Creating the Enterprise Analytics Roadmap at the University of Michigan Health System
As information and data capabilities rapidly expand in health care, balancing enterprise and analytics projects through coordinated data management and architecture becomes increasingly important. Whether it is quality-based reporting, financial modeling, or Big-Data projects such as personalized health and basic science discoveries, information assets are becoming more voluminous, diverse and costly to generate, maintain, and exchange among competing needs. An enterprise analytics roadmap positions institutions to “do more with less” by creating efficient foundations upon which any analytic project can be built. The speakers will discuss how one such plan was developed at the University of Michigan Health System and is now being implemented in support of its clinical, research, education and administrative missions.
Introduction: Speakers

**Andrew Rosenberg MD**, is the Chief Medical Information Officer for the University of Michigan Health System and the Executive Director of Information and Data Management where he oversees reporting, data warehousing, enterprise document management and HIE services. Dr. Rosenberg is also the Health IT Steward for the University of Michigan. He is a tenured associate professor of Anesthesiology Critical Care, & Internal Medicine. Dr. Rosenberg attended the Johns Hopkins Medical School where he completed a residency in Internal Medicine. His recent work in informatics has been in the areas of designing and implementing enterprise analytics programs for academic medical centers and integrating large scale enterprise clinical electronic information systems to health system research IT capabilities. His expertise includes initiating and maturing a variety of governance organization and implementation strategies to successfully accomplish these socio-technical projects to advance learning health organizations.

Andrew can be reached by email at arosen@med.umich.edu

**Michael Brooks**, is a Specialist Leader in the Information Management practice where he focuses on the unique needs of health plans and healthcare providers. Michael has over 25 years’ experience in business intelligence, data warehousing, analytics and reporting, healthcare information technology planning, IT and data governance, healthcare information exchange, and other areas. He has authored over two dozen publications on various information management and analytics topics, including co-authoring the book, Implementing Business Intelligence in Your Healthcare Organization. Michael co-chairs the HIMSS Clinical & Business Intelligence Community and is a member of Deloitte Consulting’s Data Management Working Committee. Finally, Michael is a Certified Business Intelligence Professional, Certified Professional in Healthcare Information Management Systems, and Certified Professional Accountant “Inactive”.

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Increase in Global Data

The production of data is expanding at an astonishing pace. Experts now point to a 4300% increase in annual data generation by 2020. Drivers include the switch from analog to digital technologies and the rapid increase in data generation by individuals and corporations alike.

[1] CSC Insights; Figure 1; http://assets1.csc.com/insights/downloads/CSC_Infographic_Big_Data.pdf?ref=dbc
Case in Point: Critical Care

Processing Big Data: Volume + Variety + Velocity + Voracity

- Medication Types & Amounts
- Tissue Oxygenation
- Cardiac Output
- Intracranial Pressure
- EEG
- ECG
- Arterial Blood Pressure
- Venous Blood Pressure
- Urine Output
- Imaging
- Lab Data
- Blood Bank
- Medical Record
- Pharmacy
- Mechanical Ventilation
  Endtidal CO₂
  Airway Pressures
  Oxygen Levels
Monitoring in the ICU: Filtering noise from real and meaningful data

Data Aggregation

Neonate-ICU

Signal Processing & Feature Extraction

Caregiver

Classification

- Sepsis
- Necrotizing Enterocolitis (NEC)
- Patent Ductus Arteriosus

Clustering

- Baby’s Overall Condition

EHR
Logical Use Case Diagram: Acute Hemodynamic Instability

- Epic EMR
- GE monitors
- MCIT LDAP Server
- AirStrip ONE Host
- AirStrip PM Server
- Streams Hospital/Clinical
- Streams De-identification
- Streams Research/Test
- BigInsights M-CIRCC RDW
- PureData Analytics Appliance
- Advanced Analytic Modeling

Research components:
- Enterprise Data Warehouse
- Clinical Data Warehouse
Using a Cohesive Platform To Link Multiple Projects

Domain 1: Data Assets & Reuse
- HSDW
- RDW
- Registries
- CA Registry
- Bio-Repository

Domain 2: Big Data – Real Time Decision Support
- Epic Chronic Dis.
- QMP Qual Datamart
- PACE Qual Datamart
- AHI
- MCIRCC
- FFI or MiCHR
- IHPI Projects

Domain 3: Open Eco-systems
- PCORI Projects
- PROMIS
- NEPTUNE
- GWAS
- Transmart Pharmacokinetics
- Personalized Health Initiatives
- Biologic
- MyOnco Seq

UMHS Analytics

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For Big Data Projects To Succeed At UMHS…

We need an Enterprise Analytics plan

A roadmap to advance our abilities to support clinical, research and education programs and priorities currently in place or planned.
Use-Case Driven Future Vision

Shared Design Principles

- Analytics architecture is based on actual user requirements and real-world practice

- Analytics capabilities and architecture will be aligned with federated governance practices

- Common toolsets supported by pre-packaged analytics and standards minimize time to value
Enterprise Analytics Planning Framework

**Roadmap Progression**

“Where we are going”

“How we will get there”

“How we will manage”

**Enabling Pillars**

9 Use Cases
3 Domains
54 User-Informed Scenarios
Functional Requirements
Federated Analytics Architecture
Total Cost of Ownership
Federated Enterprise Data Governance

Over 50 Enterprise Analytics Recommended Projects
Capability Summary
Use Case 7: Translational Research

Description
Translational research includes two areas of translation. One is the process of applying discoveries generated during research in the laboratory, and in preclinical studies, to the development of trials and studies in humans. The second area of translation concerns research aimed at enhancing the adoption of best practices in the community. Cost-effectiveness of prevention and treatment strategies is also an important part of translational science. (Source: Rubio et al., 2010).

Stakeholders
- Oncologists
- Patients
- Honest Broker Office
- Bioinformaticists
- Researchers
- Principal Investigators
- Care providers

Issues Identified
- Limited de-identification capability
- Fragmented research infrastructure
- Lack of standard toolsets across research groups
- Lack of enterprise master data management and coordination of ontologies and vocabularies
- Data access and analysis manually intensive

Shared Requirements
- Self-service reporting
  - Visualization
- Big data analytics
- Streaming data
- Machine learning
- Research repositories
- Collaboration with external affiliates
  - Natural language processing

Unique Requirements
- Omics data sets
- Health services research
- Biomarker identification
- Real World Evidence analytics
### Analytic Applications Heat Map

**Use Case:**
- **1: Population Health**
  - Risk Identification & Stratification
  - Disease Specific Registries
- **2: Quality**
  - KPIs
  - Regulatory Reporting
  - Comparative Effectiveness
  - Provider Scorecards
- **3: Operations & Outcomes**
  - KPIs
  - Operations Performance Management
  - Supply Chain Analytics
  - Staffing & Scheduling Optimization & Productivity Analysis
- **4: Finance**
  - KPIs
  - Demand Forecasting
  - Revenue Cycle Analytics
  - Activity-Based Costing
  - Total Cost of Care
  - Financial Reporting
  - Budgeting & Forecasting
  - Revenue Recognition
- **5: Longitudinal Health**
  - Health Outcomes Analysis
  - Public Health Surveillance
  - Longitudinal Data Marts with Study Specific Data for Defined Cohort Populations
  - Disease Specific Registries
  - Advocacy Analytic Data Sets
- **6: Basic Research**
  - 'Omics Data Management
  - Advocacy Analytic Data Sets
- **7: Translational Research**
  - TranSMART
  - 'Omics Data Management
- **8: Clinical Research**
  - Biorepository
  - Cancer Registry
  - Clinical Effectiveness
- **9: Education/Learner Analytics**
  - KPIs
  - Learner Portfolio
  - Learner Performance Tracking
  - Curriculum Evaluation
  - Learner Access to Clinical De-identified Databases & National Research Databases

**Output Cases:**
- **3: Operations & Outcomes**
  - Clinical Program Performance
  - Workforce Effectiveness
  - Utilization Analysis, Prediction & Management
  - Preference Items Analysis
  - Capacity Planning
  - Competitive Analysis
  - Reimbursement Modeling
  - Package Pricing
  - Profitability Analysis

**Applications:**
- **1: Population Health**
  - Registry Pre-Processing
  - Access to Offline/Historical Data
- **2: Quality**
  - Patient Registries
- **3: Operations & Outcomes**
  - Provider Scorecards
- **4: Finance**
  - Gaps in Care
- **5: Longitudinal Health**
  - Compensation & Outcomes Modeling
- **6: Basic Research**
  - Patient Readmissions Analyzer
- **7: Translational Research**
  - Provider Database & Network Adequacy Analytics
- **8: Clinical Research**
  - Mobile Health Application for Wellness Management
- **9: Education/Learner Analytics**
  - Population Health Surveillance

**Note:** Please refer to Appendix for details on the scoring and analyses supporting the heat maps.
## Heat Maps

*Technology Systems/Tools Heat Map*

### Architecture Layer
- **Data Acquisition**:
  - Research Electronic Data Capture
  - Human Resources
  - Claims Data
  - Medical Devices
  - Patient Monitoring System
  - Clinical Notes
  - Imaging
  - External Data Integration
  - ‘Omics Data Integration

### Technology Enablers
- **Real-Time and Near Real-Time Clinical Interfacing**
  - Data Virtualization
    - ETL
    - Data Replication
    - Natural Language Processing

### Data Staging Layer
- Business Staging Engine
- Change Data Capture
- Streaming
- Distributed Data Processing
- Big Data ETL
- Data Federation

### Analytical Data Layer
- **Research Data Warehouse**
  - Clinical Data Warehouse
  - Quality Data Warehouse
  - Registries
- **Master Data Management**
  - Enterprise Vocabularies & Ontologies (Reference Data)
- **External Data Catalog**
- **‘Omics Data Warehouse**
  - Streaming Engine
  - Distributed File Storage
  - Non-Relational Data Store

### Discovery & Analytics
- **De-Identification/Re-Identification**
  - SHRINE
  - i2b2
- **Clinical Research**
  - Finance Decision Support
  - Analytical Data Sets
- **External Collaboration Portal**
- **Patient Portal**

### Information Sharing
- **Data Virtualization**
- **Data Federation**
- **Distributed Data Processing**
- **Streaming**
- **Big Data ETL**
- **Data Federation**

### Identity and Access Management
- Audit and Performance Management
- Clinical Knowledge Content Library
- Data Quality Management

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Note: Please refer to Appendix for details on the scoring and analyses supporting the heat maps.
Domain-Specific Technical Architecture

The High-Level Technical Architecture represents the composite view of the three domain architectures.

Domain 1: Federated Information Management
- Ex. Quality Analytics

Domain 2: Big Data and Real-Time Decision Support
- Ex. M-CIRCC

Domain 3: Open Analytics Ecosystem
- Ex. Digital Health Engine
Domain 2: Big Data and Real-Time Decision Support

High-level technical architecture for big data and real time decision support

- **Data Acquisition Layer**
  - Structured:
    - EMR
    - Clinical Trials
    - Finance
    - HR
    - Learning
    - Oncology
    - Others
  - Semi/Unstructured:
    - Biological Data Set
    - Medical Devices
    - Patient Monitoring System
    - Clinical Notes
    - Image
    - Others
  - External Data:
    - HIE
    - GIS
    - Survey
    - Claims
    - Molecular Data
    - Others (Social, etc.)
    - MyDataCon

- **Data Storage Layer**
  - Enterprise Data Assets:
    - Master Data
    - Reference Data (Data Standards)
  - EDW Environment (Common Standards):
    - Research
    - Clinical
    - Others
    - Quality
    - Omics
    - Bias
    - Repository

- **Data Analytics Layer**
  - Analytical Data Layer:
    - Research
    - Clinical
    - Others
    - Quality
    - Omics
    - Bias
    - Repository
  - Discovery and Analytics:
    - Research
    - Clinical
    - Others
    - Quality
    - Omics
    - Bias
    - Repository
  - Direct Discovery & Analytics on DFS
  - Real-Time

- **Information Sharing Layer**
  - Epic Integration
  - Knowledge Management Portal
  - External Collaboration Portal
  - Internal Shared Folder
  - FTP and SFTP
  - Patient Portal
  - External UMHS Customers

**Integration and Analytics Platform**

**Integrated Analytics Platform**

**Big Data Platform**

**Active Archival**

**De-ID**

**Non-Relational Data Store**

**Streaming Engine**

**Ingest**

**Filter**

**Transform**

**Correlate**

**Classify**

**Extract**

**MyDataCon**

**Data Virtualization Federation**

**Identity and Access Management**

**Metadata & Enterprise Architecture Standards**

**Data Quality Management**

**Audit and Performance Management**

**Clinical Knowledge Content Library**

**Natural Language Processing (NLP)**
UMHS is using the enterprise analytics strategy to support clinical research through the Early Detection of Hemodynamic Decompensation Pilot (M-CIRCC).
BIG DATA
GOT IT...
NOW WHAT?
Developing a Foundational Analytic Infrastructure

- Assess all Analytic tools, databases and data sources and…
  - Catalog!
  - Reduce duplication, maximize reuse

- Implement Enterprise Data Management
  - Streamline use of master data elements: patient, provider, subject….
  - Implement staging platform, standard tools and terminologies: reuse, access and quality

- Enterprise Service Bus
  - Data sharing and data virtualization

- Provide Enterprise Analytic Services
  - Data concierge

- Data Governance
  - Start with existing committees where possible
  - Develop enterprise data management team

- Provide Innovative Platforms
  - Big data, Streaming services, Semantic services, Natural language processing
Functional subject areas can be logically grouped into a model to form a high level conceptual data model. Master Data elements (grey) can be defined across the enterprise.
Data Governance: Federated Model

In the federated model the Data Governance Committee facilitates the monitoring and management of data with assistance from key resources at every level.
# Data Governance Roles and Responsibilities

## Data Stewards

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>Implement data standards, policies, and processes driven down by Data Governance Working Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested Members:</td>
<td>Finance Directors, Research Directors</td>
</tr>
</tbody>
</table>
| Responsibilities | • Resides in business units where they are accountable for all data definitions within subject area  
• Implements and monitors Data Governance standards, policies, and processes for functional area specific systems  
• Acts as advisor to the Enterprise Data Governance Committee and various working groups in establishing and updating Data Governance standards, policies, and processes  
• Works with data users and architects to define and translate requirements needs into technical and data specifications  
• Provides recommendations concerning data access controls ensuring data is shared appropriately and widely  
• Monitors and reports Data Governance metrics to the Enterprise Data Governance Committee  
• Responsible for defining and maintaining Business Terms Glossary, business data definition and master data definition  
• Defines business rules, parameters, and related calculations for their assigned subject area.  
• Ensures processes and controls to manage data throughout the data lifecycle  
• Validates data, reports and data quality test results to ensure data integrity.  
• Participates in root-cause analysis for data defects |
| Escalations to: | Enterprise Data Governance Committee |
| Escalations from: | Business Users, and Working Groups |
| Level | Non-IT leadership, leadership identified business user |
### Data Governance Organization Structure | Data Stewards (Illustrative)

Examples of Data Stewards, assigned subject areas and illustrative candidates are show below.

<table>
<thead>
<tr>
<th>Group</th>
<th>Executive Lead</th>
<th>Subject Area</th>
<th>Potential Steward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative</td>
<td>UMHS CEO</td>
<td>Revenue Cycle</td>
<td>Integrated Chief Revenue Cycle Officer</td>
</tr>
<tr>
<td></td>
<td>UMHS CEO</td>
<td>Facilities</td>
<td>VP Facilities</td>
</tr>
<tr>
<td></td>
<td>UMHS CFO</td>
<td>Finance</td>
<td>Exec Dir Finance (Hosp), (MGD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TBD</td>
</tr>
<tr>
<td>Clinical</td>
<td>Dean or UMHS CMO</td>
<td>Patient</td>
<td>UMHS CMO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lab</td>
<td>Chair of Pathology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provider</td>
<td>UMHS CMO/Office of Clinical Affairs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pharm/Meds</td>
<td>Chief Pharmacy Officer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TBD</td>
</tr>
<tr>
<td>Research</td>
<td>Senior Dean, Research</td>
<td>Biorepository</td>
<td>Director of Bio repository</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cancer Center</td>
<td>Director, Cancer Center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O’mics</td>
<td>Director of Bioinformatics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TBD</td>
</tr>
<tr>
<td>Education</td>
<td>Senior Dean, Education</td>
<td>Learner</td>
<td>Associate Dean of Medical Education</td>
</tr>
</tbody>
</table>
Ramp-up Plan Recommendations

Overview

The initial Data Governance structure and activities will be defined by the Enterprise Data Governance Leadership Group and will be refined prior to the structure’s implementation.

Establish

The objective of this phase is to organize the initial Data Governance team and begin establishing a foundation for enterprise Data Governance at UMHS.

Educate

The objective of this phase is to mobilize the Enterprise Data Governance Committee and identify focus areas for initial deployment.

Prioritize

The objective of this phase is to identify and establish a list of high-priority Data Governance pilot use case projects, assign responsibility and resources to begin implementation.

Expand

The objective of this phase is to expand the implementation of Data Governance through additional projects and activities.
Reducing Common Challenges for Big Data Projects

Challenges in Big Data Adoption

No matter what level or discipline, at its fundamental level healthcare is a knowledge based industry – that its primary aim is the application of specialized skills, tools and knowledge

- The complexity of our issues and opportunities demands a more data-driven approach

- Every clinical and business program requires analytics to succeed

- The volume and complexity of today’s issues raise questions that traditional applications cannot answer
An enterprise analytics program helps create the future of healthcare through discovery” and empower data driven organizations in many ways.

1. **World class patient care**
   - Population health management
   - Value based care
   - Comparative effectiveness
   - Outcomes analysis
   - Evidence-based medicine

2. **Personalized medicine**
   - Clinical Genomics
   - Genetic profiling
   - Molecular diagnostics
   - Targeted therapy

3. **Innovative scientific discovery**
   - Multi-center clinical trials
   - Registries
   - Integrated molecular data
   - Translational research

4. **Sustainable margins**
   - Refine and improve operating standards
   - Compliance to agreed organizational policies
   - Efficiencies through improved operational KPIs

5. **Continuous learning**
   - Continuous improvement
   - Capability driven delivery organization
   - Free up valuable resources for strategic work
Successful analytics programs require strong leadership, commitment, and support

Building this foundation requires a strategic approach that combines three critical elements:

- **RIGHT PEOPLE**
  - Executive sponsorship and transformational leadership
  - Champions and supporters to build awareness and momentum
  - Domain experts to bring the deep knowledge and skills

- **RIGHT PITCH**
  - Building a powerful vision for the future
  - Business value to key stakeholders at various levels
  - Tailored to build a multi-layered network of supporters

- **RIGHT PLAN**
  - Responsive to current, future, and unplanned initiatives
  - Designed to demonstrate measurable value from the beginning
  - Leverage extended resources, and other enablers to drive new value creation
Right People: Get Them Involved Early

Successful analytics programs are more about leadership, talent, and changing behavior than about technology.

**Challenges**

- Management lacks an understanding of how to apply analytics and where to get started
- Fragmented decision-making and incentives may limit ability to see the bigger picture
- Departmental initiatives address individual needs but at a hidden costs
- IT led initiatives are often perceived as unnecessary overhead by some stakeholders

**Potential Impact**

- Project delays result in missed opportunities, higher cost and brand impact
- Duplicate systems and redundant staffing
- Poor service and data quality issues
- Negative impact on financial performance, operations effectiveness and clinical outcomes
Right People: How to Engage

While engaging the right people at the right time in the right context can facilitate consensus building and accelerate momentum, it’s important to recognize that many of them are coming from different starting points and have different priorities.

Stakeholder Engagement

“Who is impacted”

“How are they involved”

Stakeholder Considerations

Who is the Executive Sponsor?
Who are the key Decision-makers?
How are decisions made?
Who is the best overall Champion to drive the agenda?
What other internal or external sources exist?
How to engage and prepare them?
Right Pitch: Focus on What Matters

An effective communications program is critical to enlist support, create awareness, and obtain feedback that may be used to fine-tune the analytics program objectives.

**Challenges**

- Identifying in-flight projects may be difficult
- Business value may be difficult to define
- Stakeholders may not be communicating within their own organization
- Different messages will resonate with different stakeholder groups

**Potential Impact**

- Department independence may create resistance
- Confusion among sponsors and stakeholders may require more time and effort than planned
- Without clear stakeholder support and communications, IT may be perceived as proceeding without a clear mandate
With many stakeholders, it is important to balance the issues of flexibility and consistency.

**Pitch Characteristics**

- Establish the “compelling vision”
- Resonates with most significant stakeholders
- Expressed in business terms and value to the stakeholder
- Link to other initiatives that already have momentum and support
- Compare to peer and competitor organizations
- Expect and seek pushback early
- Avoid overselling!!!
Successful change agents recognize that effective pitches vary from strategic to operational and from organization to organization.

### Business Impact

In many organizations, the advantage of an enterprise analytics plan lies in realigning analytics investments to deliver more value to existing programs, not just funding new initiatives.

<table>
<thead>
<tr>
<th>Operational</th>
<th>Strategic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Existing Programs Better</td>
<td>Create New Value Streams</td>
</tr>
<tr>
<td>Increase Research Efficiency</td>
<td>Improve Research Competitiveness</td>
</tr>
<tr>
<td>Update Outdated Technology</td>
<td>Bend the Cost Curve</td>
</tr>
<tr>
<td>Improve IT Efficiency</td>
<td>Improve Decision Maker Effectiveness</td>
</tr>
<tr>
<td>Improve IT Service</td>
<td>Increase Agility</td>
</tr>
</tbody>
</table>
Many strategies stall because they consider investment funding as an afterthought.

Key Planning Principles
- Strategy drives architecture and services
- Architecture provides flexibility and agility to accommodate investment priorities
- Investment model incorporates funding options
Right Plan: Emphasize Business Value

Whether starting a new analytics program or refreshing an existing strategy, a clear connection between stakeholders, analytic capabilities, and results is critical.

Planning Tips

• For each project, identify stakeholders and programs that analytics enable or enhance

• Document quantitative and qualitative business value

• Define ranking criteria (e.g., cost savings, revenue enhancers, brand builders, etc.)

• Prioritize investments into groups that resonate with decision makers and stakeholders

• Develop and socialize business case presentation with key stakeholders

• Identify your BATTOS (Best Alternative To The Optimal Solution)

• Finalize and pursue funding approval
Summary

The more significant the program, the more important it is to have a game plan that engages key stakeholders and builds support.

- What is it you want to accomplish?
- Who is most critical to your success?
- What is the right message and value proposition?
- What approach is best suited to building support for achieving the program goals?
- What adjustments are necessary?