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C-RAM:
A Case Study in
TRUE System-of-Systems
Test and Evaluation

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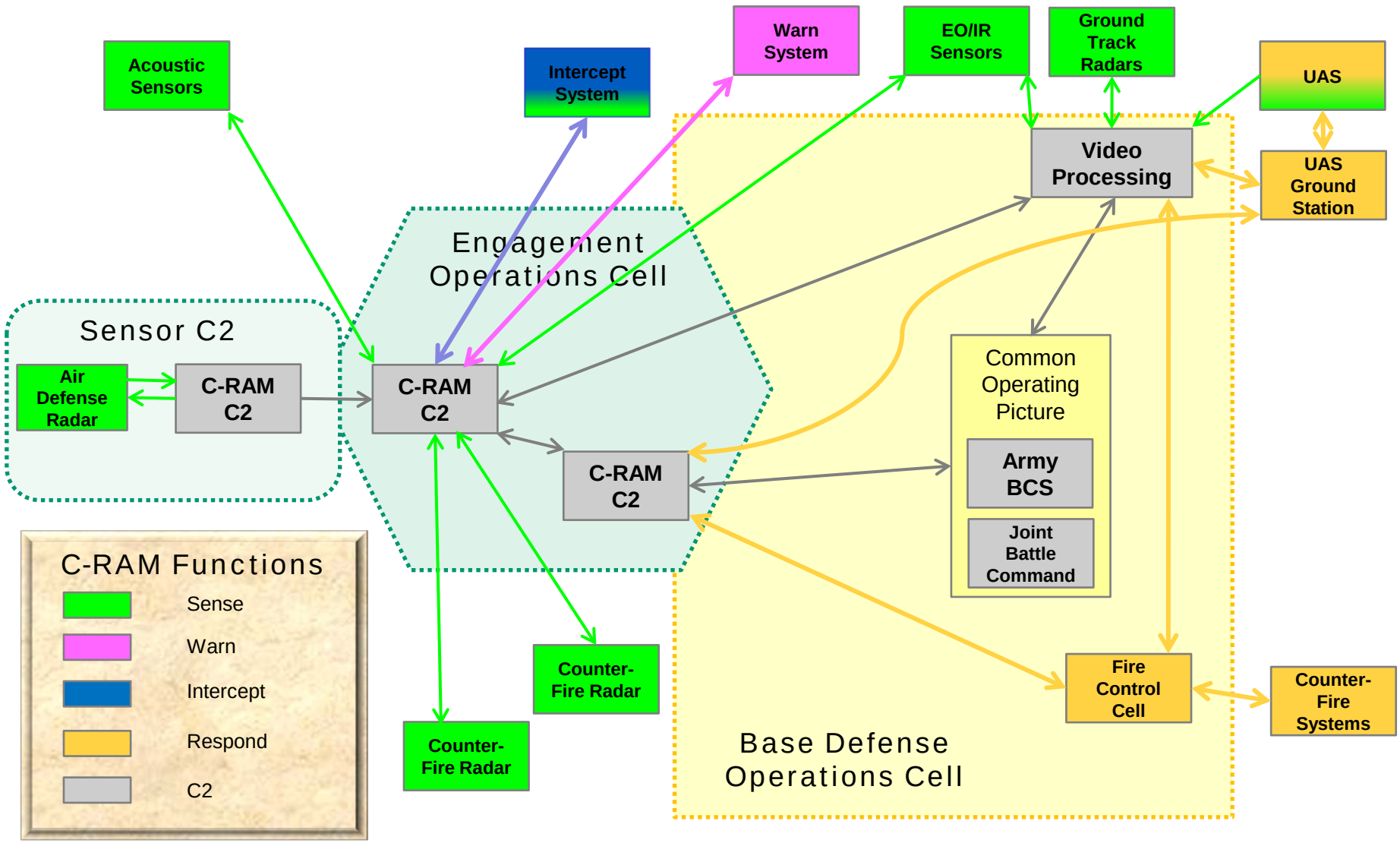
Network-Centric Warfare

Historical Background

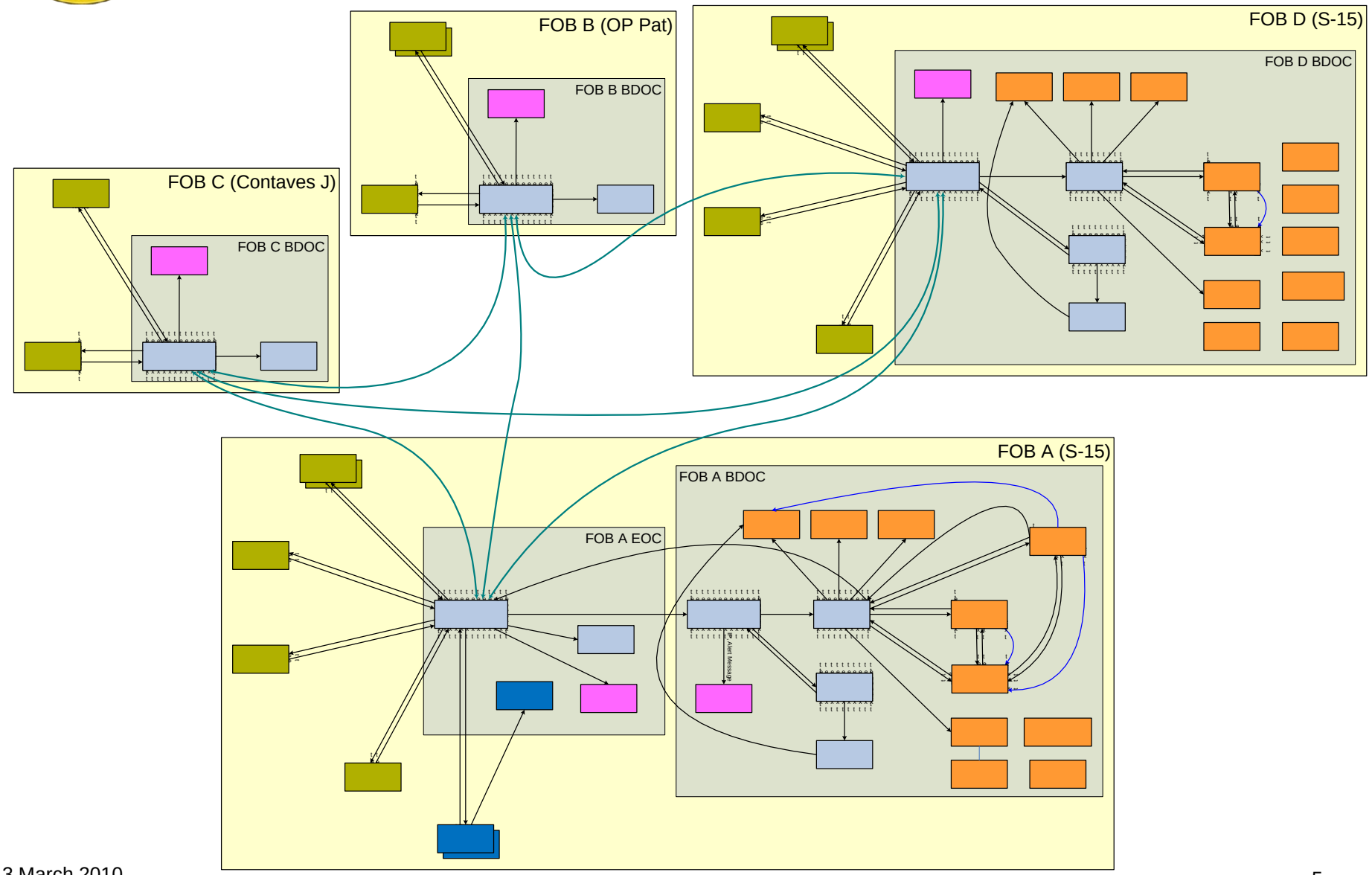
- **C-RAM Requirement**
  - Jun 2004 – Theater submitted Operational Need Statement (ONS 306-04) for a system to destroy Mortar rounds
  - Sep 2004 – The ASPB validated theater ONS and directed ABO fund C-RAM Proof-of-Principle
  - Nov 2004 – Proof-of-Principle (PoP) Demonstration at Yuma Proving Ground (YPG) AZ
  - Jan 2005 – Results of C-RAM PoP test briefed to VCSA, SecNav, and Dep SecDef
- **C-RAM Capability**
  - Feb 2005 – Sense and Warn capability validated and initial fielding begins
  - Apr 2005 – Intercept capability validated and initial fielding begins
  - Jul 2005 – IOC of Sense, Warn, and Respond capability at FOB 1
  - Sep 2005 – C-RAM supported successful attack of 2 insurgent mortar teams – 11 KIA, 5 captured
  - Mar 2006 – FOC declared at FOB 1 and first combat intercept (first ever for a Phalanx system)
- **FMS and Lease Cases approved 2QFY06**
  - May 2006 – First Coalition FOB fielded
- **IBDSoS funded 2QFY06 and fieldings begin in support of C-RAM Enhanced Response capabilities and ONS 05-466**

C-RAM Sense and Warn capability fielded to 15 FOBs, 3 of which have Intercept capability, and IBDSoS is installed at 10 FOBs

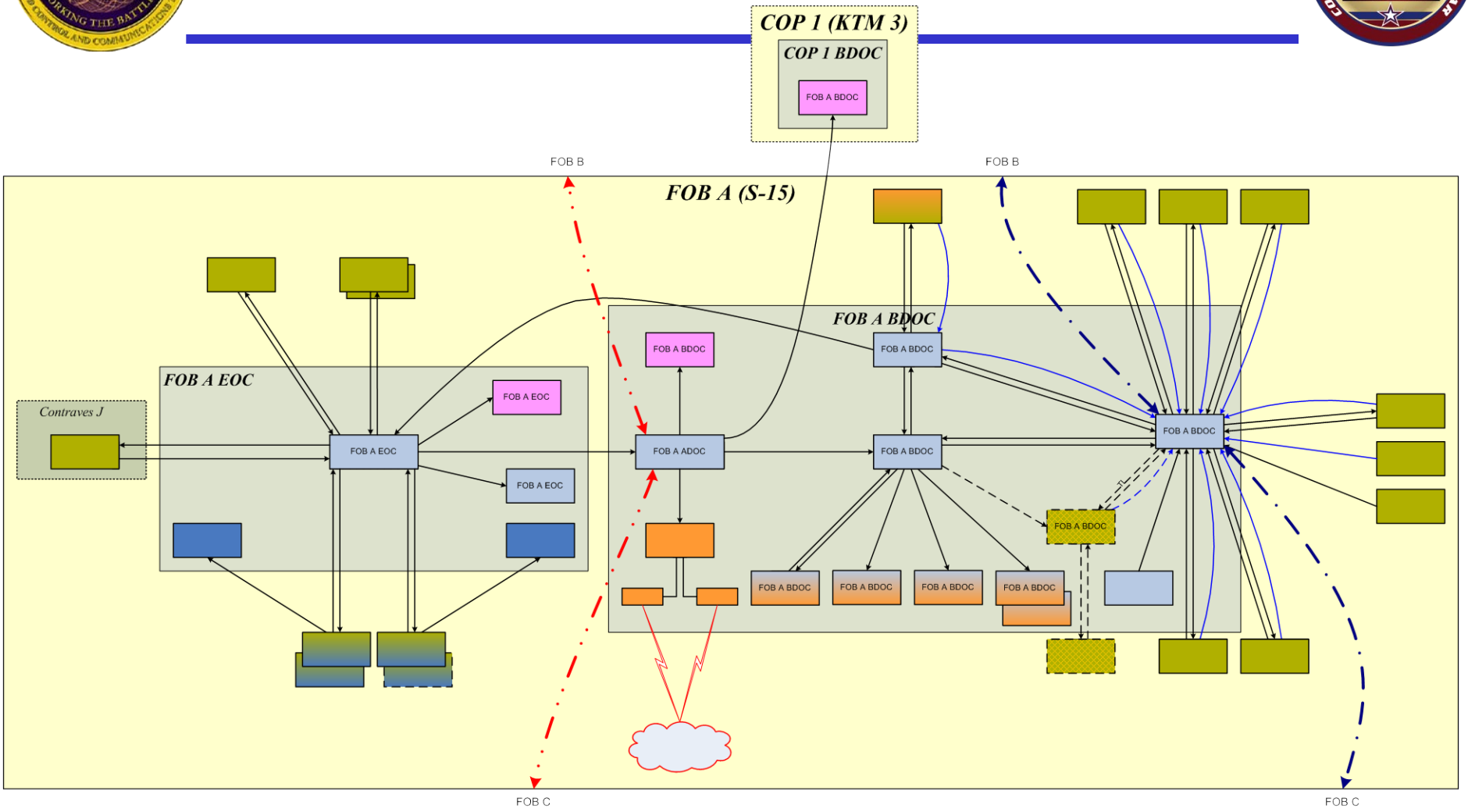
C-RAM System of Systems Architecture



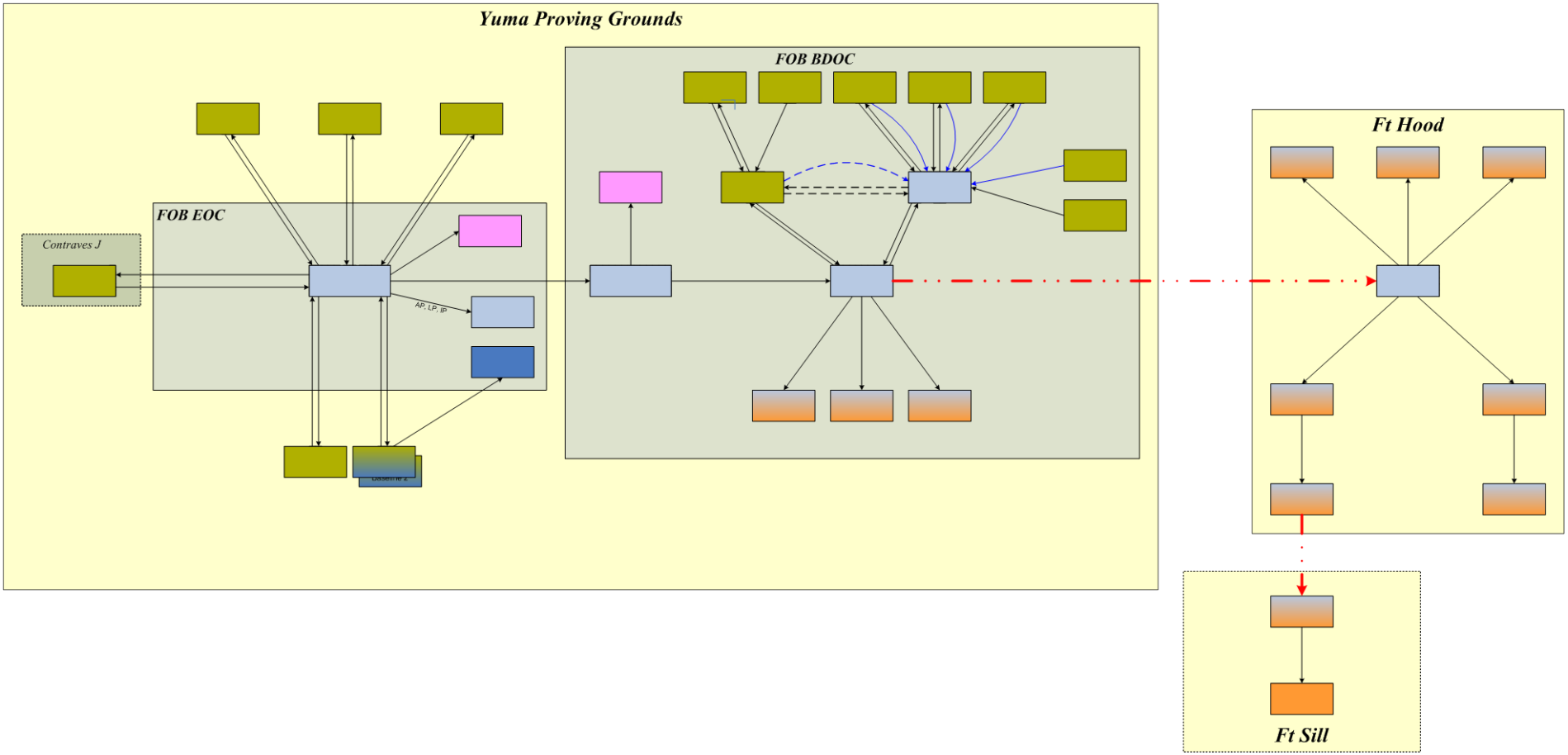
Multi-FOB SoS Architecture



FOB A Detail


COP 1 (KTM 3)
COP 1 BDOC
FOB A BDOC
FOB B
FOB B
FOB A (S-15)
FOB A BDOC
FOB A EOC
Contraves J
FOB A EOC
FOB A EOC
FOB A EOC
FOB A BDOC
FOB A ADOC
FOB A BDOC
FOB A BDOC
FOB A BDOC
FOB A BDOC
FOB A BDOC
FOB A BDOC
FOB A BDOC
FOB C
FOB C
Command & Control
Sense
Respond
Intercept
Warn
Shape
Data Flow
Video Feed
C-RAM InterFOB Network
IBDSoS InterFOB Network
LP = Launch Point (POO)
IP = Impact Point (POI)
TL = Target Location
LAP = Local Air Picture
EAP = External Air Picture
SPI = Sensor Point of Intrest

Interoperability Demo Detail



Case Study:
Integration of Multiple PM's Systems

- **System-of-Systems (SoS) PM must retain and execute integration responsibility for the entire SoS**
  - **SoS PM must conduct all trades in selection of component systems**
    - Avoids corporate biases
  - **All DoD Program of Record (POR) systems should be assessed**
    - Avoids service biases
  - **SoS PM must ensure support of the component system's PM for any necessary modifications**
    - SoS PM must assess risk and cost for these modifications
  - **When a suitable system is not available, selection of an S&T initiative or a COTS item may be appropriate**
    - SoS PM must ensure any S&T or COTS item has been adequately tested and is supportable

The Government Stakeholders Must be Bound to "Specified Time" to Avoid Schedule Slips and Cost Increases

Case Study:
Assessing SoS Capability

- **To ensure requirements are met, work with independent test agency throughout system development**
  - **C-RAM Program Office successfully integrated Army, Air Force, USMC, and Navy Program of Record (POR) systems into the C-RAM SoS and <u>fielded a SoS that met requirement just 6 months after funding</u>**
    - Requires working closely with Army Test and Evaluation Command (ATEC) in all tests, starting with the very first proof-of-principle demo in Nov 04
    - ATEC has been a full partner in the C-RAM program
      - Supporting development of test objectives and data collection plans to ensure adequate data is available to fully evaluate the capabilities being tested
      - No modifications are fielded without a Developmental Test Center (DTC) Safety Confirmation and an Army Evaluation Center (AEC) Capabilities and Limitations Report

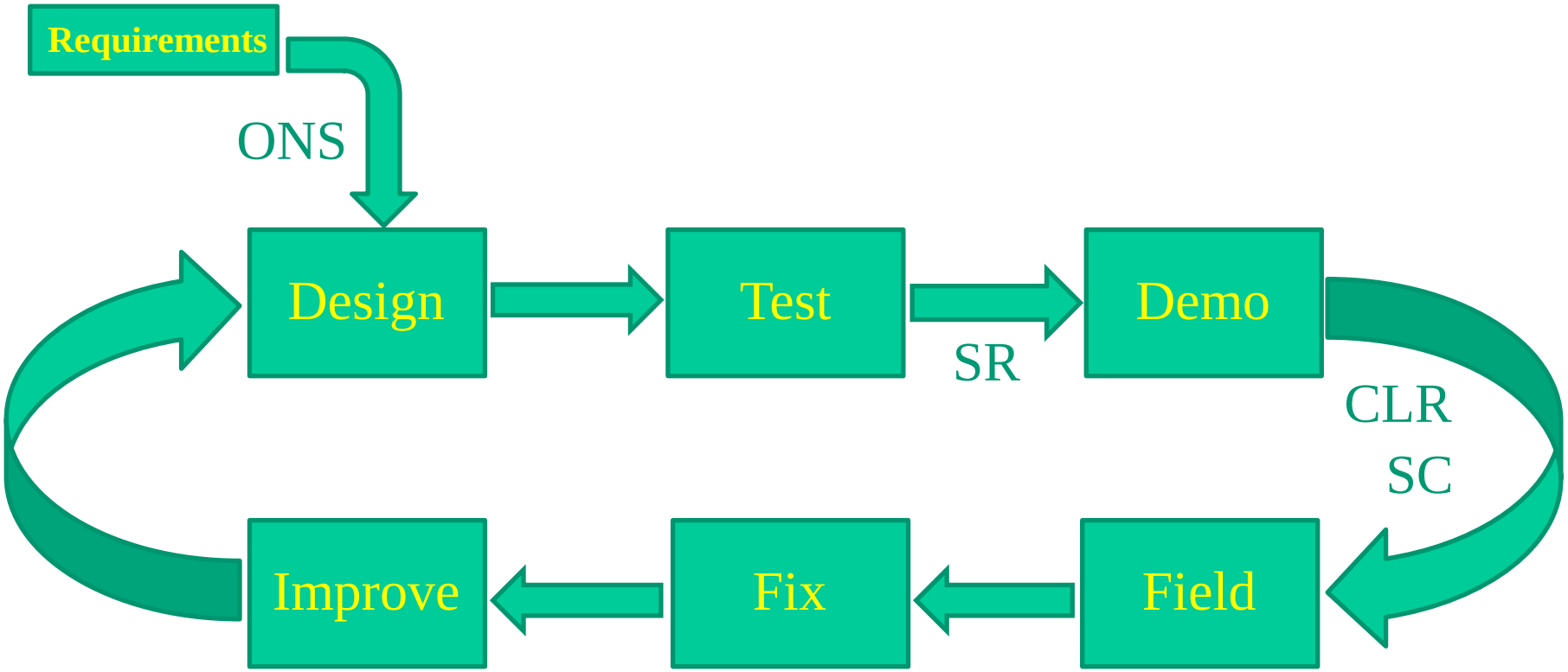
C-RAM SoS Capability Development Approach Enabled Accelerated Fielding and Continuous Improvement of a Force Multiplier in a Combat Zone

Case Study:
Funding SoS Interfaces and Capabilities

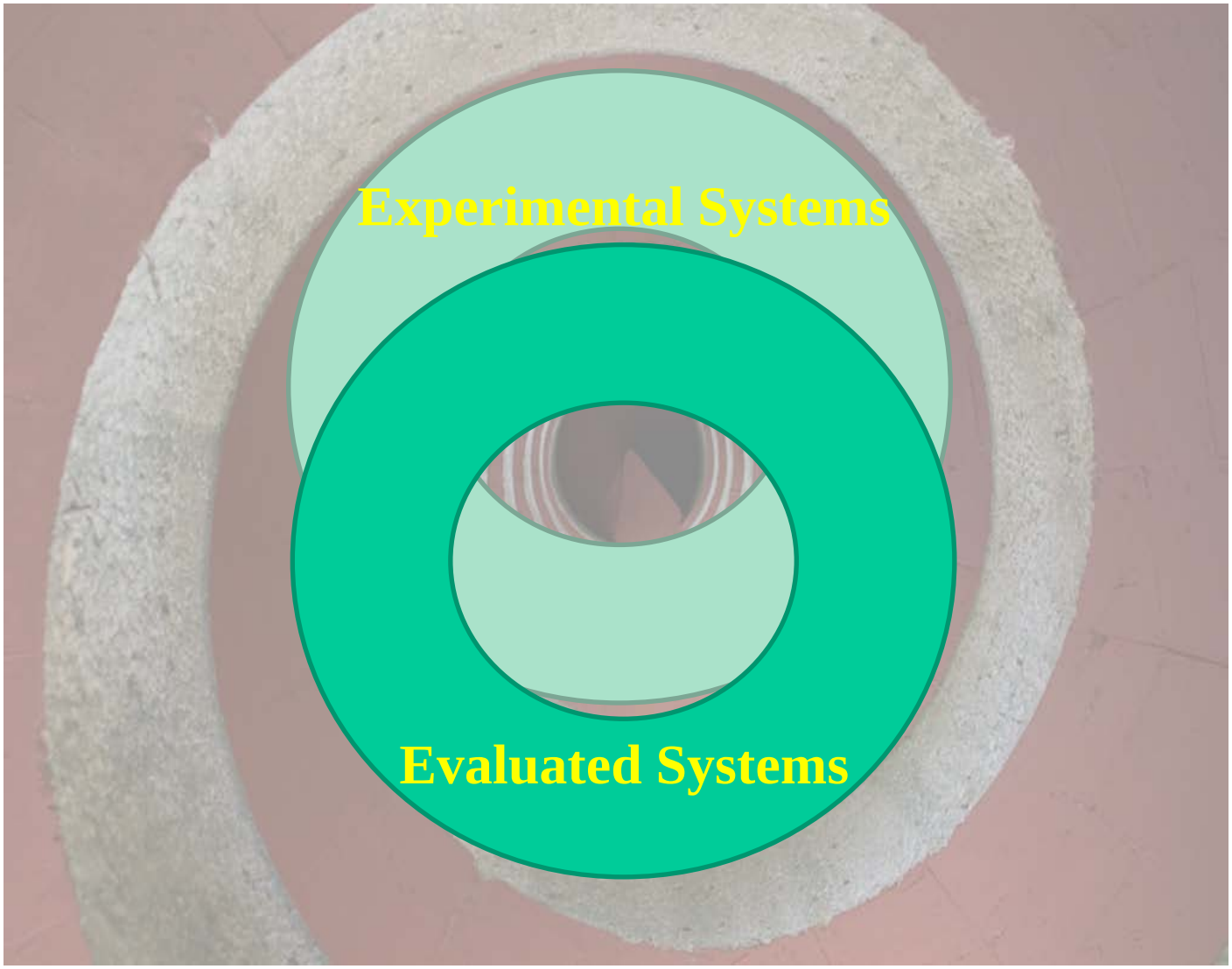
- **Lesson Learned: To reduce risk and ensure supportability, fund component system PORs to implement all changes to their systems.**
  - **Multiple changes were required in the C-RAM's POR component systems**
    - Interfaces
    - POR system capabilities
  - **All such changes are agreed to between the C-RAM and POR PMs, developed by the POR PMs, partially funded by C-RAM, and then jointly tested**
  - **When there are conflicts between the POR system's and C-RAM requirements, the Combat Developer helps define courses of action**

C-RAM SoS Capability Development Approach Enables Accelerated Fielding and Continuous Improvement of a Force Multiplier in a Combat Zone

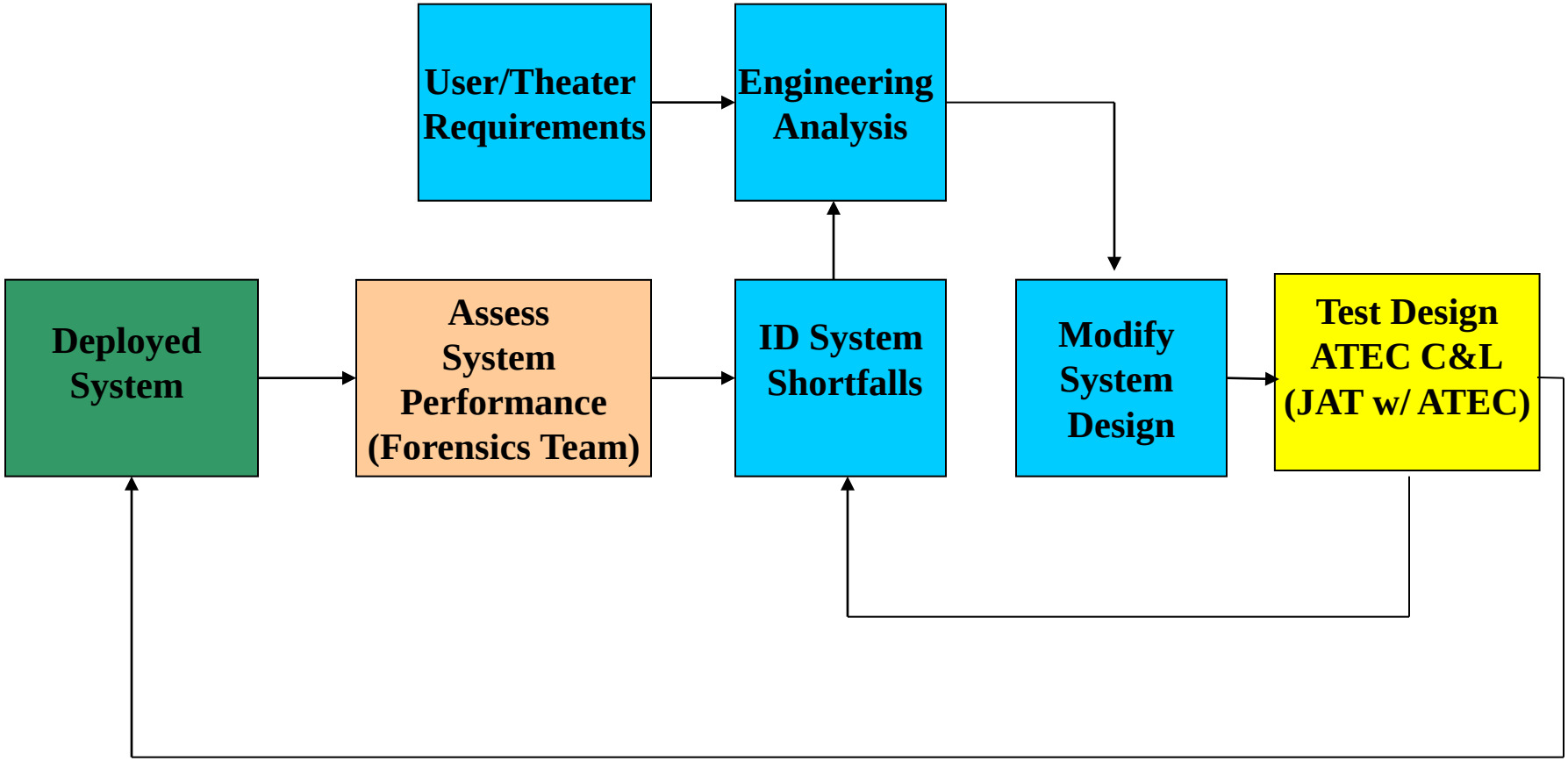
C-RAM / ATEC
Spiral Development Process



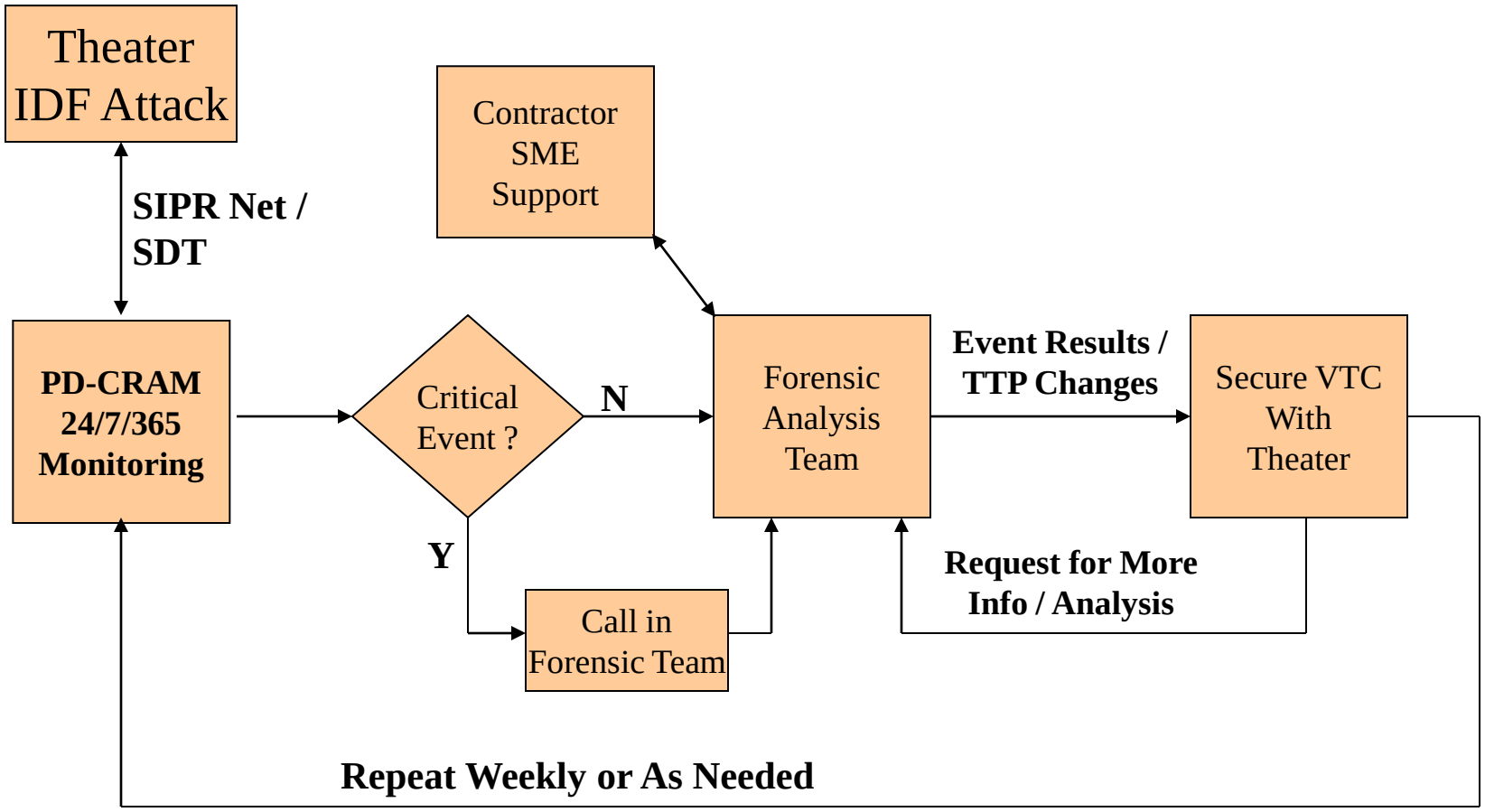
C-RAM / ATEC
Dual – Spiral Process



Systems Engineering with Embedded Forensics Process



Forensic Data Analysis Process



SUMMARY

- **Through innovative out-of-the-box thinking from the beginning, PD C-RAM has taken a multitude of diverse military, commercial and foreign systems and integrated them together to produce a viable and proven solution to an on-going threat for our warfighters in harms way.**

- **The Counter-Rocket, Artillery, Mortar Program: practicing TRUE system-of-systems Test and Evaluation to support our warfighters,**

TODAY AND TOMORROW !!

QUESTIONS