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Estimating Functional Availability of Large, Geographically Distributed System of Systems

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Overview

- ***Operational Availability (A_o)***
 - *Definition*
 - *Complexities*
- ***Radiation Detection Systems (RDS)***
 - *System of Systems (SoS)*
 - *Challenges*
- ***Geographical Representation***
 - *Simulation*
 - *Example*
- ***Conclusion***

Operational Availability

- *Definition of operational availability (A_O)*

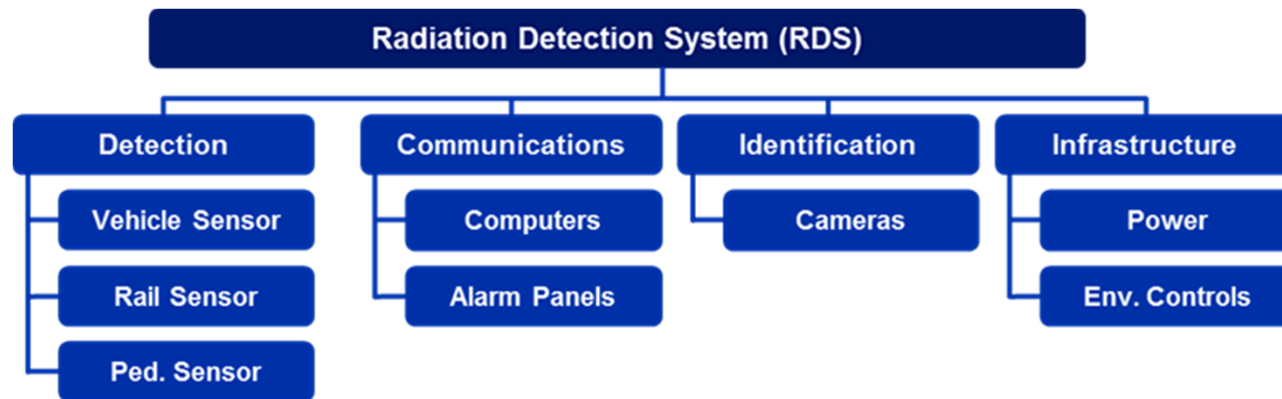
- *Calculated, estimated, and modeled for*
 - *Defined set of hardware*
 - *Performing defined operations*
 - *Over defined timeframe*
 - *With defined reliability and maintainability operational performance characteristics*
 - *And defined sustainment assumptions*
- *Generally known equation*
 - $A_O = \frac{Uptime}{Uptime + Downtime}$ or $A_O = \frac{MTBF}{MTBF + MDT}$
 - *where MTBF = Mean Time Between Failure, and MDT = Mean Downtime*

- *Complexities*

- *If the system or portions of the system are not operating 100% of the time, the equation becomes more difficult*
- *Dependencies that arise when systems are operating in a system of systems (SoS) context make estimating SoS A_O difficult without simulation*

Radiation Detection Systems

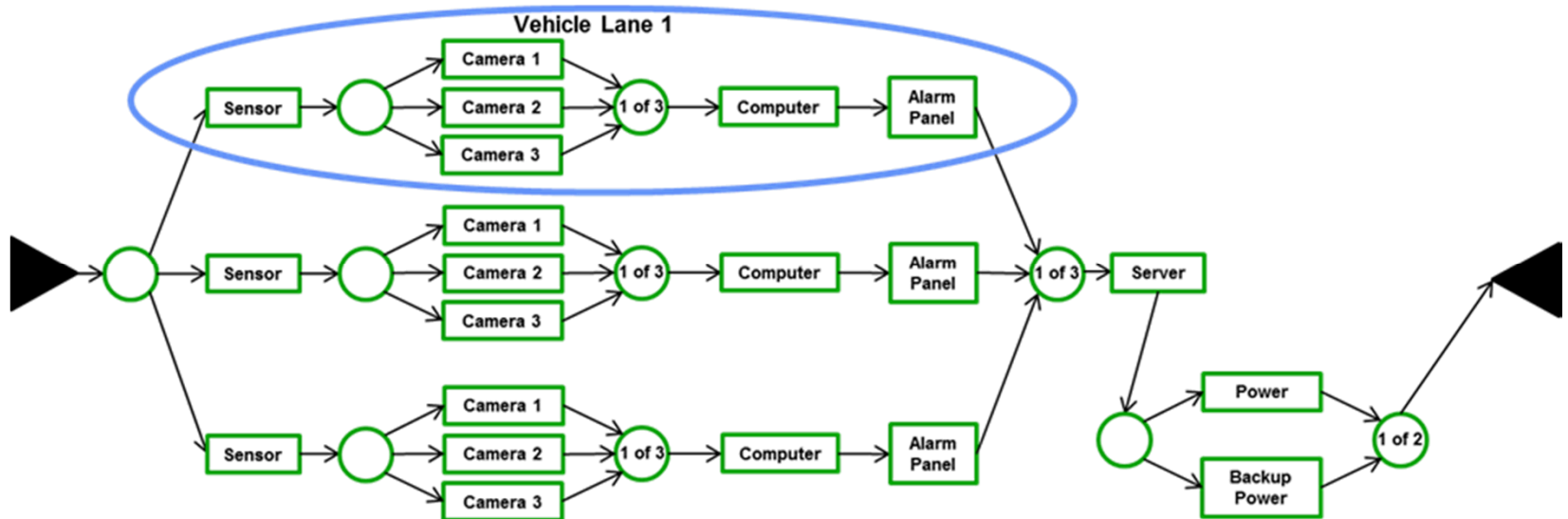
■ *RDS System Structure*



- *Multiple RDS are deployed at various sites around the world*
- *RDS at sites within countries within regions across the world act as different levels of SoS to perform intended function*
 - *Multiple lanes of traffic with RDS at a given site work together at the site*
 - *Multiple sites work together within a country*
 - *Multiple countries work together within a region*

RDS as a System of Systems

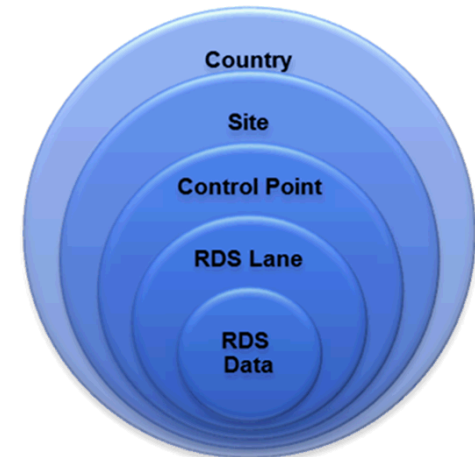
- *A System of Systems (SoS) is a collection of systems that can function independently but which provide additional functionality of interest when viewed as a network*
- *At a site, the reliability block diagram below shows how the components within various subsystems and in different traffic lanes can be dependent on one another for site functionality*



RDS A_0 Challenges

- *Defining “up” for a component may be easy*
 - *Operational/operating*
- *Defining “up” for a subsystem/systems can be done*
 - *Series/parallel/k of n*
- *Defining “up” for a site, country, region can be more difficult*
 - *Number of lanes necessary for site to be operational*
 - *Number of sites (countries) needed to be “up” for the country (region) to perform its intended function*

- *SoS A_0 needs to be estimated at various levels*

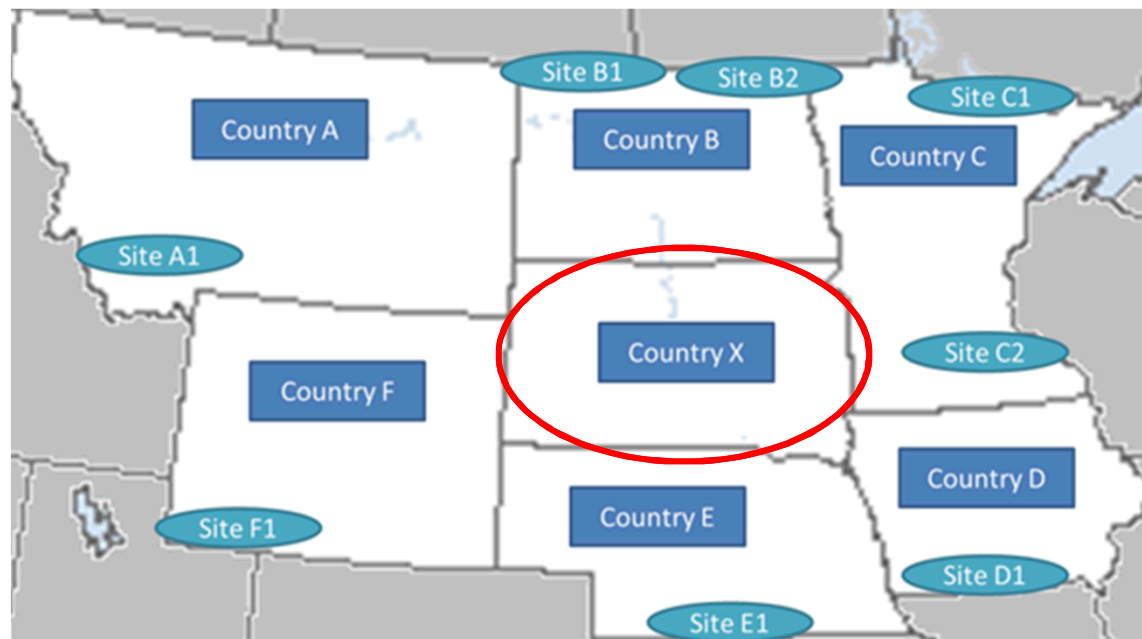


Further Challenges

- ***Environment***
 - *Same part in a different environment can have a different failure rate*
 - *Temperature, humidity, salinity*
- ***Geography***
 - *Same part in different geographical location can have a different downtime*
 - *Remote sites may have longer logistics delay times*
- ***Maintenance personnel training***
 - *Same part in a different country can have a different repair time*
 - *Experience, troubleshooting*
- ***Data collection***
 - *Some information may be viewed as proprietary by various countries*
 - *English is not the primary language in most countries*

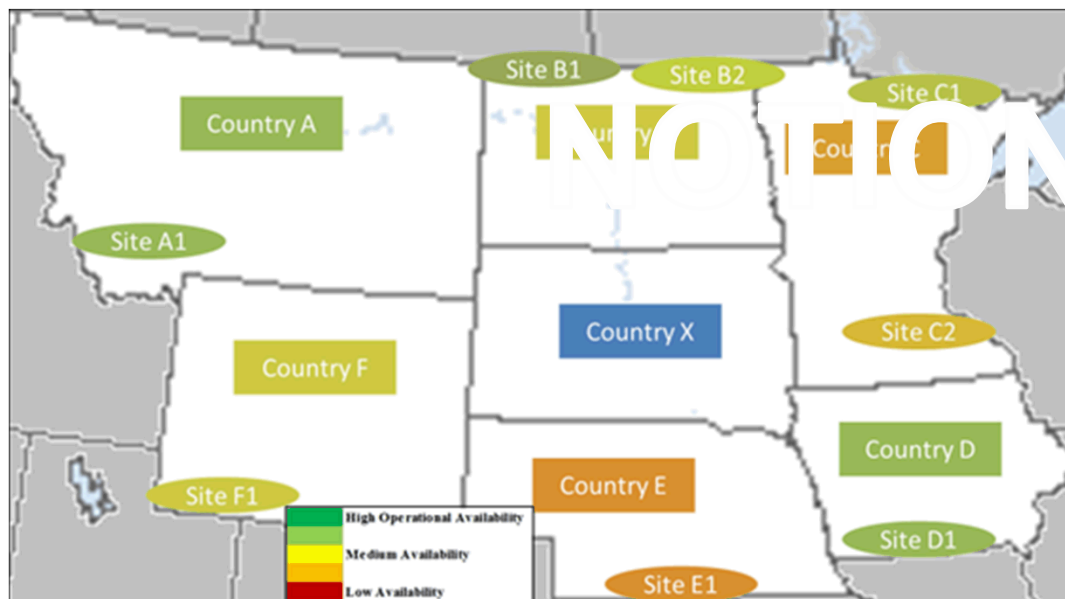
Geographical Representation

- *Estimating A_o for a complex SoS requires simulation*
 - *Allows flexibility of defining “up” for each level of interest*
 - *Simulation allows for quick visual representation of operational availability of each site, country, and region of interest*
- *Example – Goal is to keep material out of Country X*



Example Continued

- Each site, country, and region has an estimated SoS A_o
- The estimated values can be represented on the map using colors to indicate how well the site, country, and region are doing



System of Systems	A_o
Region_1-001	0.353
Country_A-001	0.985
Country_F-001	0.836
Country_X-001	0.727
Country_D-001	0.946
Country_E-001	0.750
Country_F-001	0.822
Site A1-001	0.985
Site B1-001	0.970
Site B2-001	0.861
Site C1-001	0.918
Site C2-001	0.793
Site D1-001	0.946
Site E1-001	0.750
Site F1-001	0.822

- May need improvements to some site's equipment

Conclusion

- *Operational availability for system of systems is complicated*
- *Simulation is required to determine A_o for complex SoS*
- *In order to understand effectiveness of systems working together in a SoS context, A_o must be understood*
- *Understanding the A_o for these large, geographically distributed SoS helps decision-makers mitigate varied levels of risk in different regions of the world*

Thank You!



Questions