Connecting For Success…

ELECTRIC POWER DAYS 2017

BUILT FOR IT.™

CATERPILLAR®

Design for Critical Power Loads

Bryan A. Snyder, PMP
Product Application Specialist

BUILT FOR IT.™

CATERPILLAR®

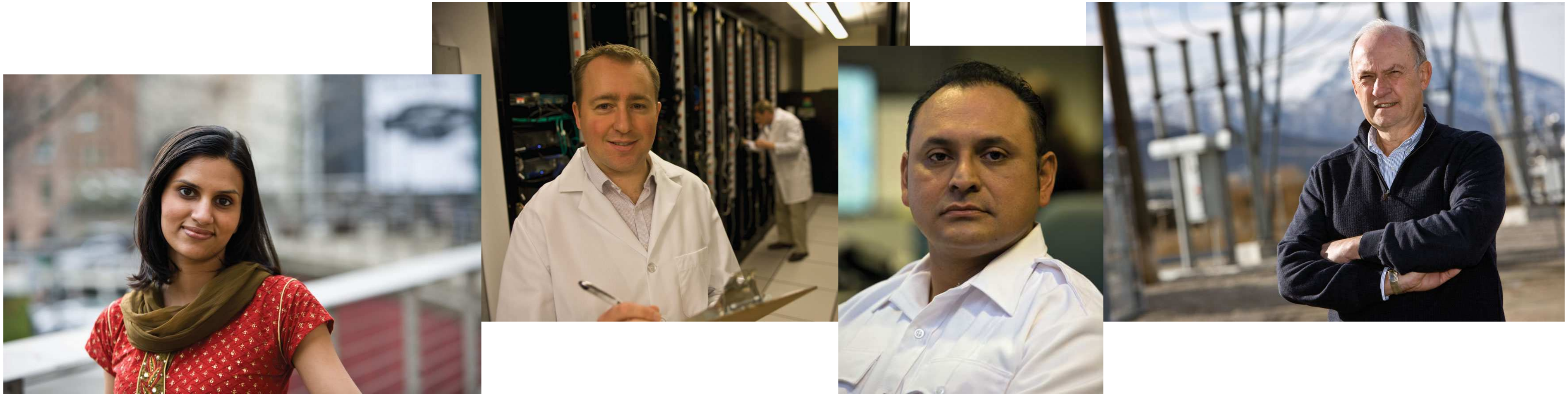
Design for a Critical Power Load

- Define critical power loads
- Ensure Reliability
- Develop Redundancy
- Integrate a Solution
- Review Availability

What is a Critical Load?

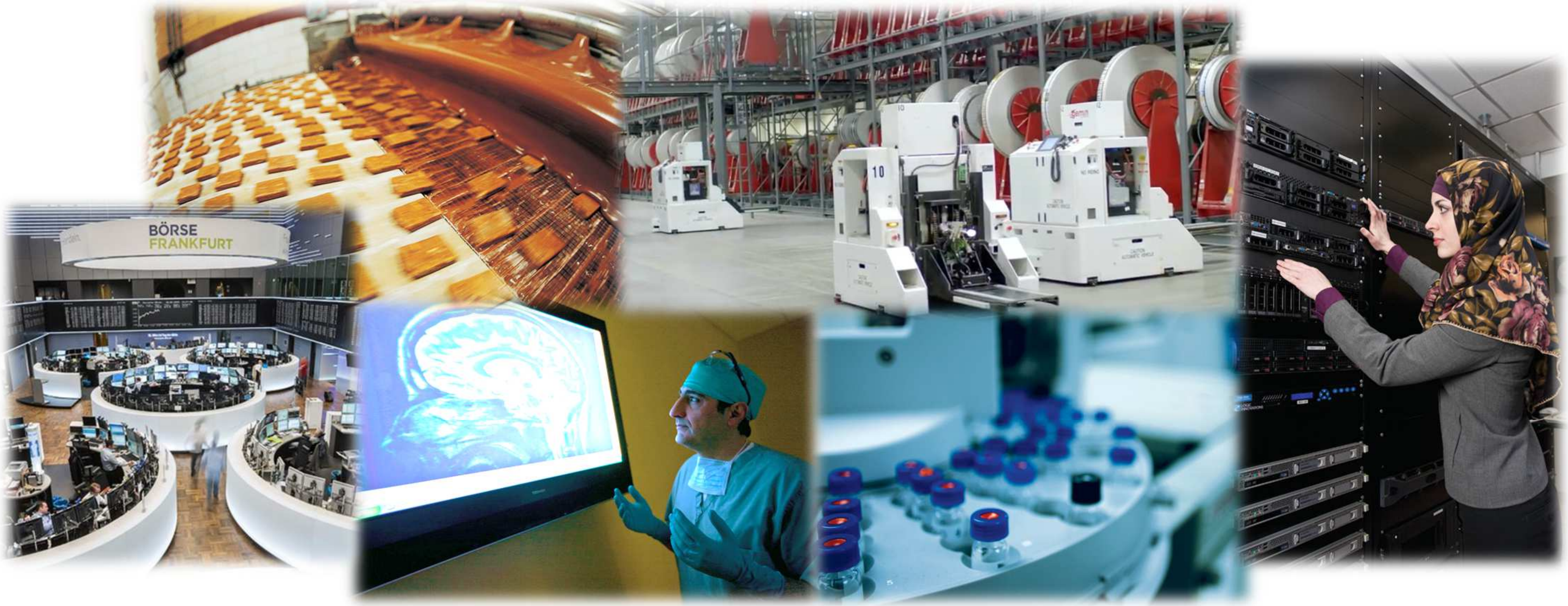
For this discussion lets assume these are addressed by Regulations, Codes and Standards

- Any load that directly impacts ~~life, safety or~~ the ability for the customer to make money.



Connecting For Success…

Any load that directly impacts the ability for the customer to make money.



Connecting For Success…

Cost of Down Time

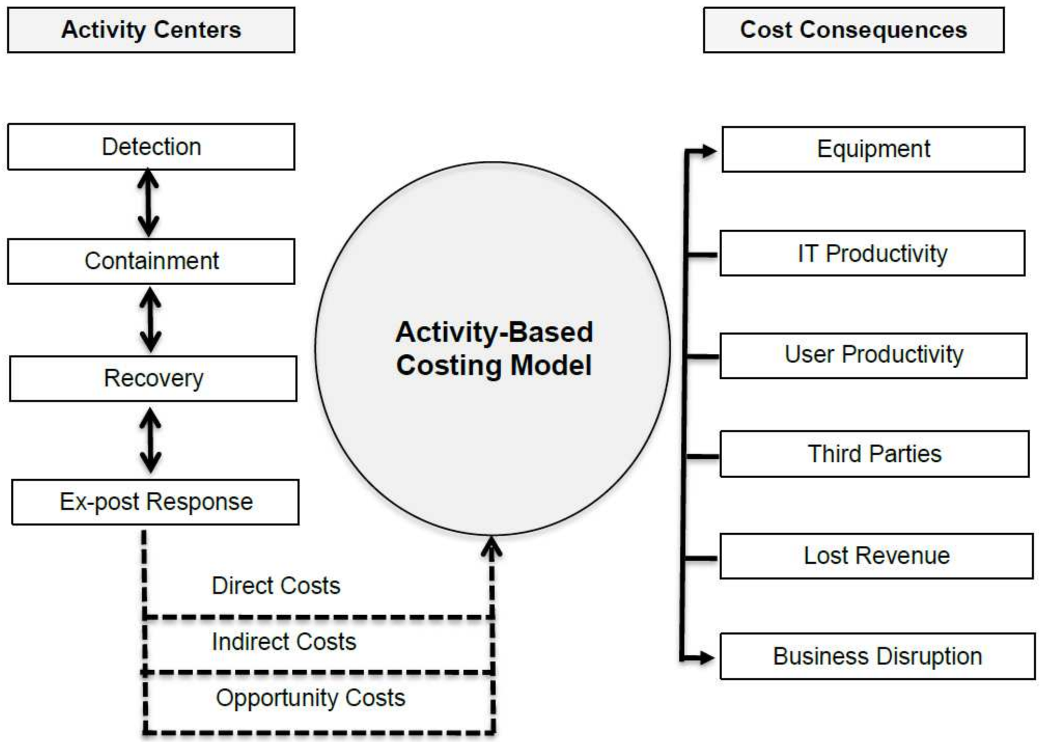
- Average cost of down time in Data Center $740,357, up 38% since 2010
  - Damage to mission-critical data
  - Impact of downtime on organizational productivity
  - Damages to equipment and other assets
  - Cost to detect and remediate systems and core business processes
  - Legal and regulatory impact, including litigation defense cost
  - Lost confidence and trust among key stakeholders
  - Diminishment of marketplace brand and reputation

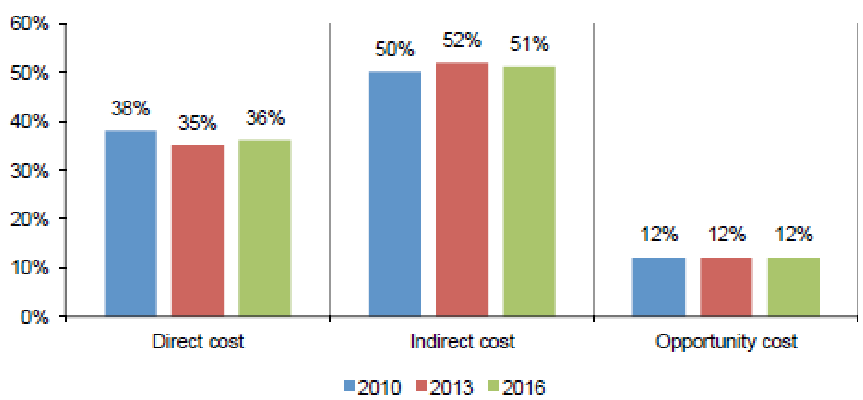
- Maximum downtime costs for 2016 was $2,409,991

"Cost of Data Center Outages", Ponemon Institute, January 2016.

Cost of Down Time

Figure 1: Activity-Based Cost Account Framework





"Cost of Data Center Outages", Ponemon Institute, January 2016.

Cost of Down Time

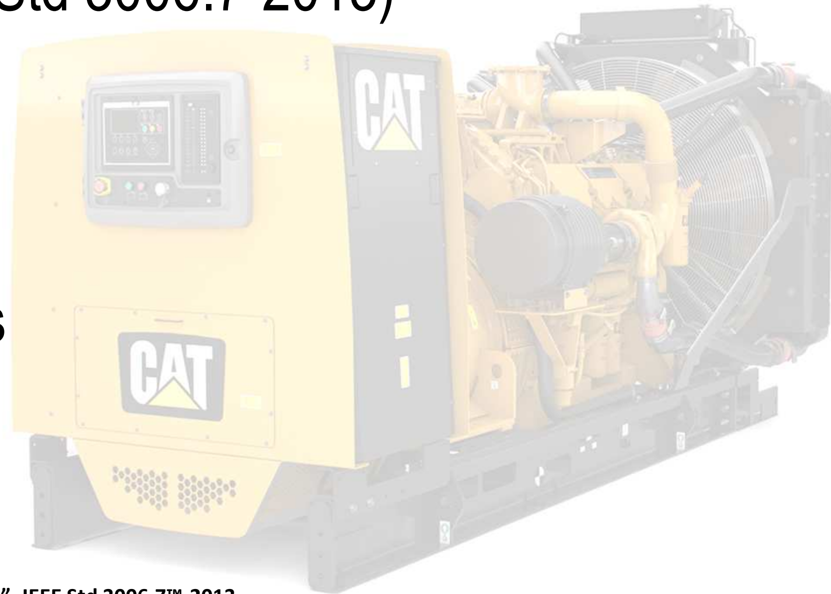
Time without power (hr)	0.25	
Time to reset (hr)	4	
Total lost production (hr)	4.25	
Outages per year	2	
Ave hr. rate per emp	$ 50.00	
# emp not working	50	
Lost Employee Productivity		$ 10,625.00
Lost Material		$ 25,000.00
Scrap with stop	50	
Average cost per	$ 500.00	
Lost Product Productivity		$ 850,000.00
Processes per hour	100	
Sales Price	$ 2,000.00	
Restoration		$ 1,400.00
Emp to reset	2	
Equipment repair	$ 1,000.00	
Total Cost of Down Time		$ 887,025.00
Annual Cost of Down Time		$ 1,774,050.00

Availability = Redundancy + Reliability

- Availability is the time a system is operating to protect the customer's load
- Redundancy is the duplication of components in a system with the intention to increase availability
- Reliability is the probability that a component or system will perform required functions under stated conditions for a stated period of time (IEEE Std 3006.7-2013)*

Ensure Reliability

- **Reliability**: The **<u>probability that a component or system will perform</u>** required functions under stated conditions for a stated period of time R(t), or (for discrete missions) a stated number of demands. (IEEE Std 3006.7-2013)*
- Industry Standards for calculating reliability:
  - Reliability Block Diagram
  - Fault Tree Analysis
  - Failure Mode Effects and Criticality Analysis



*"IEEE Recommended Practice for Determining the Reliability of 7x24 Continuous Power Systems in Industrial and Commercial Facilities", IEEE Std 3006.7™-2013

Define Failure

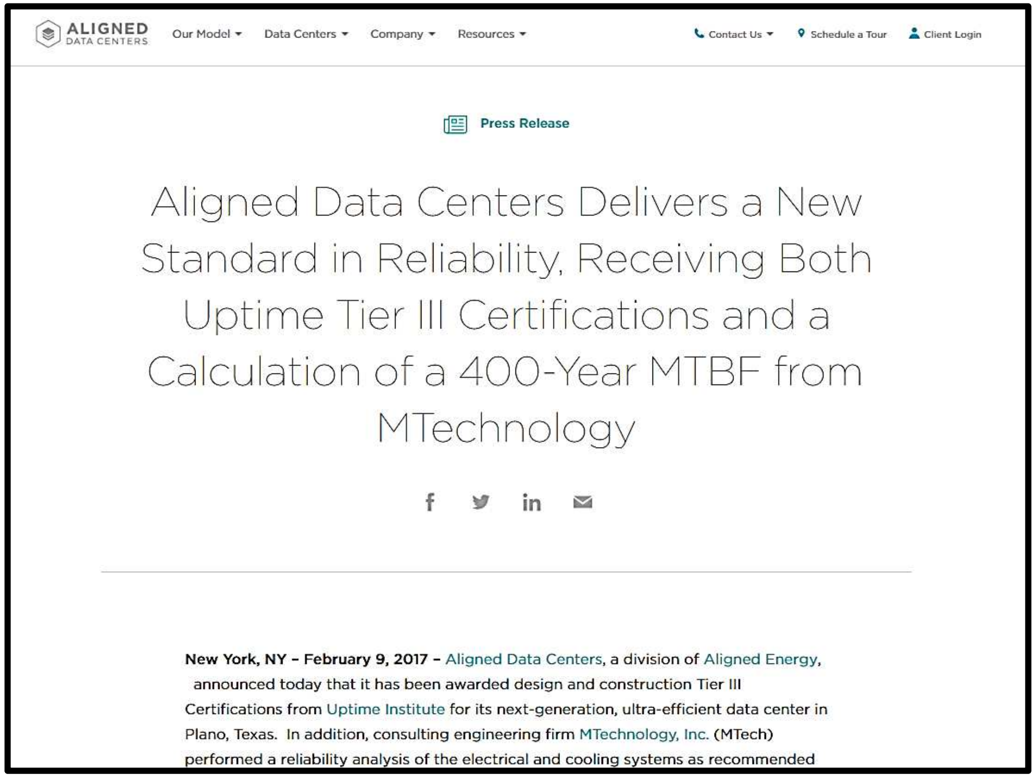
- Consider a UPS switches to internal bypass.
  - UPS vendor = success, because power to the critical load was not interrupted
  - Facility operations = failure, because UPS may require repair
  - Business manager = failure, because the critical loads are exposed to utility
  - Users of the service = success, because they are not affected

- System design should evaluate the reliability as:
  - Component Failure – Likelihood that a specific part of a product might fail (UPS Battery)
  - Subsystem Failure – Likelihood that a product might fail (UPS fails to deliver power to the load)
  - Electrical Distribution System Failure – Likelihood that the systems for delivering power might fail (Loss of power to the UPS)

*"IEEE Recommended Practice for Determining the Reliability of 7x24 Continuous Power Systems in Industrial and Commercial Facilities", IEEE Std 3006.7™-2013

Calculate Reliability

- Third party companies provide reliability calculations as a service
- "Most data centers achieve an MTBF between five and 50 years," says Stephen Fairfax, President of MTechnology.
- Utilizing these services can help to evaluate where design changes can provide the greatest impact


ALIGNED DATA CENTERS Our Model Data Centers Company Resources Contact Us Schedule a Tour Client Login

Press Release

Aligned Data Centers Delivers a New Standard in Reliability, Receiving Both Uptime Tier III Certifications and a Calculation of a 400-Year MTBF from MTechnology

New York, NY – February 9, 2017 – Aligned Data Centers, a division of Aligned Energy, announced today that it has been awarded design and construction Tier III Certifications from Uptime Institute for its next-generation, ultra-efficient data center in Plano, Texas. In addition, consulting engineering firm MTechnology, Inc. (MTech) performed a reliability analysis of the electrical and cooling systems as recommended

*MTBF(Mean Time Between Failure)

https://www.aligneddatacenters.com/news-and-events/aligned-data-centers-delivers-a-new-standard-in-reliability-receiving-both-uptime-tier-iii-certifications-and-a-calculation-of-a-400-year-mtbf-from-mtechnology

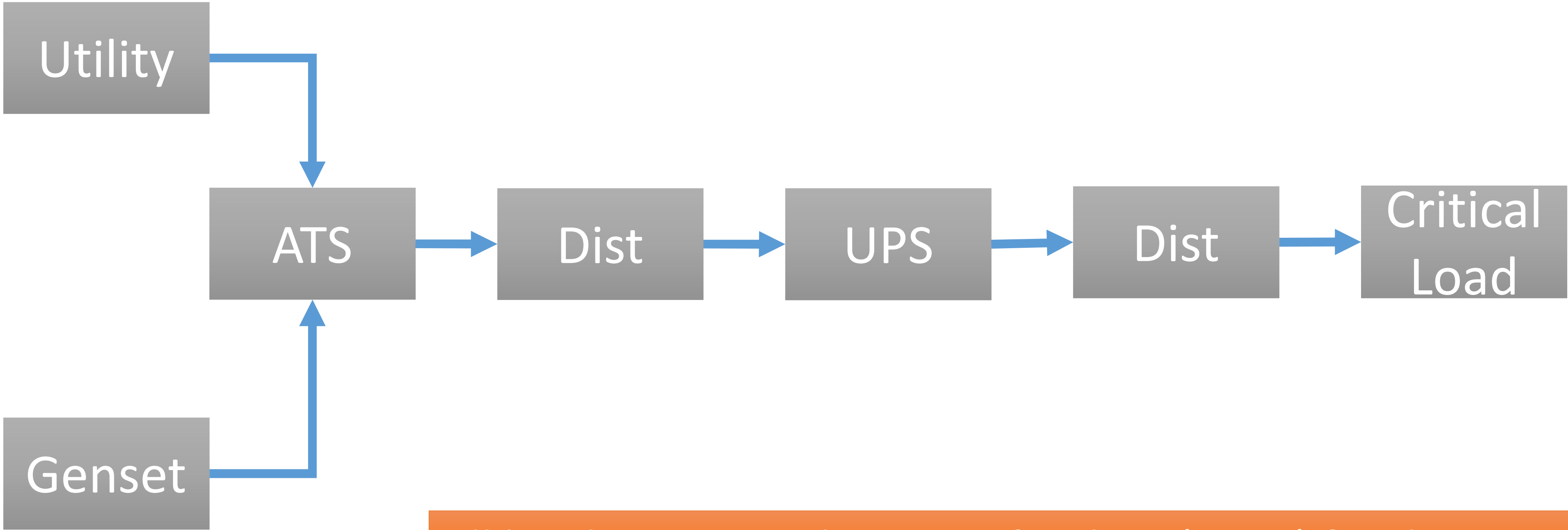
Redundancy

- Redundancy is the duplication of components in a system with the intention to increase availability

Classification	Definition	Redundancy Evaluation
N	Need, meets the base capacity requirements	Low None
N+1	One additional unit over the need. Could be attributed to a component level or system level. (Can also be N+2, N+3, …)	Moderate Some equipment can fail or be taken off-line for maintenance without impacting critical load
2N	Two completely redundant components or systems. Often used when referring to an A/B system or system with two redundant paths of power.	Good Allows for concurrent maintenance of equipment and protection from a loss of any single point within the system.
2(N+1)	Provides two completely redundant paths along with an individual level of redundancy in each path.	Highest Provides concurrent maintenance and fault tolerance by allowing a single failure in any path without impacting the paths ability to support the load.

N design

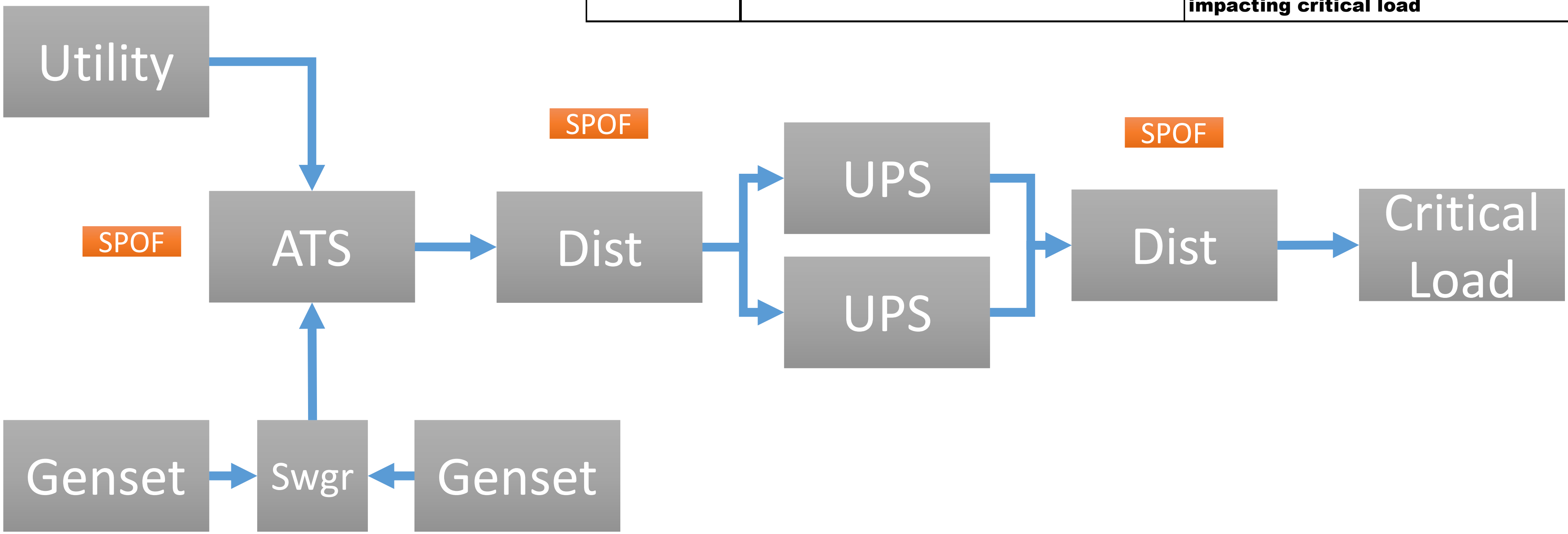
Classification	Definition	Redundancy Evaluation
N	Need, meets tha base capacity requirements	Low None



All levels are a Single Point of Failure (SPOF) for the system

N+1 design

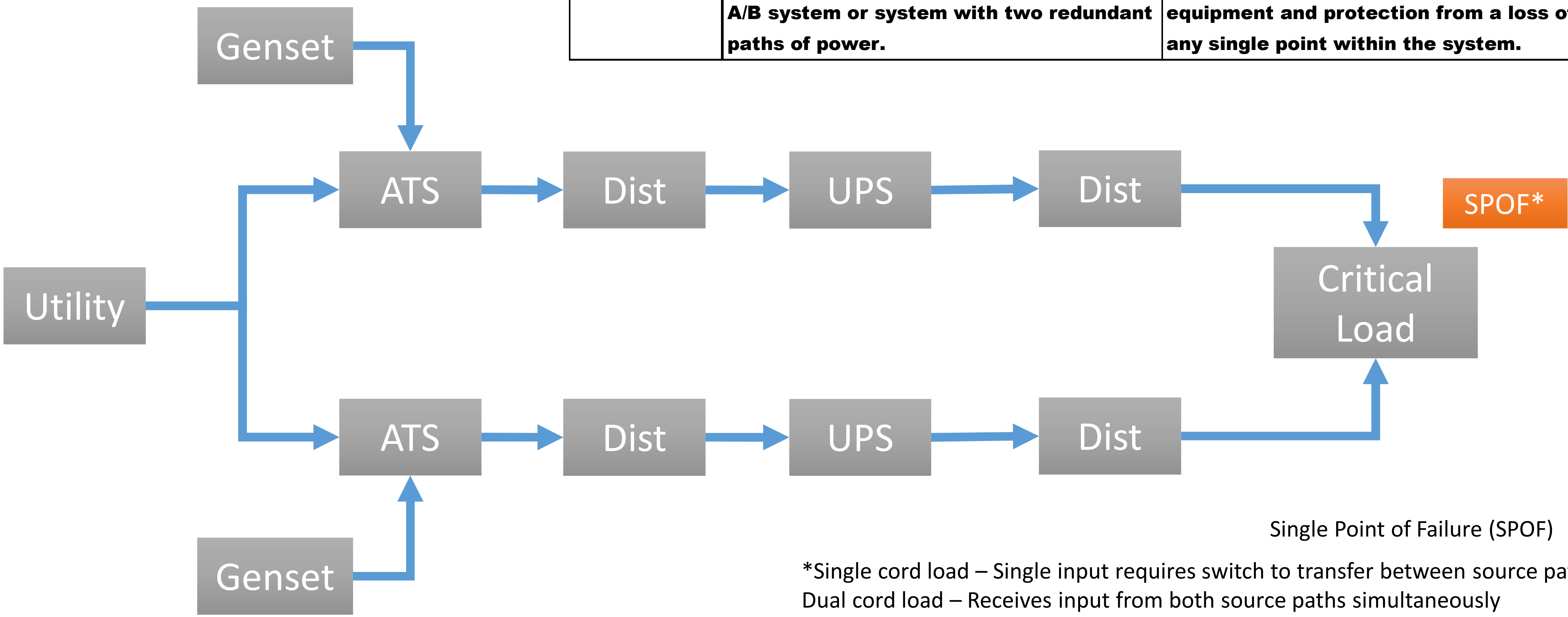
Classification	Definition	Redundancy Evaluation
N+1	One additional unit over the need. Could be attributed to a component level or system level. (Can also be N+2, N+3, ...)	Moderate Some equipment can fail or be taken off-line for maintenance without impacting critical load



Single Point of Failure (SPOF)

2N design

Classification	Definition	Redundancy Evaluation
2N	Two completely redundant components or systems. Often used when refering to an A/B system or system with two redundant paths of power.	Good Allows for concurrent maintenance of equipment and protection from a loss of any single point within the system.

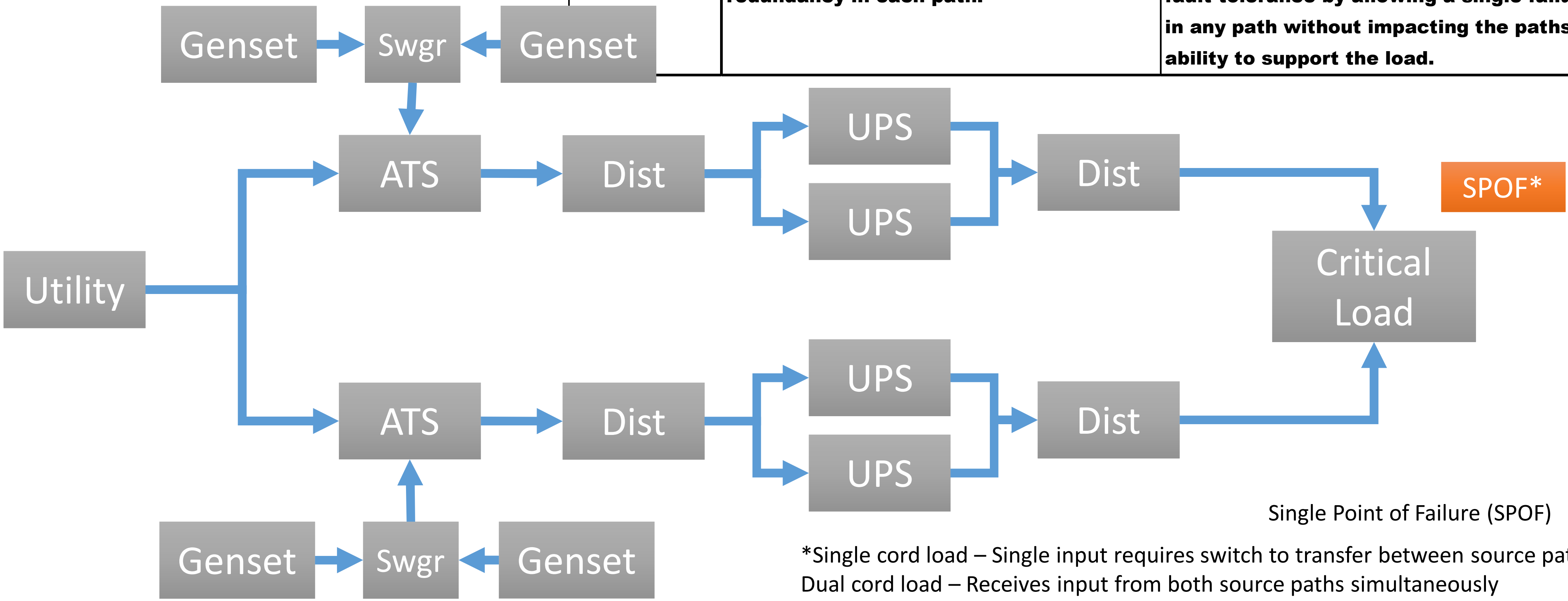


Single Point of Failure (SPOF)

*Single cord load – Single input requires switch to transfer between source path
Dual cord load – Receives input from both source paths simultaneously

2(N+1) design

Classification	Definition	Redundancy Evaluation
2(N+1)	Provides two completely redundant paths along with an individual level of redundancy in each path.	Highest Provides concurrent maintenance and fault tolerance by allowing a single failure in any path without impacting the paths ability to support the load.



Single Point of Failure (SPOF)

*Single cord load – Single input requires switch to transfer between source path
Dual cord load – Receives input from both source paths simultaneously

Is there too much redundancy?

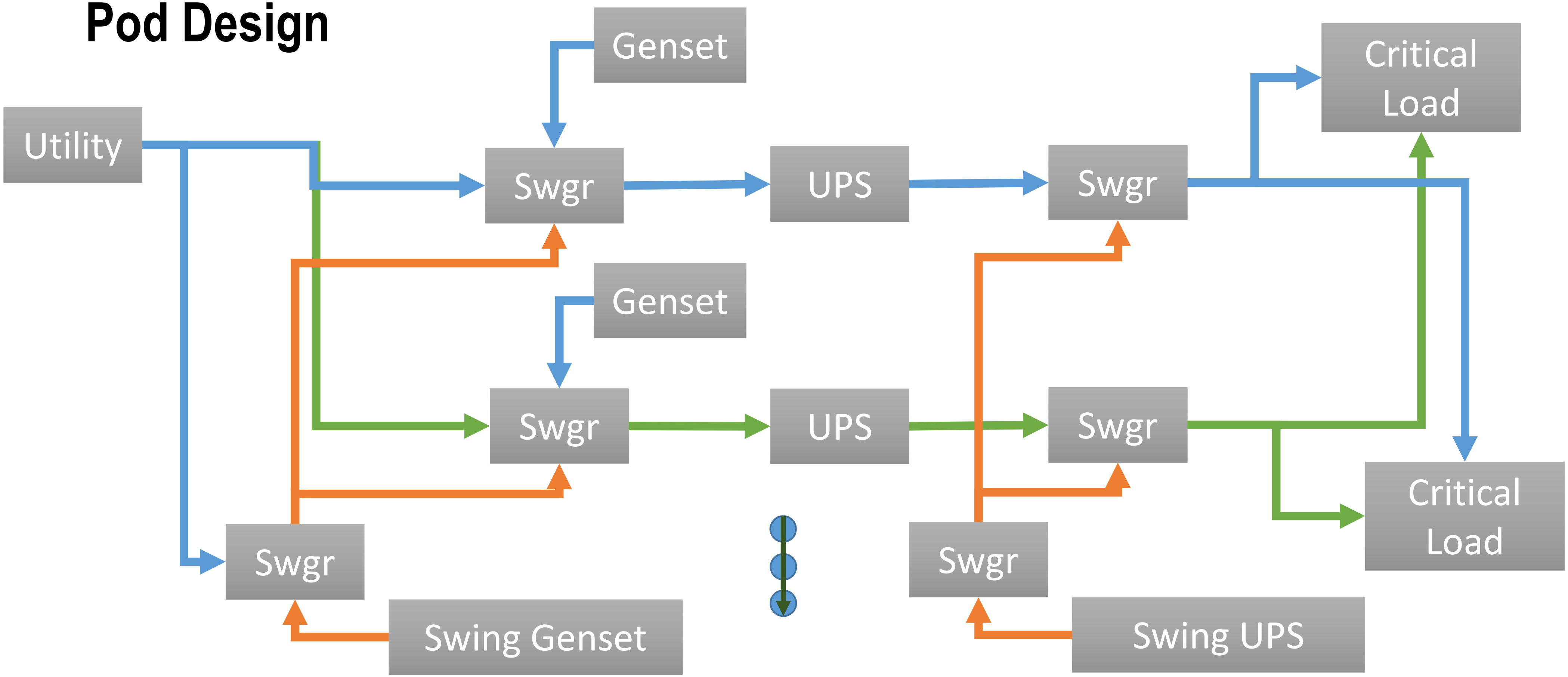
*System where N = 2 Gen and 4 UPS
With dual corded loads

Name	Description of critical distribution system	MTBF (years)	MTTR (hours)	Inherent availability	Probability of failure
N+1 Gen 2N UPS	2 + 1 = 3 Gen 2(4) = 8 UPS	66.6	2.50	0.9999957	7.57%
N+1 Gen 2(N+1) UPS	2 + 1 = 3 Gen 2(4 + 1) = 10 UPS	67.5	2.50	0.9999958	7.18%
2N Gen 2N UPS	2(2) = 4 Gen 2(4) = 8 UPS	68.9	2.57	0.9999958	6.96%

Other considerations:
Efficiency, Maintenance, Operational cost

*"IEEE Recommended Practice for Determining the Reliability of 7x24 Continuous Power Systems in Industrial and Commercial Facilities", IEEE Std 3006.7™-2013

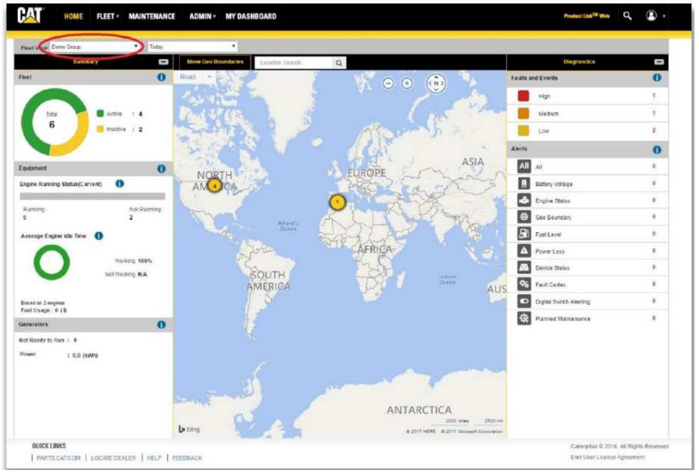
Pod Design

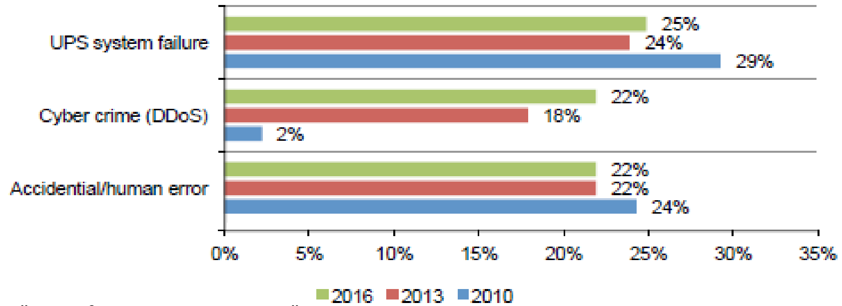


Genset
Critical Load
Utility
Swgr
UPS
Swgr
Genset
Swgr
UPS
Swgr
Critical Load
Swgr
Swgr
Swing Genset
Swing UPS

Integrating a Solution

- Complex designs require complex sequence of operation
  - Communication between devices simplifies operation
  - Integration provides centralize view of system
  - Aids in identifying failure modes at multiple levels
- Packaging delivers additional value
  - Reduced installation time and cost
  - Improved system quality
  - Reduced startup time on site
- Improved performance options
  - Storm Threat Avoidance
  - Load Sense Load Demand
- Provide alternatives for risk mitigation





"Cost of Data Center Outages", Ponemon Institute, January 2016.

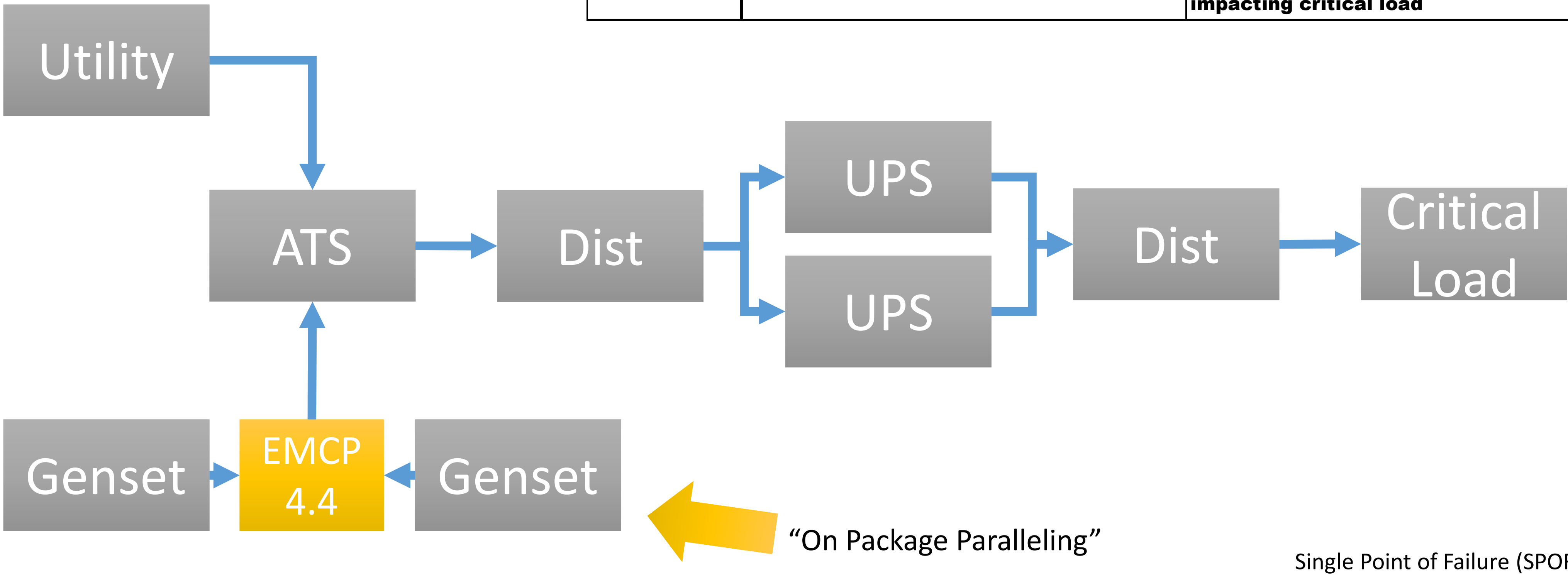
Value Engineering

Consider opportunities to reduce installation and operating costs without impacting the system design

- High Efficiency UPS (consider the operating load)
- On Package Paralleling Options
- Alternative Energy Solutions

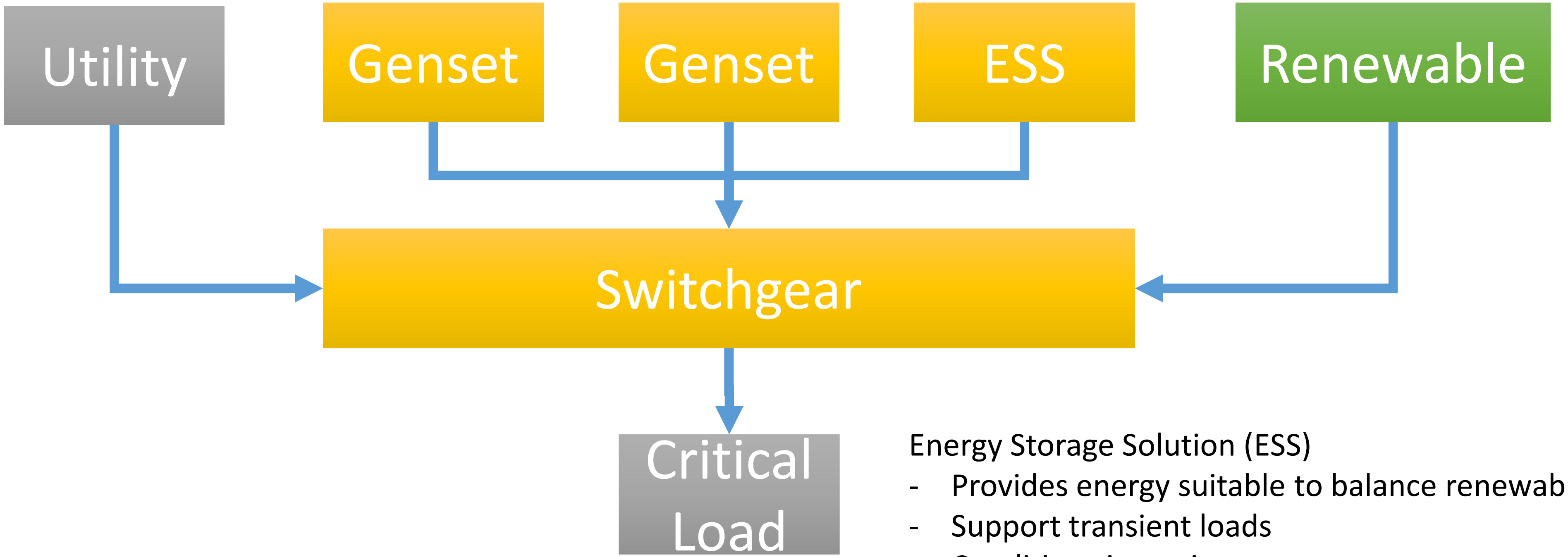
N+1 design

Classification	Definition	Redundancy Evaluation
N+1	One additional unit over the need. Could be attributed to a component level or system level. (Can also be N+2, N+3, ...)	Moderate Some equipment can fail or be taken off-line for maintenance without impacting critical load



Single Point of Failure (SPOF)

Alternative Energy Solutions



Energy Storage Solution (ESS)
- Provides energy suitable to balance renewable
- Support transient loads
- Conditions incoming power
- Provides ride-through energy for Critical Loads

Availability = Redundancy + Reliability

- Evaluate Cost of Downtime to determine customer’s risk acceptance
- Define a failure to identify success
- Consider reliability as part of Availability to provide a complete picture
- Develop the optimal level of redundancy to fit the customer’s risk acceptance
- Identify integration opportunities to deliver on maximum customer advantage
- Deliver a system that protects the customer’s future revenues

BUILT FOR IT.™

Connecting For Success...