Transforming Tactical Messaging:
Exploiting Web Information Standards for Interoperability*

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Interoperability Problem

The challenge of *interoperability* – the ability of systems to exchange services in ways that enable them to operate effectively together – has increased with the number of heterogeneous deployed automated systems. One of the most challenging aspects of this problem is that information sharing must take place despite disparate languages, cultures, command and management structures, and operational/business processes and procedures.

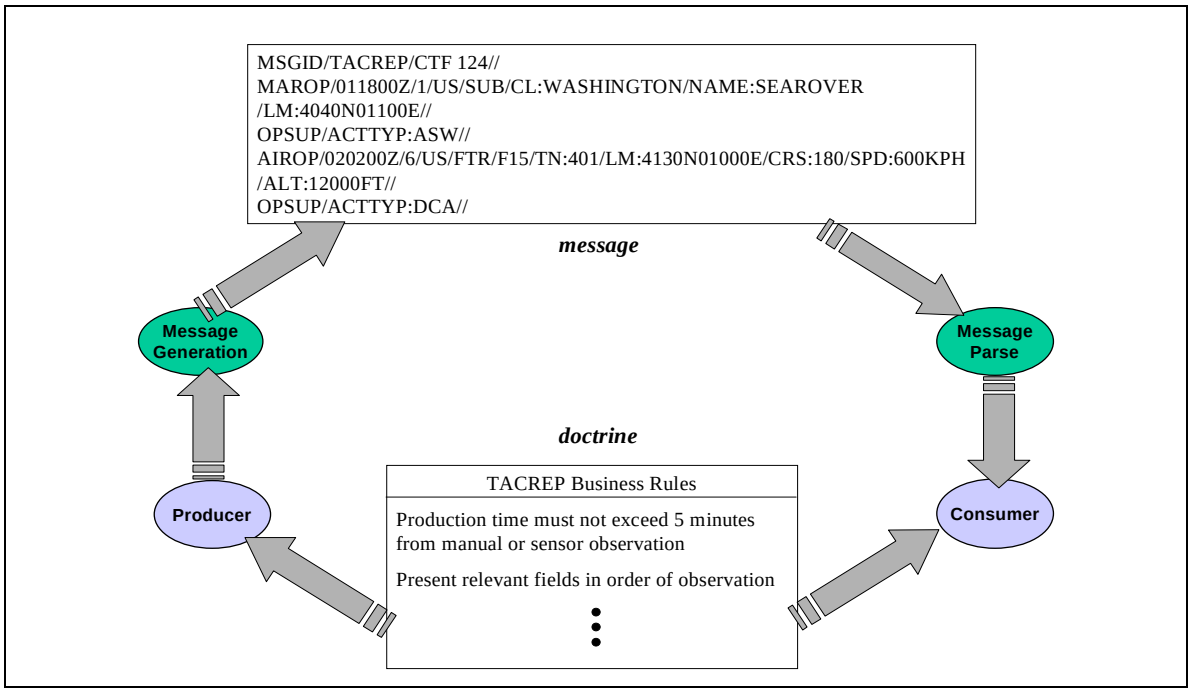

Figure 1. Batch Push Implementation

What are MTFs?

Formatted message interchange is a primary means for satisfying information exchange requirements (IERs) and for supporting system interoperability. Examples of message standards include the United States Message Text Format (USMTF) program; the North Atlantic Treaty Organization (NATO) Allied Data Publication-3 (ADatP-3) program; and the commercial Electronic Data Interchange (EDI) standard. In defense contexts, MTFs govern a significant portion of all exchanged structured text information. They support the full spectrum of military operations, including intelligence, air, fire support, maritime, logistics, and medical operations. These standards often mingle representation and presentation semantics, with proprietary formatting rules and versioning issues, making it harder to leverage commercial off-the-shelf (COTS) tools for message processing and component integration support. Figure 1 illustrates a "batch push" implementation between producing and consuming processes based on doctrine. This is still a prevailing mechanism for distributing and exchanging information.

Historical Perspective

The Air Force has recognized the need to evolve prevailing information management processes to achieve cost savings, to improve interoperability and to meet the unprecedented increases in operational tempo. For nearly twenty years the MITRE Corporation has assisted them with conceiving, exploring and prototyping proof-of-concept technologies that exploit MTF standards. Together they have collected a wealth of anecdotal knowledge analyzing the deployment of message-based and interoperability-enabling technologies in complex, dynamic, real-world environments. Research in these areas has resulted in some successes, lessons-learned and new ideas that have yet to be explored. Figure 2 shows the technology insertion history and overall plan being pursued by the Air Force to transform the USMTF standard, as well as leverage the 30 year military investment in definition and management of information exchange requirements, to meet the needs of the 21st century warfighter. Parallel activities, also initiated by the Air Force, are underway in NATO.

Accomplishments through 1998 include:

- An object-oriented, hierarchical document and meta-document object model
- A parser with selective validation capabilities (i.e., all, none, some)
- A validating editing system for document creation
- A query language for extracting and transforming document elements
- A language for specifying and enforcing constraints between arbitrary document elements
- A document processing system for extracting and delivering document elements in accordance with registered client application requests
- A hypertext help system for browsing metadata repositories
- A document compression technology that exploits shared metadata to achieve unprecedented savings in bandwidth-constrained environments.

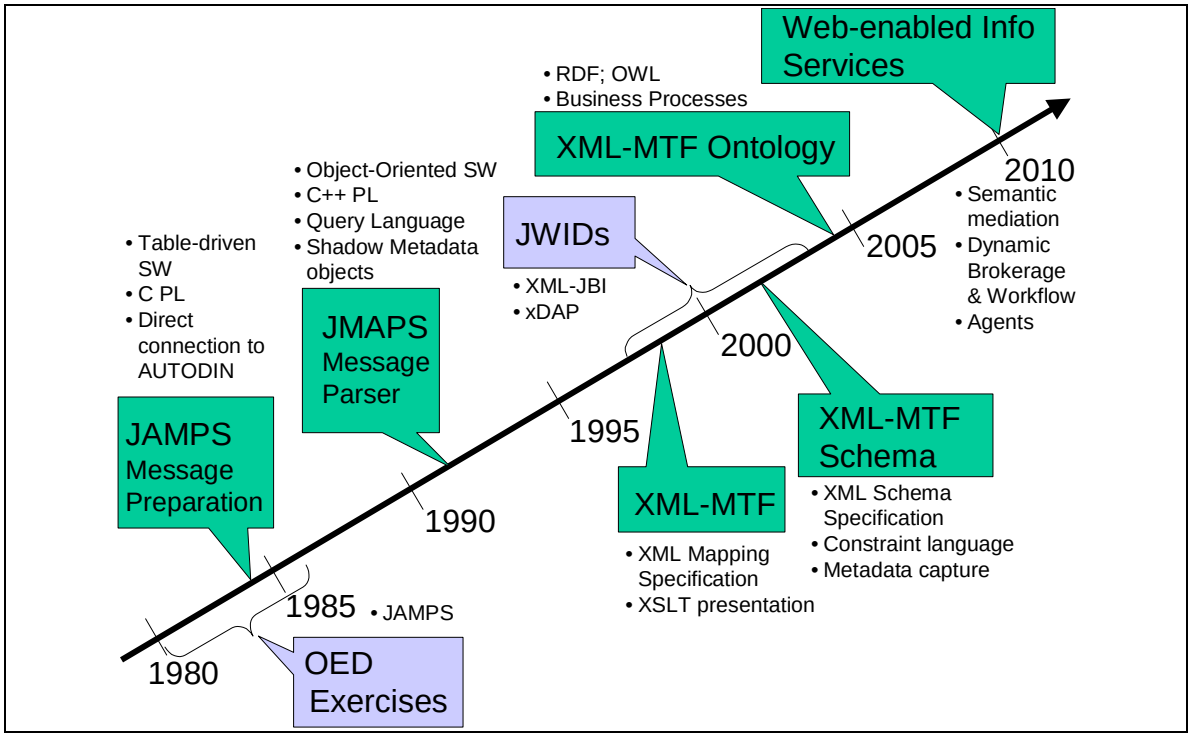

Figure 2. Technology Timeline for MTF Evolution

The extension of messaging standards to incorporate eXtensible Markup Language (XML) principles and technologies features prominently in present-day tasks supporting this evolution. The timeline shown in Figure 2 directly supports Secretary of the Air Force/USAF Chief of Staff Memorandum, "Information Technology (IT) Web-enabling Technologies and Standards for AF Applications," [SECAF/USAF Chief of Staff]; DAC Enterprise Directive 002, Web-Enabling Systems for the C2 Enterprise [DAC]; and C2 Enterprise Integration Memorandum, Extensible Markup Language (XML) Implementation Guidance [Butler] by defining the tasks necessary for transforming current C2 Information and Process requirements to XML specifications for exploitation by future web technology. It also directly supports ASD/C3I Memorandum, "Compliance with Internationally-Agreed Standards," [ASD/C3I] by providing experts to appropriate international standards committees to convey US Air Operations C2 requirements.

Why XML?

All enterprises, whether military, commercial, or non-profit, must react to change by leveraging available information to make effective decisions. They do this in the context of their *information environment*, which includes the interrelated information, processes (both human and automated), knowledge resources, and business operations employed by an enterprise to manage information and to make decisions. The exploitation of

information as a critical enterprise asset has given rise to a thriving global industry prominently supported by XML technologies.

In everyday use, the phrase *XML standard* has come to generically reference a whole spectrum of related markup standards being developed under the purview of the World-Wide Web Consortium (W3C) since 1996. XML technologies support the representation of data in ways that make meaning explicit; they separate representation from presentation and are freely available in the public domain. For these reasons, XML is playing an increasingly important role in the exchange of a wide variety of information on the World Wide Web. The W3C is rapidly evolving the various XML specifications so that many organizations from diverse fields can exploit the Web and extend their information environments within it while ensuring interoperability.

As shown in Figure 3, many XML concepts and technologies under development or consideration by the W3C community mirror existing MTF concepts and technologies. The W3C's emerging body of XML standards naturally parallels the interoperability enablers and concepts needed for evolving formatted message standards.

MTF	***XML***
MTF Message	XML Document
Data Tables	XML Schemas
JQL Queries	XML Query
JQL Shell Templates	XSL Stylesheets
MTFTools API	DOM API
MTFVal Parser	Validating Parsers (many)
JMAPS, IRIS	Windows DNA, Excelon
JMPS, IRIS Prep	Validating Editors (many)
MTF Browser	Web Browsers
Structural Notation	XML Schema; XPath

Figure 3. MTF and XML Technology Relationships

ebXML

The electronic business XML (ebXML) initiative provides a web-based model for message-based information sharing between cooperating partners. The ebXML model is based on access to specifications for data definitions, message structures, and business rules (i.e., processes) that can be managed by appropriate standards bodies, made available via repositories, and executed by business partners. Business trading partners use *information exchange specifications* to construct interfaces to their information environment, and exploit the underlying communications transport to exchange XML messages.

The XML messaging model shown in Figure 4 is based on this ebXML architecture. Tactical systems and facilities use services and exchange information via agreed information packages called XML-MTF's (described below).

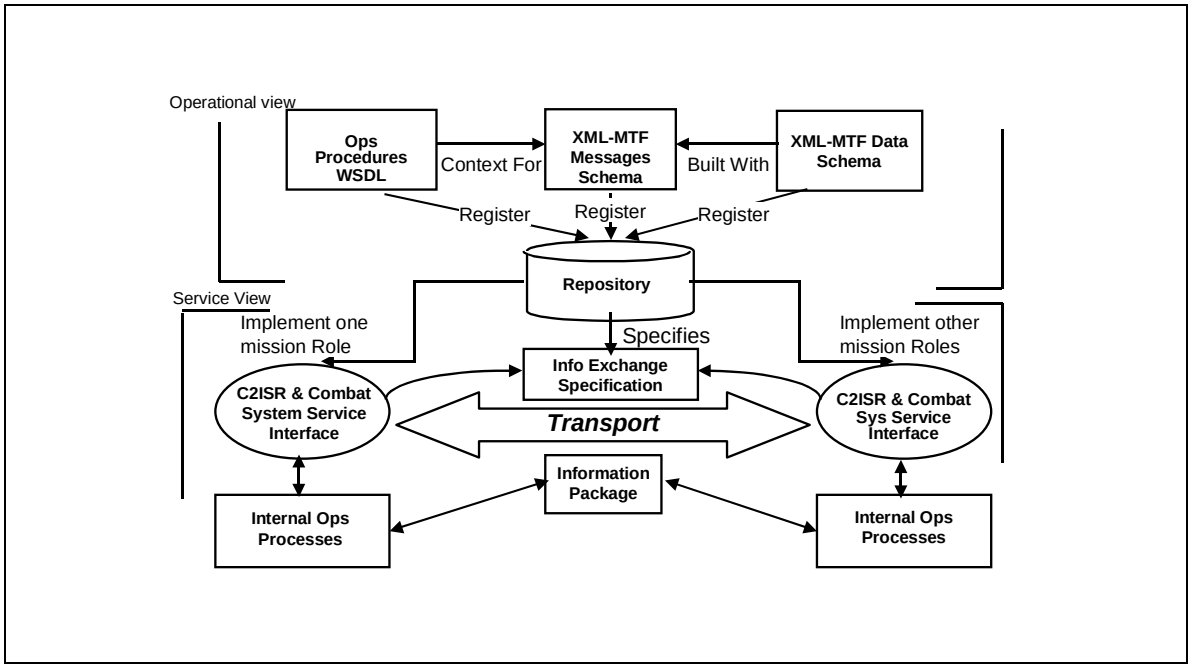

Figure 4. ebXML-based Messaging Model

Web Services

Web services can be used to realize an information environment as described earlier. Web-based services are software components that are loosely coupled, encapsulated and that can be contracted using standard Internet protocols. They can be described, published in a registry, discovered, and invoked dynamically in a distributed computing environment. To make web services work effectively, there must be some element of overall control or brokering. It also must be possible to chain web services together to produce a desired result via workflow. These two core services – brokering and workflow – together enable an information environment to support information sharing and decision-making.

A Web-based Model for Military Information Sharing

Web services and ebXML provide a web-based context for the DoD information environment, including information sharing between national and coalition systems and operational facilities. This future vision has been briefed and agreed in both joint and coalition forums. Military information standards, such as the USMTF standard (MIL STD 6040), will provide the underlying data elements and type definitions that form the information exchange specification and populate the schemas. For MTFs, we call this approach XML-MTF. Doctrinal and operational business rules captured from various sources will be represented via XML technologies. These procedures, supported by XML, will provide the context for constructing messages (e.g., XML-MTF).

As part of the future standards configuration management (CM) process, the types of XML representations needed to support a web-based model will be registered in a distributed set of repositories from which participants can access the information exchange specifications. Access may occur through a local repository via a web-based information environment via a URL. Information packages (messages) constructed in this way in support of a given IER will adhere to the specification and so can be interpreted and used as intended, thus supporting interoperability.

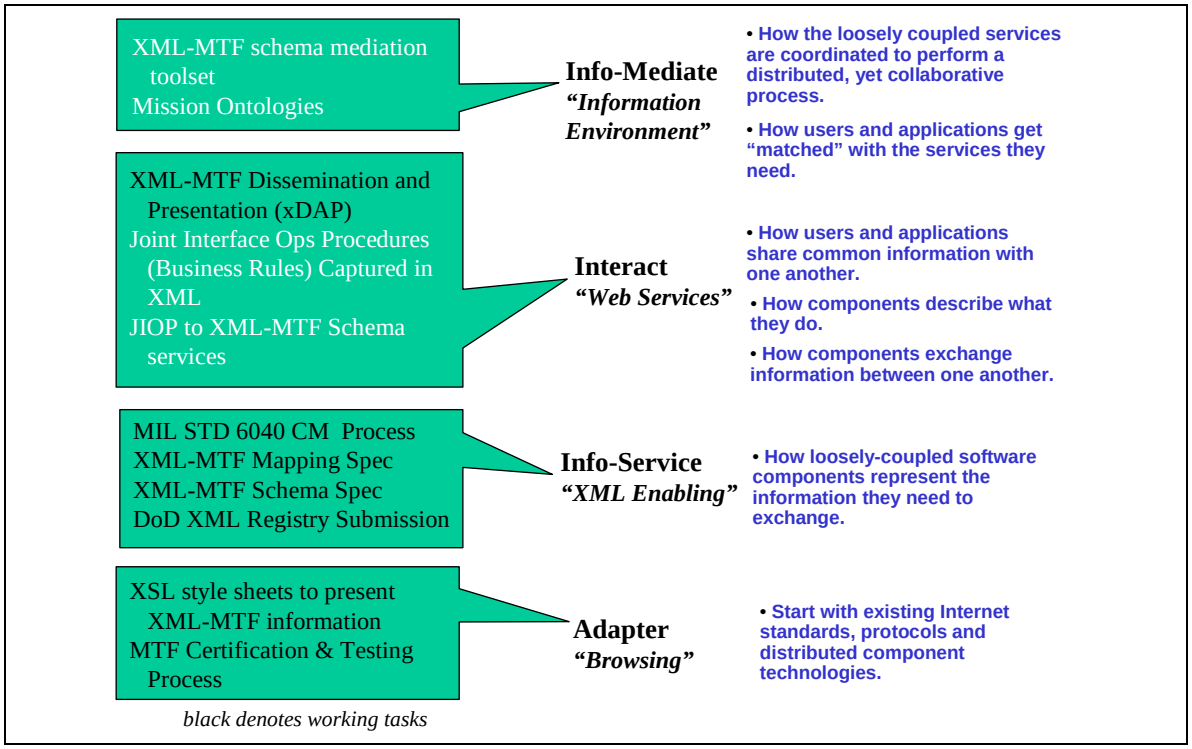

Figure 5. Web Services Efforts

Figure 5 shows various XML-based efforts initiated by AFC2ISRC/SCG at Langley AFB. Some products are already in place. These initiatives will provide products and services needed to achieve a DoD information environment based on the ebXML and web services paradigms, using XML technologies to evolve messaging.

Web Services Support for the DoD Information Environment: A Four-Layer Model

As DoD systems become web-enabled, web browsers and portals will be used at the ***Adapter*** layer to view XML-MTF information published to the information environment. XSL Style Sheets have been developed to render XML-MTFs as HTML for presentation on a web browser or through a portal.

XML is a key representation that enables the ***Info-Service*** layer, as it separates the representation of data from its presentation. To support the CM process, an approved XML-MTF Mapping Specification was developed to provide the XML tags needed to

structure the XML versions of the messages. The XML Schema formalism defines mechanisms for applications to express syntactic, structural and value constraints applicable to a class of document instances, such as the meaning, usage and relationships of the documents' constituent parts. The XML-MTF Schema Derivation Specification contains the rules to derive XML-MTF Schemas from the USMTF standard. These XML-MTF schemas are currently available to the information environment though the DOD XML Registry (http://diides.ncr.disa.mil/xmlreg/user/index.cfm).

XML-based MTF web services at the ***Interact*** layer are being made available through XML-MTF Dissemination and Presentation (xDAP) and its evolution to xDAP-Web. It adheres to Simple Object Access Protocol (SOAP) and allows client systems to employ XML-MTF-oriented services. The xDAP capability has been operationally validated in several recent JWID demonstrations and in the C4I for the Coalition Warfighter ACTD, and has recently been fielded at HQ CENTCOM.

As collections of web services allow producers and consumers to share information, additional work also will be needed at the ***Info-Mediate*** layer to address interoperability. When matching web service consumers to available web service providers, we must be able to mitigate potential differences in the structure and definitions of the information to be exchanged. So brokering and workflow services must be able to mediate such semantic differences that inevitably occur in joint and coalition environments.

Further work is needed in the areas listed in white text in Figure 5. That is, we need to provide XML representations of military procedures and doctrine to capture the business rules between military operations. Services and tools also must be developed to tie these operational procedures to information exchanges via schemas so IERs keep pace with the changing mission. These services and their interfaces might be cataloged in a Universal Description, Discovery and Integration (UDDI) registry using the XML-based Web Services Description Language (WSDL).

With the increasing complexity of our military missions and reduction in reaction time needed to confront our adversaries, we need our military systems to interact at a human level. Ontologies represented in XML, through the evolving Ontology Web Language (OWL), can be employed to support this interaction by maximizing the amount of knowledge we can utilize. An ontology is used to define the terms used to describe and represent an area of knowledge (e.g., tactical mission) by defining a vocabulary and the meaning of that vocabulary. Figure 6 depicts an ontology fragment that defines and relates the knowledge contained in various MTFs in support of combat air missions.

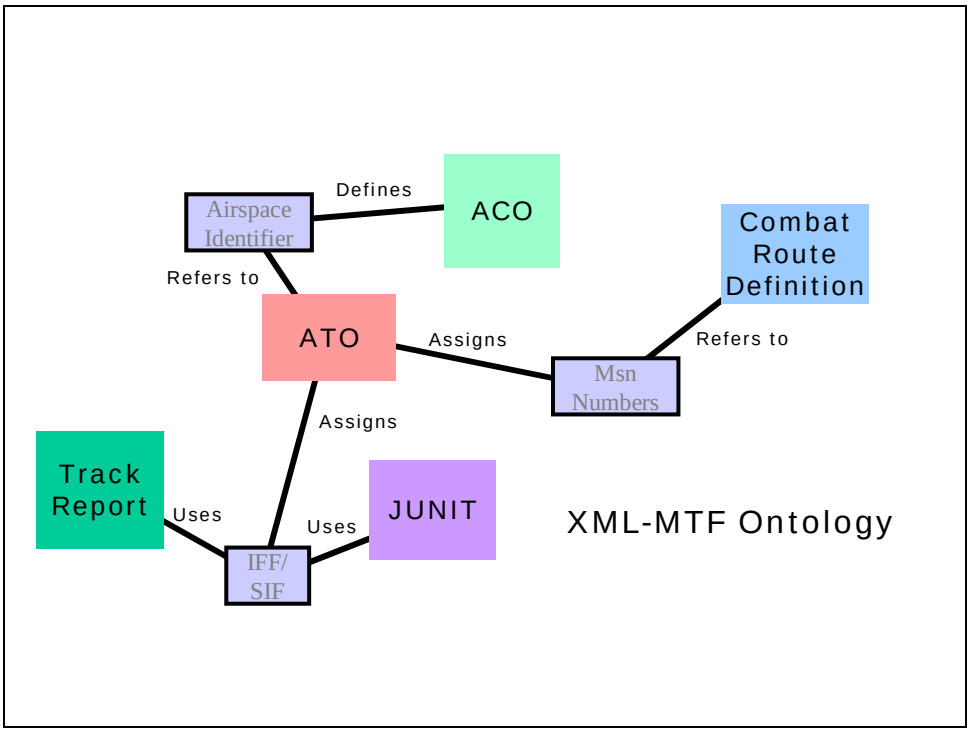

Figure 6. Notional Combat Air Mission Ontology Fragment

On the Horizon

Over the next few years, the DoD will be adopting XML standards and technologies in support of the migration of military systems to the Web. As C2 service systems evolve, the use of XML to manage and exchange information, including MTFs themselves, will grow significantly. This evolution is being documented in a USMTF/XML Roadmap currently being staffed in the AFC2ISRC. The foundational work described above should convince readers that the XML standards are equal to the task of enhancing formatted message-based interoperability.

Increasingly, coalition-oriented operations will be facilitated through "plug and play" information infrastructures. Operational procedures will be captured in business-to-business (B2B) processing models. Based on MTF CM, these models will capture the evolving XML-MTF information exchanges. Systems will find and communicate with each other adaptively -- Web Services will enable systems to describe themselves and repositories will facilitate automating the information sharing among them. Such an environment will adapt dynamically to changes on the battlefield and in policy. XML-based security guards exploited by Web services will improve security in this coalition environment.

A collaborative framework based on XML-MTF will integrate disparate information producers and consumers. As shown in Figure 7, such a framework will provide new and innovative ways to manage information processes. Through semantic linkage to operational procedures (business rules), massive amounts of information will be manipulated and exploited quickly and predictably to provide context sensitive

information and knowledge for the warfighter. Intelligent agents and the ability to affect dynamic modifications in workflow will create a highly adaptable warfighting environment – one that is better able to provide common situational awareness and address the ever-changing conditions of the battlefield.

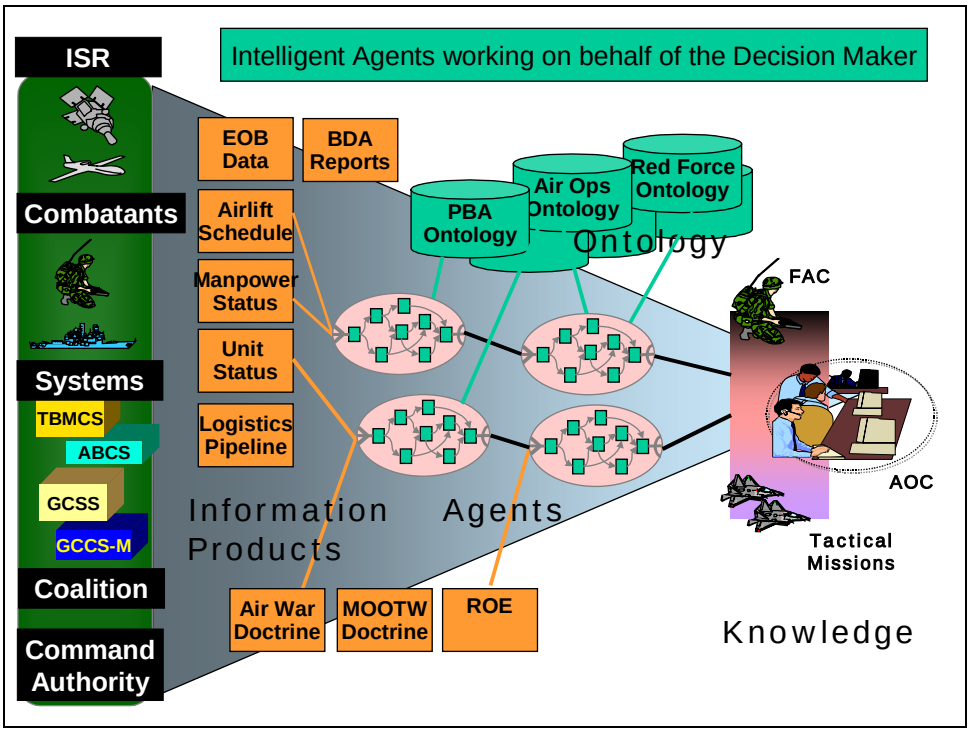

Figure 7. Intelligent Agents Leverage Information into Knowledge

Conclusion

The efforts discussed in this paper are focused on transforming and exploiting the tactical messaging standard (USMTF MIL STD 6040) management process through XML technologies. This process will lay the foundation for a DoD information environment that will prove integral to achieving and maintaining Information Superiority. It will integrate, via "plug and play" components and systems, automated agents, and human organizations, the functions, business rules, services and information required by the warfighter to make timely, effective decisions.

As further applications of the XML-MTF concept are prototyped, validated and deployed into the MTF community, we believe the current message processing model in general – and the USMTF standard in particular – will leapfrog from a circa 1970 batch-push mentality into the next generation of smart-pull, information-on-demand technologies. Early results promise rapid, low-cost technological improvements to message-based interoperability. This means facilitating *forward migration* to emerging web-based technologies and solutions in ways that still maintain *backward compatibility* with status quo business/operational processes for those who need them.

The incorporation of XML into interoperability solutions will maximize opportunities to use COTS technology (e.g., for supporting distribution, processing, configuration management) and high-quality freeware. This improvement alone should represent a considerable cost benefit. When taken together with XML's pervasiveness, XML-MTF and similar conceptual approaches are gaining developer and user "buy-in" to web-based solutions, increasing the value of these methods in next-generation C2 systems and other information-centric systems currently using formatted message exchange for interoperability.

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