GENERAL DYNAMICS
Armament and Technical Products

Opening New "DOORS" to Managing JSF Gun System Requirements

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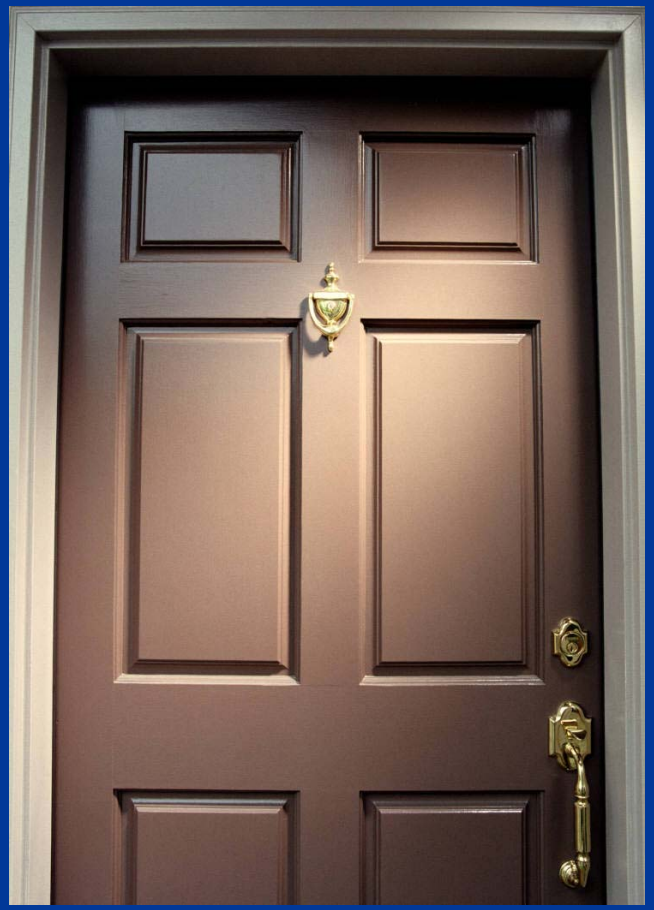
Opening New "DOORS" Outline

- Entrance – Evolution of Systems
- Previous Programs
- Current Challenge
- DOORS
- JSF Approach
- Exit – Benefits / Lessons Learned



ENTRANCE - Evolution of Systems

- Systems Engineering and Design
- Requirements
- Interfaces and Product Integration
- Design and Sourcing Approach

Comparison - Then to Now

AV-8, GEPOD

- Legacy specifications had few lower level specifications
- Traceability to other documents and impact assessments done manually
- “Product Manufacturer” - Product designed and manufactured in-house

JSF Gun Systems

- Requirements flowed to lower level configuration item specifications
- Traceability and impact assessments achieved through use of automated tool
- “System Integrator” – Product designed and manufactured with subcontractors as an integrated team

Requirements

- Legacy Programs
  - HOW - Design-based requirements
  - Referenced MIL-STDs as requirements
- JSF
  - WHAT - Performance-based requirements
  - Industry best practice
  - Reference DoD and other documents as “Guides”

DEVELOPMENT SPECIFICATION	# PAGES	# REQMTS (SHALLS)
AV-8B	29	195
JSF - CTOL	91	170
GPU-5/A (GEPOD)	46	228
JSF - MISSIONIZED	125	206

Current Challenge

- Larger requirements documents
- Intertwined and interdependent requirements
- Verification of requirements, especially unique requirements (e.g. chem bio)
- Flow down and allocation of requirements to sub systems
- Flow down of requirements to subcontractors (system integrator vs. sole designer/mfr)

Adjusting How We Manage Requirements

- Requirements have been developed and managed using a “document centered” approach
  - Separate requirements, design and test documents are developed by different organizations and stored in different locations
  - Requirement information is duplicated in many different documents to accommodate tracing and allocating requirements
  - Document management and maintenance effort is extensive and is sometimes the focus

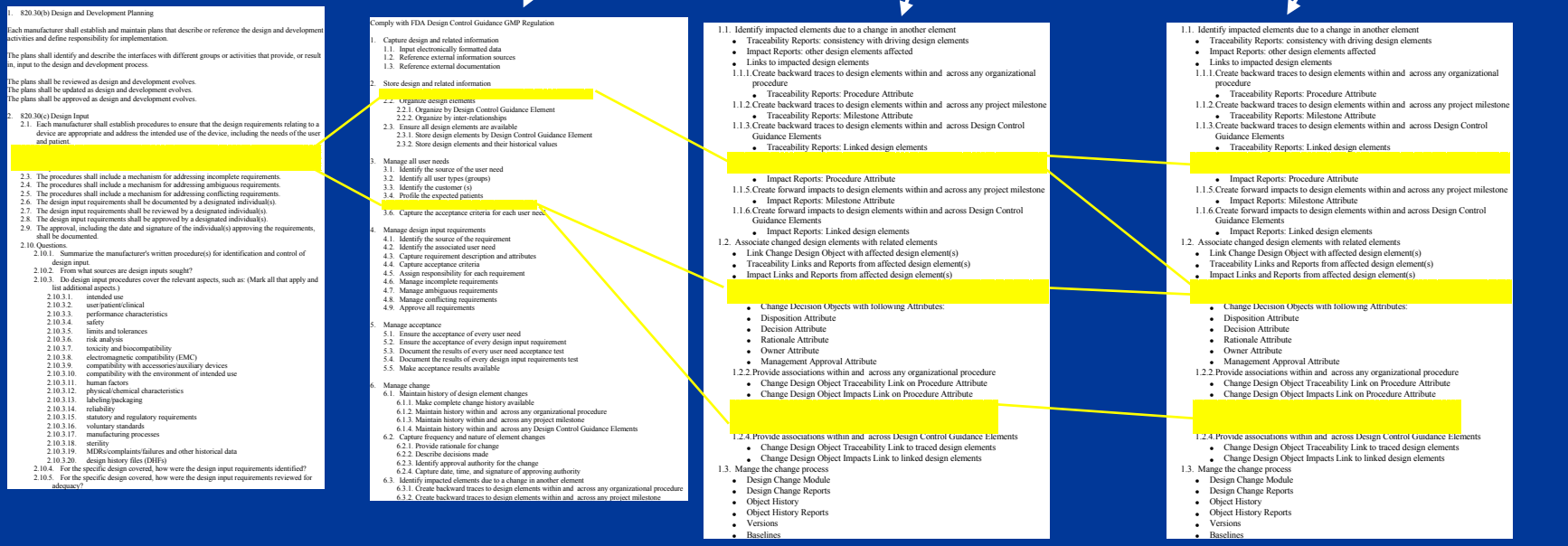
Adjusting How We Manage Requirements

- Developing and managing requirements has evolved to a “database centered” approach
  - Dynamic Object Oriented Requirements System (DOORS) is tool of choice
  - Single database, accessible to all users, contains all requirements and related documentation
  - Requires a transition from the use of traditional word processors in order to capitalize fully on DOORS functionality

Traceability

DOORS Links Provide for Traceability

User Requirements → Technical Requirements → Design Elements → Test Cases



1. 820.30(b) Design and Development Planning

Each manufacturer shall establish and maintain plans that describe or reference the design and development activities and define responsibility for implementation.

The plans shall identify and describe the interfaces with different groups or activities that provide, or result in, input to the design and development process.

The plans shall be reviewed as design and development evolves.
The plans shall be updated as design and development evolves.
The plans shall be approved as design and development evolves.

2. 820.30(c) Design Input
2.1. Each manufacturer shall establish procedures to ensure that the design requirements relating to a device are appropriate and address the intended use of the device, including the needs of the user and patient.

2.3. The procedures shall include a mechanism for addressing incomplete requirements.
2.4. The procedures shall include a mechanism for addressing ambiguous requirements.
2.5. The procedures shall include a mechanism for addressing conflicting requirements.
2.6. The design input requirements shall be documented by a designated individual(s).
2.7. The design input requirements shall be reviewed by a designated individual(s).
2.8. The design input requirements shall be approved by a designated individual(s).
2.9. The approval, including the date and signature of the individual(s) approving the requirements, shall be documented.
2.10. Questions.
2.10.1. Summarize the manufacturer's written procedure(s) for identification and control of design input.
2.10.2. From what sources are design inputs sought?
2.10.3. Do design input procedures cover the relevant aspects, such as: (Mark all that apply and list additional aspects.)
2.10.3.1. intended use
2.10.3.2. user/patient/clinical
2.10.3.3. performance characteristics
2.10.3.4. safety
2.10.3.5. limits and tolerances
2.10.3.6. risk analysis
2.10.3.7. toxicity and biocompatibility
2.10.3.8. electromagnetic compatibility (EMC)
2.10.3.9. compatibility with accessories/auxiliary devices
2.10.3.10. compatibility with the environment of intended use
2.10.3.11. human factors
2.10.3.12. physical/chemical characteristics
2.10.3.13. labeling/packaging
2.10.3.14. reliability
2.10.3.15. statutory and regulatory requirements
2.10.3.16. voluntary standards
2.10.3.17. manufacturing processes
2.10.3.18. sterility
2.10.3.19. MDRs/complaints/failures and other historical data
2.10.3.20. design history files (DHFs)
2.10.4. For the specific design covered, how were the design input requirements identified?
2.10.5. For the specific design covered, how were the design input requirements reviewed for adequacy?

Comply with FDA Design Control Guidance GMP Regulation

1. Capture design and related information
1.1. Input electronically formatted data
1.2. Reference external information sources
1.3. Reference external documentation

2. Store design and related information
2.2. Organize design elements
2.2.1. Organize by Design Control Guidance Element
2.2.2. Organize by inter-relationships
2.3. Ensure all design elements are available
2.3.1. Store design elements by Design Control Guidance Element
2.3.2. Store design elements and their historical values

3. Manage all user needs
3.1. Identify the source of the user need
3.2. Identify all user types (groups)
3.3. Identify the customer (s)
3.4. Profile the expected patients
3.6. Capture the acceptance criteria for each user need

4. Manage design input requirements
4.1. Identify the source of the requirement
4.2. Identify the associated user need
4.3. Capture requirement description and attributes
4.4. Capture acceptance criteria
4.5. Assign responsibility for each requirement
4.6. Manage incomplete requirements
4.7. Manage ambiguous requirements
4.8. Manage conflicting requirements
4.9. Approve all requirements

5. Manage acceptance
5.1. Ensure the acceptance of every user need
5.2. Ensure the acceptance of every design input requirement
5.3. Document the results of every user need acceptance test
5.4. Document the results of every design input requirements test
5.5. Make acceptance results available

6. Manage change
6.1. Maintain history of design element changes
6.1.1. Make complete change history available
6.1.2. Maintain history within and across any organizational procedure
6.1.3. Maintain history within and across any project milestone
6.1.4. Maintain history within and across any Design Control Guidance Elements
6.2. Capture frequency and nature of element changes
6.2.1. Provide rationale for change
6.2.2. Describe decisions made
6.2.3. Identify approval authority for the change
6.2.4. Capture date, time, and signature of approving authority
6.3. Identify impacted elements due to a change in another element
6.3.1. Create backward traces to design elements within and across any organizational procedure
6.3.2. Create backward traces to design elements within and across any project milestone

1.1. Identify impacted elements due to a change in another element
- Traceability Reports: consistency with driving design elements
- Impact Reports: other design elements affected
- Links to impacted design elements

1.1.1. Create backward traces to design elements within and across any organizational procedure
- Traceability Reports: Procedure Attribute

1.1.2. Create backward traces to design elements within and across any project milestone
- Traceability Reports: Milestone Attribute

1.1.3. Create backward traces to design elements within and across Design Control Guidance Elements
- Traceability Reports: Linked design elements
- Impact Reports: Procedure Attribute

1.1.5. Create forward impacts to design elements within and across any project milestone
- Impact Reports: Milestone Attribute

1.1.6. Create forward impacts to design elements within and across Design Control Guidance Elements
- Impact Reports: Linked design elements

1.2. Associate changed design elements with related elements
- Link Change Design Object with affected design element(s)
- Traceability Links and Reports from affected design element(s)
- Impact Links and Reports from affected design element(s)
- Change Decision Objects with following Attributes:
- Disposition Attribute
- Decision Attribute
- Rationale Attribute
- Owner Attribute
- Management Approval Attribute

1.2.2. Provide associations within and across any organizational procedure
- Change Design Object Traceability Link on Procedure Attribute
- Change Design Object Impacts Link on Procedure Attribute

1.2.4. Provide associations within and across Design Control Guidance Elements
- Change Design Object Traceability Link to traced design elements
- Change Design Object Impacts Link to linked design elements

1.3. Mange the change process
- Design Change Module
- Design Change Reports
- Object History
- Object History Reports
- Versions
- Baselines

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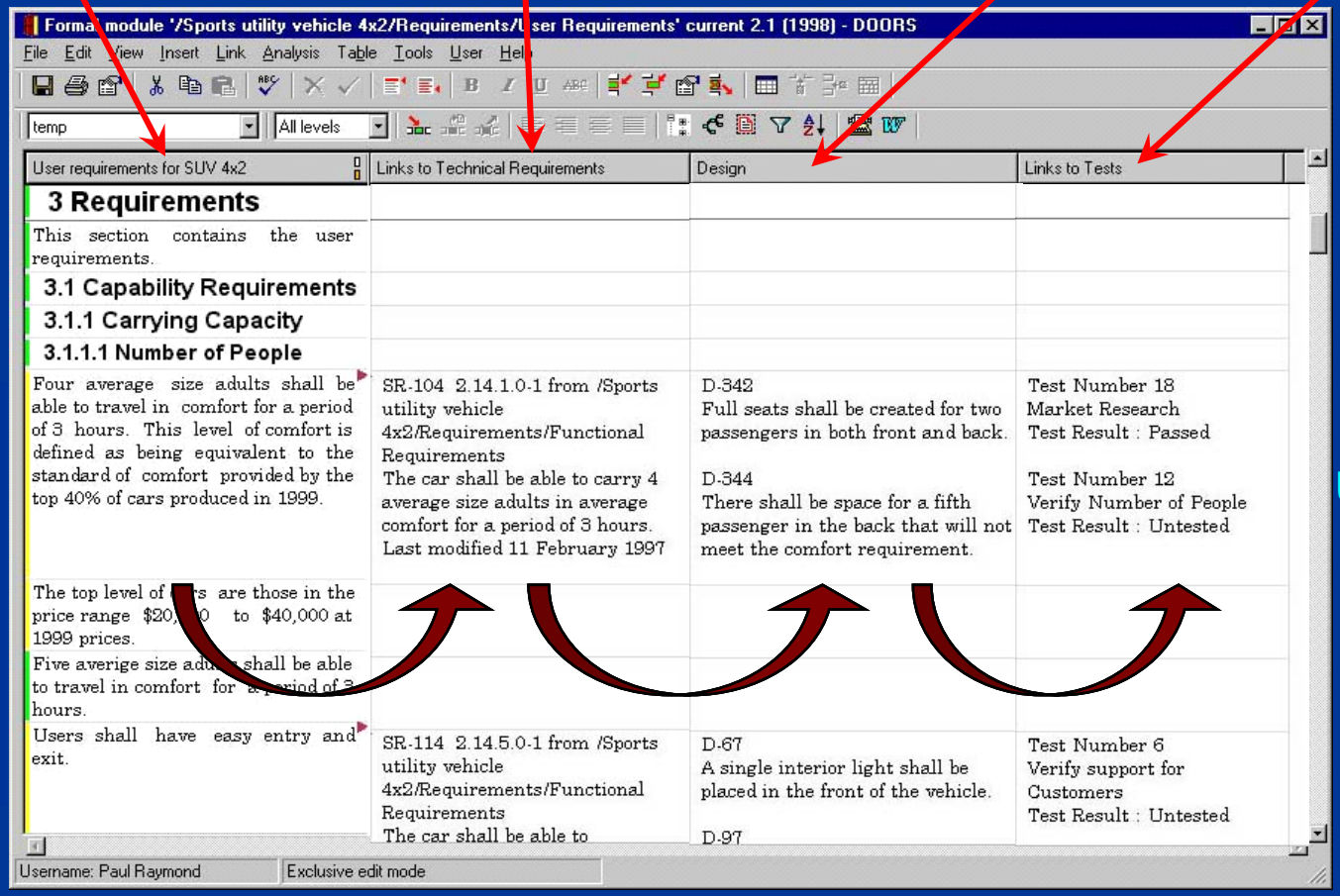
Impact analysis is the first step towards determining the cost of a change

Understand the change before you make it

DOORS View With Multiple Documents

User Requirements | Technical Requirements | Design Elements | Test Cases

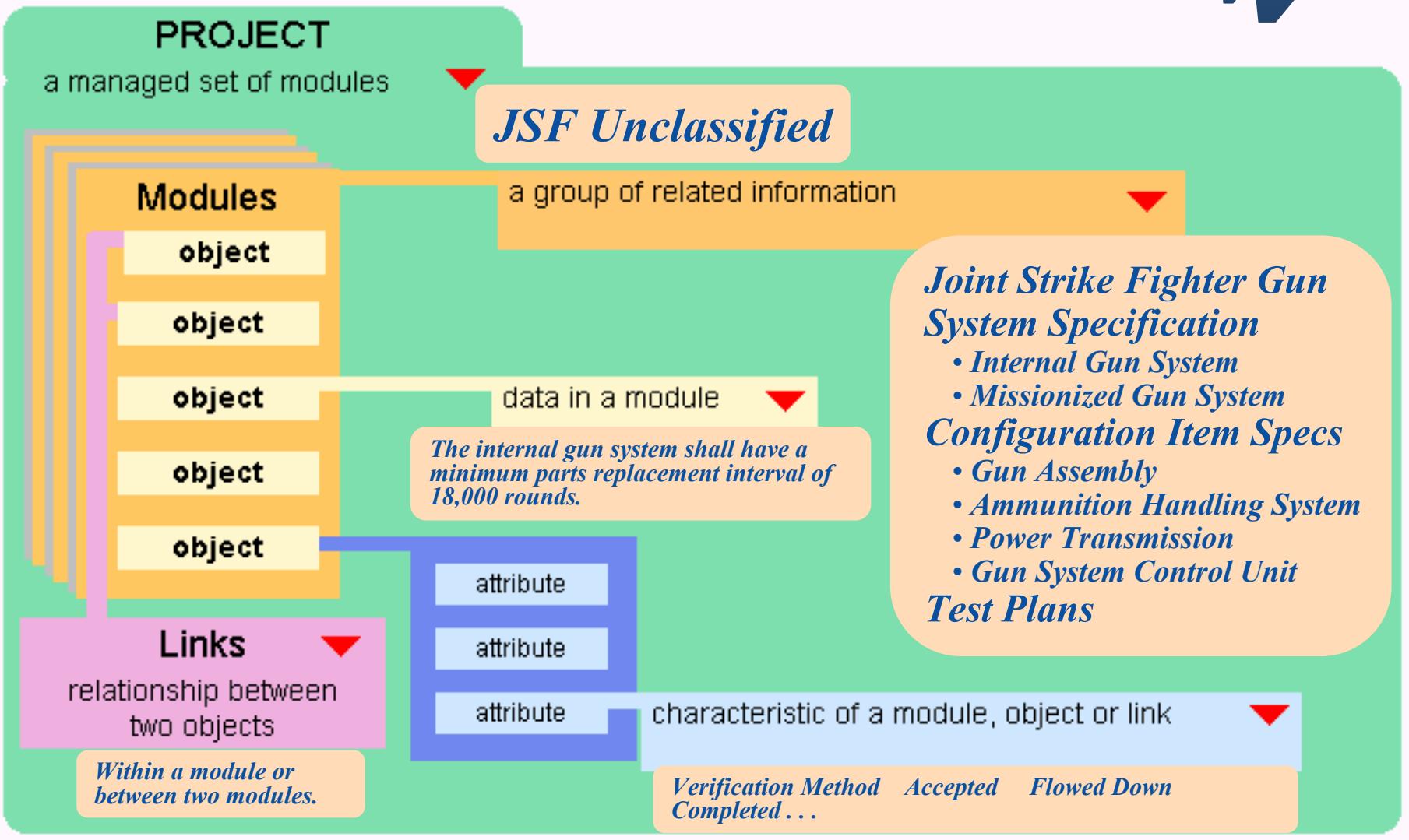


Impact analysis is the first step toward determining the cost of a change

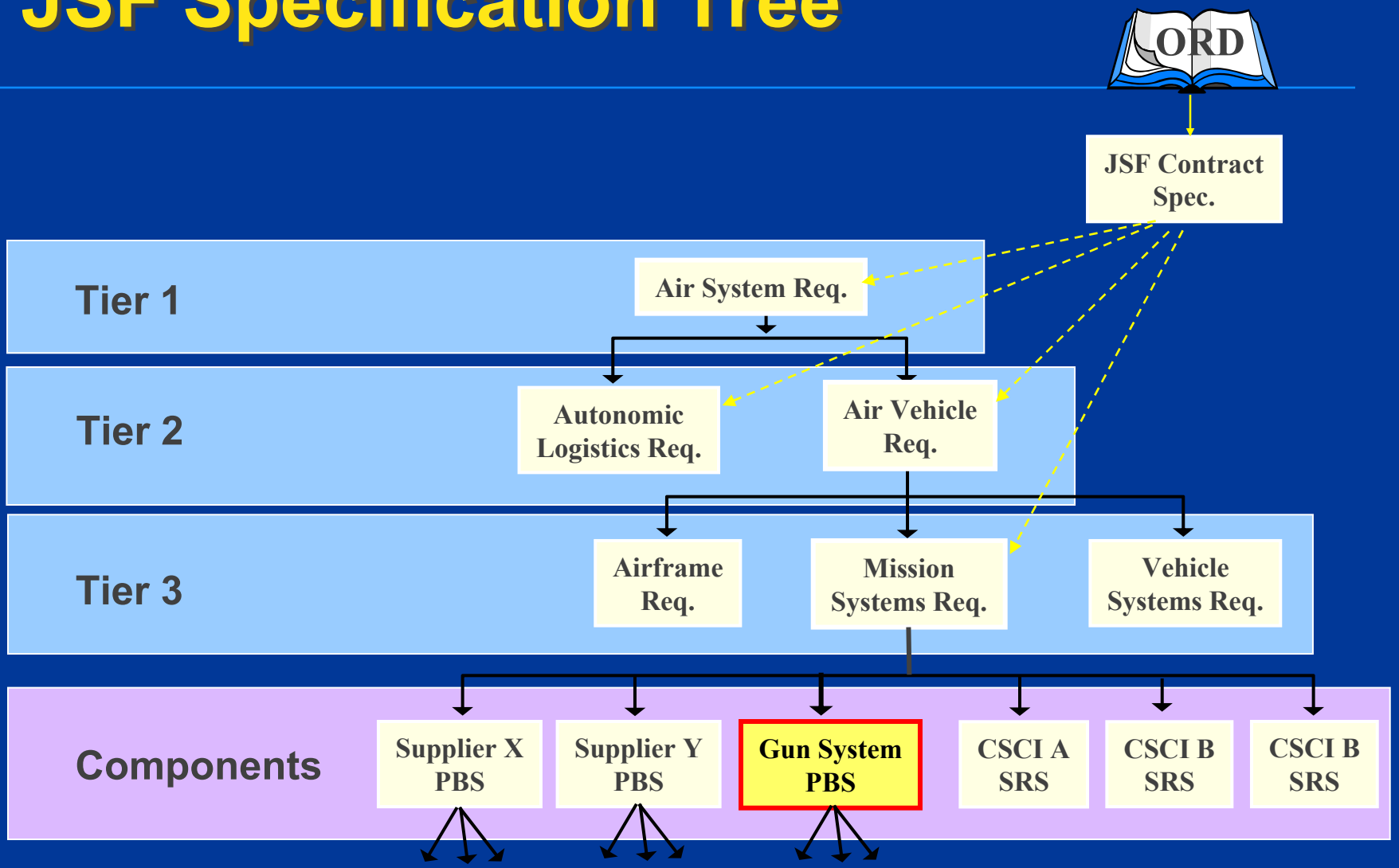
Understand the change before you make it

End-to-end visual validation in a single view

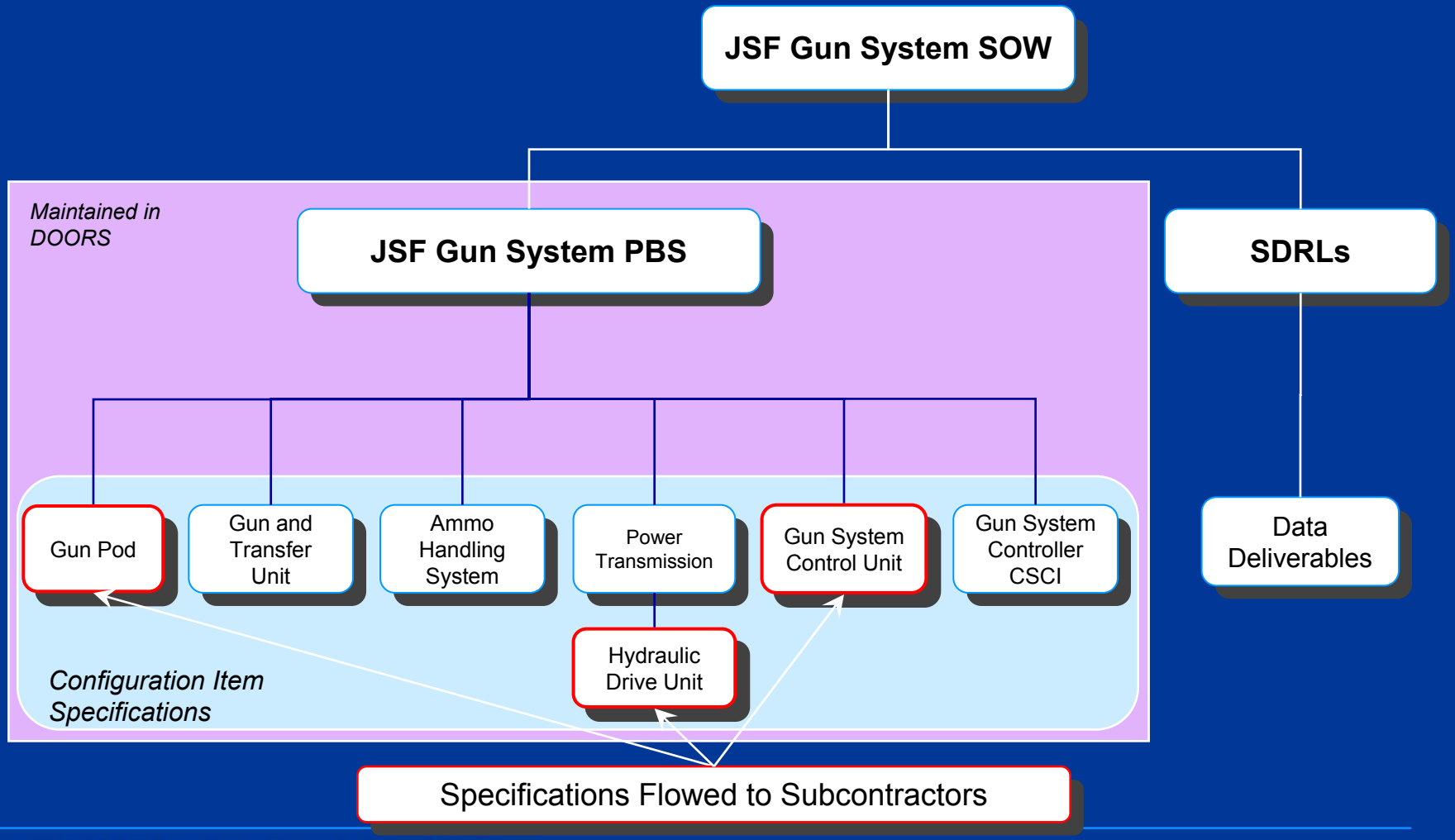
JSF DOORS Structure Summary



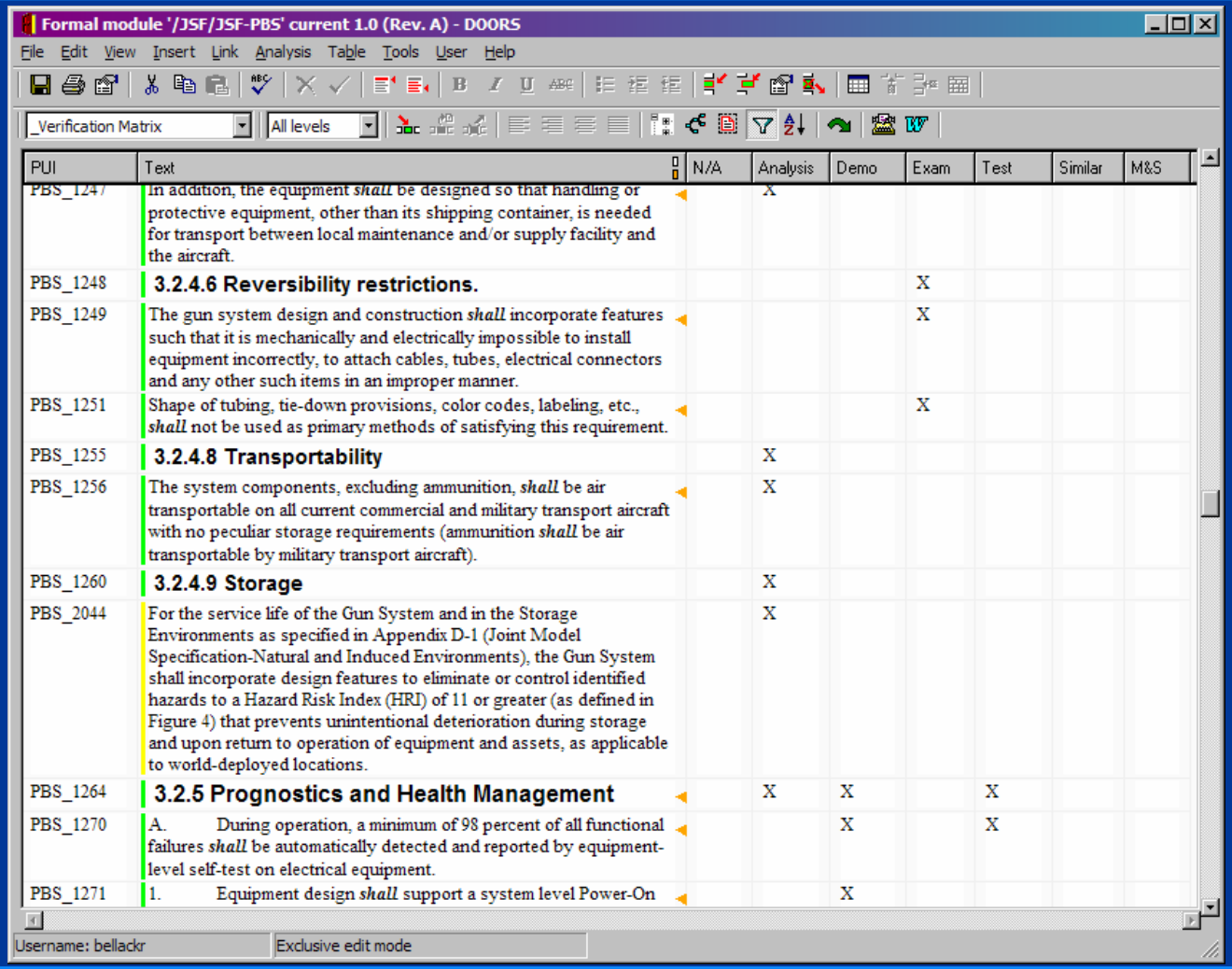
JSF Specification Tree



JSF Gun System Requirements Flow Down

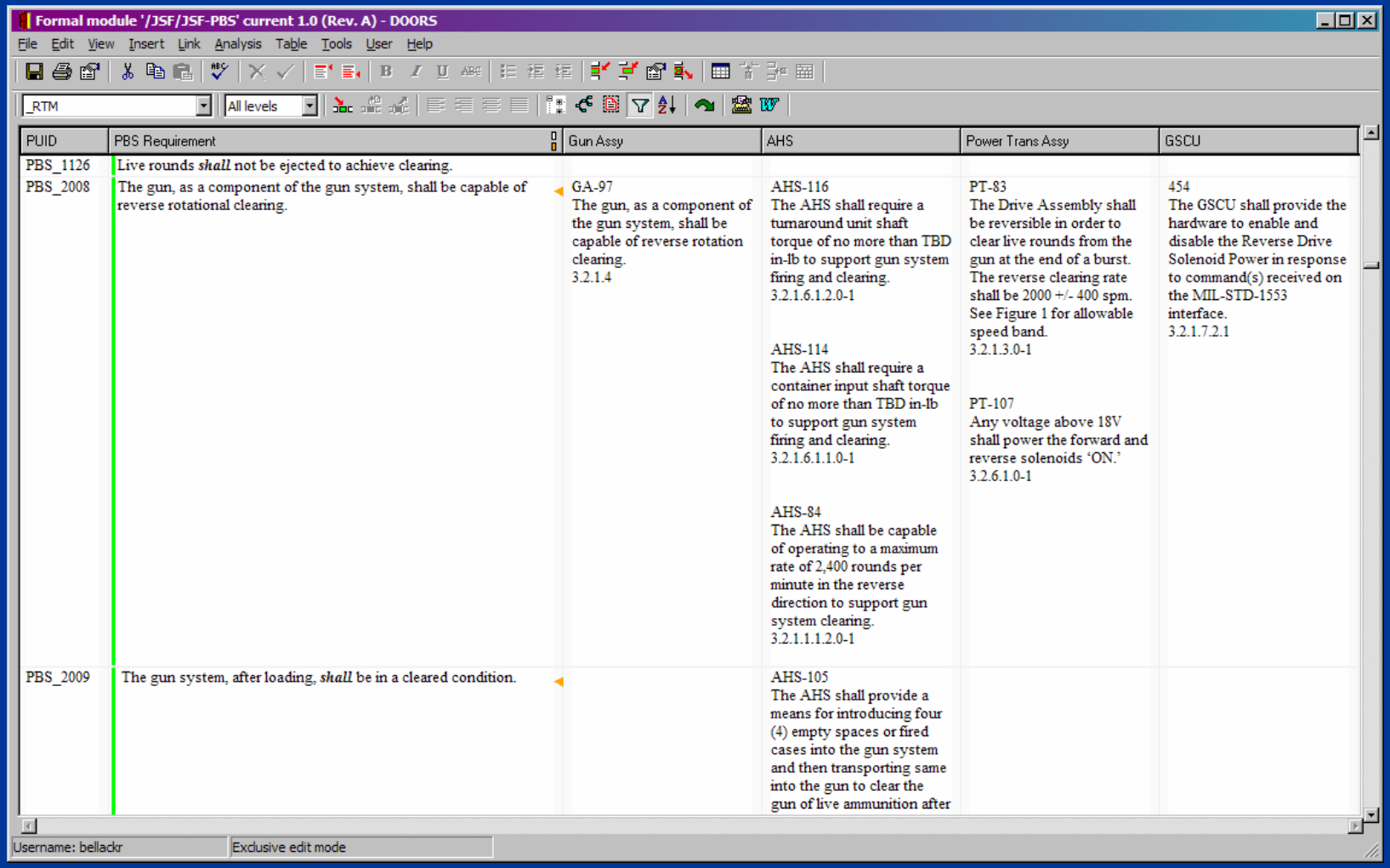


Verification Matrix



PUI	Text	N/A	Analysis	Demo	Exam	Test	Similar	M&S
PBS_1247	In addition, the equipment ***shall*** be designed so that handling or protective equipment, other than its shipping container, is needed for transport between local maintenance and/or supply facility and the aircraft.		X					
PBS_1248	**3.2.4.6 Reversibility restrictions.**				X			
PBS_1249	The gun system design and construction ***shall*** incorporate features such that it is mechanically and electrically impossible to install equipment incorrectly, to attach cables, tubes, electrical connectors and any other such items in an improper manner.				X			
PBS_1251	Shape of tubing, tie-down provisions, color codes, labeling, etc., ***shall*** not be used as primary methods of satisfying this requirement.				X			
PBS_1255	**3.2.4.8 Transportability**		X					
PBS_1256	The system components, excluding ammunition, ***shall*** be air transportable on all current commercial and military transport aircraft with no peculiar storage requirements (ammunition ***shall*** be air transportable by military transport aircraft).		X					
PBS_1260	**3.2.4.9 Storage**		X					
PBS_2044	For the service life of the Gun System and in the Storage Environments as specified in Appendix D-1 (Joint Model Specification-Natural and Induced Environments), the Gun System shall incorporate design features to eliminate or control identified hazards to a Hazard Risk Index (HRI) of 11 or greater (as defined in Figure 4) that prevents unintentional deterioration during storage and upon return to operation of equipment and assets, as applicable to world-deployed locations.		X					
PBS_1264	**3.2.5 Prognostics and Health Management**		X	X		X		
PBS_1270	A. During operation, a minimum of 98 percent of all functional failures ***shall*** be automatically detected and reported by equipment-level self-test on electrical equipment.			X		X		
PBS_1271	1. Equipment design ***shall*** support a system level Power-On			X				

Traceability to CI Specifications



PUID	PBS Requirement	Gun Assy	AHS	Power Trans Assy	GSCU
PBS_1126	Live rounds ***shall*** not be ejected to achieve clearing.				
PBS_2008	The gun, as a component of the gun system, shall be capable of reverse rotational clearing.	GA-97 The gun, as a component of the gun system, shall be capable of reverse rotation clearing. 3.2.1.4	AHS-116 The AHS shall require a turnaround unit shaft torque of no more than TBD in-lb to support gun system firing and clearing. 3.2.1.6.1.2.0-1 AHS-114 The AHS shall require a container input shaft torque of no more than TBD in-lb to support gun system firing and clearing. 3.2.1.6.1.1.0-1 AHS-84 The AHS shall be capable of operating to a maximum rate of 2,400 rounds per minute in the reverse direction to support gun system clearing. 3.2.1.1.1.2.0-1	PT-83 The Drive Assembly shall be reversible in order to clear live rounds from the gun at the end of a burst. The reverse clearing rate shall be 2000 +/- 400 spm. See Figure 1 for allowable speed band. 3.2.1.3.0-1 PT-107 Any voltage above 18V shall power the forward and reverse solenoids 'ON.' 3.2.6.1.0-1	454 The GSCU shall provide the hardware to enable and disable the Reverse Drive Solenoid Power in response to command(s) received on the MIL-STD-1553 interface. 3.2.1.7.2.1
PBS_2009	The gun system, after loading, ***shall*** be in a cleared condition.		AHS-105 The AHS shall provide a means for introducing four (4) empty spaces or fired cases into the gun system and then transporting same into the gun to clear the gun of live ammunition after		

EXIT – JSF Gun System Benefits / Lessons Learned

- Traceability effort has been dramatically reduced with proper tools. DOORS database:
  - Contains entire document and associated trace information
  - Avoids updating multiple documents to the current requirements' baseline
  - Eliminates the need to correct consistency errors
- Requirement status, comments, or any other information can be readily associated with each requirement
- Through linking, relationships between requirements, design information, and test information are dynamically managed

GENERAL DYNAMICS