

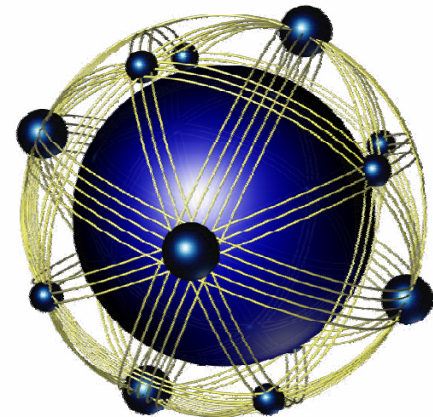
# ***NDIA 11<sup>th</sup> Annual Systems Engineering Conference***

---

## ***“Daily Challenges of Requirements Engineering”***

***October 22, 2008***

Frank Salvatore  
High Performance Technologies, inc.  
3159 Schrader Road  
Dover NJ, 07801  
(973) 442-6436 ext 249  
fsalvatore@hpti.com



# ***Outline***

---

- Requirements Elicitation**
- Requirements Capture and Management**
- Requirements Traceability**
- Requirements Control**
- Reaching Consensus**
- Eliciting Verifications**
- Communicating Requirements**
- Metrics**

# Requirements Elicitation

---

How do you gather the requirements?

- Interviews
- QFD Workshops
- Web Based Surveys
- Vignettes and Scenarios
- Questionnaires
- Brainstorming and Mind Mapping
- Analysis/Derivation
  - ✓ Hazard
  - ✓ Fault Tree
  - ✓ Sensitivity
  - ✓ Trade Studies
- Existing Documentation and or Policies
- Quality Assurance Provisions

*It involves a lot of research and is evolutionary!*

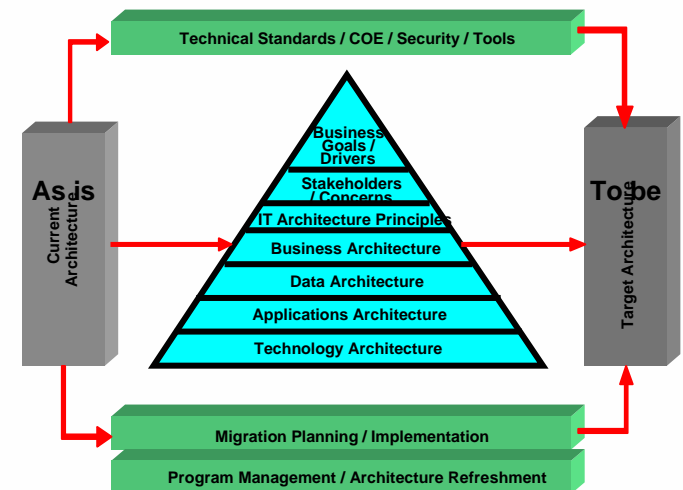
*Don't forget to Document Rational. It will save you time latter when you will need to defend the requirements.*

# Interview Based Elicitation

Using an Enterprise Architecture approach one can first probe into Business Goals and Architecture Principles by asking questions to understand:

- Mission and Values of your organization
- Understand importance (PM Level)
- Understand organization structure
- Understand Products
- Understand Customers and Stakeholders
- Understand Daily Activities

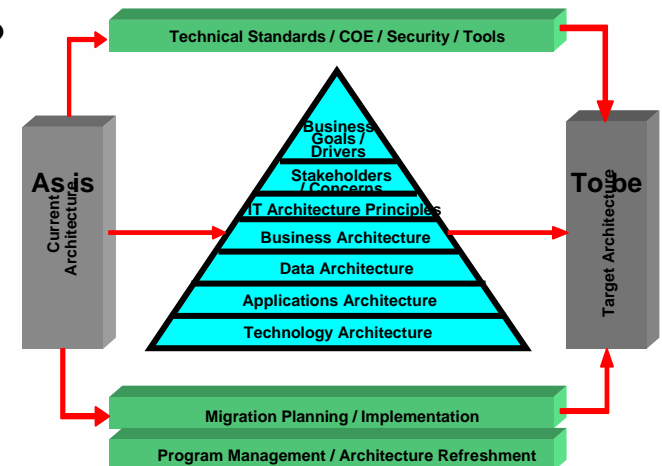
**Mostly used for Business Systems**



# Interview Based Elicitation

Project and Product Data can be understood by asking these leading questions

- What are the Projects/Products that the organization manages?
- Who do you interact with?
- What data types do you manage?
- How do you organize your data?
- What data do you view as being most important?
- Who are the Customers for each product?
- Who are the stakeholders for each product?
- What are the day to day activities that go on for the projects you choose?



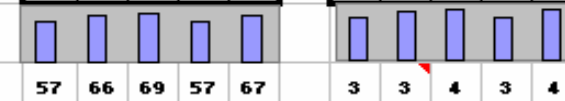
# QFD Based Elicitation



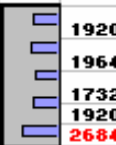
		Engineering Metrics											Customer Importance	Relative Importance	
		Engineering Measur 1	Engineering Measur 2	Engineering Measur 3	Engineering Measur 4	Engineering Measur 5	Engineering Measur 6	Engineering Measur 7	Engineering Measur 8	Engineering Measur 9	Engineering Measur 10	Engineering Measur 11			
USER NEEDS	User Needs	Customer Need 1.0	9	9	0	0	0	9	9	9	0	0	9	5.00	26%
	Customer Need 2.0	0	0	9	9	9	9	9	3	0	0	9	3.00	16%	
	Customer Need 3.0	0	0	0	0	0	3	9	1	9	0	3	5.00	26%	
	Customer Need 4.0	0	0	0	0	0	1	3	9	0	0	1	4.00	21%	
	Customer Need 5.0	0	0	0	0	0	1	1	1	0	5	1	2.00	11%	

USER RATING									
Absolute Score					Relative Score				
Concept A	Concept B	Concept C	Concept D	Concept E	Concept A	Concept B	Concept C	Concept D	Concept E
3	5	1	3	2	0.79	1.3	0.3	0.8	0.5
3	2	3	3	3	0.47	0.3	0.5	0.5	0.5
3	5	5	3	4	0.79	1.3	1.3	0.8	1.1
3	2	5	3	5	0.63	0.4	1.1	0.6	1.1
3	1	5	3	4	0.32	0.1	0.5	0.3	0.4

Organizational Difficulty													
Absolute importance	45	45	27	27	27	93	131	97	45	10	93		
Relative Importance	7%	7%	4%	4%	4%	15%	20%	15%	7%	2%	15%		



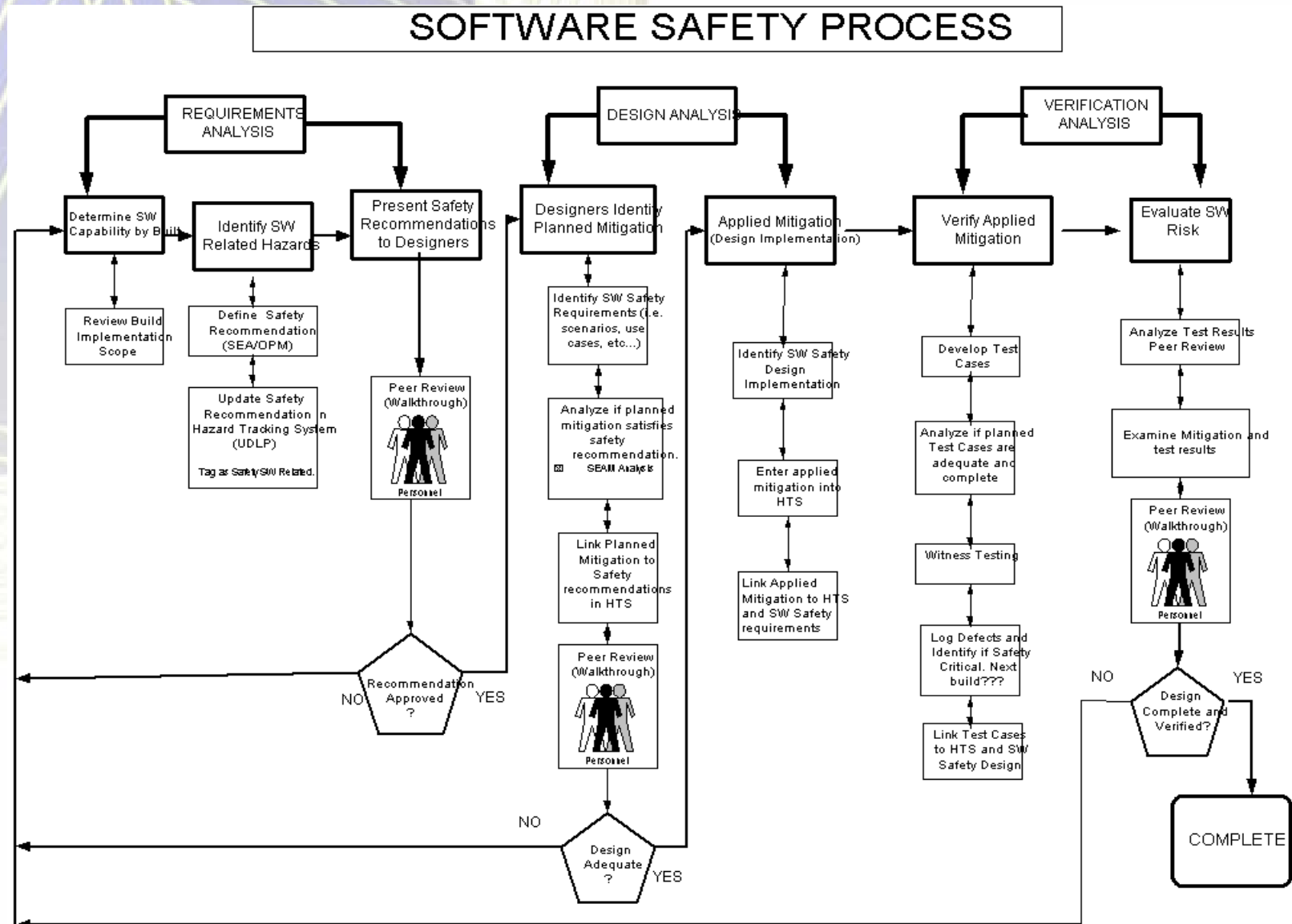
ENGINEERING RATING		Raw Score														
		Concept A	Concept B	Concept C	Concept D	Concept E	Concept A	Concept B	Concept C	Concept D	Concept E	Concept A	Concept B	Concept C	Concept D	Concept E
Weighted Score	Concept A	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Concept B	4	3	2	4	3	5	3	2	1	3	3	3	3	3	3
	Concept C	4	3	3	4	5	4	1	2	4	3	2	2	2	2	2
	Concept D	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Concept E	2	5	3	4	5	5	5	4	3	3	4	3	3	4	4



RISK	Technical	Schedule	Cost

**Also helps to Build Consensus and Understanding of complex relationships as well as importance.**

# Requirements are Discovered Thru The SW Safety Process



# ***Eliciting Verification Methods***

---

**Similar to Requirements. Stakeholders are different. Methods are typically thru Analysis, Test, Inspection, Measurement.**

- Use Interview**
- Use Questionnaires**
- Include Stakeholders Early and Often.**
- Have Stakeholders Peer Review Requirements**
- Use a JCCB**



Graph: Interface Definition

TRL:  TRL5  
 TRL6  
 TRL7

IPT Name: Ammo Handling  
Module Name: AHR

ion: 3.1.2.0-1

Requirements: The Ammo Handling Subsystem will interface with the Turret Structure, Gun Assembly, Fire Control, Ammo Suite and Secondary Armament.

ATD/Objective Force:

This enables and disables the required field warning:

Switch to View Mode

**TRL 5** Verification Method:

~~~Please Select a Method~~~

Responsibility:

- Analysis
- Inspection
- Measurement
- Test
- N/A

(e.g.: IPT Name, Subcontractor, System Integrator)

Critical Test:

Location of Verif:

(e.g.: Picatinny, Contractor Facility, Proving Ground)

~~~Please Select a Test~~~

Verification Procedure: Briefly describe the procedure you recommend at this TRL level to validate or confirm the requirement.

If the requirement will not be verified at this time please indicate so:

~~~Please Select a Method~~~

[Empty text box for verification procedure]

Data Collected:

[Empty text box for data collected]

Clear

Reset

**TRL 6** Verification Method:

~~~Please Select a Method~~~

Responsibility:

[Empty text box]

(e.g.: IPT Name, Subcontractor, System Integrator)

Critical Test:

Location of Verif:

[Empty text box]

(e.g.: Picatinny, Contractor Facility, Proving Ground)

~~~Please Select a Test~~~

Verification Procedure: Briefly describe the procedure you recommend at this TRL level to validate or confirm the requirement.

If the requirement will not be verified at this time please indicate so:

[Empty text box for verification procedure]

Data Collected:

[Empty text box for data collected]

Clear

Reset

**TRL 7** Verification Method:

~~~Please Select a Method~~~

|< << >> >|

Record [ ] of [ ]

Exit

# ***Requirements Capture and Management***

---

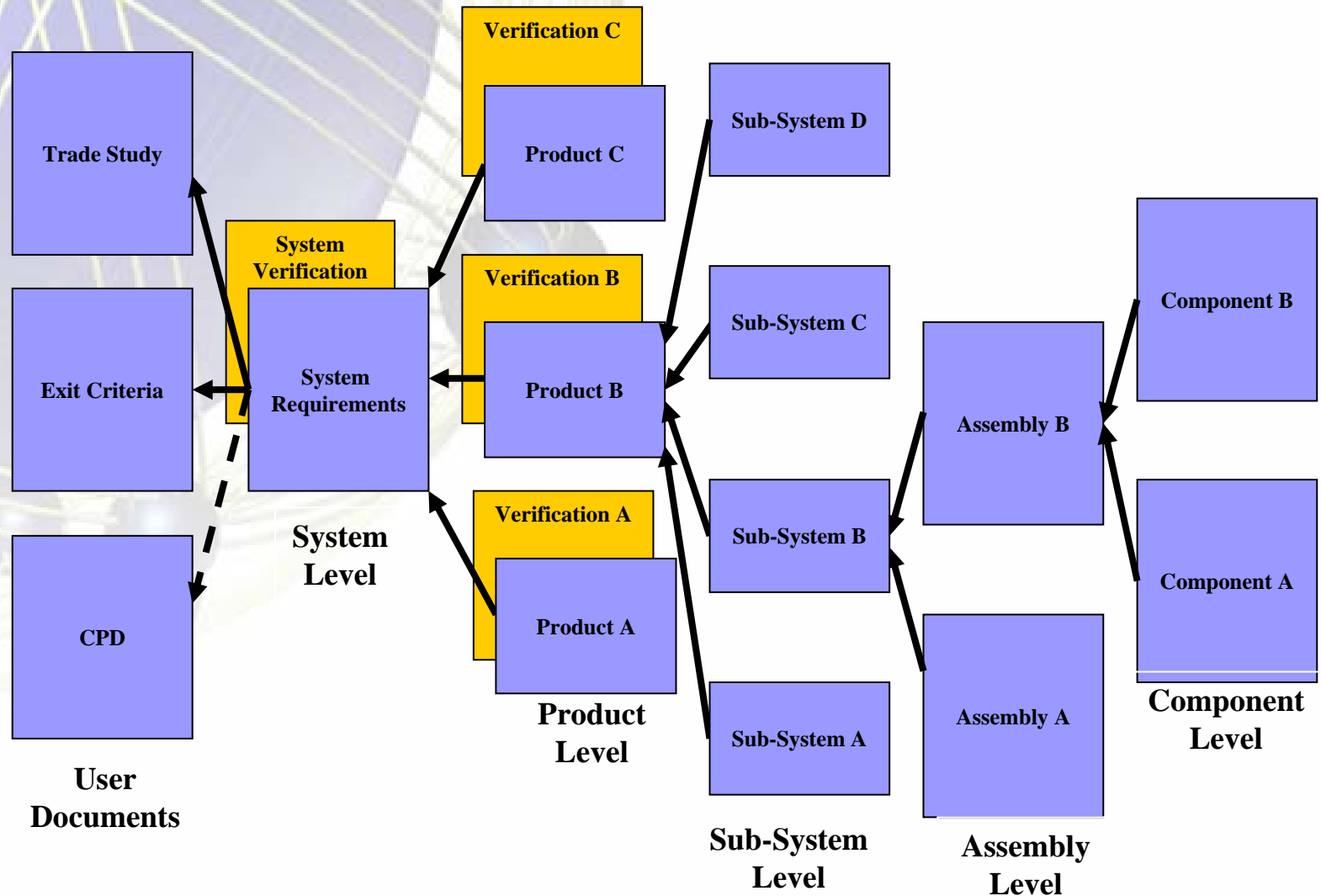
**How and where do you store the requirements?**

**Word Documents are standard. Tools are useful and can Help. But try to get everyone to use them consistently!!!!**

- Access**
- Excel**
- DOORS**
- RTM**
- Requisite Pro**
- RM Calibre**
- etc....**

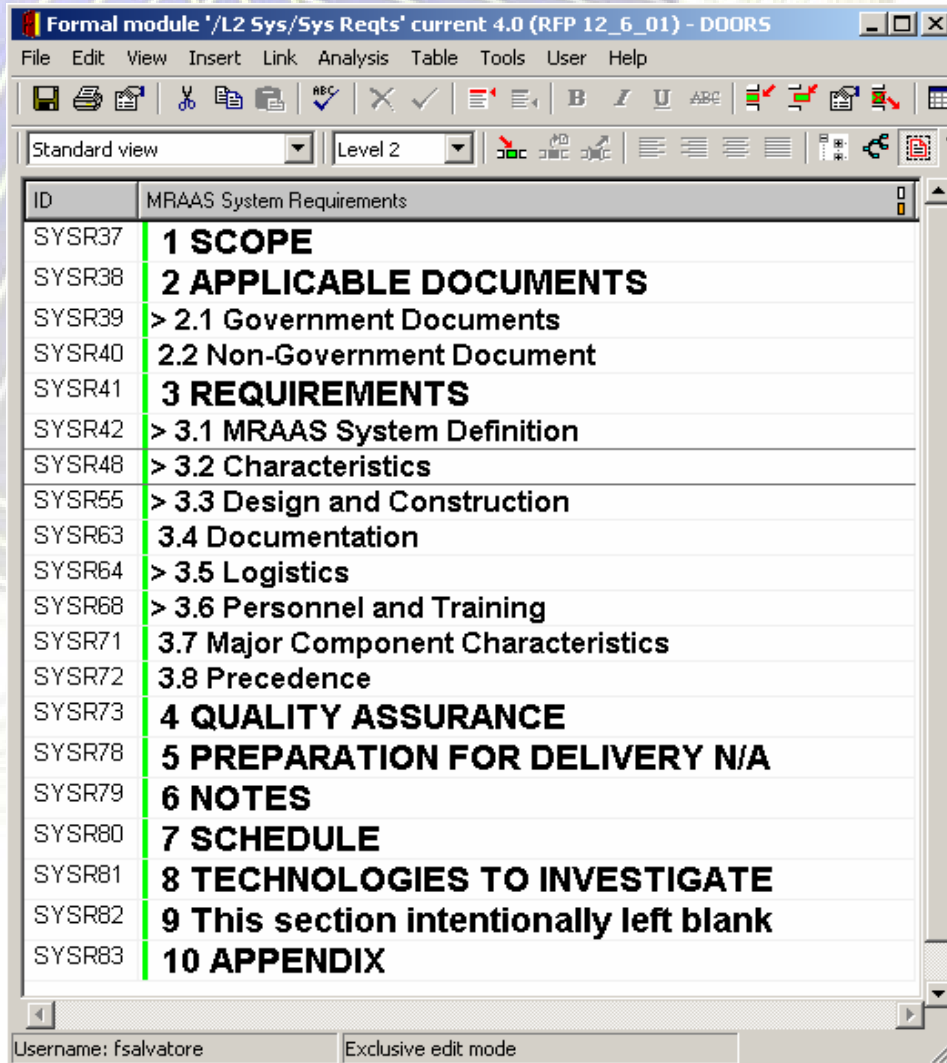
***Use Document Templates Based On Standards. Also IM is Important for Efficiency.***

# Requirements Management Specification Hierarchy



**Establish Hierarchy and Naming Convention, Follow IEEE Standard**

# Document Outline is Standard Throughout Project.



The screenshot shows a software application window titled 'Formal module "/>

| ID     | MRAAS System Requirements                      |
|--------|--|
| SYSR37 | <b>1 SCOPE</b>                                 |
| SYSR38 | <b>2 APPLICABLE DOCUMENTS</b>                  |
| SYSR39 | > 2.1 Government Documents                     |
| SYSR40 | 2.2 Non-Government Document                    |
| SYSR41 | <b>3 REQUIREMENTS</b>                          |
| SYSR42 | > 3.1 MRAAS System Definition                  |
| SYSR48 | > 3.2 Characteristics                          |
| SYSR55 | > 3.3 Design and Construction                  |
| SYSR63 | 3.4 Documentation                              |
| SYSR64 | > 3.5 Logistics                                |
| SYSR68 | > 3.6 Personnel and Training                   |
| SYSR71 | 3.7 Major Component Characteristics            |
| SYSR72 | 3.8 Precedence                                 |
| SYSR73 | <b>4 QUALITY ASSURANCE</b>                     |
| SYSR78 | <b>5 PREPARATION FOR DELIVERY N/A</b>          |
| SYSR79 | <b>6 NOTES</b>                                 |
| SYSR80 | <b>7 SCHEDULE</b>                              |
| SYSR81 | <b>8 TECHNOLOGIES TO INVESTIGATE</b>           |
| SYSR82 | <b>9 This section intentionally left blank</b> |
| SYSR83 | <b>10 APPENDIX</b>                             |

Username: fsalvatore Exclusive edit mode

- ☑ Using Mil-STD-490/961C standard template
- ☑ Standardized Documentation format makes it easier to find what you are looking for

# Level 1 User Requirements

3159 DOORS Database: /L1 User - DOORS

File Edit View Tools Help

3159 DOORS Database

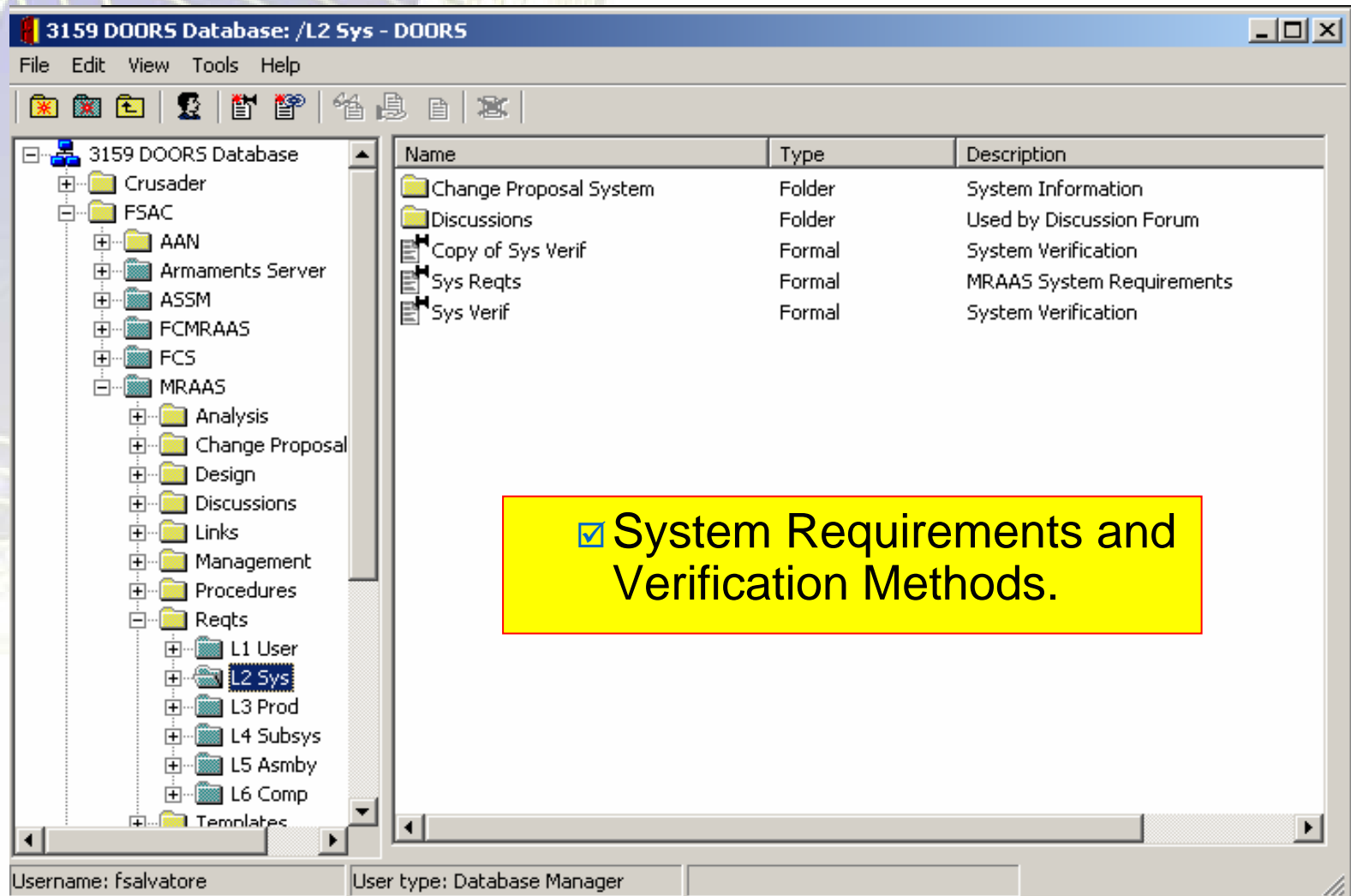
- Crusader
- FSAC
  - AAN
  - Armaments Server
  - ASSM
  - FCMRAAS
  - FCS
  - MRAAS
    - Analysis
    - Change Proposal
    - Design
    - Discussions
    - Links
    - Management
    - Procedures
    - Reqts
      - L1 User
      - L2 Sys
      - L3 Prod
      - L4 Subsys
      - L5 Asmby
      - L6 Comp
    - Templates

| Name                   | Type   | Description             |
|------------------------|--------|-------------------------|
| Change Proposal System | Folder | System Information      |
| ATD Reqts              | Formal | ATD Reqts               |
| MNS                    | Formal | Mission Needs Statement |
| Trade Study            | Formal | Trade Study             |

Username: fsalvatore User type: Database Manager

- This is where the User Requirements would be stored.
- Everyone on the project can read only few can change.

# Level 2 System Requirements



The screenshot displays the 3159 DOORS Database interface. The title bar reads "3159 DOORS Database: /L2 Sys - DOORS". The menu bar includes "File", "Edit", "View", "Tools", and "Help". The left pane shows a tree view of the database structure, with "L2 Sys" selected under the "MRAAS" folder. The right pane shows a table of the selected folder's contents.

| Name                   | Type   | Description               |
|------------------------|--------|---------------------------|
| Change Proposal System | Folder | System Information        |
| Discussions            | Folder | Used by Discussion Forum  |
| Copy of Sys Verif      | Formal | System Verification       |
| Sys Reqts              | Formal | MRAAS System Requirements |
| Sys Verif              | Formal | System Verification       |

System Requirements and Verification Methods.

Username: fsalvatore      User type: Database Manager

# Level 3 Product Requirements

3159 DOORS Database: /L3 Prod - DOORS

File Edit View Tools Help

3159 DOORS Database

- Crusader
- FSAC
  - AAN
  - Armaments Server
  - ASSM
  - FCMRAAS
  - FCS
  - MRAAS
    - Analysis
    - Change Proposal
    - Design
    - Discussions
    - Links
    - Management
    - Procedures
    - Reqts
      - L1 User
      - L2 Sys
      - L3 Prod**
      - L4 Subsys
      - L5 Asmbly
      - L6 Comp
    - Templates

| Name                   | Type   | Description                      |
|------------------------|--------|----------------------------------|
| Change Proposal System | Folder | System Information               |
| Discussions            | Folder | Used by Discussion Forum         |
| ASR                    | Formal | Ammo Suite Requirements          |
| ASV                    | Formal | Ammo Suite Verification          |
| MAR                    | Formal | Main Armaments Requirements      |
| MAV                    | Formal | Main Armament Verification       |
| SAR                    | Formal | Secondary Armaments Requirements |
| SAV                    | Formal | Secondary Armament Verification  |

Username: fsalvatore User type: Database Manager

Product Requirements and Verification Methods.

IPT's Manage and communicate changes to SEIT.

# Level 4-6 Subassembly to Component Requirements

3159 DOORS Database: /AS - DOORS

File Edit View Tools Help

FSAC

- AAN
- Armaments Server
- ASSM
- FCMRAAS
- FCS
- MRAAS
  - Analysis
  - Change Proposal
  - Design
  - Discussions
  - Links
  - Management
  - Procedures
  - Reqts
    - L1 User
    - L2 Sys
    - L3 Prod
    - L4 Subsys
      - AS
    - Discussio
    - MA
    - SA
  - L5 Asmbly

| Name                   | Type   | Description                      |
|------------------------|--------|----------------------------------|
| Change Proposal System | Folder | System Information               |
| AKR                    | Formal | Adv KE Reqts                     |
| AKV                    | Formal | Adv KE Verification              |
| PR                     | Formal | Propulsion Assembly Requirements |
| PV                     | Formal | Propulsion Verification          |
| SSR                    | Formal | Smart Suite Reqts                |
| SSV                    | Formal | Smart Suite Verification         |
| WHR                    | Formal | Warhead Reqts                    |
| WHV                    | Formal | Warhead Verification             |

Username: fsalvatore User type: Database Manager

- ✓ IPT's Own and work to requirements
- ✓ Designers communicate Changes and assess impact.
- ✓ Everyone works together to achieve a common goal.



# ***Requirements Traceability***

---

**How do you understand how the requirements are being satisfied, are complete, are accurate, etc.....**

- Trace Matrices are Typical and require constant care and feeding to maintain.**
- Use a tool to manage your requirements and capture traceability so you can search and query when doing impact analysis.**
  - ✓ **More accurate**
  - ✓ **More efficient**
  - ✓ **More complete**

***No tool will automatically generate but they will preserve it once you do it the first time.***

***If a requirement isn't traceable to anything it doesn't belong!!!***

***This is Important when performing Impact Analysis, doing FCA and PCA, etc....***

# ***Requirements Change Control***

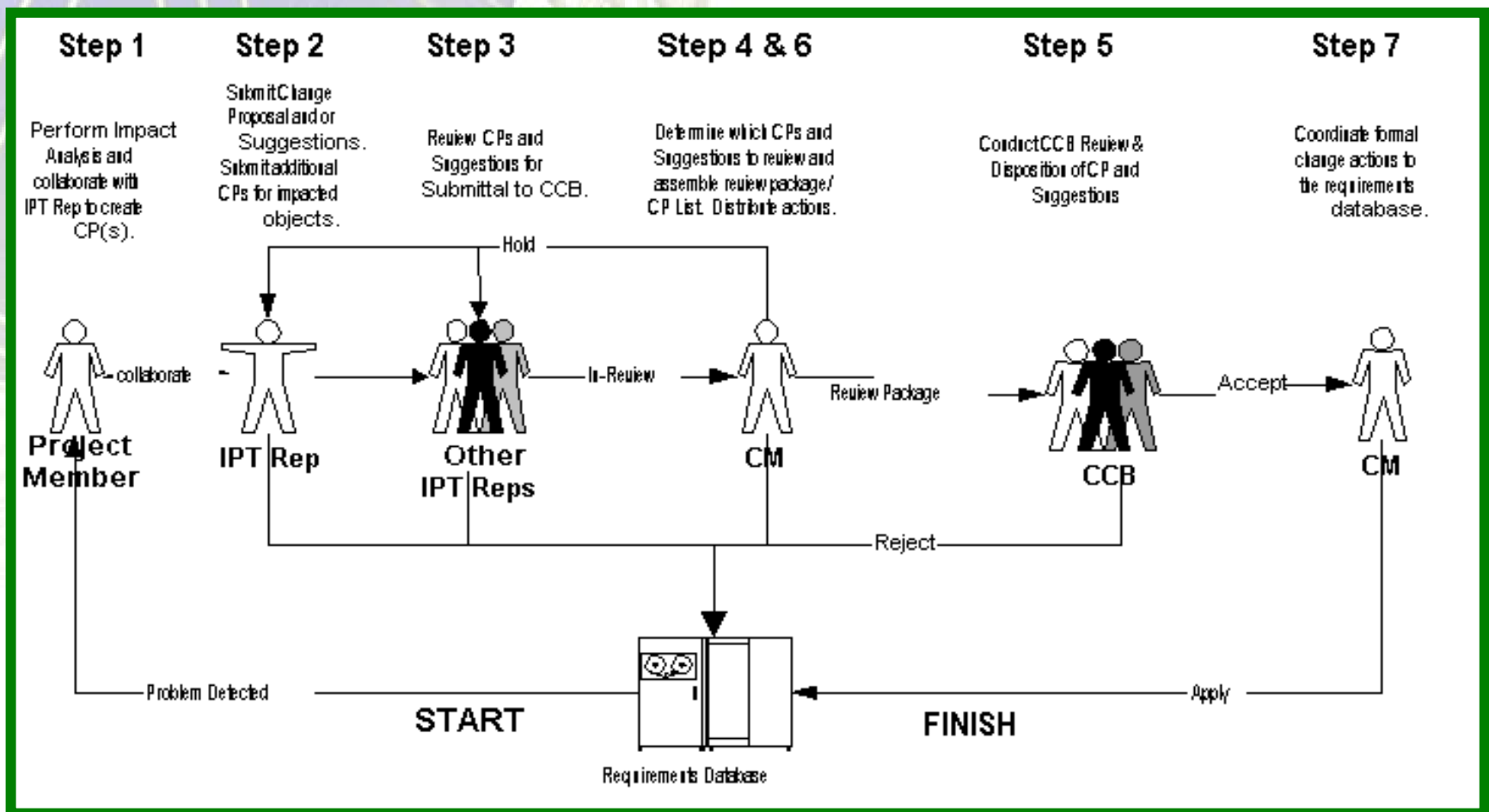
---

**If a Requirement is changed, how do we determine effects on other Requirements, Verifications or Schedule Events?**

- Use Inter-IPT Coordination**
- Use Impact Analysis & Visualization Tools**
- Use Formal Change Control Procedures**
- Attributes**

***With a tool you have better and more efficient ways of controlling the requirements.***

# Follow a Change Proposal Process



# ***Starting the Change Process***

---

**IPT Member brings an issue to attention of IPT Lead**

**IPT Lead makes an initial determination:**

**PURSUE – Proposed change has merit and is worth further investigation**

**DISCARD – Proposed change does not have merit or is not worth further investigation at this time**

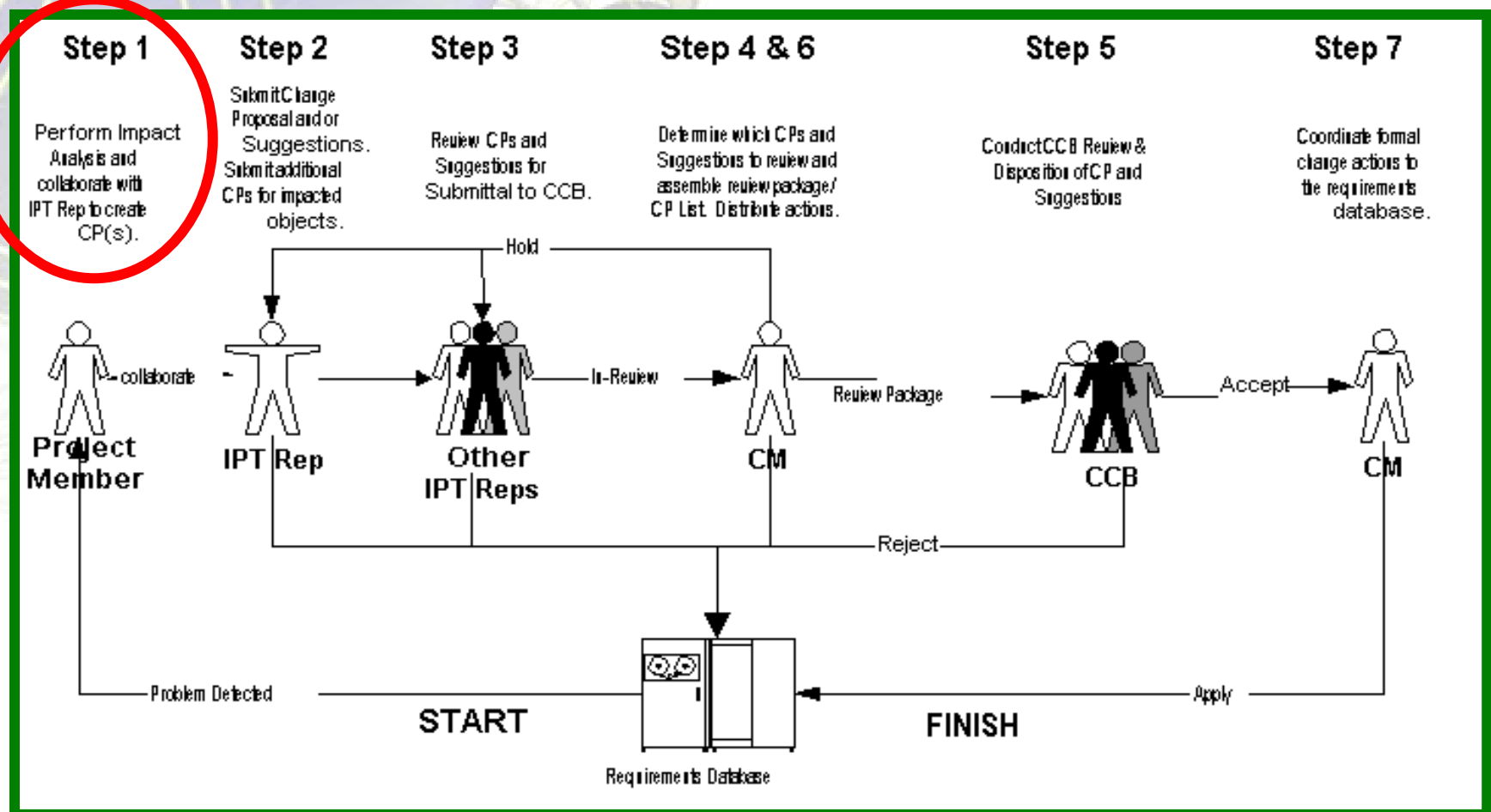
**If you choose to PURSUE the potential change:**

- 1. Coordinate with other IPT's to discuss**
- 2. Initiate working group(s) as needed**

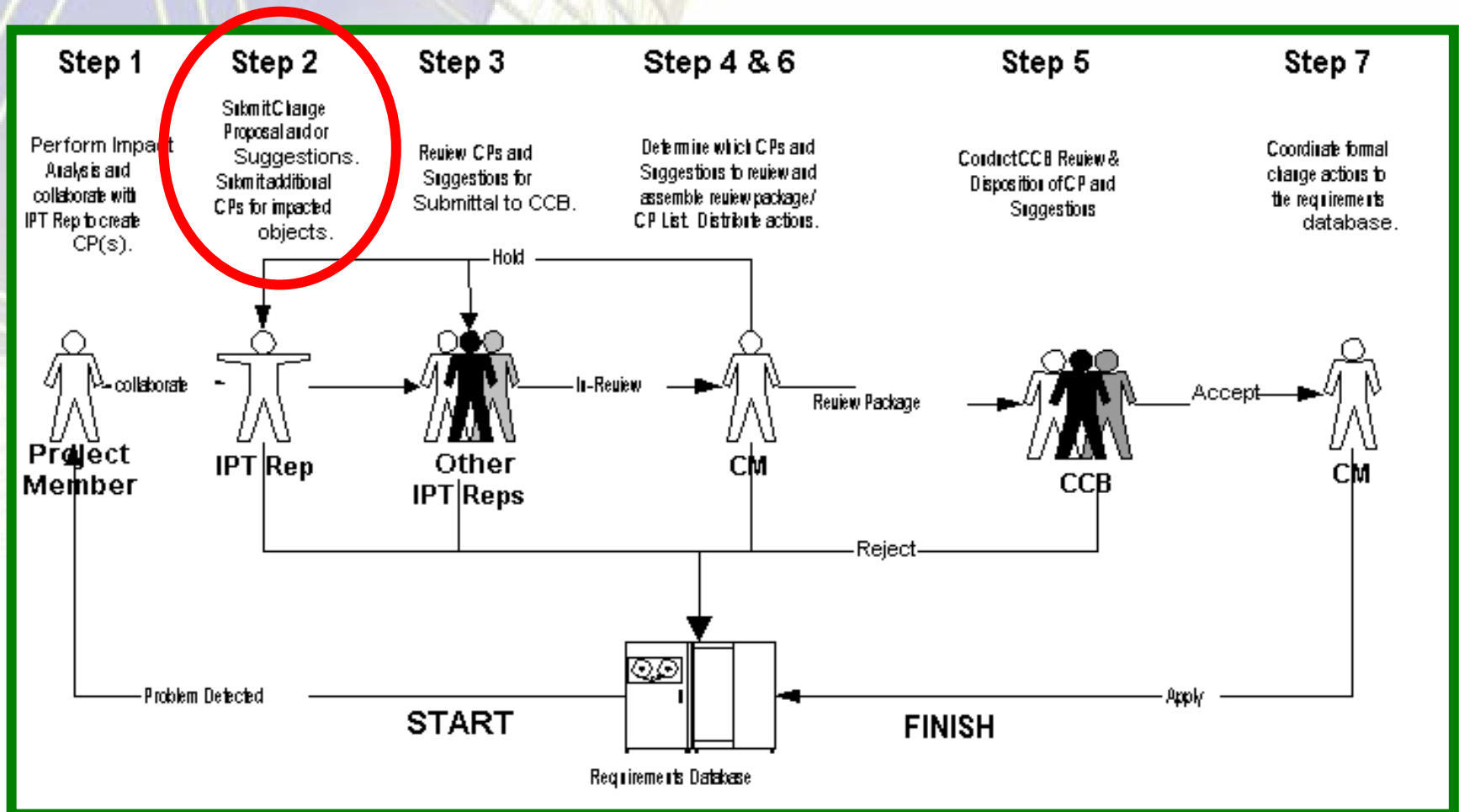
**COMMUNICATE !!!**

# Starting the Change Process

Still think a change is needed? Perform an “Impact Analysis”



# Impact Analysis Complete... Submit a Change Proposal



# Submit Change Proposal

Fill out appropriate fields in the 'Proposed' half of the Change proposal Form. Remember to address any affected attributes.

Change Proposal for module "LAR" - DOORS

Change proposal for object: LAR360 In-links: 0

Pending change proposals for this object: 1 Out-links: 1

Current

Object Heading

Object Text

The muzzle brake shall not generate a muzzle exit pressure above 12ksi.

ATD

Proposed

Object Heading

Object Text

The muzzle brake shall not generate a muzzle blast overpressure above TBD. (Driven by muzzle exit pressure of 12 ksi)

Show attribute: ATD/

ATD

Reason for change:

Muzzle blast overpressure is correct term. Muzzle Brake will be designed to minimize blast overpressure.

Other impacted requirements are:

Change type:  Priority:

Submit

Select Change Type

Make adjustments to the Reason for change as needed. BE SURE TO NOTATE ANY CONTRACTUAL IMPLICATIONS!!!

Select Very High, High, Medium or Low (refer to CPP Document for details)

When satisfied with form, press Submit to create the new Change proposal

# Submit Change Suggestion

When 5 or more actions need to occur (I.e., Change proposals) in order to fully satisfy a Change Proposal, a Change Suggestion should be created instead of a change proposal.

**Suggestion for project 'MRAAS' - DOORS**

Suggestion:

(r-ids.) [The total Gun Assembly imbalance is equal to 6063 r-ids. Gun mount is 63 r-ids.] - ATD/Objective Attribute = ATD, TRL Attribute = TRL 7. Link requirement to GAR new requirement 1.

GAR242: The Gun Assembly shall have an imbalance of no more than 1.011 x e7 N-mm. (7457 ft-lbs.) - Change TRL Attribute to read TRL 5 & 6 Only. De-link from MAR 281, MAR282, MAR283, MAR284 (Weapon Pt. Errors), MAR89 (The Main Armament shall be capable of elevating and depressing at a rate of 400 mils/sec), MAR133 (The Main Armament shall be capable of elevation in the range of -10 to 55 degrees.) and link to MAR new requirement 1 below.

GAR new requirement 1: GAR242: The Gun Assembly shall have an imbalance of no more than 8.22 x e6 N-mm. (6063 ft-lbs.) - ATD/Objective Attribute = ATD, TRL Attribute = 7. Link requirement to MAR new requirement 2.

MAR new requirement 1: The Gun Assembly shall have an imbalance of no more than 1.011 x e7 N-mm. (7457 ft-lbs.)

Reason for change:

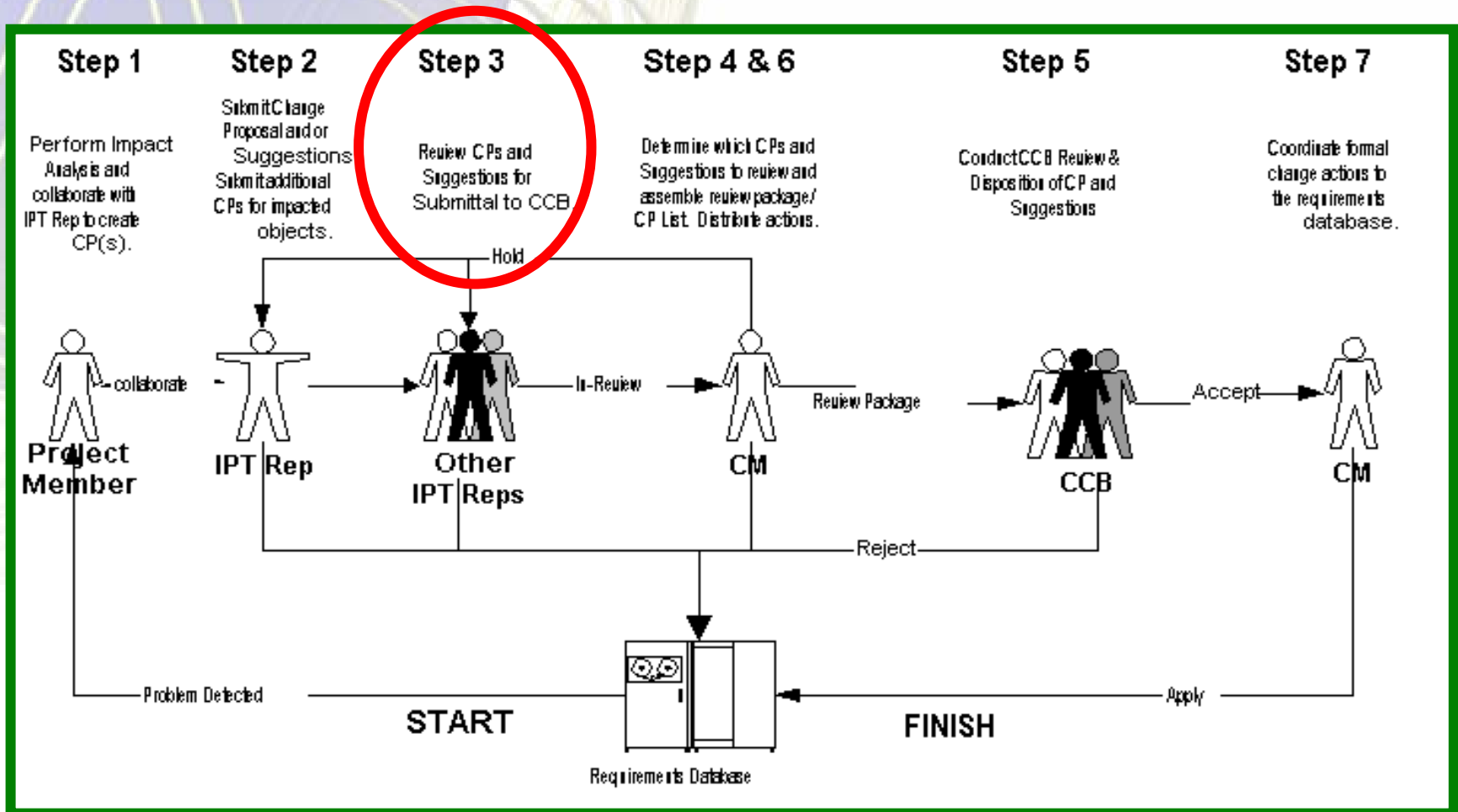
Currently the imbalance requirement (LAR 335) of 7394 ft-lbs for Launcher is the same for TRL 5, 6, 7. Need a different imbalance requirement for TRL 7 of 6000 ft-lbs. Need to flow up the new requirement to GAR and MAR. The old requirement must also flow-up to MAR. Need imbalance requirement in MAR to link gun imbalance to FC requirements.

Suggestion type:  Priority:

Fill out fields as needed and press **Submit** to create a new suggestion. The JCCB will approve and apply suggestions via the Change Proposal System.



# Review CP's and Suggestion



# Predefined Views Can Help

The screenshot shows a software window titled "Formal module 'L5 Asmbly/GA/LAR' current 4.0 (RFP 12\_6\_01) - DOORS". The window contains a table with columns for "Object Identifier", "Launcher Assembly Requirements", and "CP Status List".

| Object Identifier | Launcher Assembly Requirements   | CP Status List  |
|-------------------|--|---|
| LAR37             | <b>1 SCOPE</b>   |   |
| LAR41             | <b>3 REQUIREMENTS</b>  |   |
| LAR48             | <b>3.2 Characteristics</b>   |   |
| LAR49             | <b>3.2.1 Performance Characteristics</b>   |   |
| LAR250            | <b>3.2.1.9 Launcher Assembly</b>   |   |
| LAR252            | <b>3.2.1.9.1 Tube Assembly</b>   |   |
| LAR360            | The muzzle brake shall not generate a muzzle exit pressure above 12ksi.  | <b>CP L1-35</b><br><b>Change Type:</b> Modification<br><b>Priority:</b> Medium<br><b>Status:</b> New<br><b>Reason For Change:</b> Muzzle blast overpressure is correct term. Muzzle Brake will be designed to minimize blast overpressure.<br><br>Other impacted requirements are:<br><br>GAR258: The Gun Assembly shall not generate a muzzle exit pressure above 12ksi.<br>MAR353: The Gun Assembly shall not generate a muzzle exit pressure above 12 ksi.<br>SYSR613: The maximum muzzle exit pressure shall not exceed 12 ksi.<br><b>Submitted by:</b> alagasca<br><b>Submitted on:</b> 27 February 2002 |
| LAR50             | <b>3.2.2 Physical Characteristics</b>  |   |
| LAR334            | <b>3.2.2.4 Imbalance</b>   |   |
| LAR335            | The Launcher Assembly shall have an imbalance of no more than 1.0025 x e7 N-mm (7394 ft.-lbs.) (The total Gun Assembly imbalance is equal to 7457 ft.-lbs. Gun Mount is 63 ft.-lbs.) | <b>CP L1-34</b><br><b>Change Type:</b> Modification<br><b>Priority:</b> Medium<br><b>Status:</b> In Review<br><b>Reason For Change:</b> Related to CP   |

**Views can be built in an RM Tool to help in the review process.**

Username: talameda | Exclusive edit mode

# Forms Can Also Help

**Review Change Proposals - DOORS**

CP L1-35 submitted by 'alagasca' on 27 February 2002.

**Current**

Object Heading:

Object Text:

ATD:

**Proposed**

Object Heading:

Object Text:

Show attribute:

ATD:

Reason for change:

Priority:

Other impacted requirements are:

Status:

- New
- In Review**
- Approved
- On Hold
- Rejected

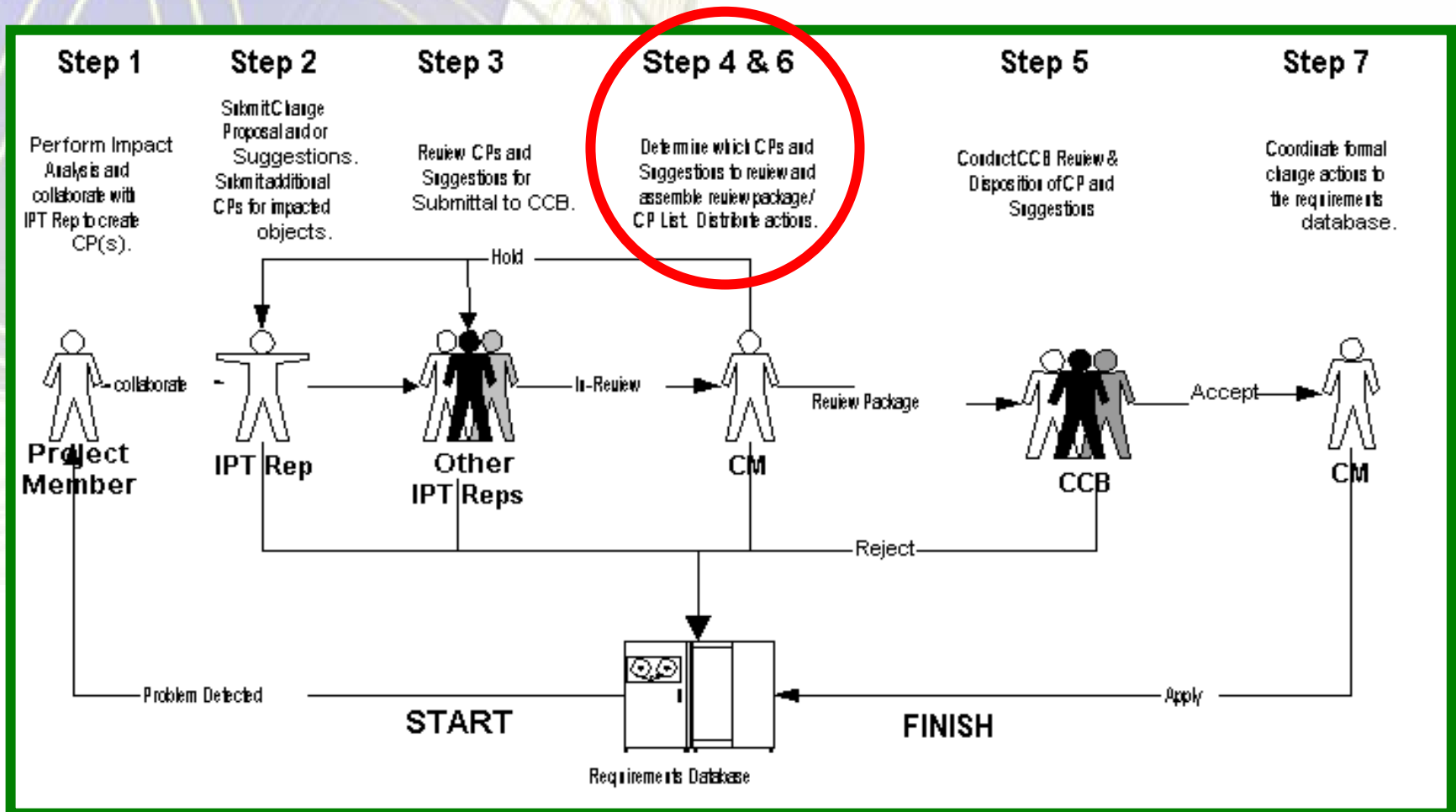
Reviewer comments:

Commit Change

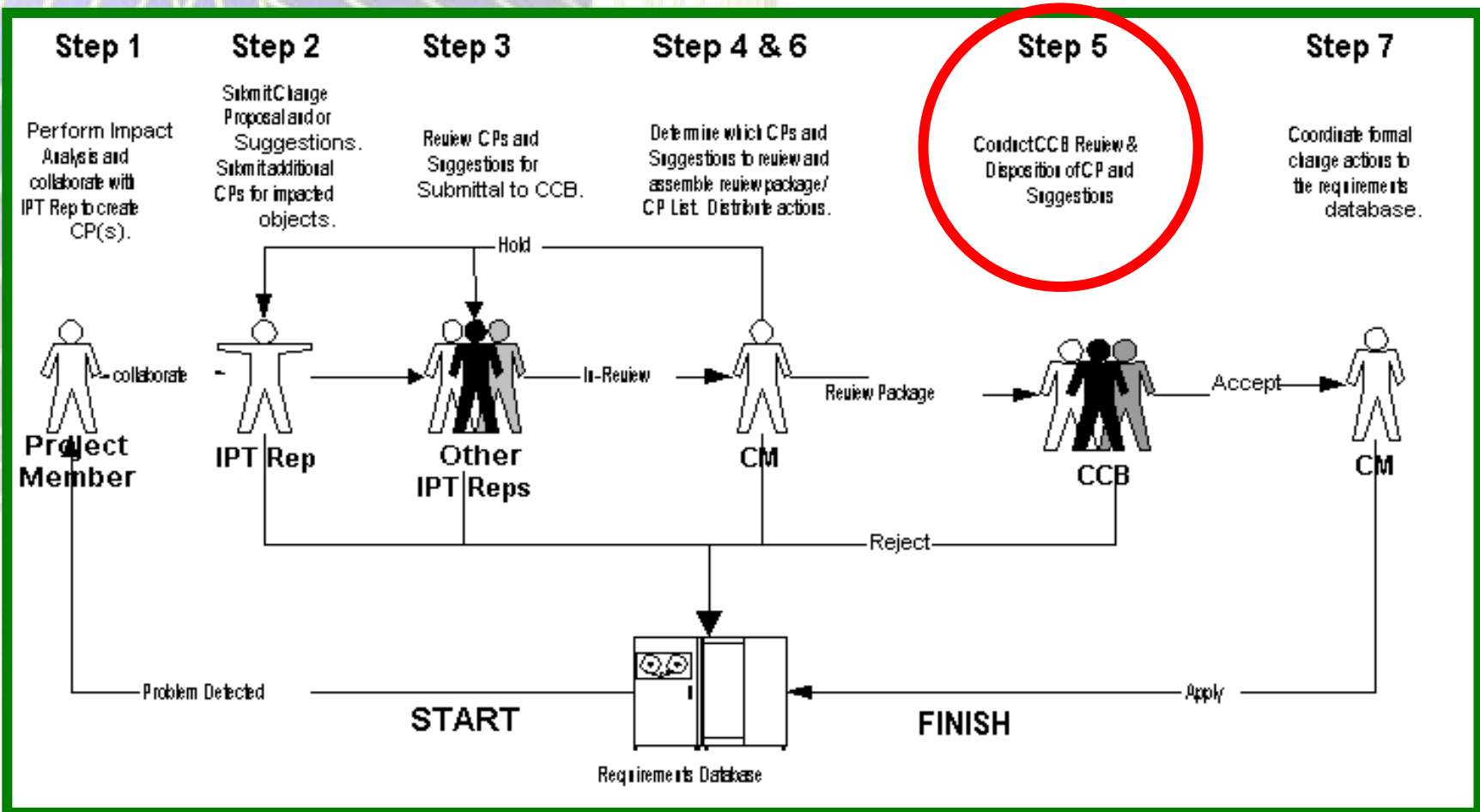
Show proposals:

**Forms are another way of stepping thru changes and suggestions made by the IPT.**

# ID CP's and Suggestions and Schedule JCCB



# Perform JCCB and Update dB with Results.



**Approved** (ready for implementation)

**On-Hold** (further investigation needed)

**Rejected** (requested change discarded)

# ***Reaching Consensus***

---

## **Use IPT forum to Elicit Requirements.**

- Include Stakeholders Early and Often.**
- Have Stakeholders Peer Review Requirements**
- Document Rational. It will save you time latter when you will need to defend the requirements.**
- Use a JCCB**
- Try using QFD Method to Build Consensus**

# ***Communicating Requirements***

---

## **Use of DOORS has helped BUT!!**

- Culture shock is hard to overcome.**
- Revert back to WORD and EXCEL documents.**
  - ✓ **Not so efficient and may introduce errors.**
- May need to hold hands**
- Provide Training and Tailor it to the project.**
- Need to pay close attention to Permission and database administration details.**
- JCCB has forced communication to happen and has made it mandatory.**
- Will need good IT support to reach remote locations when using a tool.**

# ***Requirements Metrics***

---

**Select metrics you will use.**

**Don't try to many or they won't be managed.**

**You can build them into an RM tool.**

**Some Examples Include:**

**Volatility**

**# Requirements**

**# TBD**

**# Verified**

***Using a tool will produce  
metrics naturally.***



# *Requirements Attributes*

---

Attributes are additional defined characteristics of a requirement and they provide essential information in addition to requirement text

|                      |  |
|----------------------|--|
| <i>Source</i>        | Who specified this requirement?                        |
| <i>Priority</i>      | What is the priority of this requirement?              |
| <i>Verifiability</i> | Is the requirement verifiable?                         |
| <i>Accepted</i>      | Has this requirement been accepted by the developers?  |
| <i>Review</i>        | Review status of this requirement                      |
| <i>Safety</i>        | Is this a safety-critical requirement?                 |
| <i>Comments</i>      | Any comments on the requirement to clarify its meaning |
| <i>Questions</i>     | Any questions that must be clarified with the source   |

**You can define attributes that will support your process and make your database more productive for you**

# ***Summary***

---

**The use of an RM tool is an enabling technology to achieve greater accuracy and efficiency when engineering requirements.**

**There are definite skills and disciplines required to do requirements engineering**

**Not only will One need to understand how to:**

- Elicit Requirements**
- Capture and Control Them**
- Establish and maintain Traceability**
- Reach Consensus**
- Elicit Verification Methods**
- Communicate Requirements**
- Defined some Metrics and Attributes**

**They will also need to be proficient in using and tailoring an RM Tool**



---

**Questions?**