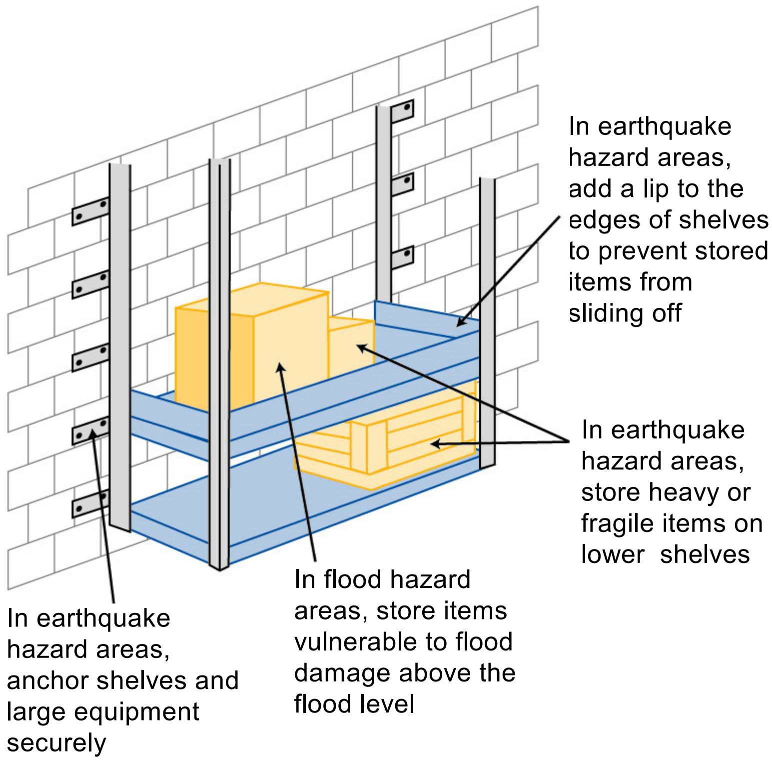


Figure 8

Secured equipment

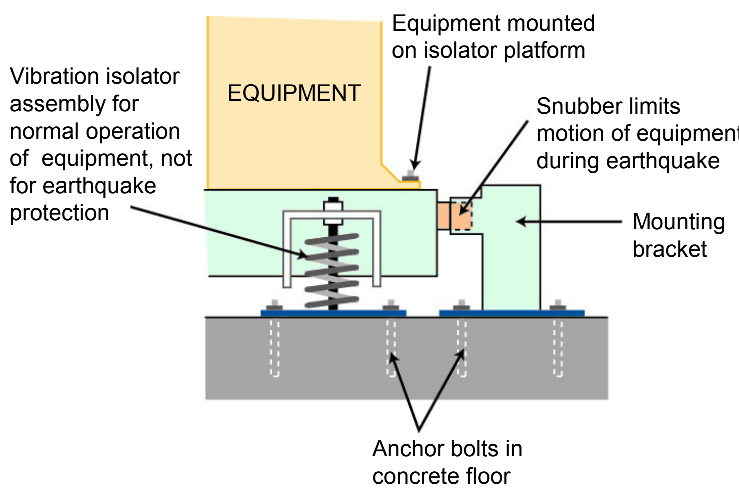


Figure 9

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.

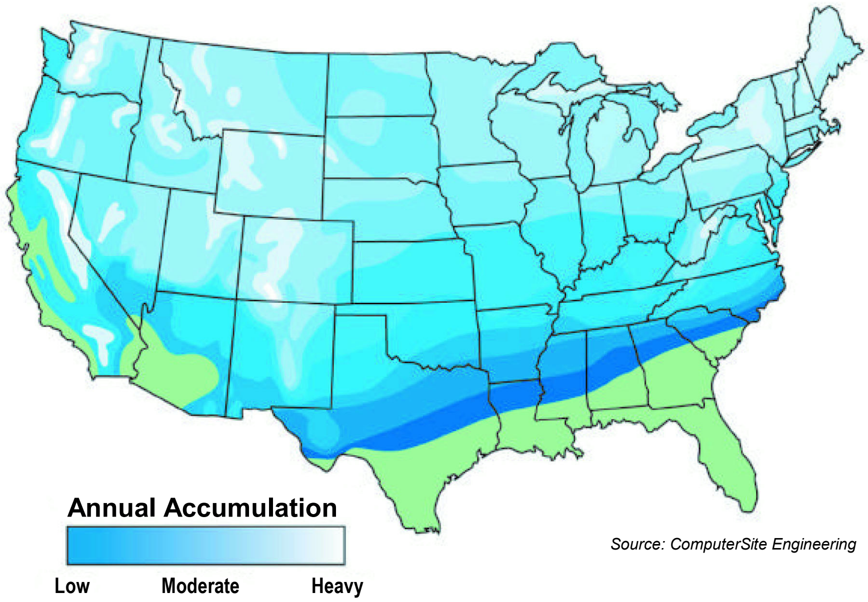


Figure 10

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.

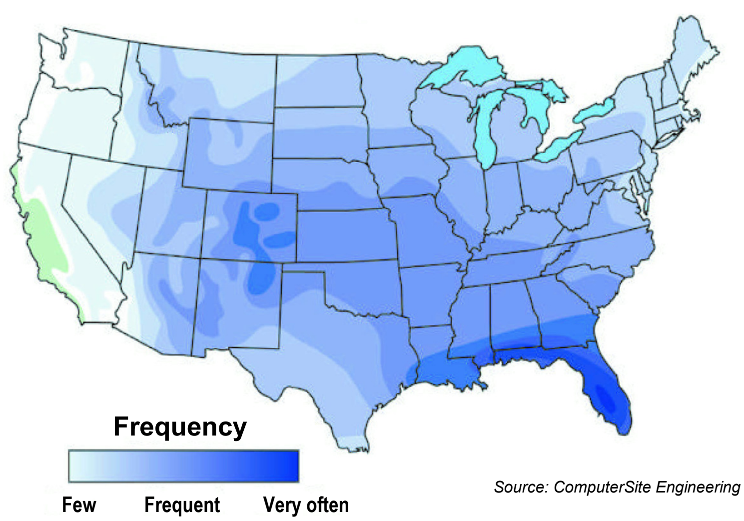


Figure 11

Thunderstorms

The following can be done to mitigate the risk of damage and downtime during a thunder-storm 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.

Site-related risks

In addition to geography, there are many other factors to consider when selecting a site. Site-related characteristics could significantly drive the availability of the business. This includes facts about the site, its community, and potential man-made risks.

The type of area your building is located in significantly contributes to your power quality. Cities are heavily populated, which means larger consumption of power and typically 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. Some additional factors to consider within rural areas include the distance to the nearest fire station should a fire occur; bugs or animals that could potentially crawl into air ducts; warm electrical equipment such as transformers and generators, or affect cooling towers; trees located where they could fall on the building or on necessary utility lines, or have branches and leaves fall into equipment; and accessibility to the site during major storms.

The robustness, diversity, remaining capacity, and location of the local utility's transmission grid are all factors. The closer you are to the substation, the less likely you are to experience power events. This is because there is a shorter distance of wires and electric poles that are subject to human error, animals on lines, and weather. The more diverse the utility grid, the better off the business is.

Wiring that is above ground 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 factors don't exist. When it does fail, however, it typically takes longer to repair.

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.

It is also important to consider the volume and type of construction that is going on in the neighborhood of the facility. There are several reasons that downtime increases when neighborhood construction exists.

1. Sags can be caused due to overloading the lines
2. The local distribution lines are subject to construction accidents, which can take down power lines completely
3. Construction near power lines sometimes results in scheduled shutdowns in the area.

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, chemical storage, freeways, rail lines, natural gas and other pipelines, electrical transmission and distribution lines. Another factor to consider is the probability of a hunter or trespasser impacting operations.

Assess what community services and resources are available in the event of an emergency. What fire protection is provided by the community and where is it located? What water capacity is available to support fire sprinkler systems? What are the sources of electric, natural gas, water, sewer, and communications services supplying the site? This information helps in planning construction and emergency preparation.

Building risks

The building itself will have a huge impact on the availability of the business. This includes factors such as complying with wiring 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. Also find out whether the building offers a service level agreement. If it does, make sure the agreement is in line with your business's objectives and the infrastructure fault tolerance it demands.

Economic risks

Economic possibilities will vary by site, city, county, and state. When selecting a new site, there are many economic issues to consider. Below is a short list of the types of issues that need to be addressed.

1. Electric utility's rate structure; the cost of electricity is typically the largest operating cost of a data center.
2. Tax and other incentives that may be offered. It is worthwhile to initiate incentives negotiations with local and state economic development agencies.
3. Overall operating costs of the site relative to other sites.
4. Land and construction costs.
5. The availability of skilled labor in the region.
6. Size of facility, and whether it meets both short-term and long-term projections.

Before selecting the site, it is important to review whether it meets your business objectives. Consider whether the facility will meet both short-term and long-term size requirements, and whether the new facility meets the operating requirements for the first five years.

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 minimize these risks can seem high, consider the potentially huge cost of a major downtime event on your business.

About the author

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