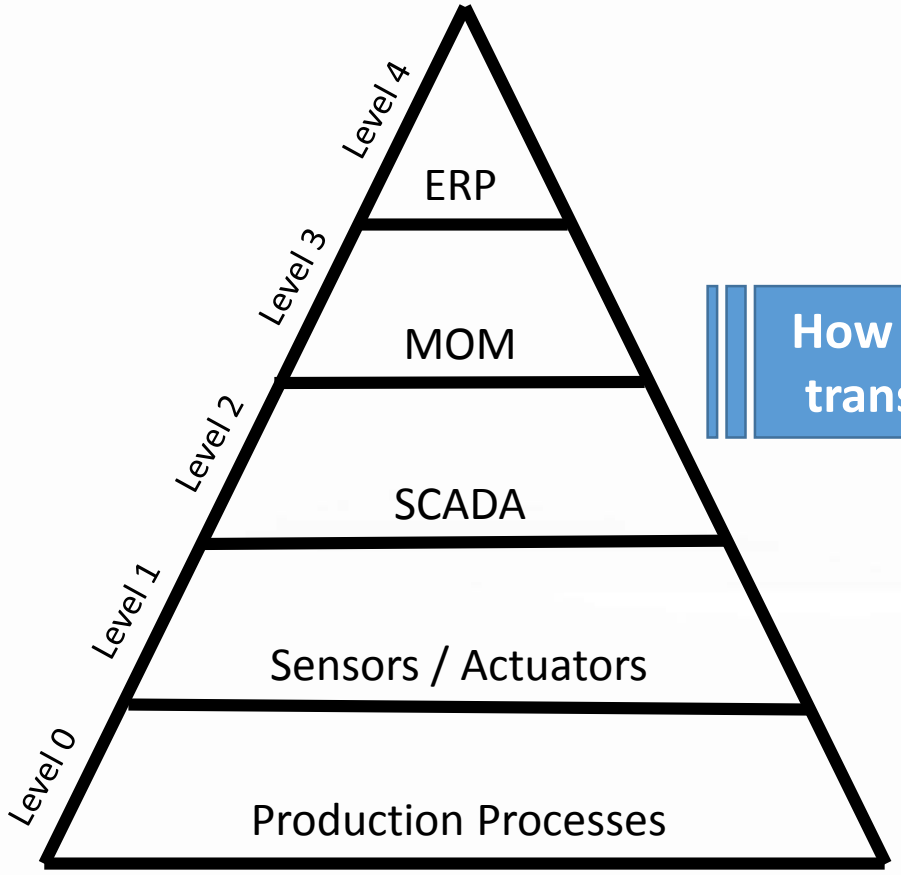
Service-Oriented Architectures for Smart Manufacturing Project

Nenad Ivezic
Systems Integration Division
Engineering Laboratory
NIST

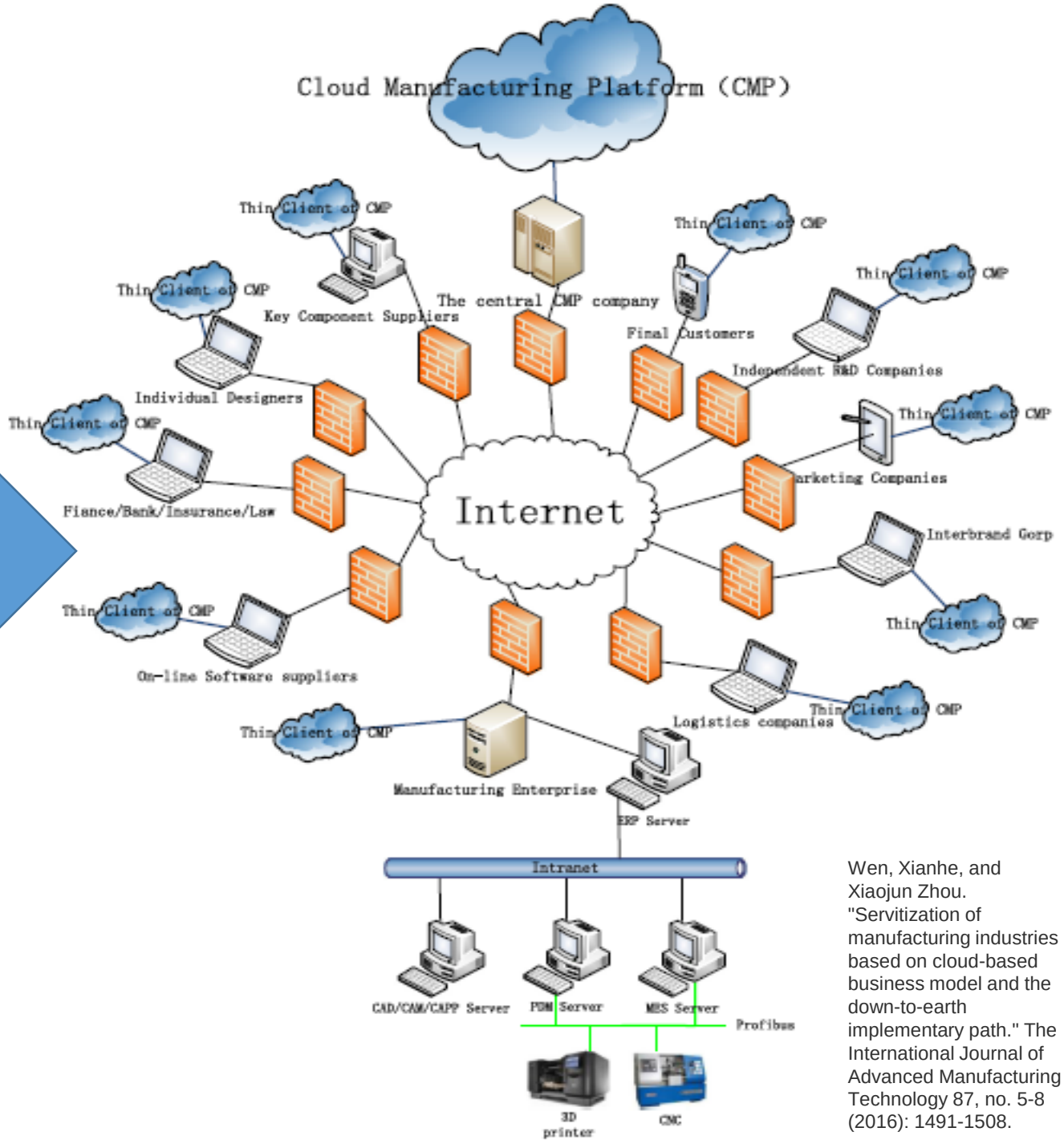
Agenda

- SOA for Smart Manufacturing Project: An Overview
- Message Standards Development and Use: Problems and Needs
- A Model-Driven Approach: Core Components Standard Approach
- Traditional vs. Model-Driven Approach to Message Standards Use
- NIST Tools in Support of Model-Driven Message Standards
- Summary

Cloud-Enabled Service-Oriented Manufacturing



How best to transition?



ERP – Enterprise Resource Planning
MOM – Manufacturing Operations Management
SCADA – Supervisory Control and Data Acquisition

Wen, Xianhe, and Xiaojun Zhou. "Servitization of manufacturing industries based on cloud-based business model and the down-to-earth implementary path." The International Journal of Advanced Manufacturing Technology 87, no. 5-8 (2016): 1491-1508.

Integrability, Interoperability, and Composability

- Integrability
  - Enables correct information exchange by using correct protocols.
- Interoperability
  - Enables correct understanding of meaning by using correct conceptual models.
- Composability
  - Enables correct consequences of interaction by using correct behavior models.

Integrability, Interoperability, and Composability

- Integrability
  - Enables correct information exchange by using correct protocols.
- **Interoperability**
  - **Enables correct understanding of meaning by using correct conceptual models.**
- Composability
  - Enables correct consequences of interaction by using correct behavior models.

Message standards are key to achieving services interoperability.

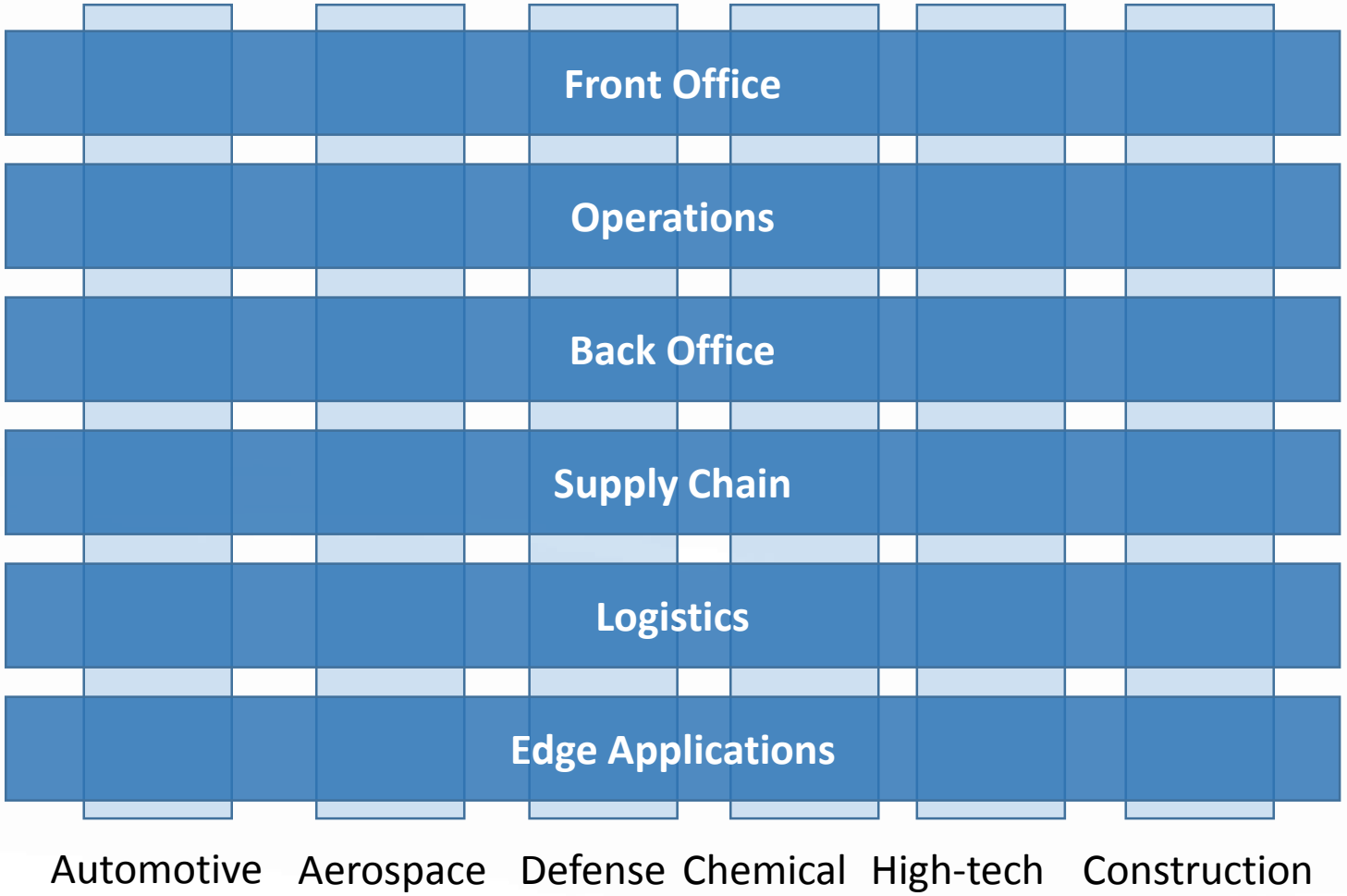
Why is This Significant?

- The number of manufacturing services is growing substantially.
- Soon, all manufacturers will need to be using those services.

Need: Increased Efficiency of Services Integration

- Manufacturers will need to assure their business processes are supported and improved by services
- They will be looking for optimal services out there
  - Ease of integration, configuration, and re-configuration
- The services will need to be interoperable and composable, **based on standards.**

A Leading Message Standards Development Organization: Open Applications Group Inc.



Who Uses Open Applications Group Integration Specification (OAGIS)?

Copyright 2016 Open Applications Group, Inc. All Rights Reserved

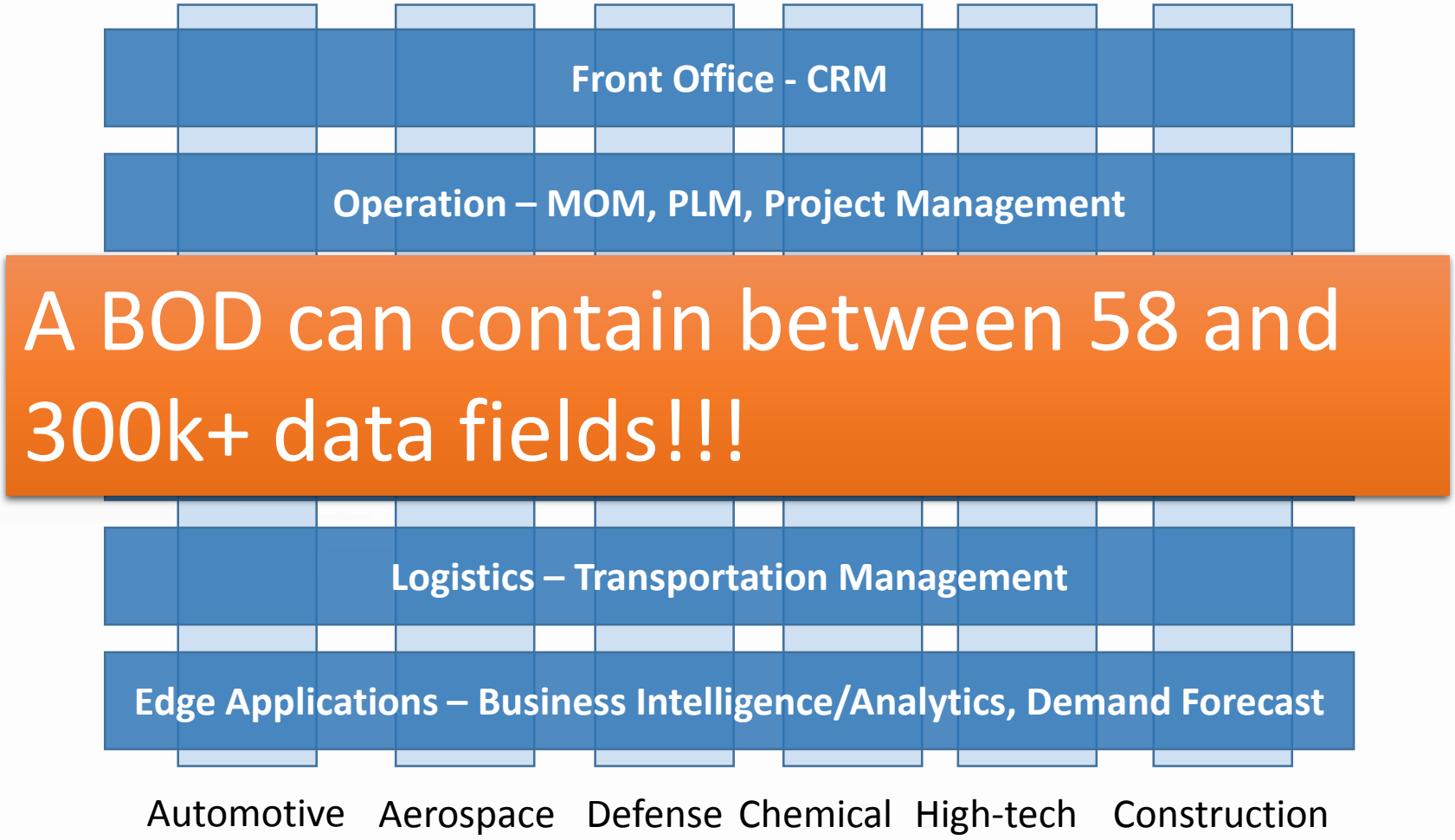
Overview of the OAG Integration Specification (OAGIS)

- Specifies message definitions (BODs) for integrations of business and engineering applications (***manufacturing services***)
- Supports many industries
  - Automotive, Aerospace, Defense, Process Manufacturing, Electronic Manufacturing, Construction, etc.
- Supports nearly all operational areas of a manufacturing enterprise
  - Sales, manufacturing, supply, and financials
- Contains 1000+ BODs

Problems

- BOD complexity
- Single syntax support

Problem: A Complex Standard



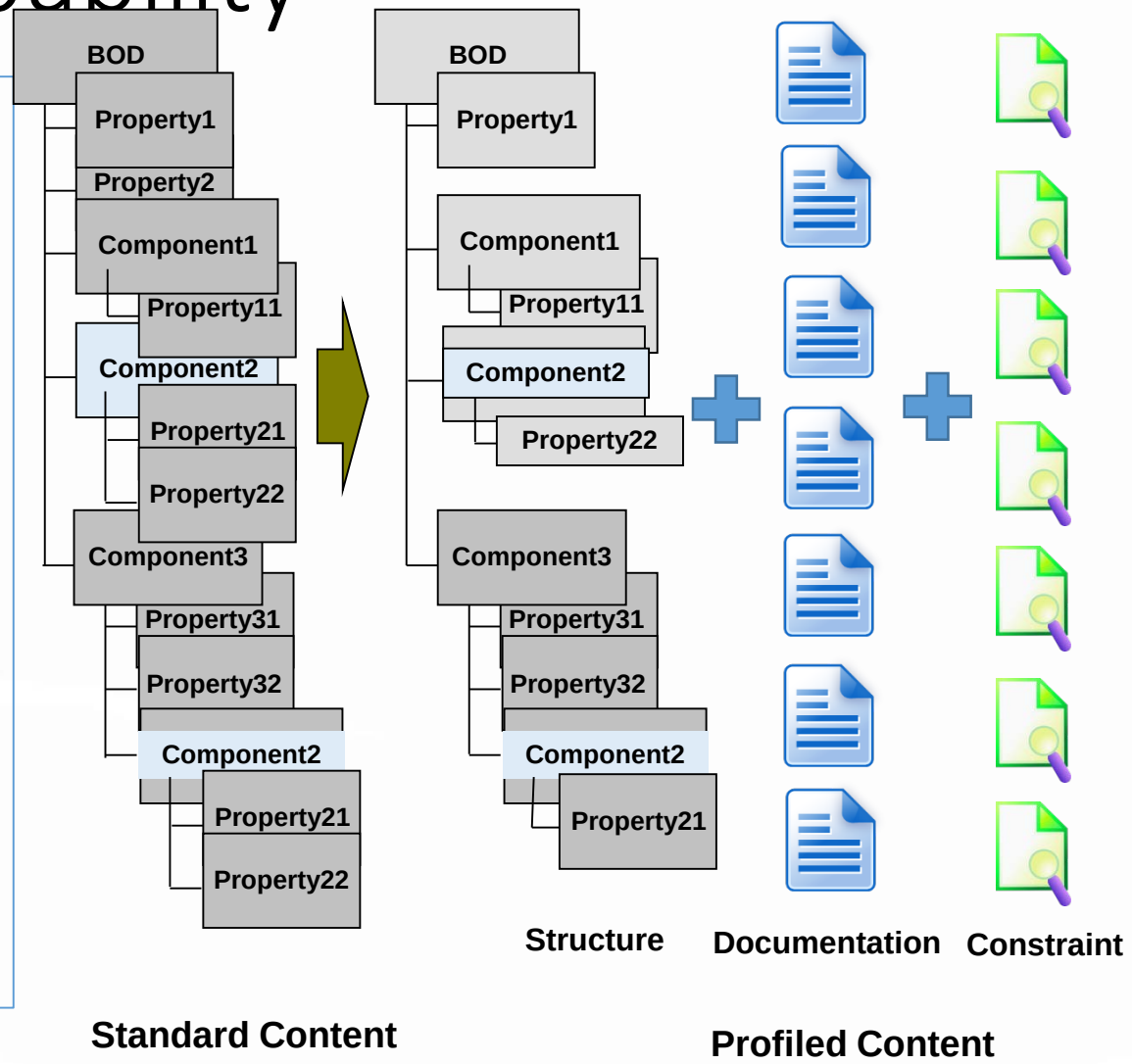
Need: Profiling Capability

The ability to create from a standard BOD

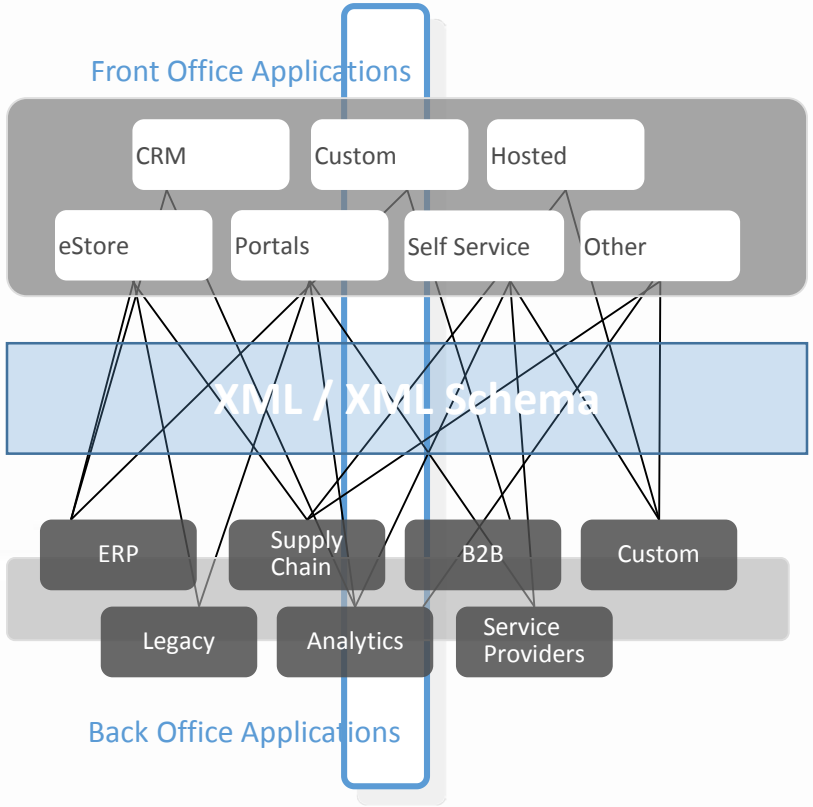
- Simpler
- More specific, and
- More precise

BOD specification, for

- Each specific industry
- Each specific process
- Other specific aspects



Problem: A Syntax Specific Standard



Need: Multiple Syntax Support

Model Driven Approach

Model

Syntax Independent OAG Standard

Production Rule for JSON Schema

Production Rule for XML Schema

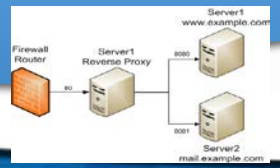
Production Rule for OWL/RDF Schema

Cloud and Mobile Platform

OAG JSON Schema Standard

Enterprise Integration Platform

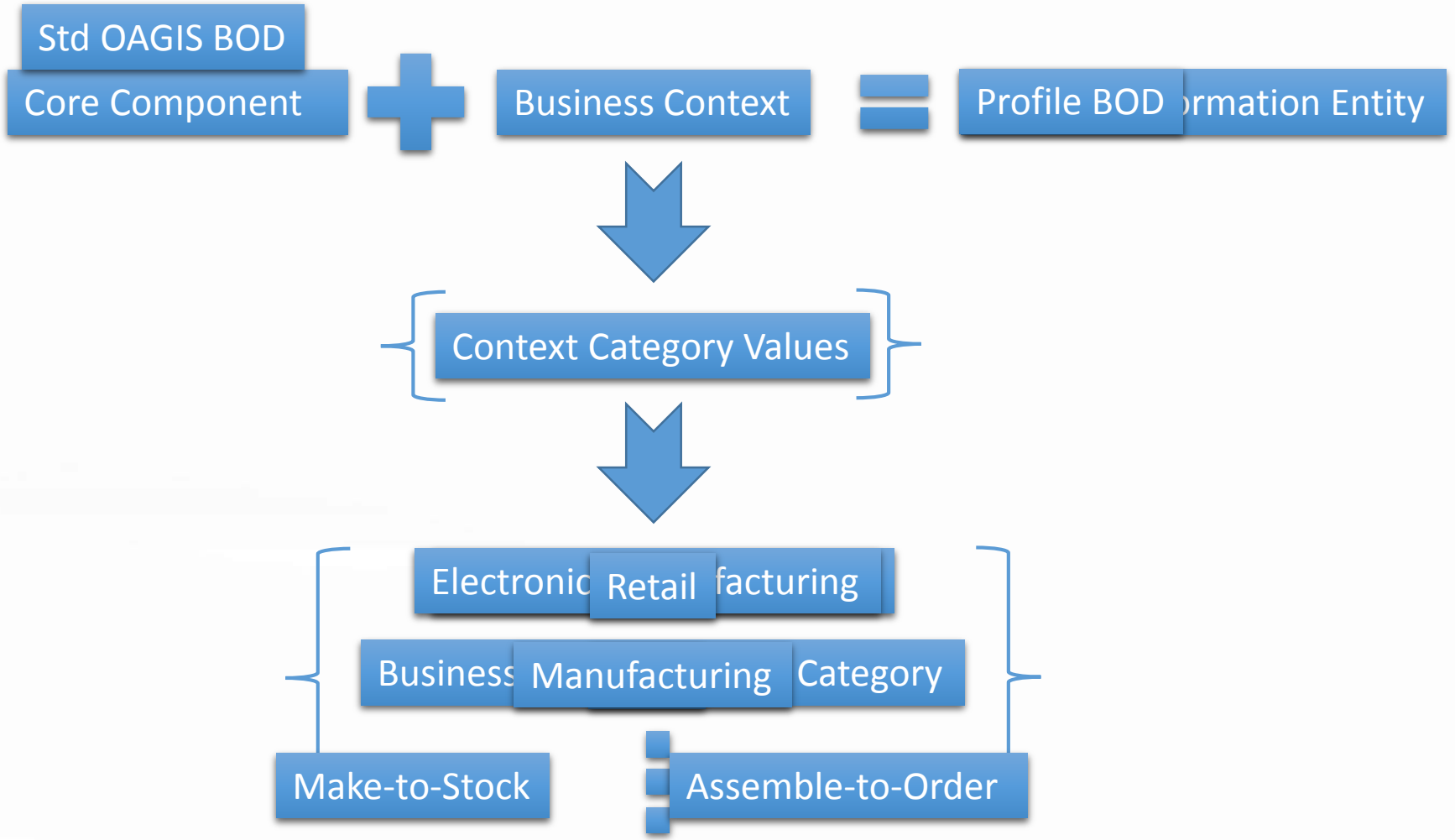
OAG XML Schema Standard



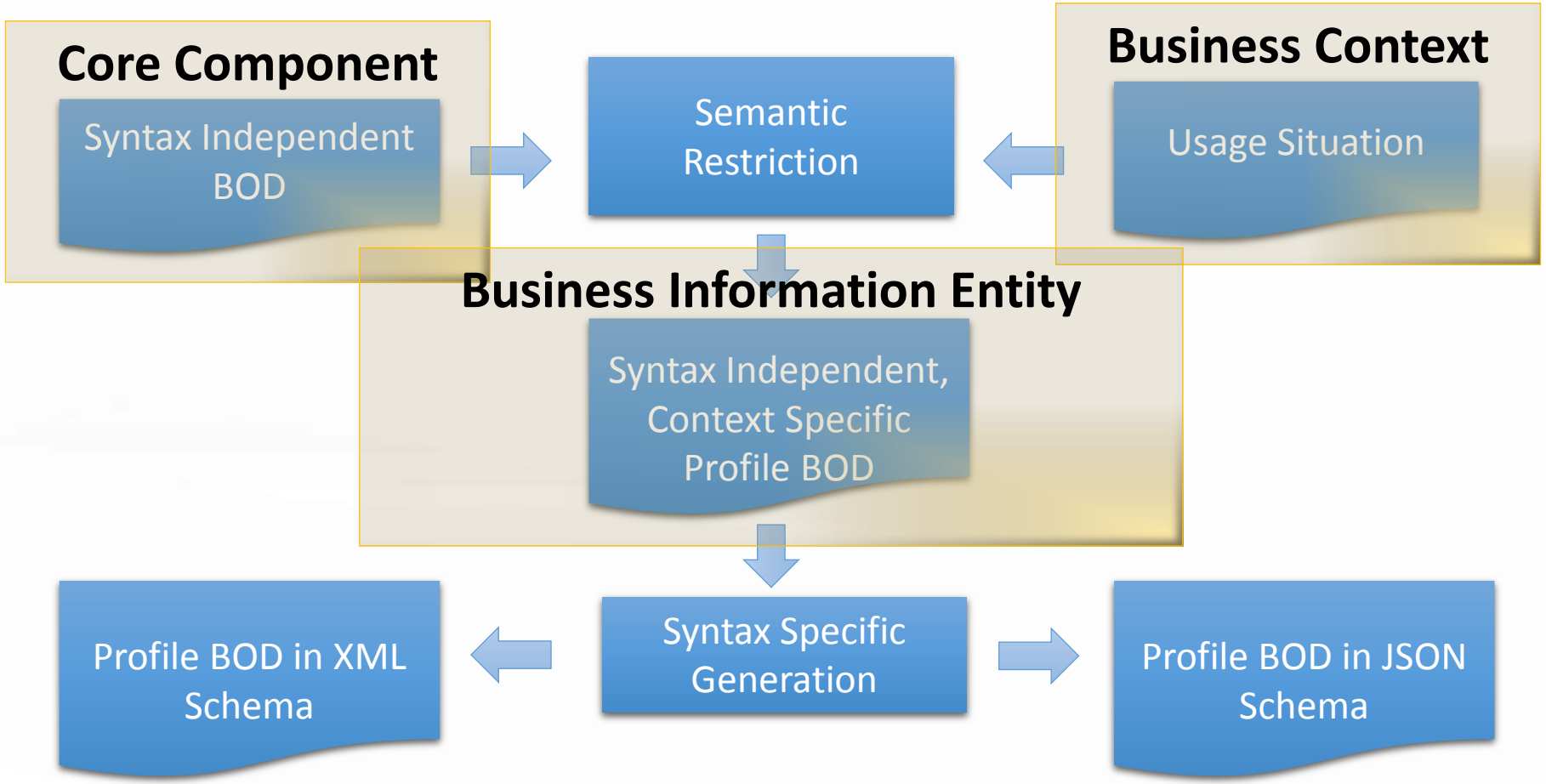
Business Intelligent Platform

OAG RDF Schema Standard

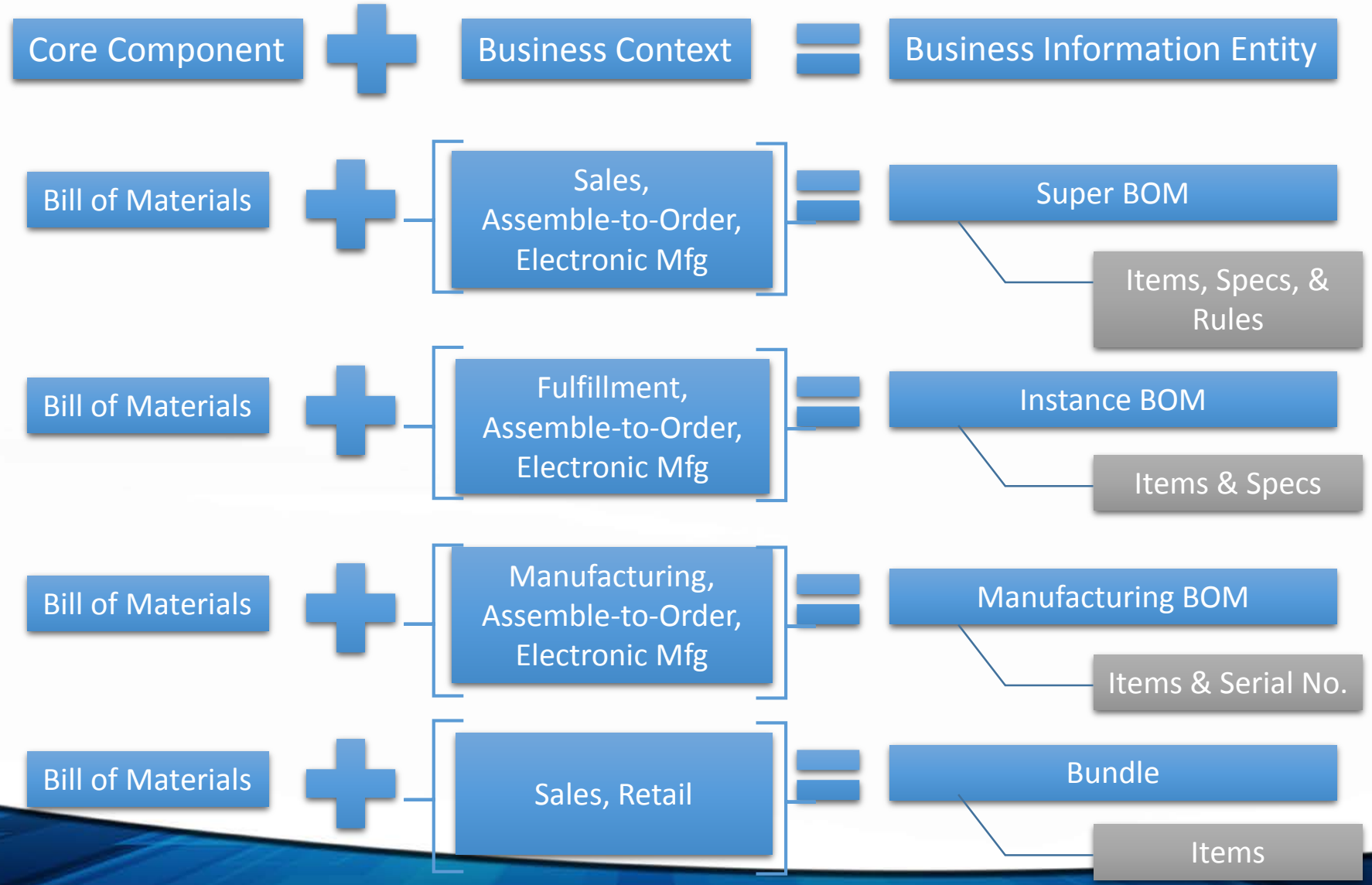
Overview of CCS Modeling Methodology



Functional Requirements to CCS Mapping



Example


Core Component
Business Context
Business Information Entity
Bill of Materials
Sales, Assemble-to-Order, Electronic Mfg
Super BOM
Items, Specs, & Rules
Bill of Materials
Fulfillment, Assemble-to-Order, Electronic Mfg
Instance BOM
Items & Specs
Bill of Materials
Manufacturing, Assemble-to-Order, Electronic Mfg
Manufacturing BOM
Items & Serial No.
Bill of Materials
Sales, Retail
Bundle
Items

Traditional Message Standards Use (1)

Legend:

Manual Effort or Human Readable Document

Automated Process or Computer Processable Resource

Traditional Message Standards Use (2)

Business Process Analyst

Integration Requirements

Design Phase

Implementation Phase

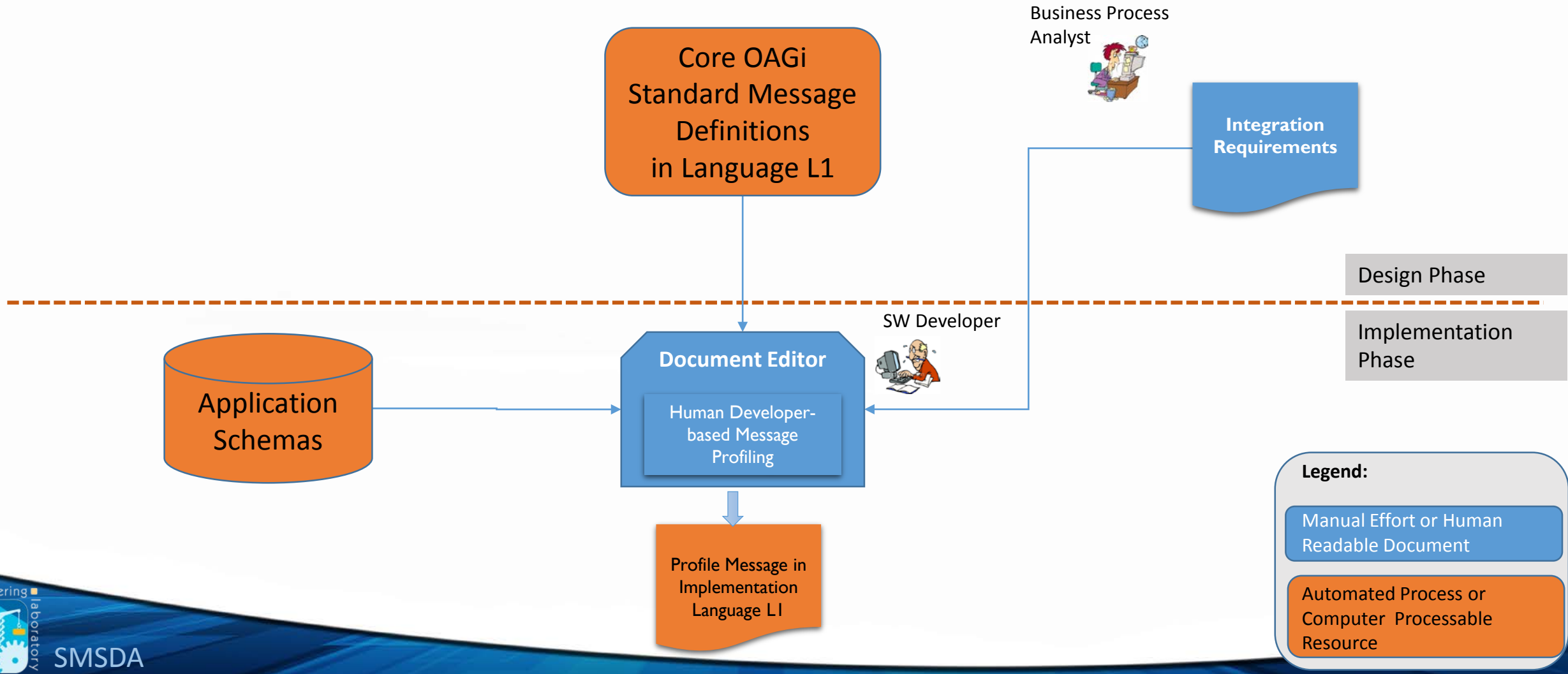
Profile Message in Implementation Language LI

Legend:

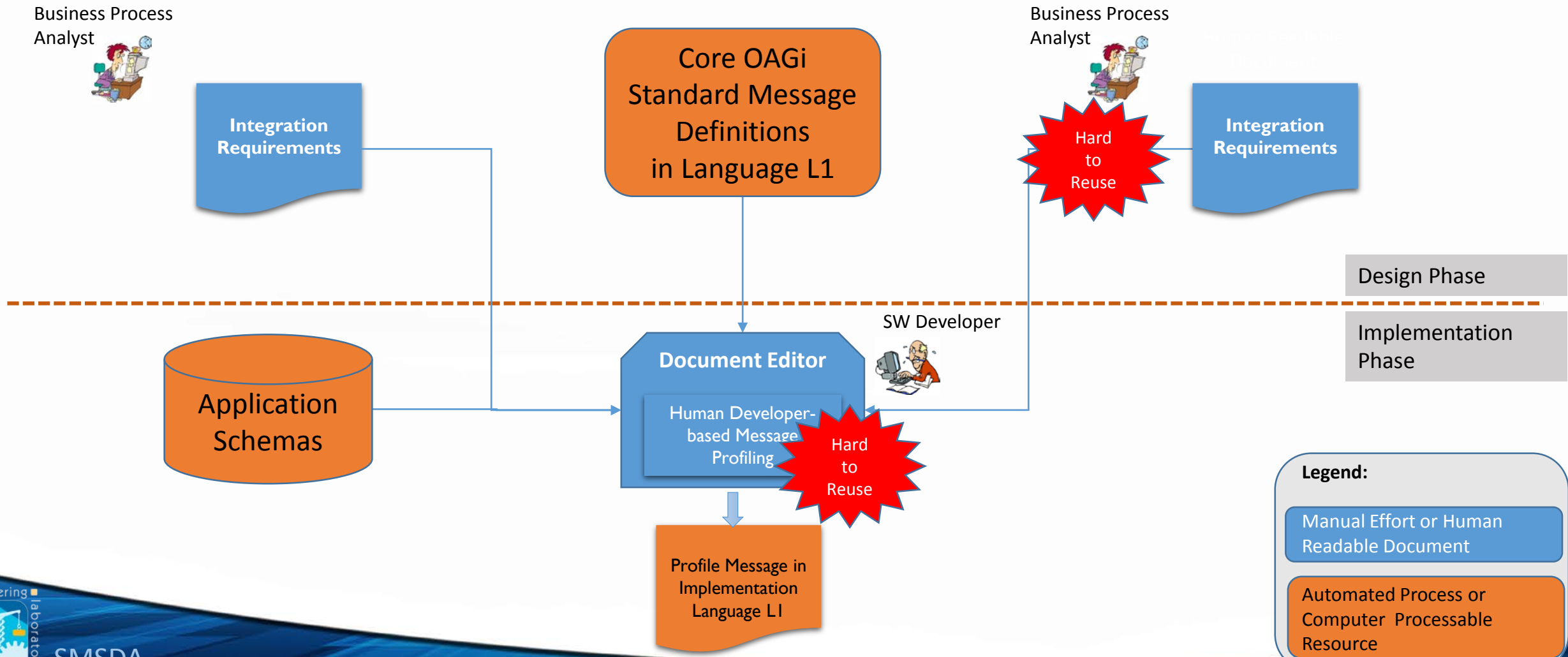
Manual Effort or Human Readable Document

Automated Process or Computer Processable Resource

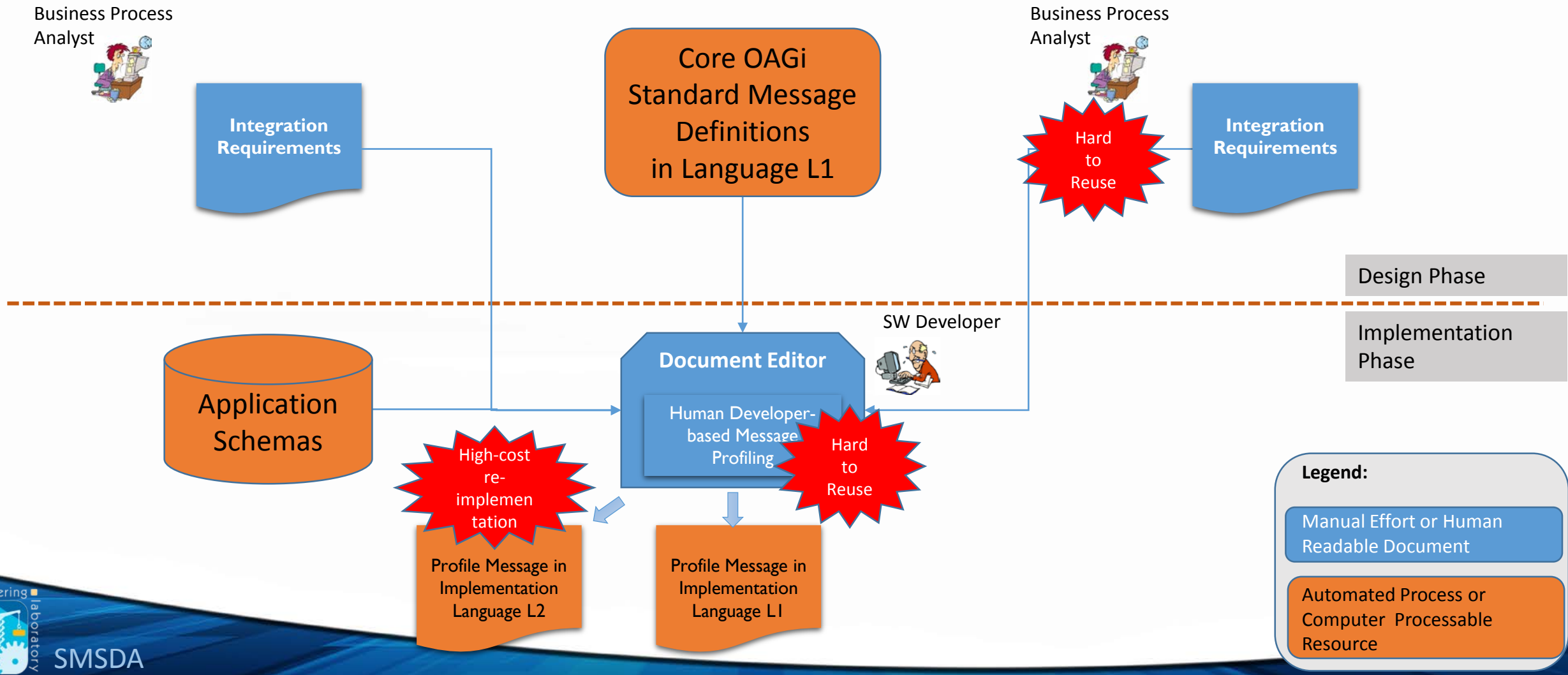
Traditional Message Standards Use (3)



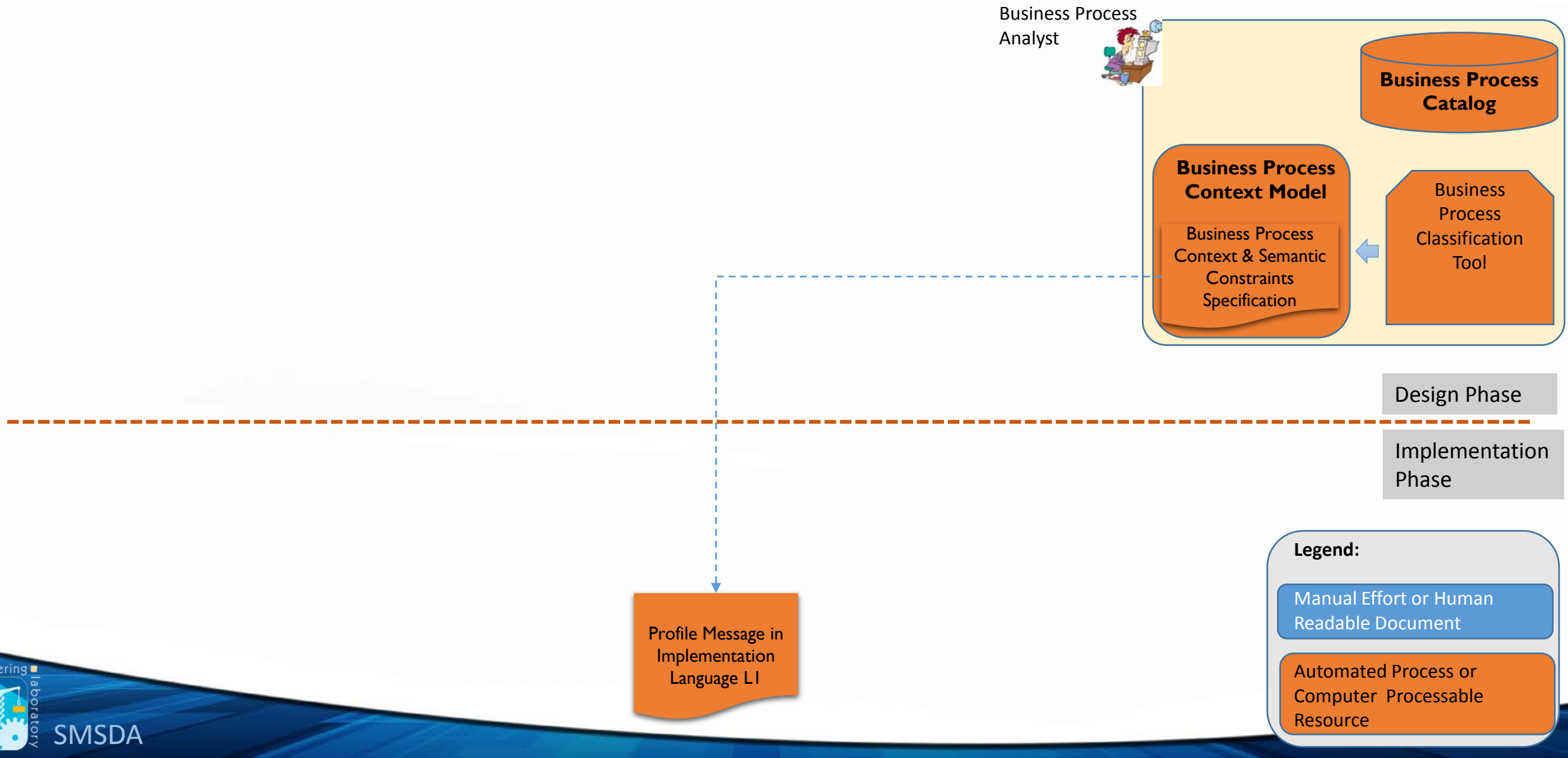
Traditional Message Standards Use (4)



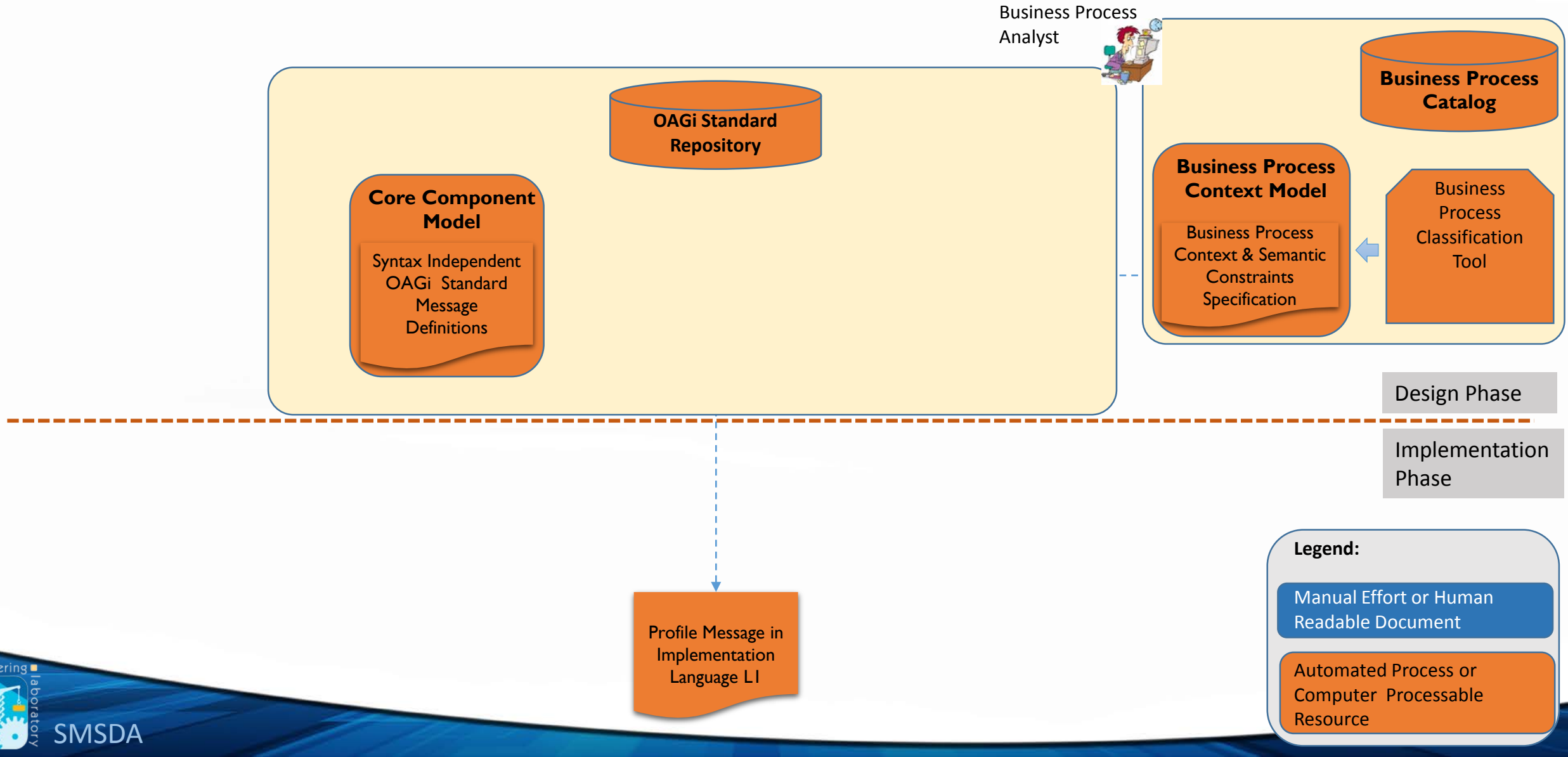
Traditional Message Standards Use (5)



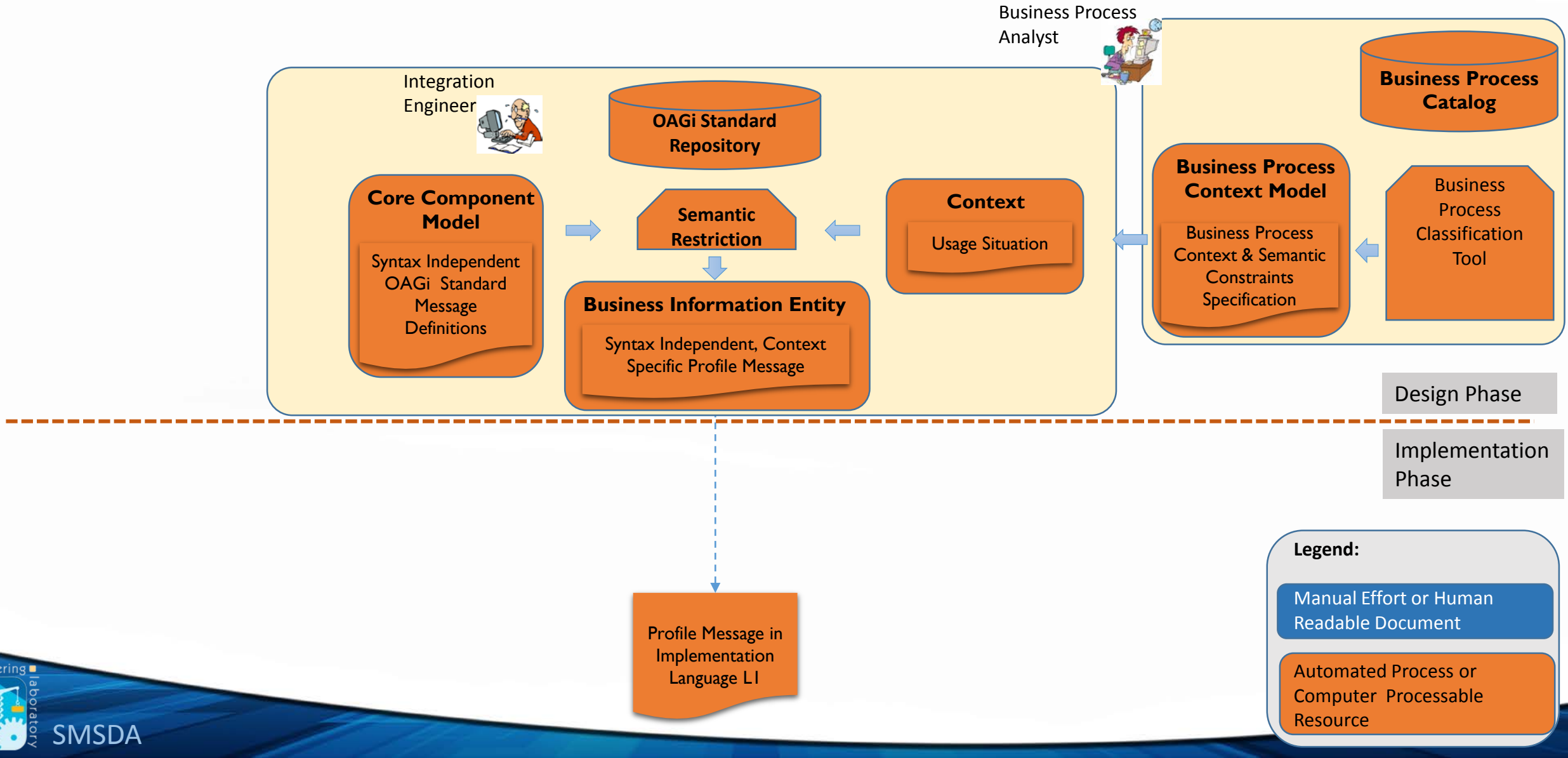
Model-Driven Message Standards Use (1)



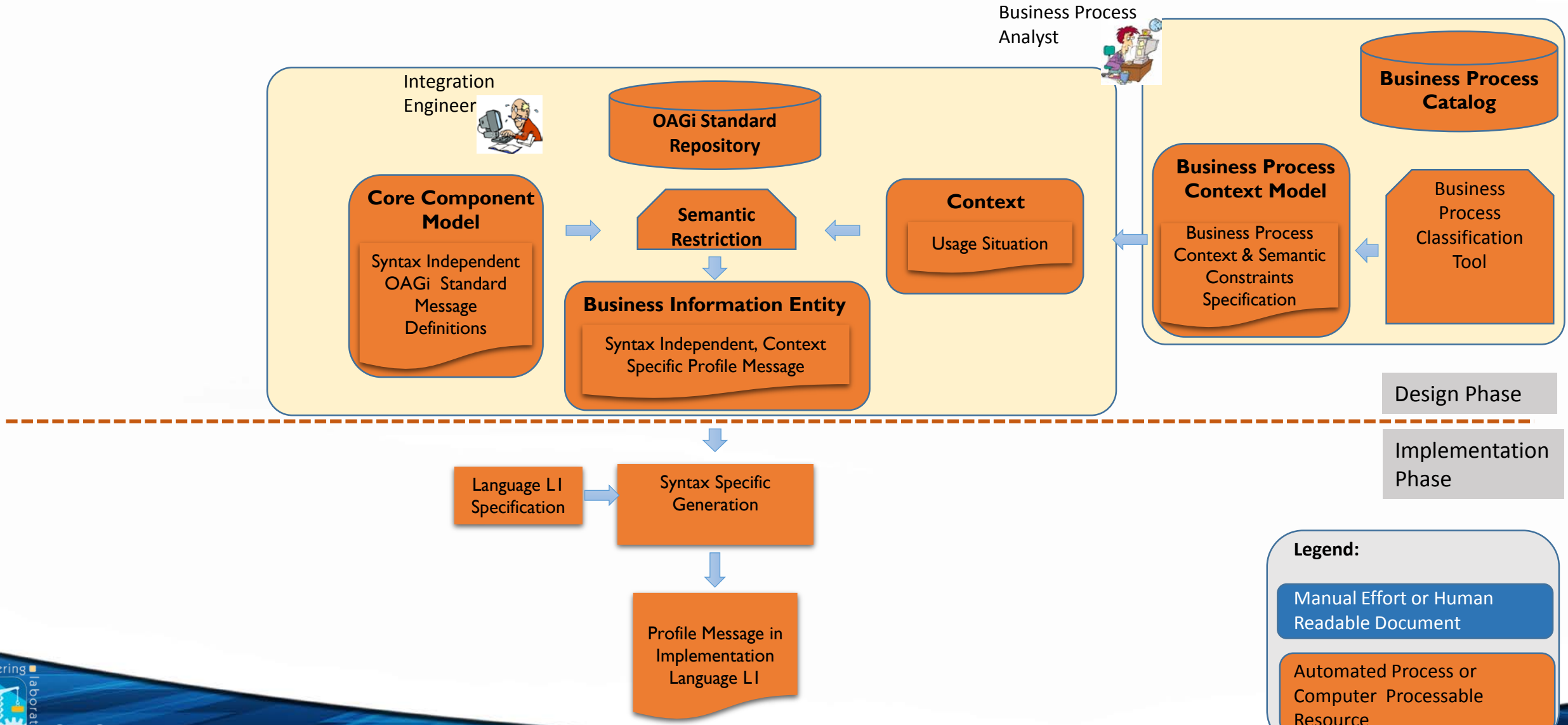
Model-Driven Message Standards Use (2)



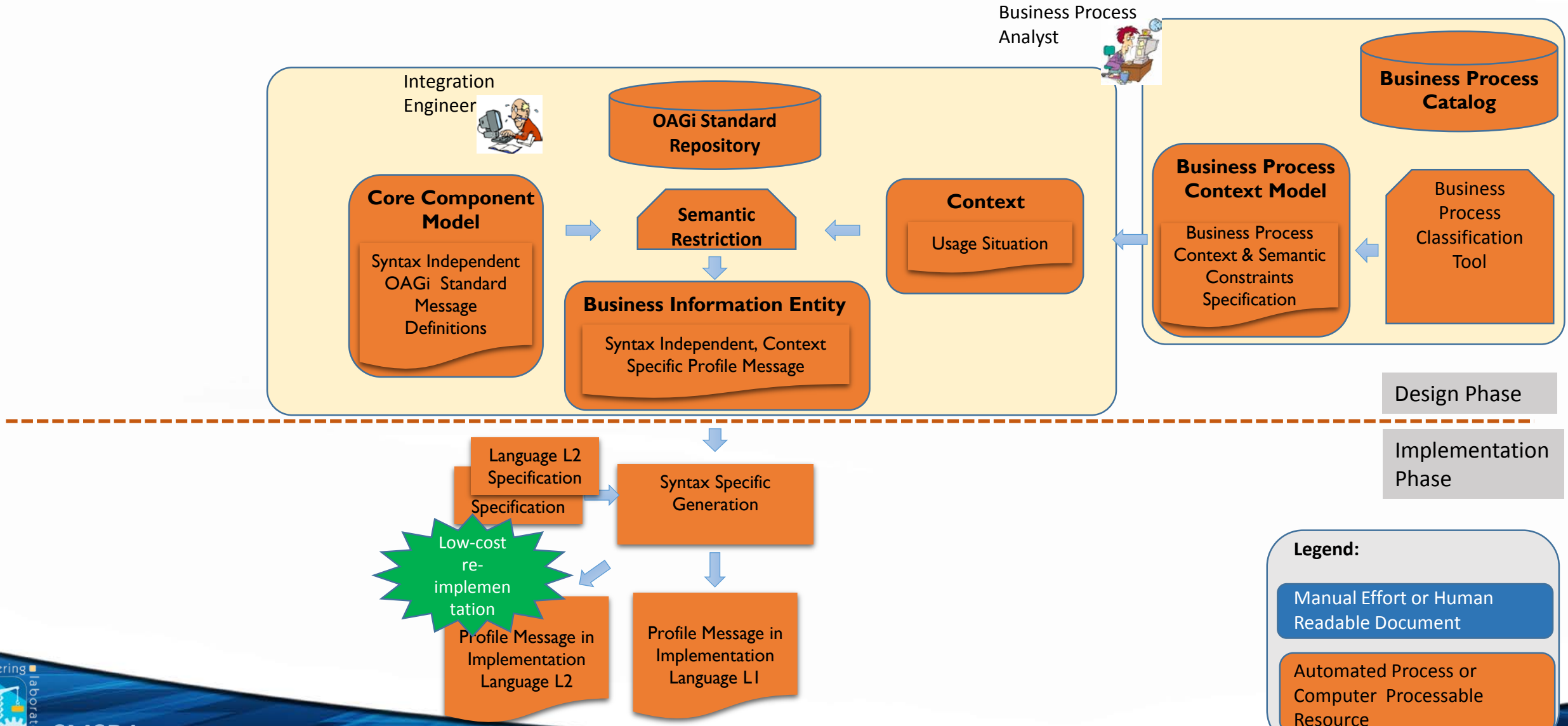
Model-Driven Message Standards Use (3)



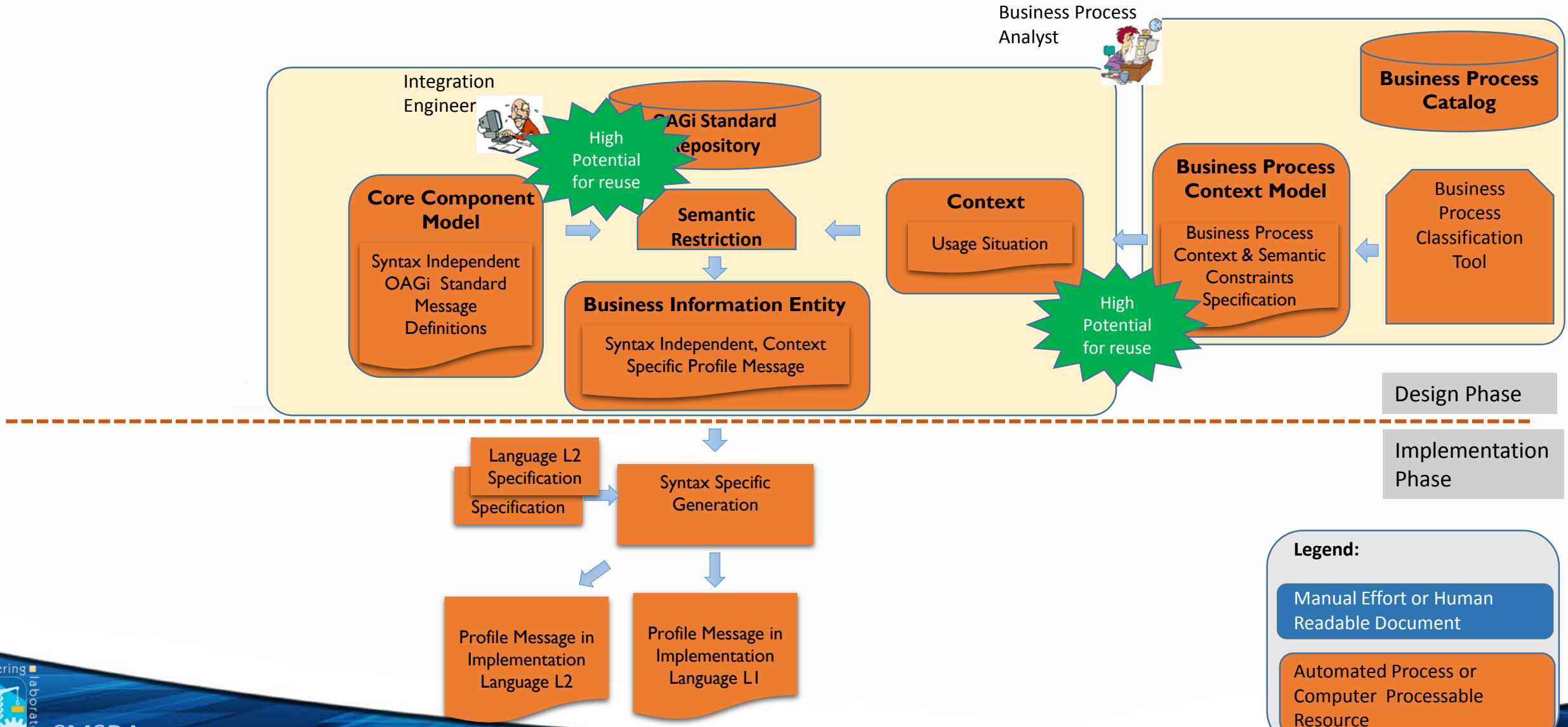
Model-Driven Message Standards Use (4)



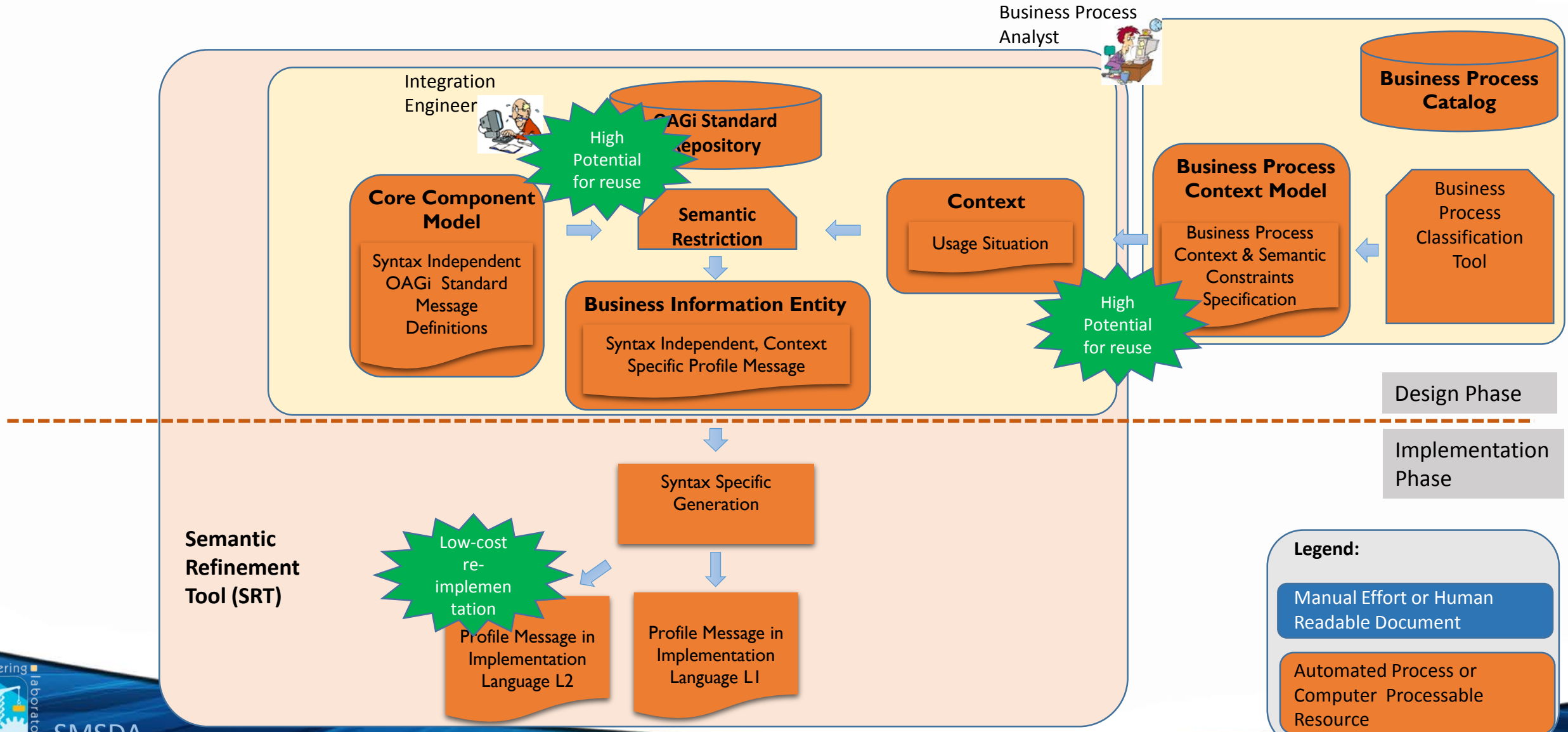
Model-Driven Message Standards Use (5)



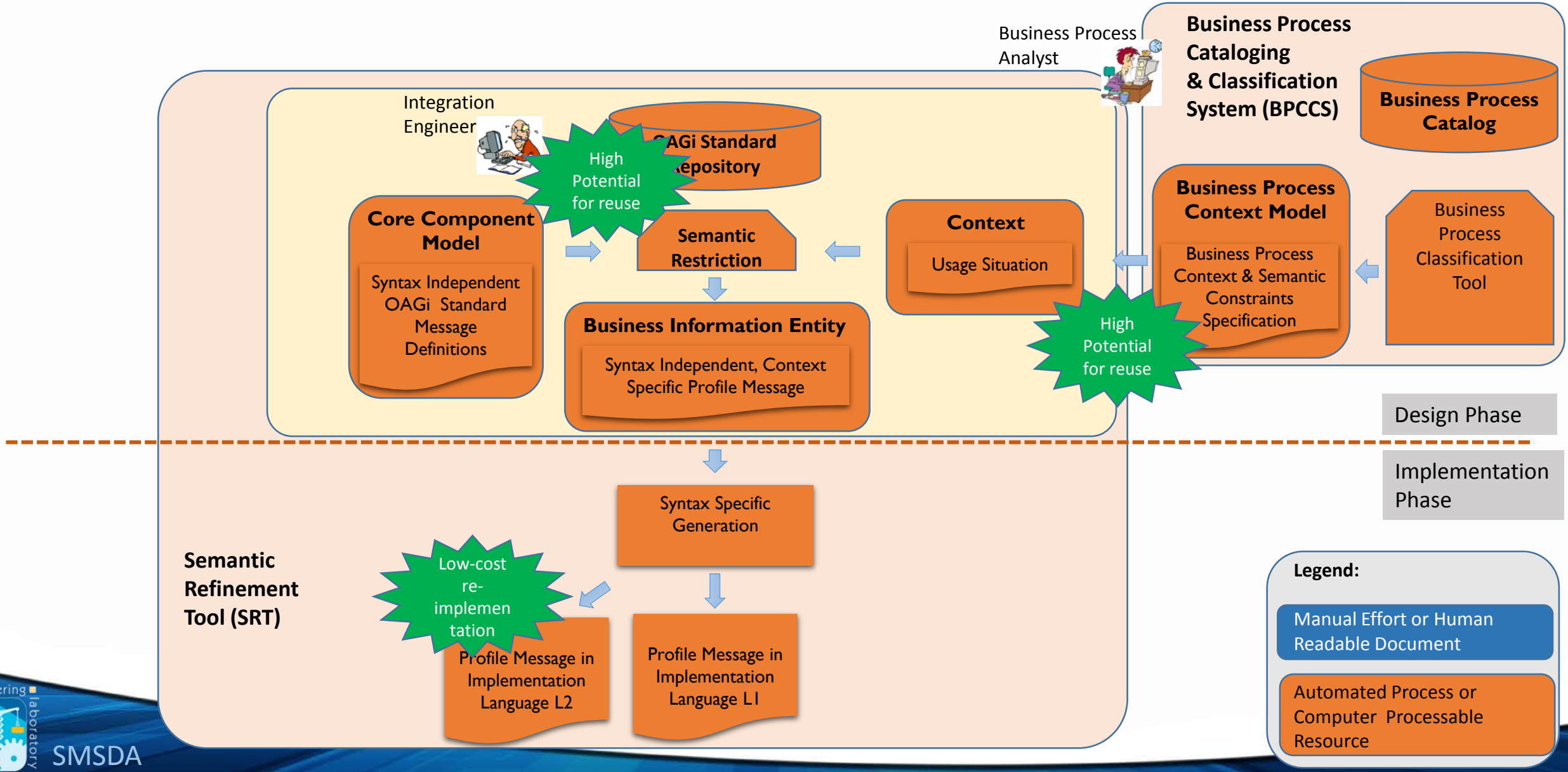
Model-Driven Message Standards Use (6)



Model-Driven Message Standards Use (7)



Model-Driven Message Standards Use (8)



Why These Two Tools?

- Semantic Refinement Tool & Business Process Cataloging and Classification System have been selected to
  - Boot-strap Model-Driven approach to message standards
  - Enable low-hanging fruit and engage industry early in the R&D process

Semantic Refinement Tool: Quick Overview

- Developed a new **syntax-independent data model and structure** for OAGIS standard - based on CCS (ISO 15000-5) standard
- Designed a cloud-based architecture for collaborative message specification management
- NIST developed and verified a prototype Semantic Refinement Tool (SRT) with feedback from OAGi members.
- NIST transitioned the prototype to develop a cloud-based multi-tenant implementation

Business Process Cataloging and Classification System: A Quick Overview

- Created the BPCCS meta-model based on ebRIM (ISO/TS 15000-3) standard
- Developed and verified a BPCCS prototype with feedback from OAGi industry members.
- Validating prototype for message profiling and business process search

Summary

- The project helps industry address interoperability challenges for Service-Oriented Manufacturing (SOM)
- Industry requires improved message standards and their development processes
- The project team worked with industry and responded with
  - New model-driven approach to development and use of message standards
  - Software tools in support of the new approach
    - Semantic Refinement Tool (SRT)
    - Business Process Cataloging and Classification System (BPCCS)