

DEFINING, MEASURING, AND ASSIGNING RESILIENCE REQUIREMENT

Categories for energy availability and recovery

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Power System Resilience

▶ 6 nines - 5 nines - 4 nines - 3 nines
0.9999999 0.999999 0.99999 0.999

▶ More nines = greater availability

- ▶ - Quality equipment
- Easiest to repair
- Then, add redundancy

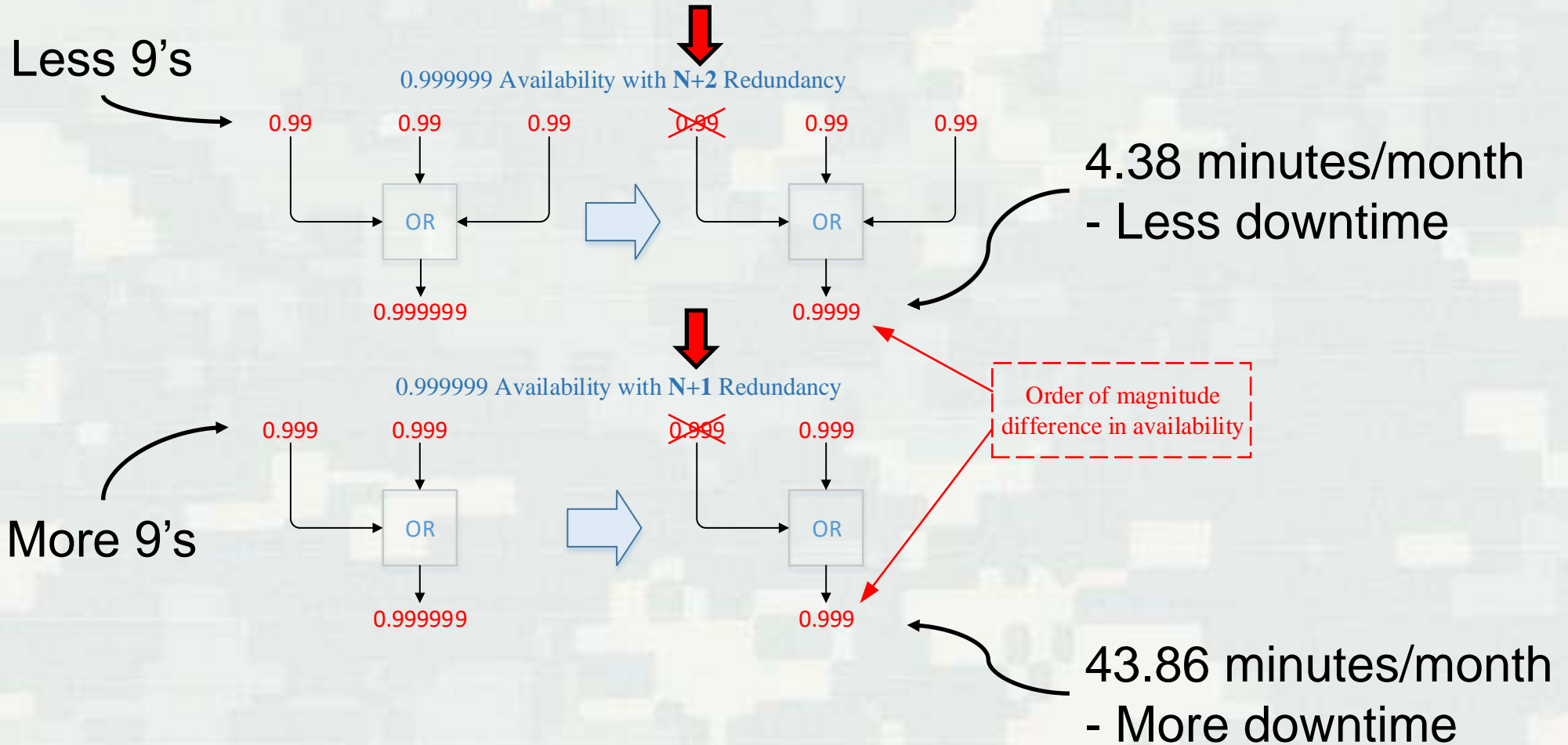
▶ 3 nines / 0.999 = 43.83 minutes/month downtime

6 nines / 0.9999999 = 2.63 seconds/month downtime

*Magnitude of
difference*

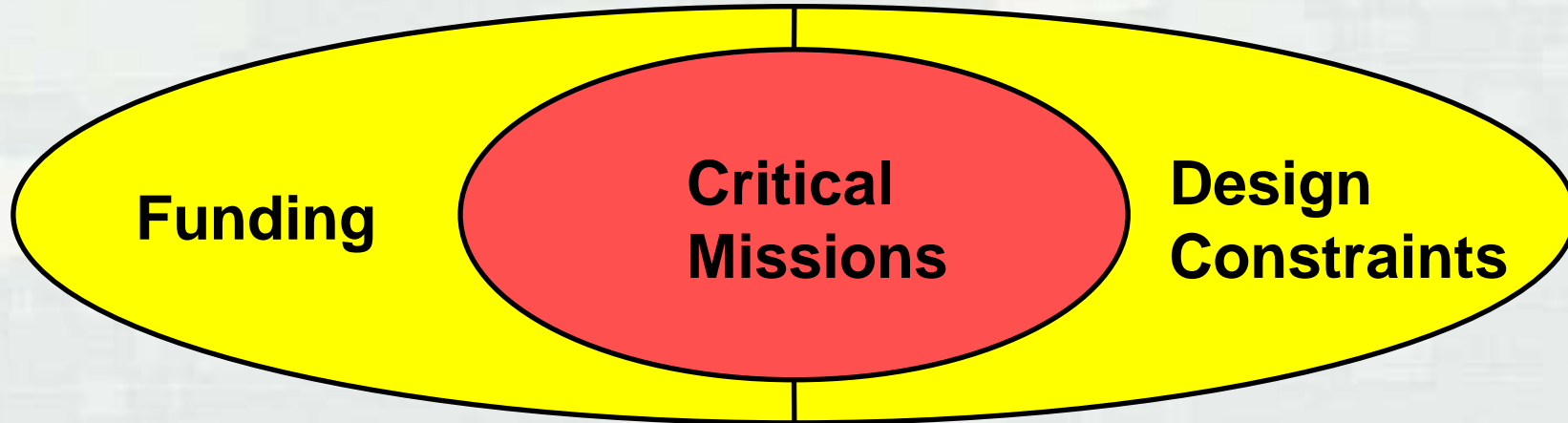


Power System Resilience



Criticality

Critical mission function = function vital to continuation of operations



Sum of following metrics:

- Effect
- Recoverability
- Substitutability
- Mission Functionality
- Repairability

DRIVES

Facility criticality classification:

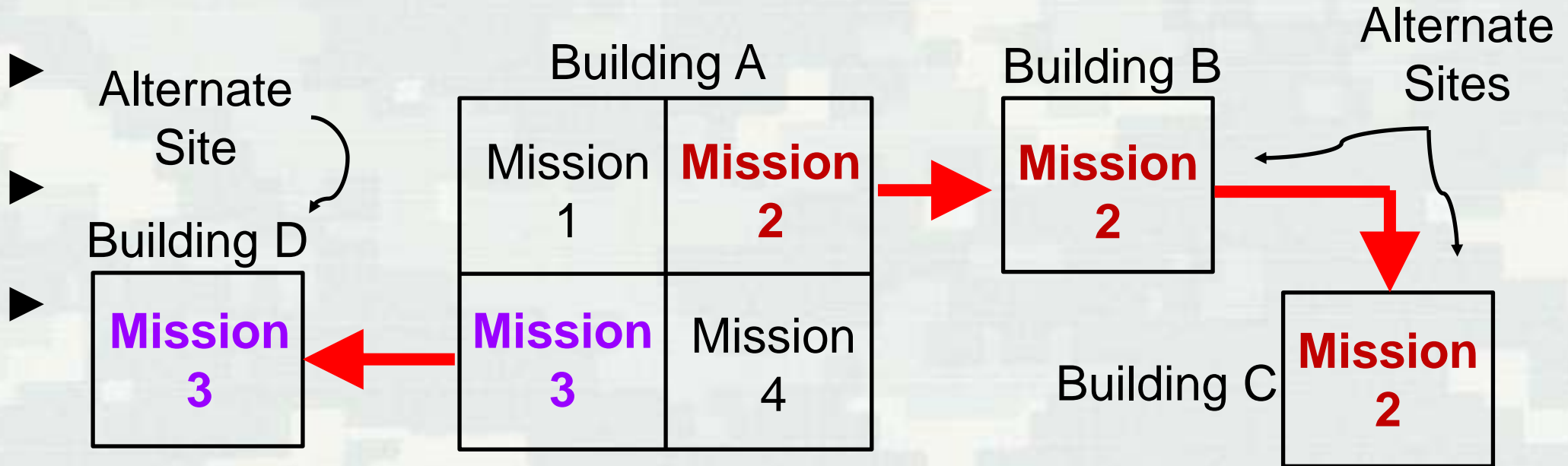
- Low
- Moderate
- Significant
- High

Remoteness

- ▶ Geographical location (outside of U.S., island, arctic)
 - ▶ Unique accessibility factors (mountains, water, primitive roads)
-
- ▶ Qualified repair crew
 - ▶ Repair tools and equipment
 - ▶ Repair spare parts

Numerical Rating	Low (0 – 6)	Moderate (7-12)	Significant (13-160)	High (17-20)
Description	Immediate/low cost or short-term/ moderate cost to repair (0 to 72 hours)	Mid-term repair / significant cost to repair (more than 72 hours, less than 7 days)	Long-term / high cost to repair (more than 7 days, less than 30 days)	More than 30 days or no repair possible

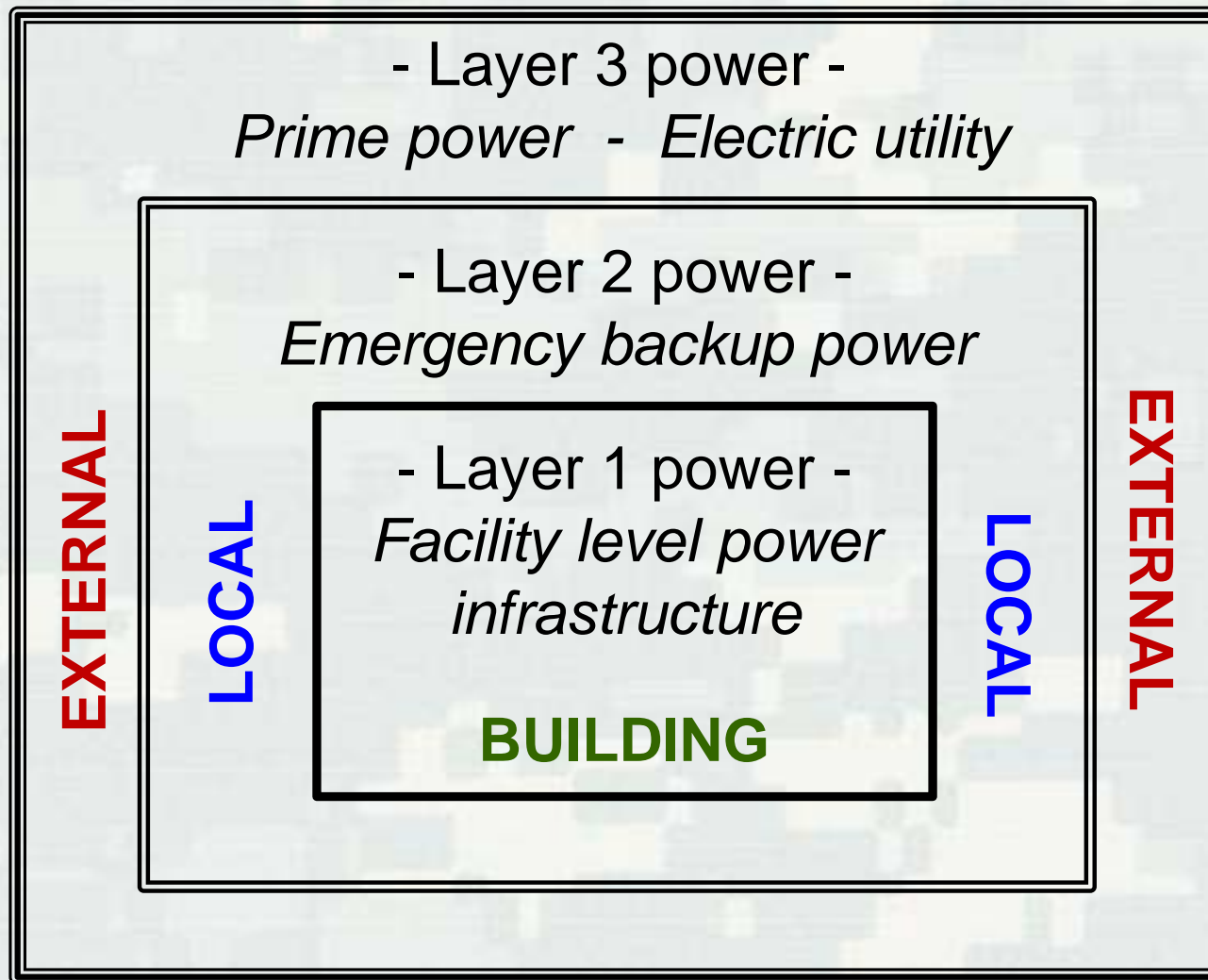
Facility Redundancy



High (0 – 6)	Significant (7-12)	Moderate (13-16)	Low (17-20)
Not difficult to accomplish mission using facilities providing similar capabilities (redundancy > 150%)	Difficult to accomplish mission using facilities providing similar capabilities (redundancy 60 to 150%)	Very difficult to accomplish mission using facilities providing similar capabilities (redundancy 35 to 55%)	Limited substitutes for facilities providing similar capabilities are available (redundancy < 30%)



Energy Availability & Max Single Event Downtime



Energy Availability & Max Single Event Downtime

Power Delivery = 3 Mechanisms (Layers)

Layer 1: - (Power ride-through until Layer 2 provides power)

- ▶ Uninterruptable Power Supply
- ▶ Automatic Transfer Switch

Layer 2: - (Sized for max time to repair ideally)

- ▶ Building dedicated generator (critical load sized)
- ▶ Solar assist (building dedicated)
- ▶ Wind assist (building dedicated)

Layer 3:

- ▶ Utility substation
- ▶ Utility medium voltage distribution
- ▶ Campus wide distributed generation

Categories for Energy Availability & Recovery

Evaluate  Criticality + Remoteness + Redundancy

- Then determine -



Resilience Phase
= Availability + Recovery

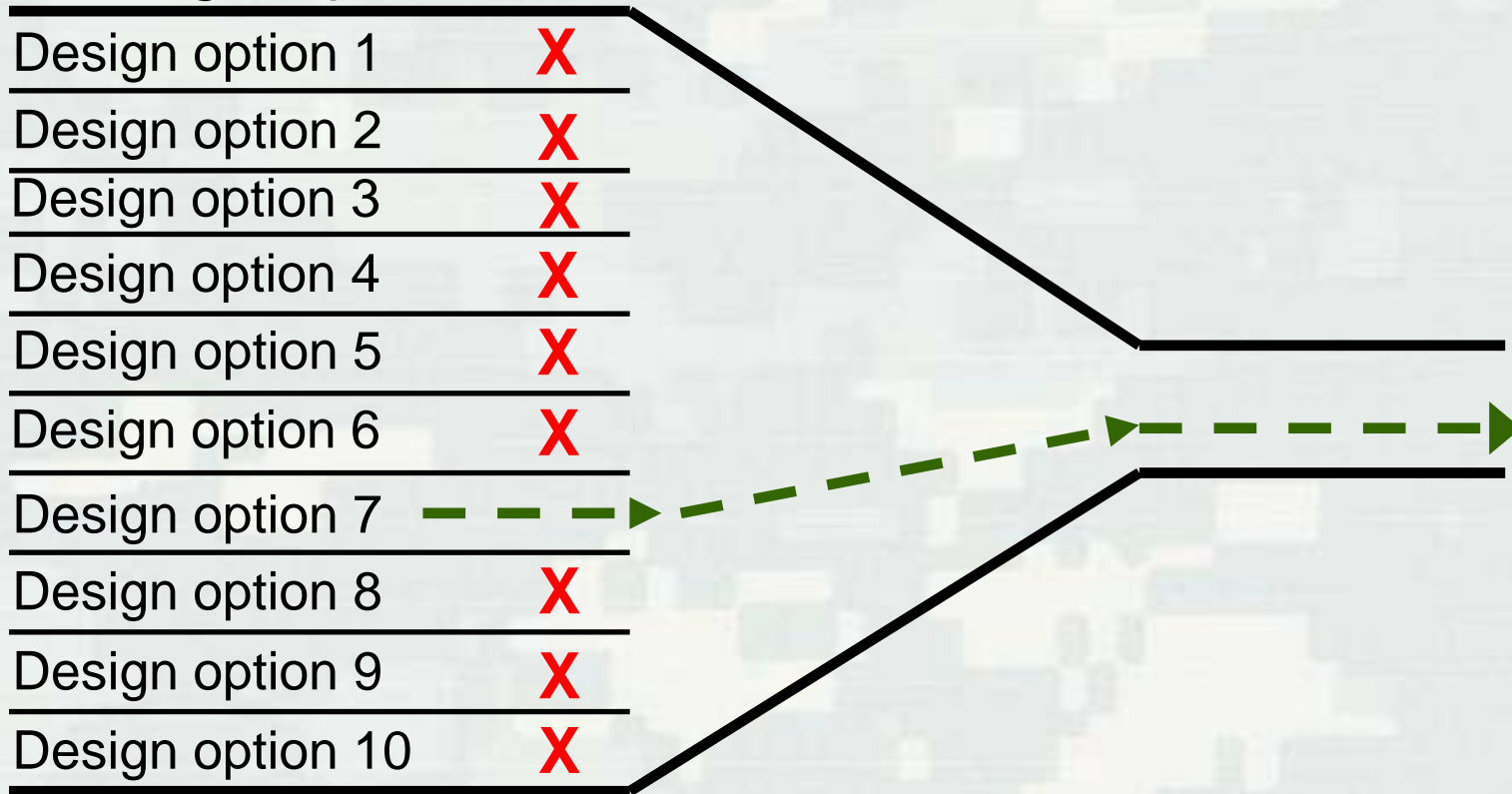
Resilience Metric Requirement			
Low	Medium	Significant	High
Offices, administrative, housing, recreation facilities, etc.	Intelligence processing, district office buildings, etc.	Medical centers, logistics warehouses, etc.	Warfighting facilities, IC, hospitals, continuity of government operations, critical communications facilities, nuclear command and control, etc.



Energy Availability & Max Single Event Downtime

Unify Design

Design Options



Energy Availability & Max Single Event Downtime

- ▶ Additional level of granularity for more accurate direction as to the most appropriate category of resiliency.
 - Assist in the ability to select the most appropriate category.
- ▶ More flexibility for a project to identify the lowest Resilience Metric Requirement level that is appropriate.
 - Avoid over design beyond appropriate that increases cost.
- ▶ Assistance to a project team to resist invention of a resilience level that is not represented in less granular criteria.
 - Providing sufficient levels to fit a wide variety of project.

Energy Availability & Max Single Event Downtime

Resilience Metric	Facility Level	Resilience Sub-Metric	Category	Degraded State Availability	Acceptable Average Weekly Downtime (Minutes)	Maximum Single Event Downtime (Minutes)
Low	Primary	Low	LP/1	0.92	806.4	2,419
		Moderate	LP/1+	0.95	504	1,500
	Secondary	Low	LS/0	0.9	1008	3,024
		Moderate	LS/0+	0.92	806.4	2,419
Moderate	Primary	Low	MP/2	0.99	100.8	302
		Moderate	MP/2+	0.995	50.4	150
	Secondary	Low	MS/1	0.95	504	1,500
		Moderate	MS/1+	0.99	100.8	302
Significant	Primary	Moderate	SP/3	0.999	10.08	30
		Significant	SP/3+	0.9995	5.04	15
	Secondary	Moderate	MS/2	0.95	504	1,500
		Significant	MS/2+	0.99	100.8	302
High	Primary	Significant	HP/4	0.9999	1.008	3
		High	HP/4+	0.99999	0.1008	0.3
	Secondary	Significant	HS/3	0.9995	5.04	15
		High	HS/3+	0.9999	1.008	3



Energy Availability & Max Single Event Downtime

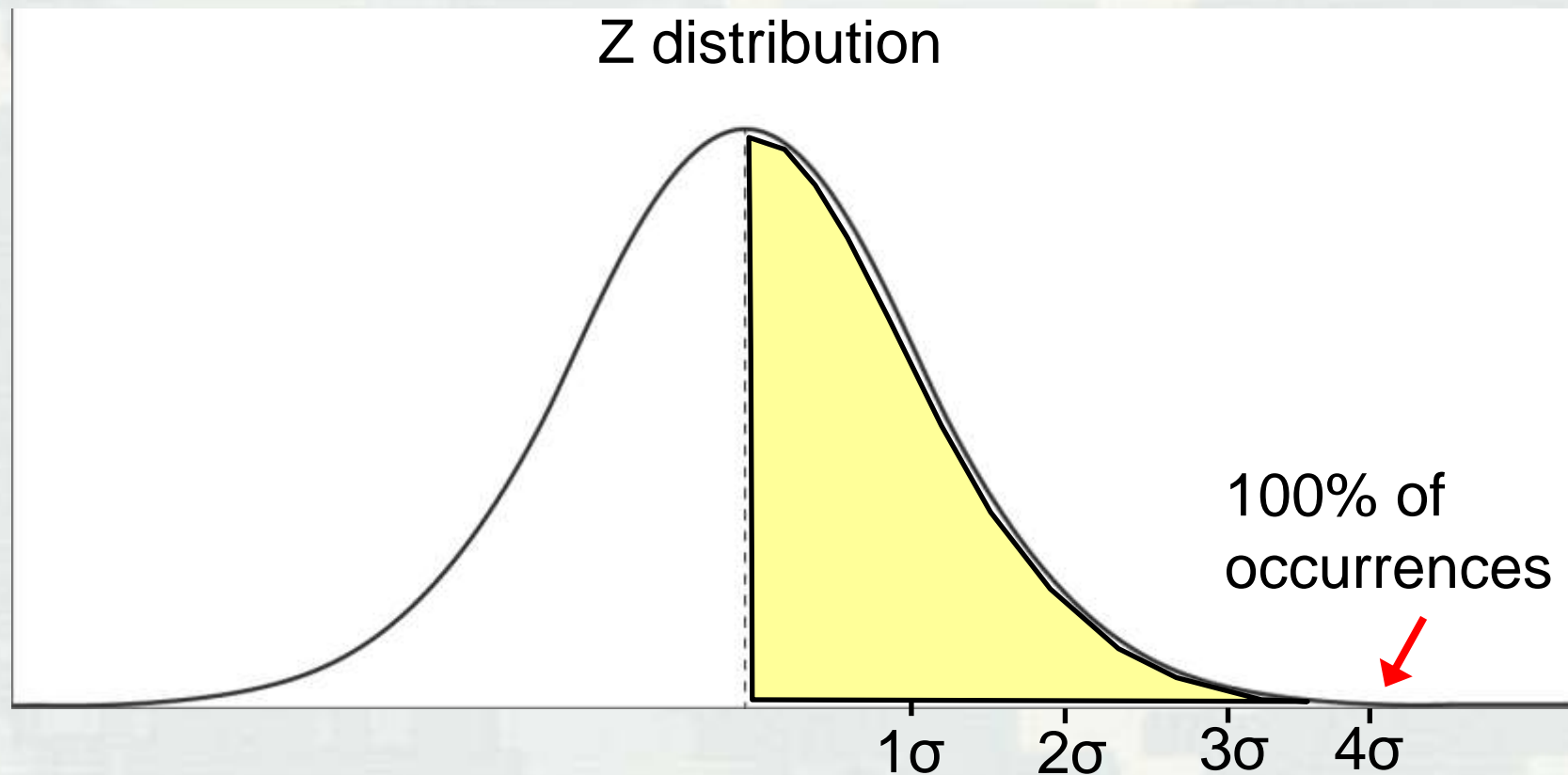
Mission & customer are interested in the Max downtime potential

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Energy Availability & Max Single Event Downtime

What will be the maximum downtime for the design option selected ?

MaxSEDT = Max Single Event Down Time = 4 standard deviations



Energy Availability & Max Single Event Downtime

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