Schema Design Best Practice
Schema Design Best Practice

Learning Objectives for this session

**Skills**
- organize your tables, linkage and hierarchy for optimum efficiency, display, capabilities and traceability
- choose the appropriate attribute types for your data

**Understanding**
- The objectives that guide decisions when you design a GRANTA MI database
What is Schema?

- Data organization
  
  Database
  
  Tables
  
  Folders

- Objects that enable:
  - Capabilities
    - e.g. Standard Names needed for FEA export
  - User experience
    - e.g. search masks, report templates
## Database Design in GRANTA MI

- **Relational database design (e.g. SQL)**
  - Formal database normalisation rules

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary key</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>No repeating groups</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Atomic columns</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>No partial dependencies</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>No transitive dependencies</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Every non-trivial functional dependency involves either a superkey or an</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>elementary key’s subkey</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Every non-trivial, multi-value dependency has a superkey</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Every non-trivial join dependency is implied by a candidate key</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Every constraint is a consequence of domain constraints and key constraints</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Every join dependency is trivial</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>


- **GRANTA MI database design**
  - Best practice guidelines, influenced by GRANTA MI capabilities
  - Encapsulated in GRANTA MI Templates
GRANTA MI Schema Design Aspects

• **Efficiency & maintainability**
  – reduce duplication and make easy to maintain

• **Display**
  – can data be understood with little training and interpretation?

• **Capabilities**
  – can the database support our business processes?

• **Traceability**
  – “how was this design allowable made?”
  – “where did this alloy batch come from?”
GRANTA MI Schema Design Aspects

Decisions
- Tables & Links
- Hierarchy
- Data Types

Objectives
- Efficient & maintainable
- Display
- Capabilities
- Traceability
Tables & Links
Tables and Links

- **Introduction to Tables and Links**
  - what data do I need to store?
  - how is that data linked?
Tables and Links

• Example: Materials in Medical Devices Reference

[Diagram: Medical Devices Table with categories such as Cardiovascular Devices, Orthopaedic Devices, Neurological Devices, Surgical Devices, Adhesives, Producers, Specific Grades, Drugs, Coatings, Processes, Authors, References, and Materials]
Tables and Links

- **Examples: Composite Template**

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**Tables & Links**

- Composite system
- Design data
- Report
- Pedigree: Reinforcement
- Pedigree: Polymer matrix
- Pedigree: Intermediaries
- Pedigree: Laminate
- Pedigree: Coating
- Test data: Tension
- Test data: Compression
- Test data: Interlaminar shear
- Test data: In-plane shear
- Test data: Bearing
- Test equipment
- Test specimen

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**MI: Composites Template**

Click on a data table to open it in the left-hand tree.

**Material Pedigree**

- Reinforcement
- Polymer matrix
  - Intermediaries
  - Laminate

**Test Information**

- Test Equipment
- Test Specimen

**Test Results**

- Tensile
  - No hole, OHT, FHT

- Compression
  - No hole, OHC, FHC CAI

- Interlaminar Shear
  - Short Beam

- In-plane Shear
  - V-notched beam

- Flexural
- Bearing
Tables and Links

- Examples: AM Template
Tables and Links

• Tables store “similar data”
  – how similar? For example…

merge?
Tables: Fatigue / Tensile Test Data

**Reasons to split**

- **Key attributes** are different
  - Avoid long datasheets
    - (user experience for editing / attribute search / charts / reports)

**Reasons to merge**

- **Many attributes** are the same
  - Avoid attribute duplication in schema
    - (Ease of maintenance when creating new attributes, managing importers...)

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**Display**

- Tensile response (11 axis)
- Cyclic Results
  - Cyclic life: 140 cycles
  - Fatigue failure: Failed in Gage

**Efficient & maintainable**

- Project Information
  - Project name: New Supplier Qualification - Titanium Group
  - Project code: PR01
  - Funding organization: US Defense Department
  - Data ownership: Government
  - Data ownership (other): US Defense Department
  - Project notes: Tensile Testing of New Supply of Materials for Engine Use

- Source of Testing
  - Test Information
  - Specimen Information
  - Pre-Test Conditioning
  - Measurement
    - Test Conditions
      - Test temperature: °C
      - Test humidity: %
      - Test environment: %
      - Soak time: min
      - Control mode: % strain
      - Strain rate: % strain/s
      - Strain rate is equivalent

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*GRANTA*

*MATERIAL INTELLIGENCE*
Tables: Fatigue / Tensile Test Data

Reasons to split
Clearer, separate traceability paths
→ Never mix up types of test data

Reasons to merge
Compare and combine data easily

Traceability

Capabilities

<table>
<thead>
<tr>
<th>Origin of data</th>
<th>Test temperature (°C)</th>
<th>0.02% Offset yield stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti-8Al-4V, Plate, 700°F</td>
<td>98</td>
<td>545</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cyclic frequency (Hz)</th>
<th>Target r-ratio</th>
<th>Test temperature (°C)</th>
<th>Maximum stress (MPa)</th>
<th>Total stress range (MPa)</th>
<th>Cyclic life (cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1</td>
<td>0.1</td>
<td>204</td>
<td>889</td>
<td>800</td>
</tr>
<tr>
<td>30001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>0.1</td>
<td>204</td>
<td>862</td>
<td>772</td>
</tr>
<tr>
<td>30002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>0.1</td>
<td>204</td>
<td>820</td>
<td>745</td>
</tr>
<tr>
<td>30003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tables: Fatigue / Tensile Test Data

Reasons to split
Find missing tests by browsing the hierarchy “shape”

Reasons to merge
Query all test data with an attribute search

Display

Capabilities
Tables: Dealing with Large Schemas

Reasons to merge

Too many tables can overwhelm users…but we can **mitigate** this with:

- Good naming conventions
- Good homepage with schema diagram
- Profiles
- Explore views
Links

- Usually represent workflow / flow of data

**Diagram:**

- MI: Training Metals
  - Design Data
  - Statistical Data
  - Metals Pedigree
  - Test Data

**Tables & Links**

**Demo**

**Traceability**
• Which link type?

1. Static record links
2. Smart record links
3. Data links
4. Tabular attribute
5. Tabular attribute + Associated Records

Advantages:
• Don’t need rules to set up
• Search on attributes in linked tables

Disadvantages:
• Need active maintenance if record values change
• Record-to-record only
• Can’t export

Use for:
• Linking records where rules are complex, or not well defined
• Linking is static
• Where records are imported, and auto-linking can be used
Links

• Which link type?

1. Static record links
2. Smart record links
3. Data links
4. Tabular attribute
5. Tabular attribute + Associated Records

**Advantages:**
- Never need populating or updating
- Search on attributes in linked tables
- Multi-attribute linking criteria (up to 3)

**Disadvantages:**
- Only simple linking rules (\(A=B \text{ AND } C=D\))
- Record-to-record only

**Use for:**
- Linking records where rules are well defined
- When records are created manually (in MI:Viewer or MI:Explore)
- When linking values may change often
Links

• Which link type?

1. Static record links
2. Smart record links
3. Data links
4. Tabular attribute
5. Tabular attribute + Associated Records

Advantages:
• Data-to-data or data-to-record
• See linked data values

Disadvantages:
• Static only
• Linked values not searchable
• No access via Scripting Toolkits

Use for:
• Data value sourcing; reference citations (populate on import)
Links

• Which link type?

1. Static record links
2. Smart record links
3. Data links
4. Tabular attribute
5. Tabular attribute + Associated Records

Advantages:
• Logical, clear display of linked data
• Blend linked and local data
• Search on linked (or local) values*

Disadvantages:
• Very simple linking rules (1 attribute)
• Data storage heavy (every row is a hidden record)
• Can’t add to record list in this form (see #5)

Use for:
• Test summaries, substance queries, complex material pedigrees…

*from MI 11
Links

• Which link type?

1. Static record links
2. Smart record links
3. Data links
4. Tabular attribute
5. Tabular attribute + Associated Records

Advantages:
• Can add to record list
• Multiple hops in 1 click
e.g. design data → statistical data → raw test data
• Reverse links

Disadvantages:
• All the disadvantages of tabular data (data heavy, simple linking rules)
• Conceptually complex
• Depend on (multiple) record IDs being properly filled in

Use for:
• Test summaries, substance queries, complex material pedigrees…
• Alternative to smart links
Hierarchy
Hierarchy: Organisation

- How best to organize my records?
  - How do your users think the data should be categorized?
    - Company standard?
  - For reference data, Granta borrows conventions from standards organization
    - e.g. MMPDS by section

What if we can’t decide?
Hierarchy: Organisation

• Alternative: set up MI:Explore for end-users
  – they will not see hierarchy

Filters replace hierarchy
Hierarchy

- Grouping records to be used together
  - generate reports (add to list)
  - analyse records in MatAnalyzer
  - manipulate records in MI:Toolbox
Hierarchy

- Can be used purely for access control
  - permission-based
Hierarchy: How Deep?

- Easy to browse…

  ![Hierarchy Display]

  **VS.**

  - Slow browsing *(too deep)*
  - Fast browsing *(well designed)*
  - Slow browsing *(too shallow)*

Aim for 5 – 20 records per folder
Data Types
# Data Types

<table>
<thead>
<tr>
<th>Category</th>
<th>Data type</th>
<th>Abbreviation</th>
<th>Units?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerical</td>
<td>Integer</td>
<td>INT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Point</td>
<td>PNT</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>RNG</td>
<td>✓</td>
</tr>
<tr>
<td>Text</td>
<td>Short text</td>
<td>STXT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long text</td>
<td>LTXT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discrete</td>
<td>DCT</td>
<td></td>
</tr>
<tr>
<td>Functional</td>
<td>Float functional</td>
<td>FDA</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Equation and Logic</td>
<td>MAFN</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Discrete functional</td>
<td>FDD</td>
<td></td>
</tr>
<tr>
<td>Media</td>
<td>Picture</td>
<td>PIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hyperlink</td>
<td>HYP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>File (embedded media)</td>
<td>FIL</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Logical</td>
<td>LOG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Date</td>
<td>DAT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tabular</td>
<td>TABL</td>
<td>✓</td>
</tr>
</tbody>
</table>
Numerical Data Decision Tree

1. Simple numerical data
   - Multiple values?
     - Yes → Min - Max or open range?
       - Yes → Range
       - No → Multi-value Point
     - No → Requires units?
       - Yes → Point
       - No → Must be a whole number
         - Yes → Integer
         - No → Point
Text Data Decision Tree

- **Text data**
  - >256 characters? Flexible formatting?
    - Yes → **Long Text**
    - No → Precise searching required? e.g. values will be used for linking or autoplacement
      - Yes → **Discrete**
      - No → Finite set of values?
        - Yes → **Discrete**
        - No → **Short Text**

- **Finite set of values?**
  - Yes → **Discrete**
  - No → **Short Text**

- **>256 characters? Flexible formatting?**
  - Yes → **Long Text**
  - No → Precise searching required? e.g. values will be used for linking or autoplacement
    - Yes → **Discrete**
    - No → Finite set of values?
      - Yes → **Discrete**
      - No → **Short Text**

- **Finite set of values?**
  - Yes → **Discrete**
  - No → **Short Text**

- **Flexible formatting?**
  - Yes → **Long Text**
  - No → **Short Text**

- **>256 characters?**
  - Yes → **Long Text**
  - No → Precise searching required? e.g. values will be used for linking or autoplacement
    - Yes → **Discrete**
    - No → Finite set of values?
      - Yes → **Discrete**
      - No → **Short Text**

- **Precise searching required? e.g. values will be used for linking or autoplacement**
  - Yes → **Discrete**
  - No → Finite set of values?
    - Yes → **Discrete**
    - No → **Short Text**

- **Finite set of values?**
  - Yes → **Discrete**
  - No → **Short Text**

### Table: Base material vs. Food contact

<table>
<thead>
<tr>
<th>Base material</th>
<th>Food contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxide</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxide</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxide</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxide</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxide</td>
<td>Conditional</td>
</tr>
<tr>
<td>Fe (Iron)</td>
<td>Yes</td>
</tr>
<tr>
<td>PVC-P (Polyvinyl chloride, flexible, plasticized)</td>
<td>Yes</td>
</tr>
<tr>
<td>PVC-P (Polyvinyl chloride, flexible, plasticized)</td>
<td>Yes</td>
</tr>
<tr>
<td>PVC-P (Polyvinyl chloride, flexible, plasticized)</td>
<td>Yes</td>
</tr>
<tr>
<td>Al (Aluminum)</td>
<td>No</td>
</tr>
<tr>
<td>Ti (Titanium)</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Graphical Data Decision Tree

- **Graphical data**
  - Data is searchable
  - Data can be compared
  - More than one parameter
  - Y-axis, x-axis, or other parameters have units
  - Data can be plotted or viewed as a table
  - Some parameters are descriptors (i.e. Test Data / Fitted Data)

- Data is summarized as an equation?
  - Yes
    - Equations and Logic
  - No
    - Functional
Media Data Decision Tree

- Media data
  - SMB?
    - Yes: Hyperlink
    - No: Regularly updated on server / website?
      - Yes: Content should be searchable?
        - Yes: File
          - Image file type? (* .jpg, *.png, etc)
            - Yes: Picture
              - Image file type? (* .jpg, *.png, etc)
                - Yes: File
                - No: Image file type? (* .jpg, *.png, etc)
                  - Yes: Picture
                  - No: File
Data Model Guide

• Detailed reference for data structure, schema objects and features
• Release via My Granta in December 2018 (and within MI 12)
GRANTA MI Monthly Online Training Archive

Find previous sessions by logging in to My Granta: https://mygranta.grantadesign.com/TrainingVideos
Training schedule

Next training is November 13 –
*Track Materials Business Processes in MI:Workflow*

[http://www.grantadesign.com/products/mi/training.htm](http://www.grantadesign.com/products/mi/training.htm)