

# ***Headquarters U.S. Air Force***

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## **Hierarchical and Networked Assessment Models**



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Lt Col Kyle Novak  
phone: 571-256-7681  
kyle.novak@us.af.mil

This briefing is unclassified

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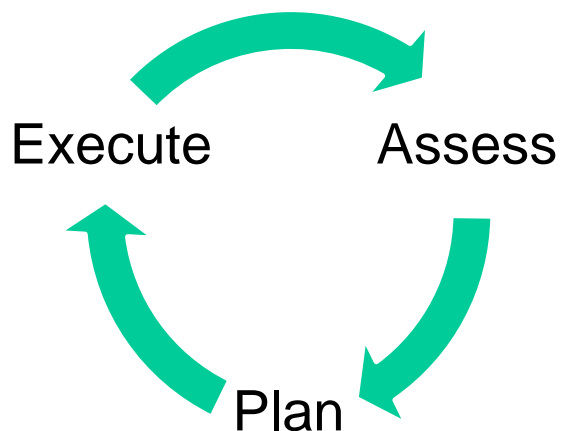
# *Overview*

- **Hierarchical & Network Assessment Models**
- **Assessment Spaces**
- **Roll-up Methodologies**



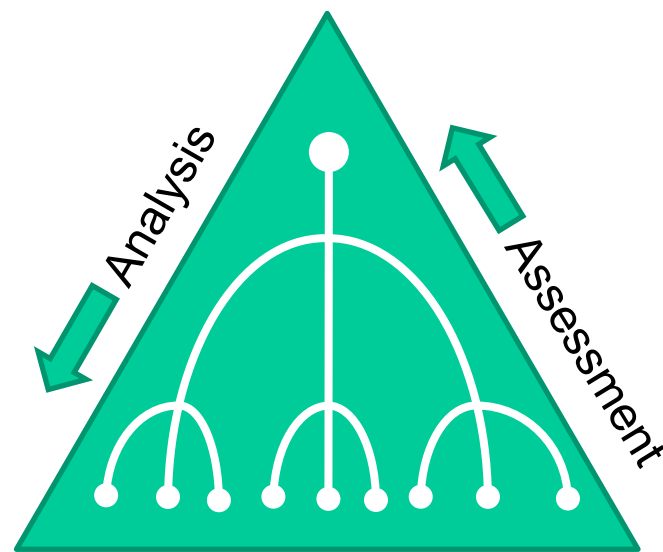
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# Role of Assessment in Decision Analyses



OODA: **Observe** – Orient – Decide – Act

JATC: Plan – Task – Execute – **Assess**

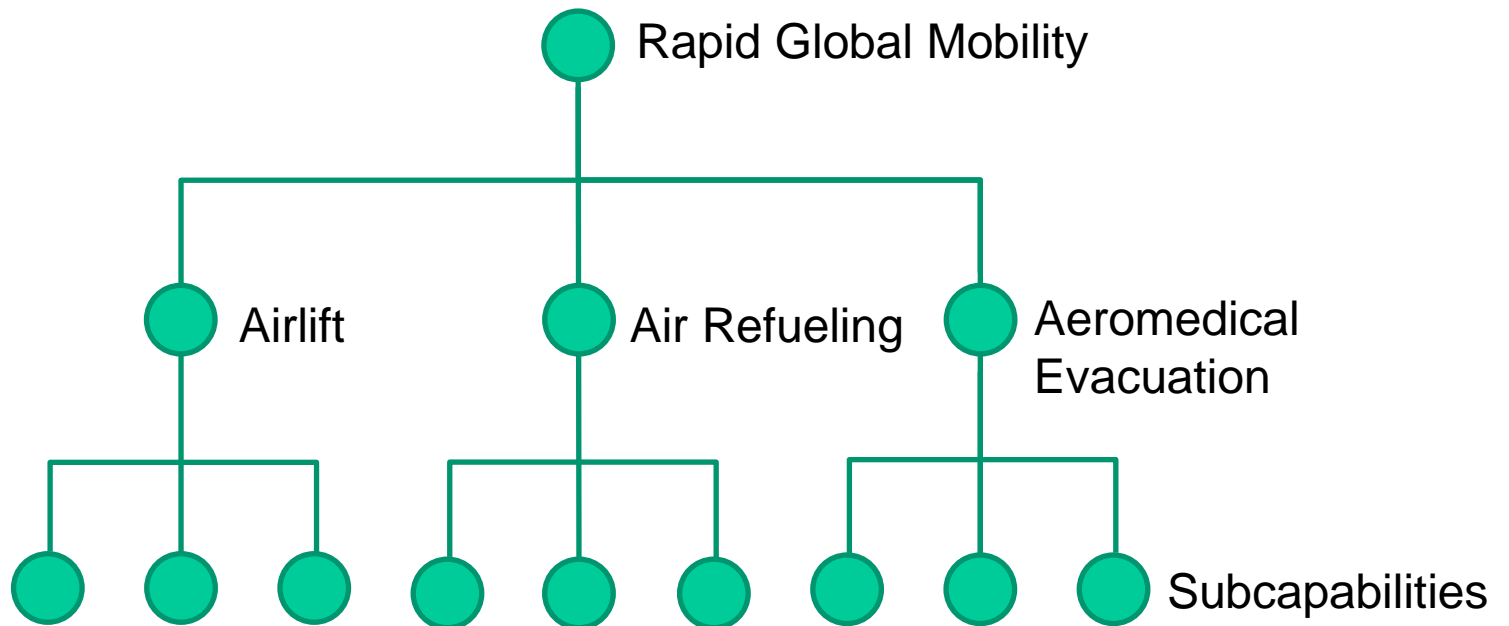


**Analysis: Understanding**  
**Assessment: Judgment**



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# *Hierarchical Model*

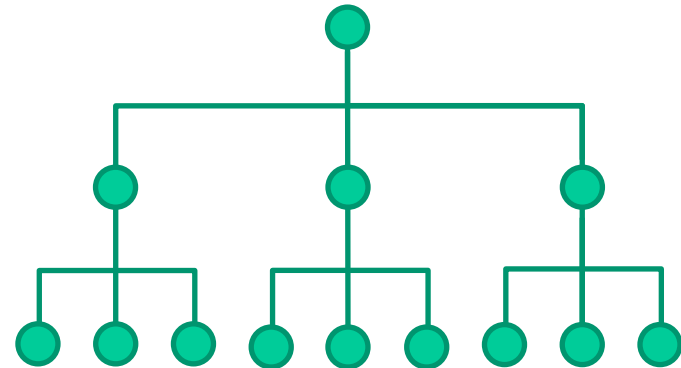




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# ***Hierarchical Model***

- Top-down planning / bottom-up assessment
- Strategy-to-task
- Objectives to Lines of Effort to Measures of Effectiveness
- Chain of Command
- Staff Tasking Structure
- Headquarters to Field



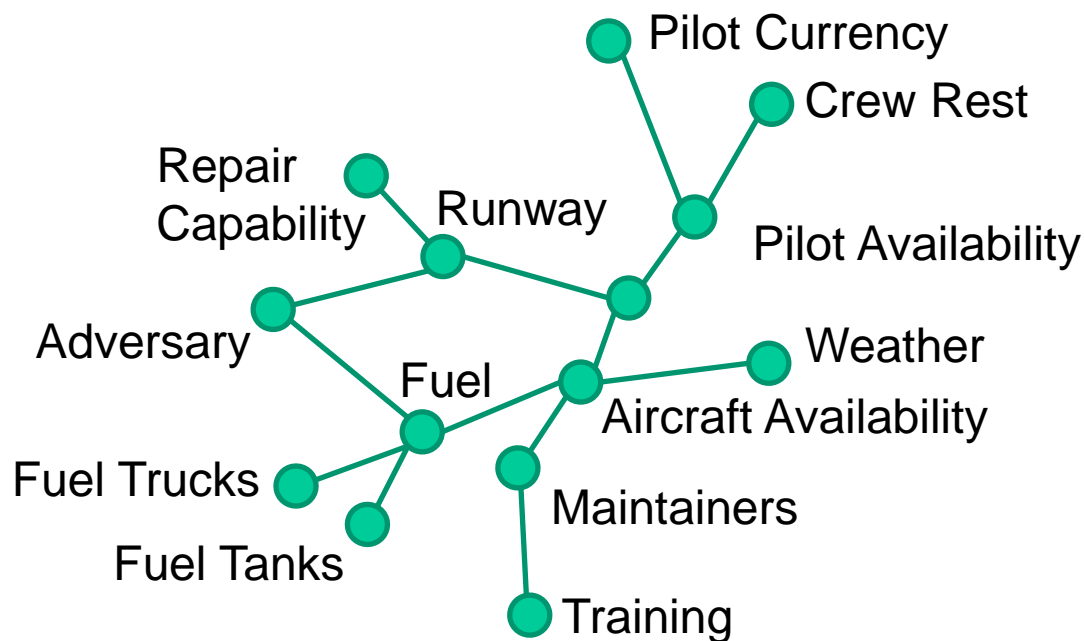
- ✓ Natural organizational and planning structure
- ✗ Hierarchy may not fit scenario
- ✗ Stovepipe misses second-order effects and dependencies



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# Network Model

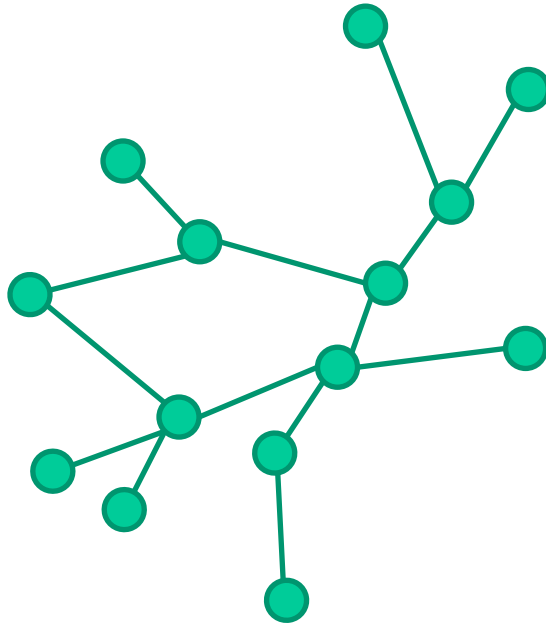
## Sortie Generation





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# ***Network Model***



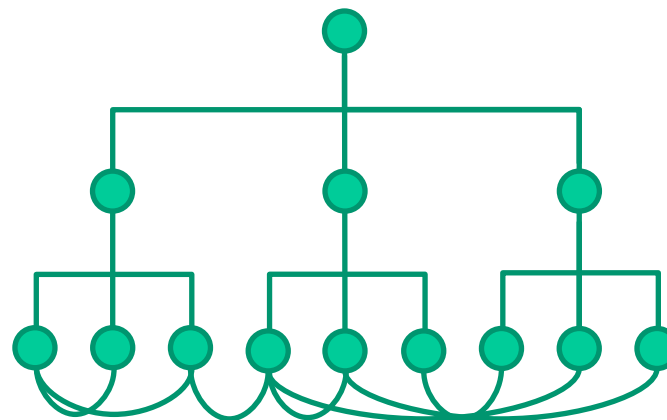
- Interdependencies of Effects/Capabilities
  - Effect Chains
  - Value Chain (Economic Development)
  - Theater Security/Building Partnership
  - Insurgency influence network
- 
- ✓ Higher-order effects & dependencies
  - ✗ Complex and can be difficult to assess for large network



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# ***Integrated Models***

- ✓ Mitigates shortcomings of Hierarchical and Network
- ✗ Even more complexity



## **Examples:**

- PACAF Warfighter Capability Assessment
- AF Comprehensive Core-Capability Risk Assessment Framework





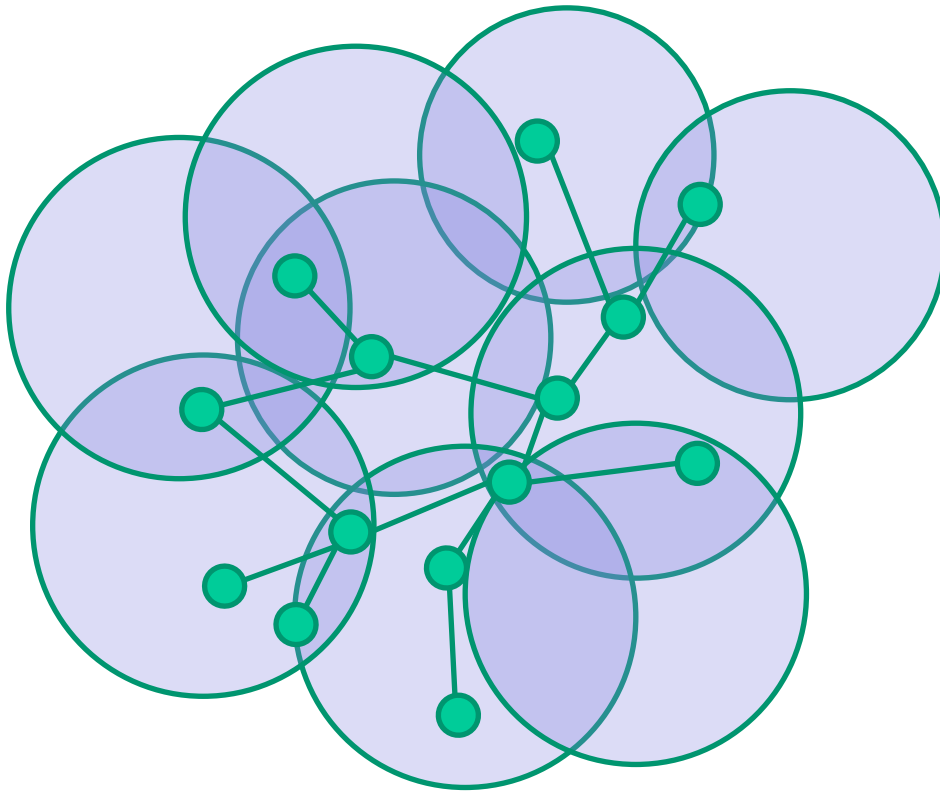
# ***PACAF Warfighter Capability Assessment***

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## **Integrated Product Team of Functional SMEs**

Ex. Aircraft/Munitions/POL/Personnel/Cyber/Installation



✓ **Quick / Robust / Flexible  
for Contingency and  
Crisis Operations**

✗ **Highly dependent on  
good SMEs**

**Ex. Runway Repair: A7 + A3 + A2 + A4 + FM**



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# Comprehensive Core Capabilities Risk Assessment Framework (C3RAF)

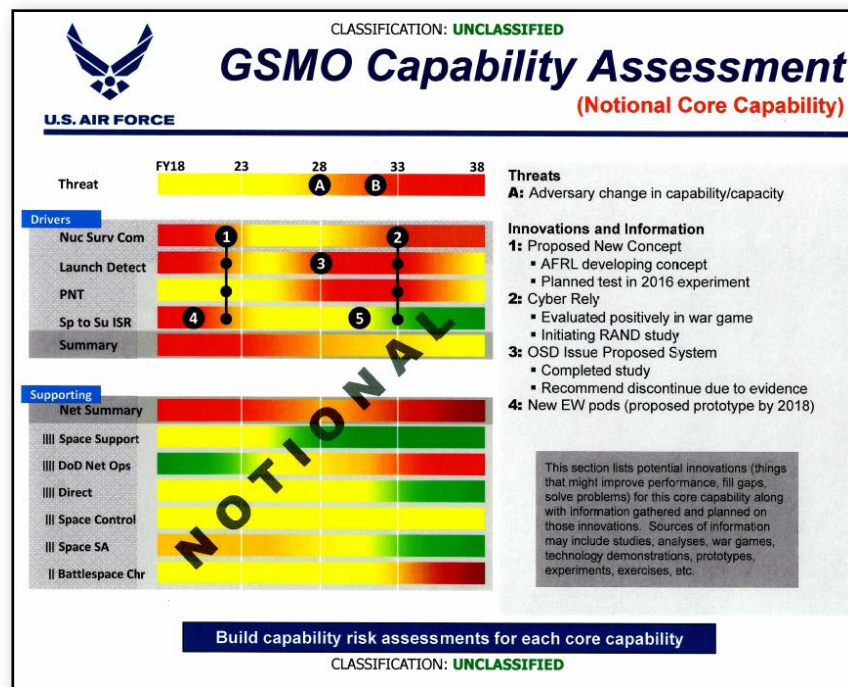


5 Core Mission Areas

12 Core Functions

45 Core Capabilities

**Core Capability Interdependencies:**  
Likelihood of failure of one capability causing failure of another





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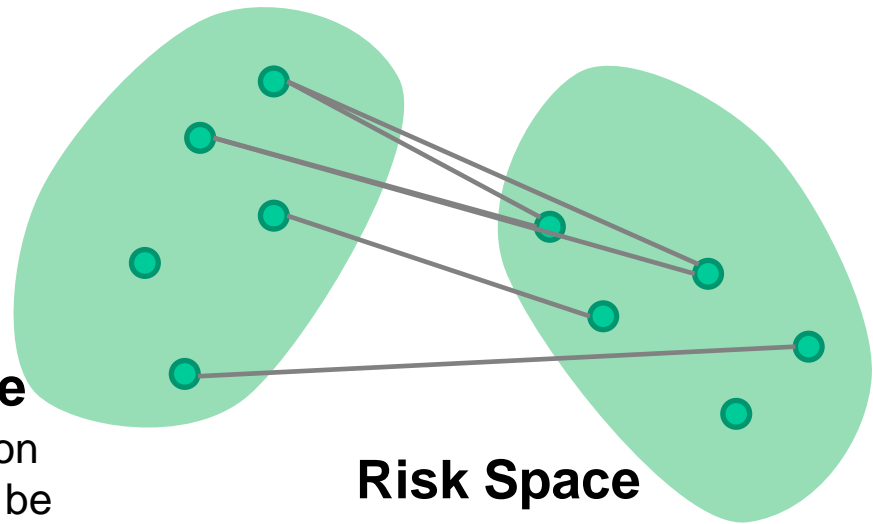
# Assessment Spaces

## Space is a set with added structure

- Capability/Capacity/Resource/Schedule
- Risk
- Decision
- Metrics
- Constraints
- Relationships between variables
- Roll-up methodology

### Capability Space

*Metric:* How many million ton-miles per day can be airlifted?



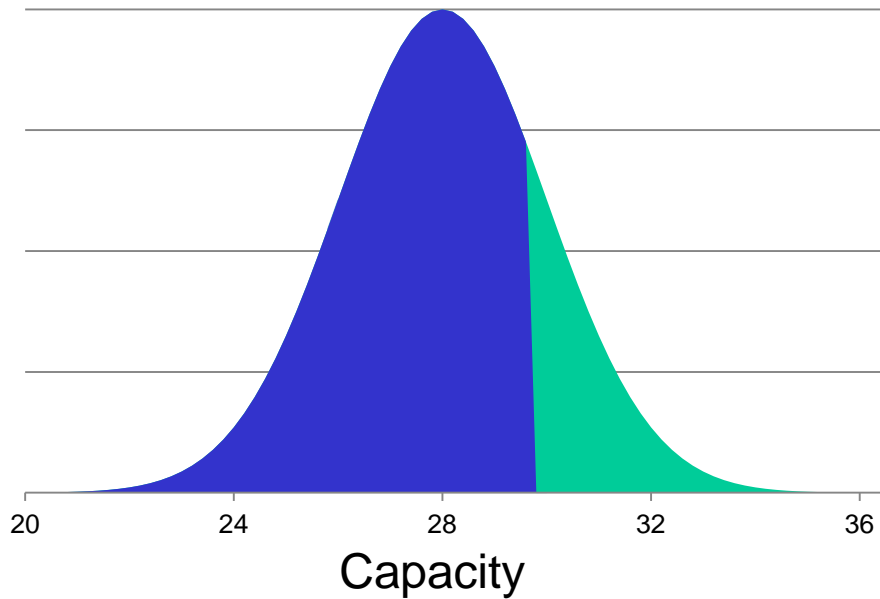
### Risk Space

*Metric:* What is the likelihood of airlifting 30 million ton-miles per day?



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# Mapping Risk to Capability



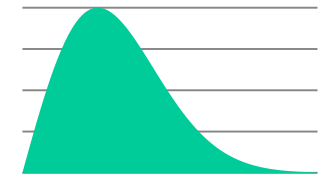
## Central limit theorem:

The sum of many random variables has approximately a normal distribution

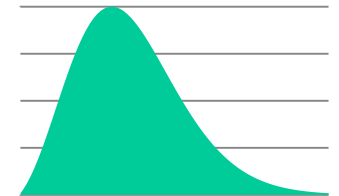
**What is the likelihood of airlifting 30 million ton-miles per day?**

Random variables such as variability in maintenance, fleet availability, crew rest, weather, adversary, RoEs, etc.

Weibull distribution:  
failure



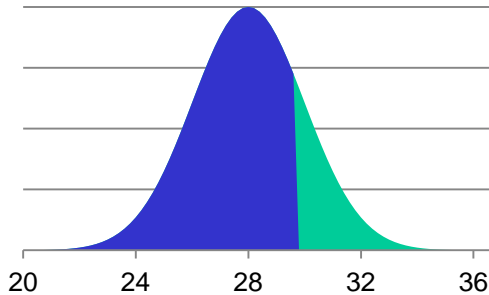
Poisson distribution:  
scheduling





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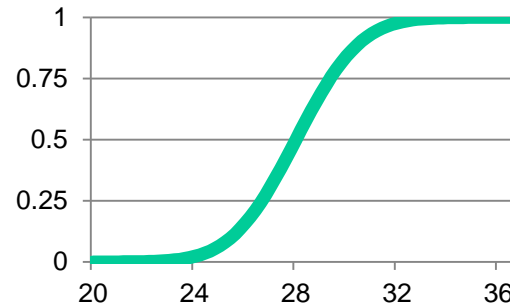
# Mapping Risk to Capability



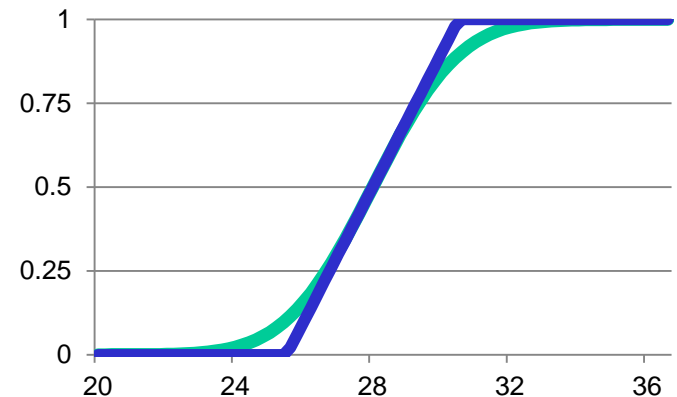
***Probability  
Density Function***

**What is the likelihood of airlifting  
30 million ton-miles per day?**

***Integrated to a  
Cumulative Density  
Function***



***Approximated by a  
Stepwise Linear Function***





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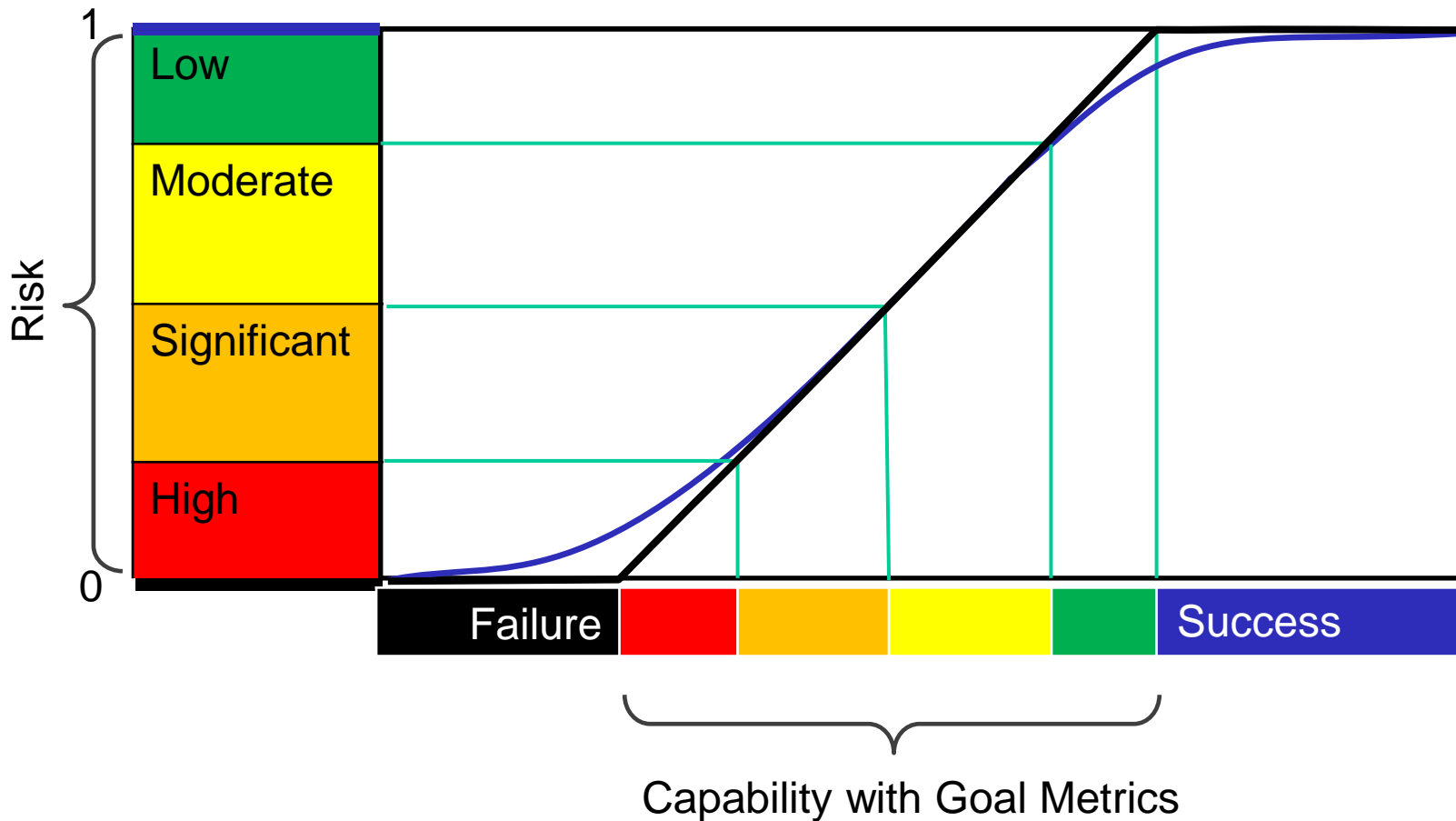
# *Air Force Risk Assessment Framework*

Low	Achieving Objective is <b>Very Likely</b>	80-100%
Moderate	Achieving Objective is <b>Likely</b>	50-80%
Significant	Achieving Objective is <b>Questionable</b>	20-50%
High	Achieving Objective is <b>Unlikely</b>	0-20%



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# Air Force Risk Assessment Framework

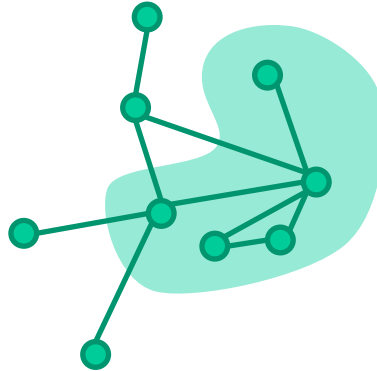
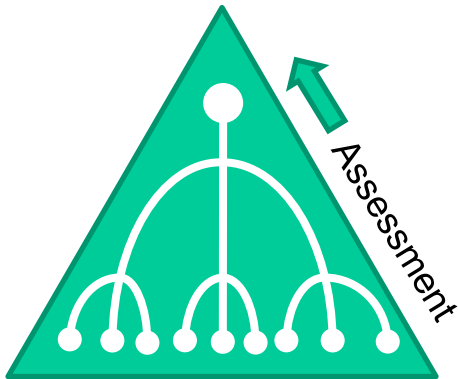


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# Roll-Up Methodologies



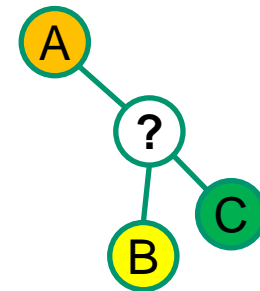
- Are we accomplishing objectives?
- What is the aggregate risk?
- What is the “big picture”?

## Exhaustive and independent

$$P(A \cap B \cap C) = P(A|B \cap C)P(B|C)P(C)$$

$$P(Q) = P(Q|A)P(A) + P(Q|B)P(B)$$

$$R(Q) = w_A P(A) + w_B P(B)$$







# Generalized Mean

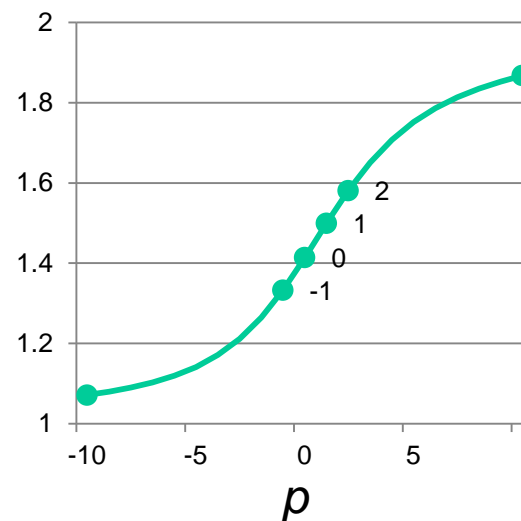
## Generalized mean

$$\left( \sum_{i=1}^n w_i c_i^p \right)^{1/p} \quad \text{where} \quad \sum_{i=1}^n w_i = 1$$

w: cost, effect, trustworthiness, etc.  
p: Controls impact of outliers

p	Type	Typical Use
$-\infty$	Min	Worst/best case scenario
-1	Harmonic mean	Ratios/Rates/Schedules
0	Geometric mean	Cumulative rate
1	Mean	Simple average
2	Root mean square	Signals analysis
$+\infty$	Max	Best/worst case scenario

Average of 1 and 2





## Roll-up Examples

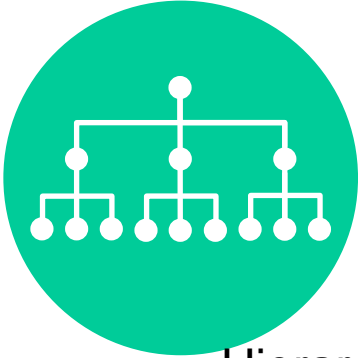
$$\left( \sum_{i=1}^n w_i c_i^p \right)^{1/p}$$

- **PACAF Warfighter Capability Assessment**
  - Airbase roll-up of personnel readiness by SORTS
  - **w**: Based on operational response times
  - **p**: Chosen using several “model” airbases
- **AF Comprehensive Core-Capability Risk Assessment Framework**
  - **Truncated Weighted Mean**
  - **w**:  $\sum_{i=1}^n w_i c_i$  where  $0 \leq c_i \leq 1$   $\sum_{i=1}^n w_i = 1$
  - **p**: 1

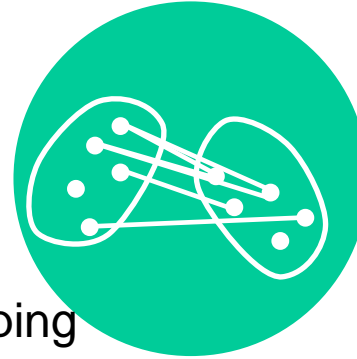


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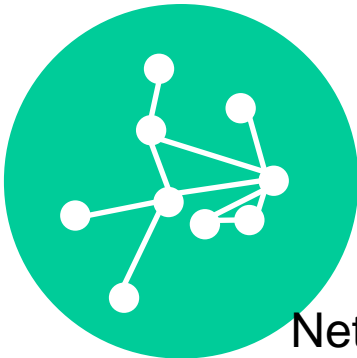
# *Bringing it all back together*



Hierarchical Model



Mapping Spaces



Network Model



Roll-up Methodology





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then you've gone to far.*

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left blank.**



# ***Dos and Don'ts of Assessment***

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## **Flaws in Assessment**

Over-optimism  
Promiscuous/blinkered metrics collection  
Junk arithmetic [ordinal vs. cardinal]  
Simplistic color coding  
Logical failures  
No compelling roll-up of assessments  
No compelling connection of objectives with metrics and assessments  
No compelling connection between assessment and end state  
Higher-command demand for objective assessments

## **Assessment Guidelines**

Transparent  
Defendable and backed up with analyses  
Linked up (tactical, operational, strategic) and across (DIME/other components)  
Connect metrics to end states  
Collect appropriate metrics  
Obey basic math principles  
Measurable  
Repeatable  
Traceable  
Incorporates Military Judgment  
Implementable

Martin-Downes, *Operations Assessment in Afghanistan Is Broken*  
JDN 1-15 *Operation Assessment*