US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Functional Decomposition, Uses and Misuses

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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David A. Minchala
US Army ARDEC,
Picatinny Arsenal NJ, 07806-5000
(973) 724-8723
david.a.minchala@us.army.mil

Outline

- Background
- Definition of Terms
- State of Practice
- Good Uses of FD
- Misuses of FD
- Examples
- Insights/Conclusion

Background

- **Effective formulation of solutions to any complex engineering problem requires segmenting/cutting the problem into the proverbial "chewable parts"**

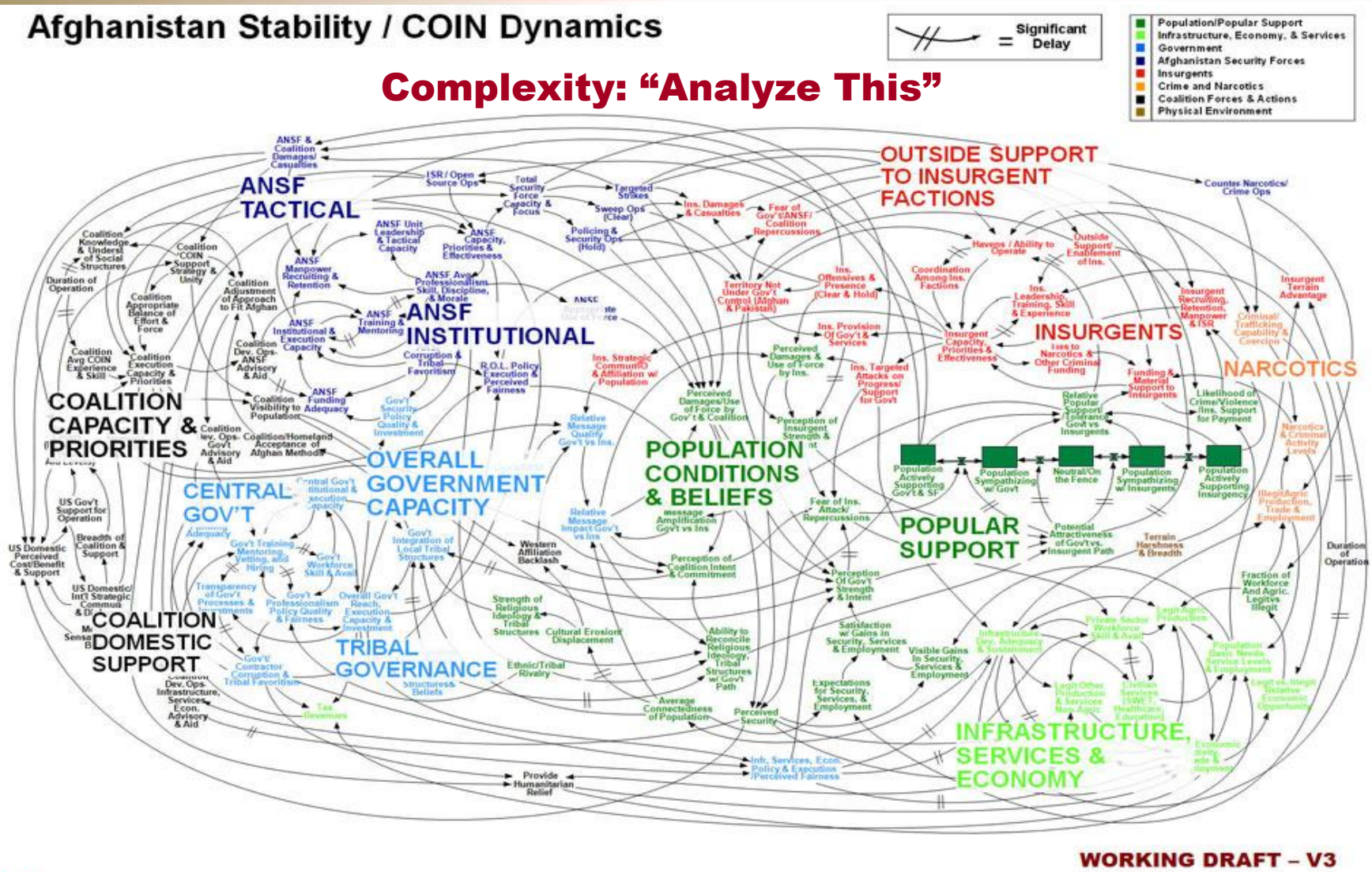
- **Good systems engineering practice requires unraveling complexity in order to attain understanding of some otherwise indiscernible systems' functions and interfaces**

Background

- **Modern systems can be Complicated and Complex**
  - **Ship building is complicated - but by following certain steps we attain the expected results fairly well**
  - **Defining and designing system's interoperability, interfaces, and anticipating emergent behaviors in a SoS environment are complex tasks**
    - **Indiscernible tangles of conflicting functions, goals, roles, and constraints, unaccounted risks, concealed intents, etc.**
- **Functional Decomposition is a common practice used to deal with complexity more effectively**

Complex systems can have two types of properties: one that is simply an aggregation of the same property of its constituent parts and one that [is] emergent and cannot be seen on the lower level of its parts: Course on Network Analysis: http://sites.google.com/site/networkanalysisacourse/schedule/an-introduction

Background



The McChrystal Afghanistan PowerPoint slide: can it get any more complex?

Definition of Terms

What Is Functional Decomposition?

- Since this practice is more of an art than an exact science, there is no one official definition of Functional Decomposition

- There is an abundance of definitions, depending where you look and what field this activity supports

Definition of Terms

Examples:

- **"… in its most basic form, the functional architecture is a simple hierarchical decomposition of the functions with associated performance requirements.": DoD System Engineering Fundamentals, Ch 5.2**

- **"A business analysis technique for breaking down a "business operation" into functional components": Guide to Functional Decomposition, CHALES STURT UNIVERSITY, Australia**

Definition of Terms

A "Practical" Answer

- **Functional Decomposition is a fundamental analysis technique utilized to:**
  - **Methodically breakdown complex functions into smaller parts or sub-functions**
  - **Facilitate**
    - **logical analysis**
    - **functional integration**
    - **technical decision-making, and**
    - **other lower level analytical, engineering, and design activities**

State of practice

Functional Decomposition is practiced in many different ways and from many different viewpoints

Examples:

- **Operational/Mission View**
- **DoD Acquisition View**
- **Systems Engineering view**
- **Software view**
- **Business Analysis view**
- **Programmatic view**

State of practice

- **Operational/Mission View**
  - **Identify capabilities critical to strategic mission tasks**
- **DoD Acquisition View**
  - **Ensure that "the functional [definition] / architecture is in balance with the stakeholder requirements":** DAG
- **Systems Engineering view**
  - **As a technique or means to define / discover the relationship of constituent parts of a complex system:** Wikipedia (Functional Decomposition)

State of practice

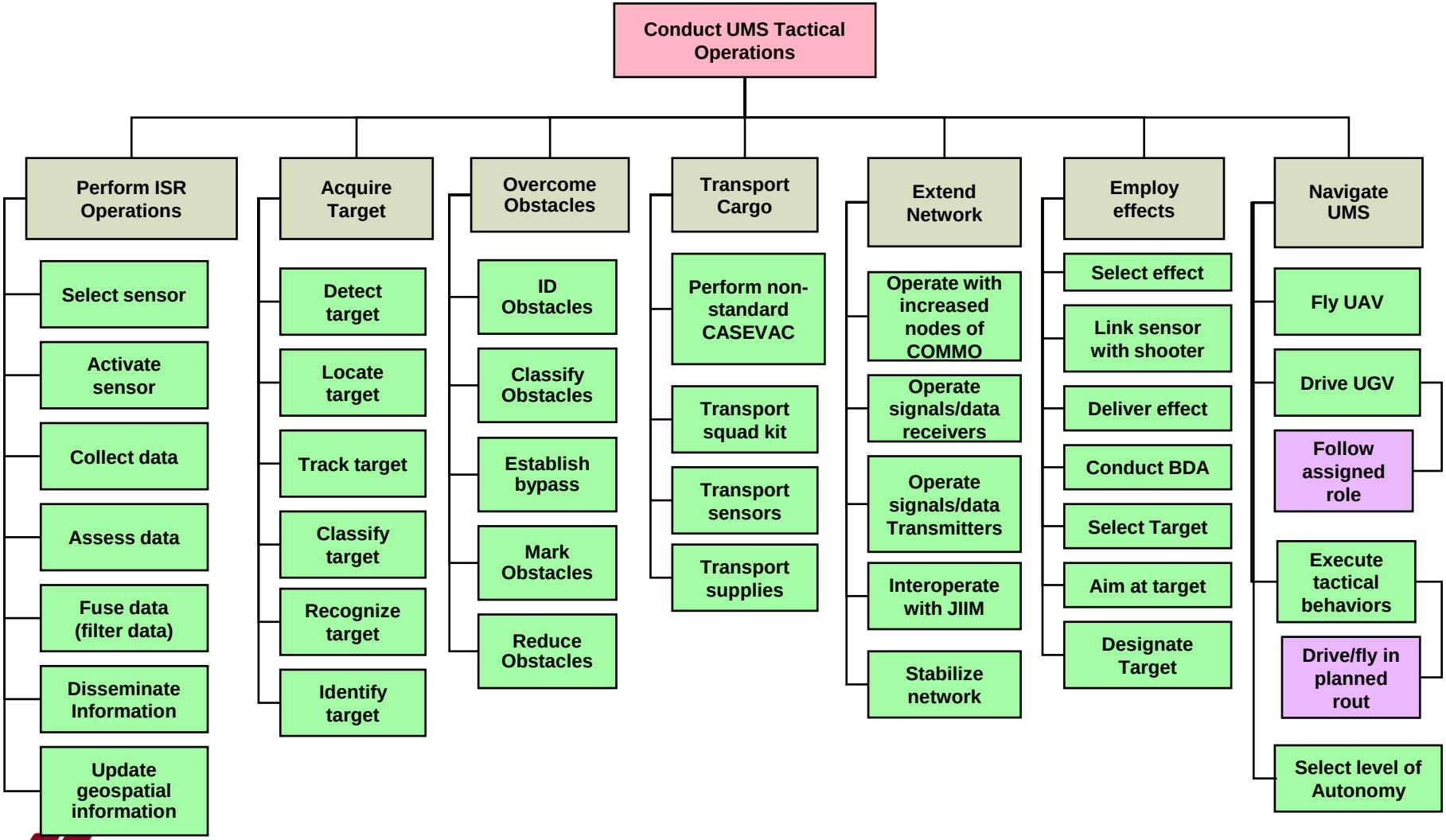
- **Software view**
  - **To breakdown a large system into progressively smaller classes or objects (*Object-oriented decomposition)* that are functional part of the system:** Booch, et al
- **Business Analysis view**
  - **To facilitate understanding of the enterprise business operations or functions**
- **Programmatic view**
  - **Assist in defining functional teams**

Good Uses of Functional Decomposition (FD)

Hierarchical Functional Decomposition

- Identifies the necessary system capabilities to support intended system end-use
- Identifies and delineates the ***critical*** top-level system functions, or business operations to be decomposed
- Decomposes each top-level function or business operation in discernable parts
- Hierarchically organizes functions and requirements
- Keeps operational user functions separate from system-to-system interface functions
- Does not directly imply functional system design

Good Uses of Functional Decomposition (FD)



Hierarchical Functional Decomposition
[Operational Activity Model Node Tree Diagram (OV-5)]

Good Uses of Functional Decomposition (FD)

Comprehensive FD

- Generates a well-documented functional decomposition
  - Graphical models, and
  - Textual description of functions
- Generated with input from the subject matter experts, those who manage and/or work with the system/business operation

Good Uses of Functional Decomposition (FD)

Comprehensive FD

- Decomposes the first level components with their functions and continues to decompose to lower levels until sufficient level of detail is achieved.
- Graphically documented models of the initial functional decomposition can be used to obtain immediate feedback front of the experts, getting them to confirm the components
- Facilitate logical analysis and functional integration
- Provide guidance for sound technical decision-making

Good Uses of Functional Decomposition (FD)

Functional Decomposition Record, ARDEC template

Function Name	**Name the System Functions according to their functional goal.**
Function description	**Define goal to be achieved by the Function. What does the function do / accomplishes. Write a concise, results-oriented description.**
Rationale	**Provide a clear and concise written explanation of why this Function is necessary.**
Assumptions	**Describe key assumptions required for the understanding of the Function – but may not be logical under all circumstances.**
Trigger	**Specifies the action (event) which initiates the Function.**
Preconditions	**List general activities or conditions which are required for valid execution of the Function and the state of the system prior to execution of the Function.**

Good Uses of Functional Decomposition (FD)

Functional Decomposition Record, ARDEC template

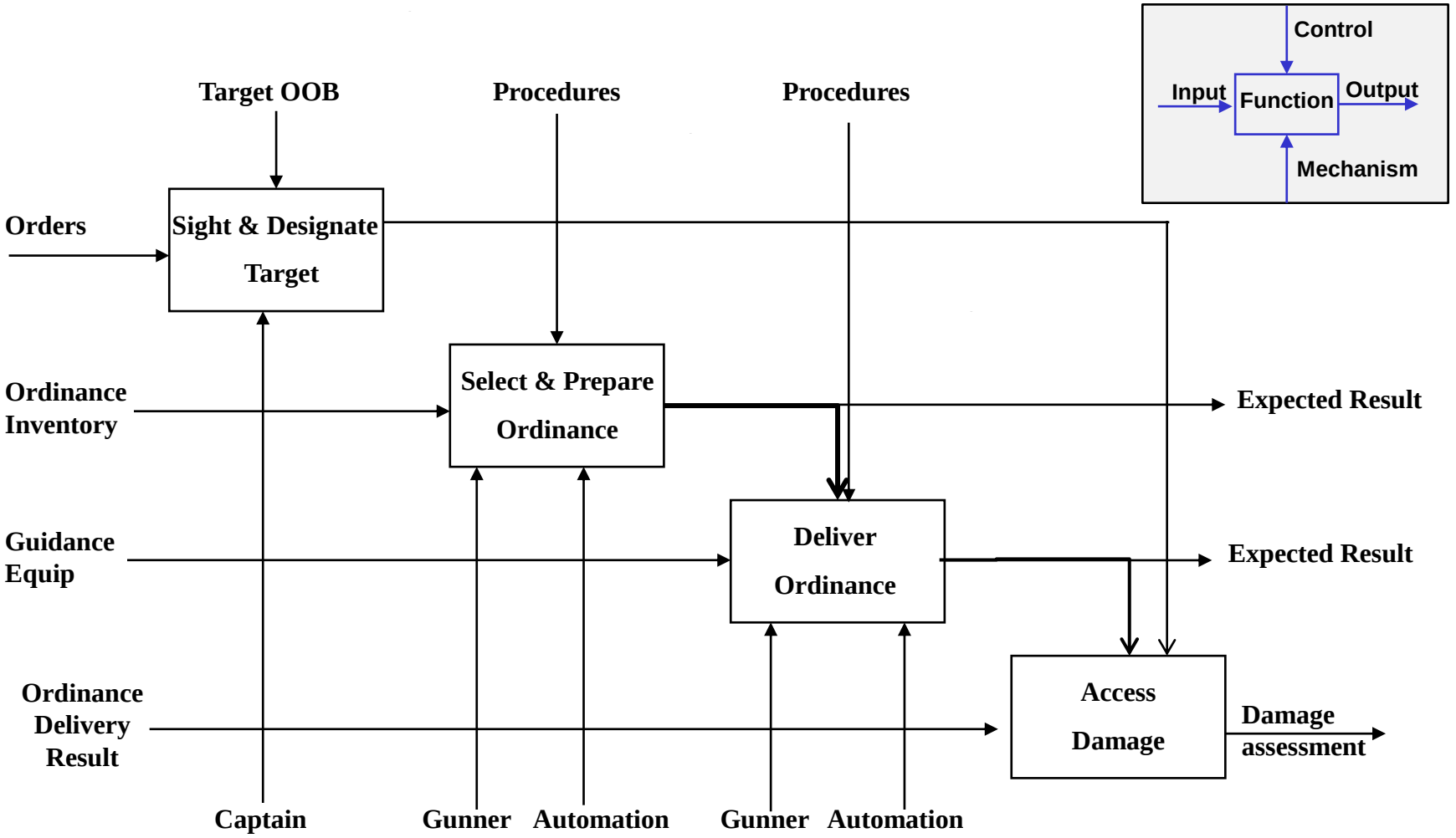
Post-conditions	Describes general characteristics for the state of the system after execution of the Function. This may include a description of the accomplished success scenario / criteria.
Additional / Interface Requirements	List special requirements from other documents / sources which are relevant for the current Function. Normally non-functional or other general requirements should be placed in another document, which is general for all Functions.
Notes & Outstanding Issues	Include notes of caution or functional definition / specification of issues, which are not resolved at the time the Function was written. It may identify who is most suitable to resolve the issue, and the time frame involved.
Improvements	List any additional improvements for this Function.

Good Uses of Functional Decomposition (FD)

		Level 1	Level 2	Level 3	Description
1.0	Conduct Operations				
2.0	Function # 2				
3.0	Function # 3				
3.1		Sustain Personnel			Sustain personnel from all organizations, NGO's, contractors, refugees, detainees
3.1.1			Provide Sustenance		
3.1.1.1				Provide Food	
3.1.1.2				Provide Water	
3.1.2			Provide Field Services		Personal health and hygiene
3.1.2.1				Provide Means to Maintain Personal Hygiene	
3.1.2.2				Provide Means to Clean Clothes	
3.1.2.3				Provide Latrine	
3.1.2.4				Repair Clothing	
3.1.3			Provide Medical & Health Services		
3.1.3.1				Provide Medical Treatment	Includes mental health
3.1.3.2				Monitor Water Quality	Water quality testing to ensure safe water supplies are present throughout the base. NOTE: Interface point with “Function ABC".

Functional Decomposition Matrix

Good Uses of Functional Decomposition (FD)



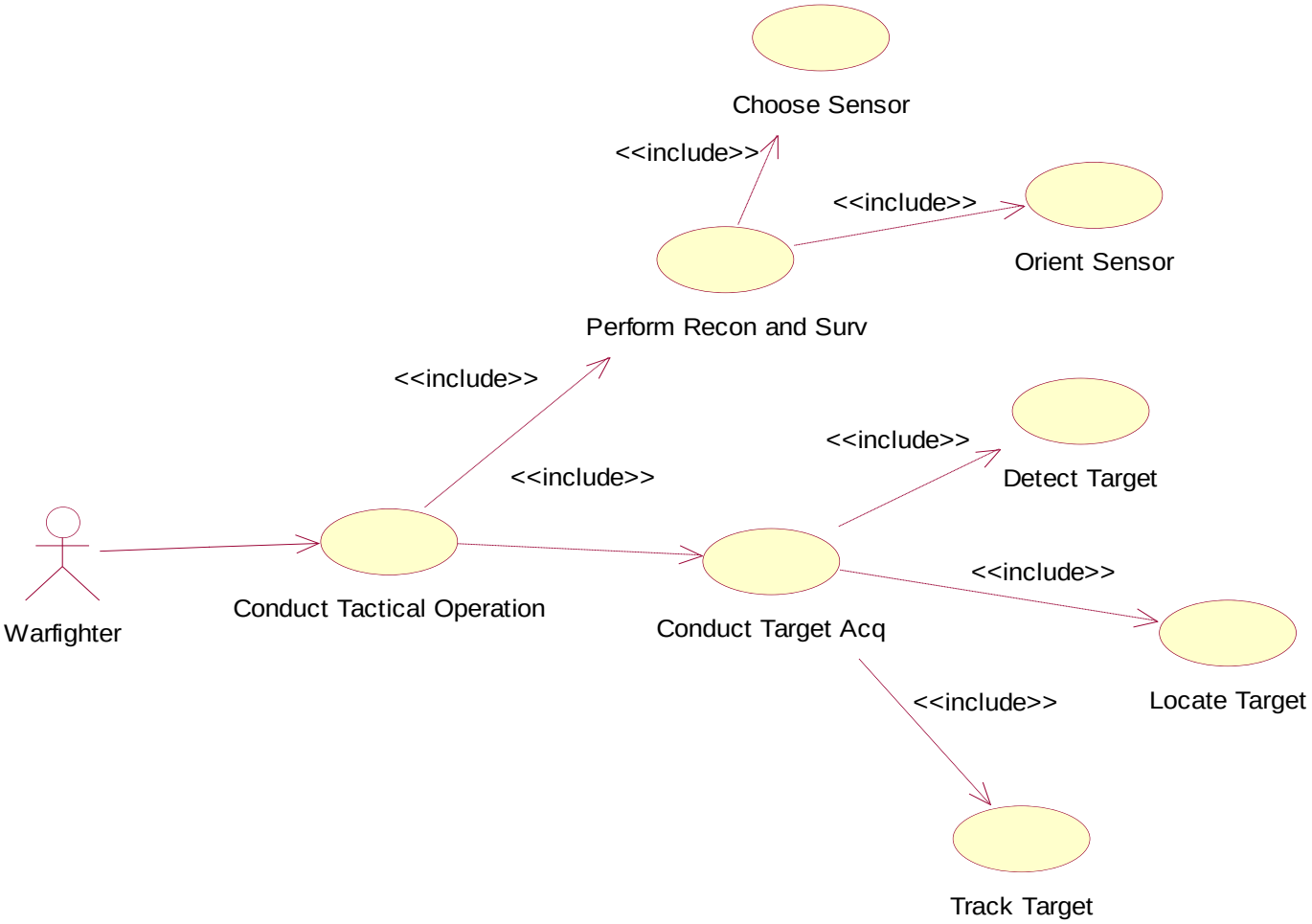
Functional logical analysis

Good Uses of Functional Decomposition (FD)

FD in support of functional behavior definition

- An airplane and a land vehicle behave differently in converting power to motion
- Functional behavior is directly related to product structure
- FD facilitates definition of desired behavior before product-design decision
- FD and logical analysis are leading engineering activities that help define product behavior

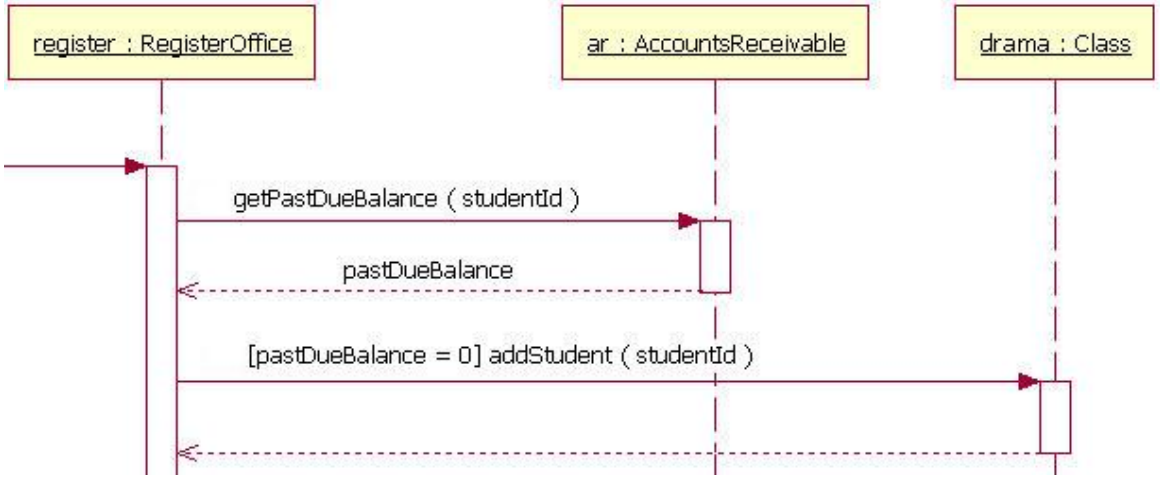
Good Uses of Functional Decomposition (FD)



Functional logical analysis (Use Case)

Good Uses of Functional Decomposition (FD)

Analysis of operational events - Behavioral analysis
Sequence diagram in which the "addStudent" message has a guard



UML basics: The sequence diagram; Donald Bell, IT IBM Corporation

Functional logical analysis (sequence diagram)
[OV-6c: Event-Trace Description]

Misuses of Functional Decomposition (FD)

Defining a simple hierarchical classification of functions as a complete functional decomposition

- **Void of logical analysis**
- **Unrelated to functional behavior**

Hand-off the product of the hierarchical "functional decomposition" process directly to the design team for design concept formulation

- **Assume that designers can produce solutions by using a functional decomposition process**
- **Assume that FD provides enough information to formulae solutions**

Misuses of Functional Decomposition (FD)

Believe that the functional decomposition (FD) models are complete / valid system models

- Using FD alone as sufficient problem description
- Using FD to specify system performance
- Using FD to allocate components (SW CIs) to functions

Using FD process for unintended purposes

- Directly allocate tasks to functional teams
- Use FD as principal guide for defining program Work Breakdown Structure
- Use FD as reference frame for assessing system performance and effectiveness
- Perform FD only to comply with deliverables in contract data requirements lists (CDRLs)

Misuses of Functional Decomposition (FD)

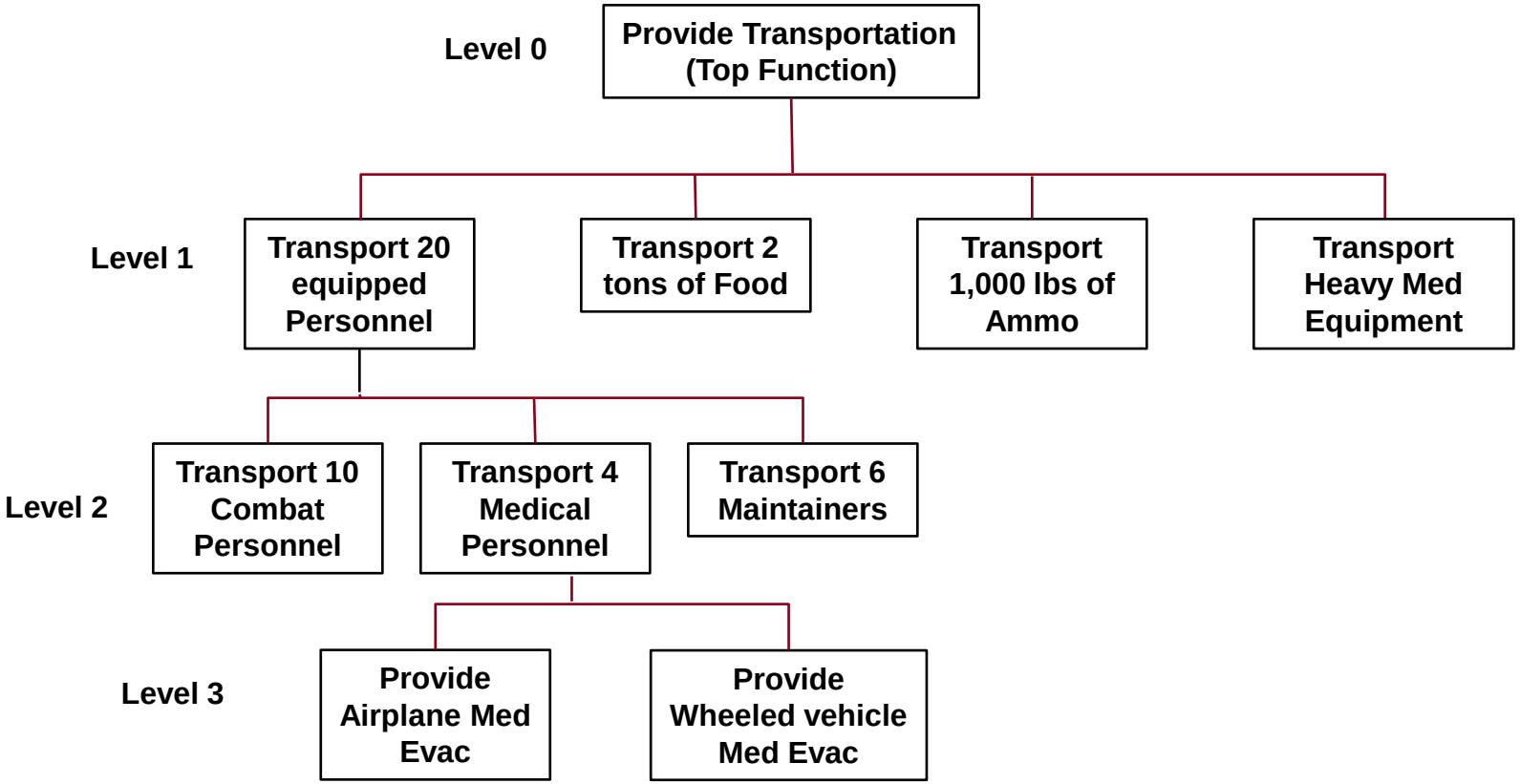
Example:

Building a land vehicle strictly using functional decomposition

- **The functions of Move forward, move reverse, idle, an tow, will each require the following functions:**
  - **Start power generator (ignition switch)**
  - **Generate power (Engine)**
  - **Transfer power (transmission)**
  - **Anchor power pack (chassis holding power-pack)**
- **As a result, we would specify four ignition switches, four power generators (engines), four transmissions, and four chassis to anchor components for each "function"**

- **Avoid the misuse:**
  - **After functional decomposition / analysis tasks**
    - **perform functional synthesis tasks to associate common components**
    - **Associate common functional elements in a common functional model**
    - **Generate a single component set model supporting multiple functions**

Misuses of Functional Decomposition (FD)



FD is an effective tool/method for systems requirements analysis, but not for specifying system performance and / or physical / component design decision

Insights/Conclusions

- **Defining subsystems by using FD can lead to poor architectural concepts**
- **FD alone cannot be used to determine whether the subsystems will provide common functionalities that could be used across many requirements.**
- **Using functional decomposition /allocation to create architecture, can produce subsystems with duplicate functionality**
- **Designing subsystems with duplicate functionalities will create unnecessarily large and complex systems**

Insights/Conclusions

- **The logical functional decomposition enables**
  - **Realization that multiple system functions/requirements can be met by each component or subsystem**
  - **Formulation of alternate functional concepts; e.g. utilizing subsystems interactions to meet several system requirements**

- **Subsystems should, ideally, provide services in a "one-to-many, many-to-one" relationship:**
  - **One system requirement can be decompose into many subsystem requirements**
  - **One subsystem requirement may be derived from many system requirements**
  - **The approach to subsystems service definition is a form of functional decomposition (determining subsystems first, and then deriving their requirements)**

Questions and Answers

QUESTIONS ???