Crown Jewels Analysis (CJA)

A Mission Criticality Analysis Technique Using Dependency Maps

A Presentation and Demonstration for Boston SPIN

20 February 2018

Jim Watters

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Background

- Advanced Persistent Threats (APT) use sophisticated capabilities to attack, and maintain a presence in, our mission systems
- As a result, it is not realistic to use a defensive strategy based on stopping all threats at the boundary
- Instead, we must assume that the APT can penetrate, deny, and/or degrade our Cyber Assets (CA)
- A defensive strategy based on that assumption is to harden mission-critical CA so we can operate through an APT attack
- Cyber resiliency techniques help us identify the mission-critical CA, evaluate the risks facing those CA, and develop mitigation strategies

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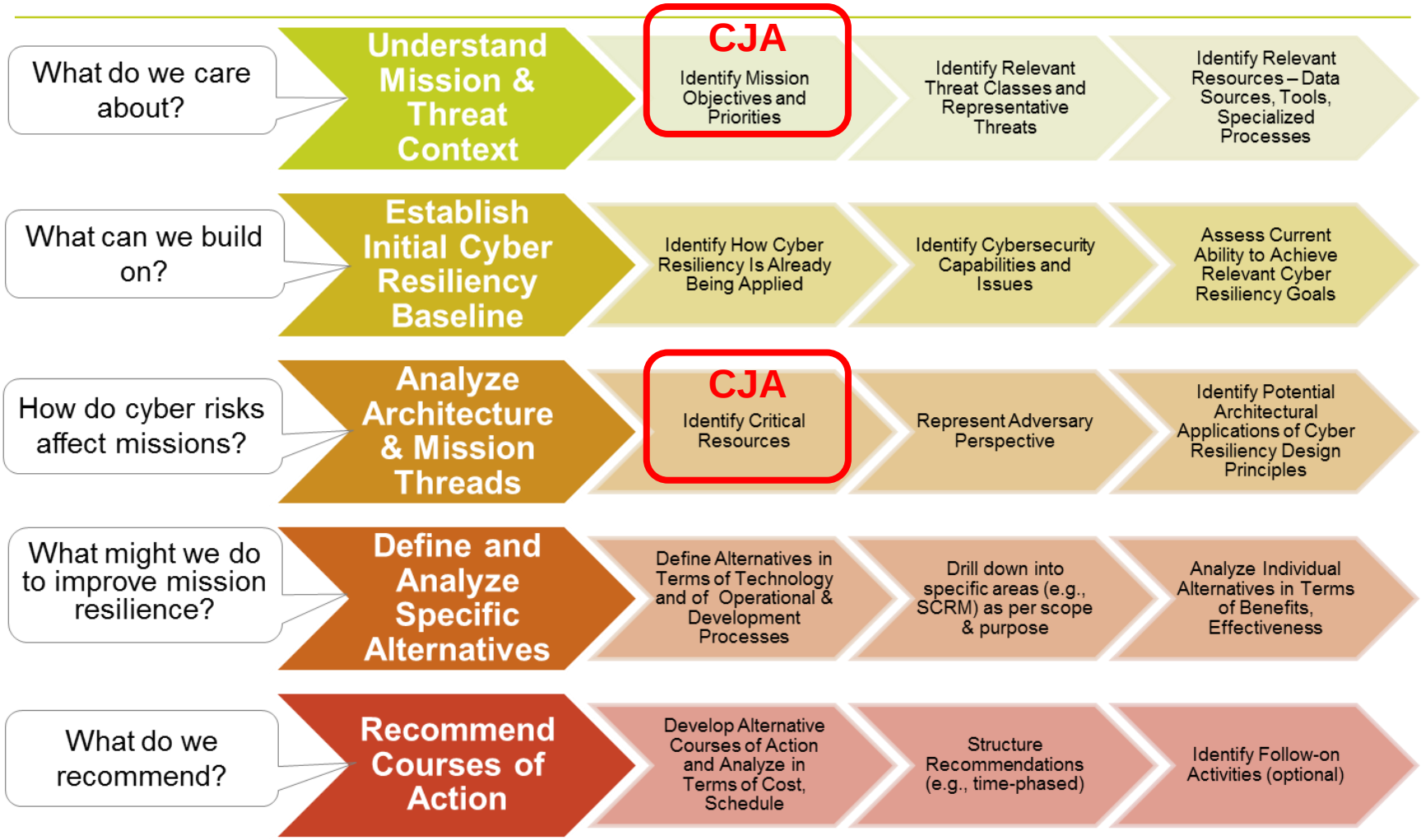
CJA As a Cyber Resiliency Technique



Ref: Structured Cyber Resiliency Analysis Methodology (SCRAM), by D. Bodeau and R. Graubart

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What is CJA?

- **MITRE-developed Mission Criticality Analysis technique**
  - *First used during Operations Without Space deep-dive at 613th Air and Space Operations Center (AOC) in 2009*
- **CJA's Dependency Map approach combines expert input with established techniques:** *AHP, QFD, and FMEA*
- **Definitions when applied to Cyber/IT systems**
  - *"Cyber Asset" = A logic-bearing device including its hardware, firmware, software, and initialization/configuration data*
    - *We have also included non-logic bearing devices; e.g. comm links*
  - *"Mission-Critical Cyber Asset" = A Cyber Asset whose failure or degradation causes mission failure; a "Crown Jewel"*

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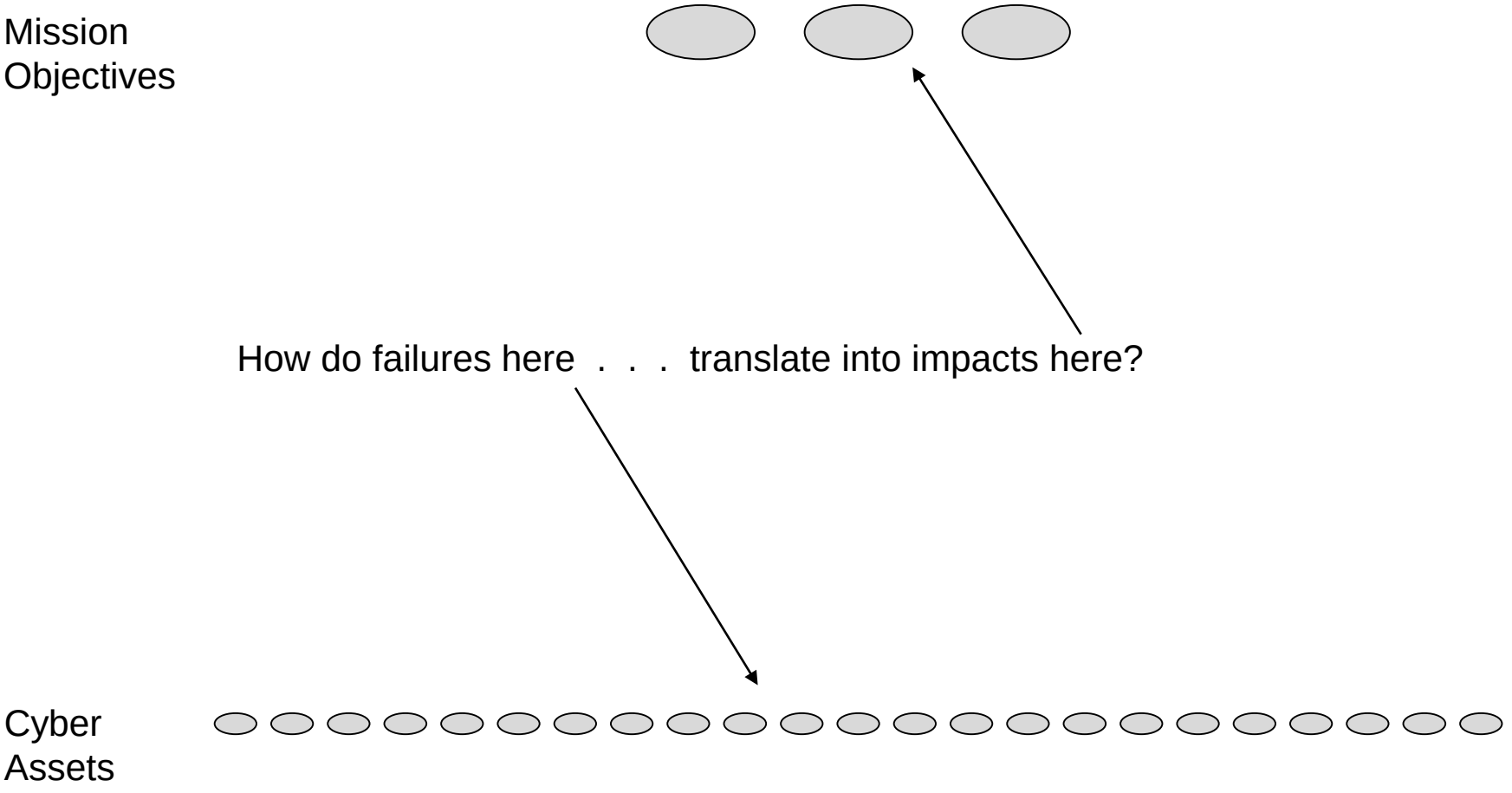
CJA Helps Us Answer a Key Question



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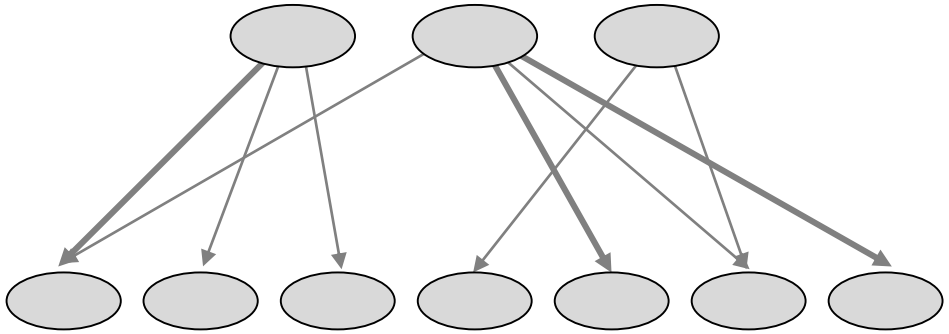
We Start by Identifying the Tasks That Support Each Mission Objective

Mission Objectives

Operational Tasks



Cyber Assets

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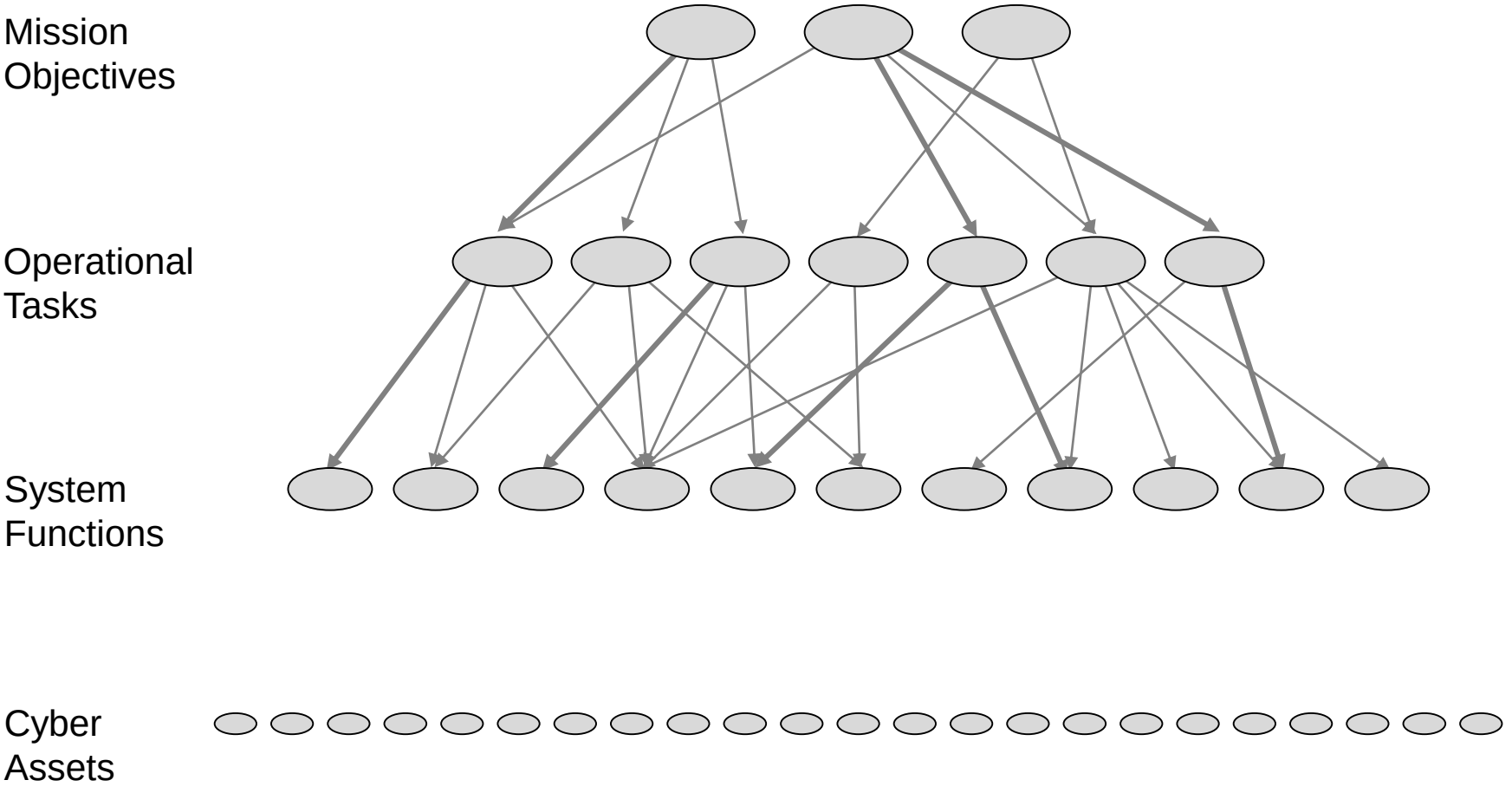
Next, We Identify the System Functions That Support Each Task



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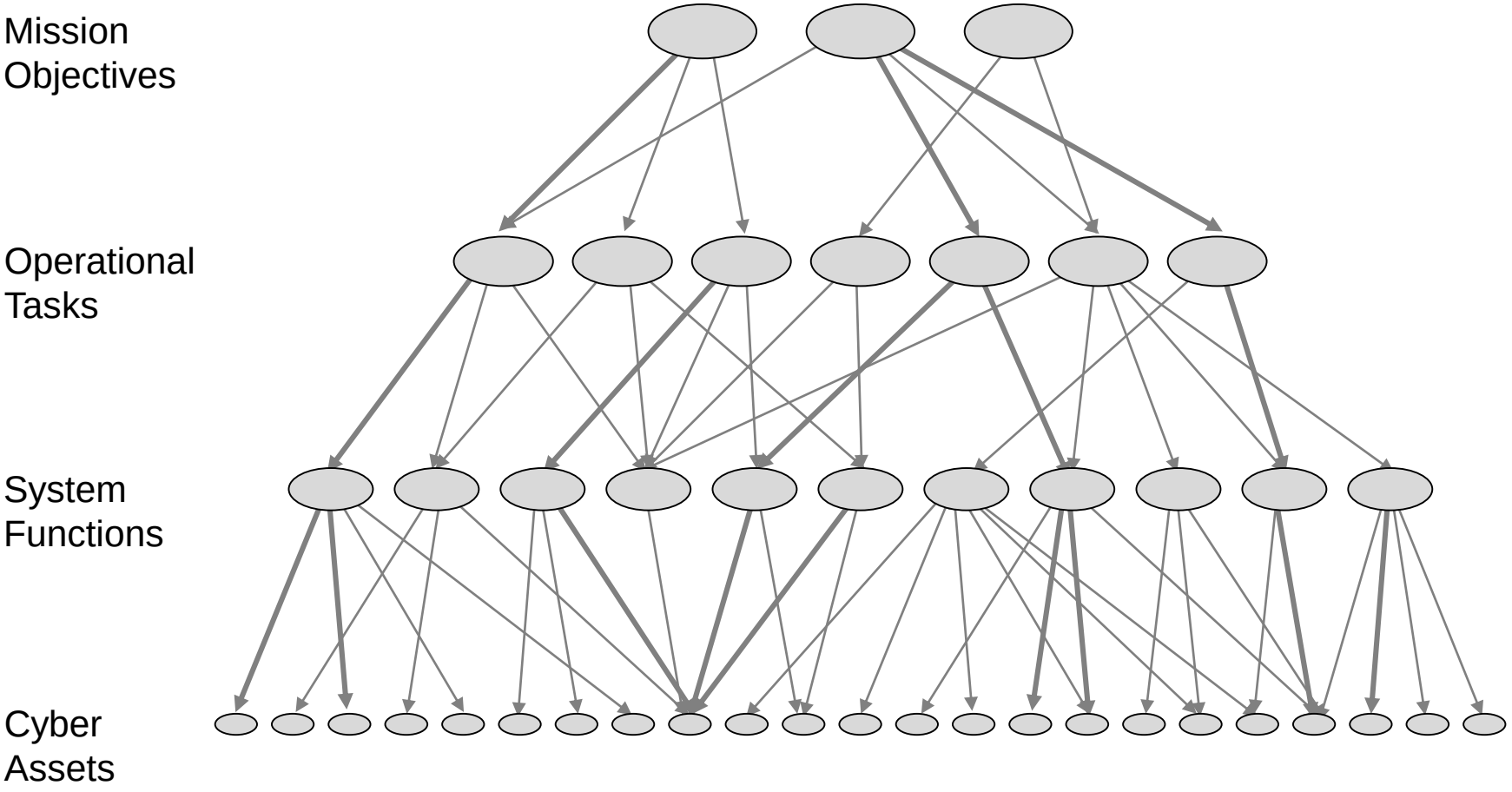
Finally, We Identify the Cyber Assets That Support Each System Function



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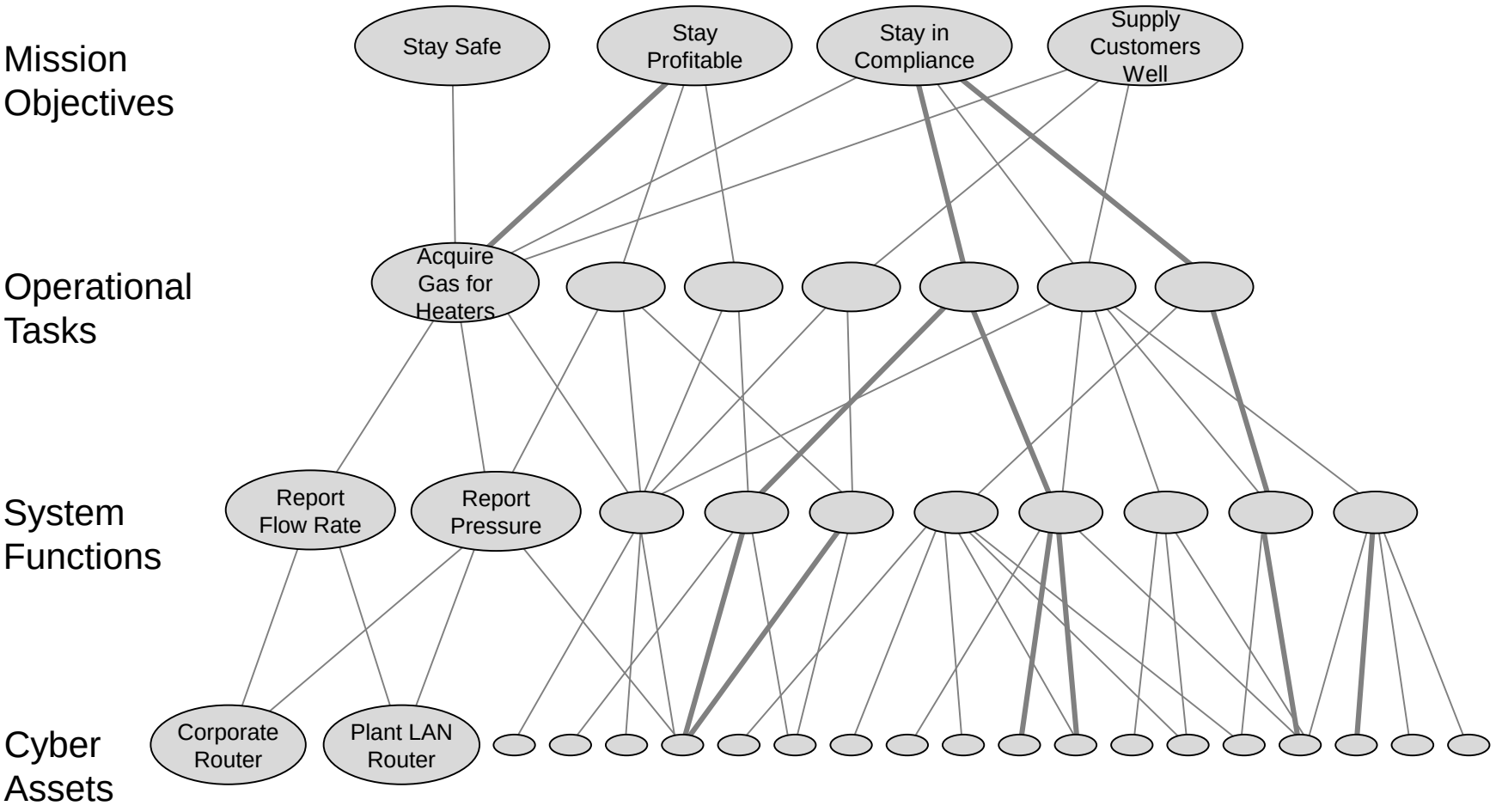
Dependency Mapping - Refinery Example



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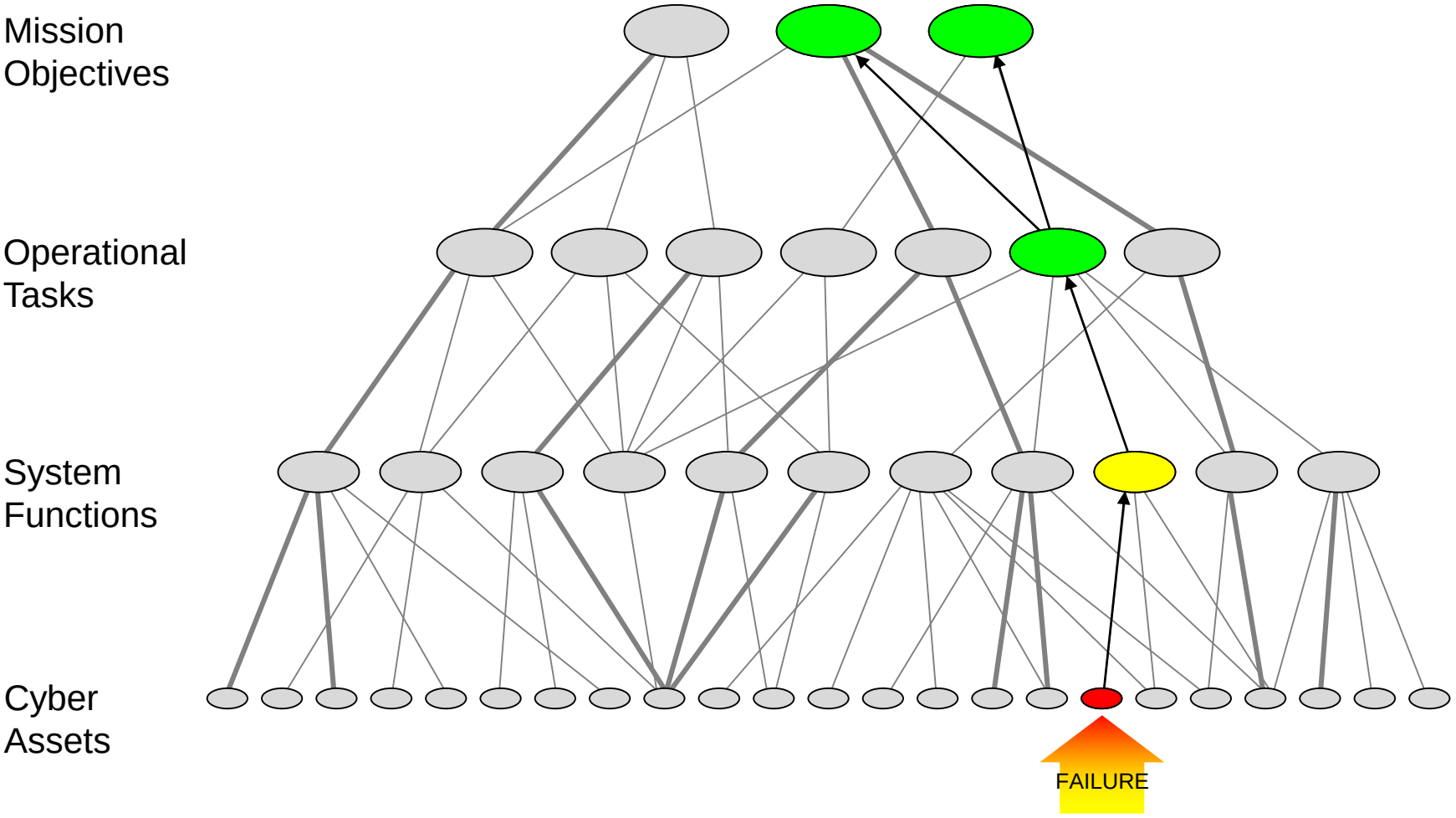
We Use the Dependencies to Predict the Impact of Cyber Asset Failures



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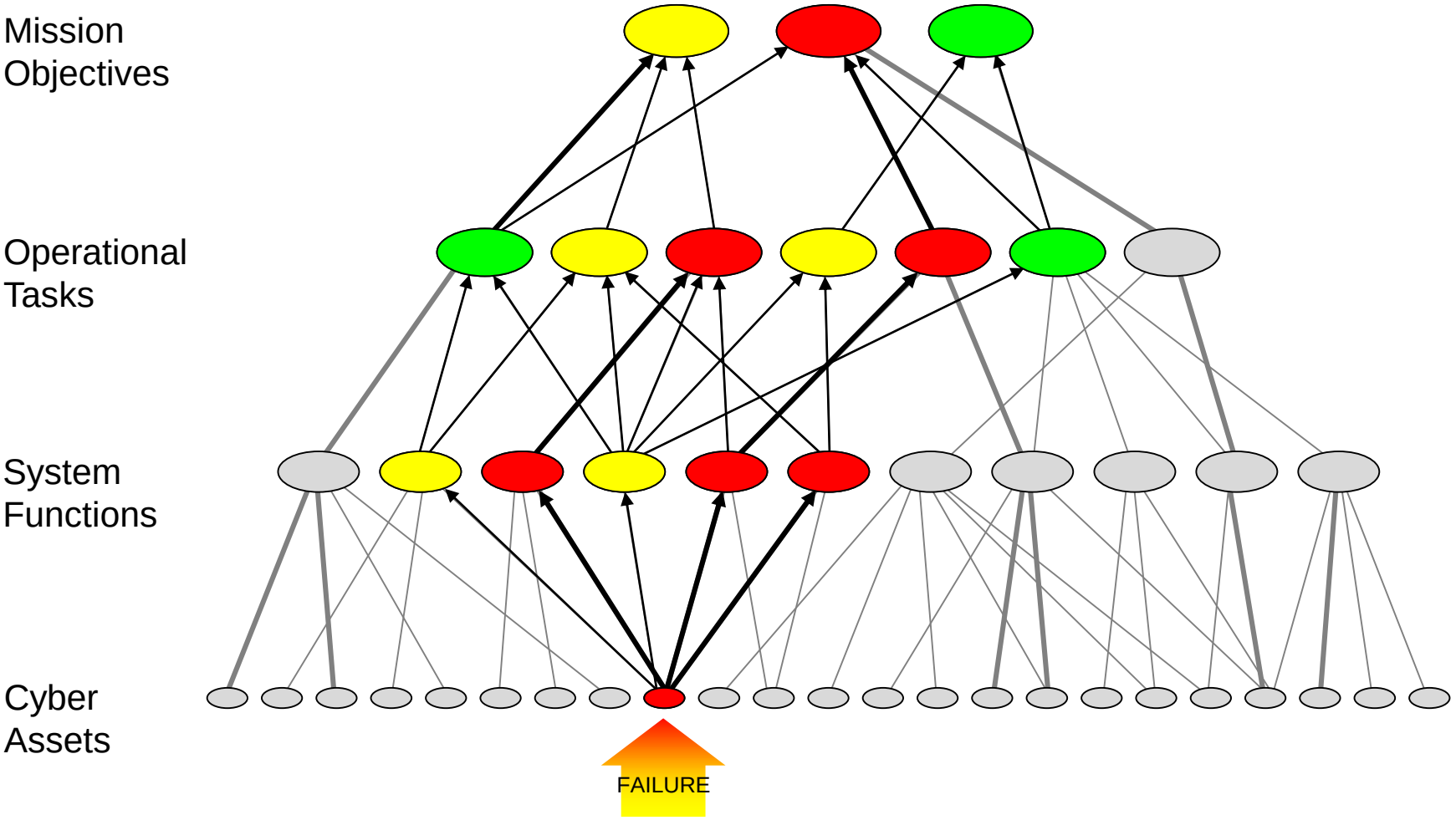
Greater Dependency Means Greater Impact from Cyber Asset Failure



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How Do We Evaluate a Dependency?

- **For our purposes, a dependency is a need**
  - *Achieving a Mission Objective depends on one or more Tasks being performed as intended*
  - *Performance of a Task depends on one or more System Functions executing as intended*
  - *Execution of a System Function depends on one or more Cyber Assets operating as intended*

- **We express the degree of dependency in terms of criticality**
  - *Criticality describes the impact of loss of an asset, based on the effect the loss would have on operations and the ability to fulfill the mission*
  - *We define four levels of impact: Failure, degradation, a work-around is required, and none*

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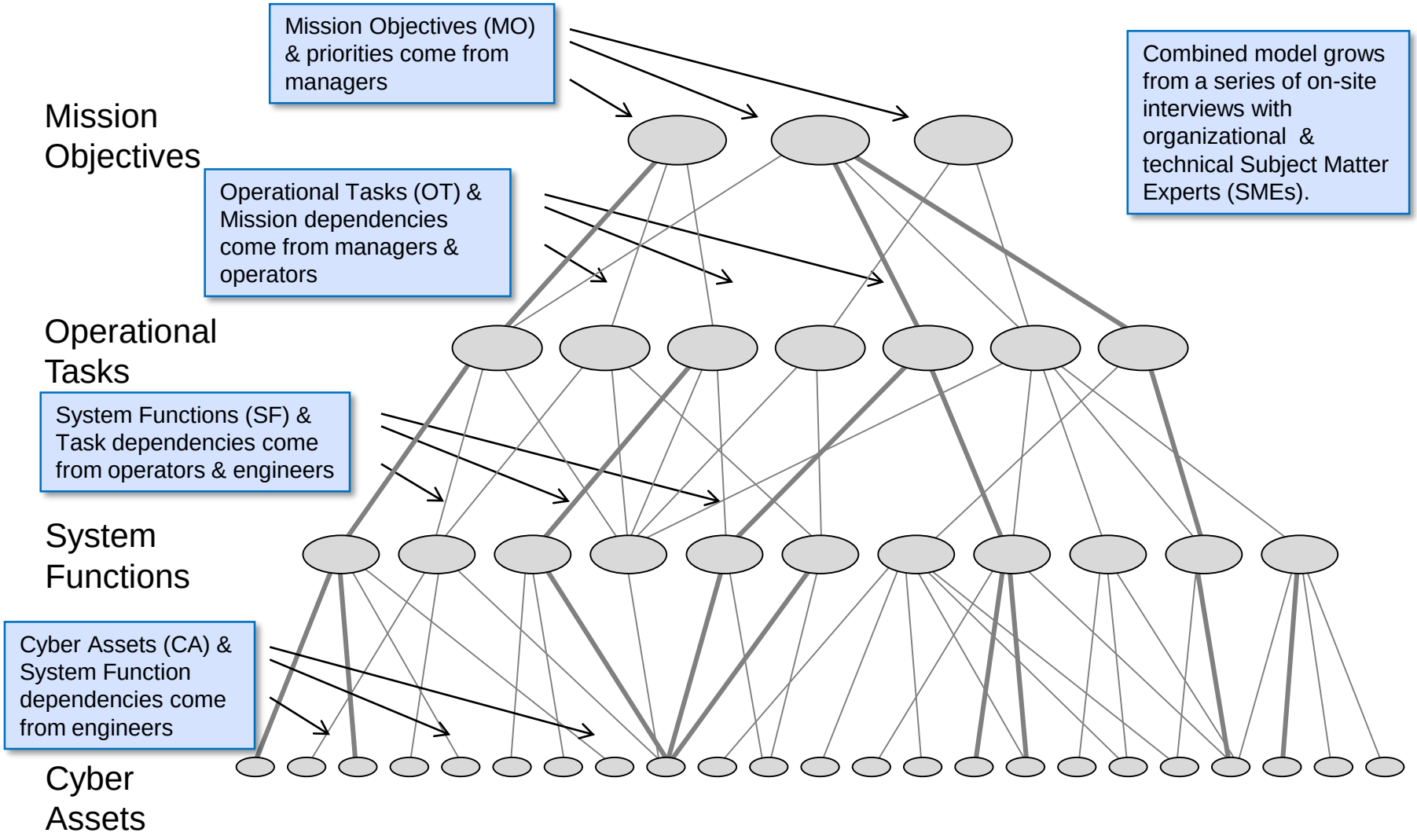
Where Does the Information Come From? (Option 1)



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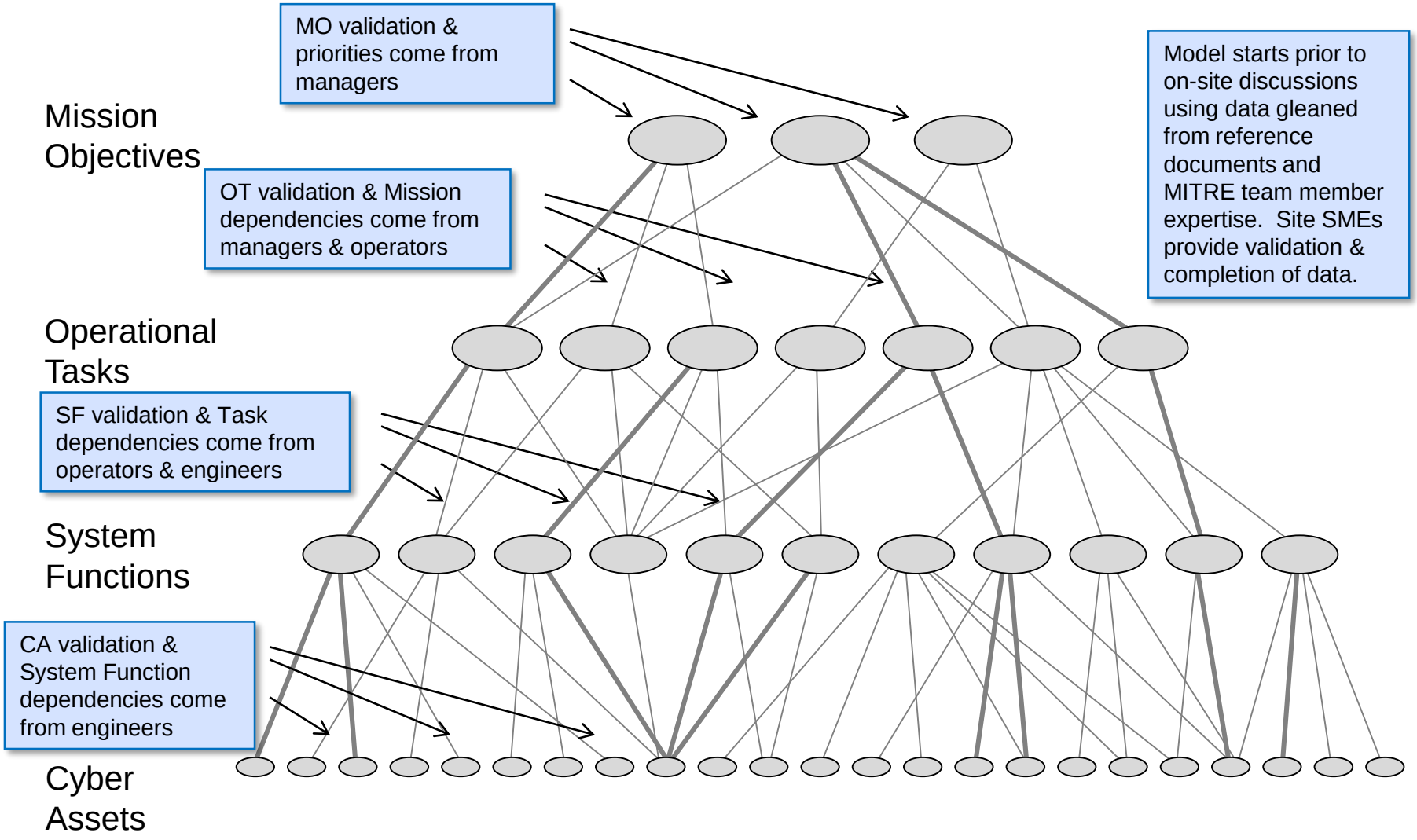
Where Does the Information Come From? (Option 2)



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How Do We Limit Subjectivity?

1. **We use structured question-and-answer sessions with the operational and technical experts on the system**

   a. *Managers/Operators: What is the impact on Mission Objective "MO1" if Task "T1" is not performed as intended?*

      – *No impact? Work-Around Required? Degradation? Failure?*

   b. *Operators/Engineers: What is the impact on Task "T1" if System Function "SF1" does not execute as intended?*

      – *No impact? Work-Around Required? Degradation? Failure?*

   c. *Engineers/Administrators: What is the impact on System Function "SF1" if Cyber Asset "CA1" is not operating as intended?*

      – *No impact? Work-Around Required? Degradation? Failure?*

2. **Scoring tables provide a reference, to ensure consistency**

   – *We define "as intended" to mean no failures and no degradation*

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How Do We Identify the Mission-Critical Cyber Assets?

1. **From the dependency identification, we know the following:**
   a. *If Task "T1" fails, the impact on achieving Mission Objective "MO1" is one of the following:*
      - *No impact, work-around required, mission degradation, or mission failure*
   b. *If System Function "SF1" fails, the impact on performing Task "T1" is one of the following:*
      - *No impact, work-around required, task degradation, or task failure*
   c. *If Cyber Asset "CA1" fails, the impact on the performance of System Function "SF1" is one of the following:*
      - *No impact, work-around required, function degradation, or function failure*
2. **We can use these "if-then" statements to predict the impact at each level in the dependency map**
   – *We call this step in the CJA the Mission Impact Analysis (MIA)*

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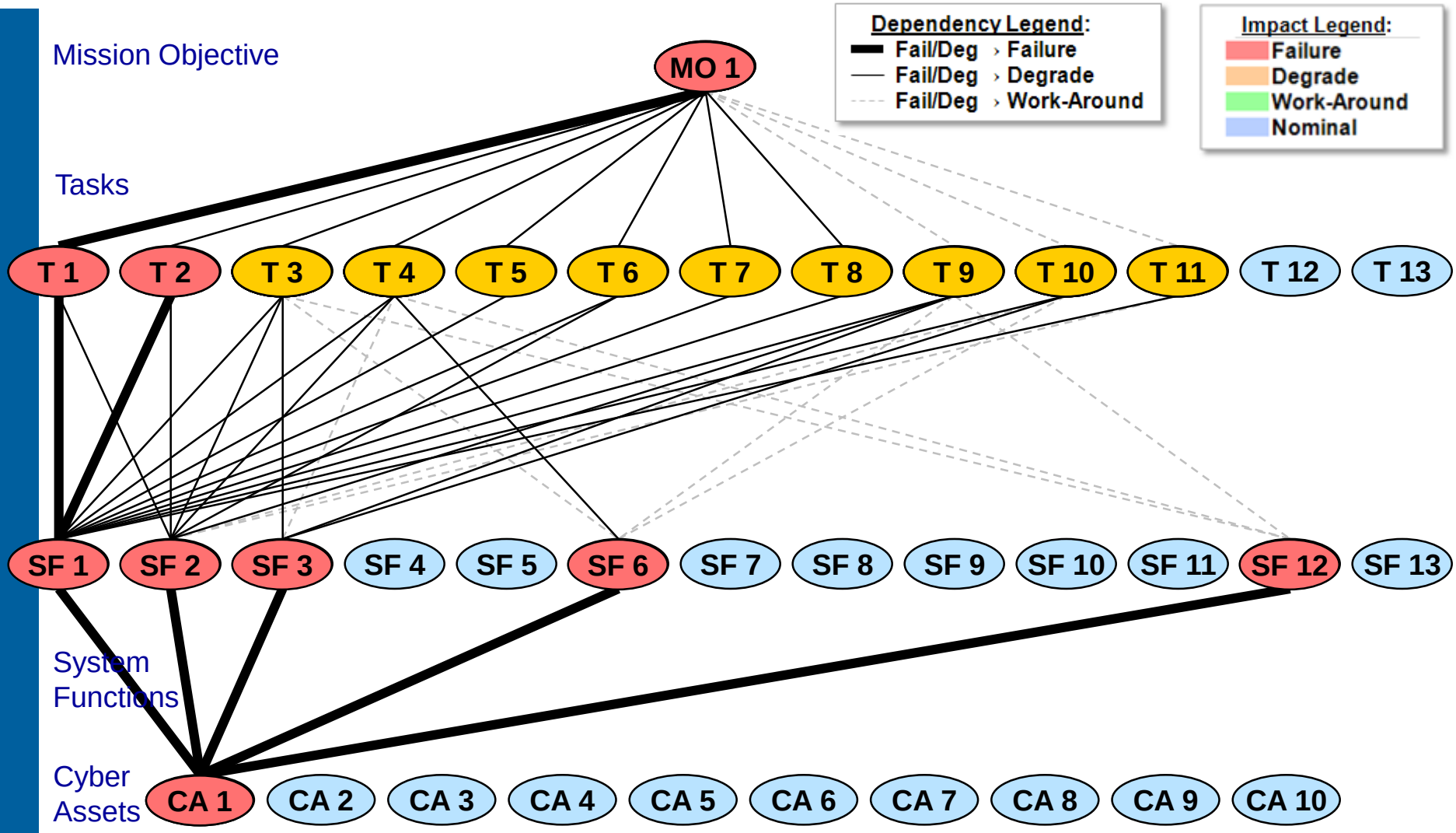
In the MIA We Consider Each CA As Failed, Starting with CA1



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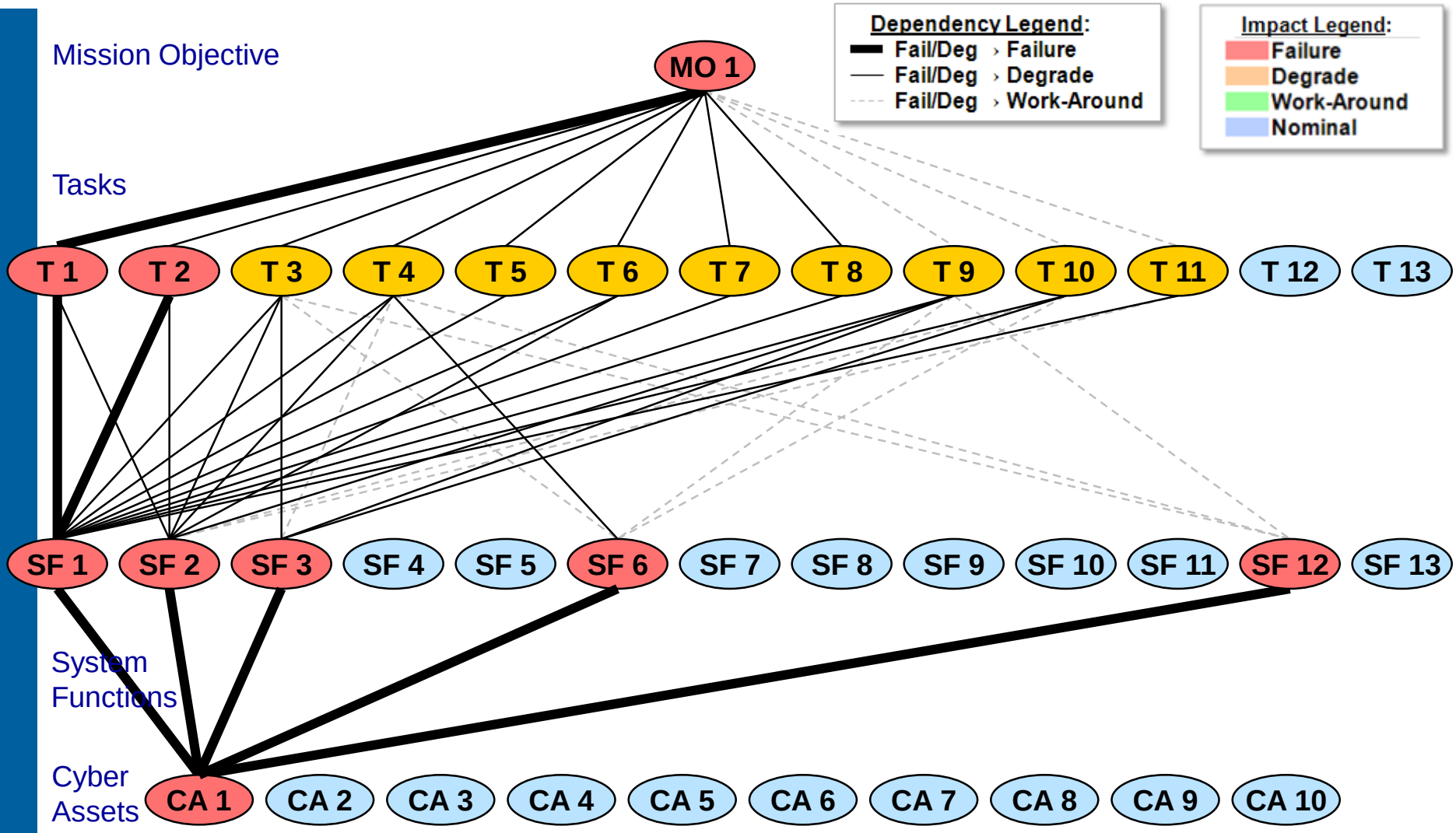
CA1's Failure Causes Several SF and Tasks to Fail, Causing MO1 Failure



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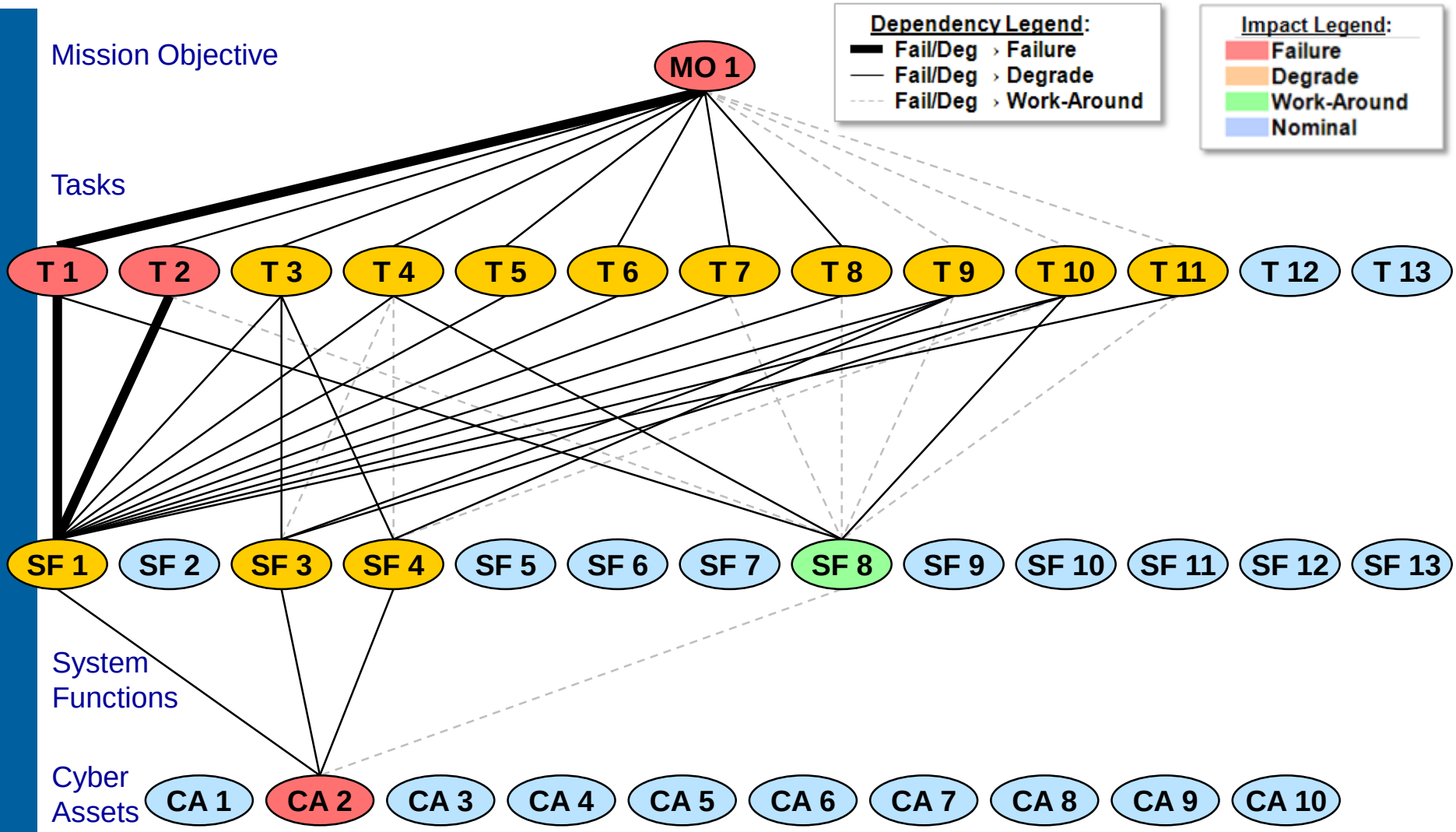
CA2's Failure Degrades SF1, Causing Task T1 to Fail, Causing MO1 Failure



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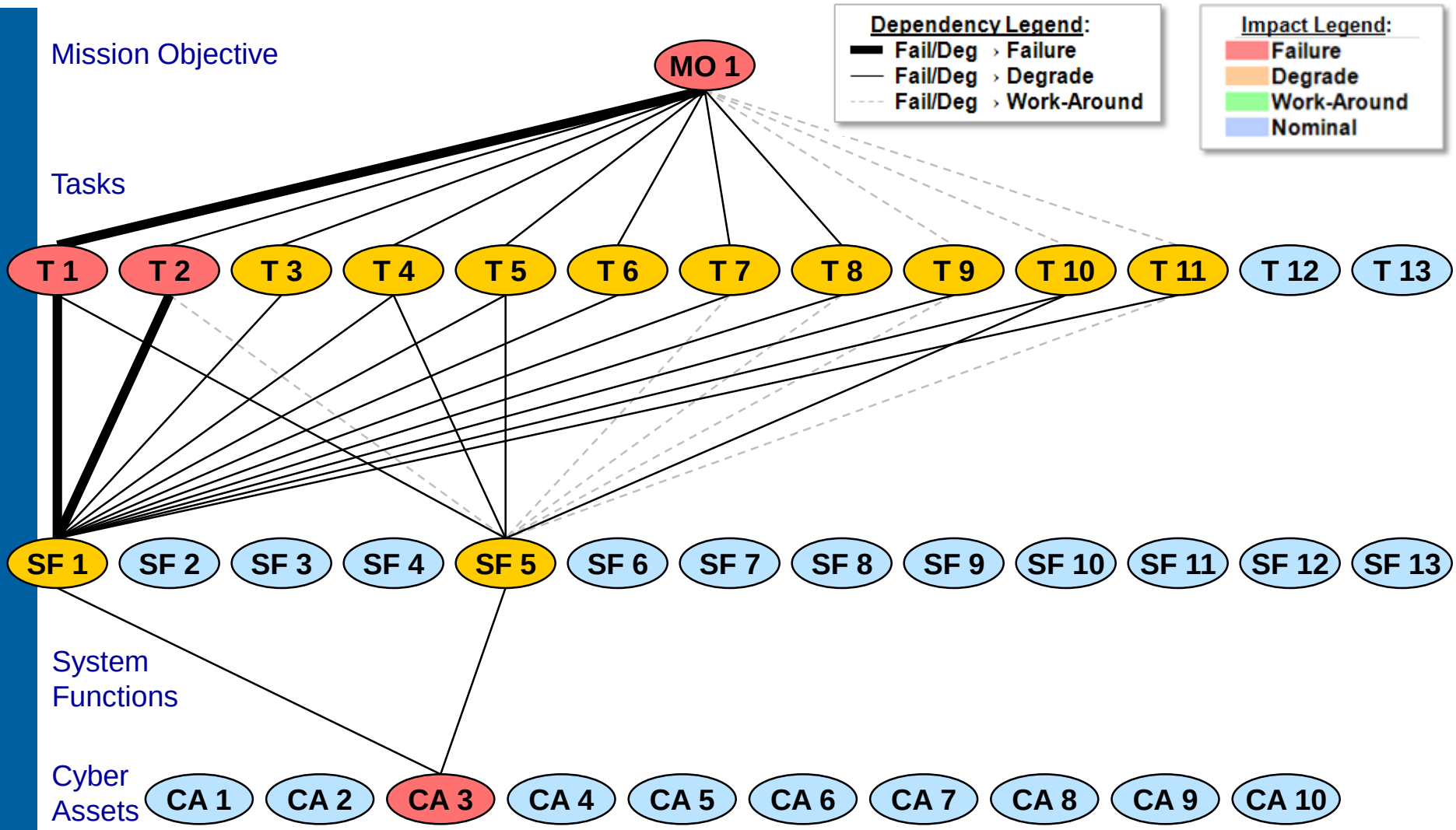
CA3's Failure Has an Effect Like That of CA2's Failure – Causing MO1 Failure



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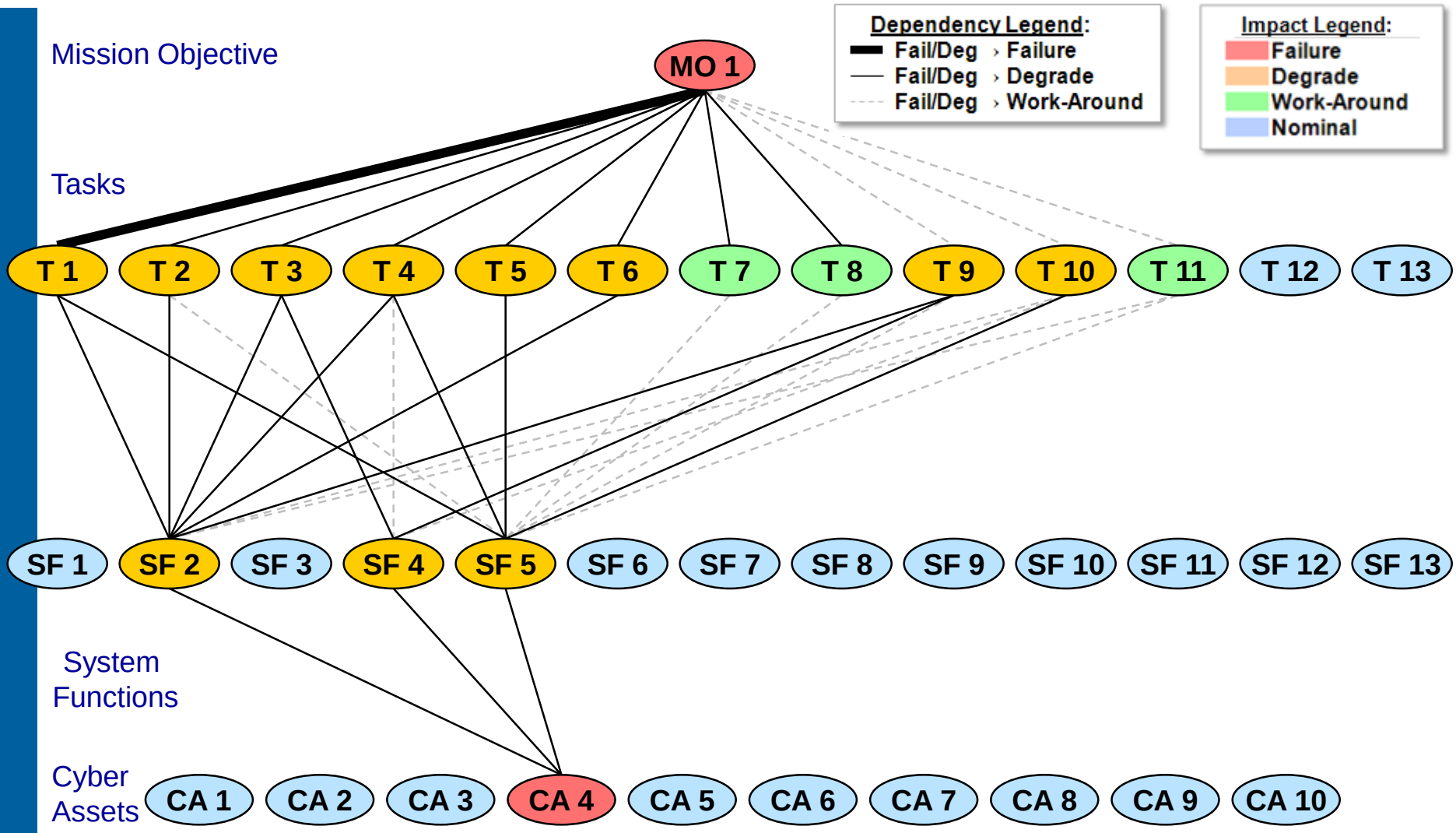
Because CA4's Failure Degrades SF2 and T1, It Causes MO1 Failure



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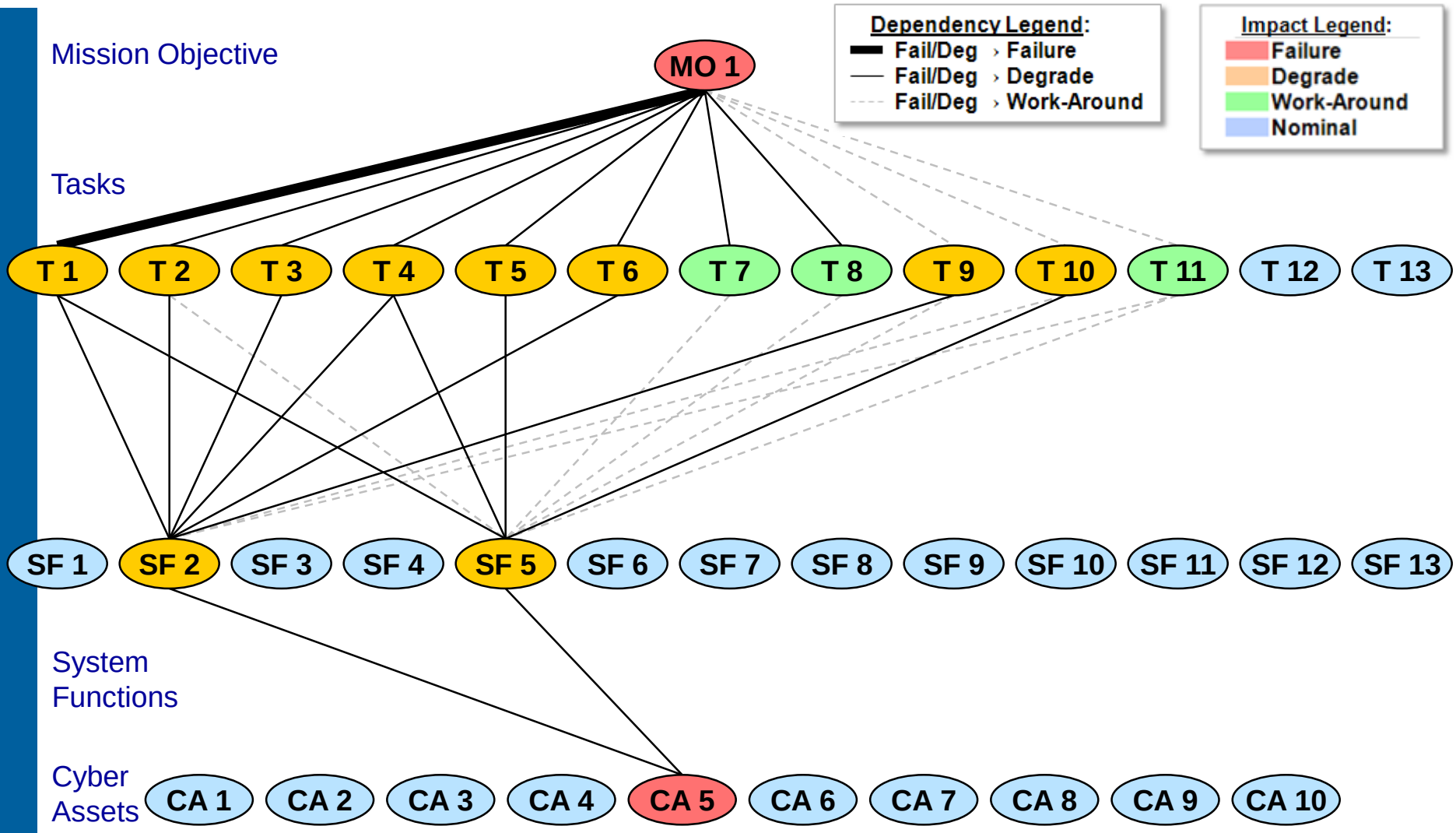
CA5's Failure Has an Effect Like That of CA4's Failure – Causing MO1 Failure



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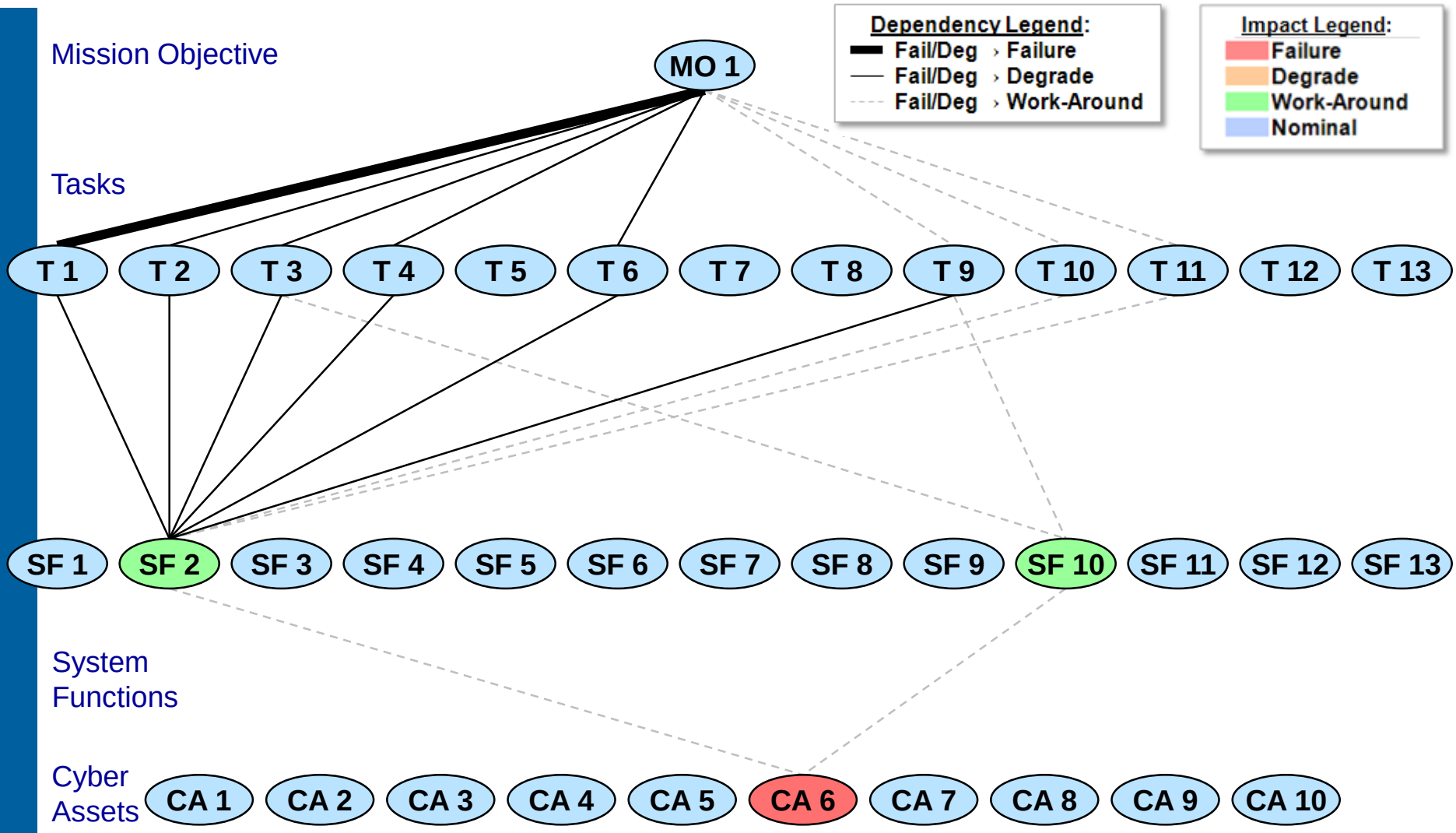
CA6's Failure Requires a Work-Around for SF2 and SF10 – No MO1 Impact



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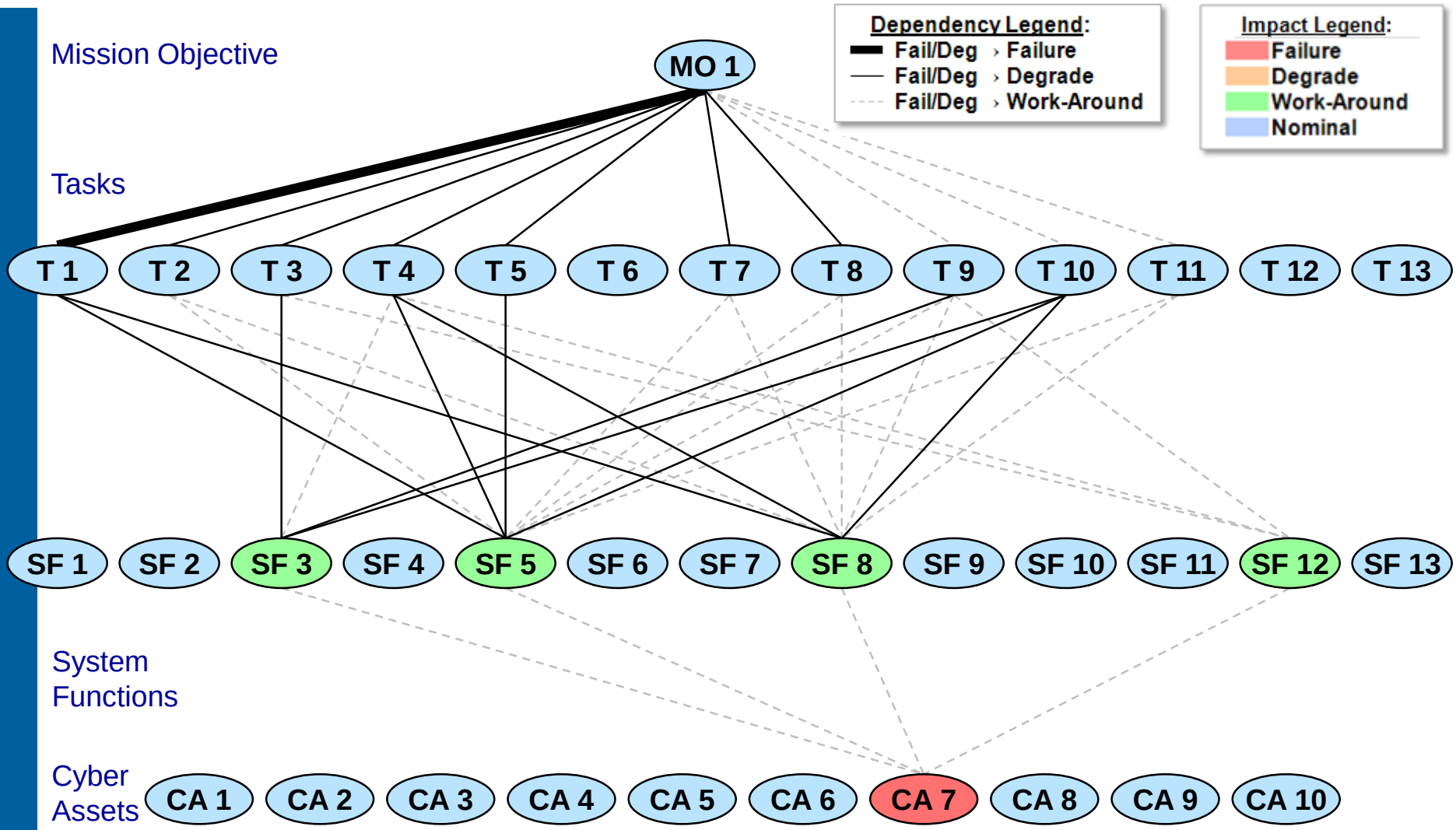
CA7's Failure Has an Effect Like That of CA6's Failure – No MO1 Impact



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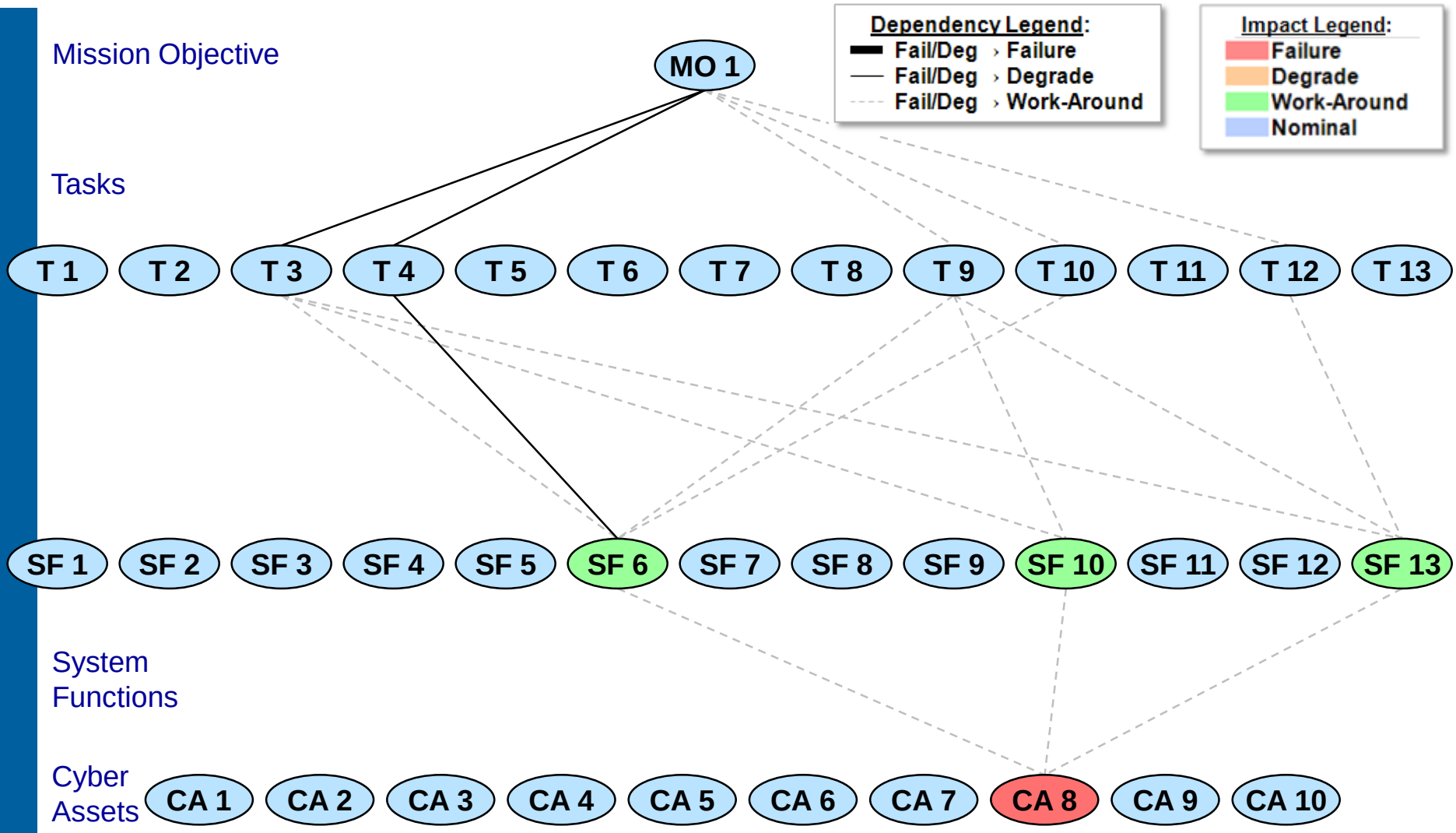
CA8's Failure Has an Effect Like That of CA6's Failure – No MO1 Impact



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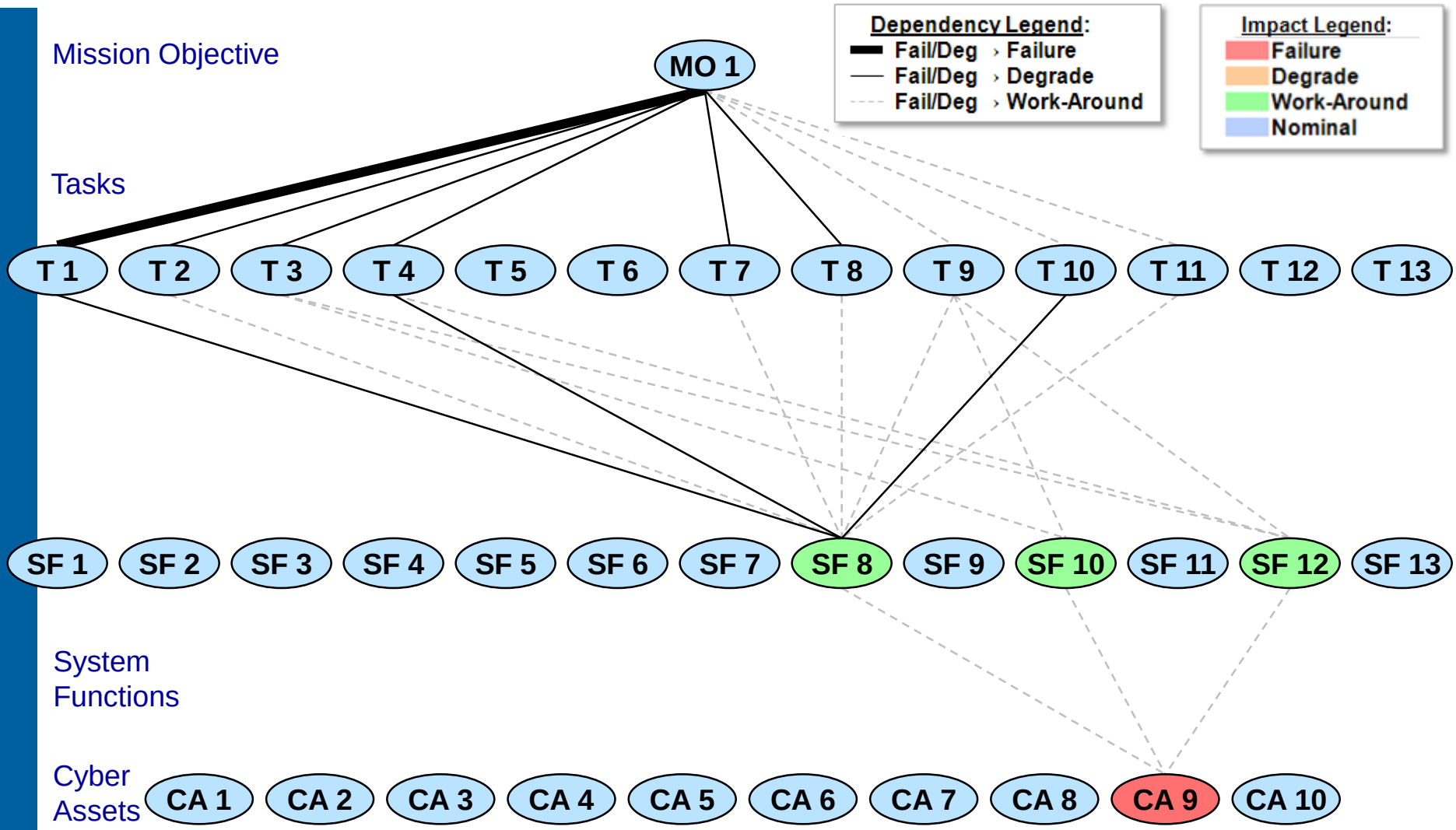
CA9's Failure Has an Effect Like That of CA6's Failure – No MO1 Impact



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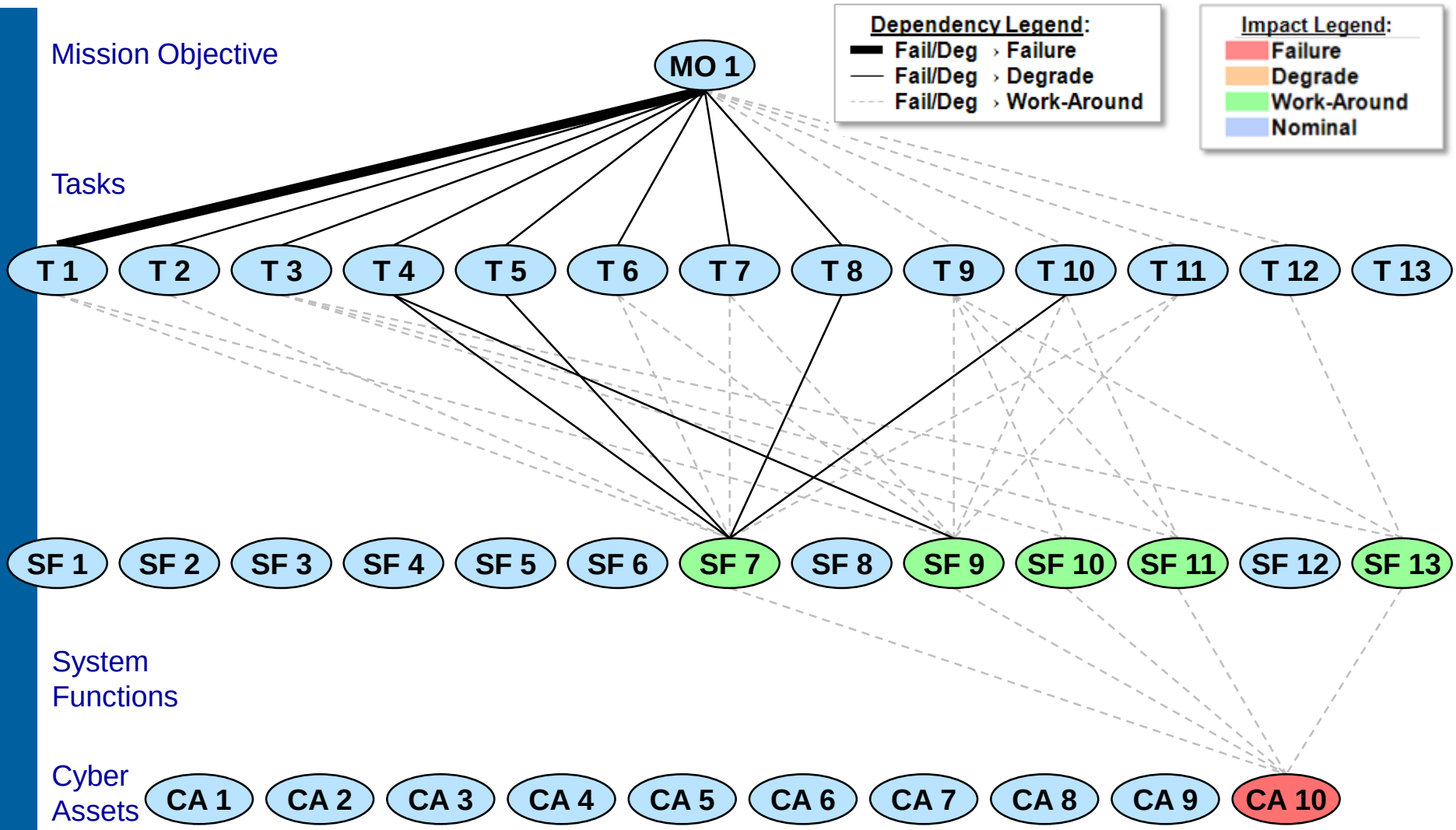
CA10's Failure Has an Effect Like That of CA6's Failure – No MO1 Impact



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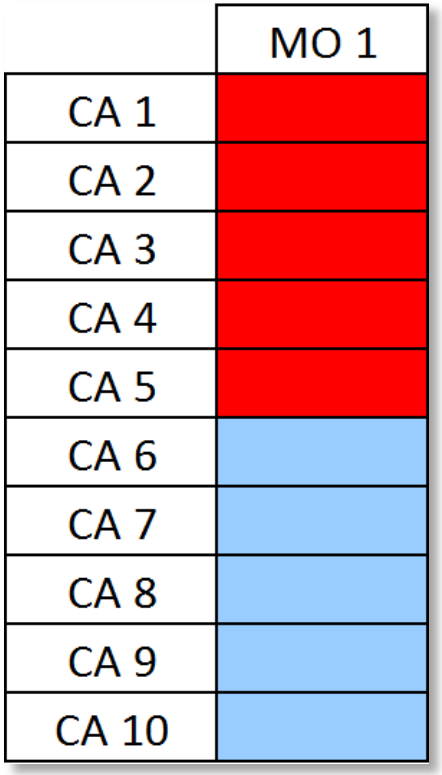
The Results Can Be Compacted For Easy Viewing

- **Cell color indicates the Mission Objective's Impact resulting from each CA failure**
- **Red means that MO1 fails, and Blue means that MO1 is nominal**
- **In this example, CA1 through CA5 are Mission-Critical Cyber Assets since their failure would cause MO1 to fail**
- **Cyber Assets CA1 through CA5 are Mission-Critical Cyber Assets – the "Crown Jewels"**



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A Typical Case Shows Mission-Critical CA for Several Mission Objectives

Result of CA Failure/Degrade: Blue = Mission Nominal Green = Mission Work Around Yellow = Mission Degrade Red = Mission Failure	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4	Mission Objective 5	Mission Objective 6	Mission Objective 7	Mission Objective 8	Mission Objective 9	Mission Objective 10
Cyber Asset 1										
Cyber Asset 2										
Cyber Asset 3										
Cyber Asset 4										
Cyber Asset 5										
Cyber Asset 6										
Cyber Asset 7										
Cyber Asset 8										
Cyber Asset 9										
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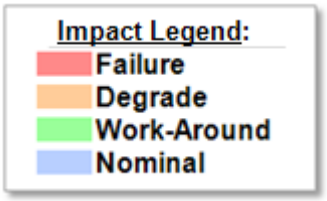

- **A single CA in a highly integrated infrastructure will affect more than one MO**
- **The total mission impact of each CA is shown across each row**
- **For each MO, the column below it shows the CA that are critical to its achievement**

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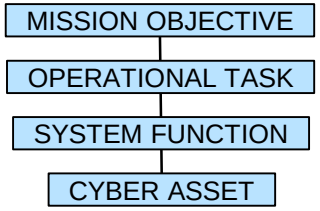
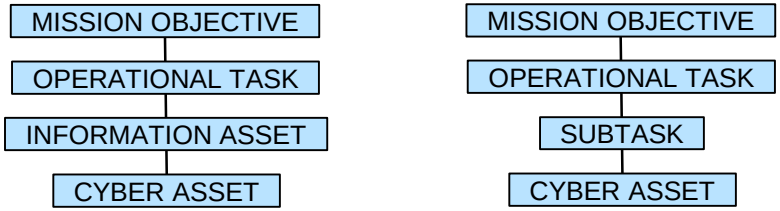
The CJA Methodology Allows For Flexibility

- **The preceding slides show a CJA based on the 4-tier model shown here:**



  - *Different models are also used, depending on the reference information available to the CJA team*

- **Alternative 4-tier models:**



  - *An Information Asset is operational information needed to perform a task*

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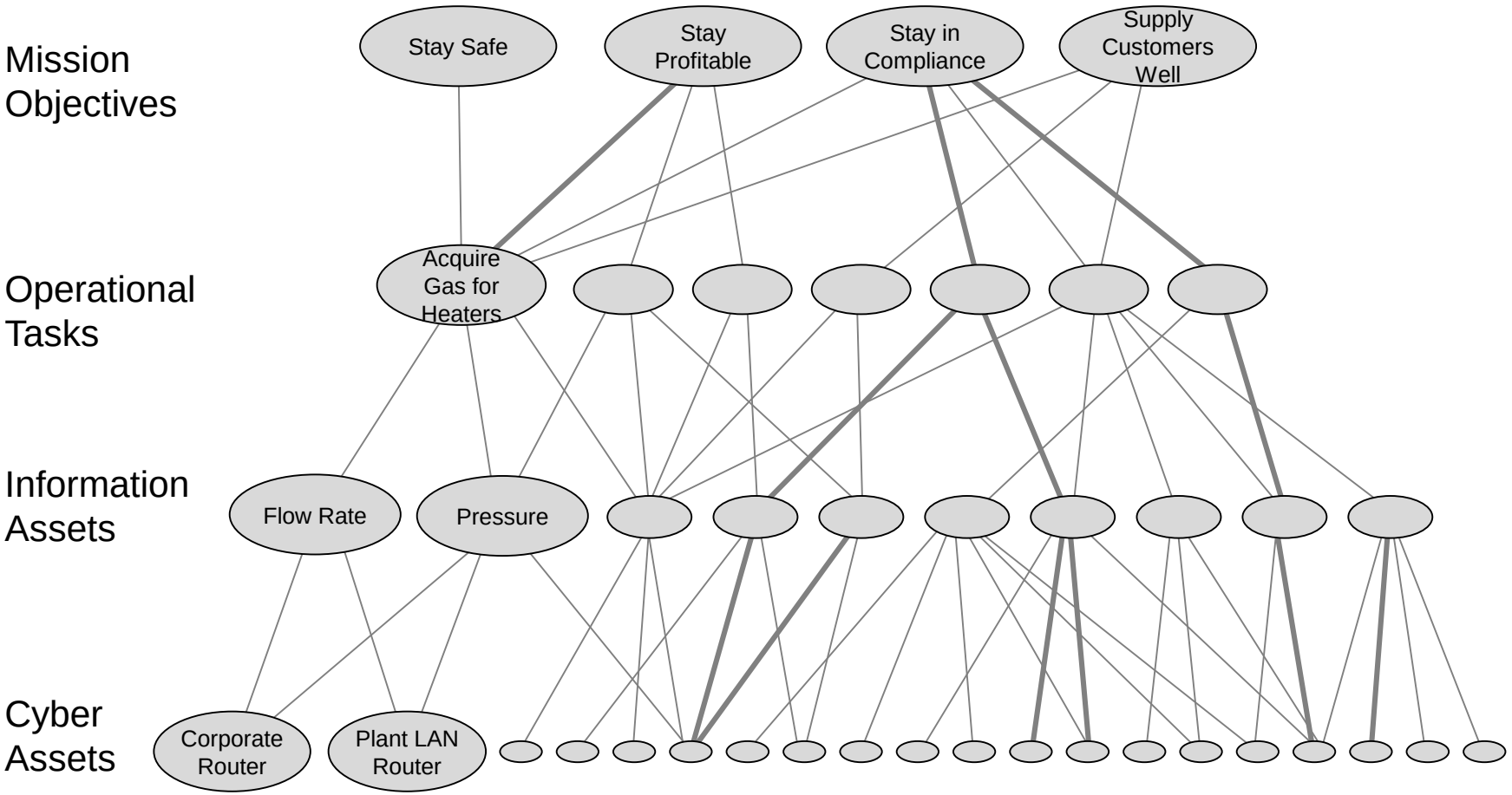
Alternative Model Using Information Assets - Refinery Example



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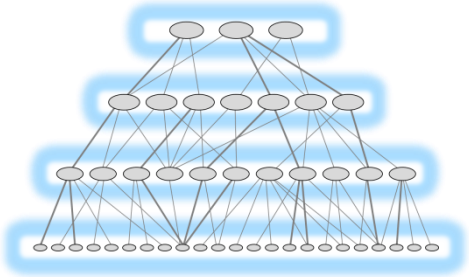
We Use the CJA Tool to Help Build the Dependency Map



Cyber Asset Weights

Info Asset/ Sys Funct Weights

Task Weights

Objective Weights

Mission-Critical CA Candidates

4 CA

IA / SF

3 IA / SF

Tasks

2 Tasks

Object's

1 Object's

Object's

Identify Dependencies on Tasks

… and on Info Assets or System Functions

… and on Cyber Assets

Prioritize Mission Objectives

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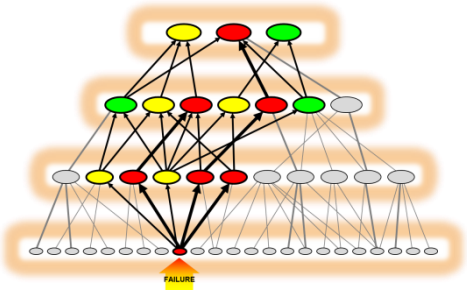
Next, The CJA Tool Automatically Completes the Mission Impact Analysis (MIA)



Propose
CA Failures/
Degrades

CA
Criticality

IA/SF
Criticality

Task
Criticality

5 Scenarios
CA's

4c CA
IA/SF

3c IA/SF
Tasks

2c Tasks
Object's

CA
Impact

IA/SF
Impact

Task
Impact

Roll-Up Rules Utilize User-Input
Criticality Scores

Mission
Impact

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Tool Demonstration

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For More Information:

CJA article in MITRE's Systems Engineering Guide:

- http://www.mitre.org/publications/systems-engineering-guide/enterprise-engineering/systems-engineering-for-mission-assurance/crown-jewels-analysis

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