Responsive Decision Making through Automated Policy-Enabled Systems

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Baghdad, we have a problem…

Situation

- ROE for Urban Environment
  - Minimize Collateral Damage
  - Protect Cultural and Religious Areas
  - Maximize Safety
  - Use Precision Guided Munitions
  - Avoid Dud Producing Munitions
- Target
  - Small and Mobile Requires Quick Response
  - Not Armored

Assets

- Air – Response Time too slow
- Artillery
  - Rocket/Missile (MLRS)
    - Dud Producing
    - Large Minimum Safe Distance
  - Cannon
    - Not Considered Precision Guided

Copperhead Overlooked

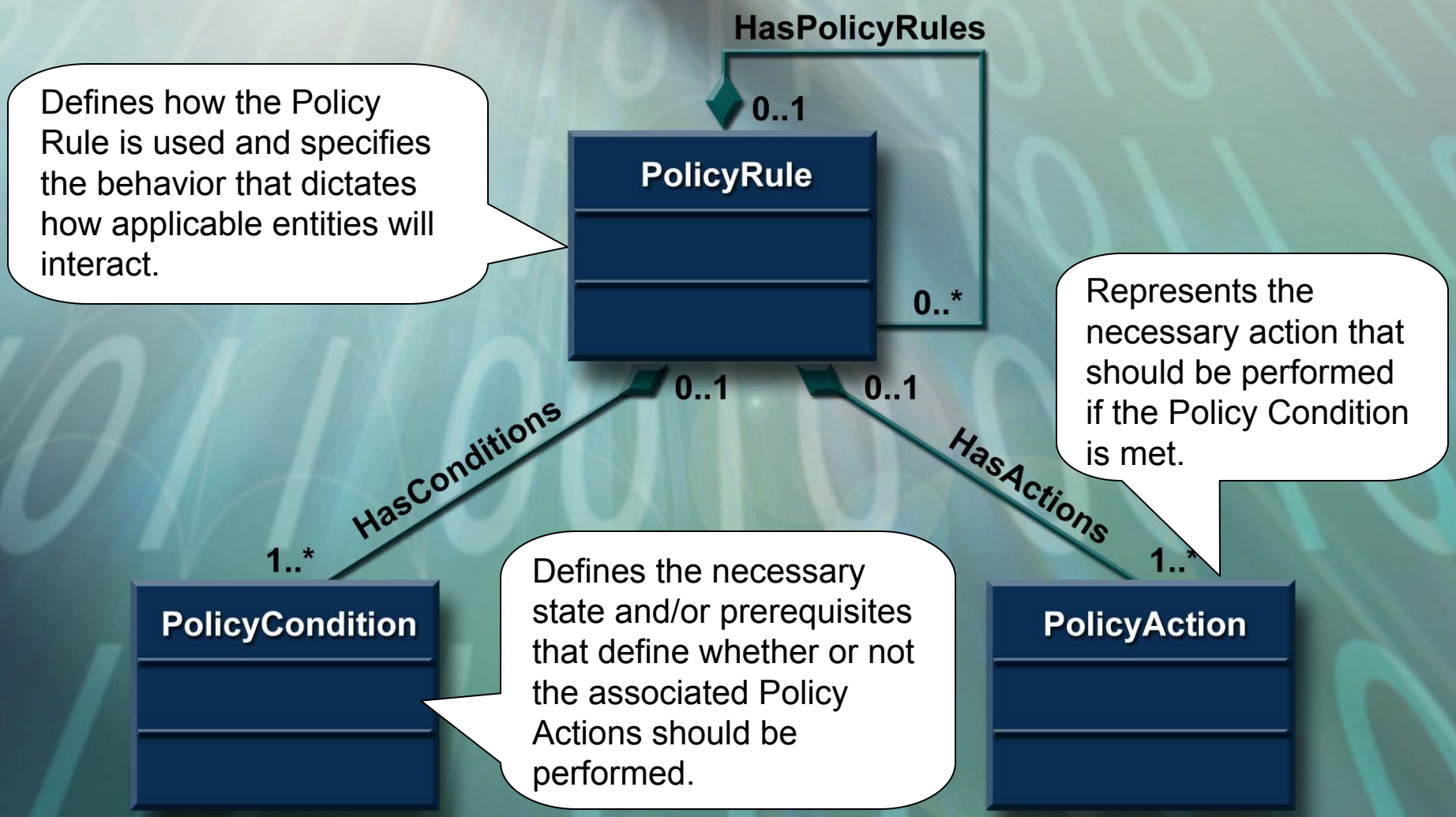
Capabilities…

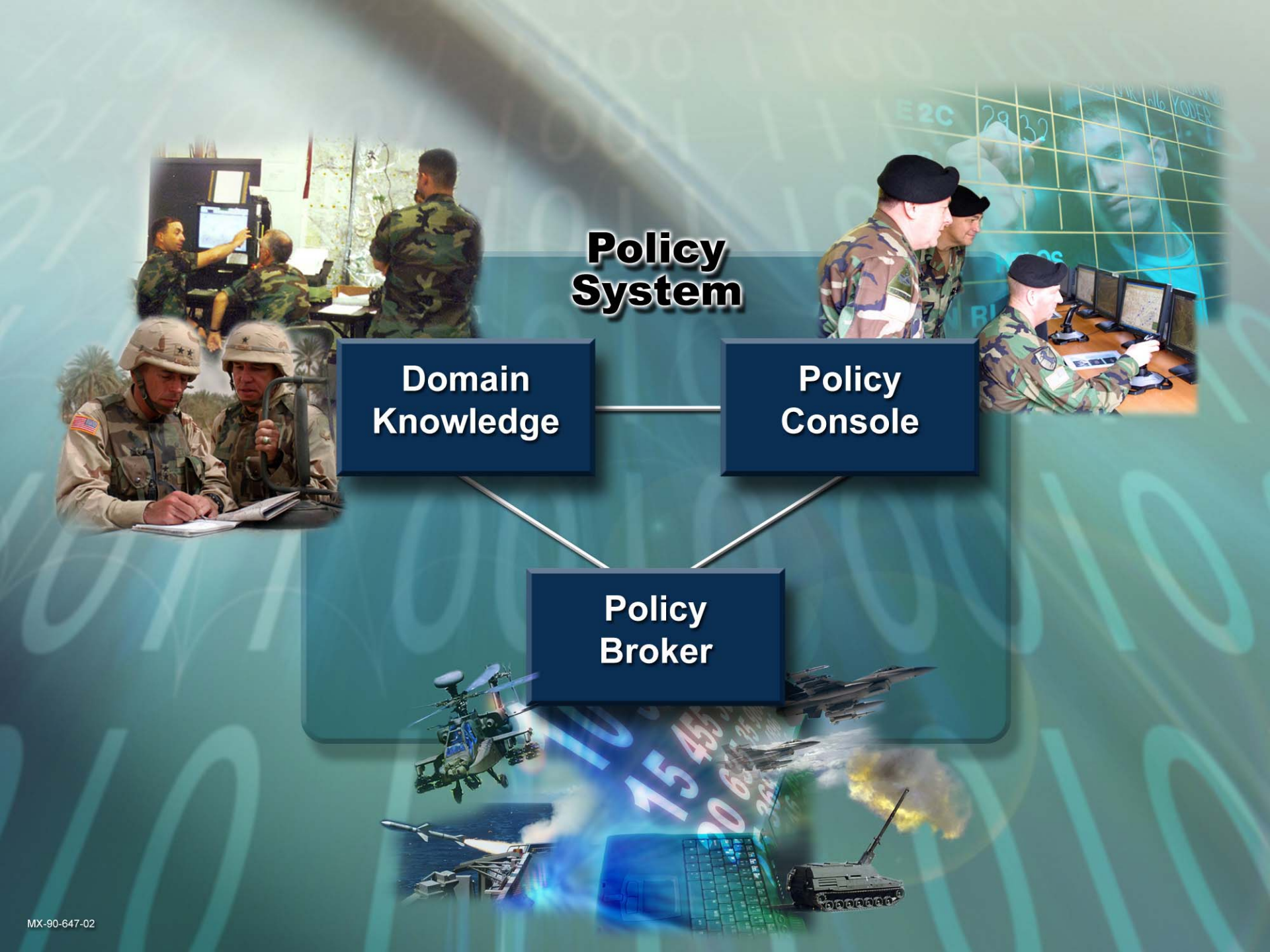
- Laser Guided
- Unitary Warhead
- Quick Response
- Small Minimum Safe Distance

Overlooked by the Automated System

- System had hard-coded relationships
- Selected based on target type rather than capability
- Anti-tank role

Policy Model – Primary Classes




Policy System
Domain Knowledge
Policy Console
Policy Broker
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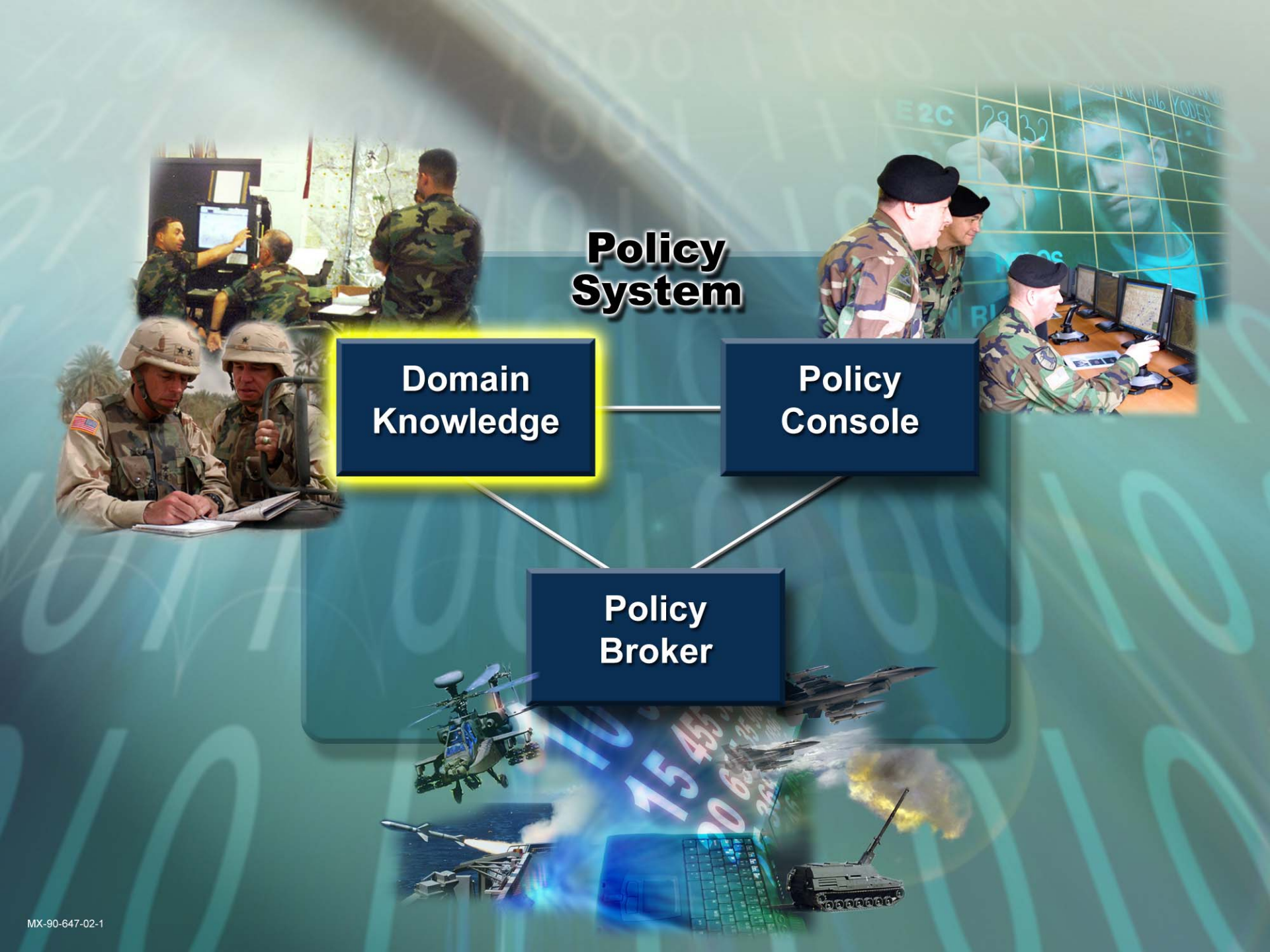
Policy System
Domain Knowledge
Policy Console
Policy Broker
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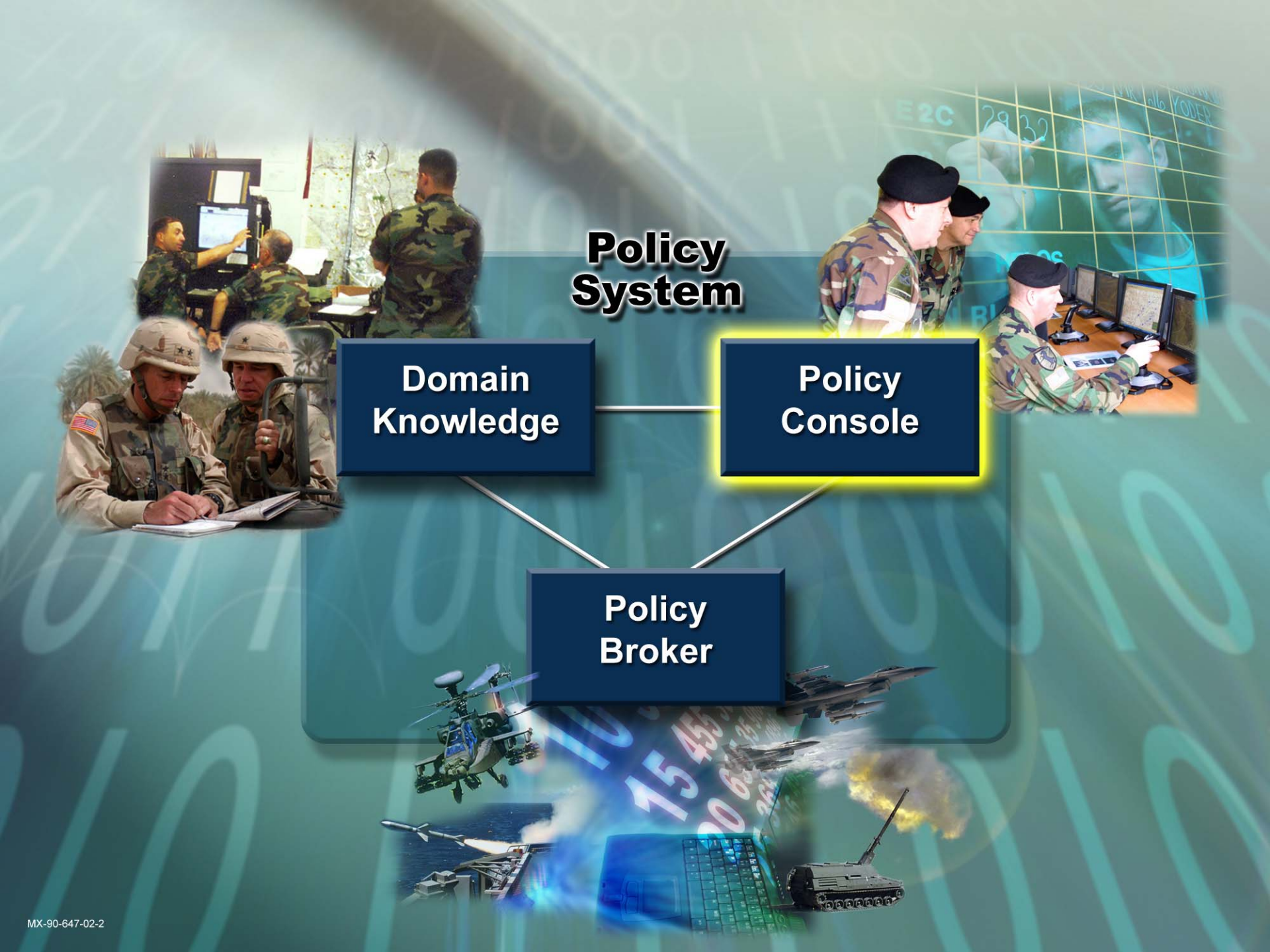
Domain Knowledge

- Representation of Problem Space
  - Formalized
    - e.g. APICM and DPICM are both ICM munitions
  - Machine Interpretable
- Used to…
  - Constrain rules definition in Policy Console
  - Determine Applicable Rules in Policy Broker
  - Aid Decision-Making in Policy Consumer
- Flexible
  - Adapt to Changing Problem Space
  - Ability to Represent Newly Discovered Relationships


Policy System
Domain Knowledge
Policy Console
Policy Broker
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Policy Console

- User Interface – Graphical or Textual
- Defines Rules
- Captures Commander's Intent / Guidance
  - e.g. Use precision guided munitions in an urban environment
- Constrained by Complexity of the Domain Knowledge

Policy System
Domain Knowledge
Policy Console
Policy Broker
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Policy Broker

- Stores Policy Rules
  - "Targets in an Urban Environment **MUST** use munitions that have a Precision Guided System"
  - "ICM is preferred for an FS Target"
- Brokers Requests from Policy Consumers
- Uses Domain Knowledge to Relate Rules to the Request Criteria

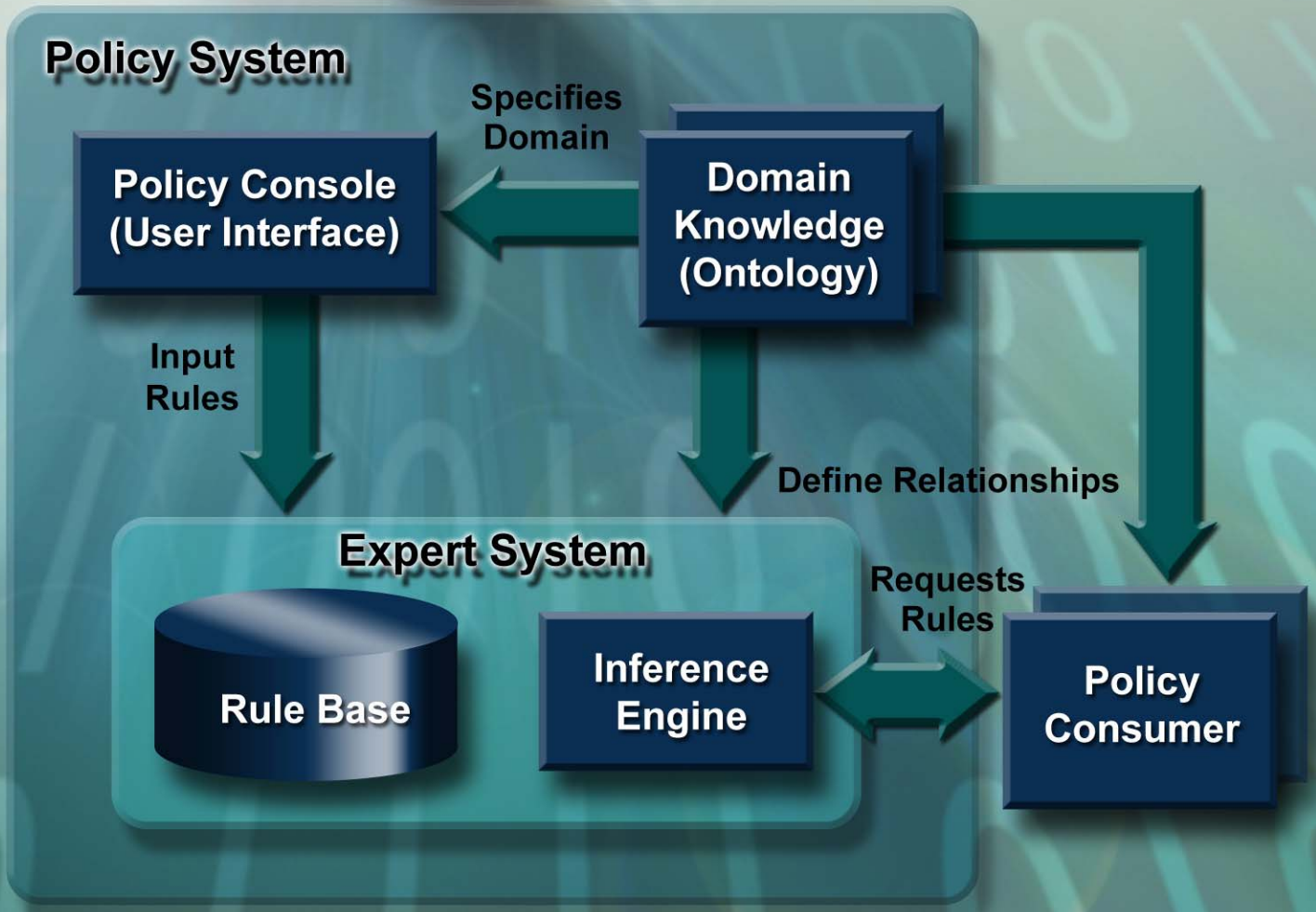
Key Technologies

- Ontology
  - Formal Representation of Domain Knowledge
    - Formal Language
    - Captures Semantics and Vocabulary of the Domain
      - Describes relationships and attributes
      - Enables inference
  - Machine Interpretable
    - Enables Machine Learning

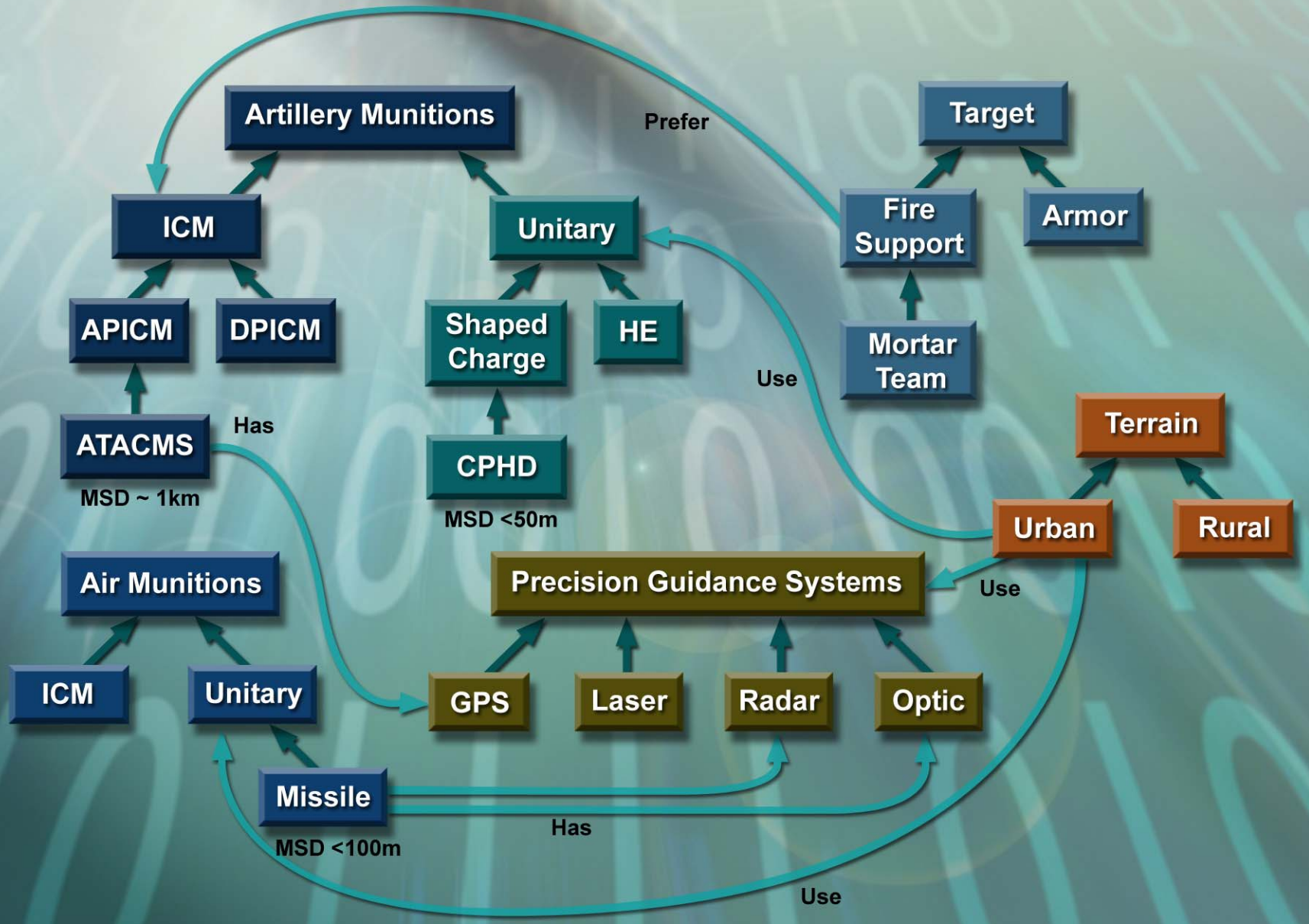
Key Technologies

- Expert System
  - Declarative programming, not procedural programming
  - Describes “what” rather than “how”
  - Composed of an inference engine, a rule base and a fact base
  - Uses rules to reach conclusions from a set of premises

High-Level Design



Ontology Example



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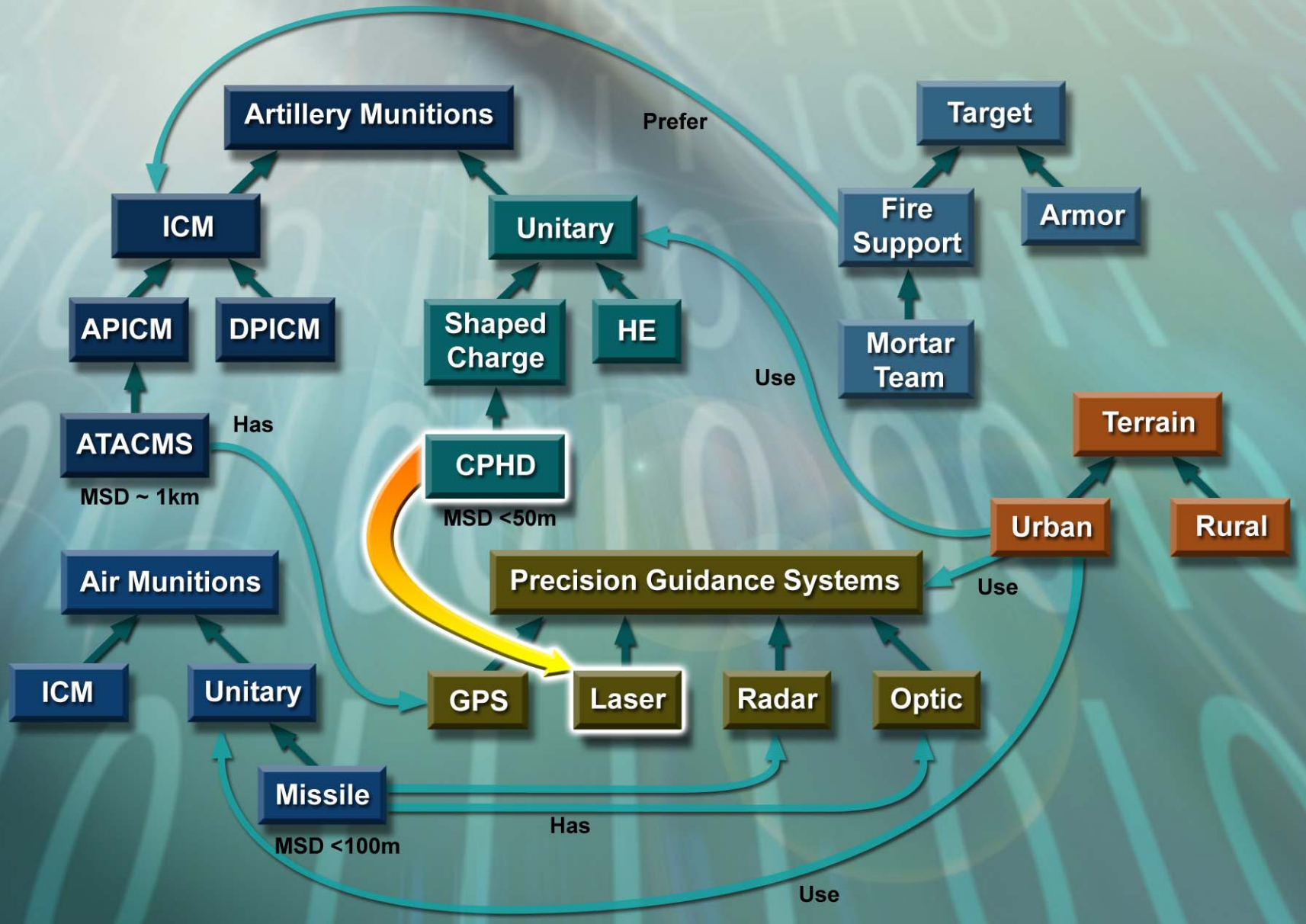
Rule Base

- Policy Rules
  - Preferred munitions for FS targets is ICM
  - Targets in an urban environment must use precision guided munitions
  - Targets in an urban environment must use munitions with a unitary charge
- Policy Result
  - Use Air Missiles

Ontology Example Updated



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Same Rule Base – New Result

- Copperhead is now recommended based on capability
  - Unitary
  - Small Minimum Safe Distance
  - Precision Guided
  - Quick Response

Net Centric Operations

- DOD Trend toward Net Centric Operations
  - Future Combat Systems (FCS)
  - DDX
  - Distributed Common Ground System (DCGS)
  - Persistent Surveillance Dissemination System of Systems (PSDS2)
- Recognize Need for Sophisticated Policy Applications
- Dynamic Policy Environment
- Growing Implications of Legal and Geopolitical Factors

Cognitive Extensions

- Ontologies and Expert Systems Enable Cognition
  - Learn from Decision Patterns
  - Recognize Uncertainty
  - Identify Conflicts in Policy
  - Recommend New Policy

Next Steps

- Additional Research is Needed
  - Policy Conflict Identification and Resolution
  - Knowledge Elicitation
  - Performance and Trust
  - Guaranteed Service
  - Supportability, Training and Testing

Summary

- Current Force applications can’t keep up
- Policy environment is dynamic
- Ontologies and Expert Systems are key technologies
- Proposed a new approach

Questions?

Acknowledgments

Companion Paper – *Responsive Decision Making through Automated Policy-Enabled Systems*, Buibish, Lange, and Woitalla, March 2005.

The foundation of this paper was based on a paper of the same title authored by Anne-Marie Buibish for the 2004 Graduate Independent Study course: “Cognitive Enablers” for Dr. Kenneth Modesitt, Professor of Computer Science and Associate Dean in the School of Engineering, Technology and Computer Science at Indiana University-Purdue University Fort Wayne (IPFW).

Video Footage provided by Raytheon Company, “Excalibur: Close Combat Precision” v3702, 3/22/2005. Approved for Public Release.

Author Biography - Buibish

Anne-Marie is a Principal Systems & Software Engineer and Team Leader for Raytheon's Joint Battle Management Advanced Technology programs in Fort Wayne, IN. She has more than 15 years experience in all phases of software architecture, software system design, and integrated development of applications for real-time computer systems.

Anne-Marie provides technical direction and focuses the efforts of integrated software development teams developing command and control (C2) and battle management software solutions for DoD applications including the Advanced Field Artillery Tactical Data System (AFATDS), Advanced Warfighter Experiments and Demonstrations, and the Joint Warfighter Demonstration. Additionally, Anne-Marie is a major contributor to Raytheon research and development (R&D) initiatives.

Author Biography - Lange

Amy is a Senior Software Engineer for Raytheon's Joint Battle Management Advanced Technology programs in Fort Wayne, IN. She has more than 12 years experience in IR&D hardware design, working on transmitters and receivers for electronic warfare. The last 9 years she has worked on software design and development for command and control systems and contributes to several IR&D efforts. She recently lead an effort in the rapid deployment of PSDS2 and is currently the software lead for Targeting Situational Awareness (TSA).

Author Biography – Woitalla

Michael is a Senior Systems Engineer for Raytheon's Joint Battle Management Advanced Technology programs in Fort Wayne, IN. He develops requirements and specifications for command and control (C2) and battle management software solutions for DoD applications currently fielded and numerous rapid prototyping applications. Additionally, Michael provides operational insight and recommendations for battle management applications.

Michael has just recently joined Raytheon from the United States Army. He joined Raytheon in 2002 after working as the Division Assistant Fire Support Coordinator for the 4th Infantry Division at Fort Hood, Texas. During his duties at Fort Hood, Michael tested and integrated Army Battle Command Systems (ABCS) during the 4th Infantry Division's transformation to the First Digitized Division. Most recently, Michael deployed to Iraq to provide on site technical support for AFATDS and EMT during Operation Iraqi Freedom. He has also been employed for multi-service and joint experiments and demonstrations including Operation Silent Hammer and the JFI-LOE.