Using an FMEA approach to REDUCE HUMAN ERROR

A Rolls-Royce Case Study

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Rolls-Royce Civil Aerospace

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Rolls-Royce Civil Aerospace
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.
Ian Riggs Introduction

- Worked for Rolls-Royce Aerospace for past 18 years
- Currently the Global Quality & HSE Executive for Civil Aerospace, Assembly & Test Operations
- 16 years experience working for Automotive, including Cosworth High Performance Engines (owned by Audi AG) and Harman International
- Awarded an Engineering Doctorate by Warwick University in 2005
- Founding member of the AESQ in 2013
  - Served two terms as Chairman
  - Led the writing team for AS13100 and AS13003
  - Team leader for RM13004 Interest Group
- Trained over 1500 Rolls-Royce and Supplier Leaders in our Zero Defects Program
Steve Roebuck Introduction

- Worked for Rolls-Royce Aerospace for the past 11 years
- Currently Head of Certification & Quality Assurance Civil Aerospace, Assembly & Test Operations
- Previous Quality Leadership roles in Domestic and Supply Chain Quality at Rolls-Royce
- Previous experience outside of Rolls-Royce working in various Quality Assurance roles across the Aerospace and Pharmaceutical Industry
- Current Human Factors Deployment Lead for Assembly & Test Operations
- First AESQ Webinar after presenting at the AESQ conference in February
AS13100 Webinar Series : Using FMEA to Reduce Human Error

The management of Human Factors plays an important part in any organizations' ability to achieve its quality and safety goals.

AS13100 and RM13010 define requirements and guidance to what an effective Human Factors system should include.

In this Webinar we shall share how Rolls-Royce Civil Large Engine Assembly & Test facility has developed a preventative approach to Human Factors related causes by using a Process Failure Mode & Effects Analysis (PFMEA) approach.

Section 1: The Approach

1. What is meant by Human Factors
2. Failure Mode & Effects Analysis (FMEA) Simple Overview
3. Using FMEA to reduce the risk of Human Factors – Overview of the approach

Section 2: Case Studies

4. Case Study 1: Final Inspection
5. Case Study 2: Certification Office

Section 3: Help & Guidance

6. HF FMEA Summary & Insights
7. Frequently Asked Questions
8. AESQ Support
9. Questions & Answers
506 people registered representing 273 companies in 26 Countries
How to Engage with Us

Please complete the Poll Questions when asked (they are anonymous).

Use the Chat Function to ask a question, at any time, or to make a comment.
Which Function listed below best describes where you work?
What City are you joining from?

① Start presenting to display the poll results on this slide.
Section 1: The Human Factors FMEA Approach

1. Overview of Human Factors in AS13100

2. FMEA OVERVIEW

3. Human Factors FMEA Overview
What is/are Human Factors?

Human Factors can influence us at work every day and can negatively impact performance without us knowing it!

Being aware and understanding Human Factors plays an important role in Manufacturing and Assembly Operations

The primary focus of any Human Factors initiative is to improve safety, quality, and efficiency by reducing and managing human errors made by individuals and organizations

There are many disciplines around the study of human factors but today we are going to focus on the Dirty Dozen
Sources of Further Information & Guidance

1. Reference Manual RM13004 and RM13010 are available free of charge from the AESQ website

2. Subject Matter Interest Group to support RM13004 and RM13010 Deployment are established and contactable through AESQ Website

https://aesq.sae-itc.com
RM13004 is focused on Product Failure Modes and so is not relevant to what we will describe today. The only relevance to Human Factors FMEA is the template used and the 'FMEA thinking' approach.

RM13010 describes a wide range of Human Factors topics to support the deployment of AS13100. For this Human factors FMEA approach we are focusing mainly on the concept of the 'Dirty Dozen' as described in Section 5.1.
Aero Engine Assembly Operations

30,000 Components

6,000 Manual Operations

HUMAN FACTORS play a critical part in assuring PRODUCT QUALITY & SAFETY
Does your Company have a Human Factors Program?
How many of the Dirty Dozen can you name?
Human Factors

The Dirty Dozen

1. Lack of Communication
2. Complacency
3. Lack of Knowledge
4. Distraction
5. Lack of Team Work
6. Fatigue
7. Lack of Resources
8. Pressure
9. Lack of Assertiveness
10. Stress
11. Lack of Awareness
12. Norms
The Dirty Dozen

1. Lack of Communication  
2. Complacency  
3. Lack of Knowledge  
4. Distraction  
5. Lack of Teamwork  
6. Fatigue  
7. Lack of Resources  
8. Pressure  
9. Lack of Assertiveness  
10 Stress  
11. Lack of awareness  
12. Norms

Distraction Safety Nets

1. Always finish the job or unfasten the connection  
2. Mark the uncompleted work  
3. Lockwire where possible or use Torque seal  
4. Double inspect by another or self  
5. When you return to the job always go back 3 steps  
6. Use a detailed check-sheet.

Posters adapted from  
http://www.marss.org/poster.htm#
The Dirty Dozen

1. Lack of Communication
2. Complacency
3. Lack of Knowledge
4. Distraction
5. Lack of Teamwork
6. Fatigue
7. Lack of Resources
8. Pressure
9. Lack of Assertiveness
10. Stress
11. Lack of awareness
12. Norms

Pressure Safety Nets

1. Be sure the pressure isn’t self-induced
2. Communicate your concerns
3. Ask for extra help
4. Just say No

Hurry up or we’re going to be late again!

Posters adapted from http://www.marss.org/poster.htm#
The Dirty Dozen

1. Lack of Communication
2. Complacency
3. Lack of Knowledge
4. Distraction
5. Lack of Teamwork
6. Fatigue
7. Lack of Resources
8. Pressure
9. Lack of Assertiveness
10. Stress
11. Lack of awareness
12. Norms

Complacency Safety Nets

1. Train yourself to expect to find a fault
2. Never sign for something that you did not do.

Posters adapted from http://www.marss.org/poster.htm#
**Training/Awareness**
- Initial Training
- 2 yearly refresher training
- Toolbox Talks

**Open Reporting Process**
- MARS Process – Manage the Action Report System

**Human Factor Requirements**
- AS13100

**Improvements/Maturity**
- HF FMEA
- HF Deployment Maturity Assessment

- **5.2.1.1 Continually improving the maturity of Human Factor deployment**

**Investigations**
- Human Factors checklist – considering human factors (Dirty Dozen) during root cause investigations

- **10.2.1 An approach for recognizing and addressing Human Error causes in investigations.**

**Just Culture**
- MEDA investigations
- Event Review Group – Line in the sand

- **4.4.3 An open reporting culture, encouraging the sharing of mistakes without fear of inappropriate retribution.**
Are you familiar with using FMEA?
FMEA Simple Overview

What you are trying to achieve (Requirements) → How you may fail to achieve your requirements (Failure Modes) → What could cause the Failure Mode (Potential Causes) → Can the Potential Causes be prevented? (Prevention Controls) → How bad could it be if it did fail? (Severity Rating 1-10) → How can you detect the Failure Mode or Potential Cause (Detection Control) → How effective is your detection control? (Detection Rating 1-10) → What is the likelihood that the potential cause can occur? (Occurrence Rating 1-10) → What would happen if it did fail? (Potential Effects) → How effective is your detection control? (Detection Rating 1-10) → Risk Priority Number
<table>
<thead>
<tr>
<th>Step</th>
<th>Requirements</th>
<th>Potential Failure Modes</th>
<th>Potential Effects of Failure</th>
<th>Severity Score</th>
<th>Potential Causes of Failure</th>
<th>Prevention Controls</th>
<th>Occ Score</th>
<th>Detection Controls</th>
<th>Detection Score</th>
<th>RPN</th>
<th>Improvement Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP10 CNC Drilling</td>
<td>Fuel Hole 50mm Diameter +/- 0.1mm</td>
<td>Diameter Too Big</td>
<td>Fuel Leaks leading to a potential explosion in use</td>
<td>9</td>
<td>Drill Oversize</td>
<td>Drill Tool presetting check</td>
<td>4</td>
<td>Bore micrometer at OP 50</td>
<td>7</td>
<td>252</td>
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<td>Spindle alignment error – spindle not running true</td>
<td>Asset Care &amp; machine calibration schedule</td>
<td>3</td>
<td>Operator Weekly Ball bar check (Go / No GO)</td>
<td>8</td>
<td>189</td>
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<td>Part Loose in Fixture</td>
<td>Air detection system on fixture</td>
<td>1</td>
<td>Bore micrometer at OP 50</td>
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<td>Scrap Part</td>
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<td>Swarf / Debris on tool</td>
<td>None</td>
<td>4</td>
<td>Bore micrometer at OP 50</td>
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<td>Requirement</td>
<td>Potential Failure Mode(s)</td>
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<td>Prevention Controls</td>
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<td>No errors due to Human Factors</td>
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<td>Distractions</td>
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<td>The Dirty Dozen</td>
<td>Lack of Knowledge</td>
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<td>Lack of Resources</td>
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(Simplified FMEA template for illustration purposes only. Some columns are missing e.g. the scoring is not included)
**Human Factors**

**Using the FMEA Approach**

### Requirement

- No errors due to Human Factors

### Potential Failure Mode(s)

- Complacency
- Distractions
- Fatigue
- Lack of Assertiveness
- Lack of Awareness
- Lack of Communication
- Lack of Knowledge
- Lack of Resources
- Lack of Teamwork
- Pressure
- Stress
- Unhealthy Norms

### Potential Cause(s)

### Prevention Controls

### Detection Controls

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### The Dirty Dozen

What things could cause distractions in the workplace?

(Simplified FMEA template for illustration purposes only. Some columns are missing e.g. the scoring is not included)
What things could cause distractions in the workplace?
Human Factors

Using the FMEA Approach

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Potential Failure Mode(s)</th>
<th>Potential Cause(s)</th>
<th>Prevention Controls</th>
<th>Detection Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>No errors due to Human Factors</td>
<td>Complacency</td>
<td>Mobile Phone usage</td>
<td>Mobile Phone usage</td>
<td>Leadership walks</td>
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<td></td>
<td>Distractions</td>
<td>Fellow worker</td>
<td>Policy defined &amp;</td>
<td>Area Supervision</td>
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<td>distraction</td>
<td>Trained out</td>
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<td></td>
<td>Fatigue</td>
<td>Management / visitor distraction</td>
<td>Defined areas for access restrictions / Hi visibility vest when completing key tasks</td>
<td>Leadership Walks</td>
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<td>Lack of Assertiveness</td>
<td>Quality Issues</td>
<td>Zero Defects Quality Improvement Plan</td>
<td>Area Supervision</td>
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<td>Lack of Awareness</td>
<td>Tooling Issues</td>
<td>Tooling Preventative Maintenance Schedule</td>
<td>Quality Performance Reports / Losses Capture</td>
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<td>Lack of Communication</td>
<td>IT Issues</td>
<td>IT Preventative Maintenance Plan</td>
<td>IT Issues / Losses Capture</td>
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<td>Lack of Knowledge</td>
<td>Environment (noise, heat, etc.)</td>
<td>Facility Control Standard</td>
<td>Losses Capture</td>
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<td>Unhealthy Norms</td>
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</tbody>
</table>

(The Dirty Dozen)

(Simplified FMEA template for illustration purposes only. Some columns are missing e.g. the scoring is not included)
Section 2: The Human Factors FMEA Case Studies

1. Case Study 1
   Final Inspection

2. Case Study 2
   Certification Office

3. Summary & Conclusions
Scenario 1 – Final Inspection

Final Inspection includes three main activities;
• Post Test Engine Inspection
• Engine Preparation for Transport
• Final Documentation for Certification

When engines get to Final Inspection they have a specific time window to complete these activities before the transportation is ready to take it off site to be delivered to the customer.

The teams work a 12 hour shift pattern and provide 24 hour cover, seven days per week.

Any delays to this process can cause disruption to the transportation and customer delivery schedule. Delays can be caused by;
• Quality issues found at inspection
• Resource constraints
• Paperwork discrepancies
Which of the Dirty Dozen apply in this Scenario?
Scenario 2 – Certification Office

Certification process includes three main activities;

- Ensuring all Assembly and Test operations are complete
- Ensuring all non-conformances are closed out
- Creating CAA Form 1 and Engine Logbook

- When the Certification team receive the final paperwork they have a specific time window to complete these activities before the transportation is ready to take it off site to be delivered to the customer.

- The team works 2 shifts and often cover weekends. Each engine has an owner but sometimes engines have to be passed on to the next shift or weekend shift to complete.

- Delays can be caused by incorrect/missing documentation or open non-conformances.
Which of the Dirty Dozen apply in this Scenario?
# Human Factors FMEA – Certification Office Extract

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Failure Mode</th>
<th>Potential Effect</th>
<th>Severity</th>
<th>Class.</th>
<th>Potential Cause(s) of the Failure Mode</th>
<th>Prevention Control(s) for the Potential Causes</th>
<th>Occurrence</th>
<th>Detection Controls of the Failure Mode and/or the Potential Causes</th>
<th>Detection</th>
<th>RPN</th>
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</thead>
<tbody>
<tr>
<td>No Distraction</td>
<td>Distraction</td>
<td>Delays to despatch of the engine</td>
<td></td>
<td></td>
<td>Paperwork Errors</td>
<td>Gated Process</td>
<td></td>
<td>Individual Observation</td>
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<tr>
<td>No Pressure</td>
<td>Pressure</td>
<td>Escape to the customer</td>
<td></td>
<td></td>
<td>Delivery Pressure</td>
<td>Team allocation of tasks/daily meeting</td>
<td></td>
<td>Individual Observation</td>
<td></td>
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</tr>
<tr>
<td>Good Communication</td>
<td>Lack of Communication</td>
<td>Escape to the customer</td>
<td></td>
<td></td>
<td>Poor handover of engine</td>
<td>Daily engine review</td>
<td></td>
<td>Engine status board</td>
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<tr>
<td>All Resources</td>
<td>Lack of Resources</td>
<td>Delays to despatch of the engine</td>
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<td>Lack of consumables</td>
<td>Consumable champion</td>
<td></td>
<td>Weekly 5S audit</td>
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<tr>
<td>Full Awareness</td>
<td>Lack of Awareness</td>
<td>Repeat escapes to the customer</td>
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<td>Unaware of errors made</td>
<td>Weekly team meeting to feedback errors</td>
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<td>None</td>
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</tbody>
</table>

AESQ – Aerospace Engine Supplier Quality Strategy Group

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Meet the Certification Team....

Play Video
Assembly & Test

Human Factors FMEA

Heat Map

Each area will have its own, unique Human Factor risk profile (and this will change over time)

<table>
<thead>
<tr>
<th>Area</th>
<th>Certification Office</th>
<th>Final Inspection</th>
<th>Engine Test</th>
<th>Engine Build</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complacency</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Distractions</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
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<td>Fatigue</td>
<td>Medium</td>
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<td>Assertiveness</td>
<td>Medium</td>
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<td>Awareness</td>
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<td>Communication</td>
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<td>Knowledge</td>
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<td>Resources</td>
<td>High</td>
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<td>Teamwork</td>
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<td>Pressure</td>
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<td>Stress</td>
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<tr>
<td>Unhealthy Norms</td>
<td>High</td>
<td>Medium</td>
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<td>Medium</td>
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</tbody>
</table>

Key: No / Low Impact | Medium Impact | High Impact

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Key Benefits

• Increased Awareness of Human Factors risks across the teams/organisation

• Increased engagement on Human Factors improvements

• Majority of improvements are low cost but high impact

• Increased levels of MARS (HF) reporting

• Reduction in errors/escapes
Human Factor FMEA: Tips for Success

Tips for Effective Deployment include:

a) Develop FMEA at the team level (Can be done for **Operational** or **Transactional** Processes/Teams)

b) Ensure that the team is **Cross Functional**

c) Use **REFERENCE FMEAs** and adapt them to the local situation

d) Create **Tangible Mitigation Actions** based on Risk

e) Conduct **Regular Reviews** with the team and keep the FMEA updated

f) Keep it **Simple!**
Section 3 : Further Help & Guidance

1. Frequently Asked Questions

2. AESQ Support

3. Q&A

4. Close

AESQ – Aerospace Engine Supplier Quality Strategy Group
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Why don’t you add the Human Factors FMEA into the Part Specific Process FMEA as described in RM13004?
### RM13004 Process FMEA & Human Factors

<table>
<thead>
<tr>
<th>OP / Step</th>
<th>Requirement</th>
<th>Failure Mode</th>
<th>Potential Effect</th>
<th>Severity</th>
<th>Class.</th>
<th>Potential Cause(s) of the Failure Mode</th>
<th>Prevention Control(s) for the Potential Causes</th>
<th>Occurrence</th>
<th>Detection Controls of the Failure Mode and/or the Potential Causes</th>
<th>Detection</th>
<th>RPN</th>
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<td>Human Error</td>
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This is not a Product Failure Mode.

Failure Modes in an AS13004 PFMEA describe Product nonconformance.

(RM13004, Chapter 4, (f))
RM13004 Process FMEA & Human Factors

<table>
<thead>
<tr>
<th>OP / Step</th>
<th>Requirement</th>
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</thead>
</table>
| Assemble Part xyz in correct orientation | Part fitted in incorrect orientation | Distraction | This is not a Cause & Effect Relationship.  
If the Potential Causes occurs we should expect the part Failure Mode to occur  
We must avoid simple ‘operator error’ as a Potential Cause | (RM13004, Chapter 4, (i)) | Human Factors are not related to specific part nonconformance.  
Instead, they relate to the working environment and can impact any products manufactured in that area. |
Subject Matter Interest Groups on the AESQ Website

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

Opportunity to Submit questions

AESQ – Aerospace Engine Supplier Quality Strategy Group
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NEW!
SAE C2212 AS13100 and RM 13010: Human Factors for Aviation
A 2 Day Course

Who Should Attend: This course is for suppliers and quality
practitioners who manage or work with AS13000 requirements in the
aerospace engine sector and need background in Human Factors.

It supports compliance with SAE's AS13100 requirements related to
Human Factors, RM13010.

Both new and experienced quality practitioners should be trained in
this powerful defect prevention methodology.

Other SAE AS13100 Aligned Courses
C1862 RM13000 8D Problem Solving
C1889 RM13004 FMEA and Control Plans
C2213 RM13145 APQP & PPAP
C1878 RM13003 Measurement Systems
Analysis (MSA)

• VILT and In-person in 2023
• Available for CL
• All English
Please use the Chat Function to ask any questions
Thank you

Please keep a look out for future AESQ Webinars

Ian

Steve