Case Study: Defining and Measuring Protection Signal Exchange Speed, Latency, and Reliability Within Digital Trip Circuits

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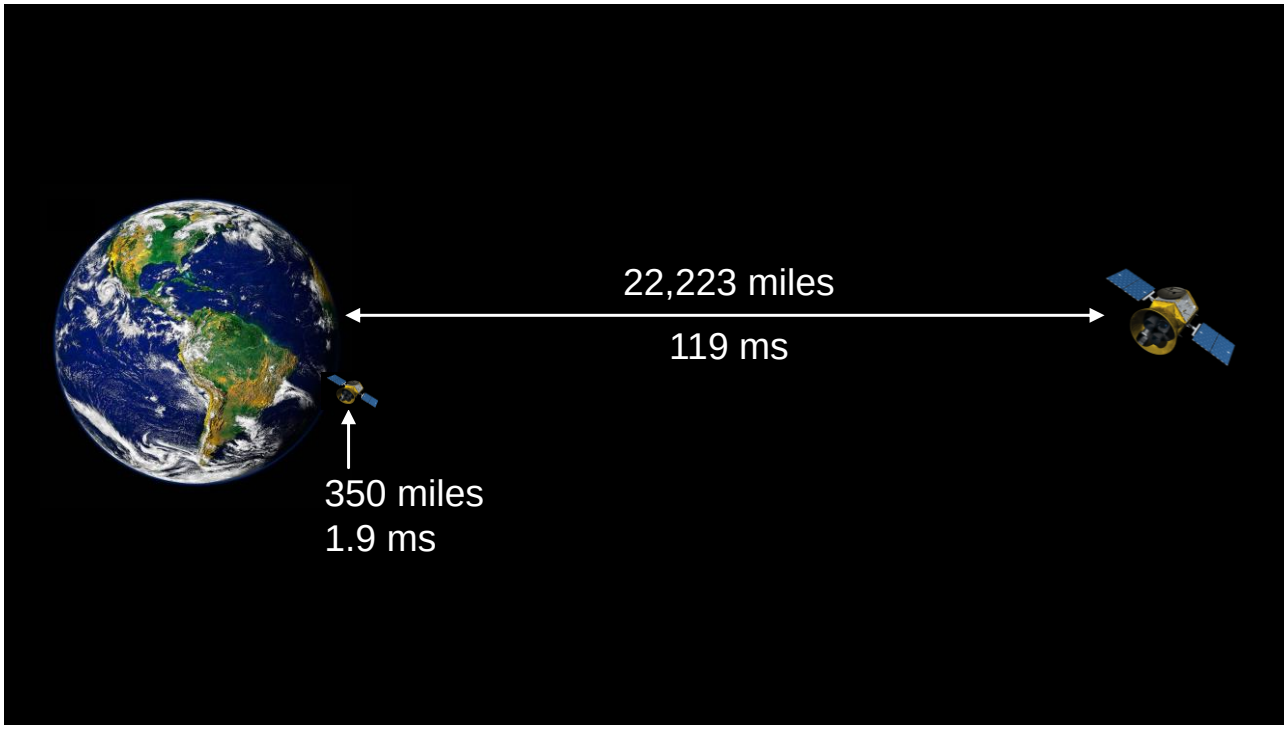
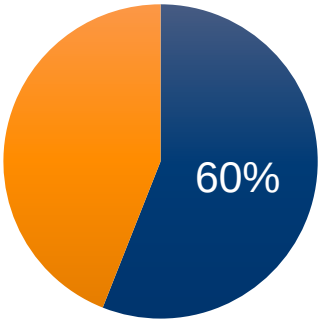


What design decisions impact protection systems?

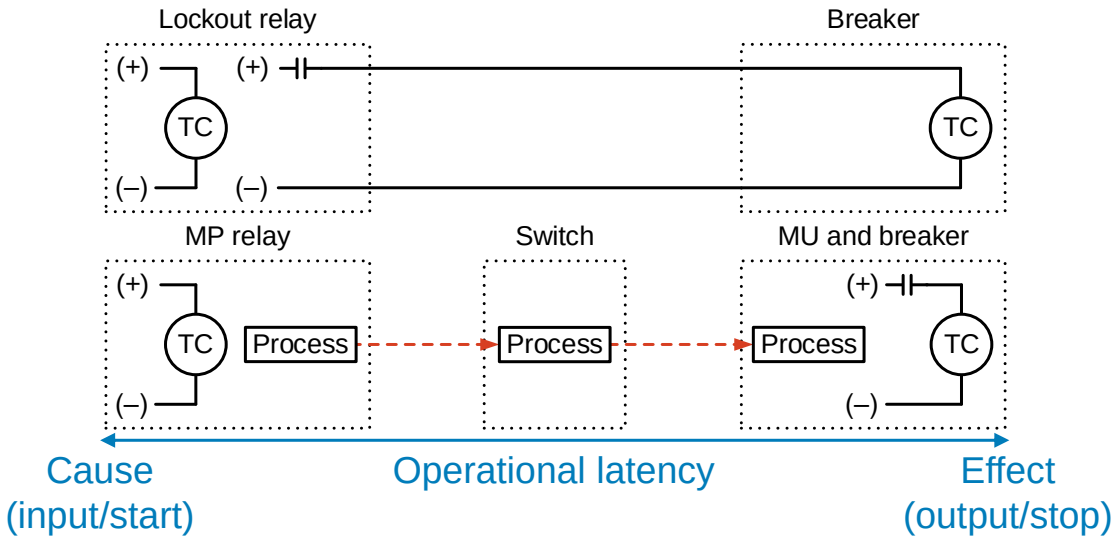
> Increasing **complexity in protection**…could **negatively impact system resilience**…"
>
> —NERC

> **56%** of respondents plan on replacing hardwired I/O in their system with digital communications"
>
> —Newton-Evans

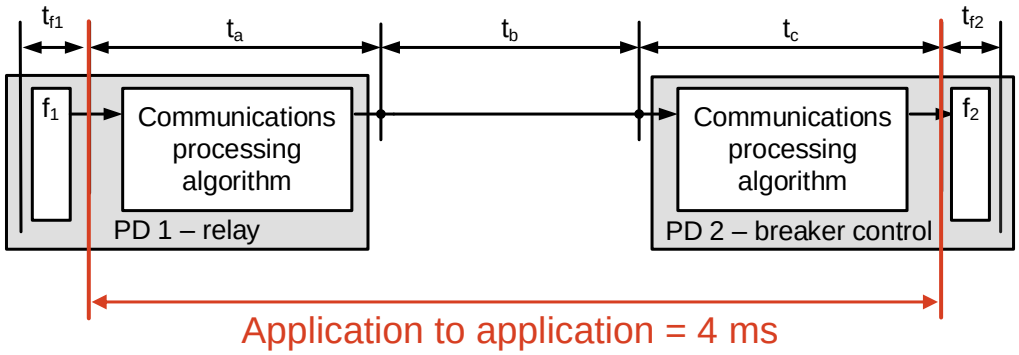
Misoperations-design, hardware, and communications



What is operational latency in trip circuits?

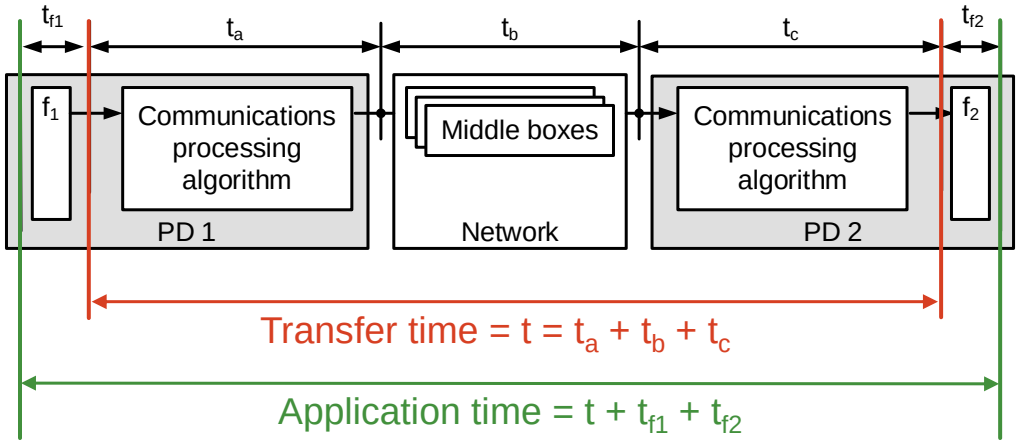


IEEE P1525 circa 2000

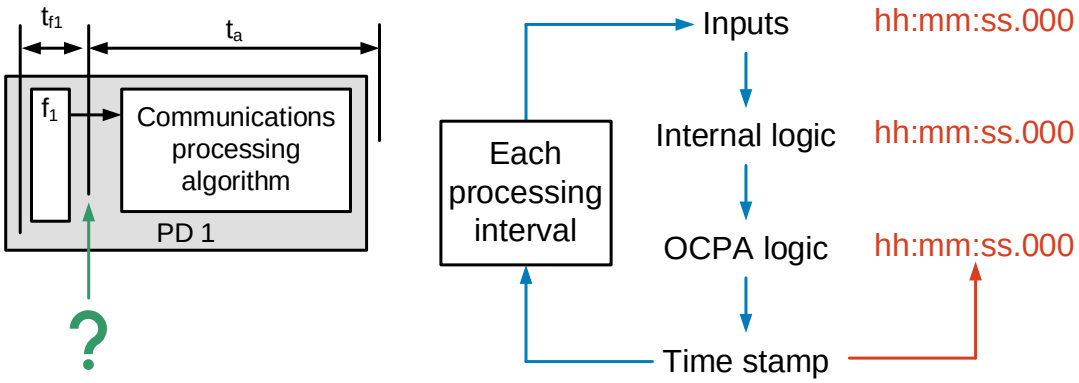


“How much additional time are you willing to accept?”

IEEE 1525 and IEC 61850 transfer time definition

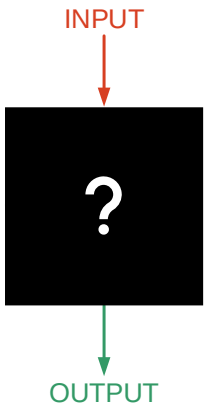


You cannot measure what you cannot see

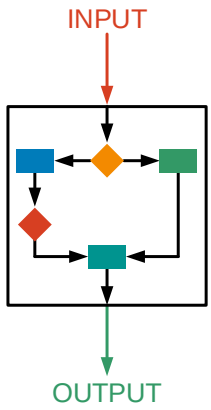


Black-box and white-box testing

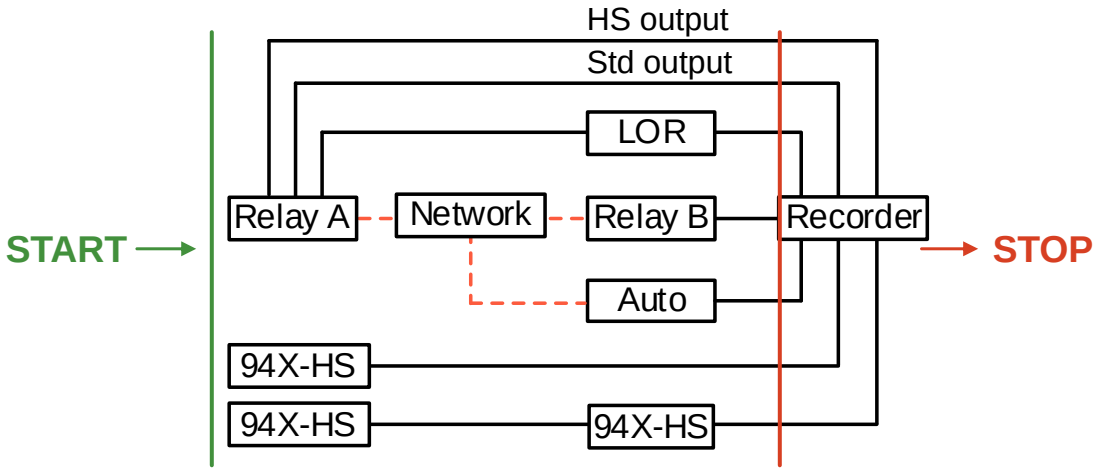
Black box



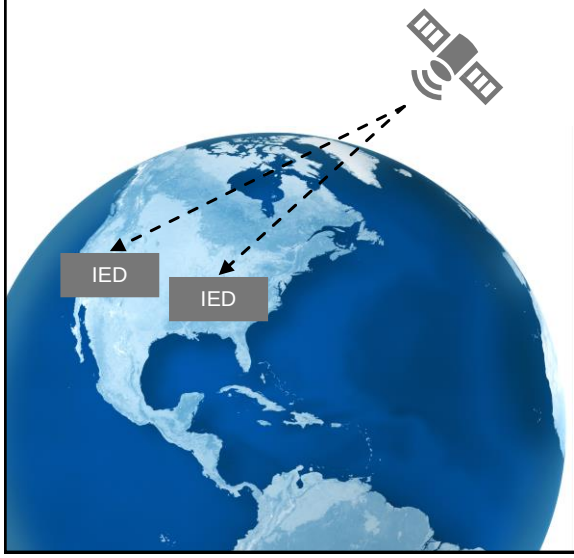
White box

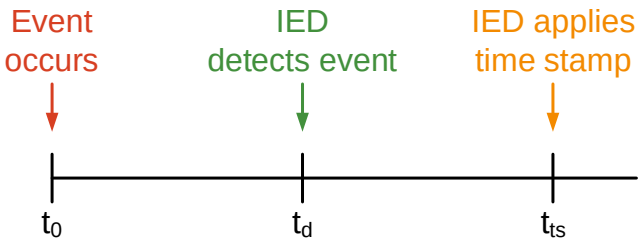


Measuring latency for multiple technologies



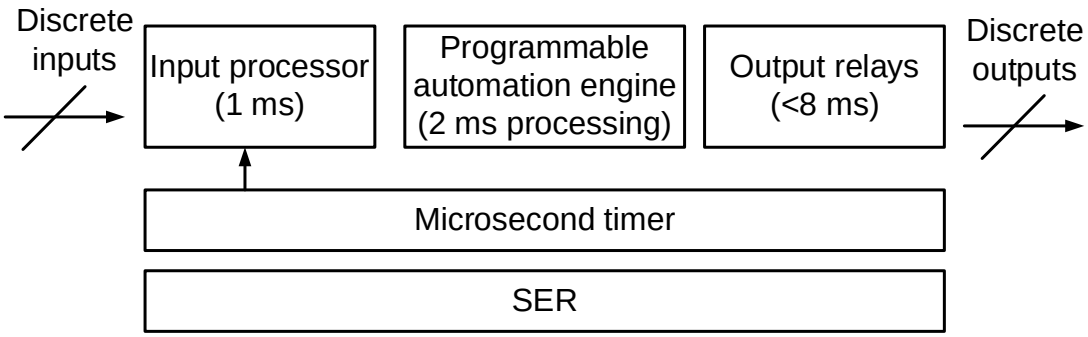
Understanding SER time accuracy and error





Using an automation controller to record operational latency

- 1 µs SER time stamp resolution
- 9 µs input assertion accuracy



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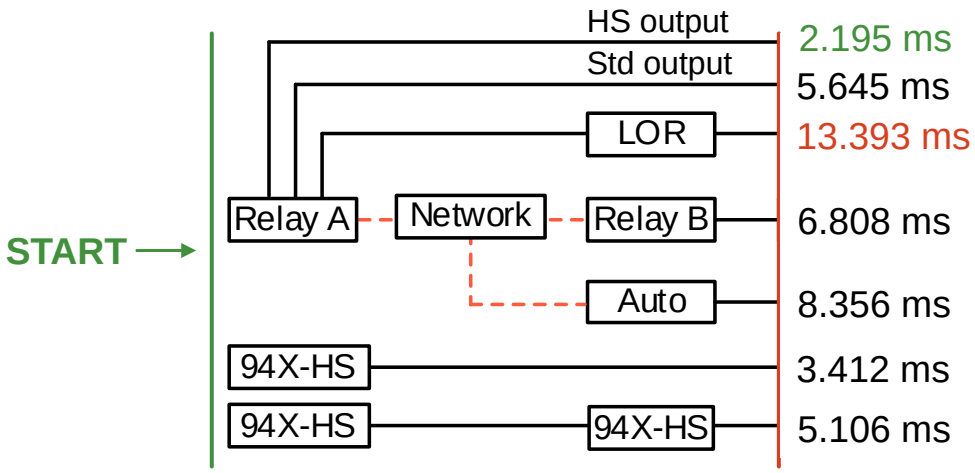
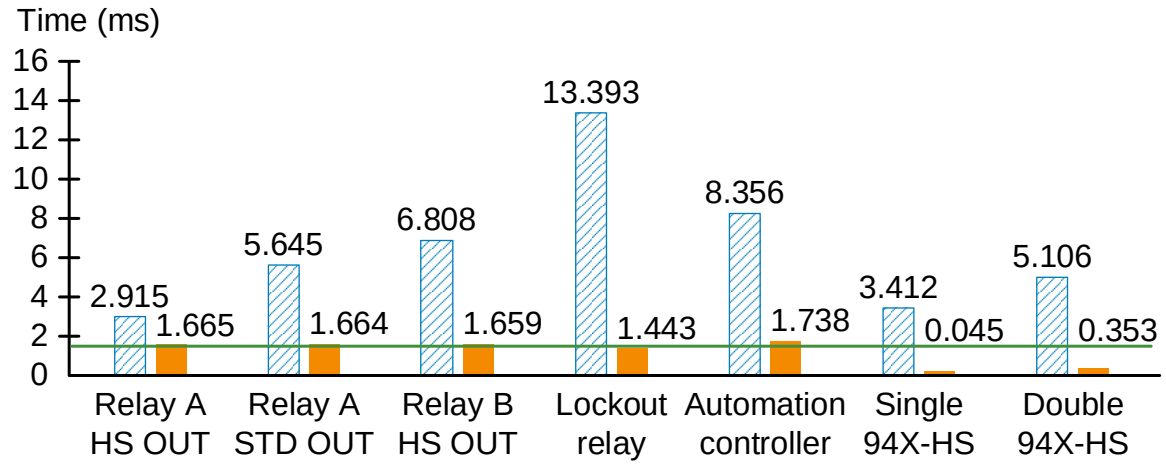
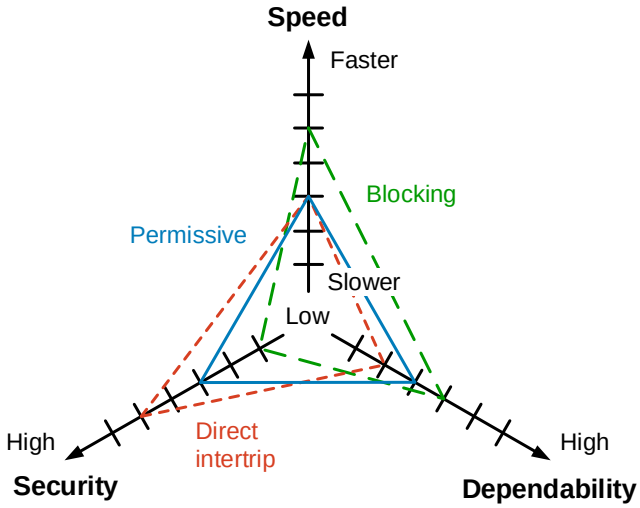


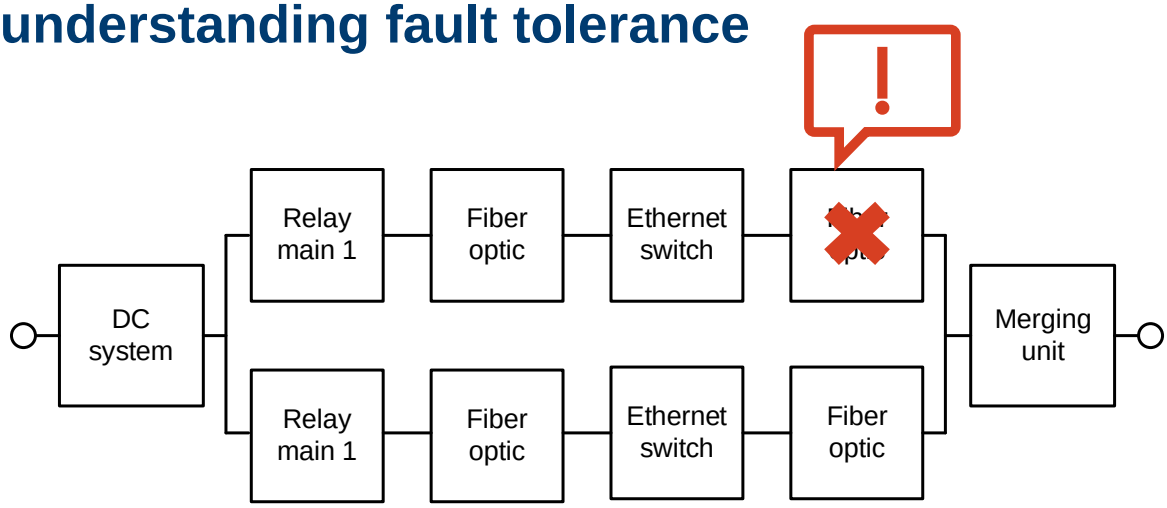
Average latency and jitter for different trip circuit technologies



You need more than just speed



Designing for reliability understanding fault tolerance



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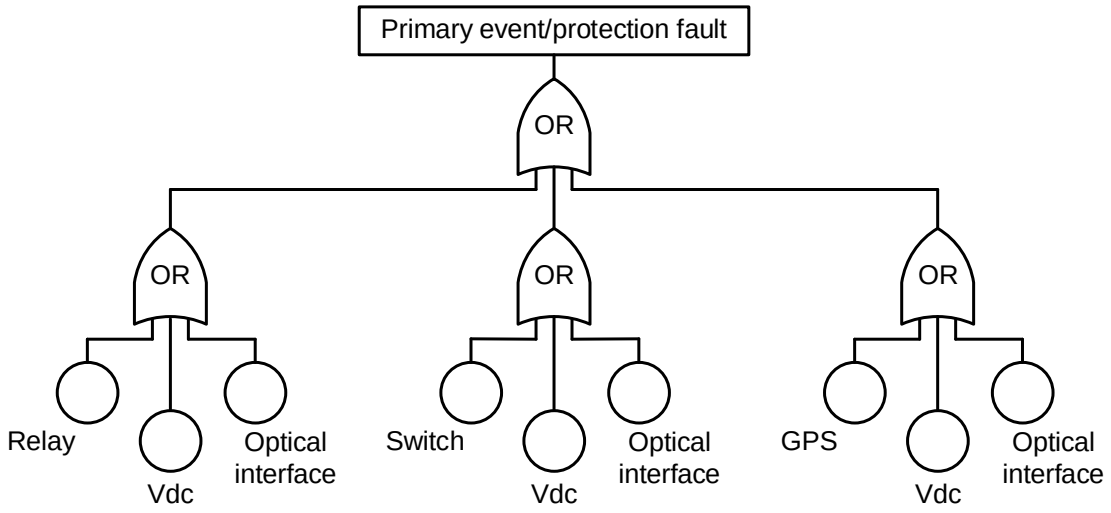
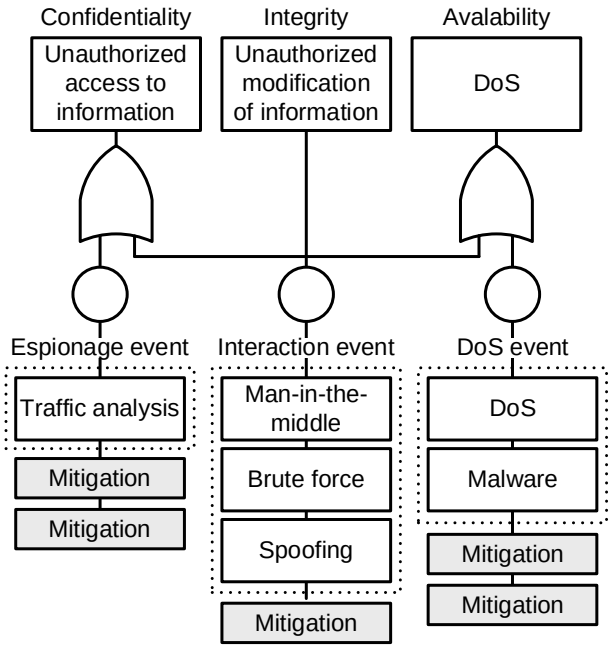
Using fault tree analysis to compare systems



Using attack tree analysis to compare systems



Limited vulnerability design methods create better understanding and specifications

Identify and investigate design **gaps**

↓

Recognize vulnerabilities introduced by design gaps

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Evaluate associated risks with vulnerabilities

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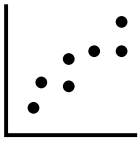
Limit vulnerability based on cost, schedule, and performance design choices

Establishing performance requirements using service level agreements

Understand ownership between different groups

Agree on security requirements and response to component failures

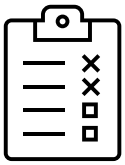


Define maximum signal transfer time and packet delay variation

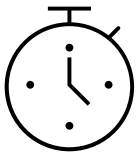
Conclusion

As we contemplate and implement digital trip circuits…

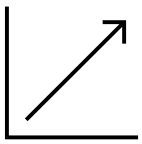
Define



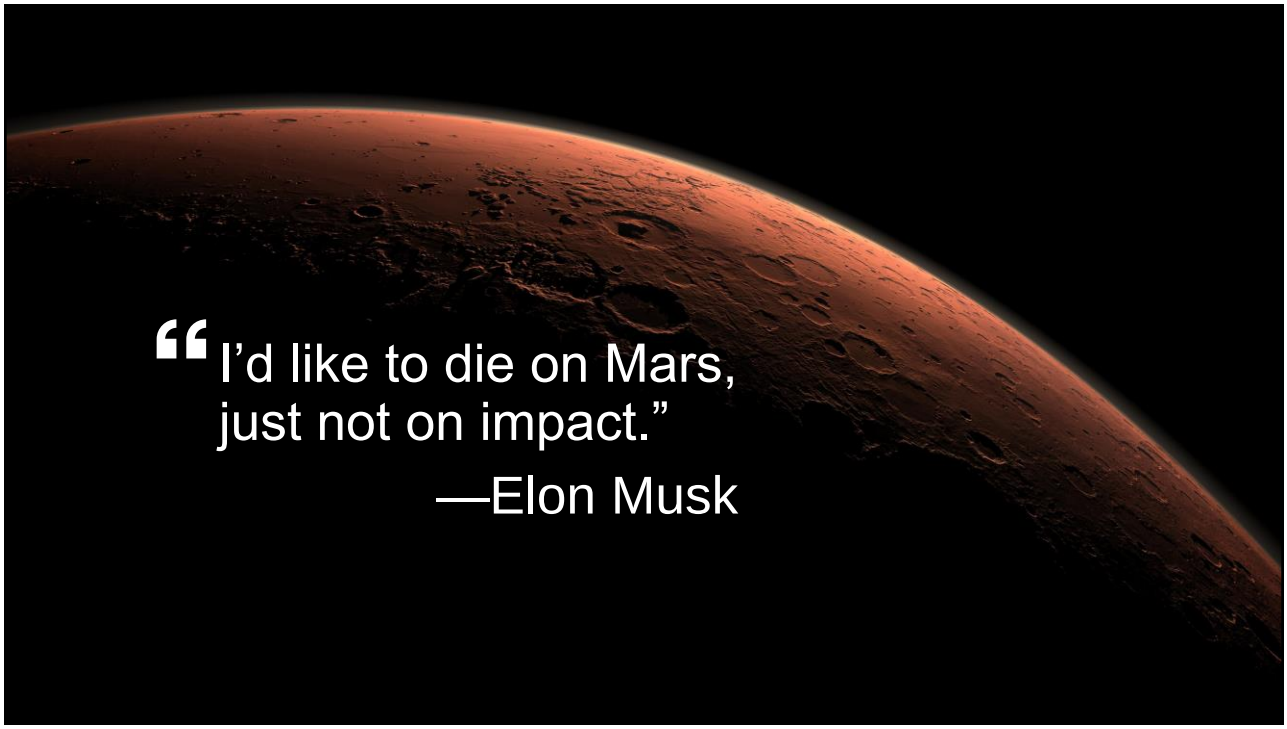
Test



Measure



Improve



Questions?