DESIGN FAILURE MODE & EFFECTS ANALYSIS

AS13100 DESIGN FMEA REQUIREMENTS WEBINAR

Rob Farndon
Chief of Mechanical Systems
Rolls-Royce Civil Aerospace

Andrea Neumann
Safety and Certification Engineer, Airworthiness
MTU

June 22nd 2022

Webinar Overview

We are **recording** today's webinar and will distribute the video link following the close of the webinar. It will also be posted on the AESQ website for free viewing.

We will take **questions** during today's webinar using the **Chat** feature.

Please remain on Mute during the presentation to prevent background noise. We will also be muting all lines at the start of the session.

RM13004 DESIGN FMEA Webinars

June 22nd & 23rd 2022

AS13100 & RM13004 DESIGN FMEA - Understanding the Requirements

Led by Rob Farndon, these interactive webinars are designed to describe the intent of the AESQ AS13100 requirements for Design FMEAs and how they link to the effective deployment of Advanced Product Quality Planning (APQP) and a Zero Defect Strategy.

These webinars shall explain how AS13100 Design FMEA can be developed, maintained and improved using real examples of best practice from across the industry.

SESSION 1 AS13100 DFMEA Requirements and Overview (June 22nd 14.00 – 16.00 UK Time)	**SESSION 2** Key Care Points when Creating the Design FMEA (June 23rd 14.00 – 16.00 UK Time)
Overview of the requirements for Design FMEA in Chapter C of AS13100 and their link to the APQP / PPAP process Explanation of the intent of each requirement and what success looks like Overview of the Design FMEA approach aligned to the RM13004 Reference Manual Links to further help and guidance	A closer look at some of the key steps when creating Design FMEAs to illustrate the intent of the AS13100 requirements, including; a) Requirements & Potential Failure Modes b) Potential Effects & Severity Rating c) Potential Causes d) Prevention Controls & Occurrence Rating e) Detection Controls & Detection Rating f) Calculating the Risk Priority Number (RPN) g) Prioritizing Improvements
Questions & Answers	**Questions & Answers**

Rob Farndon Introduction

- Worked for Rolls-Royce for 33 years.
- Career including Design Practitioner, Manager and Specialist roles in Civil Aerospace.
- Currently Chief of Mechanical Systems Capability .
- Design Process Specialist, and Subject Matter Expert for APQP/PPAP and Defect Prevention toolset including DFMEA.
- Led creation of design processes as part of RR Civil Aerospace APQP/PPAP transformation.
- Lead Design Coach for Civil Large Engines.
- Led authoring team for RM13004 and AS13100 DFMEA content.
- Deputy Team Leader for RM13004 Subject Matter Interest Group.

Andrea Neumann Introduction

- Worked for MTU Aero Engines AG for 2 years
- Career including Type Inspector for Propulsion Systems at German Military Airworthiness Authority
- Currently Safety- and Certification Engineer at Airworthiness Department MTU
- System Safety Assessment Specialist
- Subject Matter Expert for DFMEA
- Led process definition of interfaces between DFMEA and System Safety Process
- Supported definition of Design Failure Mode and Effect Analysis Process at MTU

How to contribute

Use the **Chat Function** to ask a question, at any time, or to make a comment.

Steven W. Finup
Consulting Engineer
GE Aviation

Stéphan DAUX
APQP Leader & Master
Safran Aircraft Engines

Registration Status (June 20th)

Over 210 people registered from 20 Countries

Webinar 1 : Overview

AESQ STRATEGY GROUP
A Program of SAE ITC

1

RM13004 DFMEA REQUIREMENTS

2

DESIGN FMEA OVERVIEW

3

WHERE TO GET FURTHER INFORMATION

We do amazing things…

.. but the consequences of poor quality can be very serious

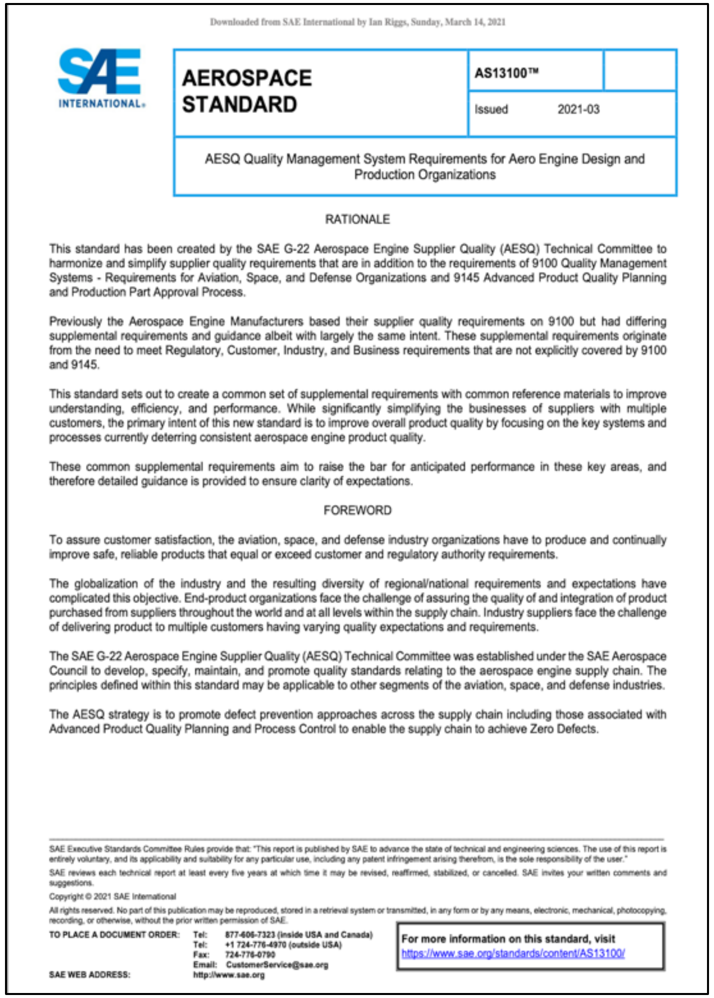
We have a great responsibility to keep our customers, passengers and our families safe.

Planning for Quality is key.

“QUALITY HAS TO BE CAUSED, NOT CONTROLLED.”

PHILIP B. CROSBY

AS13100 FMEA Requirements & Guidance



SAE INTERNATIONAL

AEROSPACE STANDARD	AS13100™	
	Issued 2021-03	
AESQ Quality Management System Requirements for Aero Engine Design and Production Organizations		

RATIONALE

This standard has been created by the SAE G-22 Aerospace Engine Supplier Quality (AESQ) Technical Committee to harmonize and simplify supplier quality requirements that are in addition to the requirements of 9100 Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations and 9145 Advanced Product Quality Planning and Production Part Approval Process.

Previously the Aerospace Engine Manufacturers based their supplier quality requirements on 9100 but had differing supplemental requirements and guidance albeit with largely the same intent. These supplemental requirements originate from the need to meet Regulatory, Customer, Industry, and Business requirements that are not explicitly covered by 9100 and 9145.

This standard sets out to create a common set of supplemental requirements with common reference materials to improve understanding, efficiency, and performance. While significantly simplifying the businesses of suppliers with multiple customers, the primary intent of this new standard is to improve overall product quality by focusing on the key systems and processes currently deterring consistent aerospace engine product quality.

These common supplemental requirements aim to raise the bar for anticipated performance in these key areas, and therefore detailed guidance is provided to ensure clarity of expectations.

FOREWORD

To assure customer satisfaction, the aviation, space, and defense industry organizations have to produce and continually improve safe, reliable products that equal or exceed customer and regulatory authority requirements.

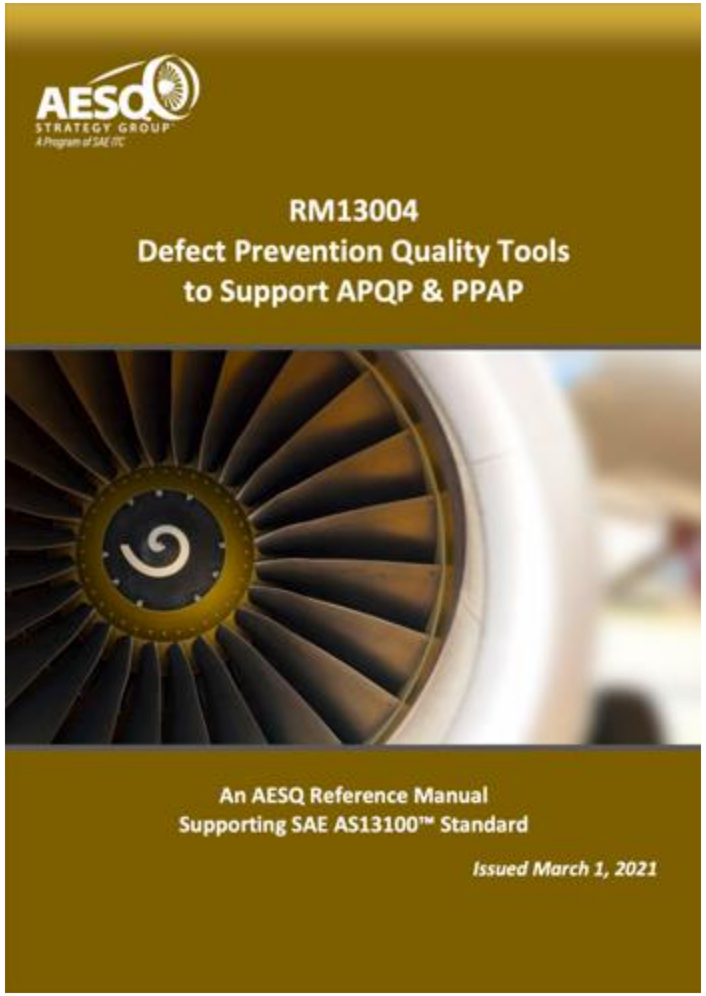
The globalization of the industry and the resulting diversity of regional/national requirements and expectations have complicated this objective. End-product organizations face the challenge of assuring the quality of and integration of product purchased from suppliers throughout the world and at all levels within the supply chain. Industry suppliers face the challenge of delivering product to multiple customers having varying quality expectations and requirements.

The SAE G-22 Aerospace Engine Supplier Quality (AESQ) Technical Committee was established under the SAE Aerospace Council to develop, specify, maintain, and promote quality standards relating to the aerospace engine supply chain. The principles defined within this standard may be applicable to other segments of the aviation, space, and defense industries.

The AESQ strategy is to promote defect prevention approaches across the supply chain including those associated with Advanced Product Quality Planning and Process Control to enable the supply chain to achieve Zero Defects.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit https://www.sae.org/standards/content/AS13100/



AS13100 Chapter C Requirements

AS13100 Requirements	Chapter A AS9100 Rev D Supplemental Requirements										Chapter B AS9145 Supplemental Requirements						Chapter C Quality Tools to Support APQP							
Clause Number	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	DFMEA	Product KCs	Process Flow Diag.	PFMEA	Process KCs	Control Plan	MSA	Process Capability
AS13100 Support Material											**RM13145 APQP & PPAP**						**RM13004**						**RM13003**	**RM13006**

AS13100 Chapter C

21.1 Design Failure Mode & Effects Analysis (DFMEA)

21.2 Product Key Characteristics

21.3 Process Flow Diagrams (PFD)

21.4 Process Failure Mode & Effects Analysis (PFMEA)

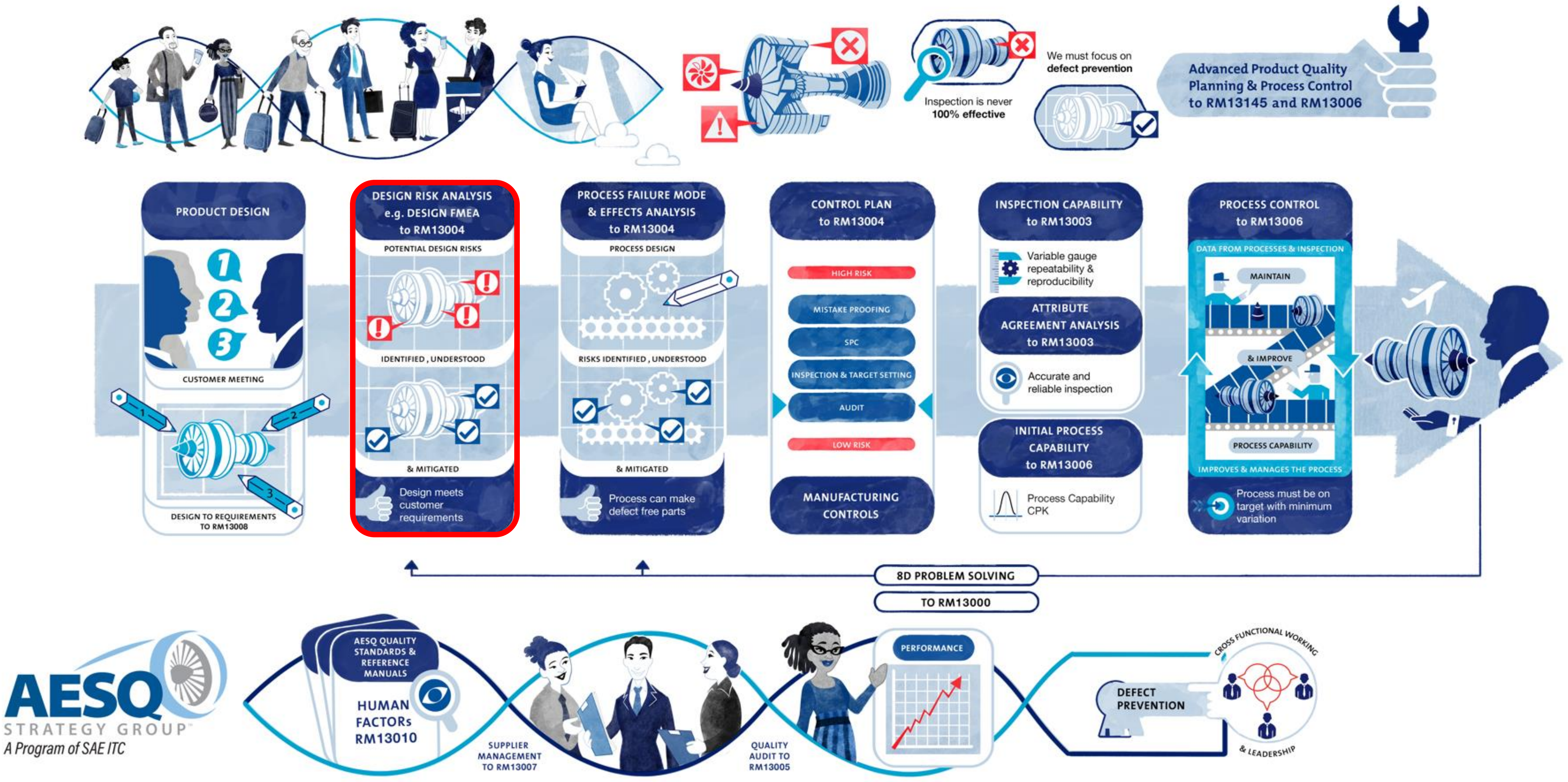
21.5 Process Key Characteristics

21.6 Production Control Plan

21.7 Measurement Systems Analysis (MSA)

21.8 Initial Capability Studies

Defect Prevention Key Quality Tools for Zero Defects



See Full Video at https://aesq.sae-itc.com

Quick Chat 1

Use the **Chat Function** to ask a question, at any time, or to make a comment.

Steven W. Finup
Consulting Engineer
GE Aviation

Stéphan DAUX
APQP Leader & Master
Safran Aircraft Engines

(a) Have you read AS13100?

I. Yes

II. No

(b) Have you read RM13004?

I. Yes

II. No

(c) How would you judge your knowledge of Design FMEA?

I. No Knowledge

II. I know of it but no experience of using it

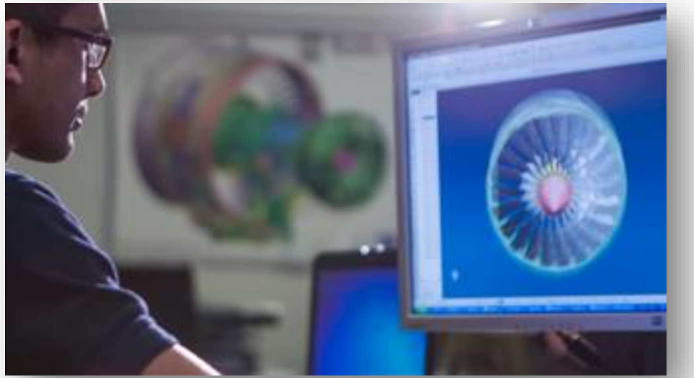
III. I have used it a few times

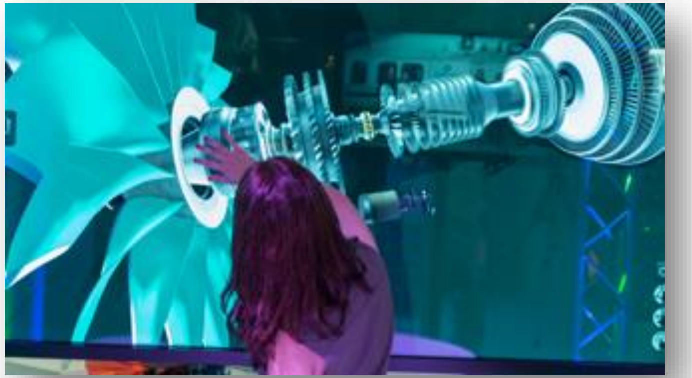
IV. I consider myself to be an expert

1
DESIGN FMEA REQUIREMENTS IN AS13100

FMEA in AS13100

As a minimum, Design FMEA shall be applied;





(a) New Design
(21.2.2.5 Case 1)

(b) Changes to existing design
(21.2.2.5 Case 2)

(c) Use of existing design in a new application, location, or environment.
(21.2.2.5 Case 2)

AS13100 DFMEA Requirements

Unless otherwise agreed with the customer the DFMEA shall be;

- Completed in line with the process laid out in Chapter 2 of the Reference Manual RM13004, (21.1)
- Assessed using the scoring criteria in RM13004 for Severity, Occurrence and Detection (21.1.3.1)
- RPNs shall be calculated for each Failure Mode – Potential Cause combination (21.1.3.1)
- Prioritized for improvement actions in the following order (21.1.3.3 & 4);
  - High Severity Failure Modes
  - Combination of High Severity and Occurrence scores
  - RPN scores

AS13100 DFMEA FMEA Requirements

Must be Created & Maintained by a **CROSS FUNCTIONAL TEAM**

(20.1.2.4)

- “engineers with expertise in design, analysis/testing, manufacturing, assembly, service, quality, and reliability”
- “stimulate the interchange of ideas between the functions affected and thus promote a team approach”
- “is strongly recommended that manufacturing/assembly engineering participate in the Design FMEA”

Cross Functional Teamwork

59%

Chance of success
Working alone

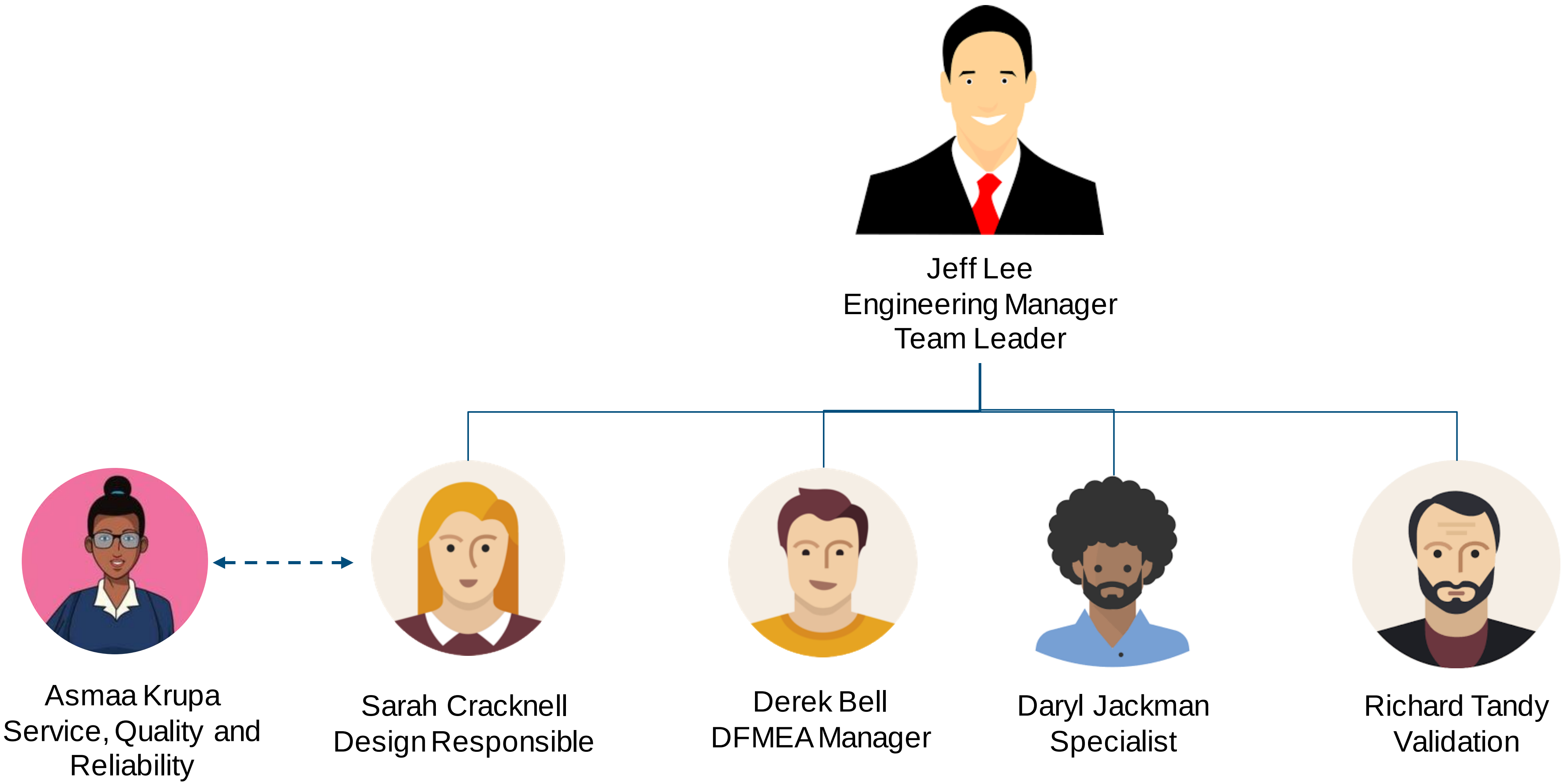
99.9%

Chance of success
With three subject matter experts working as a team

Terricone & Luca, Successful Teamwork: A Case Study (2002)

Typical Cross Functional Team

Support also from other functions and specialists as required



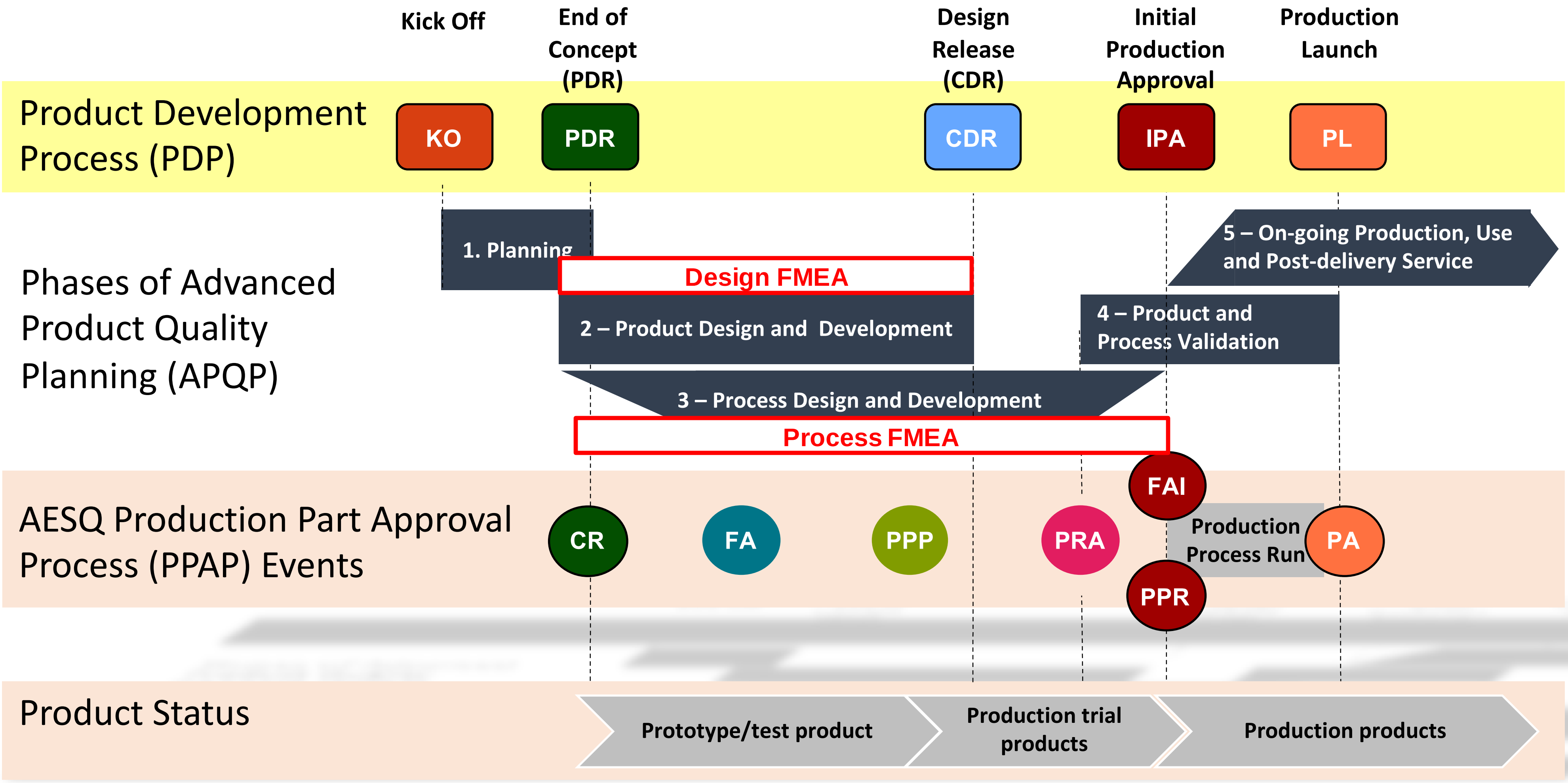
AS13100 Design FMEA Requirements

Must be Created & Maintained by a **CROSS FUNCTIONAL TEAM**
(20.1.2.4)

DFMEA be started during the Planning Phase of APQP
(21.1.2.1)

- "The earlier the Design FMEA is started during the product development process (PDP), the better the chances of optimizing the design in a cost and time effective manner"

FMEA as part of an
Advanced Product Quality Planning (APQP) System



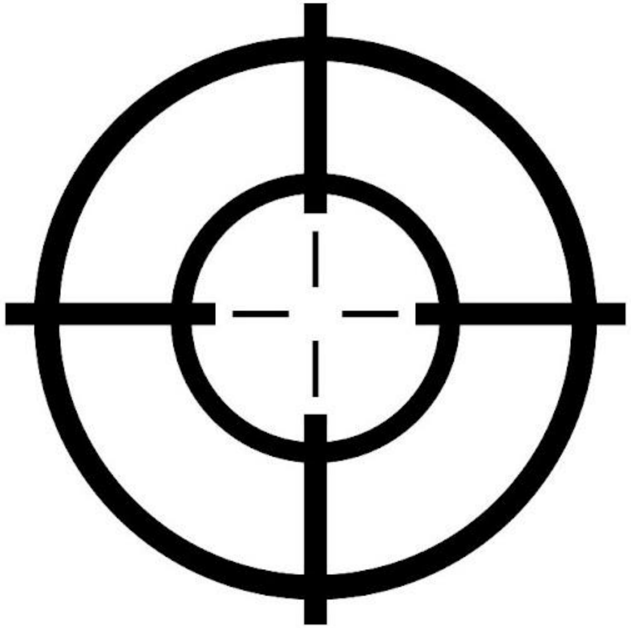
AS13100 Design FMEA Requirements

Must be Created & Maintained by a **CROSS FUNCTIONAL TEAM**
(20.1.2.4)

DFMEA be started during the Planning Phase of APQP
(21.1.2.1)

Scope shall encompass the items which the team is responsible for designing
(21.1.2.5)

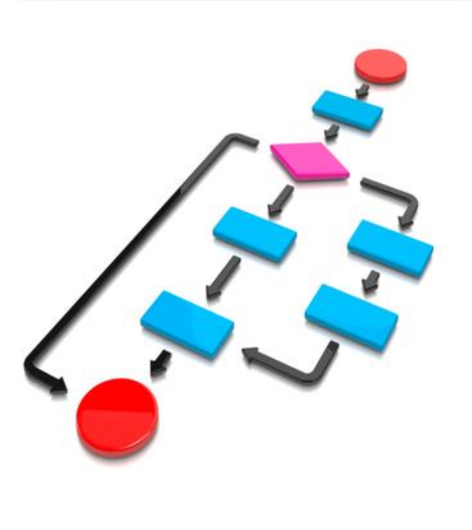
System Architecture and Interfaces & Interaction have to be considered
(21.1.2.6 & 7)



Design FMEA Scope

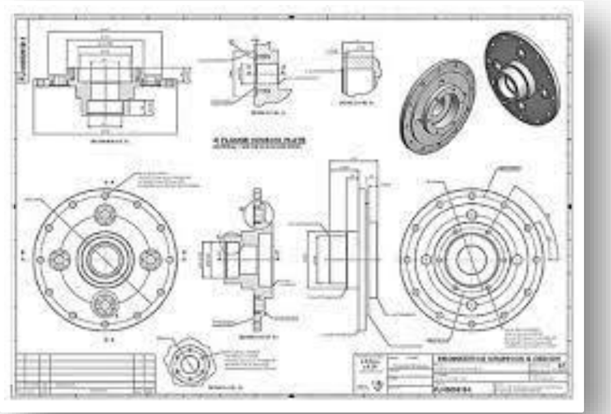
What is the scope of DFMEA?

1. For a new design the complete design of the item shall be included to a level of detail which is sufficient to establish risk level for all the Item's intended functions
2. For changes to an existing design the DFMEA shall focus on effective scope of change (it is assumed that there is a previously completed Design FMEA available for use. If not a complete Design DFMEA should be conducted)



Why do we need the System Architecture?

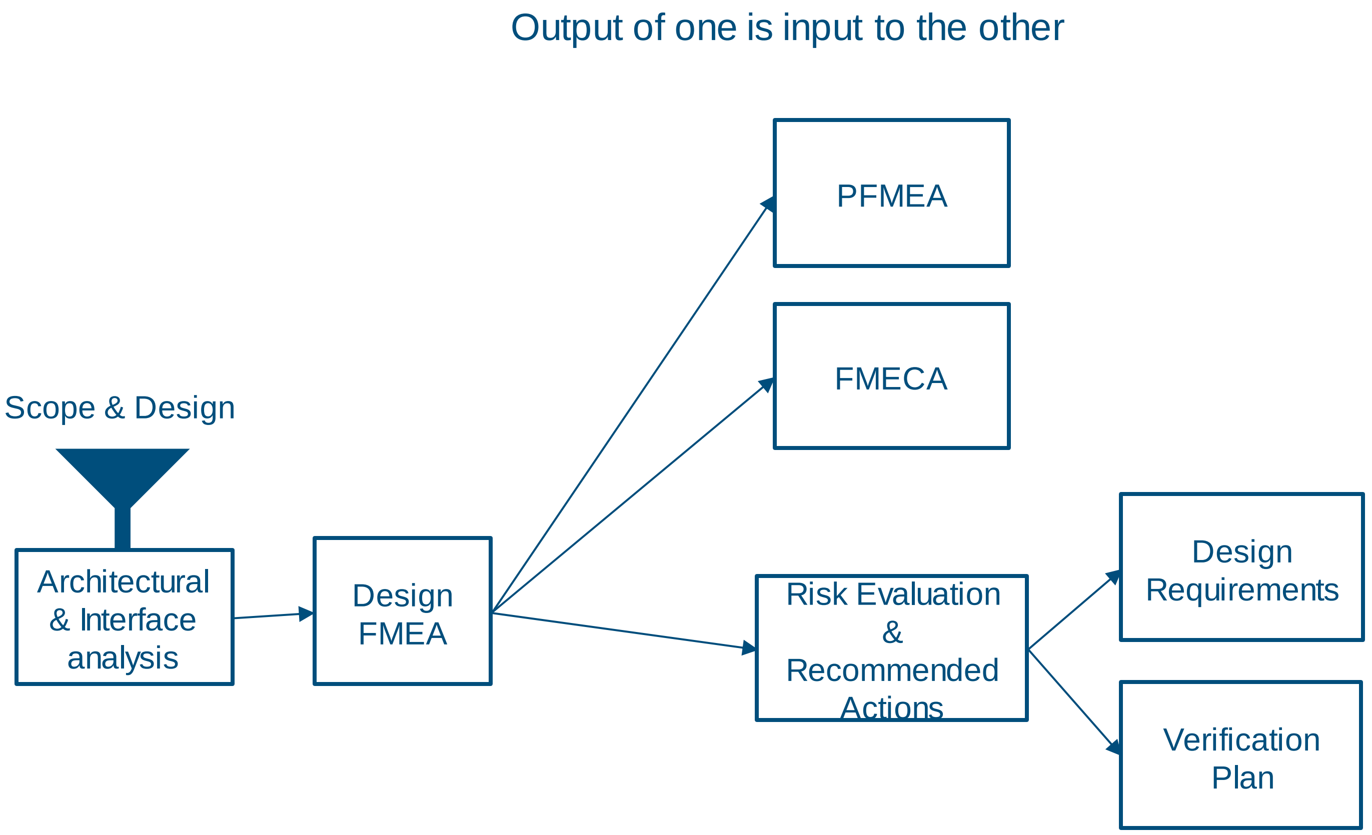
- At the beginning the scope has to be defined.
- The role the item plays in the overall design has to be considered.
- This includes design architecture specified by the customer as a constraint



Why do we need Interfaces and Interactions?

- Interfaces to other components, subsystems or systems has to be discussed.
- Physical and functional interfaces could be important for safety impact

Design FMEA is Part of a System



DFMEA could give information to different further process steps.

DFMEA is an important part of quality closed loop approach.

Every Function, Every Feature & Every Failure Mode

The DFMEA is a process to highlight the key areas of risk of design– that is the output of the DFMEA

If we pre-select the inputs based on what we 'think' is high risk then we may miss some important issues

We must sift through all functions and features.

Our products are in service for 30 years or more :

- Designs change
- Deviation exists
- Service experience is generated

➔ Information could be documented and assessed in DFMEAs

AS13100 Design FMEA Requirements

Must be Created & Maintained by a **CROSS FUNCTIONAL TEAM**
(20.1.2.4)

DFMEA be started during the Planning Phase of APQP
(21.1.2.1)

Scope shall encompass the items which the team is responsible for designing
(21.1.2.5)

System Architecture and Interfaces & Interaction have to be considered
(21.1.2.6 & 7)

DFMEAs must **DRIVE ACTIONS** to reduce risk
(21.1.2.10)

Keep up to date – They are **LIVE** documents
(20.1)

Design FMEA Updates

Information from similar products

Changed interfaces or Interactions during design phase

Design changes during design phase

Changed application, location, or environment during design phase

Design FMEA

Analysis and Testing Data

In-Service Data

Information

New/Changed Design DFMEA

In Aerospace products may be in production for 30 years or more

The DFMEA should capture all of the ‘up to date’ knowledge of how to make the part / assembly throughout its life

There should be a continuous drive to lower the associated RPN profile

Rob Farndon
Rolls-Royce

Andrea Neumann
MTU

Steven W. Finup
GE Aviation

Stéphan DAUX
Safran Aircraft Engines

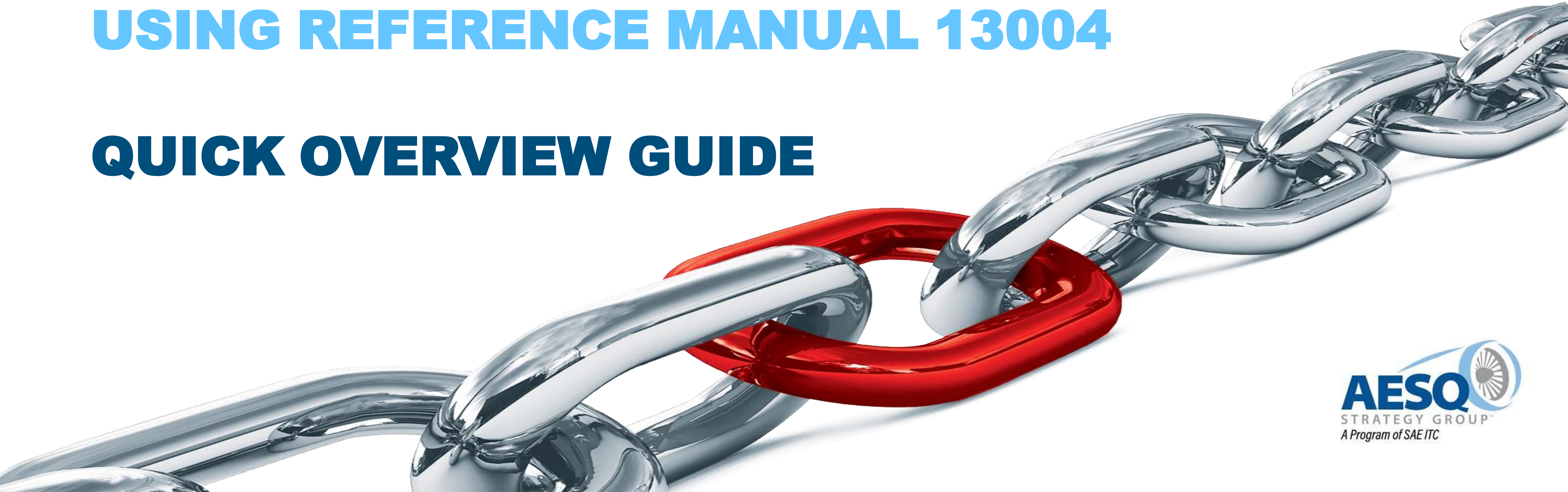
AESQ

DESIGN FAILURE MODE & EFFECTS ANALYSIS

ZERO DEFECTS TOOLKIT

CREATING A DESIGN FMEA USING REFERENCE MANUAL 13004

QUICK OVERVIEW GUIDE



AESQ STRATEGY GROUP
A Program of SAE ITC

FMEA Definition

Item	Function	Requirement	Potential Failure Mode	Potential Effect(s) of Failure	SEV	Potential Causes of Failure	Prevention Controls	OCC	Detection Controls	DET	RPN	Improvement Actions
Fuel Air Bracket	Prevent excessive lateral motion of fuel tube #XYZ	Fuel Tube lateral motion constrained to < x mm	Fuel Tube lateral motion > x mm	Increased high cycle fatigue Stresses on fuel tube tube cracking; Fuel leaking leading to fire, explosion, safety hazard (10)	10	Tube locating hole allowable diameter defined as too large	Bracket design Standard work document XYZ (2) Analysis – tube high cycle fatigue and wear (conducted at nominal dimensions only) (6)	6	Test – Engine XYX Durability testing with post-test hardware inspections (8)	8	480	Conduct high cycle fatigue and tube wear analysis at RSS Worst-case combination of max. hole ID. Min tube OD
Fuel Air Bracket	Prevent excessive lateral motion of fuel tube #XYZ	Lateral static load < X N	Lateral static load > X N	Increased bending loads on tubes and fittings; Early fuel tube cracking; Fuel leaking leading to fire, explosion, safety hazard (10)	10	Tube locating hole positional variation callout error	Fuel tube system tolerance stackup analysis (2) Bracket design Standard work document XYZ (2)	2	Engine XYX build process will detect (6)	6	120	None

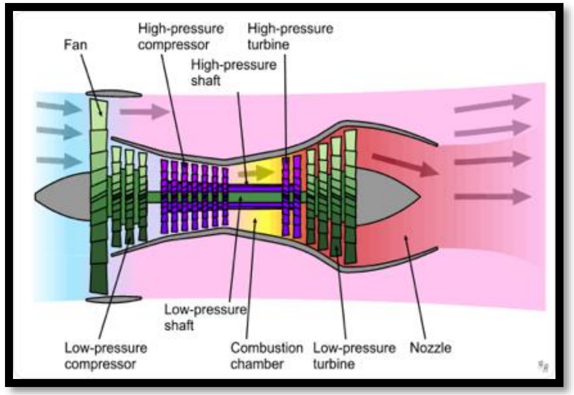
Failure Mode and Effects Analysis (FMEA) is a method designed to:

1) Recognize and evaluate the potential functional failures of an item and the effects and design related causes of those failures

2) Identify actions that eliminate or reduce the chance of the potential failures occurring

3) Document the management of design risk

Different Types of FMEA



Design FMEA

Process FMEA

FMECA

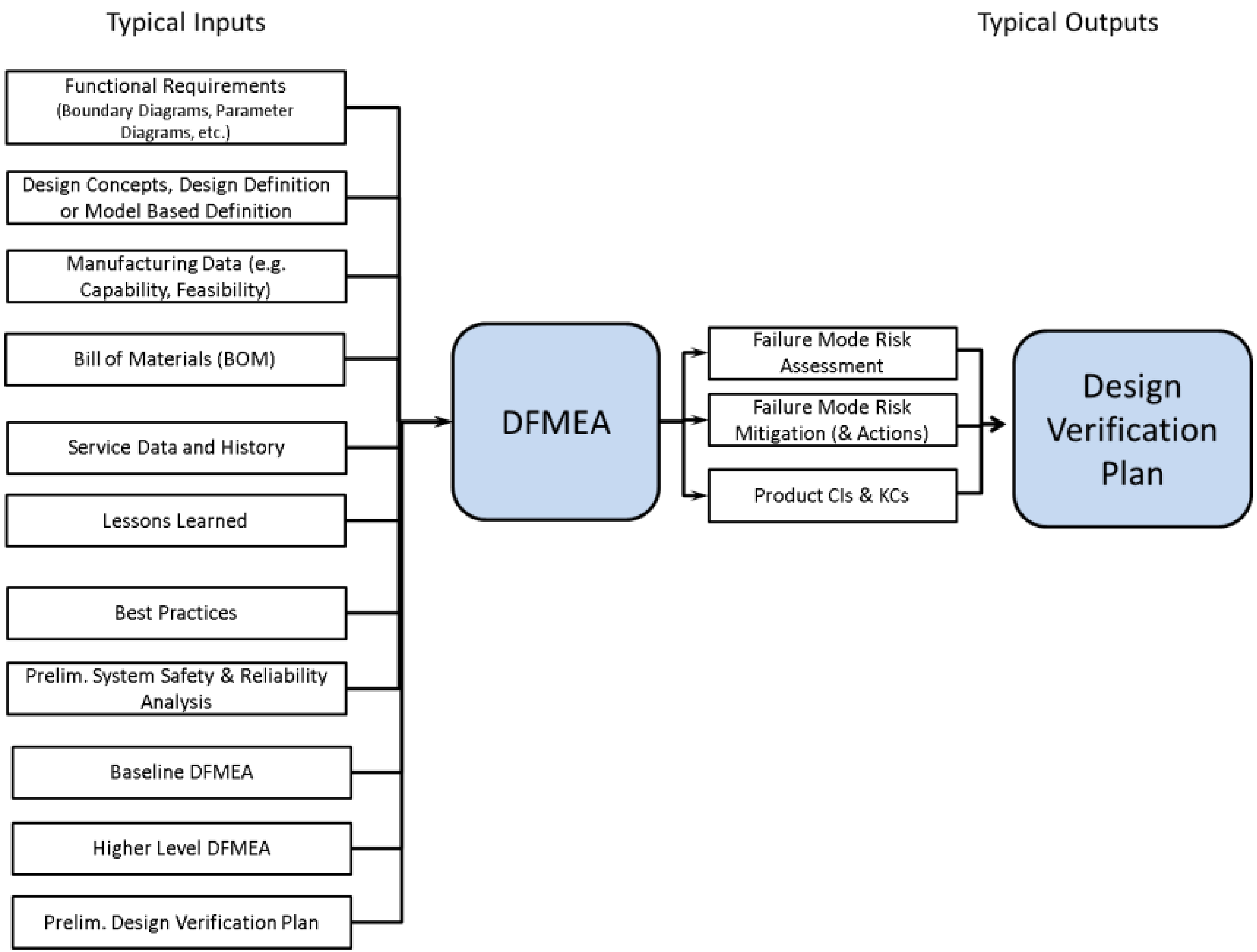
The primary objective of an FMEA is to <u>improve the product:</u>

a) For Design FMEAs, the objective is to improve the design of the system, subsystem or component.

b) For Process FMEAs, the objective is to improve the design of the manufacturing & assembly process.

c) For FMECA, the objective is to enumerate the risks associated with the operation of the product.

DFMEA FMEA Inputs and Outputs



The Design FMEA Template

AESQ
STRATEGY GROUP
A Program of SAE ITC

Section 1			Section 2			Section 3			Section 4		Section 5	Section 6
Item	Function	Requirement	Potential Failure Mode	Potential Effect(s) of Failure	SEV	Potential Causes of Failure	Prevention Controls	OCC	Detection Controls	DET	RPN	Improvement Actions
Fuel Air Bracket	Prevent excessive lateral motion of fuel tube #XYZ	Fuel Tube lateral motion constrained to < X mm	Fuel tube lateral motion > X mm	Increased high cycle fatigue Stresses on fuel tube tube cracking; Fuel leaking ... fire, explosion, safety hazard (10)	10	Tube locating hole allowable diameter defined as too large	Bracket design Standard work document XYZ (2) Analysis ... high cycle fatigue and wear (conducted at nominal dimensions only) (6)	6	Test: Engine XYX Durability testing with post-test hardware inspections (8)	8	480	Conduct high cycle fatigue and tube wear analysis at RSS Worst case combinations of max hole ID Min tube OD
Fuel Air Bracket	Apply minimal lateral static loads to fuel tube 'XYZ	Lateral static load < X N	Lateral static load > X N	Increased ... on tubes and fittings; Early fuel tube cracking; Fuel leaking leading to fire, explosion, safety hazard	10	Tube locating hole positional variation callout error	Fuel tube system tolerance stackup analysis (2) Bracket design Standard work document XYZ (2)	2	Engine XYX build process will detect (6)	6	120	None

Section 1:
What is the item that you are focusing on (Item)?
What function does the item have? (Function)
What are you trying to achieve (Product Requirements)?
Defined by Engineering Drawings & Specifications Or Assembly Instructions
DFMEA must include ALL Functions

Section 2:
How could you get the Requirements wrong (Failure Modes)?
What could happen if it did go wrong (Potential Effects)?
How bad would it be if it did go wrong (Severity Score)?

Section 3:
What could we get wrong in the design to cause the Failure Mode to occur (Potential Causes)?
How could this be prevented (Prevention Controls)?
How likely is it to be wrong (Occurrence Score)?

Section 4:
How will you check if the Cause and/or Failure Mode occur (Detection Controls)?
How likely are you to detect the Cause or Failure Mode if it was defective (Detection Score)?

Section 5:
Risk Priority Number (RPN)

Section 6:
List of Improvement Actions required to mitigate the key Risks Identified

Function and Requirement Focus | **Design Process Focus** | **Risk Mitigation**

Design FMEA Information Flow

AESQ STRATEGY GROUP
A Program of SAE ITC

Item	Function	Requirement	Failure Mode	Potential Effect	Severity	Potential Cause	Prevention Control	Occurrence	Detection Controls	Detection	RPN
Fuel Air Bracket	Prevent excessive lateral motion of fuel tube #XYZ	Fuel Tube lateral motion constrained to < x mm	Fuel Tube lateral motion > x mm	fire, explosion safety hazard (10)	10	Tube locating hole allowable diameter defined as too large	Analysis – tube high cycle fatigue and wear (conducted at nominal dimensions only) (6)	6			480
						Bracket thermal growth defined as > tube thermal growth	Analysis – Components thermal growth (4)	4			320
									Test – Engine XYX Durability testing with post-test hardware inspections (8)	6	

Design FMEA Information Flow

AESQ STRATEGY GROUP
A Program of SAE ITC

Item	Function	Requirement	Failure Mode	Potential Effect	Severity	Potential Cause	Prevention Control	Occurrence	Detection Controls	Detection	RPN
Fuel Air Bracket	Prevent excessive lateral motion of fuel tube #XYZ	Fuel Tube lateral motion constrained to < x mm	Fuel Tube lateral motion > x mm	fire, explosion safety hazard (10)	10	Tube locating hole allowable diameter defined as too large	Analysis – tube high cycle fatigue and wear (conducted at nominal dimensions only) (6)	6	Test – Engine XYX Durability testing with post-test hardware inspections (8)	6	480
						Bracket thermal growth defined as > tube thermal growth	Analysis – Components thermal growth (4)	4	Test – Engine XYX Durability testing with post-test hardware inspections (8)	6	320

The description in each column must flow directly from the description in the relevant cell

If the Requirements column is incorrect then everything to the right will be incorrect.

Precision of language is vital

DFMEA FMEA Data Sources

Architecture/Design

Service Data
Lessons Learned
Baseline DFMEA
Prelim. System Safety & Reliability Analysis

Item	Function	Requirement	Potential Failure Modes	Potential Effects of Failure	Severity Score	Potential Causes of Failure	Prevention Controls	Occ Score	Detection Controls	Detection Score	RPN

Functional Requirements

Drawings, Assembly
Instructions &
Engineering Specifications

Standard Work
Service Data
Experience from other projects

Validation & Verification Plan

Design FMEA Ranking Criteria

Ranking	Severity Category (Product)	Criteria: Severity of Effect Effect on Product – DFMEA
10	Safety and/or Regulatory Compliance	Potentially hazardous failure without warning. Failure potentially affects safe operation of the product or causes regulatory non-compliance.
9		Potentially hazardous failure with warning. Failure potentially affects safe operation of the product, causes regulatory non-compliance or results in a significant reduction in safety margins.
8	Primary Function	Product is not operational; safety not compromised. Failure causes major customer dissatisfaction and severe disruptions.
7		Operability severely affected; primary functions/systems may be degraded. Failure causes high degree of customer dissatisfaction or severe disruptions.
6	Secondary Function	Operability significantly degraded; secondary systems may be inoperable. Failure causes significant customer dissatisfaction or significant disruptions.
5		Moderate effect on operability; secondary systems may be degraded. Product secondary systems do not conform to operational requirements. Failure causes customer dissatisfaction, often resulting in operational disruption.
4	Annoyance	Moderate effect on operability. Non-compliance to functional requirement, although all systems operational. Failure causes some customer dissatisfaction noticed by most customers, often requiring in-service repair.
3		Minor effect on operability. Non-compliance to functional requirement. Failure causes minor customer dissatisfaction noticed by many customers, often requiring action at next overhaul.
2	Awareness	Slight effect on operability. Non-compliance to functional requirement. Failure causes slight customer annoyance noticed by few customers, potentially resulting in additional overhaul cost.
1	No Effect	No discernible effect on product operation.

Ranking	Likelihood of Design Error	Criteria: Occurrence of Cause (DFMEA)
10	Inevitable	No guiding practices upon which to base design are available for this technology - design system will developed for the first time for this technology in this application. New technology with no history of successful application in any industry. Design process will almost certainly produce a deficient design on first attempt, requiring design itera detection activities.
9	Almost Inevitable	Very limited guiding practices for this technology may be available from other industries upon which t design. New technology with only limited relevance / limited application in other industries. Design process will almost certainly produce a deficient design on first attempt, requiring design itera detection activities.
8	Highly Likely	Some standard practices for this technology may be available from other industries upon which to ba New technology with moderate amount of successful relevant application. Design process is highly likely to produce a deficient design on first attempt, most likely requiring des iteration(s) after detection activities.
7	Likely	Existing standard methods are not applicable to the current design situation. Existing technology, but extremely different duty cycle, operating conditions or application. Past expe is of limited to no relevance. Design process is likely to produce a deficient design on first attempt, likely requiring design iteration detection activities.
6	Possible	Existing standard methods are only partly applicable to the current design situation. Existing technology, but highly different duty cycle, operating conditions or application. Past experier partial relevance. Design process could produce a deficient design on first attempt, may require design iteration(s) after detection activities.
5	Plausible	Existing standard methods are moderately applicable to the current design situation. Existing technology, but moderate differences in duty cycle, operating conditions or application. Past experience base is of moderate relevance. Design process could produce a deficient design on first attempt, may require design iteration(s) after detection activities.
4	Unlikely	Existing standard methods are highly applicable to the current design situation. Existing technology, but slight differences in duty cycle, operating conditions or application. Past experience base is of good relevance. Design process is unlikely to produce a deficient design on first attempt, unlikely to require design iteration(s) after detection activities.
3	Highly Unlikely	Similar successful past experience guiding design practices and choices. Existing technology, but minor differences in duty cycle, operating conditions or application. Past experience base is of good relevance. Design process is highly unlikely to produce a deficient design on first attempt, highly unlikely to require design iteration(s) after detection activities
2	Extremely Unlikely	Probability of design error is significantly minimized through application of prevention controls - identical, highly relevant, & successful past experience guiding design practices. Existing technology, no differences in duty cycle, operating conditions or application. Past experience base is completely relevant, and of moderate extent. Design process is extremely unlikely to produce a deficient design on first attempt, extremely unlikely to require design iteration(s) after detection activities
1	Prevented	Design error is either physically impossible or eliminated through application of prevention controls - extensive, identical, highly relevant, & successful past experience guiding design practices. Existing technology, no differences in duty cycle, operating conditions or application. Past experience base is completely relevant, and of significant extent. Design process will almost certainly not produce a deficient design on first attempt, will not require design iteration(s) after detection activities.

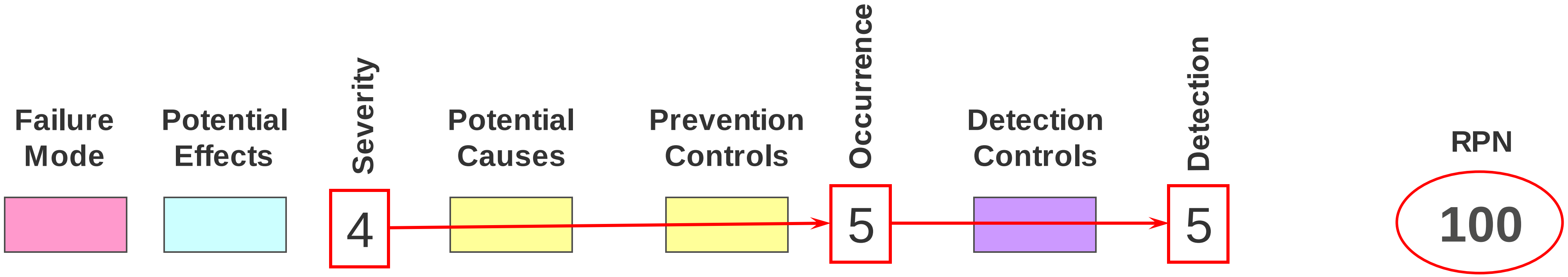
Ranking	Detection Category	Criteria: Likelihood of Detection (Design Verification) - DFMEA
10	Will not detect	No current design control; Design control will not and/or cannot detect a potential failure cause/mechanism
9	Not Likely to Detect or detected post Production Launch	Design analysis/detection controls are not likely to detect a potential failure cause/mechanism; Testing is post Production Launch, virtual analysis is of low fidelity and is not correlated to anticipated actual product operating conditions.
8	Post Design Freeze and Prior to Production Launch	Failure cause/mechanism detected during product verification/validation testing. Detected prior to Production Launch with "pass /fail" testing*or by uncorrelated late detailed analysis.
7		Failure cause/mechanism detected during product verification/validation testing. Detected prior to Production Launch with "test to failure" testing* or by late partially correlated detailed analysis.
6		Failure cause/mechanism detected during product verification/validation testing. Detected prior to Production Launch with "degradation" testing*, or by correlated late detailed analysis.
5	Prior to Design Freeze	Failure cause/mechanism detected prior to Design Freeze using "pass/fail" testing* or by uncorrelated detailed analysis.
4		Failure cause/mechanism detected prior to Design Freeze using "test to failure" testing* or by partially correlated detailed analysis.
3		Failure cause/mechanism detected prior to Design Freeze using degradation testing* or by correlated detailed analysis.
2	Robust Early Detection	Design analysis/detection controls are virtually assured to detect a potential failure cause/mechanism. Virtual analysis is conducted early in the design phase and is highly correlated with actual and/or expected operating conditions.
1	Failure Prevented; Detection not Applicable	Failure cause/mechanism cannot occur because it is fully prevented through preventive design controls (e.g. proven design standard/best practice, proven common material, etc.)

AESQ STRATEGY GROUP
A Program of SAE ITC

1) The Ranking Criteria for Severity, Occurrence and Detection defined in RM13004 *should* be used

2) Alternative Ranking Criteria *may* be used only if approved by the customer.

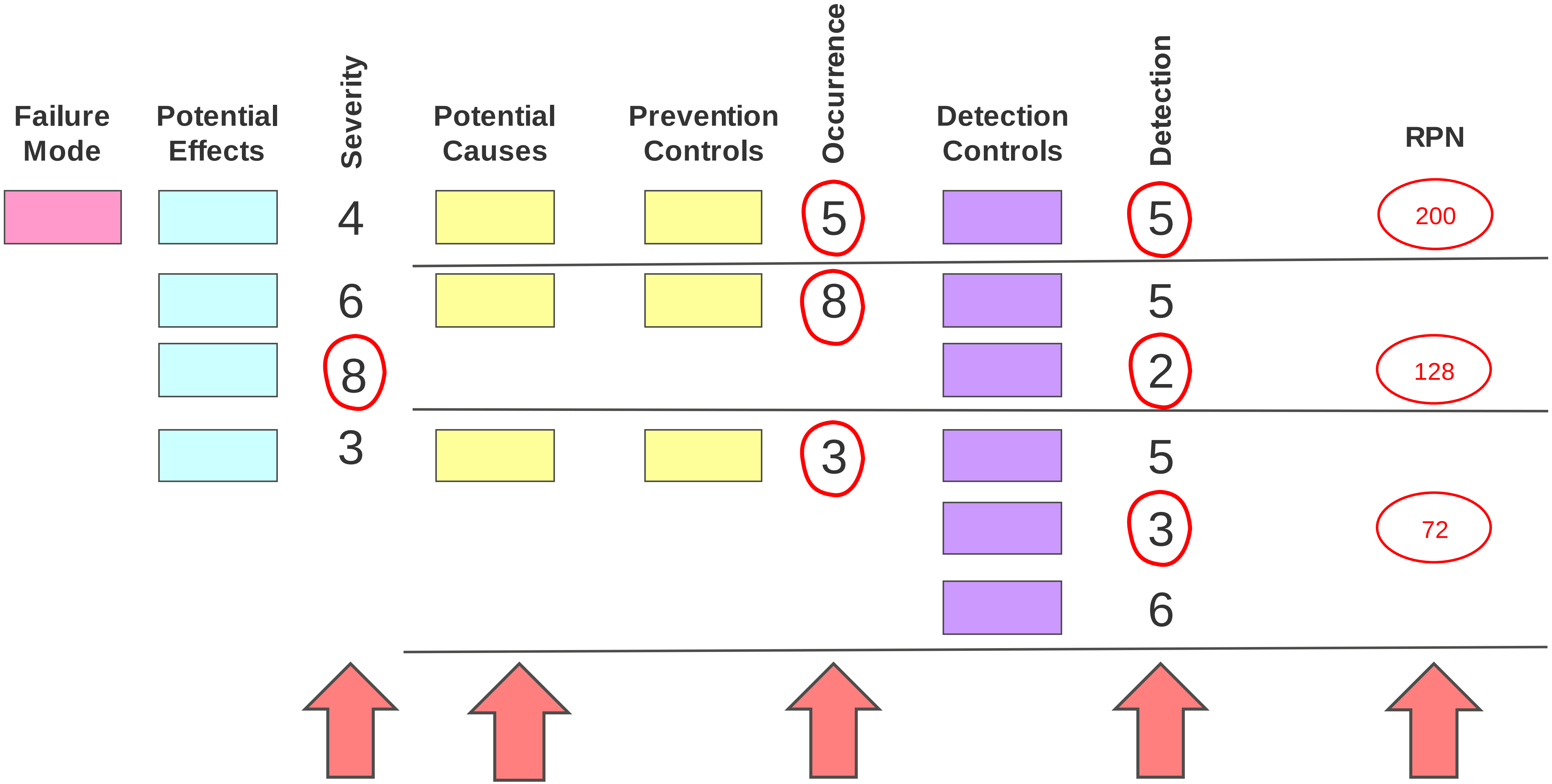
FMEA Risk Priority Number Scoring



Severity x Occurrence x Detection = RPN

4 x 5 x 5 = 100

FMEA Risk Priority Number Scoring



The **Highest** Severity Score corresponding to the failure effects

Each cause gets separate line in DFMEA

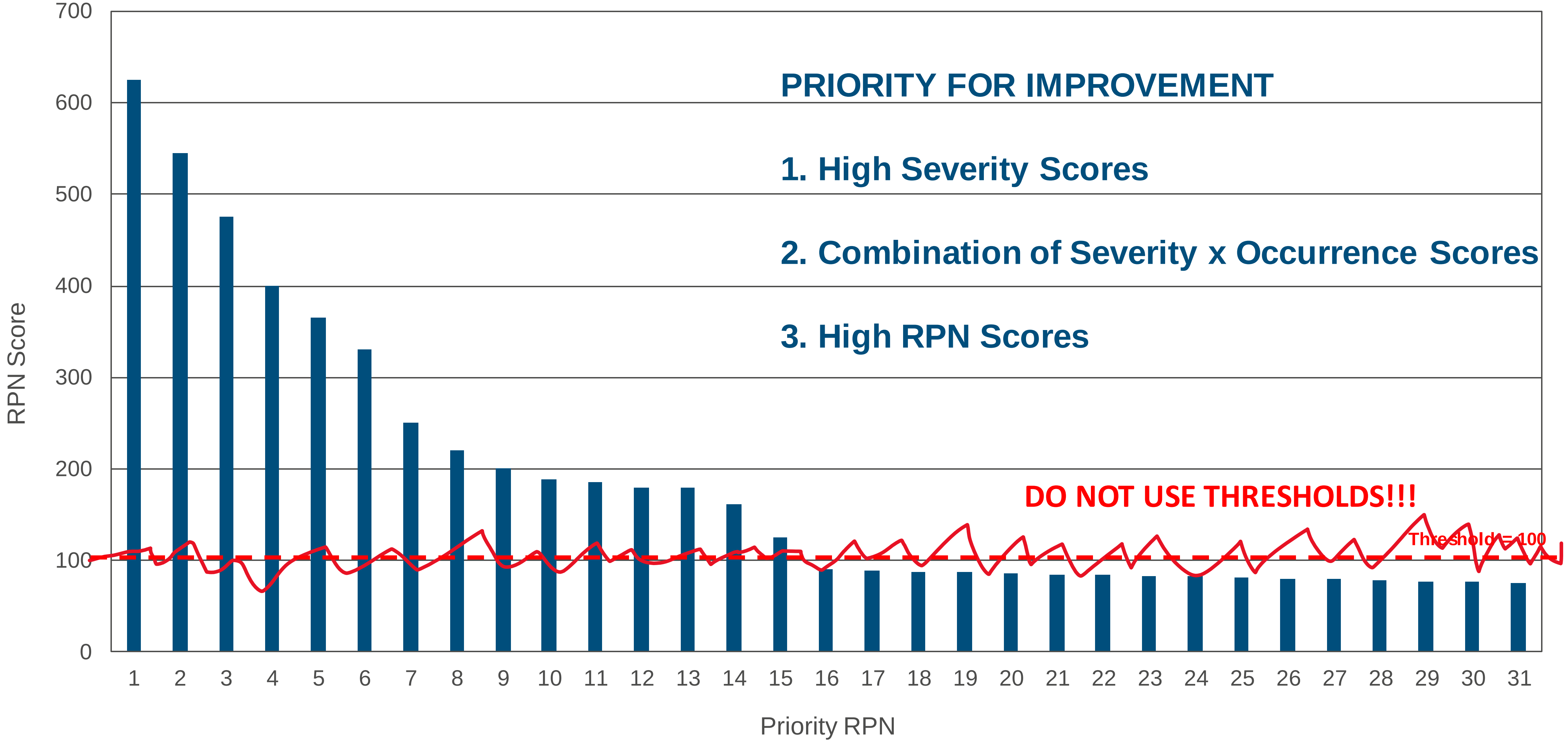
Lowest Occurrence Score corresponding to the best prevention control

The **Lowest** Detection Score Corresponding to the best detection

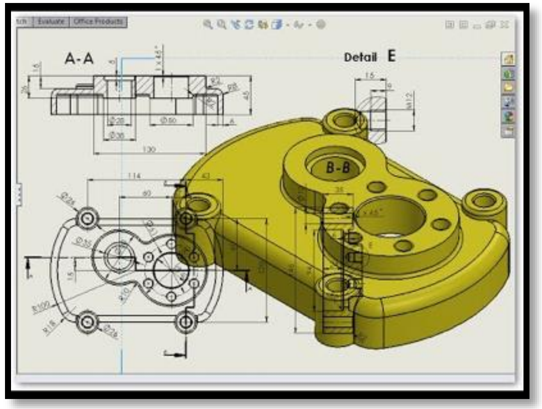
An RPN Score For every Potential Cause & Failure Mode Combination

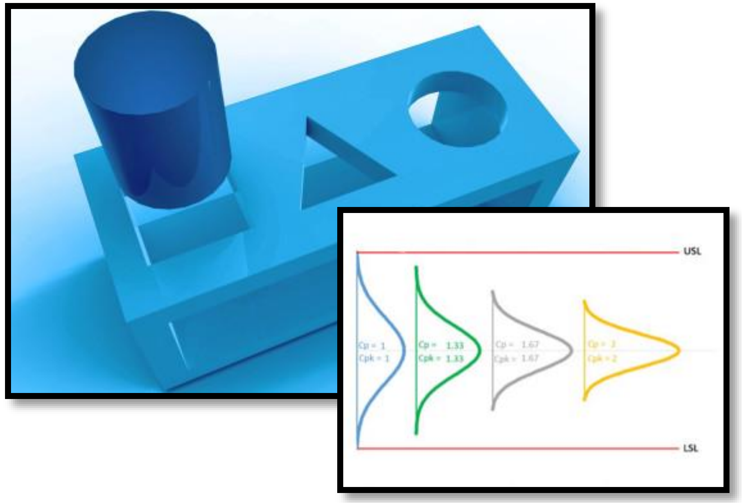
FMEA Action Prioritization

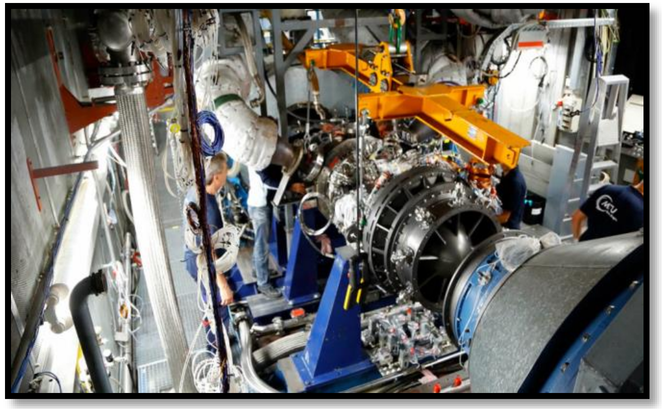
RPN PARETO



Notes on Risk Mitigation







Severity Scores

Can only be reduced through Product Redesign e.g. removing the need for a function or providing a 'fail safe' solution.

Occurrence Scores

Can be reduced through generating more experience with analysis and/or testing during the design phase

Detection Scores

Can be reduced through enhanced and/or earlier testing

DFMEA FMEA Improvement Actions

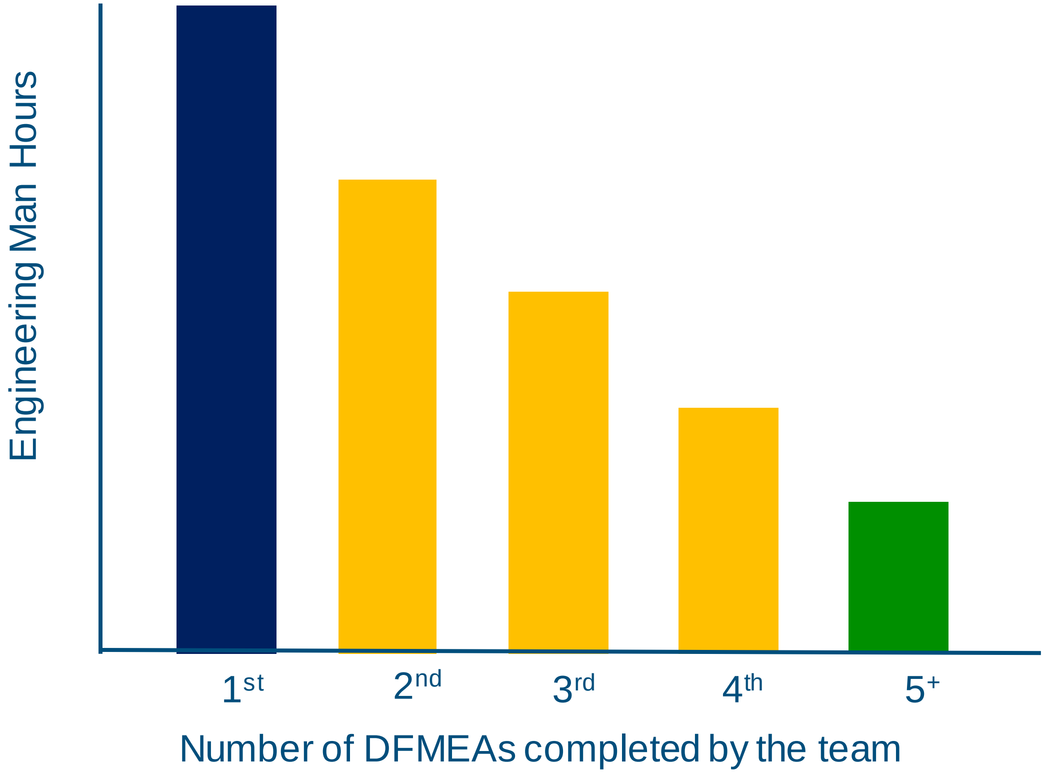
Hole Diameter Too Big				
Sev	Potential Cause	Occ	Det	Risk Priority Number
10	Tube locating hole allowable diameter defined as too large	6	8	480

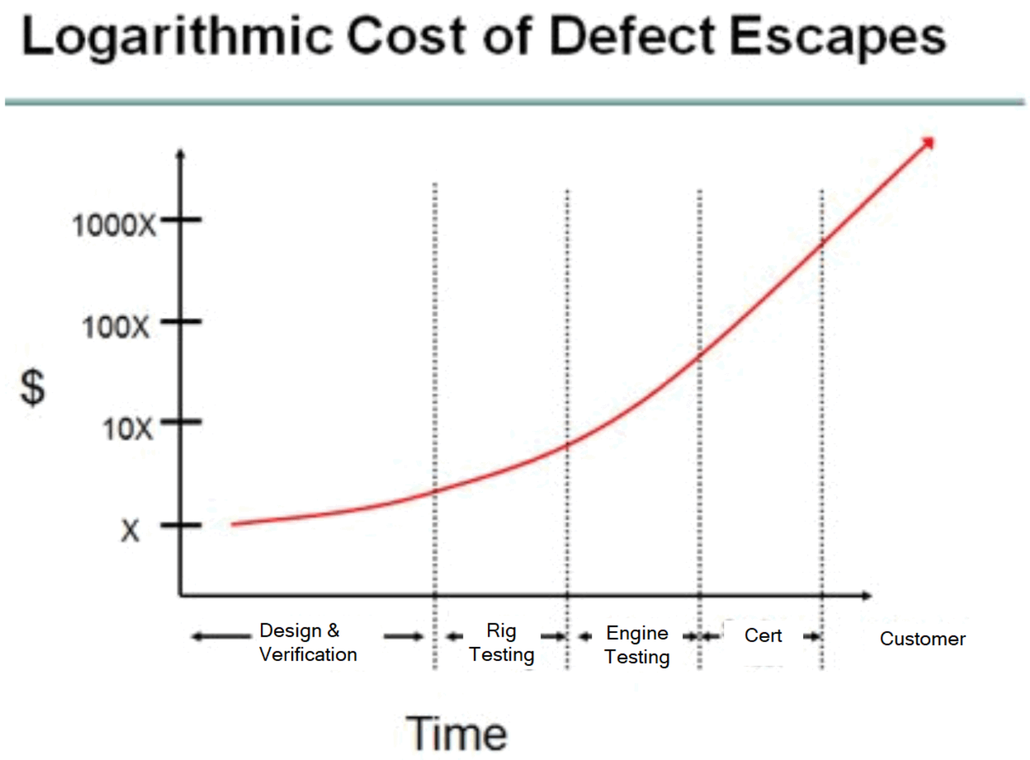
IMPROVEMENT ACTIONS							
Recommended Actions	Responsibility	Target Date	Action Taken	Sev	Occ	Det	RPN
Conduct high cycle fatigue and tube wear analysis at RSS Worst-case combination of max. hole ID. Min tube OD *(Improved OCCURRENCE Score)*	Daryl Jackman	July 7th	Introduced June 25th	10	2	8	160
Conduct accelerated stress test to determine limits of max. hole ID, min tube OD configuration *(Improved DETECTION Score)*	Sarah Cracknell	June 1st	Introduced May 29th	10	6	4	240

Improved Occurrence Score from 6 to 2 by gain more experience with design

Improved Detection Score from 8 to 4 by changing verification schedule

How long will it take? What is the benefit ?





Quick Chat 2

CHAT NOW

Use the **Chat Function** to ask a question, at any time, or to make a comment.

Steven W. Finup
Consulting Engineer
GE Aviation

Stéphan DAUX
APQP Leader & Master
Safran Aircraft Engines

(a) How does your organization currently comply to AS13100 and RM13004

I. Not at all, we do not do Design FMEAs

II. It is very different to how we currently do it

III. We comply with more than 75% of the requirements but there is more we need to do

IV. This is how we conduct Design FMEAs

Rob Farndon
Rolls-Royce

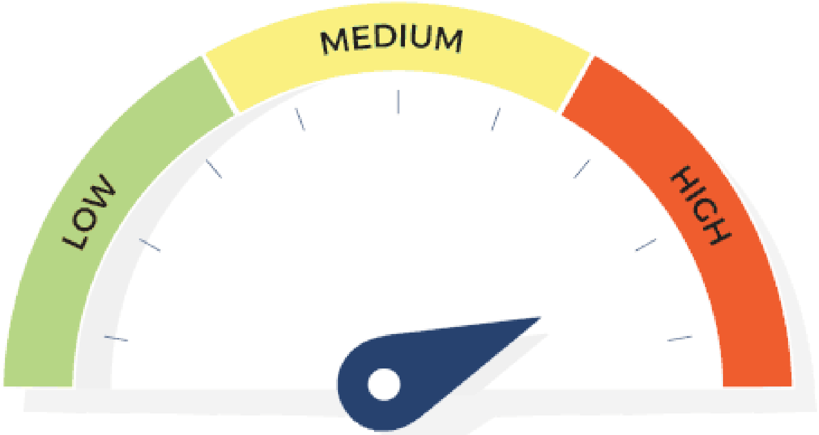
Steven W. Finup
GE Aviation

Andrea Neumann
MTU

Stéphan DAUX
Safran Aircraft Engines

3
DESIGN FMEA SUMMARY & FURTHER INFORMATION

Design FMEA Efficiency : Success Factors



Risk Priority Number

EFFECTIVE DFMEAs WILL TRANSFORM YOUR DESIGN PERFOMANCE!

Tips for Efficient Deployment include;

a) Do the right preparation

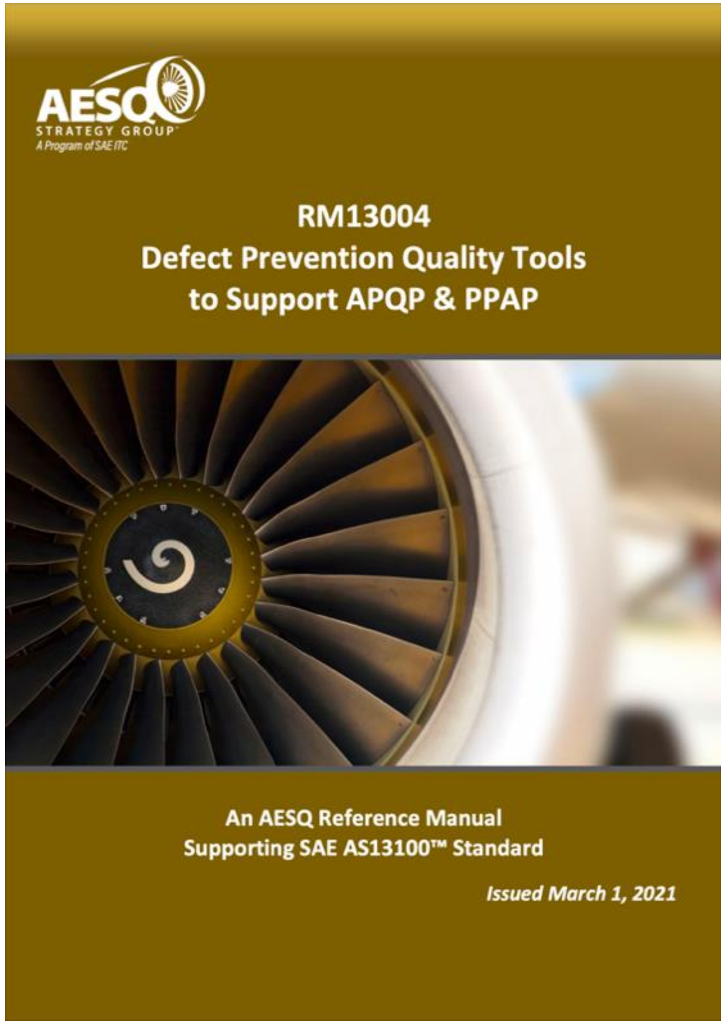
b) Work with a **CROSS-FUNCTIONAL** Team

c) Teams that are prepared to **GET ON** and try it, avoid procrastination

d) Have the right **MIND-SET**

e) Right choice of **SOFTWARE** to manage data

Sources of Further Information & Guidance



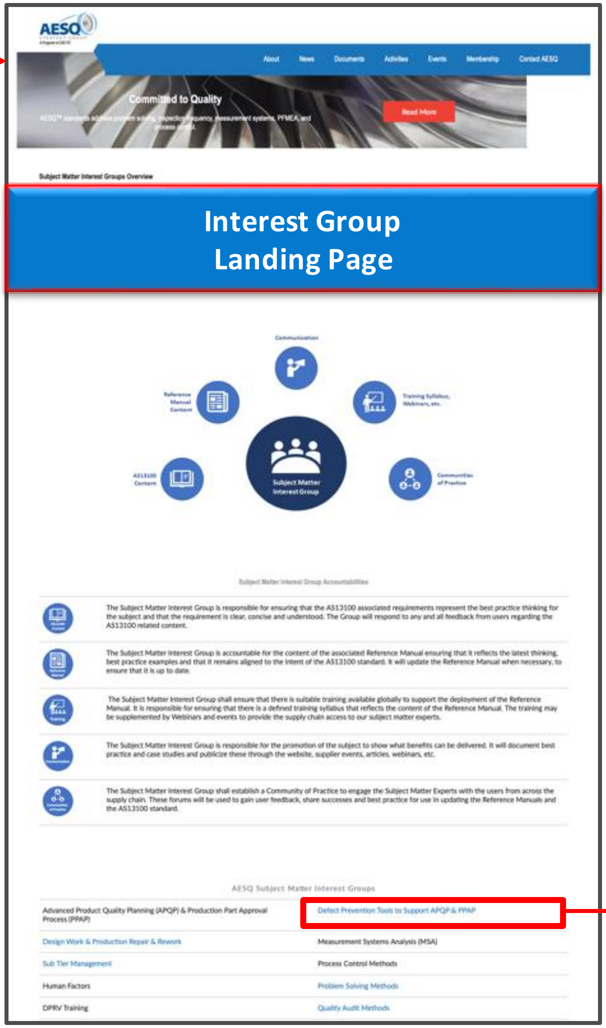
1. **Reference Manual RM13004 is available free of charge from the AESQ website**

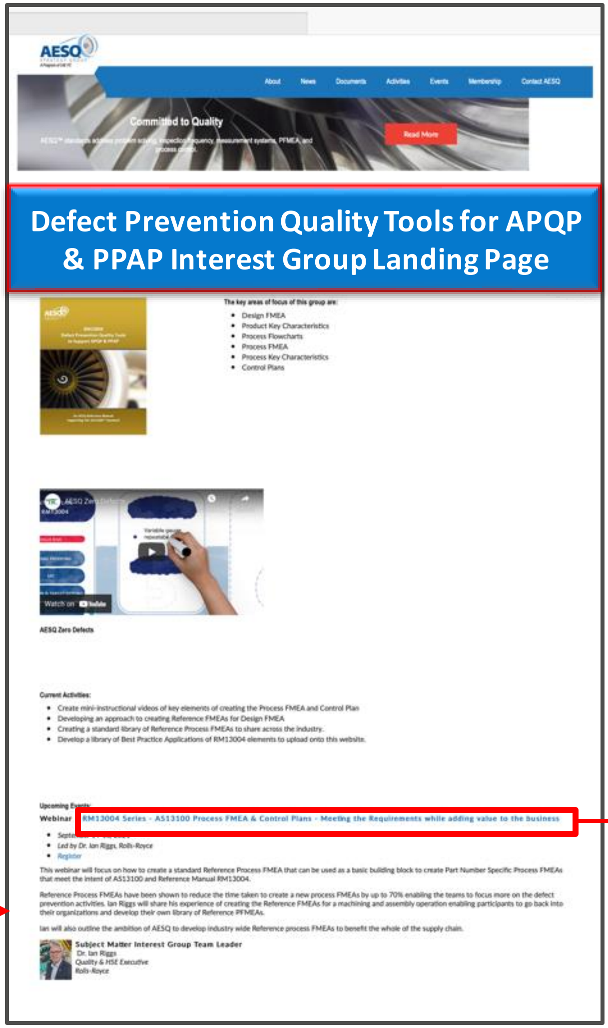
2. **Global FMEA training is available to support this approach through the SAE.**

3. **Subject Matter Interest Group to support RM13004 Deployment established and contactable through AESQ Website**

https://aesq.sae-itc.com

Subject Matter Interest Groups on the AESQ Website





Further links to support materials, events, social media pages, etc.

Submit questions

RM13004 DESIGN FMEA Webinars

June 22nd & 23rd 2022

AS13100 & RM13004 DESIGN FMEA - Understanding the Requirements

Led by Rob Farndon, these interactive webinars are designed to describe the intent of the AESQ AS13100 requirements for Design FMEAs and how they link to the effective deployment of Advanced Product Quality Planning (APQP) and a Zero Defect Strategy.

These webinars shall explain how AS13100 Design FMEA can be developed, maintained and improved using real examples of best practice from across the industry.

SESSION 1 AS13100 DFMEA Requirements and Overview (June 22nd 14.00 – 16.00 UK Time)	**SESSION 2** Key Care Points when Creating the Design FMEA (June 23rd 14.00 – 16.00 UK Time)
Overview of the requirements for Design FMEA in Chapter C of AS13100 and their link to the APQP / PPAP process	A closer look at some of the key steps when creating Design FMEAs to illustrate the intent of the AS13100 requirements, including; a) Requirements & Potential Failure Modes b) Potential Effects & Severity Rating c) Potential Causes d) Prevention Controls & Occurrence Rating e) Detection Controls & Detection Rating f) Calculating the Risk Priority Number (RPN) g) Prioritizing Improvements
Explanation of the intent of each requirement and what success looks like	
Overview of the Design FMEA approach aligned to the RM13004 Reference Manual	
Links to further help and guidance	
Questions & Answers	**Questions & Answers**

AESQ STRATEGY GROUP
A Program of SAE ITC

Thank You For Attending!

Please join again tomorrow