Summary

- Biography
- Intro & Problem Definition
- System Overview & Objectives
- Needs Analysis
- Concept of Operations
- Requirements Analysis
- Functional Analysis
- Conceptual Design
- Trade Study
- Risk Management
- System Specification
- Concept Evaluation & Future Work
- Project Management & Schedule Evaluation
- Lessons Learned & Recommendations
Personal Information

• **Education** - University of Virginia
  • BS, Systems Engineering
    • Concentration: Computer and Information Systems
    • Minors: Computer Science, Engineering Business

• **Current Work** - Engility Corporation
  • Requirements Manager for Department of Veterans Affairs (VA), Office of Information & Technology (OIT), Budget Tracking Tool (BTT)
    • BTT - GOTS software system that helps the VA manage a $3 billion budget
  • Primary Responsibilities:
    • Managing requirements throughout SDLC
    • Requirements elicitation /analysis
    • Release planning and supporting PM activities
    • Developing high level designs for complex system enhancements

• **Personal**
  • Resident of Arlington, VA
  • Interests/Hobbies:
    • Traveling!
    • Music (piano, guitar)
    • Hiking, biking, kayaking
Introduction & Problem Definition

- **The Problem of Warranty Fraud**
  - A major industry issue, growing increasingly significant
  - The cause of significant losses for companies, both direct and indirect
    - Costs to provide services/replacements not backed by valid warranties
    - Research & development costs
    - Security costs
    - Costs resulting from distorted product failure statistics
  - Negatively impacts to company reputations and relationships
  - Driving up warranty costs for consumers

- **What is Warranty Fraud?**
  - “The usage of services or replacement products to which one is not entitled under a valid warranty.”
  - Examples:
    - Requesting replacements for products not owned/returned
    - Receiving service for a product not actually covered by a warranty
Existing Solutions & Systems

• Manual data analysis
  • Inefficient for large data quantities
  • Pattern and anomaly detection impossible without analysis/comparison of all claims
  • Analysts focus on a subset of claims and never see the entire picture

• Existing software tools
  • Limited scope and flexibility
    • Static analysis and detection functionality against pre-defined rules
    • No ability to adapt to new forms of “attack” from fraudsters
    • Customization limited or unavailable
  • Limited interfacing capabilities
The Problem Revisited

- **Published Problem:** Warranty Fraud
- **Root Cause:** Use of disparate, unadaptable systems/software across the warranty firm to manage claims and perform business functions
  - Limited to no data sharing
  - Limited collaboration and coordination between departments
- **Solution:** A single, cohesive system to support and integrate all interrelated company functions.
  - To improve data management and transparency
  - To streamline business processes across departments
  - To align competing focuses
  - To improve fraud detection capabilities
System Overview & Objectives

• **The WFMS is...** An integrated software system that supports the entire warranty management process from warranty issuance to claim submission to claims analysis and fraud detection, with the overarching goal of decreasing the amount of undetected fraudulent claims.

• **Primary system objectives:**
  - Support a variety of interrelated business functions via a single system
  - Streamline warranty and claims tracking and processing
  - Reduce warranty costs by improving fraud detection
  - Integrate data from disparate systems that are all essential to effective claims management and fraud detection
  - Improve the effectiveness of claims analysts by allowing them to shift their focus from data management and entry and analysis of all claims, to focus on analyzing the claims that are most likely to be fraudulent
  - Improve the integrity, quality, and consistency of warranty and related data
Needs Analysis

• Needs Analysis Process
  • Research – warranty management process, warranty firm structure, industry issues, existing technology
  • Key Stakeholder Interviews
    • Program Management and Financial Functions Expert
    • Fraud Department Expert

• User Needs List: The system shall...
  1. Provide comprehensive warranty claims tracking capabilities.
  2. Provide claims creation and submission capability to Customer Service Representatives via dynamic, guided instructions and input prompts.
  3. Provide robust fraud detection and analysis capabilities.
  4. Support interfaces/data exchanges with other company systems and external system.
  5. Facilitate all claims through each stage of claims processing until the claim is either rejected or completed.
  6. Provide warranty packaging assistance capabilities.
  7. Support the complex financial analysis activities of the firm.
  8. Provide secure storage and access control of claims information and all other stored data.
  9. Be easily accessible and utilized by users while in the field conducting claims related activities.
  10. Provide dynamic reporting capabilities.
Concept of Operations

- **WFMS OV-1:**

  - Fraudster
  - Warranty Owner
  - Customer Service Representative
  - Warranty Firm Personnel
  - Warranty Firm’s Existing Systems
  - Product Manufacturers
  - Integration/Data Exchange with Firms existing systems (FMS etc)
  - Warranty Related Product Specifications
  - WFMS
  - Claims submission
  - Fraudulent Claim detection/rejection
  - Requests for claims
  - Instructions/Prompts to facilitate claim submission
  - Claim Updates/Notifications
  - Data/stats/analysis, results of automated system functions, indication of fraud
  - Queries, Data Analysis, Direct interaction with system for execution of business functions
  - Product/Warranty Package Information
  - Warranty Sales Data
  - Replacements/Spare Parts Inventory Management, Shipping
  - Supply Chain
  - Retailers/Sellers of Products & Warranties
  - Service visit for processed claims
  - Claims audit results
  - Audit scheduling
  - Service visit results
  - Claims audit results
  - Audit scheduling
  - Service Provider
  - Claims Auditor
Operational Scenarios

• S1: Submission of Valid Claim
  1. Warranty Owner calls CSR to submit claim
  2. CSR accesses WFMS to submit claim
  3. WFMS prompts CSR to ask questions and input information
  4. WFMS auto-adjusts questions/inputs based on CSR inputs
  5. CSR submits claim, stored by WFMS
  6. WFMS assesses fraud likelihood of claim
  7. Warranty Firm Personnel view claim and fraud analysis
  8. WFMS identifies next processing step for valid claims [S2][S3]

• S2: Processing a Valid Claim Requiring Replacement

• S3: Processing a Valid Claim Requiring Service

• S4: Fraudulent Claim Follow-Up

• S5: Developing Warranty Packages
  1. User queries product/sales data from client info system & specification data sent from manufacturers
  2. WFMS generates product analysis and related reports
  3. WFMS generates recommended warranty packaging structures
  4. User reviews and refines packages
  5. Packages marked complete by the user are made available to Retailers
Requirements Analysis

• Stakeholder interviews to define user needs and elicit requirements
• Translation of User Needs (Subjective) -> Operational Requirements -> System Requirements (Objective)
• Documentation of requirements in Requirements Traceability Matrix (RTM) in hierarchical structure

<table>
<thead>
<tr>
<th>Artifact</th>
<th>Total</th>
<th># Quantitative</th>
<th>% Quantitative</th>
<th>% Binary</th>
<th>% Subjective</th>
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<tbody>
<tr>
<td>Requirements Analysis Report</td>
<td>128</td>
<td>69</td>
<td>54%</td>
<td>38%</td>
<td>8%</td>
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</table>

• Continuous RTM reviews and update throughout project to account for new system knowledge and issues identified during analysis
• Analysis of requirements as a whole for consistency, duplication, ambiguity, necessity, verifiability, and feasibility
# Requirements Traceability Matrix

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Justification/Origin /Notes</th>
<th>KPP</th>
<th>Quantitative</th>
<th>Binary</th>
<th>Subjective</th>
<th>Verification Method</th>
<th>Function Trace</th>
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<tr>
<td>[UN] 1.0</td>
<td>The system shall provide comprehensive warranty claims tracking capabilities.</td>
<td>User need expressed during stakeholder interviews.</td>
<td></td>
<td>x</td>
<td>N/A</td>
<td></td>
<td></td>
<td>2.0, 2.1, 2.1.1-2.1.5.5</td>
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<td>[OR] 1.1</td>
<td>The system shall allow users to create and maintain warranty claim records.</td>
<td>From stakeholder interviews.</td>
<td></td>
<td>x</td>
<td>D, T, A</td>
<td></td>
<td></td>
<td>2.1.1-2.1.4</td>
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<tr>
<td>[FR] 1.1.1</td>
<td>The system shall store warranty claims data.</td>
<td>From stakeholder interviews.</td>
<td></td>
<td>x</td>
<td>T</td>
<td></td>
<td></td>
<td>2.1.1</td>
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<tr>
<td>[NONF] 1.1.2</td>
<td>The system shall be able to accommodate at least 50,000 new claims additions per year.</td>
<td>From stakeholder interviews-scalability requirements.</td>
<td></td>
<td>x</td>
<td>x</td>
<td>A</td>
<td></td>
<td>N/A</td>
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<tr>
<td>[FR] 1.1.3</td>
<td>The system shall allow users to view claim information for existing claims.</td>
<td>From stakeholder interviews.</td>
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<td>x</td>
<td>D, T</td>
<td></td>
<td></td>
<td>2.1.2</td>
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<tr>
<td>[NONF] 1.1.3.1</td>
<td>Warranty Firm Personnel with less than 2 hours of training shall be able to successfully locate and view an existing claim within 2 minutes of accessing the system.</td>
<td>Usability requirement. Derived based on key functions performed by users.</td>
<td></td>
<td>x</td>
<td>D</td>
<td></td>
<td></td>
<td>N/A</td>
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</table>
Functional Analysis

- Top down approach to derive high level functions, then more detailed objective functions
- Functions developed from requirements and other stakeholder information (scenarios etc.)
  - User needs and operational requirements -> high level functions
  - System requirements -> lower level functions
- Diagrams developed to model functions (inputs/outputs/interactions between functions and between functions and external entities)
  - Context Diagram
  - Functions list with traceability to requirements
  - Functional trees (Level 1 Functions, Level 2 Functions)
  - Functional Block Diagrams (Level 1 Functions, Level 2 Functions)
  - Functional N2 Diagram for Level 1 Functions
- Bi-directional traceability established between requirements and functions
  - To ensure all requirements are met by at least one function
  - To ensure completeness of requirements
  - To prevent unnecessary functions

<table>
<thead>
<tr>
<th>ID</th>
<th>Function</th>
<th>Requirements Trace</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>Support Warranty Management Process</td>
<td>[OR] 2.1, [UN] 2.0</td>
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<td>1.0</td>
<td>Provide Real-time CSR Guidance for Claim Creation</td>
<td>[OR] 2.1, [UN] 2.0</td>
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<tr>
<td>1.1</td>
<td>Display Questions for Claim Owner</td>
<td>[FR] 2.1.1, [OR] 2.1, [UN] 2.0</td>
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</table>
Functional Trees

1.0 Provide Real-time CSR Guidance for Claim Creation
  1.1 Display Questions for Warranty Owner
  1.2 Prompt CSR for Claim Information Inputs
  1.3 Receive Claim Information Inputs
  1.4 Validate Claim Information Inputs
  1.5 Determine Next Question
  1.6 Determine Next Field Inputs
  1.7 Check Required Field Completion
  1.8 Accept Claim Submission

1.0 Provide Real-time CSR Guidance for Claim Creation
  2.0 Provide Claims Management Support
    2.1 Support Claims Data Management
    2.2 Track Claim Status
    2.3 Schedule Claims Audit
    2.4 Schedule Claim Service Appointment

1.0 Provide Real-time CSR Guidance for Claim Creation
  3.0 Provide Inventory Tracking and Management Capabilities
    3.1 Add Inventory Item
    3.2 Remove Inventory Item
    3.3 Query Inventory Data
    3.4 Update Existing Inventory Item
    3.5 Link Inventory Item to Claim

1.0 Provide Real-time CSR Guidance for Claim Creation
  4.0 Support Fraud Detection and Analysis
    4.1 Provide Automated Fraud Detection
    4.2 Generate Automated Fraud Analysis
    4.3 Accept Fraud Rule Selection
    4.4 Accept New Fraud Rule Input
    4.5 Accept Fraud Rule Updates

1.0 Provide Real-time CSR Guidance for Claim Creation
  5.0 Provide Warranty Packaging Capabilities
    5.1 Receive Product Sales Data from Retailers/Client Systems
    5.2 Receive Warranty Sales Data from Retailers/Client Systems
    5.3 Receive Specification Data from Product Manufacturer System
    5.4 Generate Warranty Package Recommendations
    5.5 Display Warranty Package Recommendations
    5.6 Support Manual Warranty Package Analysis

1.0 Provide Real-time CSR Guidance for Claim Creation
  6.0 Provide Financial Analysis Support
    6.1 Receive Financial Data from Company Financial Management System
    6.2 Generate Financial Analysis
    6.3 Support Manual Financial Analysis

1.0 Provide Real-time CSR Guidance for Claim Creation
  7.0 Provide Dynamic Reporting Capabilities
    7.1 Accept Report Selection Input
    7.2 Accept Report Filter Criteria Input
    7.3 Run Report
    7.4 Display Report Results
    7.5 Support Report Creation

1.0 Provide Real-time CSR Guidance for Claim Creation
  8.0 Provide Secure Storage and Access Control
    8.1 Restrict System Access
    8.2 Accept Authentication Input
    8.3 Validate User Authentication
    8.4 Grant System Access
    8.5 Decline System Access
    8.6 Secure Data Transfers
2.0 Provide Claims Management Support

2.1 Support Claims Data Management

2.1.1 Store Claim Data
2.1.2 Display Claim Data
2.1.3 Accept Claims Data Modifications
2.1.4 Prevent Claim Deletion
2.1.5 Store Change History

2.1.5.1 Record Claims Data Change Information
2.1.5.2 Display Change History
2.1.5.3 Accept Change History Search Criteria Inputs
2.1.5.4 Query Change History
2.1.5.5 Display Change History Query Results

2.2 Track Claim Status

2.2.1 Track Claim Action's
2.2.2 Display Claim Action's
2.2.3 Calculate Next Step for Claim
2.2.4 Generate Notification of New Claim Action
2.2.5 Display Claims Status

2.3 Schedule Claims Audit

2.3.1 Accept Claims Auditor Availability Input
2.3.2 Accept Warranty Owner Availability Input
2.3.3 Assign Claims Auditor to Claim Case
2.3.4 Generate Notification of Claims Audit Appointment
2.3.5 Select Claims Audit Appointment
2.3.6 Accept Claims Audit Information Input
2.3.7 Validate Claims Audit Information Input

2.4 Schedule Claim Service Appointment

2.4.1 Accept Service Provider Availability Input
2.4.2 Assign Service Provider to Claims Case
2.4.3 Generate Notification of Service Appointment
2.4.4 Select Service Appointment
2.4.5 Accept Service Visit Information Input
2.4.6 Validate Service Visit Information Inputs
# Functional N2 Diagram

<table>
<thead>
<tr>
<th>EXTERNAL</th>
<th>1.0 Provide Real-time CSR Guidance for Claim Creation</th>
<th>2.0 Provide Claims Management Support</th>
<th>3.0 Provide Inventory Tracking and Management Capabilities</th>
<th>4.0 Support Fraud Detection and Analysis</th>
<th>5.0 Provide Warranty Packaging Capabilities</th>
<th>6.0 Provide Financial Analysis Support</th>
<th>7.0 Provide Dynamic Reporting Capabilities</th>
<th>8.0 Provide Secure Storage &amp; Access Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions to ask Warranty Owner, instructions for handling claim filing, prompts for entering claim info, claim info validation confirmation, claim submission success/failure indication</td>
<td>Requests to modify stored claims data, request to view claim actions, Service Provider/Warranty Owner/Claim Auditor availability, Service details/status, claims audit details, claim authenticity status</td>
<td>Inventory item inputs/updates, query inputs, requests to remove inventory items, shipment info</td>
<td>Fraud rule updates, new fraud rule inputs, claims queries</td>
<td>Request to run existing report, request to create new report, new report attributes</td>
<td>Requests to access system, user authentication info</td>
<td>Assigned Service Provider, Assigned Claims Auditor</td>
<td>Assigned Service Provider, Assigned Claims Auditor</td>
<td>Finalized warranty packages</td>
</tr>
<tr>
<td>Claims data, change info, claim status/actions, notifications for new claims actions, notification of service/audit appointment, validation of service/audit info</td>
<td>Claims data inputs, claim actions (claim submission)</td>
<td>Submitted claims</td>
<td>Existing claims</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Required shipment notification, updated inventory items, success/failure to remove inventory item</td>
<td>Claim actions (shipment updates, new linked inventory item)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Claims data query results, manual fraud analysis</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warranty package recommendations, warranty package manual analysis results</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Automated &amp; manual financial analysis results</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Report results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Prompts for user authentication info, notification of access granted/denied, finalized warranty packages</td>
<td>Access permissions for Service Providers/Claims Auditors</td>
<td>Product/Warranty sales data, specification data</td>
<td>Financial data</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
1.0 Provide Real-time CSR Guidance for Claim Creation

1.1 Display Questions for Claim Owner

1.2 Prompt CSR for Claim Information Inputs

1.3 Receive Claim Information Inputs

1.4 Validate Claim Information Inputs

1.5 Determine Next Question

1.6 Determine Next Field Inputs

1.7 Check Required Field Completion

1.8 Accept Claim Submission

Questions to ask Warranty Owner, Instructions for handling claim filing

Prompts for entering claim information

Request to begin claim

Claim information verbally communicated by Warranty Owners input by CSR

Claim submission verbally communicated by Warranty Owners input by CSR

Claim submission success/failure indication

Claim action (submission)

Customer Service Representative (CSR)

Claims data inputs

FUNC 2.1 Support Claims Data Management

FUNC 2.2 Track Claim Status

4.1 Provide Automated Fraud Detection
Conceptual Design

• Hardware Design
  • Identified of physical components required to run/maintain WFMS application
  • Definition of physical component interfaces via component and N2 diagrams

• Software Design
  • Decomposition of system into subsystems and components
  • Allocation of functions to software components
  • Analysis and documentation of component interfaces
  • Development of preliminary data model via entity relationship diagram
  • Development of high level Software Architecture from extensive research and known system description
Hardware Design

WFMS

Network
- Requests via internet
- Application Content over internet (HTTPS)
- Requests via browser over internet
- Application content in browser over internet (HTTPS)

User Computer
- Applications via internet
- Requests via keyboard through monitor
- Application content over internet (HTTPS)
- Server content via monitor

Maintenance User Computer
- Server Controls/Commands via intranet
- Server content via monitor

Operation Servers
- WFMS Application
- Application Updates via SFTP
- Application Content over internet (HTTPS)

Integration Servers
- WFMS Application
- Application Updates via SFTP
- Server content via intranet

Development Servers
- WFMS Application
- Application content via intranet
- Updates, requests via intranet

Developer Computer
- Application content, developer environment via monitor
- Updates, requests via keyboard, monitor

User

Maintenance Personnel
- WFMS Application
- Server controls/commands via keyboard through monitor

Developers
Software Design - Subsystems

WFMS System

System Security
- Authentication
- Data Transfer

Warranty Packaging
- Warranty Package Generation
- Warranty Package Analysis Support
- Warranty Packaging Processing/Distribution

Financial Analysis
- Financial Analysis Support
- Financial Data Synthesis

Claims Management
- CSR Claim Creation Workflow Support
- Claim Data Management
- Claims Processing
- Fraud Detection/Analysis

Reporting
- Report Creation
- Report Generation

Supply Chain
- Inventory Management
- Shipping Support

Warranty Packaging Processing/Distribution

Financial Data Synthesis
# Software Architecture

## WFMS Service Oriented Architecture

<table>
<thead>
<tr>
<th>SOA Layer</th>
<th>Architecture Graphic/View</th>
<th>Infrastructure Layer</th>
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<tbody>
<tr>
<td>Presentation Layer</td>
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<td>Business Process Layer</td>
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<td>Services Layer</td>
<td></td>
<td></td>
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<tr>
<td>Component Layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration Layer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SOA Layer
- Web Pages
- UI
- Web Services

### Infrastructure Layer
- Technical Platform Services
- System Management/Governance Services
- Security Services
- Performance Services

### Integration Layer
- Mule Enterprise Service Bus (ESB)

### Component Layer
- Service 1
- Service 2
- Service 3
- Service 4
- Service N

### Business Process Layer
- Business Process 1
- Business Process N

### External/Operational Systems
- MS SQL Server DB
- FMS
- Product Manufacturer System
- Retailer System
- Shipping Company System
Trade Study – Introduction & Alternatives

• Formal TS conducted to select an Enterprise Service Bus (ESB) software to facilitate integration

• Topic selection based on:
  • Stakeholder emphasis on external interface functionality and integration success
  • Integration failure identified as critical risk (Risk 7)

• Alternatives
  • 10 alternatives initially identified for study
  • List narrowed to 4 alternatives due to:
    • Incompatibility with existing technology/software used by the Warranty Firm
    • Incomplete feature set
    • Lack of evidence of operational success
    • Impracticality of implementation
    • Lack of performance/evaluation data
  • Final alternatives:
    • Talend ESB
    • WSO2 ESB
    • Mule ESB
    • Ultra ESB
Trade Study – Criteria & Weights

• Selection Criteria developed from requirements

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<thead>
<tr>
<th>Criterion</th>
<th>Units of Measurement</th>
<th>Mapped Requirements</th>
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<tr>
<td>Security</td>
<td>Subjective Scale 0 to 5:</td>
<td>[OR] 7.2, [PR] 7.2.1-7.2.2</td>
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<tr>
<td>Scalability</td>
<td>• 0-1 Unacceptable,</td>
<td>[NONF] 1.1.2, [NONF] 10.1.12, [PR] 10.1.10</td>
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<tr>
<td></td>
<td>• 2 – 3 Potentially acceptable (partially meets requirement)</td>
<td>[NONF] 10.1.7</td>
</tr>
<tr>
<td>Flexibility</td>
<td>• 4 – 5 Acceptable (fully meets requirement)</td>
<td>[NONF] 10.1.11, [NONF] 10.1.7</td>
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<tr>
<td>Ease of Integration</td>
<td></td>
<td>[PR] 10.1.10</td>
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<tr>
<td>Throughput</td>
<td>Transactions per second (TPS)</td>
<td>[OR] 7.2, [PR] 7.2.3</td>
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<tr>
<td>Error Rate</td>
<td>Percent (%)</td>
<td></td>
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• Pairwise comparison method applied to determine relative weights

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<thead>
<tr>
<th></th>
<th>Security</th>
<th>Scalability</th>
<th>Flexibility</th>
<th>Ease of Integration</th>
<th>Throughput</th>
<th>Error Rate</th>
<th>Row value products</th>
<th>Nth root of row value products (N=6)</th>
<th>Normalized Weighting Factor</th>
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<td>5</td>
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<td>0.500</td>
<td>1.458</td>
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<td>0.500</td>
<td>12.000</td>
<td>1.513</td>
<td>0.180</td>
</tr>
<tr>
<td>Error Rate</td>
<td>0.500</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>70.000</td>
<td>2.030</td>
<td>0.241</td>
</tr>
</tbody>
</table>

8.422 1.000 25
Trade Study – Raw Scores & Utility Functions

- Raw scores collected from internet research
- Raw scores translated to utility scores through utility functions
  - Security, Scalability, Flexibility, Ease of Integration - known to be linear scales from original studies
  - Throughput, Error Rate - utility unknown with no stakeholder feedback -> linear function
Final Analysis & Selection

- Weighted and combined scores calculated to compare alternatives

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Criteria Weights</th>
<th>Raw Score</th>
<th>Utility Score</th>
<th>Weighted Score</th>
<th>Raw Score</th>
<th>Utility Score</th>
<th>Weighted Score</th>
<th>Raw Score</th>
<th>Utility Score</th>
<th>Weighted Score</th>
<th>Raw Score</th>
<th>Utility Score</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>0.376</td>
<td>2</td>
<td>0.4</td>
<td>0.1504</td>
<td>3</td>
<td>0.6</td>
<td>0.2256</td>
<td>4</td>
<td>0.8</td>
<td>0.3008</td>
<td>3</td>
<td>0.6</td>
<td>0.2256</td>
</tr>
<tr>
<td>Scalability</td>
<td>0.126</td>
<td>5</td>
<td>1</td>
<td>0.1264</td>
<td>4</td>
<td>0.8</td>
<td>0.1012</td>
<td>4</td>
<td>0.8</td>
<td>0.1012</td>
<td>3</td>
<td>0.6</td>
<td>0.0759</td>
</tr>
<tr>
<td>Flexibility</td>
<td>0.028</td>
<td>4</td>
<td>0.8</td>
<td>0.0222</td>
<td>4</td>
<td>0.8</td>
<td>0.0222</td>
<td>5</td>
<td>1</td>
<td>0.0277</td>
<td>2</td>
<td>0.4</td>
<td>0.0111</td>
</tr>
<tr>
<td>Ease of Integration</td>
<td>0.049</td>
<td>4</td>
<td>0.8</td>
<td>0.0393</td>
<td>4</td>
<td>0.8</td>
<td>0.0393</td>
<td>5</td>
<td>1</td>
<td>0.0491</td>
<td>2</td>
<td>0.4</td>
<td>0.0196</td>
</tr>
<tr>
<td>Throughput (Transaction</td>
<td>0.180</td>
<td>2654</td>
<td>0.5477</td>
<td>0.0984</td>
<td>1899</td>
<td>0.2977</td>
<td>0.0535</td>
<td>2522</td>
<td>0.5040</td>
<td>0.0906</td>
<td>4020</td>
<td>1</td>
<td>0.1797</td>
</tr>
<tr>
<td>(Transaction s per second</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPS)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Rate (%)</td>
<td>0.241</td>
<td>0.000</td>
<td>0.9995</td>
<td>0.2409</td>
<td>0.026</td>
<td>0.9977</td>
<td>0.4601</td>
<td>0.0055</td>
<td>0.8887</td>
<td>0.2142</td>
<td>0.0000</td>
<td>0.9998</td>
<td>0.2410</td>
</tr>
</tbody>
</table>

- Sensitivity analysis conducted by zeroing out each weight to assess impact of weights on final scores
- Highest score to Mule ESB in all cases but one (zeroing Security)
- Final selection: **Mule ESB**
Risk Management

• Continuous, iterative risk management approach applied
  • Risk management processes defined during initial project planning
  • Continuous identification, assessment, monitoring, and mitigation of risks throughout project
  • Risk status and likelihood updated as applicable with each mitigation action
• Detailed documentation of risks via standardized risk worksheets and waterfall
  • Description, root case, & potential consequences
  • Mitigation strategies to reduce risk likelihood
  • Risk Cube with Likelihood/Consequence scores
  • Risk waterfall to graph likelihood changes resulting from mitigation actions
• Risk Register to track risk progression with each project deliverable

<table>
<thead>
<tr>
<th>Level</th>
<th>Likelihood</th>
<th>Your Approach and Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not Likely</td>
<td>...Will effectively avoid or mitigate this risk based on standard practices</td>
</tr>
<tr>
<td>2</td>
<td>Low Likelihood</td>
<td>...Have usually mitigated this type of risk with minimal oversight in similar cases</td>
</tr>
<tr>
<td>3</td>
<td>Likely</td>
<td>...May mitigate this risk, but workarounds will be required</td>
</tr>
<tr>
<td>4</td>
<td>Highly Likely</td>
<td>...Cannot mitigate this risk, but a different approach might be considered</td>
</tr>
<tr>
<td>5</td>
<td>Near Certainty</td>
<td>...Cannot mitigate this type of risk; no known processes or workarounds are available</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Technical</th>
<th>Schedule</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minimal or no impact</td>
<td>Minimal or no impact</td>
<td>Minimal or no impact</td>
</tr>
<tr>
<td>2</td>
<td>Minor perf shortfall, same approach retained</td>
<td>Additional activities required; able to meet key dates</td>
<td>Budget increase or unit production cost increase &lt;1%</td>
</tr>
<tr>
<td>3</td>
<td>Mod perf shortfall, but workarounds available</td>
<td>Minor schedule slip; will miss need date</td>
<td>Budget increase or unit production cost increase &lt;5%</td>
</tr>
<tr>
<td>4</td>
<td>Unacceptable, but workarounds available</td>
<td>Program critical path affected</td>
<td>Budget increase or production cost increase &lt;10%</td>
</tr>
<tr>
<td>5</td>
<td>Unacceptable; no alternatives exist</td>
<td>Cannot achieve key program milestone</td>
<td>Budget increase or production cost increase &gt;10%</td>
</tr>
</tbody>
</table>

High (Red): Unacceptable. Major disruption likely. Different approach required. Priority management attention required.

Moderate (Yellow): Some disruption. Different approach may be required. Additional management attention may be required.

Low (Green): Minimum impact. Minimum oversight needed to ensure risk remains low.
Risk Summary

- 7 risks identified and monitored throughout project
- All risks reduced to Medium or Low risk score during project
- Planned and completed mitigation actions documented in risk worksheets and register

<table>
<thead>
<tr>
<th>ID</th>
<th>Category</th>
<th>Risk Title/ Description</th>
<th>L (Initial)</th>
<th>C (Initial)</th>
<th>L (Final)</th>
<th>C (Final)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technical</td>
<td>Claims Management and Fraud Detection Subsystem Integration Failure</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Technical</td>
<td>Unauthorized User Gains Access to Fraud Detection Information</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Technical</td>
<td>Dynamic “learning” fraud detection algorithm required for WFMS operation is not technically feasible</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Programmatic</td>
<td>Cost of developing, installing, and maintaining system outweighs its benefits</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Programmatic</td>
<td>Scope of project too large to be completed during allotted project timeframe</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Technical</td>
<td>Automated Financial Analysis functionality insufficient to meet customer needs.</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Technical</td>
<td>Integration failure between WFMS and external systems (retailers, product manufactures)</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>
**Detailed Risk Tracking/Analysis**

**RISK SUMMARY WORKSHEET**

<table>
<thead>
<tr>
<th>Risk Title</th>
<th>7 – Integration Failure with External Systems</th>
<th>Team</th>
<th>JHU</th>
<th>Date</th>
<th>6/19/2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Leader</td>
<td></td>
<td></td>
<td>Sarah Reed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Description of Risk:** Integration failure between WFMS and external systems (retailers, product manufacturers)

**Statement of Basic Cause:** Integration complexity and inability to define detailed interface control requirements for the WFMS and external systems due to unavailability of subject matter expertise in these systems.

**Consequence if Risk is Realized:** Schedule slip-if subsystems are incompatible testing phases and required fixes may take longer. Loss of customer confidence/business/revenue and mission failure if integration cannot be achieved.

**Risk Reduction Plan**

<table>
<thead>
<tr>
<th>Action/Event</th>
<th>Date</th>
<th>Success Criteria</th>
<th>Risk Level if Successful</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conduct extensive research and employ tools such as formal trade studies</td>
<td>2015</td>
<td>1. Execution and approval of trade studies or other integration design decisions.</td>
<td>1. MED</td>
<td>Action 1: Formal Trade Study focused on procuring tool for simplifying the integration of WFMS and external systems. Selected ESB offers efficient, flexible way to model numerous integration scenarios for application integration. Use of ESB also offers data transformation functionality to facilitate data exchange with unlike systems.</td>
</tr>
<tr>
<td>2. Develop detailed interface descriptions and documentation to clearly define</td>
<td>2015</td>
<td>2. Development and sign-off of CDR containing detailed interface descriptions.</td>
<td>2. MED</td>
<td>Action 2: External interfaces identified and defined in more detail in the CDR, minimizing likelihood of risk occurrence. Additional effort to reduce likelihood would involve developing an Interface Control Document (ICD) for each interface with an external system (not a user) and a detailed integration and testing plan to ensure integration success.</td>
</tr>
<tr>
<td>4. Schedule additional time during the testing phase to allow for extensive</td>
<td>2016</td>
<td>4. Schedule sign-off with interface testing.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risk Mitigation

- Mitigation actions taken during project included in risk worksheet, depicted in risk waterfall, and tracked in the Risk Register updated with each deliverable.

Action 1: Formal Trade Study focused on procuring tool for simplifying the integration of WFHiS and external systems. Selected ESB offers efficient, flexible way to model numerous integration scenarios for application integration. Use of ESB also offers data transformation functionality to facilitate data exchange with unlike systems.

Action 2: External interfaces identified and defined in more detail in the CDR, minimizing likelihood of risk occurrence. Additional effort to reduce likelihood would involve developing an Interface Control Document (ICD) for each interface with an external system (not a user) and a detailed integration and testing plan to ensure integration success.

Action 3: More detailed interface requirements developed in A-SPEC, based on interface descriptions from CDR. Action 2/3 combined lowers likelihood.
System Specification & Requirements Growth

• System Requirements Statistics by Deliverable

<table>
<thead>
<tr>
<th>Artifact</th>
<th>Total</th>
<th># Quantitative</th>
<th>% Quantitative</th>
<th>% Binary</th>
<th>% Subjective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements Analysis Report</td>
<td>128</td>
<td>69</td>
<td>54%</td>
<td>38%</td>
<td>8%</td>
</tr>
<tr>
<td>Functional Analysis Report</td>
<td>126</td>
<td>75</td>
<td>60%</td>
<td>40%</td>
<td>0%</td>
</tr>
<tr>
<td>Trade Study Report</td>
<td>131</td>
<td>85</td>
<td>65%</td>
<td>35%</td>
<td>0%</td>
</tr>
<tr>
<td>Conceptual Design Report</td>
<td>131</td>
<td>85</td>
<td>65%</td>
<td>35%</td>
<td>0%</td>
</tr>
<tr>
<td>System Specification</td>
<td>223</td>
<td>171</td>
<td>77%</td>
<td>23%</td>
<td>0%</td>
</tr>
</tbody>
</table>

% Qualitative

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
<th>% Quantitative</th>
<th>% Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>[CON]</td>
<td>5</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>[NONF]</td>
<td>33</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>[FR]</td>
<td>71</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>[PR]</td>
<td>68</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>[IR]</td>
<td>46</td>
<td>83%</td>
<td>17%</td>
</tr>
</tbody>
</table>

• Requirements Evolution
  • 223 requirements in A-SPEC
  • 77% quantitative, 23% binary
  • 95 requirements added since RAR
  • 74% growth in requirements over project lifecycle
Key Performance Parameters (KPPs)

- Quantitative system attributes that must be met at the time of system acceptance
- Failure to meet these requirements could result in system rejection
- All specified during stakeholder interviews/requirements elicitation

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Justification/Origin/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>[NONF] 1.1.2</td>
<td>The system shall be able to accommodate at least 50,000 new claims additions per year.</td>
<td>From stakeholder interviews- scalability requirements.</td>
</tr>
<tr>
<td>[PR] 3.1.5</td>
<td>The system shall correctly identify claims as fraudulent that violate pre-define fraud rules 99.5% (T), 99.9% (O) of the time.</td>
<td>From stakeholder interviews.</td>
</tr>
<tr>
<td>[PR] 3.1.6</td>
<td>The system shall correctly identify claims as valid that don’t violate the pre-defined fraud rules 99.5% (T), 99.9% (O) of the time.</td>
<td>From stakeholder interviews.</td>
</tr>
<tr>
<td>[PR] 7.2.1</td>
<td>0% data loss/spillage shall occur during all data successful data exchanges.</td>
<td>Stakeholder interviews- stressed the extreme importance of security data exchange. General software security research.</td>
</tr>
<tr>
<td>[PR] 7.2.2</td>
<td>Should an error occur during a data exchange, 0% of the data shall be lost.</td>
<td>Stakeholder interviews- stressed the extreme importance of security data exchange. General software security research.</td>
</tr>
<tr>
<td>[PR] 3.1.4</td>
<td>After a claim is submitted, the system shall calculate the probability that the claim is fraudulent based on all available fraud rules, in less than 30 seconds (T), 15 seconds (O) for every 10 defined fraud rules.</td>
<td>From stakeholder interviews. Critical parameter for identifying fraud quickly.</td>
</tr>
</tbody>
</table>

- Removed as a KPP during project after reassessment
Concept Evaluation & Future Work

• Final concept reflects significant detail for the WFMS in line with stakeholder needs and operational objectives

• Additional work still needed to be ready for a formal design review
  • Work products need input/review from subject matter experts
  • Additional breakdown and addition of requirements (field level requirements, GUI requirements etc.)
  • Test planning
Project Management & Schedule Evaluation

- WBS to schedule deliverables and track work estimates vs. actuals
- Most estimates were fairly accurate except CDR & Trade Study Reports
- ~250 total hours to complete the project

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Estimated Hours</th>
<th>Actual Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept/Proposal</td>
<td>35</td>
<td>38</td>
</tr>
<tr>
<td>Requirements Analysis Report</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Functional Analysis Report</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Conceptual Design Report</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Trade Study Report</td>
<td>15</td>
<td>33</td>
</tr>
<tr>
<td>System Specification</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Risk Management Report</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Final Report</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Presentation</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>200</strong></td>
<td><strong>252</strong></td>
</tr>
</tbody>
</table>
Lessons Learned & Recommendations

- **Lessons Learned**
  - The importance of multi-dimensional teams and varied expertise in the Systems Engineering practice
  - The importance of continuous stakeholder involvement in the project AND the major challenges associated with obtaining it
  - The importance of traceability

- **Recommendations**
  - **Systems Engineering Curriculum**
    - Generalize material, with less focus on DoD and government methodologies and examples
    - Reduce repetition of material/overlap between core SE classes
  - **Master’s Project**
    - Allow students to select from a set of predefined projects identified by real companies
      - To more closely mimic real-life projects
      - To facilitate continuous client interaction