Sandia National Laboratories

SAND2013-0361P

Nuclear Security

Physical Protection System Design

Tony Aragon
International Physical Protection Department

Sandia National Laboratories is a multi-program laboratory operated and managed by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Physical Protection System

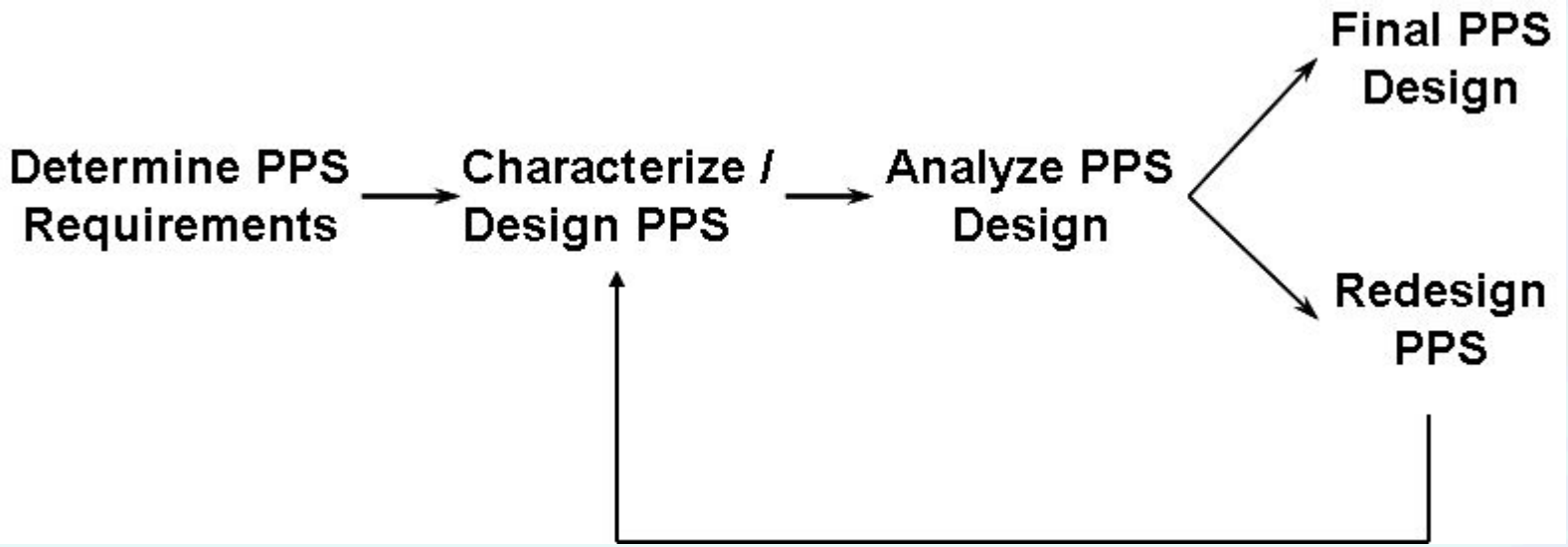
Definition:

A physical protection system is the integration of people, procedures, and equipment used to protect assets or facilities against theft, sabotage, or other malicious human attacks

Objectives of a PPS

- Protect against unauthorized removal of nuclear materials during use, storage, and transport (theft)
- Protect against sabotage of nuclear facilities and sabotage of nuclear material during use, storage, and transport (radiological sabotage)

Physical Protection System Design and Evaluation Cycle



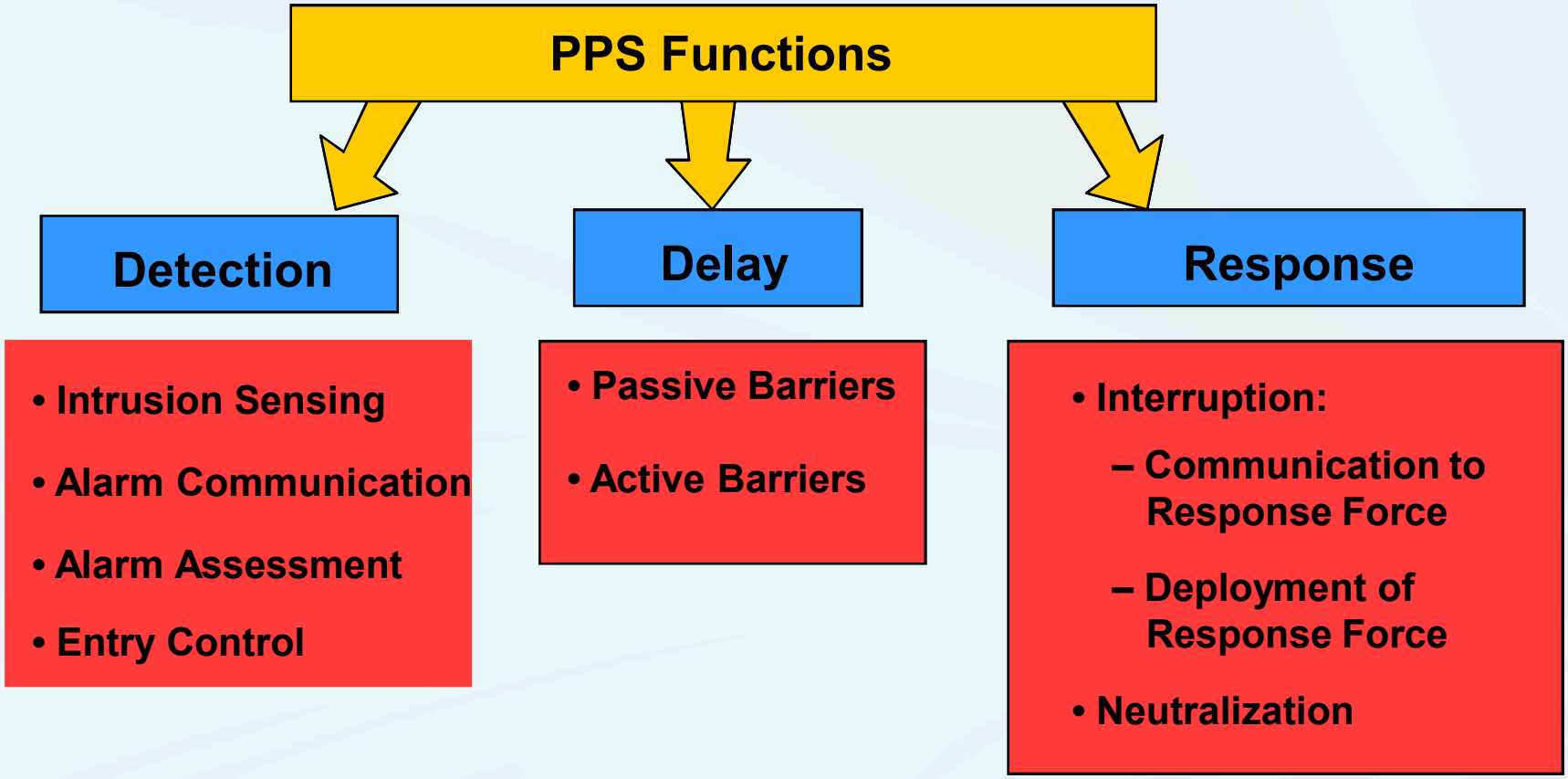
Three Questions that define the requirements for a PPS

1. What must I protect? (What are the assets to be protected?)

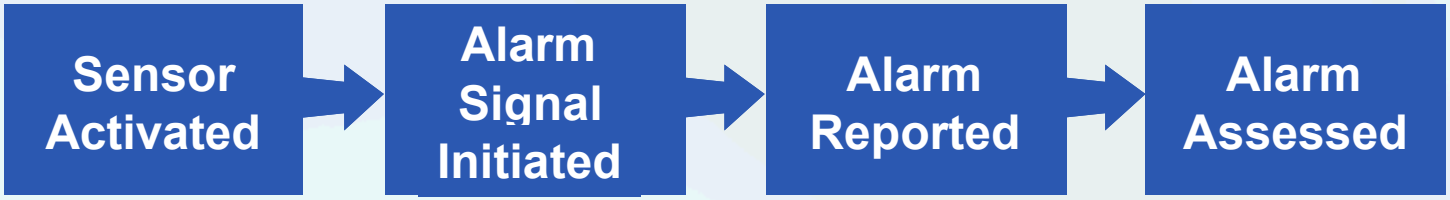
2. What must I protect against? (What is the threat against which the PPS must be designed?)

3. What level of protection is adequate? (What is the acceptance criteria for the PPS?)

PPS Functions



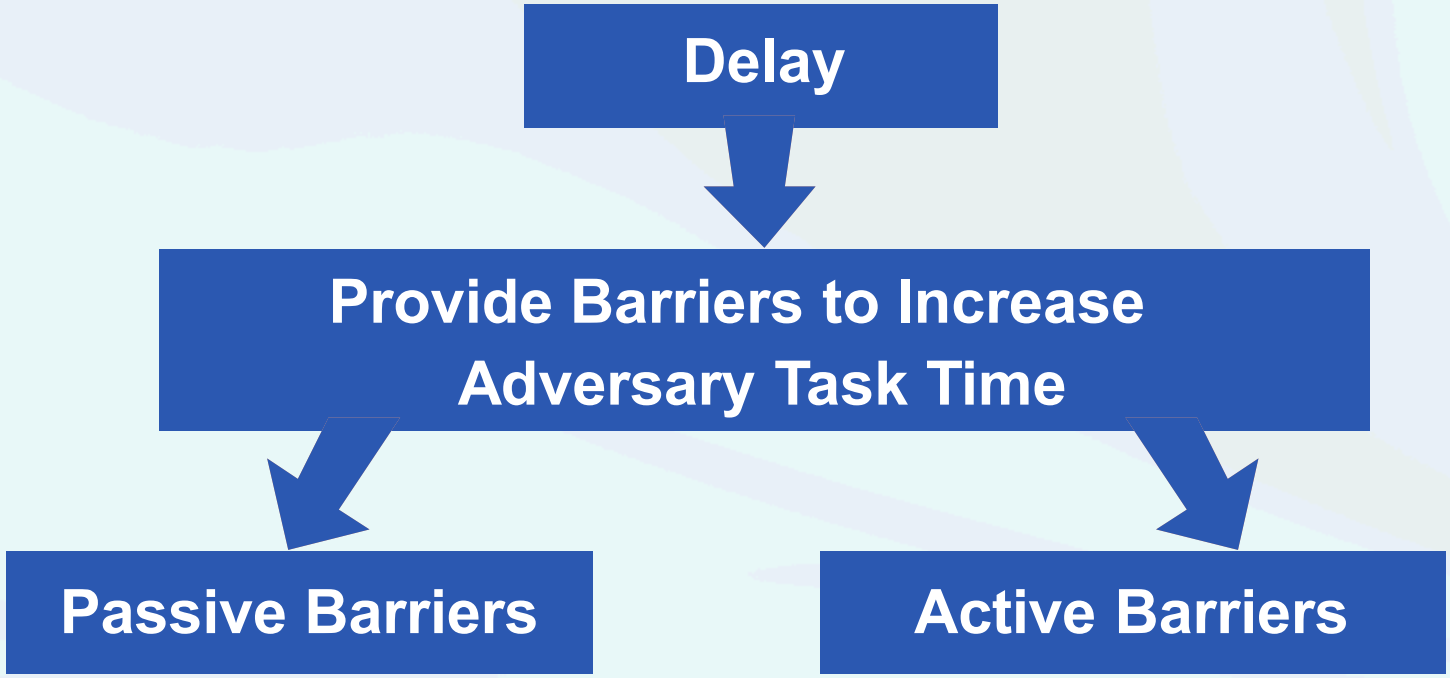
Detection Process



→ **Technologies** → **Guards**

- **Performance measures:**
  - Probability of sensor alarm
  - Communication and Assessment Time
  - Probability of Assessment
  - Nuisance Alarm Rate
  - Assessed detection

Delay Process



- **Performance measures**
  - Time to penetrate or bypass barriers
  - Time to travel across areas

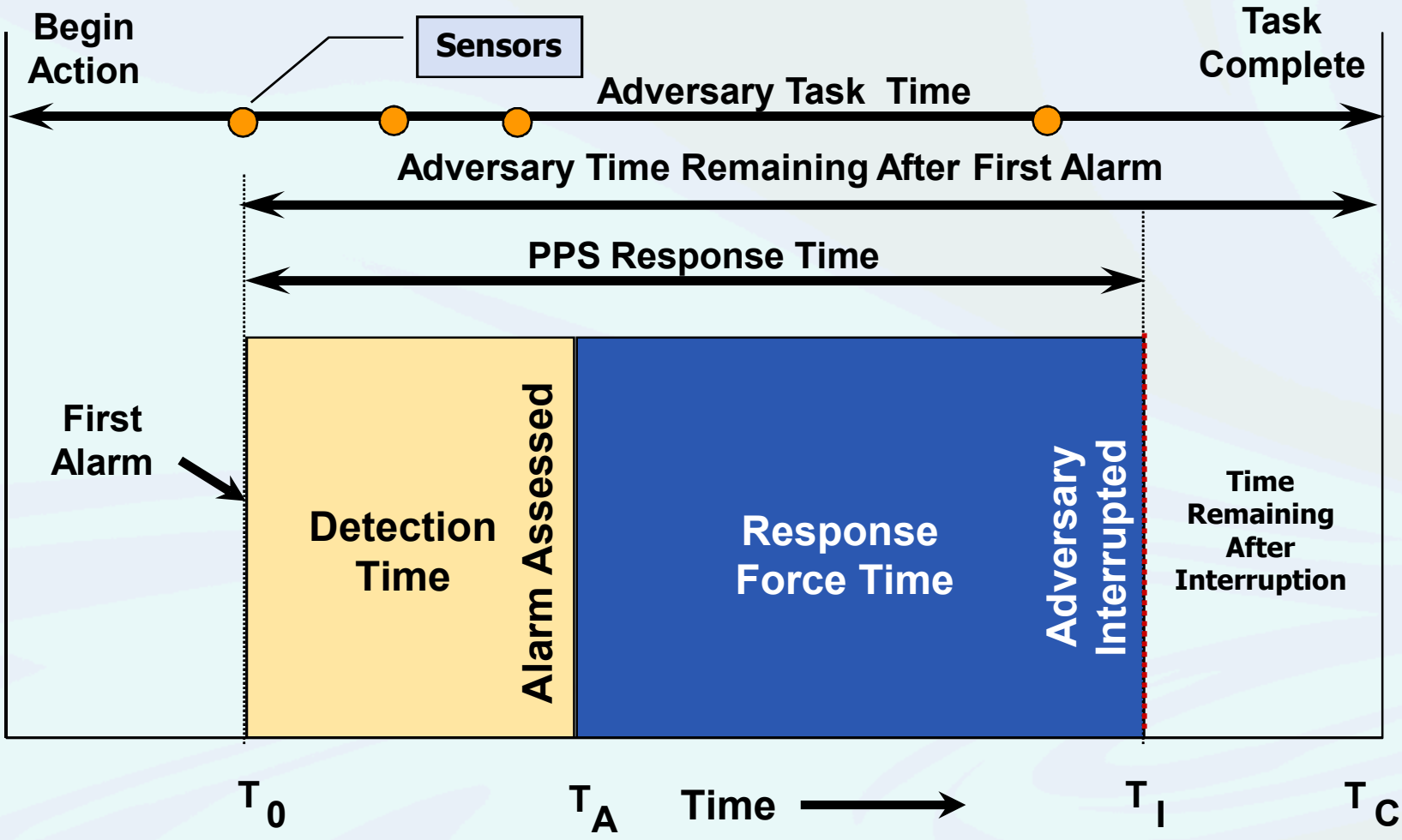
Response Process

- **Performance measures**
  - Probability of communication to response force
  - Communication time
  - Probability of deployment to adversary location
  - Deployment time
  - Response force effectiveness

Two Competing Timelines

- **Adversary Timeline**
  - Cross areas
  - Penetrate or bypass barriers
  - Remove or sabotage target
- **PPS Timeline**
  - Detection process
  - Delay process
  - Response process
- **Overlay of two timelines illustrates requirement for PPS effectiveness**

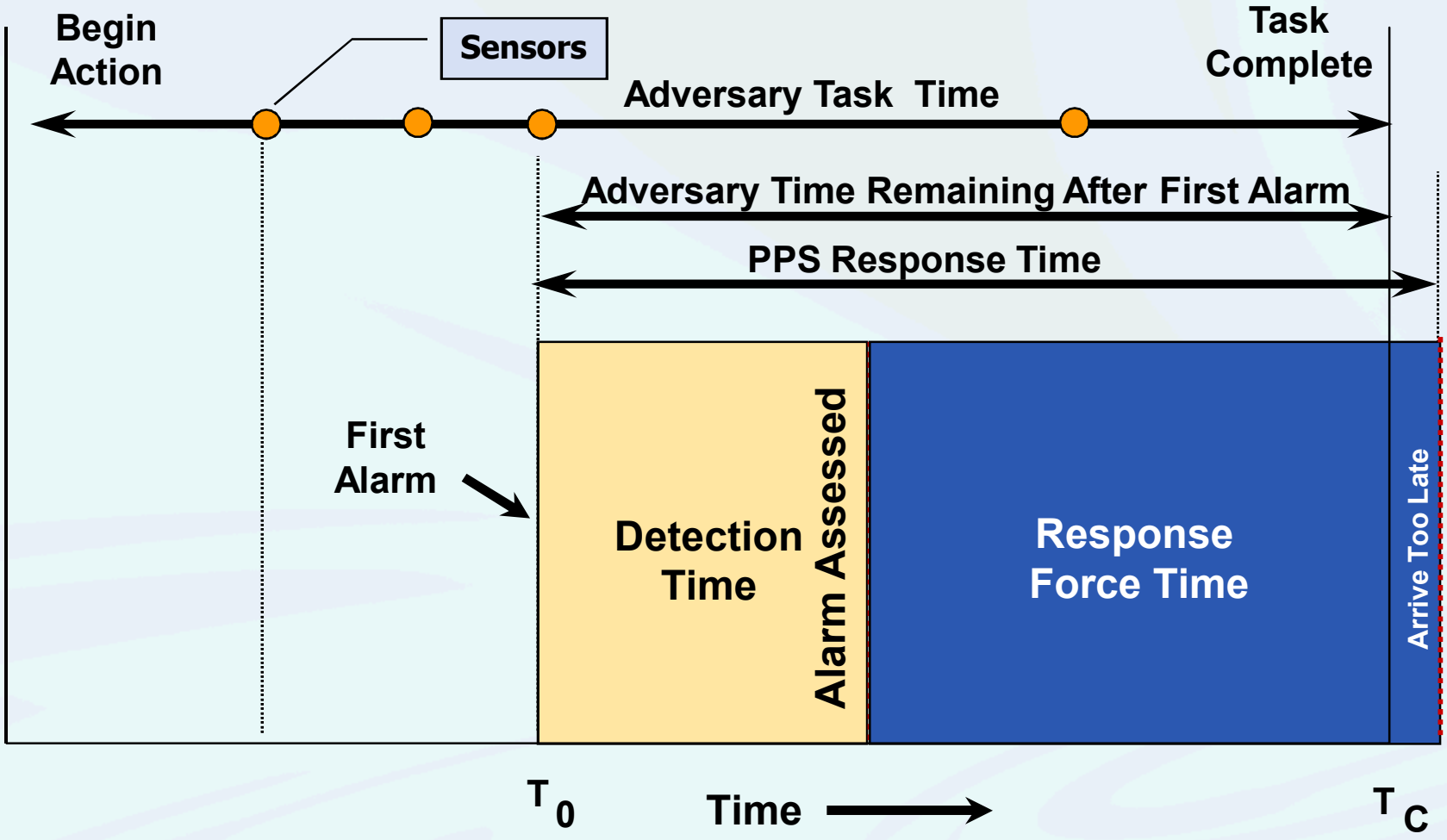
Adversary and PPS Timelines



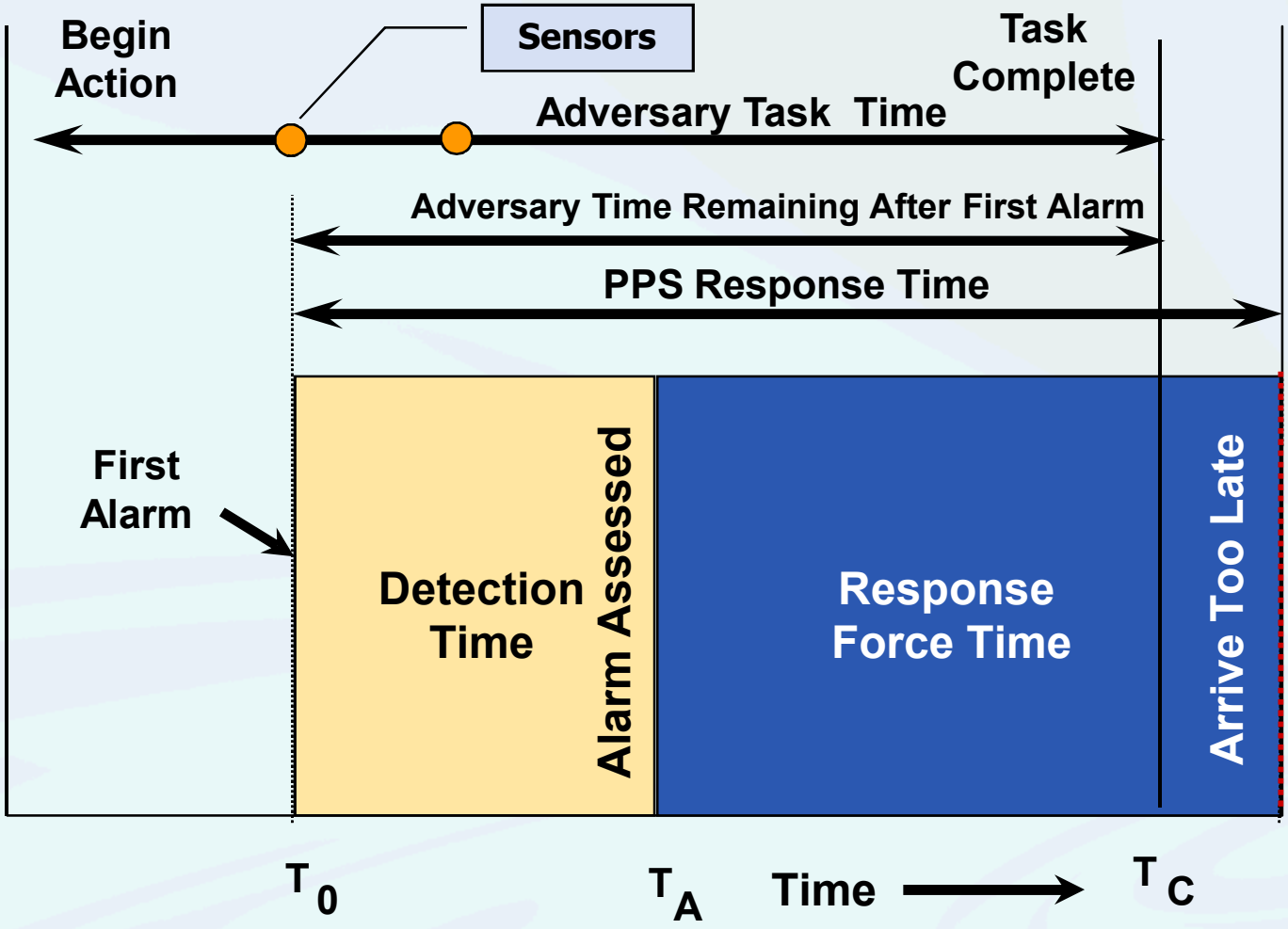
Principle of Timely Detection

- To interrupt the adversary before the theft or sabotage task is complete, the PPS response time must be less than the adversary task time remaining after first detection
- The critical detection point (CDP) is the last detection point along an adversary path for which the PPS response time is less than the adversary task time remaining after first detection
- To be an effective PPS, timely detection must be achieved against the DBT along all adversary paths

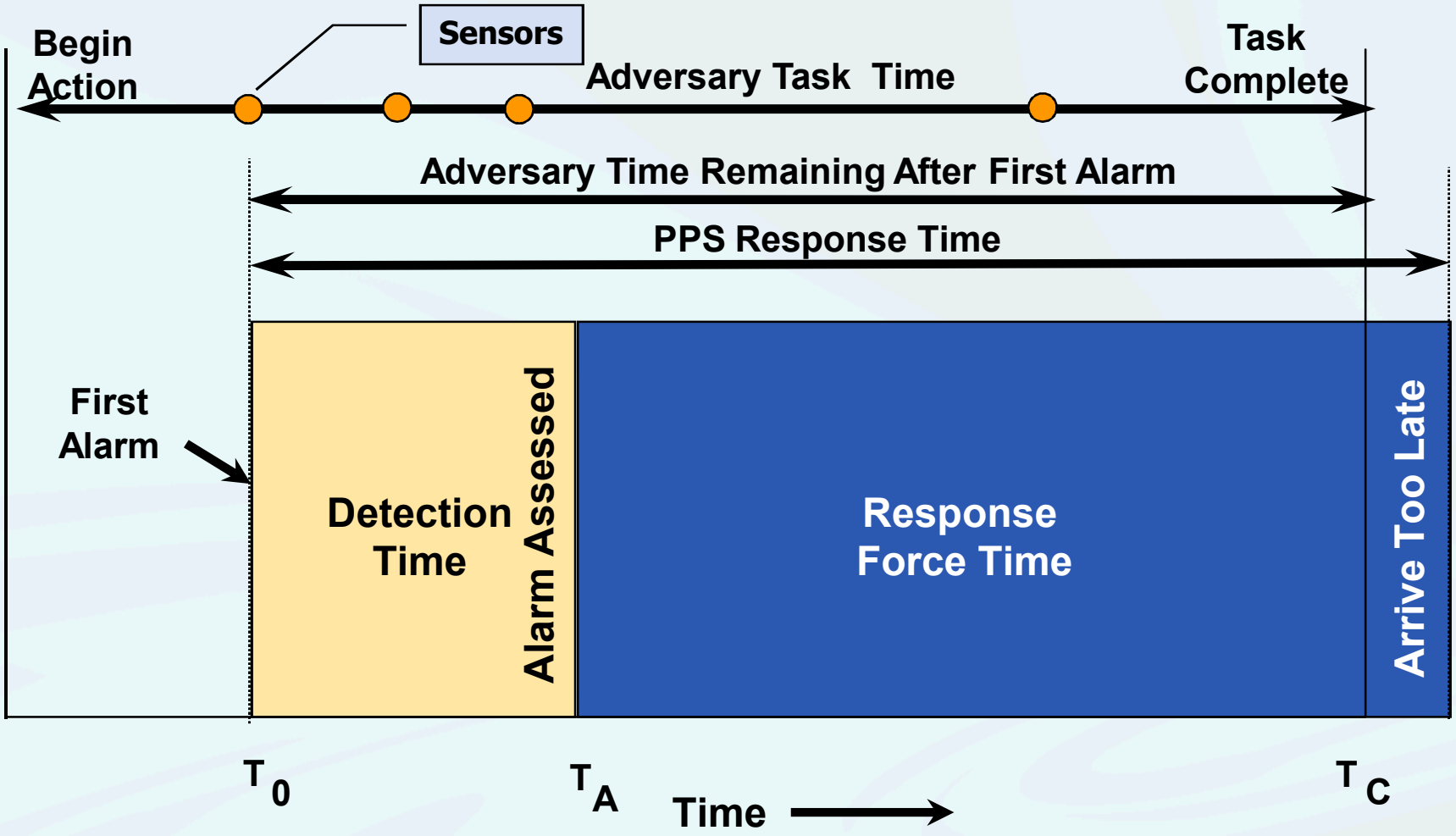
Late Detection



Insufficient Delay



Slow Response



Neutralization

- **Very difficult to measure**
- **Subject matter experts**
- **Tabletop exercises**
- **Force-on-force exercises**
- **Computer simulation models**
- **The winning combination:**
  - Right people
  - Right equipment
  - Right training

PPS for Material Transportation

- **Physical protection of nuclear material in transport presents challenges not present for fixed sites**
- **Requires similar physical protection system elements as a fixed site**
  - Detection
  - Delay
  - Response
- **Follows the same design process**
  - Determine system requirements
  - Characterize existing system
    - Detection / Delay / Response
  - Analyze PPS
- **Requires scenario analysis to determine system effectiveness**

PPS Effectiveness

In order to be effective in preventing malicious acts, the three PPS functions must be balanced in order to:

- Provide timely detection
- Provide adequate delay
- Provide effective response (prior task completion)

Characteristics of Effective PPS Design

- **Balanced protection**
  - Provide adequate protection against all threats along all adversary paths
- **Defense-in-depth**
  - Adversary must defeat or avoid a number of varied protective devices in sequence
- **High System Reliability**
  - Redundant equipment
    - Multiple complementary sensors
    - Multiple complementary barriers
    - Multiple response force groups
  - Contingency plans
    - Compensatory measures
    - Spare parts

Summary

- **Fundamental design strategy**
  - Defeat adversary – approach used in DEPO
- **Basic PPS functions**
  - Detection
  - Delay
  - Response
- **Performances measures**
  - Probability of Detection
  - Delay Time
  - Response Time, Probability of Interruption, and Probability of Neutralization

Summary (continued)

- **Principle of timely detection**
  - To interrupt an adversary before completion of the theft or sabotage task, the PPS response time must be less than the adversary task time remaining after the first sensing
- **Additional principles for designing effective PPS:**
  - Defense-in-depth
  - Balanced protection
  - High system reliability