Components of a Data-driven EA

**Business Needs**
- Mission, Brand Promises
- Operating Model, Goals & Objectives
- Performance Measures

**Business Operating Model**
- Unification
- Coordination
- Diversification
- Replication

**Data-centric EA Approach**
- Data-oriented Design Paradigm
- Middleware Infrastructure
- Application Architecture Styles

**Application Arch. Components**
- Functionally-aligned Components
- Enabling Components

**Data-Centric EA Design**
Data Strategy Framework

Business Vision
- Organization Mission
- Strategy & Objectives
- Organizational Structures
- Performance Measures

Current State
- Organizational Readiness
- Business Processes
- Data Management Practices
- Data Assets
- Technology Assets

Solution Determination
- Business Needs Analysis
- Map Needs & Current Capability
- Capability Targets (w/ Bus. Case)
- Implementation Tactics

Road Map & Execution
- Leadership & Planning
- Project Development & Execution
- Cultural Readiness

Business Needs
- Why a Company Exists
- What a Company Produces & Sells
- How a Company Does It
- How to Measure Success

Mission & Brand
- Market Positioning
- Competitive Advantage
- Operating Model
- Business Goals & Objectives
- Performance Metrics
Brand Promises - Quick Examples

- **FedEx** - Your package will get there overnight. Guaranteed.
- **Apple** - You can own the coolest, easiest-to-use cutting-edge computers and electronics
- **McKinsey & Company** - You can hire the best minds in management consulting
- **The Nature Conservancy** - Empowering you to save the wilderness
- **Data Blueprint** – Tailored Solutions, Strengthening Capabilities and Lasting Relationships

Porter’s Market Positioning Framework

**Product Differentiation:** How specifically focused are your products?

**Cost:** Are you competing on cost? How cost-sensitive is your market?

**Market Scope:** Are you focused on a narrow market (i.e. niche) or a broad market of customers?

<table>
<thead>
<tr>
<th>Cost</th>
<th>Product Differentiation</th>
<th>Market Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Cost</td>
<td>Lower Cost Leadership Strategy</td>
<td>Blue Ocean Brands</td>
</tr>
<tr>
<td>Differentiation</td>
<td>Broad Differentiation Strategy</td>
<td>Focused Differentiation Strategy</td>
</tr>
</tbody>
</table>

**Note:** (Typically) Can’t be all things to all consumers – where are you?
**Market Positioning Example**

<table>
<thead>
<tr>
<th>Lower Cost</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Low-Cost Leadership Strategy</strong></td>
<td><strong>Blue Ocean Brands</strong></td>
</tr>
<tr>
<td><strong>Focused Low-Cost Strategy</strong></td>
<td><strong>Focused Differentiation Strategy</strong></td>
</tr>
<tr>
<td><strong>Broad Range of Buyers</strong></td>
<td><strong>Narrow Buyer Segment</strong></td>
</tr>
</tbody>
</table>

**Porter’s Competitive Advantage Framework**

**Given Market Positioning, how does your organization further compete?**

- **Bargaining Power of Buyers**: The degree of leverage customers have over your company.
- **Bargaining Power of Suppliers**: The degree of leverage suppliers have over your company.
- **Threat of New Entrants**: How hard is it for new competition to enter the market?
- **Threat of Substitute Products**: How easy (or hard) is it for customers to switch to alternative products?
- **Competitive Rivalry**: How competitive is the market place?
Operating Model Framework

<table>
<thead>
<tr>
<th>Coordination</th>
<th>Unification</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Shared customers, products or suppliers</td>
<td>• Customers and suppliers may be local or global</td>
</tr>
<tr>
<td>• Impact on other business unit transaction</td>
<td>• Globally integrated business processes often with support of enterprise systems</td>
</tr>
<tr>
<td>• Operationally unique business units or functions</td>
<td>• BU’s with similar or overlapping operations</td>
</tr>
<tr>
<td>• Autonomous business management</td>
<td>• Centralized management often applying functional/process/business unit matrices</td>
</tr>
<tr>
<td>• Business unit control over process design</td>
<td>• Consensus processes for designing IT infrastructure services</td>
</tr>
<tr>
<td>• Consensus processes for designing IT infrastructure services</td>
<td>• Centralized mandated databases</td>
</tr>
<tr>
<td>• IT application decisions made in business units</td>
<td>• IT decisions made centrally</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diversification</th>
<th>Replication</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Few, if any, shared customers or suppliers</td>
<td>• Few, if any, shared customers</td>
</tr>
<tr>
<td>• Independent transactions</td>
<td>• Independent transactions aggregated at high level</td>
</tr>
<tr>
<td>• Operationally unique business units</td>
<td>• Operationally similar business units</td>
</tr>
<tr>
<td>• Autonomous business management</td>
<td>• Autonomous BU leaders with limited discretion over processes</td>
</tr>
<tr>
<td>• Business unit control over business process design</td>
<td>• Centralized control over business process design</td>
</tr>
<tr>
<td>• Few data standards across business units</td>
<td>• Standardized data definitions but locally owned</td>
</tr>
<tr>
<td>• Most IT decisions made within business units</td>
<td>• Centralized IT services</td>
</tr>
</tbody>
</table>

Business Process Standardization

Low | High
---|---

Business Goals – Quick Examples

Examples of S.M.A.R.T. Goals?

- **Starbucks:** “In fiscal 2006, we plan to open approximately 1,800 net new stores globally.”
- **Wrigley:** “In 2005, the company will decrease the long-term rate of return assumption for the assets of its U.S. (pension) plans from 8.75% to 8.5%.”
- **Walgreen:** “Second is to hire a significant number of people with disabilities in our South Carolina distribution center, scheduled to open in 2007, and achieve 20% productivity gains there.”
- **Halliburton:** “We estimate that 74% of the backlog existing on 12/31 will be eliminated the following fiscal year.”
- **UPS:** “65% of drivers will have access to the new technology (implemented in 2004) by the end of 2005,” and “In 2005, we will increase operating profit in each of our 3 key businesses: domestic, int’l, supply chain.”
- **Martha Stewart Living Omnimedia:** “In 2004 we will discontinue the Catalog for Living and its online product options, and sell remaining inventory in early fiscal 2005.”
**Business Goals and Objectives: Global Publisher Example**

**Customer**
- Deepen our relationship with learner and customer
- Own more of the educational value chain

**People**
- Establish a ‘learner centric’ culture and one globally connected company
- Retain high performing employees

**Financial performance**
- Drive increased revenue growth
- Establish clear P&L accountability
- Increase cash generation
- Increase efficiency and establish a lower cost base

**Product**
- Deliver improved learning outcomes
- Focus on a smaller number of scalable and internationally relevant products
- Drive growth in digital and services

**Market position**
- Communicate effectiveness of new strategy to investors
- Become the global market leader in provision of educational products and services
- Increase brand awareness and association with effective learning outcomes

---

**Performance Metrics: Palliative Care Example**

**By metric type**
- 40 Structure metrics (what’s in place)
- 193 Process metrics (what your team does)
- 66 Outcome metrics (the impact of your efforts)

**By 8 Domains**
- Structures and processes
- Physical
- Psychological and psychiatric
- Social
- Spiritual, religious & existential
- Cultural
- Patient care at the end of life
- Ethical and legal
- Plus “Operational”

---

---
Performance Metrics: Marrow Donation Example

Mission Metrics

- Lag to Register Donor (in Days)
- Average Days to Complete Donation Request

Business Metrics

- Percent of SLA's Hit for Donor Requests Processed
- Number of Request Processed per Donor Coordinator

Case Study: Logistic Company

- Fortune 450
- 4 Divisions
  - Truck Load (OTR)
  - Intermodal
  - Outsourcing Service
  - Broker Services
- Significant Growth over the last 10 years
- Enterprise-wide modernization program
- Recognized need to be data-driven to compete
Case Study: Mission & Brand Promises

Reach $10 Billion in revenue by the year 2020

**Mission:** “We compete with other transportation service companies primarily in terms of price, on-time pickup and delivery service, availability and type of equipment capacity, and availability of carriers for logistics services.”

Brand Promises

- Unmatched Capacity
- Unrivaled Service
- Undeniable Flexibility
- Undisputed Experts
- Unprecedented Control

Case Study: Market Positioning

**Lower Cost**

- Brokered Services
- Intermodal

**Differentiation**

- Outsourced Services
- Truck Load

Broad Range of Buyers

Narrow Buyer Segment

Blue Ocean Brand — able to compete across multiple market positions

Low Cost; Quality Service; Availability and Differentiated Equipment & Service

Overall Market Positioning
Case Study: Competitive Advantage

- Buyer Power is moderate to weak
  - 4 divisions at multiple price points ("Full Service")
  - High switching costs for some customers

- Threat of Entrant is weak
  - High capital requirements
  - Strong brand recognition

- Supplier Power is moderate to strong
  - Limited # of drivers; Very Poor Retention Rates
  - Limited railroad capacity (Intermodal)

- Threat of Substitutes is weak
  - Railroads are a strong substitute; they lead in Intermodal

Case Study: Operating Model

<table>
<thead>
<tr>
<th>Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Shared customers, products or suppliers</td>
</tr>
<tr>
<td>• Impact on other business unit transaction</td>
</tr>
<tr>
<td>• Operationally unique business units or functions</td>
</tr>
<tr>
<td>• Autonomous business management</td>
</tr>
<tr>
<td>• Business unit control over process design</td>
</tr>
<tr>
<td>• Consensus processes for designing IT infrastructure services</td>
</tr>
<tr>
<td>• IT application decisions made in business units</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Business Process Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
</tr>
<tr>
<td>Low</td>
</tr>
</tbody>
</table>

So What...

- The four divisions share the same customers
- ...but...operate as autonomous business units
- A shared (or enterprise) view of customers, drivers, equipment is difficult
- Integrated processes across business units is difficult
- Redundant solutions

Business Process Standardization* Source: Gartner
Case Study: Business Goals & Objectives

- Operate at a 98% on-time delivery service level
- Provide customers with real-time control and transparency over their orders
- Increase # of proactive order failures resolved by 20%
- Increase service offerings utilized per customer by 12%
- Reduce customer detected dispatch error rates by 14%
- Optimize asset capacity across business units by
- Operate at a 98% on-time delivery level
- Provide customers with real-time control and transparency over their orders
- Increase # of proactive order failures resolved by 20%
- Increase service offerings utilized per customer by 12%
- Reduce customer detected dispatch error rates by 14%
- Optimize asset capacity across business units by

Case Study: KPI’s

- % of on-time pick-up and delivery
- % of customer reported service failures
- Time to respond to customer ad hoc queries
- # of customer order status inquiries
- # of customer self-monitored orders
- # of errors for trailer pool data
- # of ETA errors for dispatched truck
- # of errors for train ETA data
- Time to view complete order history
- # of cross-selling orders
- # of Orders booked
- # of Auto-accept orders
- # of Load assignments
- # of Auto-assigns
- # of no-loads and am-loads
- # of Drivers per dispatcher
- # of Auto-dispatches
- # of solicitation calls and success rates
- # of turndowns
- % of allocation compliance
- Revenue per truck per day
- % of Driver utilization
- % of equipment utilization
# How EA Meets the Business Needs
- **Align to the Operating Model**

<table>
<thead>
<tr>
<th>Business Process Integration</th>
<th>Coordination</th>
<th>Unification</th>
</tr>
</thead>
</table>
| **High**                     | • Shared customers, products and suppliers  
• Impact on other business unit transaction  
• Operationally unique business units  
• Autonomous business mgmt. & process design  
• IT application align to business units | • Customers & suppliers may be local or global  
• Globally integrated business processes  
• Use enterprise systems  
• BU’s with similar or overlapping operations  
• Centralized management often matrixed  
• Centrally mandated databases and IT |

<table>
<thead>
<tr>
<th><strong>Low</strong></th>
<th>Diversification</th>
<th>Replication</th>
</tr>
</thead>
</table>
| • Few, if any, shared customers or suppliers  
• Independent transactions  
• Operationally unique business units  
• Few data standards across business units  
• Most IT decisions made within business units | • Few, if any, shared customers (per transaction)  
• Independent transactions & BU Leaders  
• Operationally similar business units  
• Standardized data definitions but locally owned  
• Centrally mandated IT services |  

<table>
<thead>
<tr>
<th>Business Process Standardization*</th>
<th>Source: MIT</th>
</tr>
</thead>
</table>

## Operating Model – Unification

- Highly Integrated and standardized operating model.
- Driven by nature of business and/or developing a competitive advantage.
- Enterprise-level governance required for EA, IT and Data

*Source: blogs.msdn.com*
**Operating Model - Coordination**

- Shared customers, products and suppliers
- Impact on other business unit transaction
- Operationally unique business units
- Autonomous business management and process design
- IT applications aligned to business units

- Business units operate independently
- Often creates confusion with customers and suppliers
- Enterprise-level governance required for EA and Data

**Operating Model - Diversification**

- Few, if any, shared customers or suppliers
- Independent transactions
- Operationally unique business units
- Few data standards across business units
- Most IT decisions made within business units

- Run as entirely independent businesses
- Enterprise-level governance is NOT required
Operating Model - Replication

- Run as entirely independent businesses
- Standards for business processes
- Enterprise-level governance is required for data and IT

What’s Driving Data-centric EA

- Scale and complexity of integration is exploding
- Large scale distributed systems are often a mix of subsystems created by independent parties
- Interfaces can change without notice
- Growing popularity of cheap and widespread data collection "edge" devices and the easy access to communication networks
- The data they produce and consume is the unifying and common denominator between disparate systems
- Data/Information being leveraged as an asset

What’s Needed: Architecture that is organized around a common "shared information model" that spans multiple systems.

Source: RTI, "Data-oriented Architecture" by Rajive Joshi, Ph.D.
Data-centric EA Goals

1. **Incremental and Independent Development** arising from the fact that systems are generally developed and evolved independently.

2. **Impedance Mismatch** arising from the non-functional differences in the information exchange between systems – both in the quantity and the quality of the data exchange.

3. **Dynamic Real-Time Adaptation** arising from the fact that the environments can change dynamically, and it is not practical to have a centralized administrator or coordinator.

4. **Scalability and Performance** arising from the need to support larger SoS as more resources are introduced, with minimal overhead.

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.
4 Domains of EA – Data-driven Approach

- Business Architecture
  - Business Process, Organization, Op Models & INFORMATION
- Data Architecture
  - Data, Services
- Application Architecture
  - Software, Services
- Technical Architecture
  - Network, OS, Hardware

Aligns more closely to today’s business needs and operating models

Typical Thinking: Application-Centric

- In support of strategy, organizations develop specific goals/objectives
- The goals/objectives drive the development of specific systems/applications
- Development of systems/applications leads to network/infrastructure requirements
- Data/information are typically considered after the systems/applications and network/infrastructure have been articulated
- Problems with this approach:
  - Ensures data is formed to the applications and not around the organizational-wide information requirements
  - Process are narrowly formed around applications
  - Very little data reuse is possible
New Thinking: Data-Centric

- In support of strategy, the organization develops specific goals/objectives
- The goals/objectives drive the development of specific data/information assets with an eye to organization-wide usage
- Network/infrastructure components are developed to support organization-wide use of data
- Development of systems/applications is derived from the data/network architecture
- Advantages of this approach:
  - Data/information assets are developed from an organization-wide perspective
  - Systems support organizational data needs and compliment organizational process flows
  - Maximum data/information reuse

Data-centric Approach to EA

Data-oriented Design Paradigm
- Expose the data and meta-data as first-class citizens; data is the primary means for hooking up components
- Hide the code, and rely on message passing to model coarse-grain interactions between components
- Separate the meta-data and data communication from the operations on the data

Middleware Infrastructure
- Facilitates integration for loosely-coupled systems
- Enables incremental and independent development
- Addresses impedance mismatch

Application Architecture Styles
- Refers to the over all architecture of a system-of-systems (SoS)
- Anchored to the data-centric design paradigm and utilizes the underlying middleware infrastructure

Source: RTI, “Data-oriented Architecture” by Rajive Joshi, Ph.D.
Data-oriented vs. Object-oriented Design

**Data-Oriented Design:** It is based on the observation that the “data model” is the only invariant (if any) in a loosely coupled system

<table>
<thead>
<tr>
<th>Data-oriented</th>
<th>Object-oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expose the data and metadata</td>
<td>Hide the data (encapsulation)</td>
</tr>
<tr>
<td>Hide the code</td>
<td>Expose methods – code</td>
</tr>
<tr>
<td>Separate data and code</td>
<td>Intermix data and code</td>
</tr>
<tr>
<td>Send only messages</td>
<td>Mobile code</td>
</tr>
<tr>
<td>Must agree on data encoding, mapping system and semantics</td>
<td>Must agree on code runtime system</td>
</tr>
<tr>
<td>Messages are primary</td>
<td>API / Object model are primary</td>
</tr>
<tr>
<td>Metadata = data model + SLA</td>
<td></td>
</tr>
<tr>
<td>Change → change declarative metadata</td>
<td>Change → read and change code</td>
</tr>
<tr>
<td>Loosely-coupled</td>
<td>Tightly-coupled</td>
</tr>
</tbody>
</table>

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.

Data-oriented Design Paradigm

It is possible to tighten up loosely-coupled software; however it is not possible to loosen up tightly coupled software; the latter can be built on top of the former.

**Data-Oriented Design based on the following principles:**
1. Expose the data and meta-data
2. Hide the code
3. Separate data and code, or data-handling and application-logic.
4. Generate data-handling code from interfaces

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.
**Data-centric EA (Network) Middleware**

- Using a Data Distribution System (DDS)

DDS data-centric publish-subscribe middleware decouples data producers from data consumers in location, space, platform, & multiplicity.

- Requires the data model be specified formally in a program language neutral manner

- Does not make any assumptions about the state at the other components

- Supports a request/offered paradigm

Source: RTI; “Data-oriented Architecture” by Rajve Joshi, Ph.D.

---

**EA Middleware Common Practice**

Large distributed environments:

- Mish-mash of systems
- Different architectural styles
- Using different middleware
- Mismatches in interfaces
- Each system may be under a different domain of control

Challenges with this approach:

- Custom interfaces
- Does not scale
- Expensive and ineffective for the business
EA Middleware – Paradigm Shift

Large distributed environments:
- Mish-mash of systems
- Different architectural styles
- Using different middleware
- Misaligned interfaces
- Each system may be under a different domain of control

Advantages with this approach:
- Common middleware
- Agnostic to different architectural styles
- Highly effective for the business

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.

Application Architecture in Data-oriented EA

Categories of Applications
- Edge systems
- Enterprise systems
- Systems-of-systems (SoS)

Functional Categories of Applications
- Workflow
- Transactional
- Analytics
- Master Data
- Utilities – Temporal Computations
- Sensors

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.
How Application Architecture Fits

- Components can be added and removed independently, without any knowledge of other components.
- Data readers and data writers of topics (data-flows) can be created, used, and deleted independently.
- Does not require any centralized configuration.
- Direct data paths are automatically established between data readers and data writers of a topic.
- Application architecture style defines a pattern for organizing & developing components to achieve objectives.

Source: RTI; "Data-oriented Architecture" by Rajive Joshi, Ph.D.

Application Architecture Styles

- Application architecture style defines a pattern for organizing and developing application components to achieve certain objectives.
- An architectural style may be realized in software using a tightly-coupled design approach or a loosely-coupled design approach.
- Examples of Application Architecture Styles
  - Data Flow Architecture
  - Event-driven Architecture
  - Service-oriented Architecture
  - Client-server Architecture

Shift in Thinking: Interactions between components are data-centric and not object-centric; often these can be viewed as “dataflows” that may carry information about identifiable data-objects.

Source: RTI; "Data-oriented Architecture" by Rajive Joshi, Ph.D.
Application Architecture Styles – Example (1)

- Data flow architectural style is most common in sensor-based edge systems and control systems.
- Sensors are data producer components that feed data into processing components.
- Controller consumes the data inputs, and produce data outputs for actuators or other components.

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.

Application Architecture Styles – Example (2)

- Event driven architectural is most common in enterprise systems.
- A significant change in state that happens inside/outside the system.
- Events commonly used to drive the real-time flow of work, and take the lag time and cost out of operations.
- Generally an event processing component is a rule-based engine.
- In a simple event processing engine, each event occurrence is processed independently.
- In a complex event processing engine new event occurrences are processed in context of prior and future events.

Source: RTI; “Data-oriented Architecture” by Rajive Joshi, Ph.D.
Application Architecture Components

Functionally-aligned Components

- Transactional Systems
  - Order Processing
  - Credit Card Processing
- ERP’s
  - Supply Chain
  - HR, Finance
- System-of-Systems
  - R&D / Product Design
  - Marketing & Sales
- Edge Systems
  - Fitbit
  - Twitter

Enabling Components

- Master Data
- Exception-based Workflow Mgmt.
- Lifecycle Management
- Decision Support (End-user Driven)
- Shared Services/Utilities

Bringing it All Together for a Data-driven EA
- Aligning to Op Model + Data-Centric EA approach

Business Needs
- Mission, Brand Promises
- Operating Model, Goals & Objectives
- Performance Measures

Aligning to the Op Model
- Unification
- Coordination
- Diversification
- Replication

Data-centric EA Approach
- Data-oriented Design Paradigm
- Middleware Infrastructure
- Application Architecture Styles

Application Arch. Components
- Functionally-aligned Components
- Enabling Components
Data-driven **Coordination** EA Model

Application architecture for enabling functionality

Shared Application Architecture

Business Unit A

Business Unit B

Data-driven **Unification** EA Model

Application architecture for enabling functionality

Application architecture for core business functionality

Data Objects

Middleware passing data objects

etc…
So what does this mean for Data Management

Allows us to frame up and correlate the data management solutions to the operating model of the organization across a spectrum: **Centralized to Decentralized**

- How to develop people, processes and technology solutions for architecture, governance & quality
- How to define roles and responsibilities. Is data governance centralized or not? How should stewardship roles be defined and organized
- Tells us how to scope solutions to functional components