"Systems Architecting and Engineering processes and methodologies: essential enablers for the acceptance of SDR into "the mainstream."

Jim Rodenkirch, Senior Technical Advisor to Diversified Technology, Inc.
Bill Bolick; Federal Programs Manager, Diversified Technology, Inc.

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Our presentation is on the Cognitive Radio piece of the SDR Forum's foci:

• Capability Based Assessments and Activity Based Modeling for Cognitive Radio

• Their relationship to Complex Systems

- The system
- The users
- The builders

• Complex System Architecting utilizing the Department of Defense Architecture Framework (DoDAF)

• The "glue" that holds it all together

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The DoD Dictionary of Military Terms [DoD JP 1-02, 2001] defines a capability as "the ability to execute a specified course of action." **

Drop bomb on target
Fight a fire
Respond successfully to an emergency with full-up local, state and federal agency involvement

A capability can be defined by one or more sequences of activities, referred to as operational threads or scenarios.

A capability may be further described in terms of the attributes required to accomplish the set of activities (such as the sequence and timing of operational activities or materiel that enable the capability) in order to achieve a given capability or mission objecti

Capability-related attributes may be associated with specific activities or with the information flow between activities, or both.

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With Capabilities defined and articulated one can accomplish Capability Based Assessments (CBA)

An orderly approach - referred to as an Activity Based Methodology - is:

Define the Capability (e.g., “Drop a bomb on target” requires Planning, Detecting, Communicating, etc.)

Define the user (e.g., War Fighter , First Responder) activities required to execute that Capability

Define the System Functions required for the War Fighter to complete his/her activities

Identify the Systems that provide those needed functions

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The main “take aways” from the previous slides are:

Capabilities = Missions

War fighters and First Responders (the users of systems) complete or “do” missions

Capabilities set the stage for identifying user activities and the attributes associated with tl

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The context in which to “take” our paper and presentation is, always, based on

Systems Thinking

So, what’s the “system(s)” we’re talking about here??

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Here are two systems

Are they complex? Certainly.

Are they complex systems?

Depends on the context in which one is asked or asks the question

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Complex System characteristics for Capability Based Assessments or Planning:

The component systems are/were chosen from a “buffet” of choices commonly referred to as a Family of Systems (FoS)

The Families of Systems were designed and acquired separately and maintain a continuing operational, yet independent existence

A complex system does not appear fully formed – its development and existence is evolutionary with functions and purposes added, removed, and modified as new capabilities, or missions are identified - **and it needs to be continually assessed or planned for**

It performs functions (i.e., provides capabilities) that do not reside in any component system or singular participating groups

The loss of any component will significantly degrade the performance or capabilities of the entire system.

It encompasses a wide/large geographic extent as information, **not energy or mass**, is exchanged between component systems

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The “complex system of interest” for our paper centered on:

First Responders and the systems employed

The War Fighter and the systems employed

- Both are complex from a characteristic and attribute perspective (previous slides)

- Are a user/customer base of interest for the SDR Forum and Cognitive Radio development

- Both have legacy system components that are going to be there for some time

- Both have HUGE concerns with interoperability

- Both “systems” require myriad considerations - from a perspective of Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities – in order to b developed and operated efficiently

- Neither can tolerate a low Ps (reliability needs to be high)

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From a capability and planning assessment perspective they're in need of architectural products

One offers an architecting framework that can "work" the Forum

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Clinger-Cohen Act (CCA)- 1996

- CCA : Information Technology Management Reform Act (ITMRA) and the Federal Acquisition Reform Act
- Focuses on the need for Federal Agencies to improve the way they select and manage information technology (IT) resources
- The CCA states "**information technology architecture, with respect to an executive agency, means an integrated framework for evolving or maintaining existing information technology and acquiring new information technology to achieve the agency's strategic goals and information resources management goals**."
- Chief Information Officers are assigned responsibility for "developing, maintaining, and facilitating the implementation of a sound and integrated information technology architecture for the executive agency."

CCA Applies to Every Executive Agency of the Federal Government

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Circular No. A-130 [OMB, 2000]

- OMB provides guidance on the implementation of ITMRA
- Defines an Enterprise **Architecture** as 'the explicit description and documentation of the current and desired relationships among business and management processes and information technology'
  - The Enterprise Architecture includes principles, an Enterprise **Architecture framework**, a **standards** profile, **current and target architectures**, and a **transition strategy to move from the current to target architecture**.
- Directs agencies to create an Enterprise Architecture that should include the following parts
  - Business Processes
  - **Information Flows and Relationships**
  - **Applications**
  - **Data Descriptions and Relationships**
  - **Technology Infrastructure** , Technical Reference Model
  - **Standards** Profile
  - Information Assurance

To acquire budget $$ OMB requires agencies to develop Architectures

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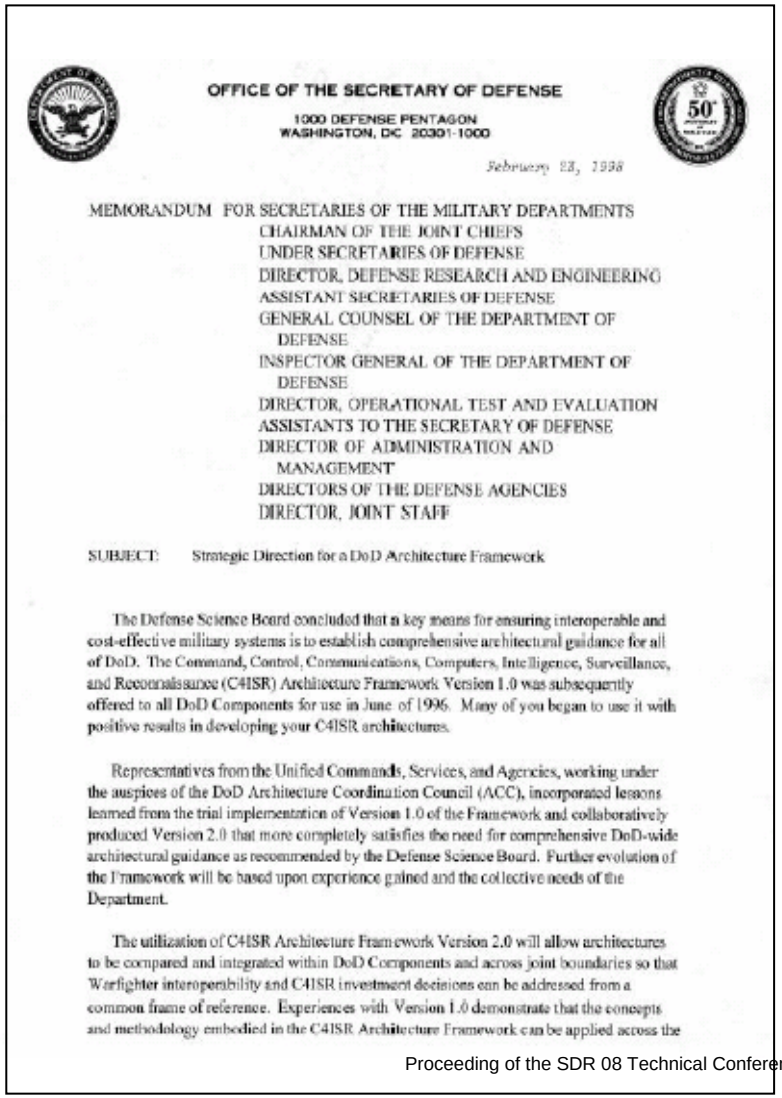
DoD's Response: Architecture Mandate Memo



OFFICE OF THE SECRETARY OF DEFENSE

1000 DEFENSE PENTAGON
WASHINGTON, DC 20301-1000

February 23, 1998

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS
UNDER SECRETARIES OF DEFENSE
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING
ASSISTANT SECRETARIES OF DEFENSE
GENERAL COUNSEL OF THE DEPARTMENT OF DEFENSE
INSPECTOR GENERAL OF THE DEPARTMENT OF DEFENSE
DIRECTOR, OPERATIONAL TEST AND EVALUATION
ASSISTANTS TO THE SECRETARY OF DEFENSE
DIRECTOR OF ADMINISTRATION AND MANAGEMENT
DIRECTORS OF THE DEFENSE AGENCIES
DIRECTOR, JOINT STAFF

SUBJECT: Strategic Direction for a DoD Architecture Framework

The Defense Science Board concluded that a key means for ensuring interoperable and cost-effective military systems is to establish comprehensive architectural guidance for all of DoD. The Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Architecture Framework Version 1.0 was subsequently offered to all DoD Components for use in June of 1996. Many of you began to use it with positive results in developing your C4ISR architectures.

Representatives from the Unified Commands, Services, and Agencies, working under the auspices of the DoD Architecture Coordination Council (ACC), incorporated lessons learned from the trial implementation of Version 1.0 of the Framework and collaboratively produced Version 2.0 that more completely satisfies the need for comprehensive DoD-wide architectural guidance as recommended by the Defense Science Board. Further evolution of the Framework will be based upon experience gained and the collective needs of the Department.

The utilization of C4ISR Architecture Framework Version 2.0 will allow architectures to be compared and integrated within DoD Components and across joint boundaries so that Warfighter interoperability and C4ISR investment decisions can be addressed from a common frame of reference. Experiences with Version 1.0 demonstrate that the concepts and methodology embodied in the C4ISR Architecture Framework can be applied across the

- Issued by the Office of the Secretary of Defense (OSD) 23 Feb 1998
- **Mandates strategic direction for a DOD Architecture Framework**
- Other agencies may employ other frameworks
  - Treasury Enterprise AF (TEAF),
  - etc…
- Many Adjacent DoD Customers use the DoDAF
  - NRO, NSA,…

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So, DoD has been charged to do good architecting

Let’s look at how we could use their architectural framework for the SDR Forum’s goals – promote a methodology or process to identify solutions for the user’s problems.

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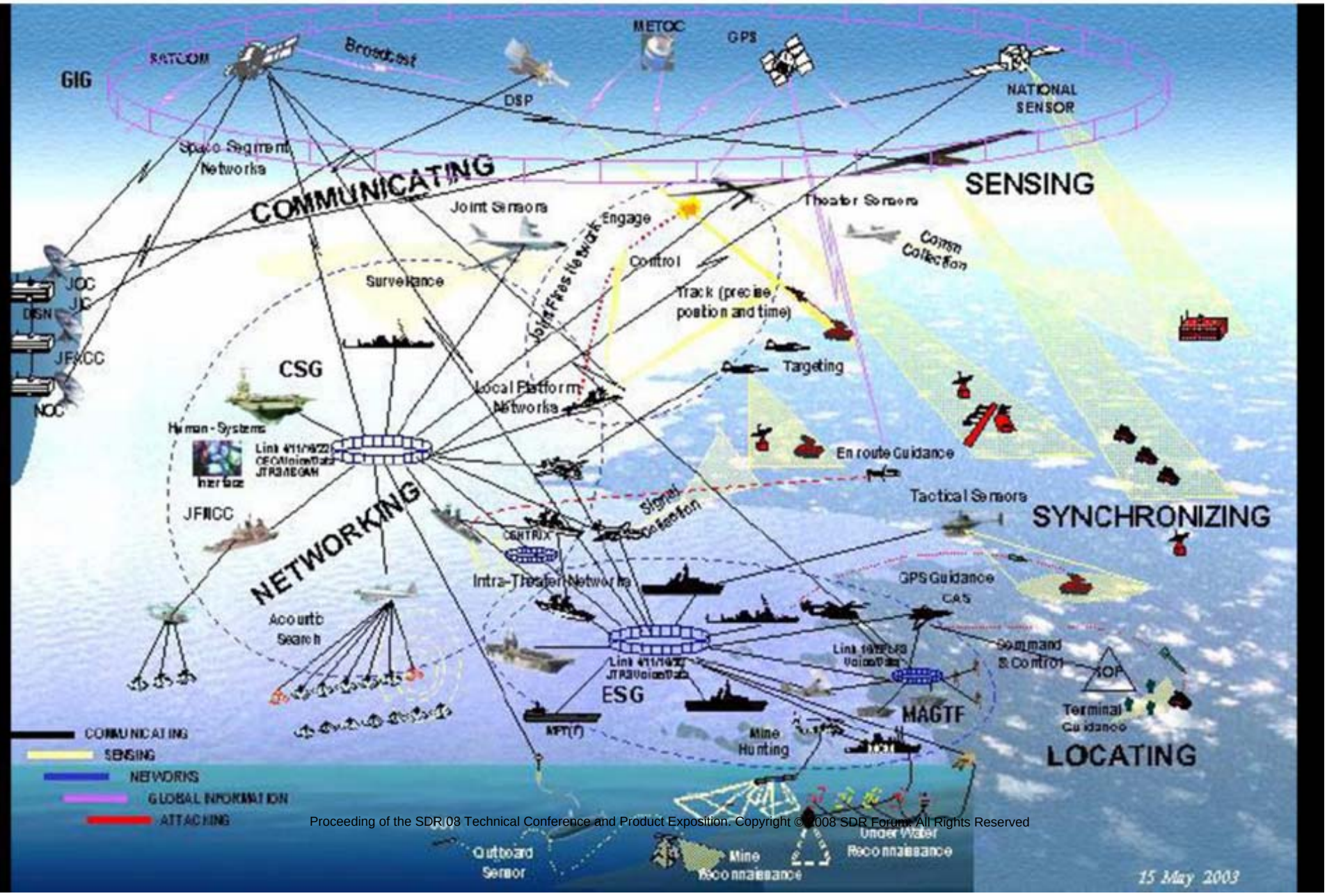
This is a simplified complex system architectural view



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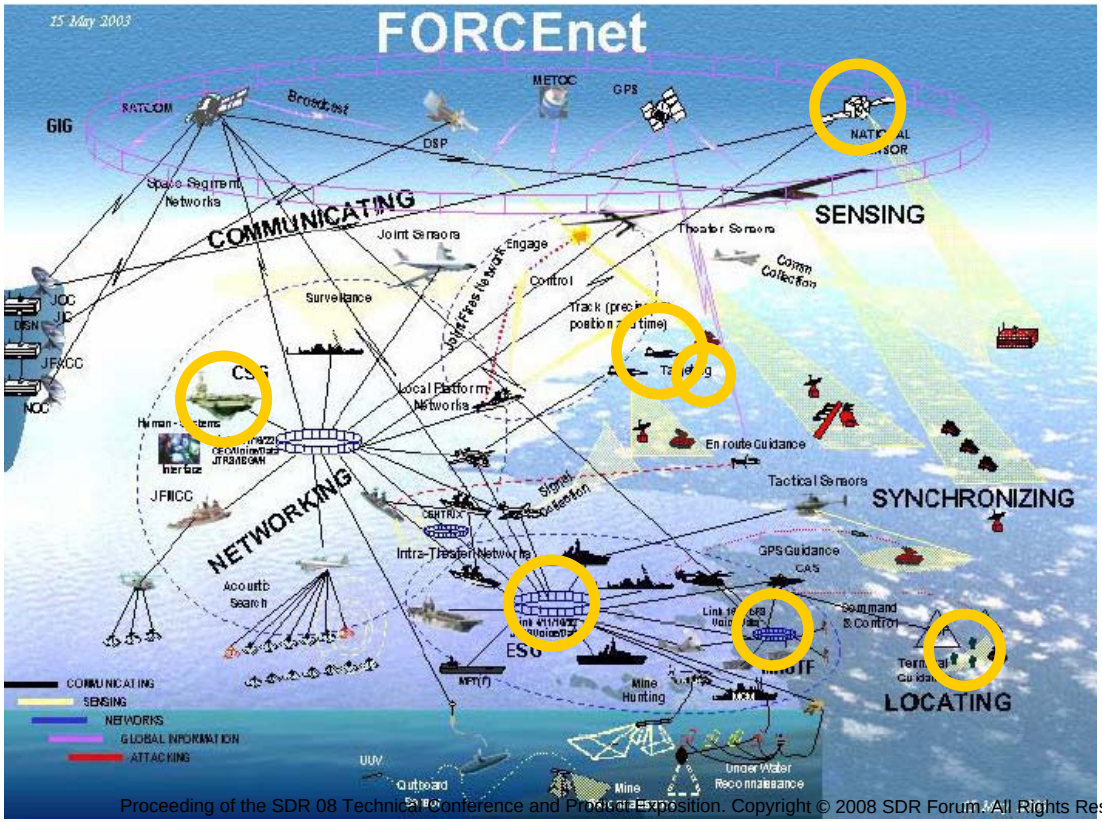
There are LOTS and LOTS of missions and capabilities within this one high level oper
view!

It's so complex that in order to truly evaluate what's going on I've got to select a singl
mission – out of all the missions that are being performed and represented.



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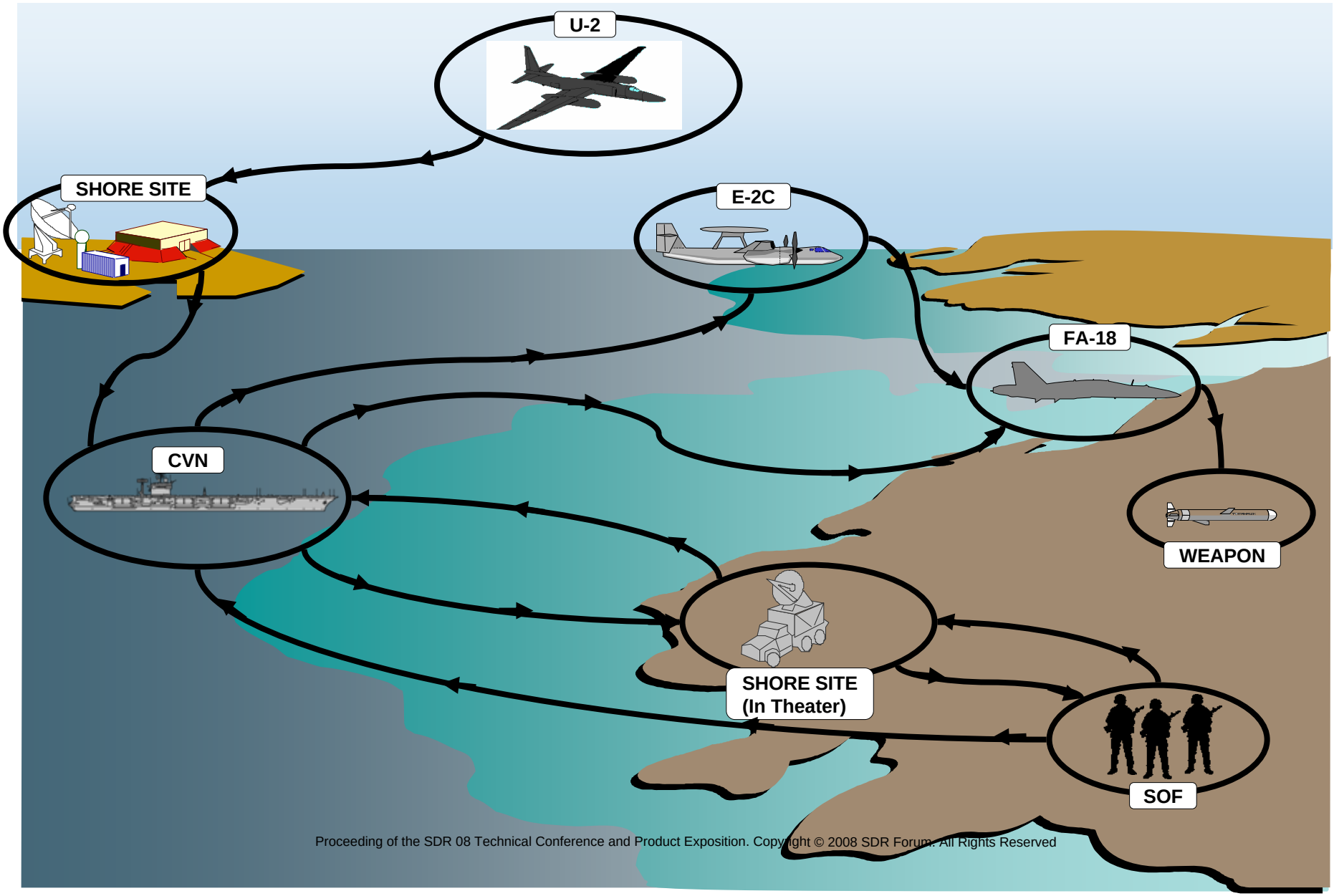
This is a Platform (Nodal) Interface diagram for that single mission or capability



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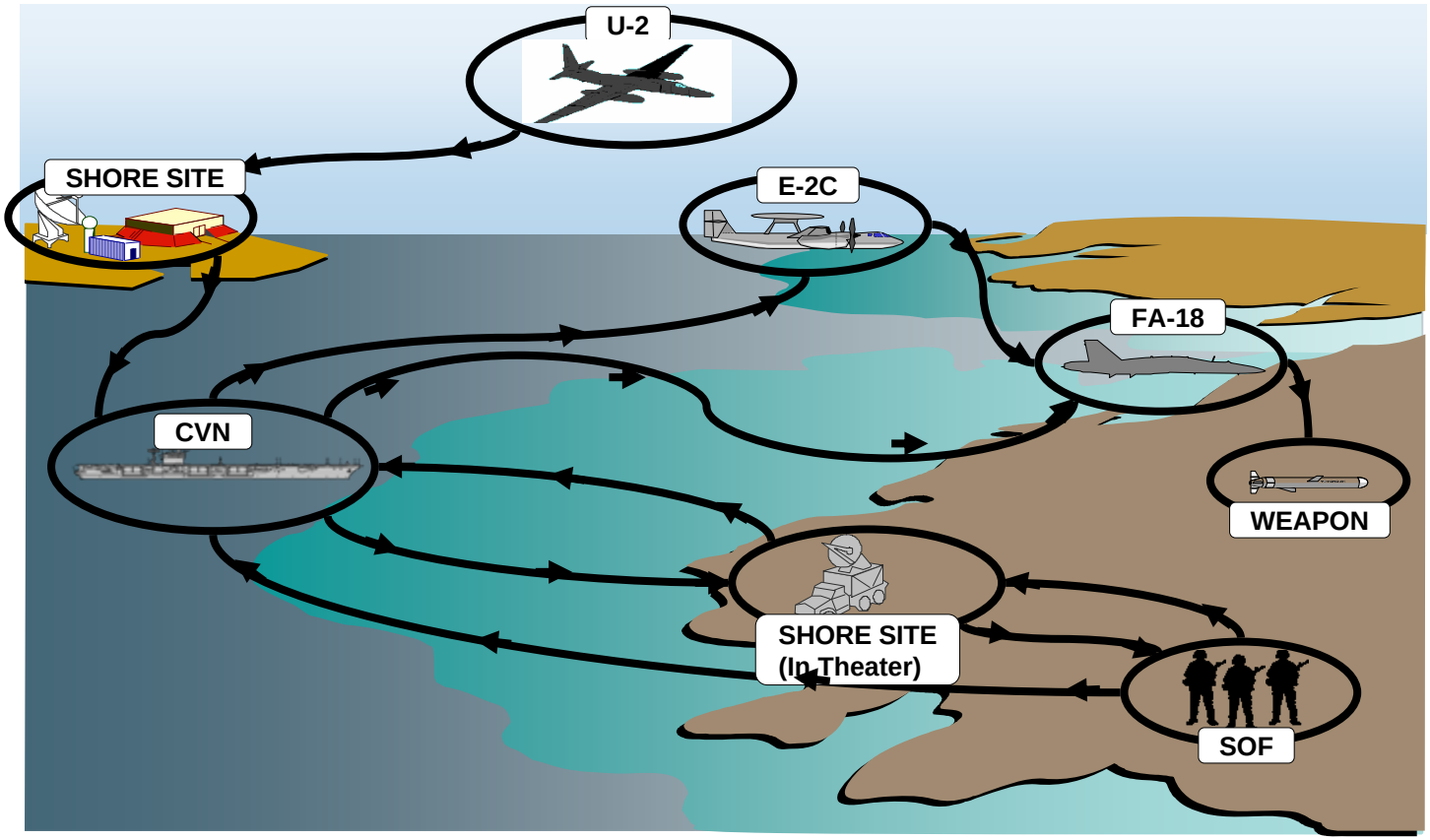

There is a lot going on here: **Intelligence being gathered**, **planning going on**, **detecting going on**, **identification**, **tracking**, **engaging** , **assessing** , **communicating**, there's……

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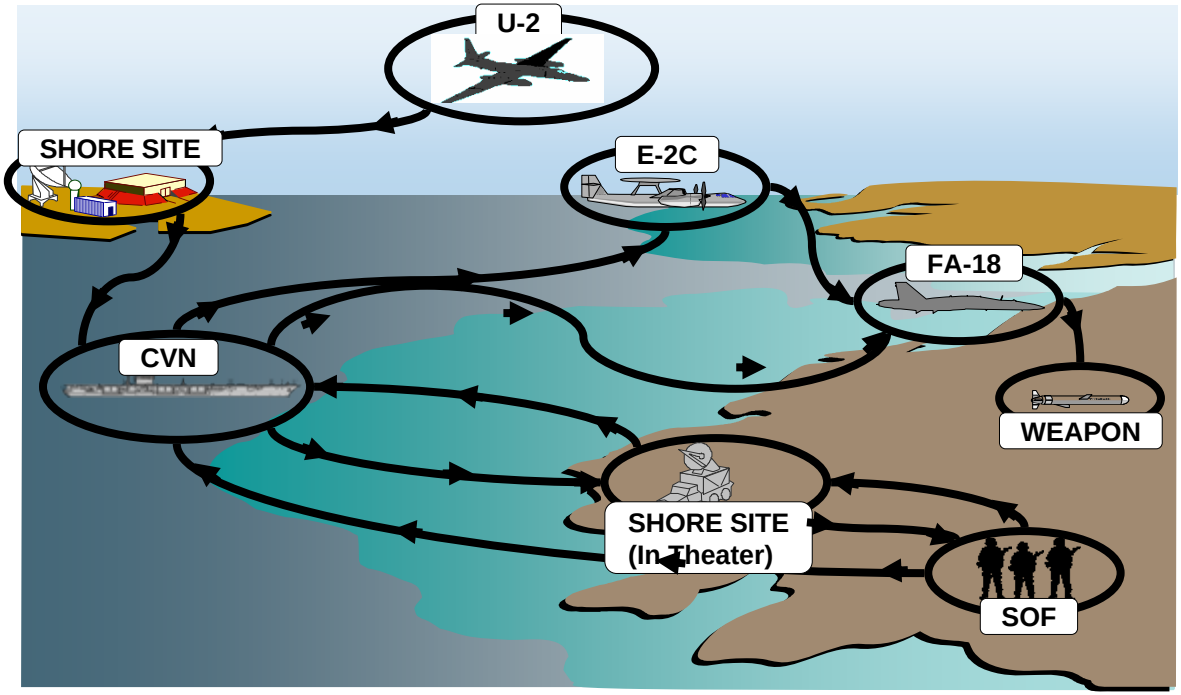
These are called **activities** and activities are verbs



Most importantly come myriad, differing constraints, attributes and characteristics:

Organizational

Political

Societal

Technological

Physics

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Cutting to the chase:

Complex systems have constraints, variables and characteristics unlike those of the Individual systems that comprise them!

Individual systems come from Families of Systems owned and operated, often, by competing agencies with differing political climates and varying cultures.

Within their “families” they work well – one can be removed and the others continue functioning

When inserted into a complex system their constraints, variables and characteristics aren’t necessarily going to “play well” with the other systems

All contribute to a low Ps of interoperability AND Reliability!

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The previous slides are War fighter activity specific but extremely analogous to First Responders

Constraints, variables and characteristics for local PD, local FD, State Police, FBI, etc., are similar and myriad

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What if we could put together a portrayal of how these various entities are connected, how they work together, how they communicate together, how they share information, how the work prior to and after being joined up to accomplish some common mission/goal/objectiv

What if (working off the SDR Forum's Public Safety SIG)

- We constructed a scenario for each mission or capability of interest for First Responders

- We could identify all of those activities (note that those are verbs, things that humans/users, for the most part, do).

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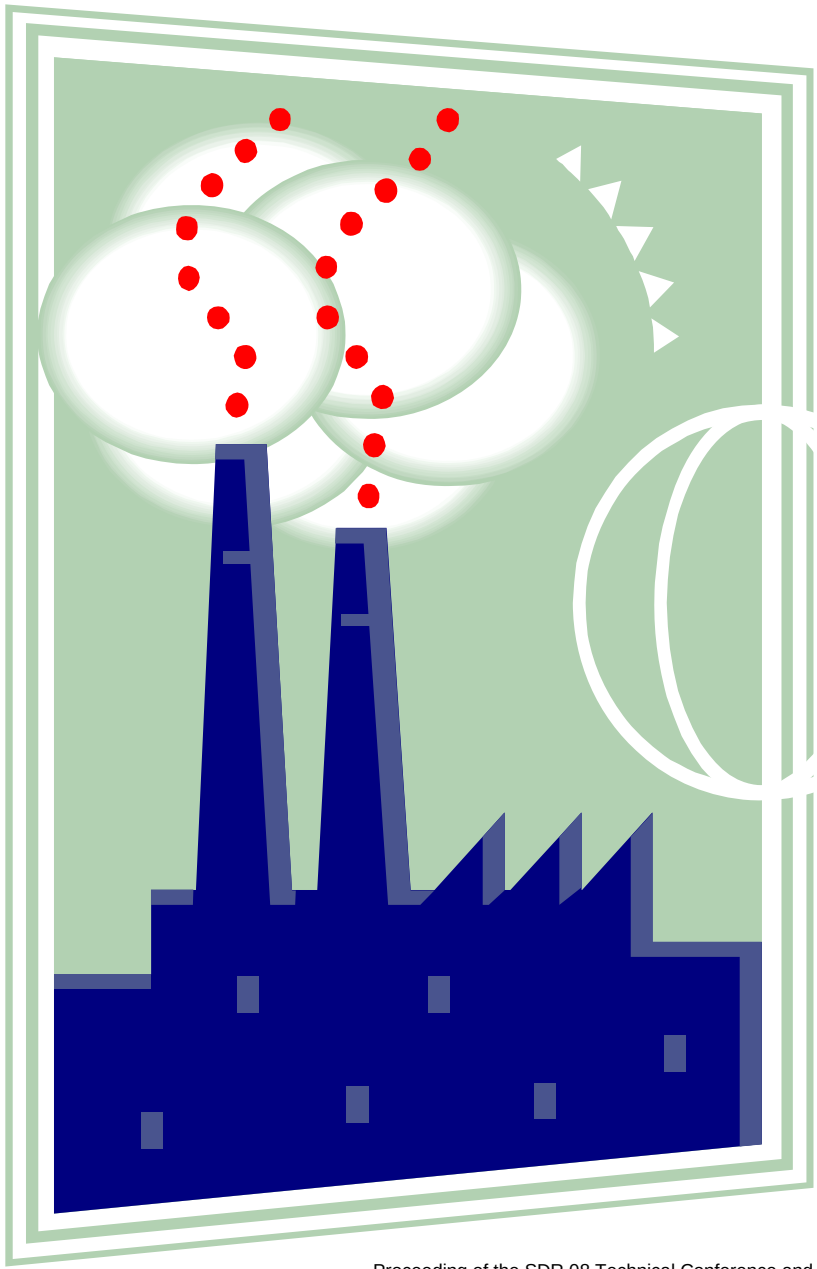

Public Safety SIG foci:

Develop a scenario for a chemical plant explos

Highlight the need for a CR through use cases

Note: an extremely complex system

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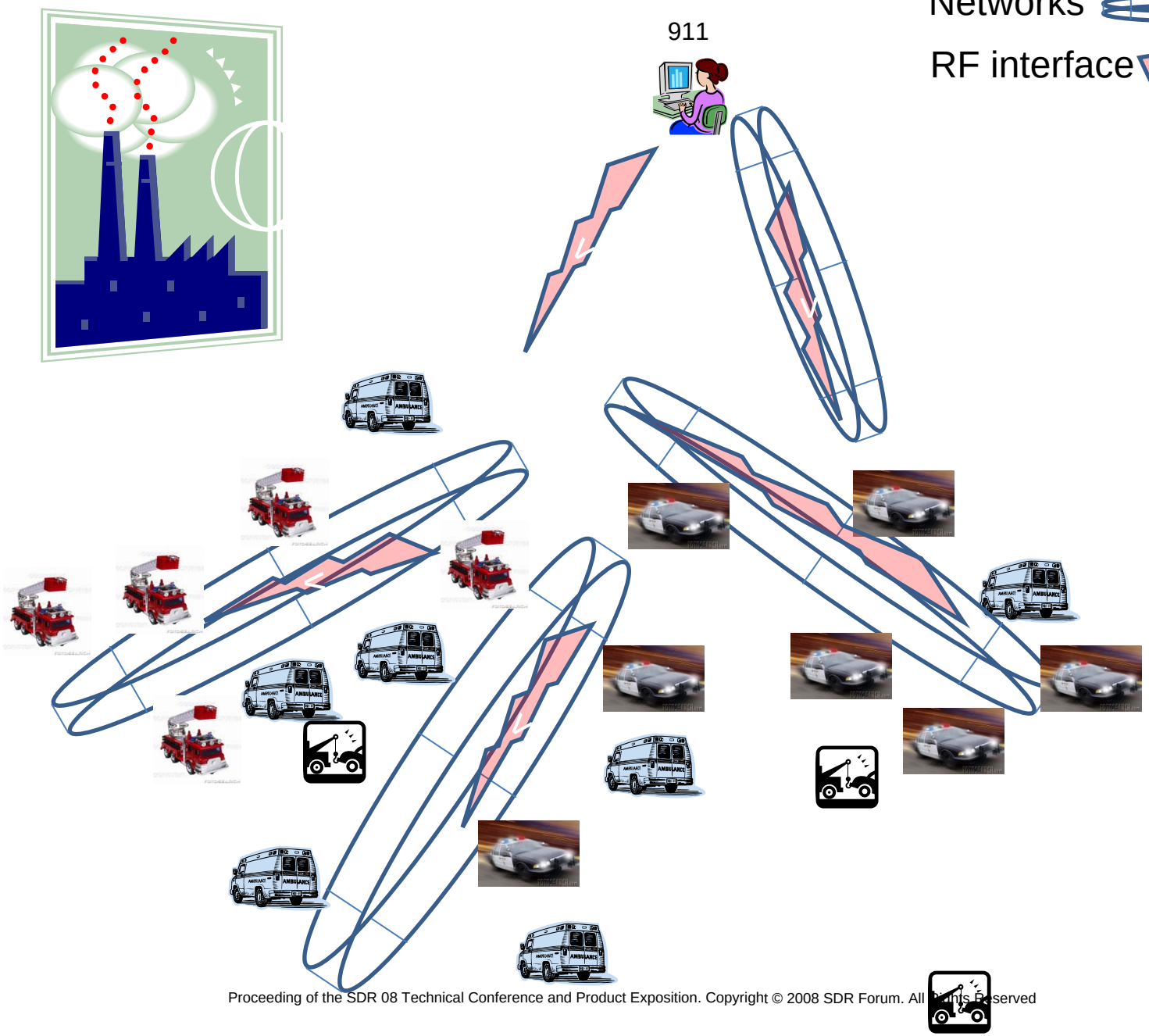

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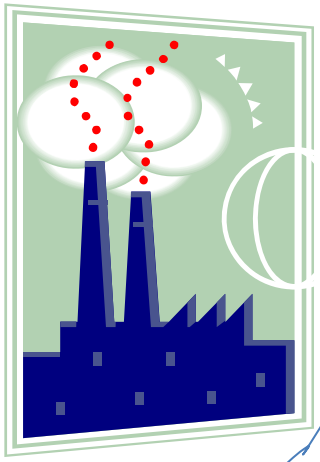

Networks

RF interface

911

State Police

State Police

Interstate

State DOT

State DOT

Ad Hoc Network

FBI

State Police

FBI

FBI

State Police

Hospital

State DOT

Hospital

State Police

State DOT

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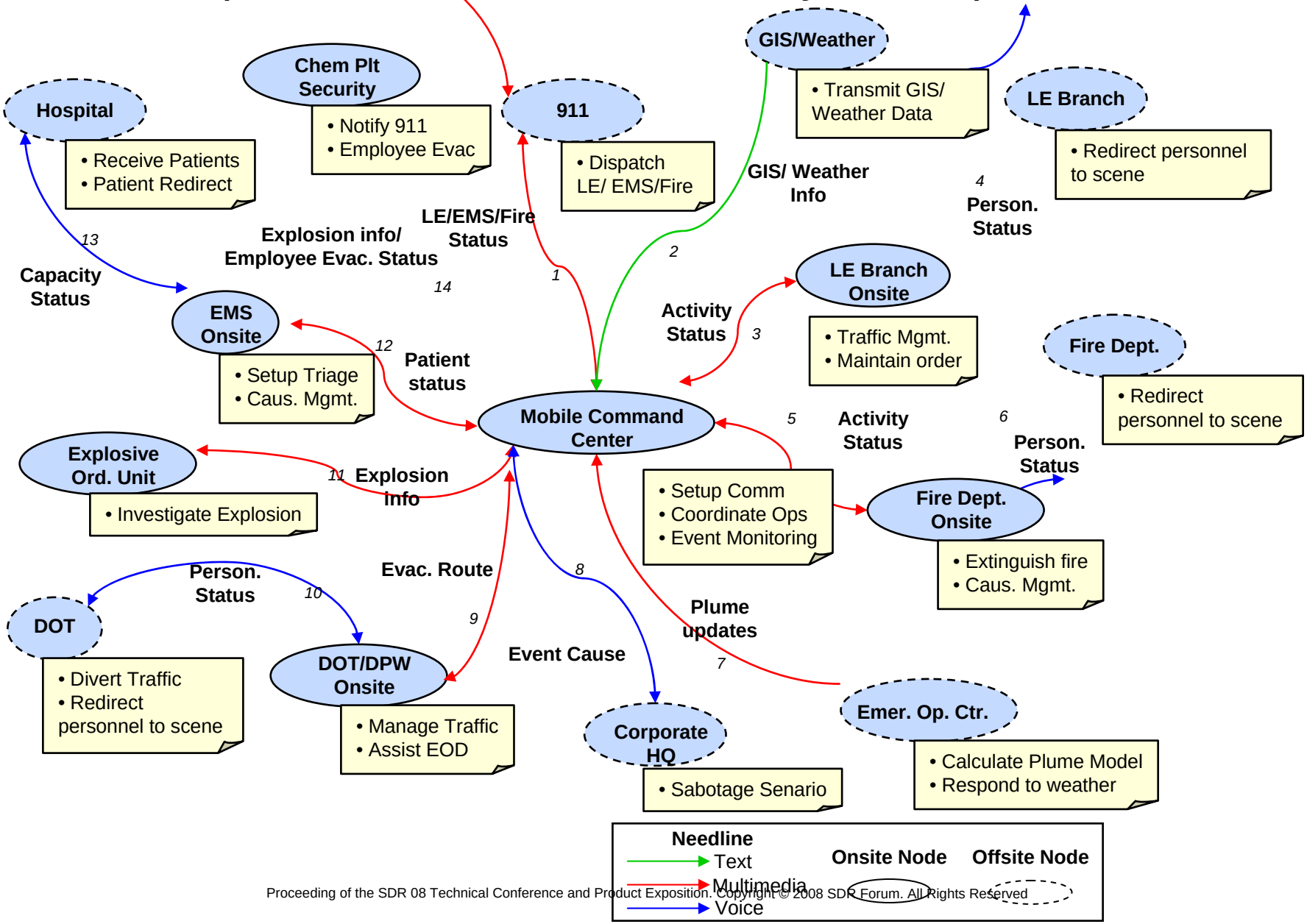
Operational Node Connectivity Description



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What if we then identified and depicted the activities relative to the organization of
this First Responder incident.

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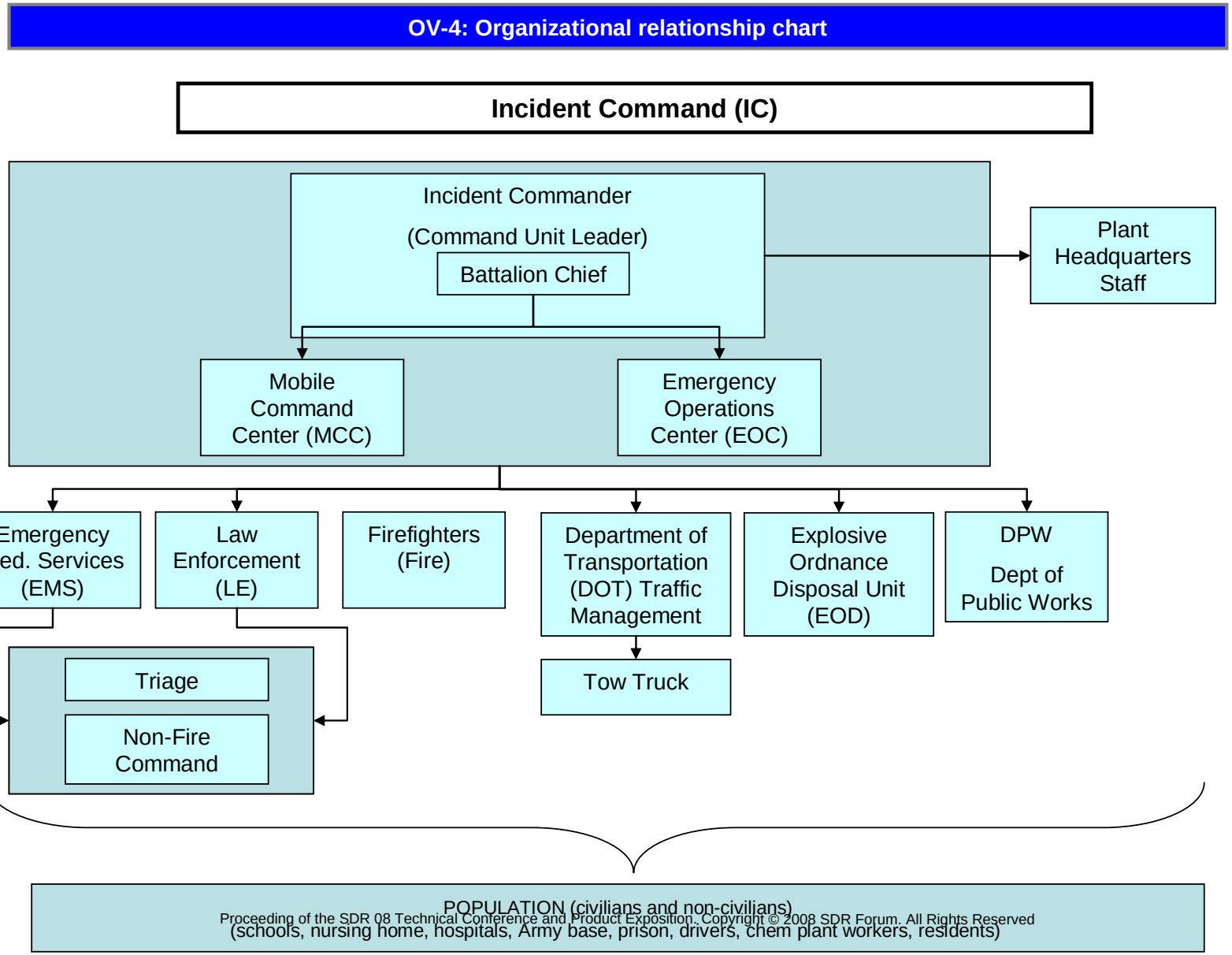
Organizational Relationship Chart



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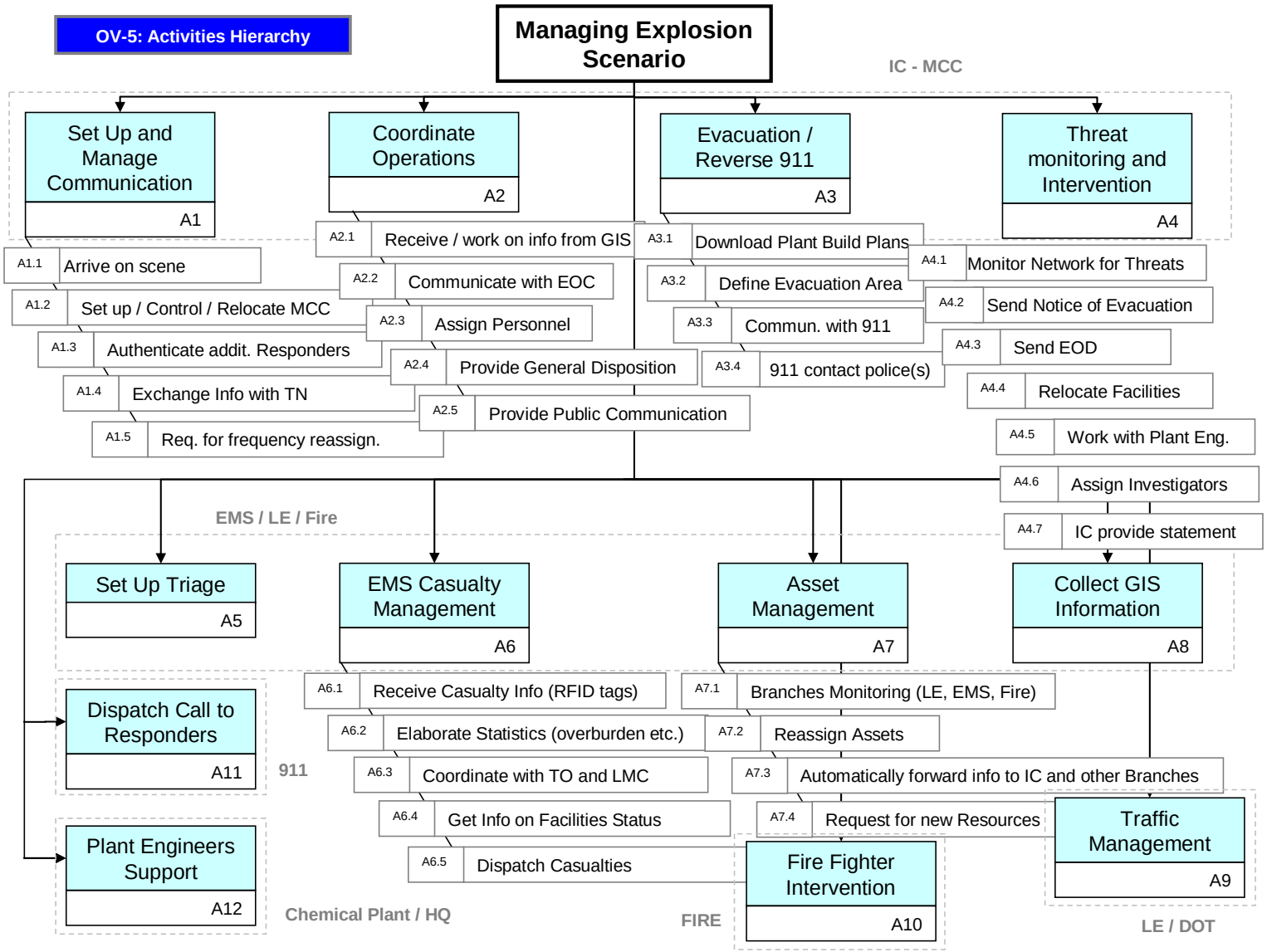
Activities Hierarchy



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What If we:

Identified the system functions the users required in order to accomplish those activities???

We could then map the user activities to the system functions.

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Activities	Functions Transmit and Receive data	Encrypt	Store Data	Retrive Data	Provide office automation	Gather weather information	identify stored chemicals
Plan							
Pass Video							
Pass Data							
Voice Communications							
Organize							
Engage							
Decide							

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We then identify the systems, available to the user today, and their functions

	System A	System B	System C	Sys D	Sys E	Sys F
Xmt/Rcv	x	x				x
Encrypt	x	x	x			
Store Data				x		
Retrieve Data				x	x	x
Automate						
Gather WX Data			x			x
Report on Stored Chemicals			x			x

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We could then assess those systems based on:

- What system functions are available to the user today for the activities the user has to perform

- What system functions would help the user perform his/her activities OR perform them better

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The result:

- System functions that the user/customer needs but doesn't have that he/she requires to accomplish the activities needed to complete the mission!

This is called a Static Assessment of our capability or mission

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	Functions						
Activities	Transmit and Receive data	Encrypt	Store Data	Retrive Data	Provide office automation	Gather weather information	identify stored chemicals
Plan			X	X			
Pass Video	X						
Pass Data	X						
Voice Communications	X	X					
Organize					******		
Engage							X
Decide						X	

Houston, we have a problem! We have a gap and the capability can not be met because the user can't complete the activity he/she needs to "do"

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Another benefit of activity to function assessments:

- you can discover systems offering the same functions

- can lead to an analysis that may answer the question

  “just why are we buying these three radios from three different manufacturing companies that all do exactly the same thing but cost us beaucoup dollars with the three incompatible life cycle support methodologies??????????”

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Then:

What if (with the correct architectural products developed):

We identified the new system(s) that were needed to overcome that gap

We then could produce a new architectural model with those systems

We then produce architectural products that portrays the sequence of events – along with timing and system interface exchange requirements, attributes and constraints - for the systems used by the user

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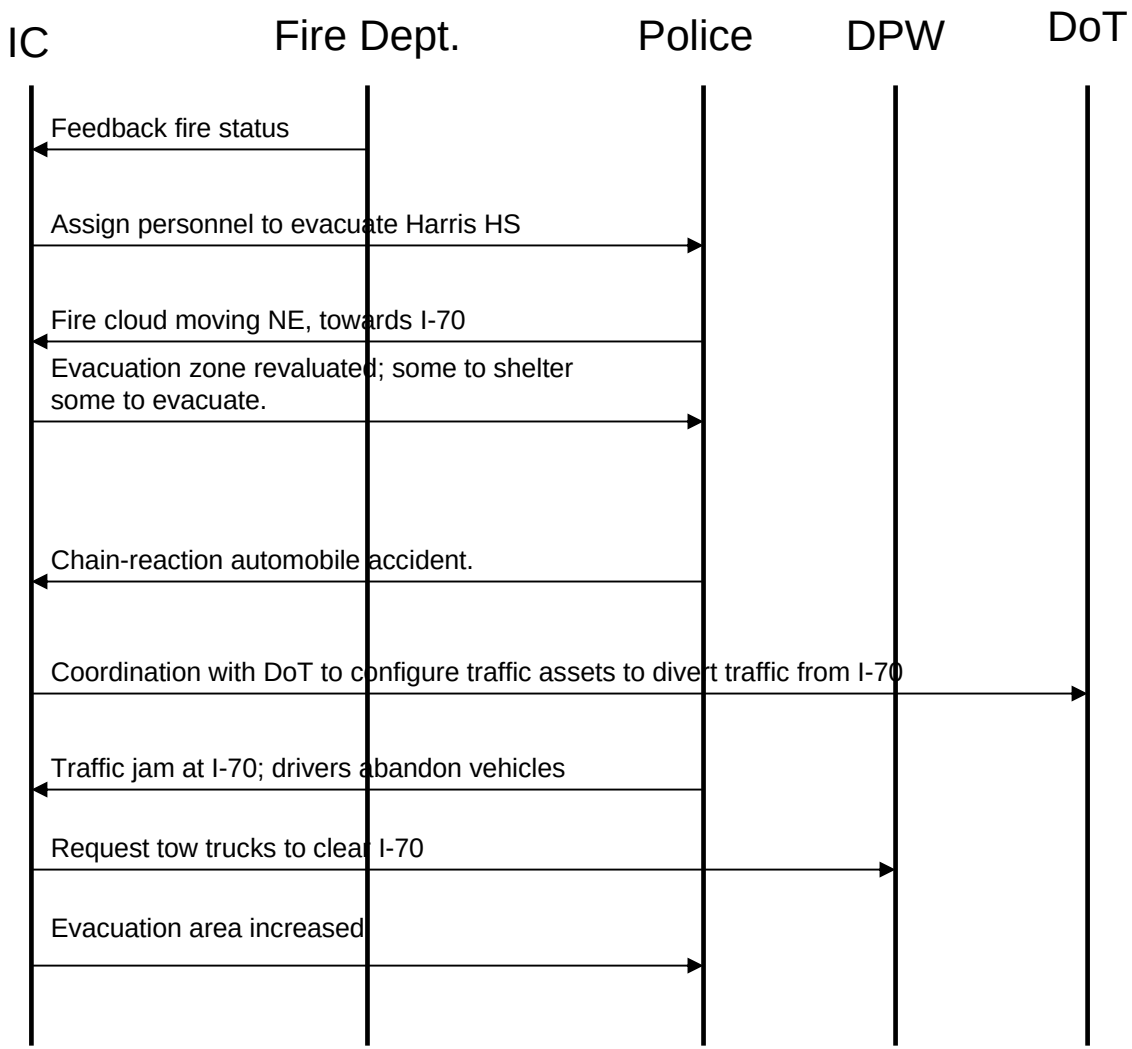
Operational Event-Trace Description

- Coordination for evacuation activity



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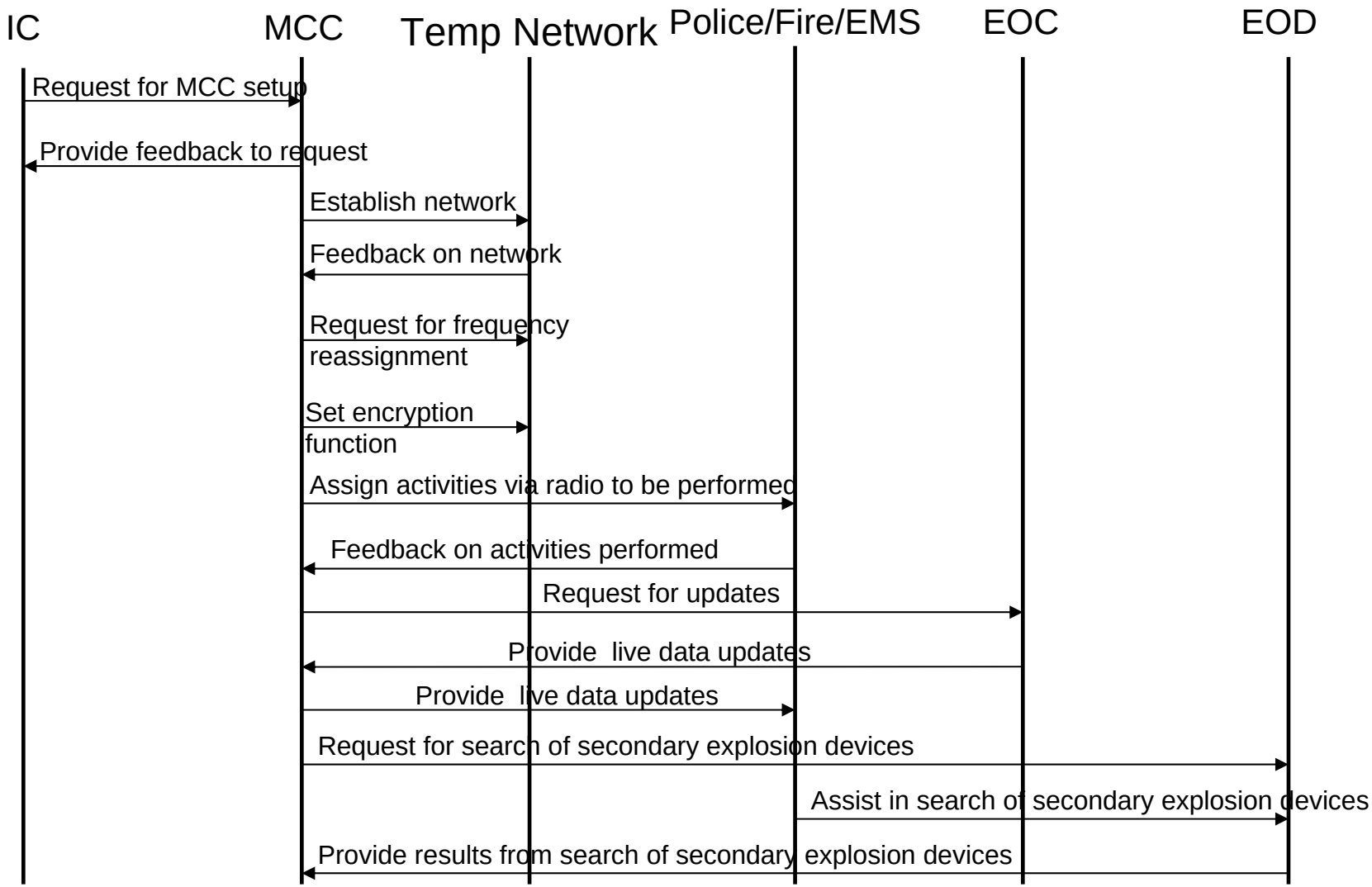
Operational Event-Trace Description

- Event-trace following 911 dispatch



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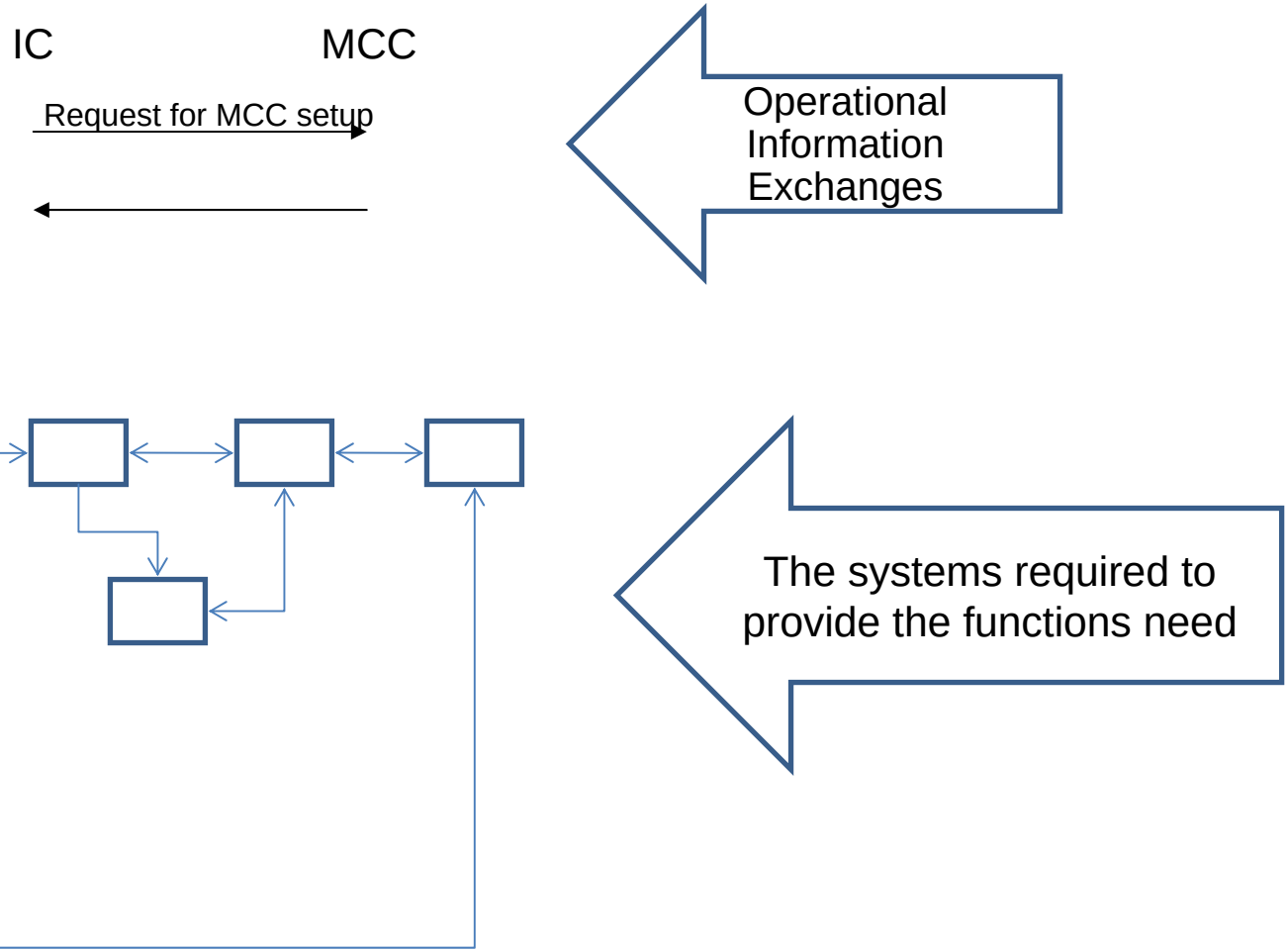

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Finally, hand those operational and system views over to a M&S group and ask them to model and simulate our new “to be” architecture.

The result – measurements of Effectiveness and Performance that verify and validate the impact of the new system(s) on the overall complex system!

In short we now have proof the new system(s) are worth moving forward on developing and purchasing.

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The previous – from Static to the M&S effort - is called a Dynamic Assessment of the capability or mission area.

The two assessments, conducted with the “correct,” validated and vetted architectural products are what makes up a Capability Based Assessment or Planning effort.

“correct” and validated – achieved via a cohesive group of system architects and engineers

Vetted – achieved through a cohesive group of system architects, engineers AND users!

Without user participation you have no buy-in that your scenarios, timing, sequence of events and activities are worth a hoot!

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Without that you can’t sell product one to the user/customer!

Finally ---------- we produce two roadmaps:

- IF the new system or solution requires new technology we can display the
  timeline of that technology's arrival

- A timeline for when the solution's functions will be available to the user

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Caution: architectural products and assessments MUST account for more than the “M”ateriel solution – what’s referred to as the technical side of the solution

The range of architectural products that deal with the Operational side of the capabilit opens up assessment opportunities for:

“D”octrine

“O”rganization

“T”raining

“M”ateriel

“L”eadership

“P”ersonnel

“F”acilities

The total of all assessment opportunities is referred to as DOTMLPF “The Total Solution Set”

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D O T M L P F

Sums up Human Systems Integration, Systems Integration, Human Factors Engineering, and Intelligent Enterprises

Architectural products set the stage for static and dynamic assessments of the complex system (in which the user operates or functions in)

Consult the user on the makeup (characteristics, attributes, timing of events, the correct activities accomplished by the correct users, etc.)

Show the user – the First Responders, the War fighters - how, with the use of architectural products that he/she was engaged in the development of, changes in doctrine, organization, facilities AND a materiel change – e.g., the addition of a Cognitive Radio – can make their working live more better.

The result – you have influenced the decision process in a positive manner because
the user and customer were brought into your methodology and process for determining, empirically that a Cognitive Radio can provide them with needed functions

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It's Miller Time!!!

Summary – up to the “glue” part

Architectural products set the stage for static and dynamic assessments of the complex system (in which the user operates or functions in)

The user is consulted on the makeup (characteristics, attributes, timing of events, the correct activities accomplished by the correct users, etc.)

The results show the user how, with the use of architectural products that he/she was engaged in the development of, changes in doctrine, organization, facilities AND a materiel change – e.g., the addition of a Cognitive Radio – can make their working live more better.

The result – you have influenced the decision process in a positive manner because
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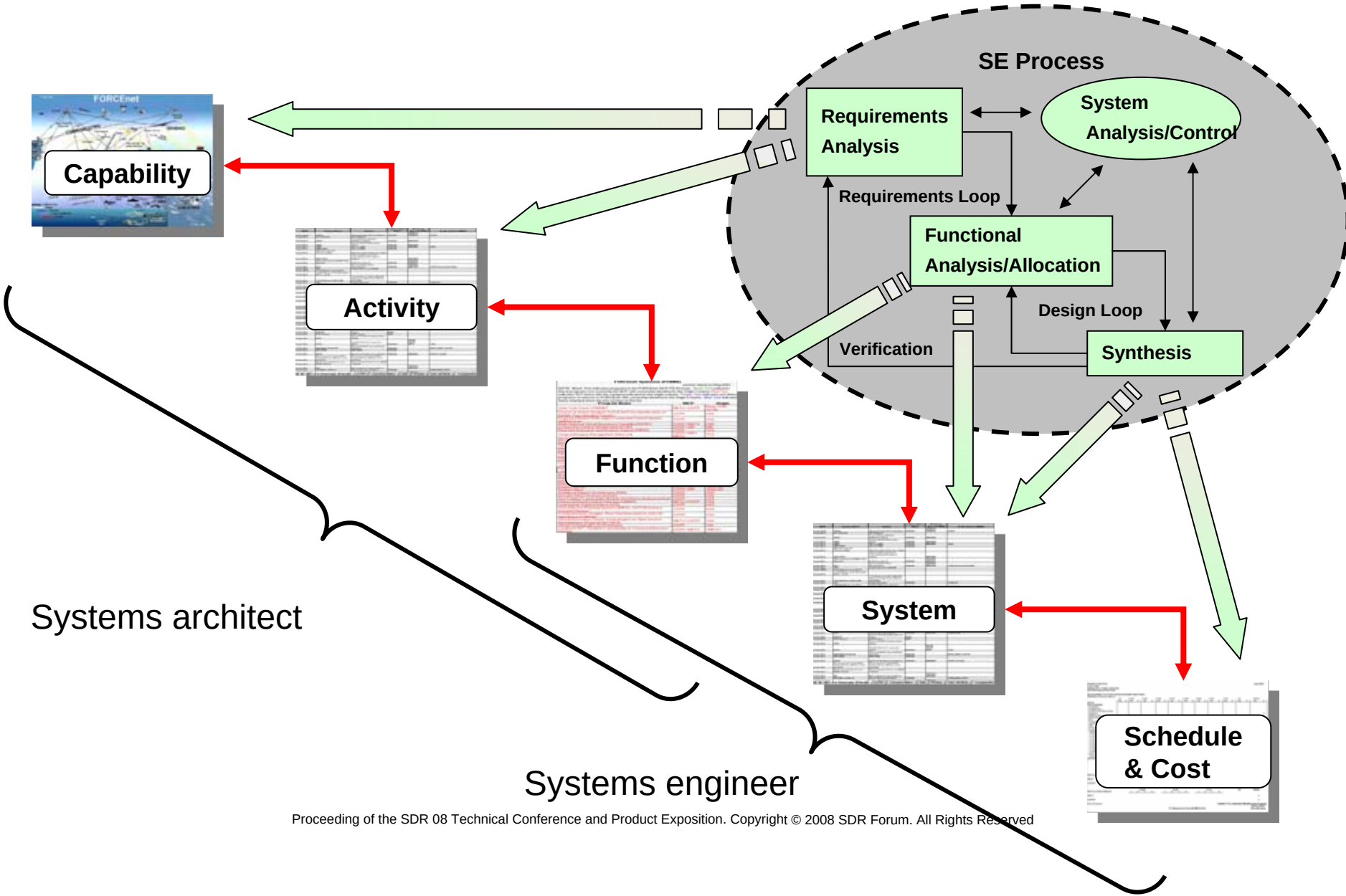
It’s Miller Time!!!

Realm of the Architect and Systems Engineer



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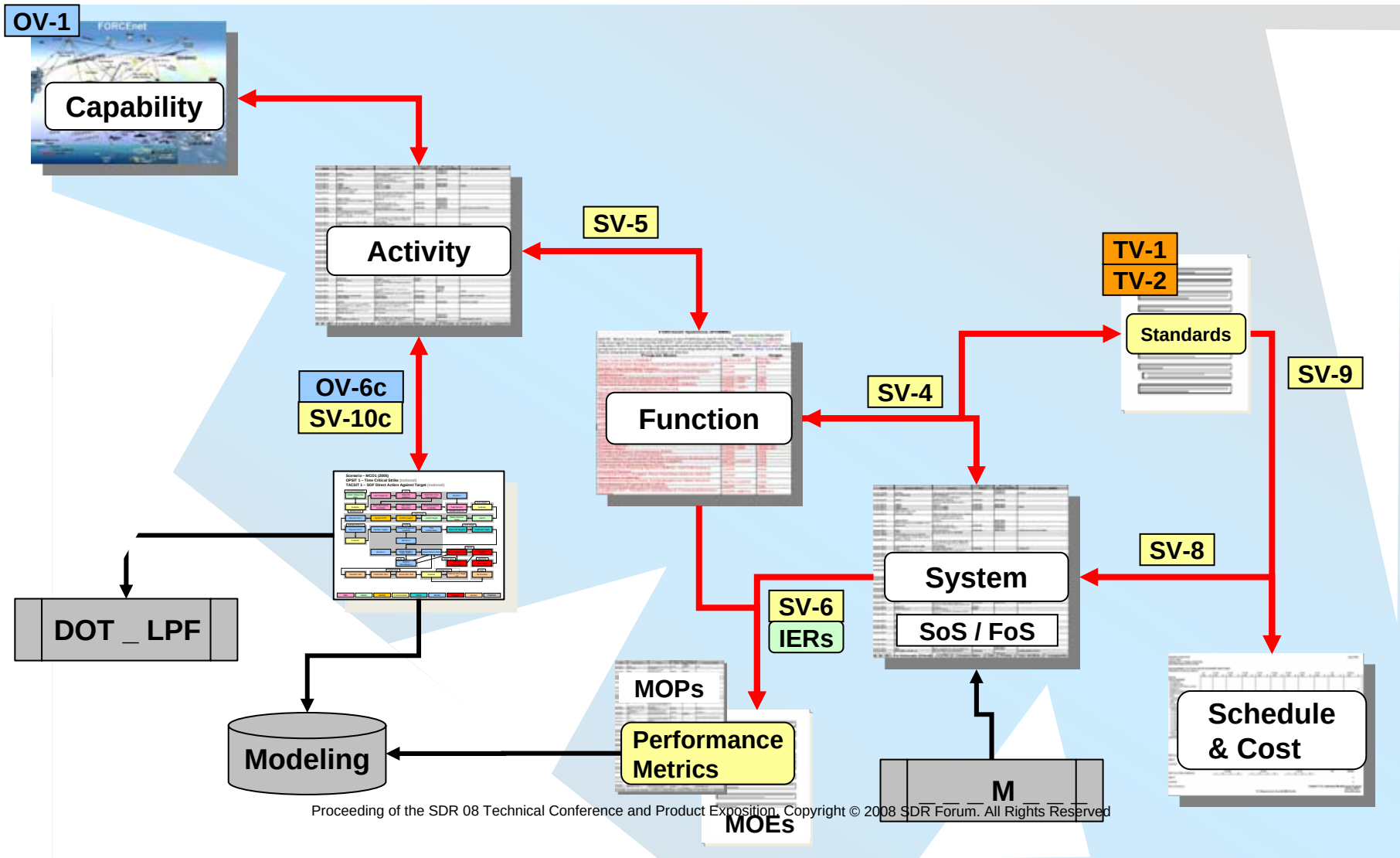
Ovs, SVs and TVs are the acronyms for Operational, System and Technical Views associ
with the Department of Defense Architecture Framework (DoDAF).

Ministry of Defense Architecture Framework (MoDAF) views add business and acquisition



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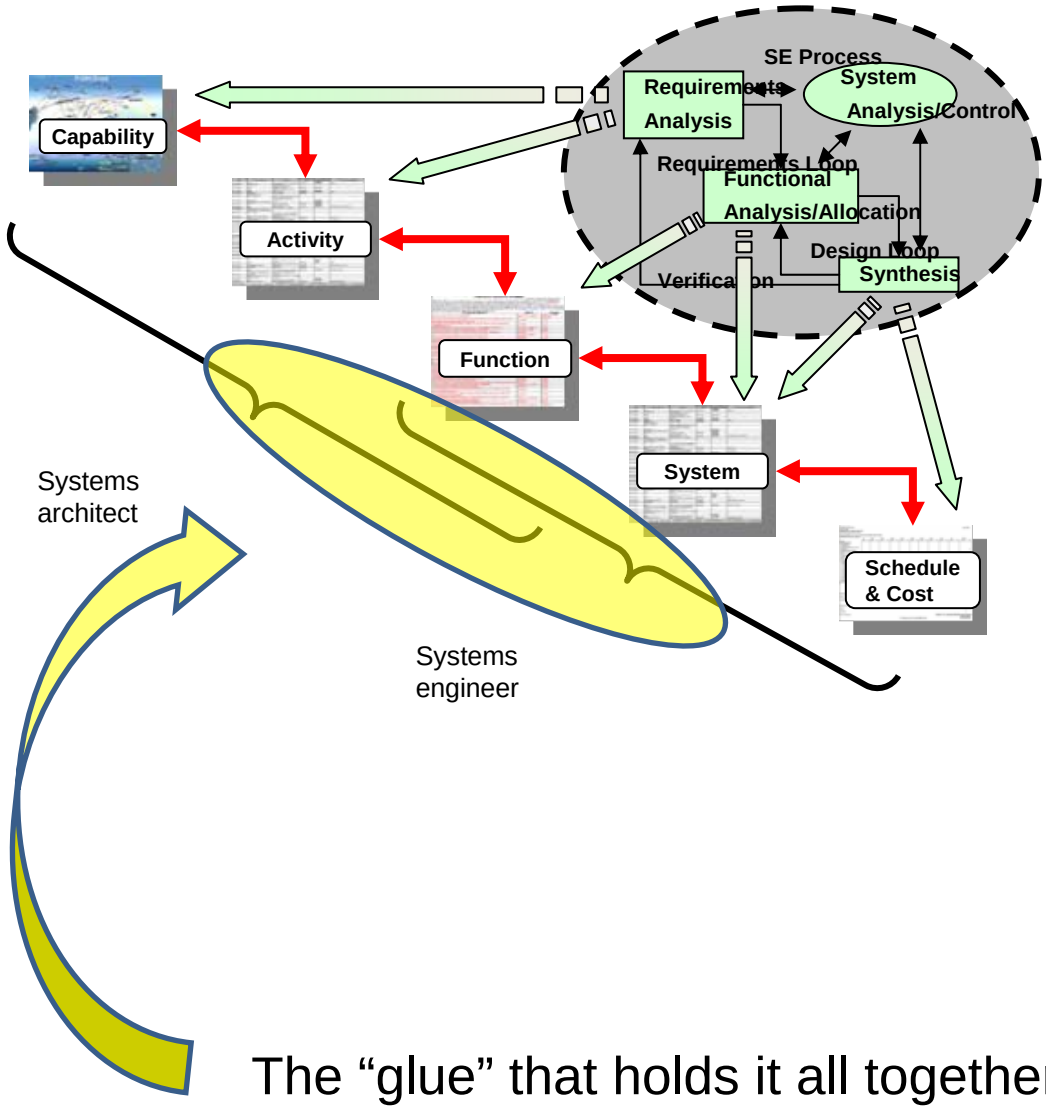

The “glue” that holds it all together and makes it “wor

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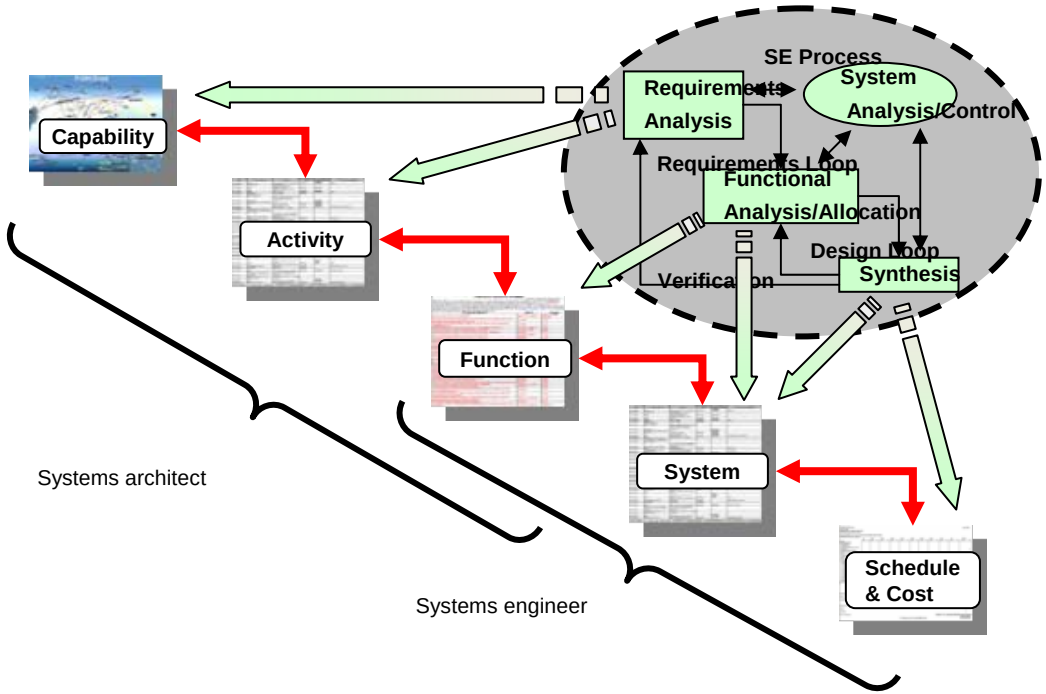

The System Architect works for the customer

The Systems Engineering works for the builder

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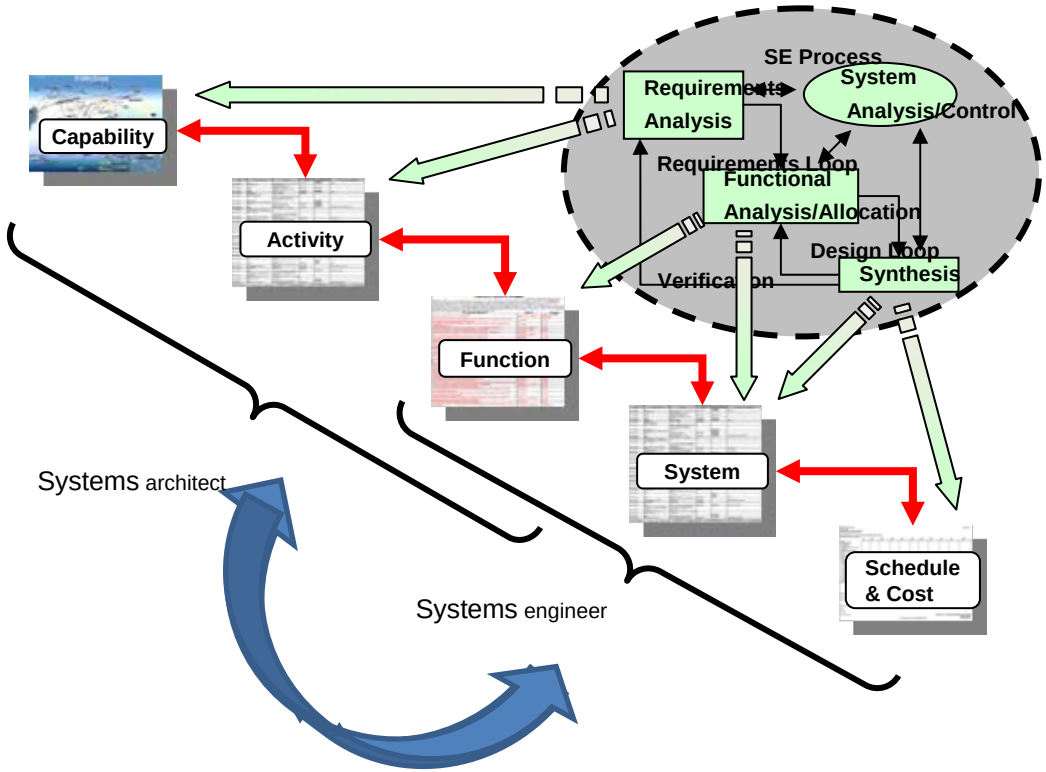

Understand the requirements
Design the solution
Build it
Test it
Sell it
Manage it all

Architect and Engineer:

Work and “flit” back and forth amongst these work-related activities with the architecture as their foundation and guide

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