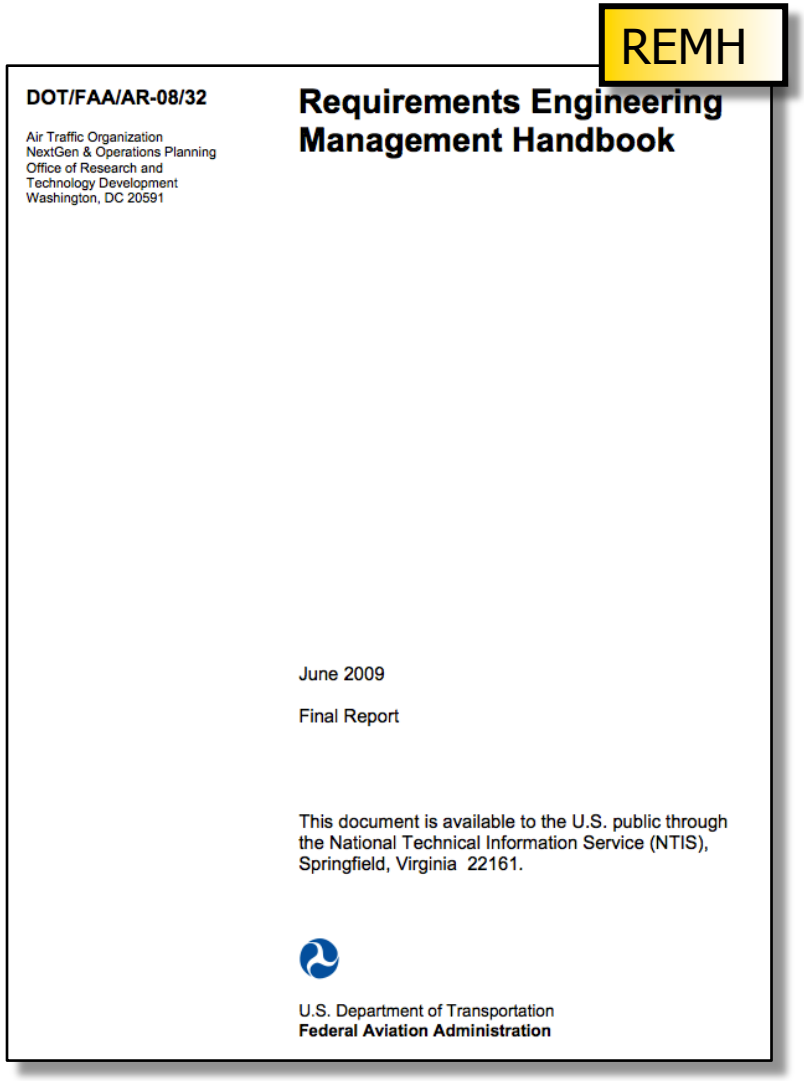
FAA Requirements Engineering Management Handbook

0. Overview

SAnToS Laboratory
Kansas State University

FAA Requirements Engineering Management Handbook (REMH)

- DOT/FAA/AR-08/32
- Written for the FAA by engineers at Rockwell Collins
  - David L. Lempia
  - Steven P. Miller
- DOT/FAA/AR-08/34
  - Companion document that provides background info and construction of a survey for collection requirements management issues from industrial engineers.



http://www.faa.gov/aircraft/air_cert/design_approvals/air_software/research/

Purpose of the REMH

- Presents a set of recommended practices on how to:
  - Collect,
  - Write,
  - Validate, and
  - Organize requirements
- Attempts to:
  - Bring together the best ideas from several approaches,
  - Organize them into a coherent whole, and
  - Illustrate them with concrete examples that make their benefits clear.

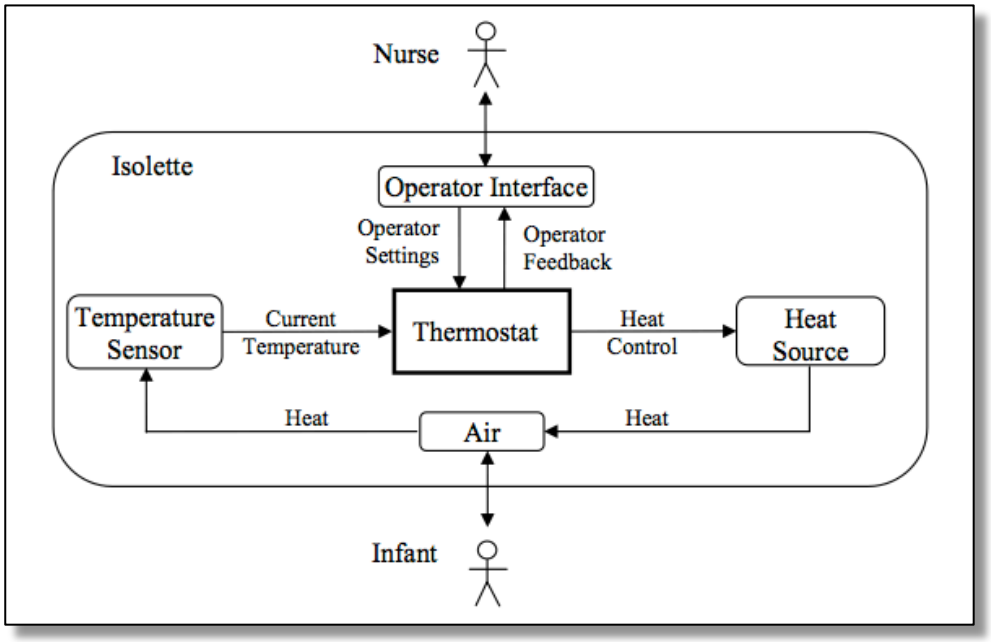
High-Level Goals of the REMH

- Targeted to the domain of real-time, embedded systems
  - Specifically to the avionics industry.
- Describes a set of recommended practices
  - Basic concepts can be practiced in isolation
  - Reinforce each other when practiced as a whole
- Enable progression from
  - An initial, high-level overview of a system, to
  - A detailed description of its behavioral and performance requirements.

Examples Used in REMH

Isolate – Thermostat for an infant incubator

"The purpose of the Isolette Thermostat is to maintain the air temperature of an Isolette within a desired range. It senses the Current Temperature of the Isolette and turns the Heat Source on and off to warm the air as needed. …"

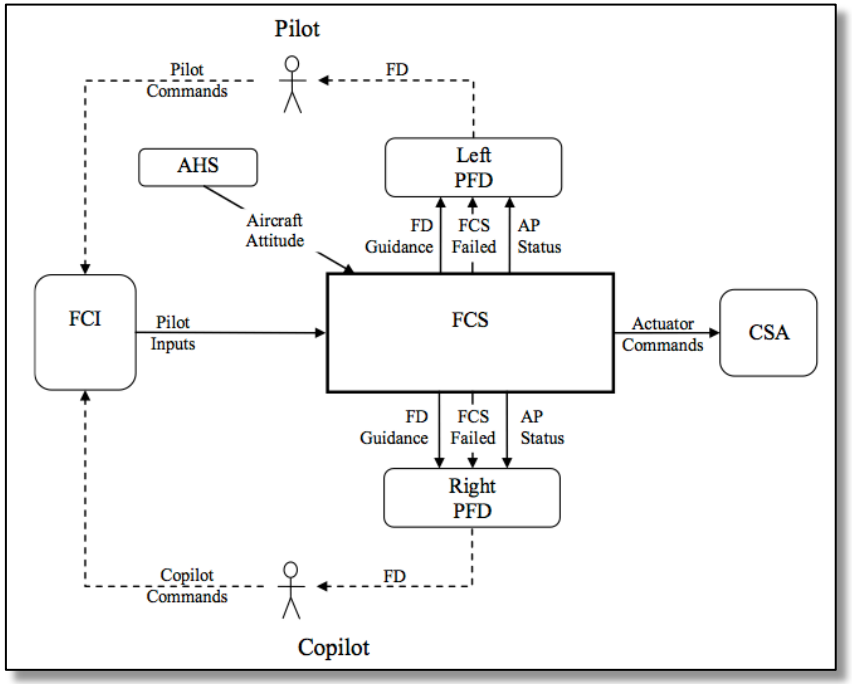


The Isolate example will be used as the primary running example in our lectures.

Examples Used in REMH

Flight Control System – Provides flight guidance and autopilot functionality for aircraft pilots

"The system being specified is a portion of an FCS. The FCS compares the measured Aircraft Attitude to a Reference Attitude and generates Flight Director (FD) Guidance commands that are displayed as visible cues, i.e., the FD, on the left and right Primary Flight Displays (PFD). …"



Examples Used in REMH

Flight Guidance System – Illustrates how the FGS of the previous FCS example could be factored out into a separate subsystem spec can given to a subcontractor.

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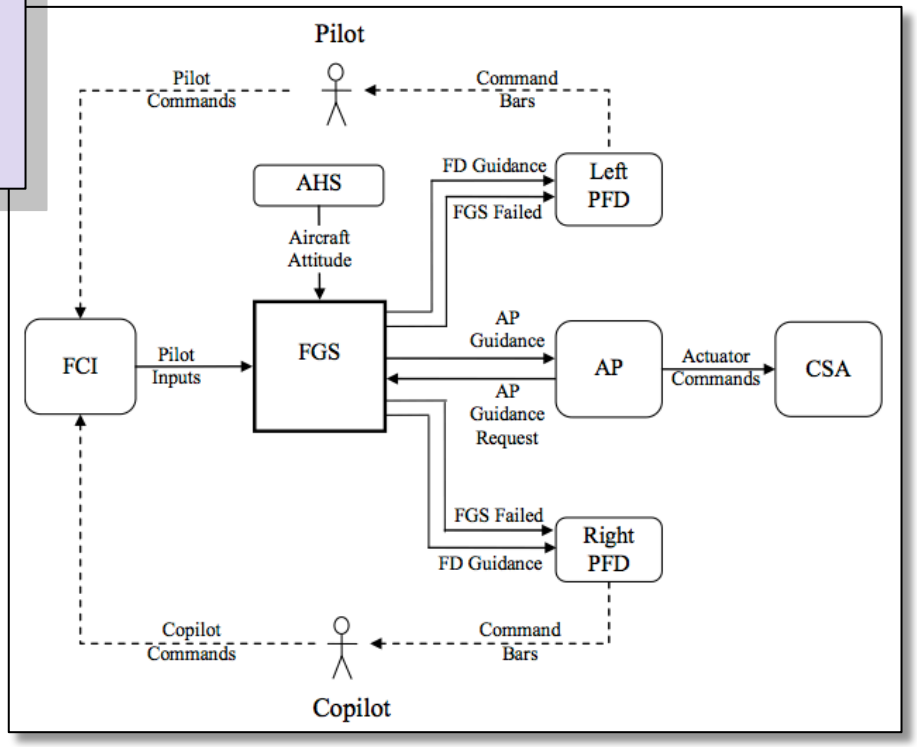


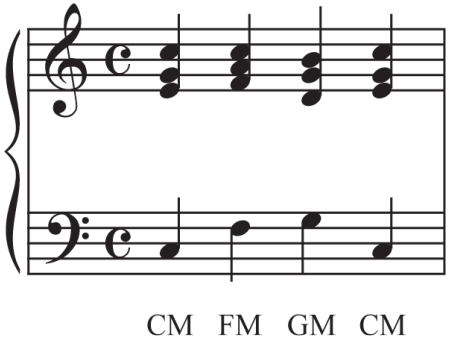
Specific Goals of the REMH

- Determine methods that enable successful
  - Management,
  - Control,
  - Integration,
  - Verification, and
  - Validation of system and software requirements (potentially developed by multiple entities)

What is a "Good" Requirement?

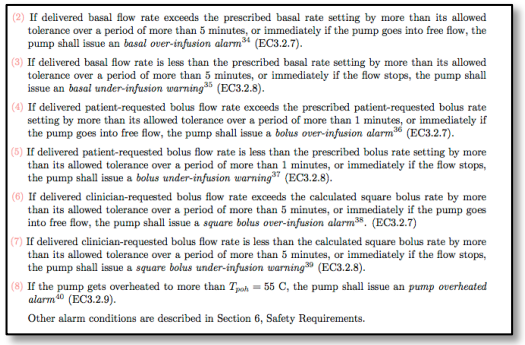
- "Describes everything necessary to produce the correct system, nothing more."
  - David Parnas (paraphrased)
- The balance that requirements need to achieve:
  - Specifying everything needed of the system to be built,
  - Not overconstraining the developers by venturing into design.
- The requirements should specify what the system will do – Not how the system will do it!

Good Requirements are a Progression



- The development of the requirements is a progression from:
  - A state in which relatively little is known about the system, to
  - One in which a great deal is known.
- The requirements engineering process needs to progress in a similar fashion
  - From informal practices early in requirements definition, to
  - More rigorous practices as the requirements are completed.

Requirements and Architecture Develop Simultaneously



(2) If delivered basal flow rate exceeds the prescribed basal rate setting by more than its allowed tolerance over a period of more than 5 minutes, or immediately if the pump goes into free flow, the pump shall issue an *basal over-infusion alarm*[34] (EC3.2.7).

(3) If delivered basal flow rate is less than the prescribed basal rate setting by more than its allowed tolerance over a period of more than 5 minutes, or immediately if the flow stops, the pump shall issue an *basal under-infusion warning*[35] (EC3.2.8).

(4) If delivered patient-requested bolus flow rate exceeds the prescribed patient-requested bolus rate setting by more than its allowed tolerance over a period of more than 1 minutes, or immediately if the pump goes into free flow, the pump shall issue a *bolus over-infusion alarm*[36] (EC3.2.7).

(5) If delivered patient-requested bolus flow rate is less than the prescribed bolus rate setting by more than its allowed tolerance over a period of more than 1 minutes, or immediately if the flow stops, the pump shall issue a *bolus under-infusion warning*[37] (EC3.2.8).

(6) If delivered clinician-requested bolus flow rate exceeds the calculated square bolus rate by more than its allowed tolerance over a period of more than 5 minutes, or immediately if the pump goes into free flow, the pump shall issue a *square bolus over-infusion alarm*[38]. (EC3.2.7)

(7) If delivered clinician-requested bolus flow rate is less than the calculated square bolus rate by more than its allowed tolerance over a period of more than 5 minutes, or immediately if the flow stops, the pump shall issue a *square bolus under-infusion warning*[39] (EC3.2.8).

(8) If the pump gets overheated to more than $T_{poh} = 55$ C, the pump shall issue an *pump overheated alarm*[40] (EC3.2.9).

Other alarm conditions are described in Section 6, Safety Requirements.

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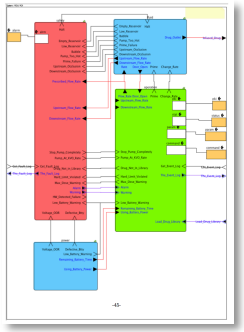


- It is usually impractical to state the detailed requirements of the system independent of the system architecture.
- Instead:
  1. High-level requirements are developed, then
  2. The next level of design is completed, then
  3. More detailed requirements are developed for each component.
- This process is continued until the necessary level of detail is reached.
- Requirements specification is interleaved with developing the system architecture.

Steps in the REMH

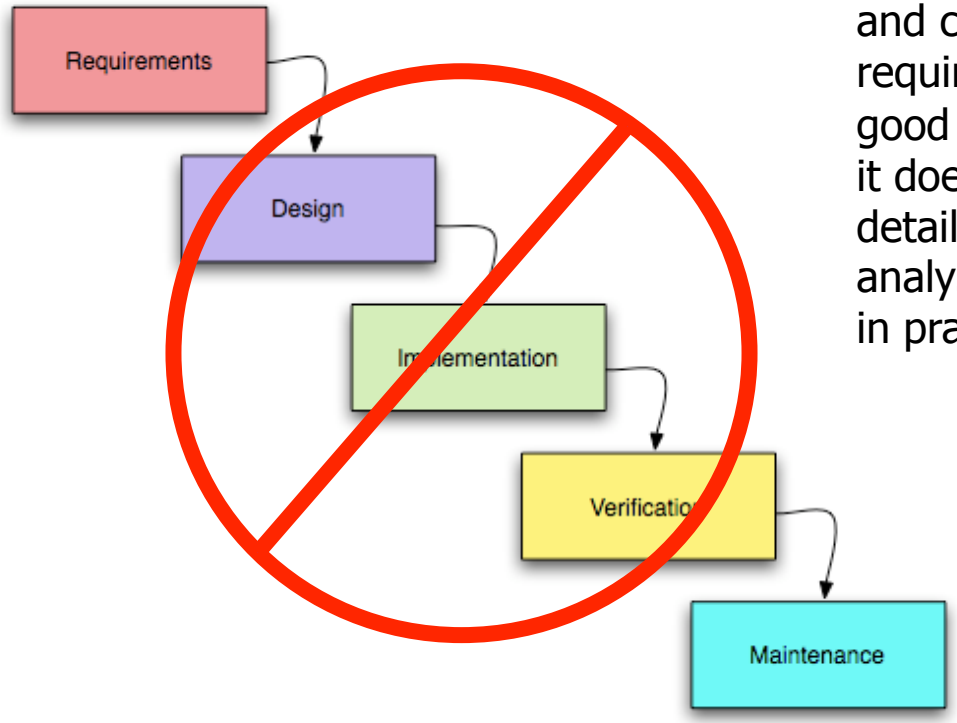
1. Develop the System Overview
2. Identify the System Boundary
3. Develop the Operational Concepts
4. Identify the Environmental Assumptions
5. Develop the Functional Architecture
6. Revise the Architecture to Meet Implementation Constraints
7. Identify System Modes
8. Develop the Detailed Behavior and Performance Requirements
9. Define the Software Requirements
10. Allocate System Requirements to Subsystems
11. Provide Rationale

Our lecture series will provide a lecture on each of the topics above!

Beware!

We don't simply write requirements then move onto other steps in development (i.e., the classic "waterfall" model of development does not match reality). Instead, requirements are refined throughout the development process.

Classic Waterfall Development Process



Many steps in develop feedback and cause us to modify requirements. FAA REMH does a good job of acknowledging this, but it doesn't fully acknowledge the details of various forms of safety analysis that we would probably do in practice.

http://www.learnaccessvba.com/application_development/waterfall_method.htm

Intertwined With Other Processes

Agree on system goals
Identify constraints on how goals can be achieved • Define accidents (unacceptable losses) • Identify hazards • Formulate system–level safety and non–safety constraints
Select a system architecture • Architectural trade analysis • Preliminary hazard analysis
Identify environmental assumptions
Create a concept of operations Perform a preliminary operator task analysis
Refine goals into testable and achievable system–level functional requirements
Refine safety constraints and functional requirements • Identify preliminary safety control structure • Perform STPA
Perform safety–driven system design and analysis • Make system–level design decisions to satisfy functional requirements and safety constraints. • Define component responsibilities • Identify potentially unsafe control actions and restate as constraints on system and component behavior
Implementation (construction and manufacturing
Document System Limitations
Perform final safety assessment
Safety Certification
Field testing, installation, and training
Operations, including maintenance and upgrades • Change analysis • Incident and accident analysis • Performance monitoring • Periodic audits
Decommissioning

(from "Safer World", Ch. 10, Leveson)

Consider Leveson's Outline of Safety Evaluation and Assessment Integrated with a System's Engineering Process

Activities in Common with REMH

Safety evaluations occurring well after architecture development drive changes in requirements

Intertwined With Other Processes

Examples of other processes that proceed in parallel or are intertwined with requirements development

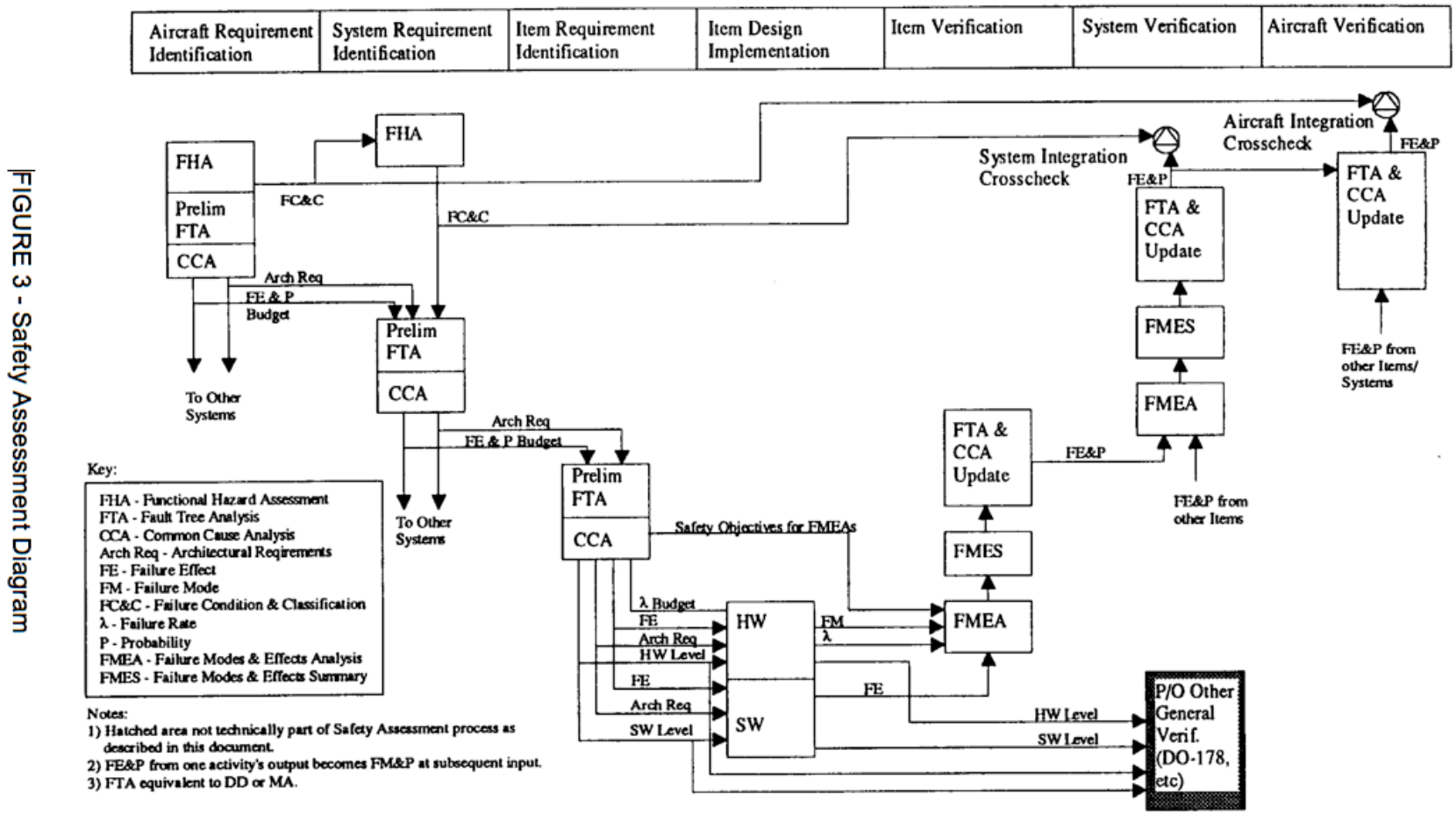


FIGURE 3 - Safety Assessment Diagram

(from ARP 4761 – Avionics Recommended Practices)

Summary

Requirements development/management is a crucial part of any significant software development project

- FAA REMH is not the only source on requirements management for embedded systems, but it does a good job pulling together best practices and illustrating them.
- Requirements development/management is a progression and even an iterative process.
- FAA REMH focuses on requirements development for safety critical systems.

For You To Do

- List the steps in the FAA REMH requirements management process.

Acknowledgements

- The material in this lecture is based almost entirely on
  - *FAA* DOT/FAA/AR-08/32*, Requirements Engineering Management Handbook.* David L. Lempia & Steven P. Miller.