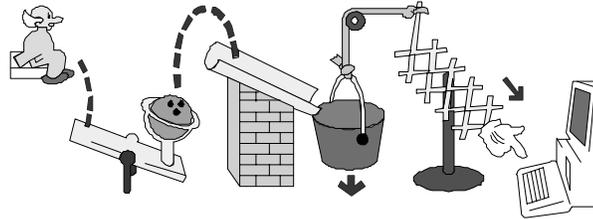


# FAA National Software Conference, May 2002

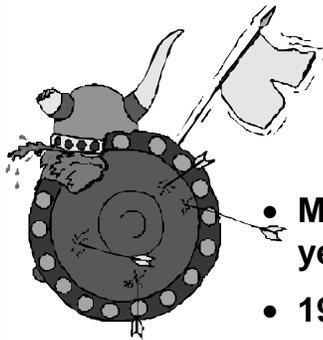
## Change Impact Analysis



### Change Impact Analysis

Will Struck  
FAA Transport Airplane Directorate  
Standards Staff ANM-111  
will.struck@faa.gov

Slide  
1



### History

- Major vs. minor issues existed for years.
- 1993-1996 - CAST developed a major/minor software paper
- 1998 - SSAC raised issue
- 1998-1999 - FAA & industry develop a position
- Status: Notice Signed on May 11, 2000 (N8110.85)

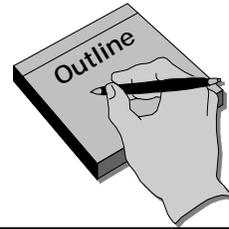
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2

# FAA National Software Conference, May 2002

## Change Impact Analysis

### Notice N8110.85 Outline

- Title: “Guidelines for the Oversight of Software Change Impact Analysis Used to Classify Software Changes As Major or Minor”
- Section 1: Purpose
- Section 2: Distribution
- Section 3: Related Publications
- Section 4: Background
- Section 5: Discussion
- Section 6: Procedures
- Section 7: Conclusion



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### Section 1-3: Purpose, Distribution, Related Publications

- Section 1 - Purpose
  - To provide a standardized process for assessing the safety impact of software changes & determining FAA’s involvement in software changes
- Section 2 - Distribution
  - FAA and designees
- Section 3 - Related Publications
  - Advisory Circular 20-115B
  - RTCA/DO-178B
  - Part 21
- Note: Notice N8110.78/89\* on Legacy Systems is also related

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4

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## Change Impact Analysis

### Overview of Section 4 Background

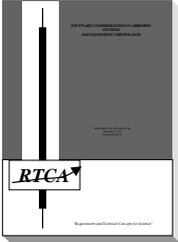
Section 4 provides:

- a. Tie to DO-178B 
- b. Rationale & purpose of Notice
- c. Tie to regulations 

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### Relationship to DO-178B

- AC 20-115B recognizes DO-178B as a means of compliance to the FARs for Software Assurance
- DO-178B addresses software changes in Section 12.1



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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Relationship to Regulations

- Regulations address major/minor changes in:
  - 21.91, 21.93(a), 21.97, 21.95, 21.99 - Type Certification
  - 21.115(b) - Supplemental TC
  - 21.611(a), (b) - Technical Standard Order (TSO)
- Regulations look at changes from the product perspective



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### FAR Quotes (1/2)



- 21.93(a) states that a “minor change’ is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product. All other changes are ‘major changes’ ...”.
- 21.95 states: “Minor changes in a type design may be approved under a method acceptable to the Administrator before submitting to the Administrator any substantiating or descriptive data.”

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# FAA National Software Conference, May 2002

## Change Impact Analysis

### FAR Quotes (2/2)

- 21.611 (a) and (b) addresses “minor” and “major” changes for TSO manufacturers. 21.611(a) basically says that minor changes (i.e., a change that’s not major) may be made without further approval by the FAA. The revised data should be submitted to the appropriate ACO. 21.611 (b) states that “Any design change by the manufacturer that is extensive enough to require a substantially complete investigation to determine compliance with a TSO is a major change.”

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### Types of Software Changes (1/2)

- **Pre-Certification**  
(During software development & before software approval)
  - Change control in place
  - Problem reporting & correction in place
  - Re-verification in place
  - Addressed in Sections 7 & 8 of DO-178B



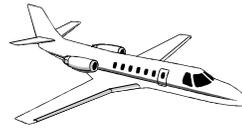
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## Change Impact Analysis

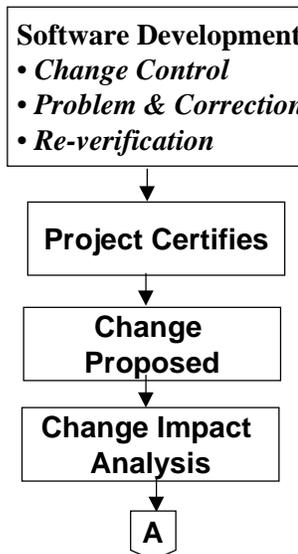
### Types of Software Changes (2/2)

- **Post-Certification**  
(After software approval and product certification)
  - Section 12.1 of DO-178B (“Use of Previously Developed Software”) addresses this kind of change
  - N 8110.85 focuses on the post-certification changes



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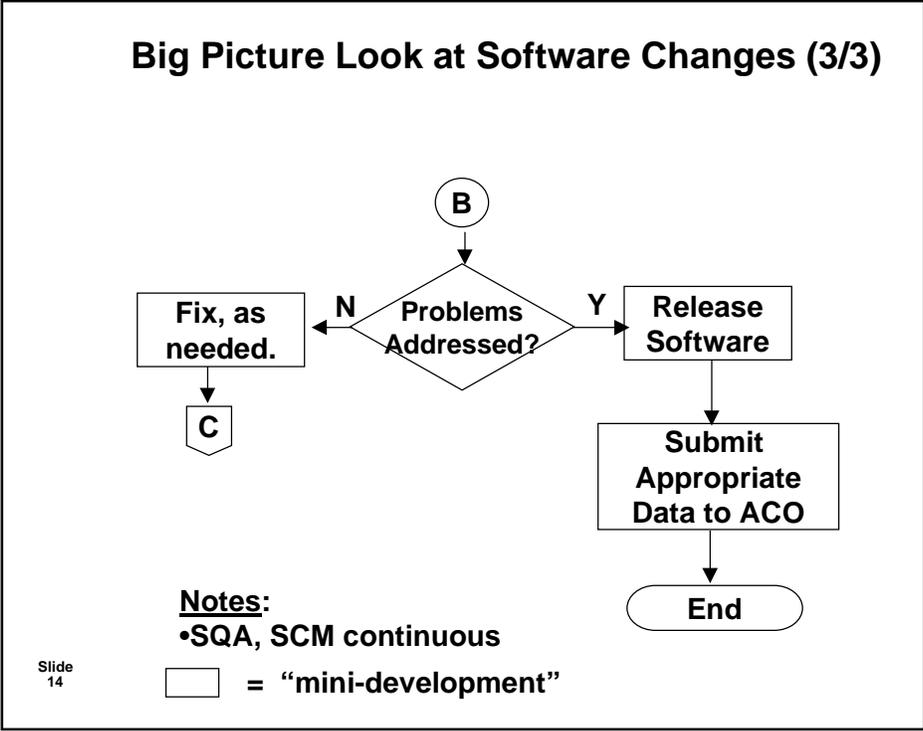
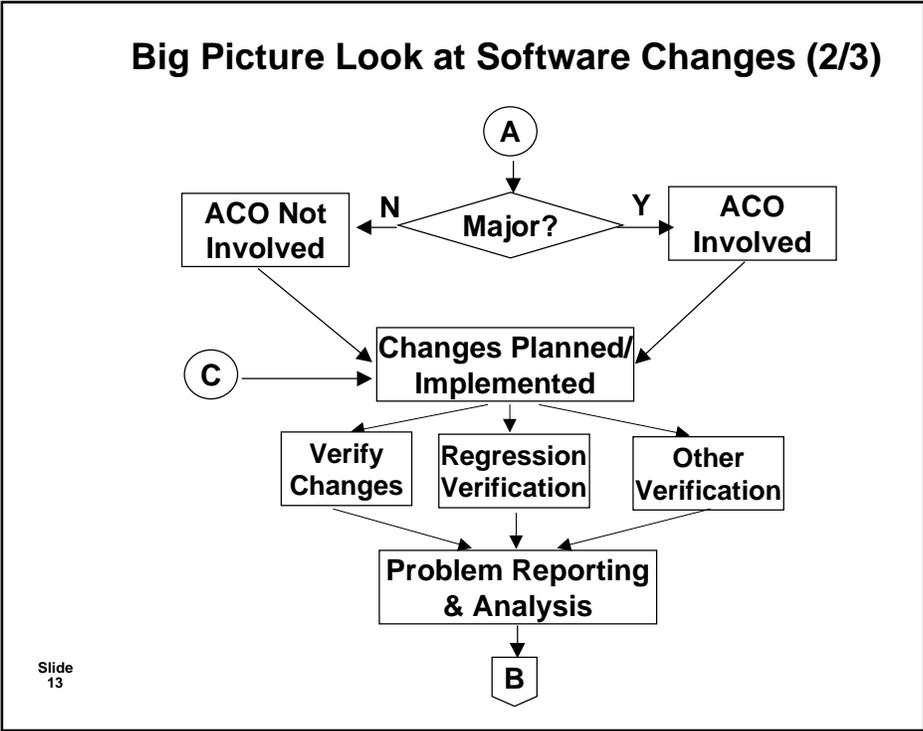
### Big Picture Look at Software Changes (1/3)



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# FAA National Software Conference, May 2002

## Change Impact Analysis



# FAA National Software Conference, May 2002

## Change Impact Analysis

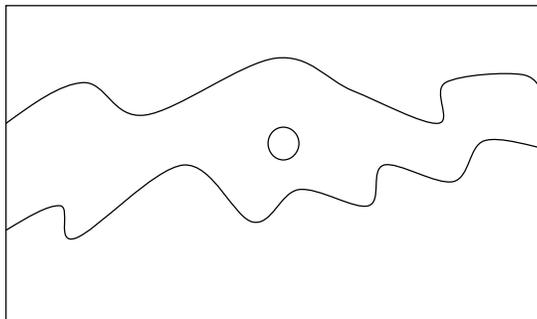
### Purpose of Change Impact Analysis (1/2)

- Identify and assess effects of the software change(s) on system performance, safety, data, etc. ...
- Assess the classification of the change (e.g., major, minor, significant, insignificant)
- Determine amount of rework and verification required
- Plan for the changes (resources, cost, schedule, ...)

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### Purpose of Change Impact Analysis (2/2)

- Identify what is affected by the change



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## Change Impact Analysis

### Overview of Section 5 Discussion

- **Technical “meat” of the Notice**
  - “WHAT”, not “HOW”
- **3 Sub-Sections:**
  - 5a) Items to be addressed by CIA, as applicable
  - 5b) Examples of changes that could cause adverse affects
  - 5c) Updating data & verification

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### Section 5a: Potential Items to Be Addressed in CIA

- **Traceability Analysis**
- **Memory Margin Analysis**
- **Timing Margin Analysis**
- **Data Flow Analysis**
- **Control Flow Analysis**
- **Input/Output Analysis**
- **Development Environment & Process Analyses**
- **Operational Characteristics Analysis**
- **Certification Maintenance Requirements (CMR) Analysis**
- **Partitioning Analysis**

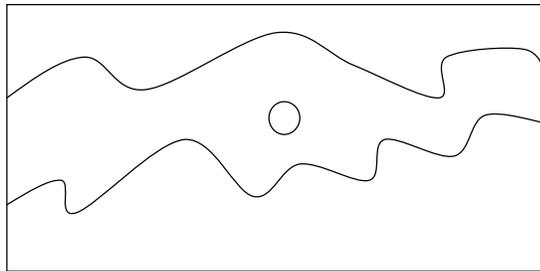
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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Traceability Analysis

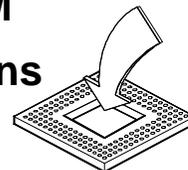
- **VERY IMPORTANT!**
- Identifies areas and aspects effected by the software change(s):
  - Requirements & Design Analysis
  - Code Analysis
  - Test Procedures and Cases Analysis



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### Memory Margin Analysis

- **Assure memory allocation requirements and margins are maintained.**
- **Examples of tasks:**
  - Estimate change to flash memory
  - Estimate change to RAM
  - Evaluate memory margins



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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Timing Margin Analysis



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- Assure timing margin issues are not introduced due to the change.
- Examples of tasks:
  - Review timing requirements
  - Review CPU task scheduling requirements
  - Review interface timing requirements
  - Review changes to the timing margins (usually want at least 10% margin)
  - Review throughput change for each task

### Data & Control Couplings Analyses

- DO-178B, Table A-7, Objective 8 recommends data & control couplings analyses for Levels A, B, & C software.
- Data & control coupling analyses assess changes in data & control flows and interfaces between components.
  - Examples of software components are procedures, packages and functions.
- Data & control coupling analyses also evaluates any adverse affects due to the change(s).

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# FAA National Software Conference, May 2002

## Change Impact Analysis

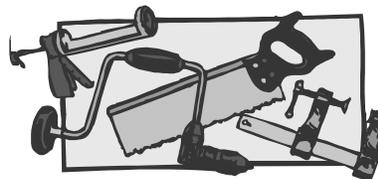
### Input/Output Analysis

- **I/O Analysis evaluates impact of any changes on the interface with the external world:**
- **Examples of tasks:**
  - Bus loading
  - External data bus I/O
  - External hardwired I/O
  - Access to memory
  - Communication with hardware

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### Development Environment & Process Analyses

- **Identify changes in the environment or processes that may have adverse affects on the system or software:**
- **Examples include changes to:**
  - Compilers, Linkers, Loaders
  - Tools (Dev. or Verif.)
  - Hardware



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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Operational Characteristics Analysis

- Identifies adverse effects in the operational environment due to software changes.
- Examples of changes that could affect the operation of the product:
  - Changes to Displayed Data
  - Gain or Limit Changes
  - Filter changes
  - Interrupt changes
  - Exception handling changes
  - Fault mitigation changes

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### Certification Maintenance Requirements (CMR) Analysis

- Determines if the software change requires new or modified CMR.
- Example:
  - Assume the software change to the anti-skid systems increases the time that the brakes are applied during landing. This could result in more frequent maintenance of the brakes and tires.



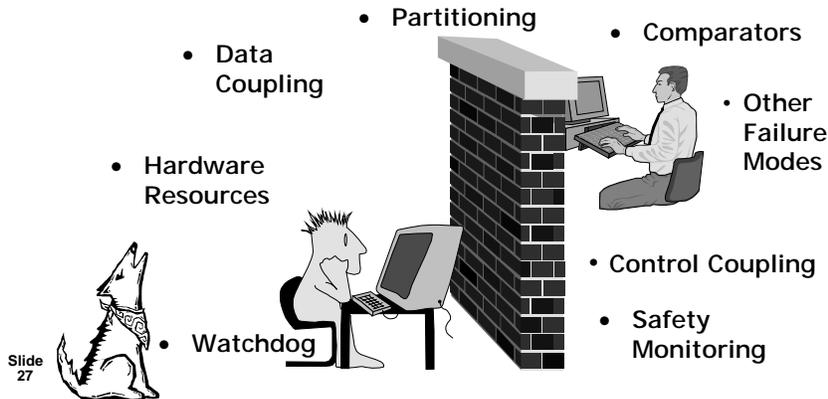
Slide  
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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Protection/Partitioning Analysis

- Determining the affect of the software change on the protective mechanisms.



### Section 5b. Examples of Adverse Affects (1/2)

- When performing the CIA activities, the focus is going to be on adverse affects. i.e., things that affect operation and safety.
- Section 5b provides examples of typical categories of change impact:
  - Change in safety-related information
  - Change in operational or procedural characteristics of the aircraft
  - New functions
  - Different interfaces
  - Significant changes to life cycle data

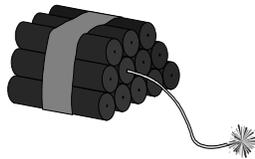
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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Section 5b. Examples of Adverse Affects (2/2)

- Changes that have adverse impacts will likely lead to a “major” change classification.



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### 5c. Updates and Verification

- Applicant updates necessary software life cycle data, whether the change is major or minor.
- Applicant verifies the software change to make sure there are no adverse effects (Continued Operational Safety).  
Example verification activities:
  - Reviews
  - Analyses
  - Regression Testing
  - Requirements-Based Testing
  - Ground & Flight Testing

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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Developer's Role For New and Changed Requirements (1/4)

- **Perform CIA to assure that the new or changed requirements:**
  - do not conflict with other requirements
  - are unambiguously stated and verifiable
  - are verified to meet requirements
  - achieve desired functionality

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### Developer's Role For New or Changed Requirements (2/4)

- **Assure that the following are completed, as needed:**
  - update the software architecture
  - change headers / design info
  - review changes against standards
  - update traceability (both forward and backward)

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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Developer's Role For New and Changed Requirements (3/4)

- **Examine data elements to assure that new or changed code does not adversely impact existing functions by:**
  - examining all areas of the code that use the same variables as those in the changed or new code
  - re-examining variable declarations and interfaces
  - examining control flow to assure that the change does not adversely impact execution sequence or timing

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### Developer's Role For New and Changed Requirements (4/4)

- **Assure that:**
  - Verification test cases for new and changed requirements exist and are updated.
  - All requirements-based tests (normal and robustness) that trace to new or changed requirements are executed.
  - Structural coverage is achieved for new or changed areas, and still valid for areas of code with dependencies
  - Verification results that document the regression analysis and testing exist.

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# FAA National Software Conference, May 2002

## Change Impact Analysis

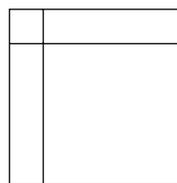
### FAA's Roles For New and Changed Requirements



- **Oversee the applicant's activities, when the change is "major"**
- **Oversee designees**
- **Perform on-site or desk reviews, as needed**

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### Examples of Change Impact Analyses (1/2)



**Tables/Forms**



**Automated Tools**

**Change  
Impact  
Analysis**

Fly-Today Company  
Ground-Proximity Warning System  
FTC-2100  
Revision A  
32400

**Formal Reports**

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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Examples of Change Impact Analyses (2/2)

- CIA's come in many forms: Some Formal and Some Informal
- No single correct format
- Extent of analysis depends on the change size, impact and affected items and interfaces
- Important to have the information available to make the necessary decisions

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### Example of a Tool Used in CIA

The screenshot shows a software tool interface for Change Impact Analysis (CIA). The interface is divided into several sections:

- Change Request (CR):** A table with columns: ID, Description, Priority, Phase, Status, Update Date.
 

ID	Description	Priority	Phase	Status	Update Date
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change		3	APPROVED	18-Apr-1999 16:40:02	P
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change		14	APPROVED	18-Apr-1999 16:42:26	P
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change		7	APPROVED	18-Aug-1999 00:00:00	P
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change		25	TEST	18-Aug-1999 00:00:46	P
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change		116	TEST	18-Aug-1999 00:00:46	P
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change		67	TEST	18-Aug-1999 00:00:50	P
- Change Path:** A table with columns: Specification, Description, Relationship.
 

Specification	Description	Relationship
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change	E-46-503 Main Software Affected	Affected
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change	E-46-503FD	Affected
- Change Element:** A table with columns: ID, Description, Status.
 

ID	Description	Status
PR_EFIS_DPL_RES_CNFG-CONFIG MISMATCH CAS message change	UNDOCH INO	
PR_EFIS_WP_26	Enter Phase 6.5 Lead 3	CLOSED

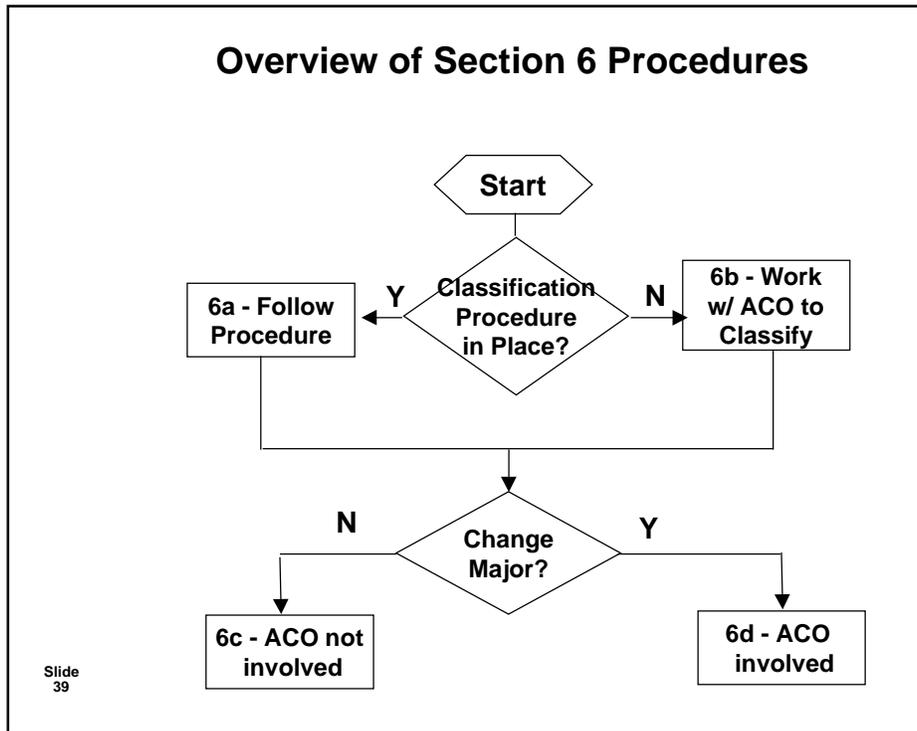
Arrows from the text labels on the left point to the following elements in the screenshot:

- Code Files Effected:** Points to the first row of the Change Request table.
- Requirements Effected:** Points to the second row of the Change Request table.
- Design Parts (code, requirements or both):** Points to the first row of the Change Path table.
- Test Change Request (TCR) (shows test effected):** Points to the fourth row of the Change Request table.
- Work Packet (WP) (used to group CR's into deliveries to customer):** Points to the second row of the Change Element table.

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# FAA National Software Conference, May 2002

## Change Impact Analysis



**6a - Applicant Has Classification Procedures (1/2)**

- Procedures in place to classify changes as major or minor
- Reference FAR Part 21
- Procedures should be reviewed & approved by the ACO

A graphic of a folder with the word 'Procedures' written on it.

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# FAA National Software Conference, May 2002

## Change Impact Analysis

### 6a - Applicant Has Classification Procedures (2/2)

- Procedures should contain process for:
  - Using CIA to classify change
  - Reviewing and approving the classification
  - Addressing minor changes
  - Addressing major changes
  - Informing FAA (e.g., PSAC, SAS, report, ...)
  - Obtaining FAA concurrence on changes

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### 6b - Without Classification Procedures

- FAA more involved
- Applicant performs CIA (using guidance of Notice)
- Applicant proposes classification (major or minor) to FAA
- FAA reviews and accepts or modifies the classification
- Applicant & FAA follow 6c for minor changes and 6d for major changes



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# FAA National Software Conference, May 2002

## Change Impact Analysis

### 6c - Minor Changes



- Change performed without FAA involvement
- Data updated, as required
- Software Accomplishment Summary (SAS), Software Configuration Index (SCI), and/or other documents submitted to FAA on a periodic basis

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### 6d - Major Changes



- FAA and/or DER involved
- PSAC and/or CIA submitted to FAA as agreed upon
- SAS, SCI, and/or other agreed upon data submitted to ACO
- ACO and/or DER reviews and approves data, as needed

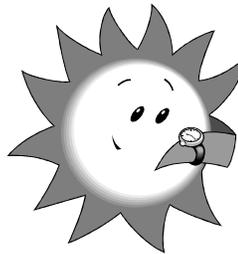
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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Section 7 - Conclusion

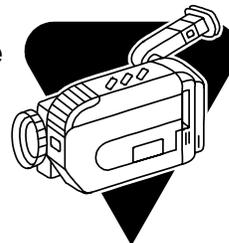
- Notice is only a supplement to AC 20-115B and DO-178B
- Guidelines only
- To be included in FAA Software Mega-Order



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### Video Availability

- May 12, 2000 - Interactive Video Teletraining Delivered to FAA
- Videos Available for Designees and Industry
- Self-Study Guide & Order Form Available on Web-site:
  - <http://av-info.faa.gov/software>



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# FAA National Software Conference, May 2002

## Change Impact Analysis

### Hints from Will

- **Benefits of a well-documented, in-compliance software process and data will be realized when making changes.**
- **Relatively easy to perform CIA on a good software design with good documentation.**
- **Difficult or nearly impossible to perform CIA on poor design with little current software data.**
- **Re-evaluate Rules-of-Thumb (e.g., 30%, only BIT)**



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## Summary

- **Purpose of Notice is to provide guidance for addressing changes to software.**
- **Intended to allow flexibility but encourage more standardization.**
- **Notice encourages use of CIA to serve as input into the major/minor classification.**
- **Send comments, questions, etc. to Leanna.Rierson and/or John.Lewis@faa.gov**

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