The Specification Process

- Background and Motivation

- Individuals and Specifications
  * Customers and End-Users
  * Information Engineers

- What’s in a Specification?
  * Application’s Perspective
  * Developmental Perspective

- Reflections and Comments
Background and Motivation

- What’s in a Specification?

  Living Document +------------------+
  Evolves/Changes |                   |
                  |                   |
                  |                   |
                  |                   |
                  |                   |
  +--------------+
  ...Etc...
  +--------------+
  | ER Diagram   |
  +--------------+
  | DFD for HTSS |
  +--------------+
  | SPEC for HTSS|
  | The HTSS ... |
  |             | ..Etc..+
  |             |
  |             |
  |             |
  +--------------+

- Focus and Emphasis on:

  Creation  Reflection  Content  Long-Term
  Extraction Evaluation Review  ????
What Does “Specification” Mean?

* Features and Characteristics of Application Domain
* Readable Document for Varied “Users”
* Contract - Customer and Company
* Contract - Designers and Engineers
* Living and Long-Lived!!

Overall, we identify the purpose, goals, scope, and content of a given problem domain.

Assume:

* Feasibility Study
* Market Projections/Potential
What’s Classical Interpretation?

- Ghezzi, et. al or Other SWE Text
- Formal vs. Informal
- Operational Specifications
  * Data Flow Diagrams
  * Finite State Machines
  * Petri Nets
- Descriptive Specifications
  * ER Diagrams
  * Formal Logic or Algebraic Specs.
- Can We Utilize Above Techniques and Other Similar Approaches to Arrive at a Framework and Blueprint for Specification Development?
Role of Object-Oriented Paradigm?

• Does an Spec. for OO Design/Impl. Need to be OO?

• If so, Why?

• If not, Why Not?

• Claim: Specification Document Transcends Implementation Domain!

• Goals: Understandability, Robustness, Completeness, Versatility, etc.


• What's the Major Intent of Spec?
Individuals and Specifications

- Spec. Serves as a Communications Medium

- Different Things to Different People at Different Times
  - Understanding an Application
  - Investigating its Details
  - Transitioning to Design and Implementation
  - Corrections and Evolution

- Customers and End-Users

- Information Engineers
Customers and End-Users

- Customer as a Generic Term
  - Actual Individual or Company
  - Targeted “Group” of Users
- Spec. Must Meet Customer's Needs!
- Spec. Document has “Non-Technical” Features
- End-Users Have Diverse Expertise
- Other Non-Technical Individuals?
- Experts in Particular Domain?

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Information Engineers (IEs)

• Charged with Engineering Information w.r.t:
  * Collection
  * Deciphering
  * Interpretation
  * Comprehension
  * Utilization
  * Creation
  * Dissemination

• IEs Interact with Technical Personnel and Non-Experts

• Attempt to Categorize Their Responsibilities
Types of Information Engineers

- **Information Specification Engineer (ISE)**
  * Create the Specification
  * Bridge Between Customer and Designers
  * Dedicated Job Responsibility
  * Completeness and Comprehensiveness of Final Document

- **Information Design Engineer (IDE)**
  * Contribute to Specification as a Transition to Detailed Design
  * Use Specification to Evaluate and Establish Design Options
  * Efforts Cannot Violate Specification Document
  * Minimal Interactions with Customer
Types of Information Engineers

- **Information Development Engineer (IDevE)**
  - Implementation of the Application
  - Coding, Testing, Integration, etc.
  - Requires Access to Design and Specification
  - Evaluate Portion/Completed Application Against Spec.

- **Information Management Engineer (IManE)**
  - Project Manager for Development Team
  - Spec. Used to Provide a View of Application’s Scope and Development Environment
  - Establish Milestones and Resource Usage Guidelines
  - Monitor/Control Entire Development Process
Types of Information Engineers

• Information Maintenance Engineer (IME)
  * Specs. Consulted for Maintenance Purposes
  * Corrections and Evolution
  * Modify Specs. for Consistency w.r.t. Changes

• Other Information Engineers
  * Specs. Used to Familiarize Oneself with Application
  * Reuse/Customize ‘Old’ Specs. for New Domains

• Information Marketing Engineer (IMarE)
  * Study Marketing and Promotion Issues
  * Categorize Target Audience

• Other Categories of IEs?
What’s in a Specification?

- All ‘Requirements’ for an Application
- Meets ‘Needs’ of Different Readers
- Broad Range of Considerations and Aspects
- Formal Specs. - Support Rigor, But Break Down When Applied to Large Apps.
- Adhere to Following Two Principles:
  * Anticipation of Change
  * Separations of Concerns
Section/Question-Based Approach

• Two Major Portions of a Spec:
  * Application Issues and Reqr.
  * Developmental/Implementation Issues

• Both Portions Contain Multiple Sections that Address Various and Particular Appl. Features

• Question-Based Approach that Motivates Content of Individual Sections

• Employ HTSS to Illustrate Techniques

• Different Portions of Spec. Address Different Needs of IEs and Other Individuals
Application Issues and Requirements

• Ten Major Sections to a Specification
  * Introduction: Appl. Overview
  * Glossary: Important Terms
  * Operating Environ.: Targeted Run-Time Environment
  * Interfaces: Users, Systems, and DBs
  * System Operation: Functional Characterization
  * Information: What and How?
  * Performance: Operating Environ. Constraints
  * Parallelism: Independent Interactions
  * Concurrent Engrg.: Dependent Interactions
  * Security: Who Uses What When?

• Incremental, Iterative, Cyclical Process

• Ordering is Changeable!

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The Introduction Section

• A Problem Statement for the Application

• Focus on its Scope, Objectives, Goals

• Highlight the Target Environment

• Investigate the Questions:
  1. What is the domain for the application?
  2. Who are intended users/companies?
  3. What is its main purpose?
  4. What is its scope/range?
  5. What are its major functionalities?
  6. What is the target environment?
  7. What are critical user/system interactions?
  8. How does user interaction occur?
  9. Unique hardware/software reqr.?
Introduction for HTSS

A supermarket chain is interested in using the newest and most up-to-date computing technology to support inventory control and to assist customers in their shopping experiences. The chain wants to integrate inventory control with

1. the cashiers functions to automatically update inventory when an item is sold

2. a user-friendly grocery item locator that indicates textually and graphically where items are in the store and if the item is out of stock

3. a fast-track deli-orderer (deli orders are entered electronically, with the shoppers allowed to pick up the order weighed and packaged without waiting).

The inventory control aspect of the proposed system would maintain all inventory for the store and alert the appropriate store personnel whenever the amount of an item drops to its reorder limit. In addition to the aforementioned functional characteristics, the system should also have extensive query capabilities that allow store personnel to investigate the status of the inventory and sales for the store over varying time periods and other restrictions.

Example Represents a Good First Attempt!

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The Glossary Section

- Identify and Collect Important Terms
- Reduce Both Confusion and Inconsistency
- A Term May Have One or More Meanings
- Investigate the Questions:
  1. What are application’s relevant terms?
  2. Are there any special terms?
  3. Are there any ambiguous terms?
  4. For each “term”, what is its scope, importance, functionality, and operation?
  5. Which terms have a restricted meaning?
  6. Any terms for different types of IEs?
  7. Any terms for Customers? End Users?
  8. Any terms for Domain Experts?
Glossary for HTSS

**Item:** Refers to a product that is sold at a supermarket, e.g., canned goods, cereals, produce, etc.

**UPC:** The Universal Product Code for all supermarket items.

**ICDB:** The Inventory Control Database, functions as a central repository that tracks the features and characteristics of all items on shelves and in the stockroom.

**I-Controller:** An I(nventory)-Controller is the individual at the supermarket who is in charge of maintaining the inventory.

** Courtesy Card:** A Check Cashing Card that has been assigned to a shopper.

**PIN:** A Personal Identification Number to pay for groceries with a ATM/Debit Card.

Etc...

Glossary Constantly Changes as Spec. Evolves!
The Operating Envr. Section

• Characterize Targeted Run-Time Environment

• Elaborate on Off-the-Shelf/Specialized HW/SW

• Utilize Prose or Itemized List or Both

• Investigate the Questions:
  1. Hardware, software, and operating environment?
  2. Off-the-shelf software systems/tools?
  3. What is the physical environment (e.g., location, temperature, etc.)?
  4. How is a hostile environment handled (e.g., Hardware/Software Threats)?
  5. Expertise of end-users?
  6. Expected usage pattern?
  7. Avg. number of users?
  8. High and Low load times?
Operating Environment for HTSS

The operating environment for the HTSS application will involve a collection of networked terminals. There are five different kinds of terminals: cashier (to total orders), deli-orderer (for shopper), deli-display (for deli workers to process orders), item-locator (for shopper), and inventory control. The two deli displays and the locator must have sealed data entry keys to insure that spills, dirt, etc., will not inhibit operation. The cashier display needs two interfaces to track the items and their costs for both the cashier and shopper. Cashiers and inventory workers will be trained to use their displays, and the input will use either keyboard or mouse technology. To allow deli workers to keep their hands free, a voice controlled interface must be developed to allow orders to be processed. Finally, since shoppers are “naive” users, the interface for the deli-orderer and item-locator must be geared towards their skill levels. The expected throughput for each cashier at peak levels is 10 customers per hour with a maximum of 20 cashiers. There are two deli-orderers and five item-locators that must ...etc...

Indicates High Interaction and Likely Complexity!

Equipment Specs. OK in Subsequent Iterations!

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The Interfaces Section

- Usage of Appl. w.r.t. Graphical, Database, and User-System Interactions

- Gives Another View of Application’s Scope

- Investigate the Questions:
  1. What are the major interfaces?
  2. Goal and purpose of each interface?
  3. Functions/responsibilities of each interface?
  4. Makeup of each user interface?
  5. Expertise of each interface user?
  6. Available information for each interface?
  7. Specific information for each interface?
  8. Required manipulation of information?
  9. Dependencies/interactions among interfaces?
 10. Restrictions on each interface?
 11. Information application requirements?

- DFDs, ERs, Screen Mockups, etc. are Apropos

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Interfaces for HTSS

Collectively, the interfaces for the cash register, scanner, deli-orderer, item-locator, deli-display, and inventory control, require the following database interfaces:

**ICDB:** A database of all items is maintained, with each interface requiring a different level of access. All of the user/system interfaces require read access to accomplish their respective tasks, e.g., the scanner must verify the UPC code of an item with its database entry. In addition, the inventory control interface will need to modify the database when items are reordered, while the cash register interface will issue a command to decrement stock on the shelves when an item is sold. This decrement operation is important, since it impacts on consistency and ensures that the item-locator has up-to-date information.

**Order DB:** A database is required to track individual customer orders. The interface to this database is required by the scanner and cash register interfaces in ringing up and totaling an order. Write access to create an entry in the Order DB is necessary.

**Deli-Order DB:** A short-term persistent database is required to hold orders entered via the deli-orderer for processing by the deli-display. The interface to this database requires both read and write access by the two aforementioned user-system interfaces.

Glossary Constantly Changes as Spec. Evolves!

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Interfaces for HTSS

- Mock-Ups for User Interfaces Needed

- Deli-Orderer:

```
+----------------------------------+
| Select Item: Ham Quantity: 1lb  |
| Select Item: Swiss Quantity: 2lbs|
| ...                              |
| End Session (Y/N): Y             |
| Order Id: 1234                   |
| *** Pick up in 20 minutes ***    |
+----------------------------------+

- Item-Locator:

```
+----------------------------------+
| Select Item: Napkins             |
| Location:                        |
|   Aisle 5                        |
|                                  |
|                                  |
| ---Shelf 2----------N------------|
+----------------------------------+

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The System Operation Section

- Characterize Major System Components and Their Interactions

- Mainly Intended for IEs

- Examine Operations from Two Perspectives:
  - General - Geared Toward ISE/IDE
  - Interface - Interactions and Access Capabilities

- Internal Operations Serves as a Bridge to Design Effort

- Interdependencies with Other Spec. Sections Occur

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The General Operation Section

- Macro-Level View of Application
- DFDs Characterize Major Functions
- Investigate the Questions:
  1. Intended paradigm for application? (e.g., event-driven)
  2. General approach to its operation?
  3. Major system actions and activities?
  4. Diagrammatic perspective of operation?
  5. Boundaries and/or Limitations?
  6. Major subsystems/components?
  7. Interactions between major components and:
     - information repository (Information)?
     - individuals and end-users (Security)?
     - related components or interfaces?

- ISEs, IDEs, IManEs, IDevEs

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General Operation for HTSS

- Macro-Level DFD from Chapter 2

- For Question 5:
  * Operates Whenever Store is Open
  * HTSS Requires Independent Power Source
  * User/System Displays Disabled During Major ICDB Updates

- For Question 7:
  * Cashier/Scanner Component Accesses ICDB
  * Customers, Cashiers, Store Manager all Have Specific Responsibilities or Roles
  * Baggers May Use Item-Locator to Check Prices
Recall DFD for HTSS

Credit/Check DB

Credit Info

Process
Order

Item

Display
Totals

Invent. Request

Access/ Modify
Invent.

List of Items

Item

Display
Result

Deli Invent.

Deli Items

Locate
Item

Order

List of Deli Orders

Display
Location

Shopper Request
Solicit Input

Display Choices

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The Interface Operation Section

- Focus on an Interface Perspective

- Identify Relevant Interface Structure and Interactions

- DFDs, FSMs, PNs, etc. are Apropos

- Investigate the Questions:
  1. Attainment of application behavior via Interfaces?
  2. General operation of each interface?
  3. Major interactions between interfaces?
  4. Interfaces and database interactions?
  5. Information Storage/Retrieval Issues?
  6. Two Views for User Interface
     * w.r.t. Customers/End Users
     * w.r.t. SWEs, IEs, IDEs, ...

- ISEs, IMANes, IDEs, IDeves, and IMEs

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Interface Operation for HTSS

- To Support Interfaces of HTSS
  - What are Functional Requirements?
  - ICDB, Order DB, DeliOrder DB Accessed?

- Identify Design Dependencies w.r.t.
  - Interface Shared Functionalities
  - Interface Information Access

- Goals:
  - Promote Communication Among IDEs, ISEs
  - Reuse of Designs
The Internal Operations Section

- Part of Document that is Transitory
- Optional w.r.t. ISEs Responsibilities
- Not Provided on Initial Passes
- Details for System Components

- Investigate the Questions:
  1. Breakdown of major components?
  2. Functionality of sub-components?
  3. Usage of information units?
  4. Storage of information units?
  5. Major building blocks?
  6. Design Reuse Issues?
  7. Identification of operational states
Internal Operation for HTSS

- Micro-Level DFDs, ADTs, Modules, etc. from Chapter 2

- Deli-Orderer Interface has Sub-Components:
  - User/System Input
  - User Displays
  - Access Protocols to Relevant DBs
  - Communication to Deli-Display

- ICDB Sub-Components Include Support for:
  - Deli-Display Reads Information
  - Cash Register/Scanner Reads Information
  - Inventory Control Reads/Write Information
  - Note: ICDB Requires Multiple Interfaces
The Information Section

- Identify All Informational Units (IUs)
- Employ ERs, ADTs, Natural Language, etc.
- Investigate the Questions:
  1. Major information units (IUs)?
  2. What is each information unit’s:
     * purpose in the application?
     * lifetime (persistent or not)?
     * usage or intended usage?
     * availability to components/interfaces?
     * accessibility by different end-users?
     * general semantic structure?
     * interactions(dependencies) with other IUs?
     * independence w.r.t. other IUs?
     * structural relationship with other IUs?
     * storage/access in the database?
The Information Section

- ISEs focus on Information Units (IUs) as
  - information source
  - information resource
  - information producer

- Bridge Between ISEs and IDEs

- DFDs (producer view) and ERs (source/resource view) Overlap with Other Phases

- Introduce Profile Concept for IU:
  - Profile Contains Pertinent Characteristics
  - Profile Represents Designer Supplied and Inferred Associations
  - Profile Captures Purpose w.r.t. Application, its Components, and its Interfaces
Information for HTSS

• Recall ER Diagram for HTSS

• Expand to Include Additional Details

• Develop Profiles for IUs, e.g., Item:
  * Description: Item contains the common features on groceries that are used by all aspects of HTSS.
  * Characteristics: Maintain UPC Code, Name, Costs, etc.
  * Associations: Interacts with specialized Items, Sales and Order relationships

• UPC Code is Non-Changeable After Item Creation
### ER: High-Tech Supermarket System

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</thead>
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<td>Item</td>
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<tr>
<td>Size</td>
<td>Deli</td>
</tr>
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<td></td>
<td>PIN</td>
</tr>
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The Performance Section

• Related to Operating Environment

• High-Level View to Bridge Gap to Performance Constraints for Developing Application

• Investigate the Questions:
  1. Application response-time requirements?
  2. User types?
  3. Maximum (minimum) number of users?
  4. Expected usage pattern?
  5. Error tolerance(video game vs. flight controller)?
  6. Expected workload pattern?
  7. Involved resources?

• Like Database, Perf. Requirements are Norm, Rather than Exception!

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Performance for HTSS

- Cast Operating Environment Restrictions into a New Light

- Store-Locator Display May Indicate that Shelf Has Items, When in Fact, Its Empty

- Is this a Tolerable Inconsistency?

- Any Time Critical Portions of HTSS?
  * Scanner/Cashier to ICDB Requires Reliability and Throughput
    1 sec. real time for item’s price
  * Locator and Orderer Must Work in a Timely Fashion
  * I-Controller Cannot Lock Out Other Users for Any Time Duration Except During Repricing
  * Other Life/Death Issues?
The Performance/Interfaces Section

- Examine w.r.t. User/System Interfaces
- Investigate the Questions:
  1. Expected response time?
  2. Expected refresh time?
  3. Failure conditions?
- In HTSS:
  * Scanner - UPC Code - ICDB - Order: Quick!
  * Deli-Orderer/Item-Locator: Timely!
  * Impact of Failure of Deli-Display?
  * Impact of Failure of Inventory Controller?
  * Replicated ICDB at Register?
    What's Impact w.r.t. Consistency?
The Performance/SysOp Section

• Relevant Time and Space Limitations

• Information/Interfaces Impacted

• Investigate the Questions:
  1. System components that impact response times?
  2. System components that do not?
  3. Communication between components and performance impact?

• In HTSS:
  * Scanner to Register Communication
  * Impacted by Information Access (Read of ICDB, Write of Order DB)
  * Average R/W Times of Information Units?
The Performance/Database Section

- Distribution vs. Sharing

- Volume vs. Throughput

- Investigate the Questions:
  1. Expected database size?
  2. Expected response time/throughput?
  3. Access patterns for IUs by Interfaces?
  4. Information Consistency Maintenance?

- In HTSS:
  * ICDB is a Shared Repository
  * Order DB Resides at Register/Scanner and is Periodically Updated to Shared Repository
  * ICDB Unavailable During Weekly Price Updates
  * ICDB Used by All Interfaces (30 Max!)
  * Remote DB Access for Debit/Credit Cards
  * Real Time Credit Checks

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The Parallelism Section

- Identify Independent Components
- Side-Effect: Implies Concurrent Engr. Needs
- Investigate the Questions:
  1. Parallel execution (access) of its components (IUs)?
  2. Overlaps of IUs for components and/or interfaces?
  3. What are the communication requirements?
  4. Independent overseer components?
  5. Information consistency for components and/or interfaces?
  6. Distribution or redundancy for IUs?
  7. Parallel portions that can be ignored?
  8. Interaction of parallel portions?
  9. Sharing of IUs and resources?
 10. How are resources protected?
 11. Impact of Failure?

- Employ Parallel CFGs
Parallelism for HTSS

• Sharing Dominates Application
• Five User/System Displays Operate in Parallel
• Controlled/Consistent Access to Shared ICDB
• Scanner/Locator Do Concurrent Reads
• Inventor Controller Reads/Writes

• How are Questions 7 and 8 Addressed?
  * UPC Cannot be Changed
  * Credit Info. Must be Protected
  * Register, Scanner, Locator, Orderer Failures should not Impact HTSS
  * ICDB Failure is Devastating!

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The Concurrent Engr. Section

- Complementary to Parallelism
- Non-Parallel are Concurrent?
- Investigate the Questions:
  1. Simultaneity of components, interfaces, and/or IUs?
  2. Sharing among different users?
  3. Simultaneity vs. information consistency?
  4. Resources for concurrent engineering?
  5. Concurrent expected usage patterns?
  6. Interactions among concurrent portions?
  7. Restrictions of interactions?
  8. IUs for each concurrent portion?
  9. Shared IUs between concurrent portions?
- Ties to Security Considerations!
- Already Discussed for HTSS

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The Security Section

• What are Critical Security Issues?

• Who Can See What When?

• MAC (Mandatory Access Control)?

• DAC (Discretionary Access Control)?

• Investigate the Questions:
  1. What is the security plan?
  2. Users (user roles) for the application?
  3. Responsibilities for each user role?
  4. IUs for each user role access?
  5. Prohibited IUs for each user role?
  6. Prohibited Interfaces for each user role?

• A User-Role Profile Contains:
  * Prose description of responsibilities
  * Associated security requirements
Security for HTSS

Application Security

In HTSS, the main security policy is to encapsulate the majority of functions that write to a database into the design of the different interfaces and system components. While the scanner and cash-register must write the Order DB, this write action should not be the result of an explicit command entered by the cashier. Rather, it should be a responsibility of the software the implements the two interfaces. The item-locator must be limited to read access of the ICDB, with the deli-orderer and deli-display allowed to modify the database. In the case of the deli-orderer, the tool controls the creation of database entries that represent customer orders. For the deli-display, the deli worker must physically issue a command that deletes the order from Deli-Order DB once it has been filled. Finally, the inventory controller is given the most access, since I-Controllers must have the ability to create, modify, and delete Items from the ICDB.

User Roles

Cashier: Responsible for ringing orders using the scanner and the cash register

Shopper/Customer: Buys groceries. Uses the deli-orderer and item-locator interfaces.

Deli-Display: Read/write access to Deli-Order DB to process and then remove orders from shoppers.

Store Manager: Has access to all aspects of the application and its interfaces, and can function as a super-user to override any restrictions.

Purchase/Order: Actions that support ordering of items.
Developmental Issues/Requirements

- How is the Application Designed, Built, Delivered, and Maintained?

- Establish a Team of IEs Headed by IManE

- Three Major Sections:
  * Development Environment.: Who, What, When?
  * Appl. Concurrent Engrg.: How?
  * Appl. Security: Support for Above Two!

- Intended for Internal Usage!

- Must Consider Team/Process Issues!

- Handled Today by Many Proven Techniques!
The Appl. Dev. Envr. Section

• Structure the Development Team

• Identify Approaches and Details

• Investigate the Questions:
  1. Team members and responsibilities?
  2. Implementation language?
  3. Software/hardware tools/environments?
  4. Targeted hardware for application?
  5. What is the expected release date?
  6. Milestones for application development?
  7. Library usage and code reuse?
  8. Relevant company policies?
  9. Chosen/required methodologies?
 10. Development management strategy?
 11. Partitioning of effort?
 12. Testing/verification issues/techniques?

• We’ve Discussed Many of These Issues!

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The Appl. Conc. Engr. Section

- Identify Components for Parallel/Shared Development

- Investigate the Questions:
  1. Components/interfaces for parallel development?
  2. Component and interface dependencies?
  3. Additional developmental resources?

- What are Obvious Choices for HTSS?
The Appl. Security Section

- Assign Different IEs Specific Responsibilities
- Responsibilities Translate to Application Access
- Employ User Roles as Discussed
- Investigate the Questions:
  1. Different roles and responsibilities?
  2. Duration of roles and privileges?
  3. Mapping of roles to IUs and application
  4. Indication of non-allowed access
  5. Mapping of application to roles
  6. For a single component, interface, or IU:
     * Which aspects are sensitive?
     * Which aspects are available when?
     * Any time restriction on aspects?
     * How is aspect used by individuals?

- IManE Assigns Privileges to IEs

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Reflections and Comments

• We’ve Examined Many Aspects of Specification

• Two Critical Concepts:
  * Profiles of IUs
  * User Roles and Profiles

• What Have We Not Considered?
  * Handling of Testing Considerations
  * Cooperative Design by ISEs and Impact on Spec.
  * Methodology or Framework for Spec. Construction
  * Convincing Management of Product Feasibility
  * Addressing Incremental Delivery Considerations
  * Anything Else on this List?
  * What’s Most/Least Important?

• Other Comments?