WELCOME
AESQ SUPPLIER FORUM

10 Oct 2018
Tokyo, Japan
LOGISTICS

TETSUYA MIZUTANI
IHI CORPORATION - HOST
WELCOME FROM IHI

HIDEO MORITA
VICE PRESIDENT OF AERO ENGINE, SPACE & DEFENSE BUSINESS, IHI
INTRODUCTION TO THE SUPPLIER FORUM

MARTIN SCHAEFFNER
MTU AERO ENGINES AG
Agenda

8:15  Welcome to IHI and AESQ – Tetsuya Mizutani, IHI & Hideo Morito, IHI
8:30  Introduction to the Supplier Forum – Martin Schaeffner, MTU
8:45  Introduction to AESQ - Martin Schaeffner, MTU
9:05  Voice of the Customer – Toshihiko Noguchi, ANA
9:45  Supplier Survey Results - Olivier Castets, Safran

10:00 Break

10:30 Published Standards (facilitated session)- Barrie Hicklin, Honeywell
10:35 Overview of AESQ Standards - Olivier Castets, Safran, Helen Djäknegren, GKN
10:45 AS13000 Problem solving – Olivier Castets, Safran
10:50 AS13000 Feedback – Barrie Hicklin, Honeywell
11:05 AS13001 Delegated product release verification training – Earl Capozzi, P&W
11:10 AS13001 Feedback – Barrie Hicklin, Honeywell
11:25 AS13002 Inspection frequency – Erika Grimm, GE
11:30 AS13002 Feedback – Barrie Hicklin, Honeywell
11:45 AS13003 Measurement System Analysis – Ian Riggs, Rolls-Royce
11:50 AS13003 Feedback – Barrie Hicklin, Honeywell

12:00 Lunch
Agenda

1:00  AS13004 PFMEA & Control Plans – Ian Riggs, Rolls-Royce
1:05  AS13004 Feedback – Barrie Hicklin, Honeywell
1:20  AS13006 Process Control methods – Peter Amsden
1:25  AS13006 Feedback – Barrie Hicklin, Honeywell
1:45  Benefits of AS13001 DPRV Training Requirements - Catherine Catarina-Graça, Safran
2:05  Benefits of AS13004 PFMEA & Control Plans incl. Voice of Supplier - Ian Riggs, Rolls-Royce and Zhu Hong Lei, SAM Suzhou
2:55  Break
3:10  Benefits of AS13003 MSA - Martin Schaeffner, MTU
3:30  Future Initiatives – Dan Eigenbrode, Pratt & Whitney
3:40  AS13005 Quality Audit Requirements – Helen Djäknegren, GKN
3:50  AS13007 Supplier Management – Barbara Negroe, GE
3:55  AS13005 & AS13007 feedback - Barrie Hicklin, Honeywell
4:10  Closing remarks – Tetsuya Mizutani, IHI and Martin Schaeffner, MTU
Introduce Yourself

1. Take the Attendee Name Sheet from your table
2. Introduce yourself to as many people as possible in 5 minutes
3. Share your name, position, company and how far you have travelled to be here today
4. By the time you go home today we hope you can complete the whole sheet.
Code of Conduct

• No Commercialism

• No discussion of cost, pricing plans, pricing policies, product usage surveys, marketing plans or any related topics

• Presentations must focus on technical issues (not on marketing aspects of products) and relate to or support the development or maintenance of G-22 Committee work

• Be aware of and follow ITAR & EAR rules and regulations governing export control

• Discussions should be open and follow the agenda or other legitimate direction agreed upon by consensus of the committee - avoid unauthorized or ‘private’ meetings
Code of Conduct

• Respect basic meeting etiquette:
  – Only one person speaking at any given time
  – Attack the issue, not the person
  – Be on time...returning from breaks/lunch
  – Respect all ideas & comments
  – No silent skepticism, be candid
  – Do not dominate discussions
  – Stay focused on the meeting & agenda

• Strive for high-quality standards to benefit all stakeholders
  – users, customers, suppliers and the industry as a whole

• Strive for an open atmosphere that promotes a free-flowing interchange of standards technical information
INTRODUCTION TO THE AESQ

MARTIN SCHAEFFNER
MTU AERO ENGINES AG
Commercial Aviation – A Growth Market

7,100 billion passenger km in 2016
17,000 billion passenger km in 2036

23,000 active aircraft in 2016
45,000 active aircraft in 2036

In 2036

4.5%/yr Increase in Passenger Traffic
2 X active aircraft worldwide

Quelle: Ascend, IATA, MTU
Aviation Safety

The Quality of our products and services are extremely important. Quality and continuous improvement are an absolute must!

Statistically two aircraft would crash every week unless reliability is further improved.

Increase in flight movements: 4-5% p.a.
Chain of Events

In many cases, it is not a single malfunction, error or failure that leads to a crash.

It is a sequence of events involving

• hidden (latent) failures
• errors of judgment/action
• a failure of the failure prevention systems
Manufacturing Quality Escapes in Turbine Engines

--> An FAA proposal for further investigation and action – January 2018

• The trend of manufacturing quality escape safety board issues that resulted in at least one operational event has been increasing.

• The percentage of total turbofan ADs associated with manufacturing quality escapes has been cyclic since 2004, but 2016 (37%) was the highest percentage in the prior four years, and second only to 2011 (44%).

• The top drivers in turbofan manufacturing quality escape ADs were related to issues with surface finish, incorrect dimensions, and forging (all with 8), followed by incorrect assembly (7).

• Life limited parts (32) made up the vast majority of the turbofan manufacturing quality escape ADs, more than three times the next closest part type.
AESQ Vision

To establish and maintain a common set of Quality Requirements that enable the Global Aero Engine Supply Chain to be truly competitive through lean, capable processes and a culture of Continuous Improvement.
AESQ Vision

In detail

• Create common standards within the engine manufacturers (OEM’s) in regard to quality

• Deploy together the written standards throughout our supply chain

• Establish capable quality processes and a culture of continuous improvement

Main targets

• To improve quality within the supply chain

• Improve on time delivery and minimize costs through a reliable quality performance

• Gain efficiency by standardized processes
AESQ Key Quality Elements

→ also aligned to AS9145 APQP & PPAP

Design Risk Assessment

Product KCs

Risk analysis and control required
Production risks identified & mitigated ensuring capable & stable manufacturing processes

Product and Process KCs

Capable measurement systems required
Measurement systems are capable & repeatable ensuring effectiveness of inspection processes

Process Control required
Manufacturing processes under variation control produce consistent product at rate

AS13004 - PFMEA and Control Plans

AS13003 Measurement System Analysis (MSA)

Supporting Standards: AS13000 Problem Solving; AS13001 DPRV Training; AS13002 Inspection Frequency; In process → AS13005 Audit; AS13007 Supplier Management

AS13006 Process Control Methods
AESQ Will Drive Progress

- AS13000, AS13001, AS13002, AS13003, AS13004 have all been flowed down by all AESQ members and are part of your Purchase Order. AS13006 is accepted by all members and will be flowed down shortly. AS13005 and AS13007 will follow soon.
VOICE OF THE CUSTOMER

TOSHIHIKO NOGUCHI, ANA
SUPPLIER SURVEY RESULTS

OLIVIER CASTETS, SAFRAN
Supplier Survey Overview

Collaboration
• Working together to drive quality performance

Feedback
• Provide input on developing standards

Integrated Supply Chain
• Drive efficiency, maximize resources, create synergies

Training
• Coordinated training efforts
Are you Aware of the Published Standards?

Answered: 43    Skipped: 0

Yes

No

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

We still have some work to do
Which Standards Have You Heard Of?

AS13000 Problem Solving (8D)
AS13001 DPRV Training
AS13002 Inspection Frequency
AS13003 Measurement Systems Analysis
AS13004 PFMEA & Control Plans
AS13005 Quality Audit Requirements
AS13006 Process Control Methods
AS13007 Supplier Management
AS9145 APQP & PPAP
AS9146 FOD prevention
AS9117 Delegated product release verification
Which Standards are in YOUR Contracts?

- AS13000 Problem Solving (8D)
- AS13001 DPRV Training
- AS13002 Inspection Frequency
- AS13003 Measurement Systems Analysis
- AS13004 PFMEA & Control Plans
- AS9145 APQP & PPAP
- AS9117 DPRV
- AS9146 FOD Prevention Program
AESQ STANDARDS OVERVIEW

OLIVIER CASTETS, SAFRAN

HELEN DJÄKNEGREN, GKN
AESQ Guiding Principles

- Simplify & Standardize supplier requirements
- Build on existing industry standards
- Common language for Quality
- Standards are simple, prescriptive & auditable
- Promote standardized 3rd party training
- Easy to adopt within existing process/systems

Deliver results rapidly through focused activities
Vision

To establish and maintain a common set of Quality Requirements that enable the Global Aerospace Engine Supply Chain to be truly competitive through lean, capable processes and a culture of Continuous Improvement

AESQ Standards - Global Deployment Status

<table>
<thead>
<tr>
<th>AESQ Member</th>
<th>AS13000 Problem Solving Requirements for Suppliers</th>
<th>AS13001 DPRV</th>
<th>AS13002 Developing and Qualifying Alternate Inspection Frequency Plans</th>
<th>AS13003 Measurement Systems Analysis Requirements for</th>
<th>AS13004 Process Failure Mode and Effects Analysis (PFMEA) and Control Plans</th>
<th>AS13006 Process Control Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arconic (P&amp;P)</td>
<td>Accepted</td>
<td>Accepted</td>
<td>Accepted</td>
<td>Accepted</td>
<td>Accepted</td>
<td>Accepted</td>
</tr>
<tr>
<td>GE</td>
<td>May-15</td>
<td>Feb-16</td>
<td>May-17</td>
<td>Mar-16</td>
<td>Aug-17</td>
<td>Sep-18</td>
</tr>
<tr>
<td>GKN</td>
<td>May-14</td>
<td>Oct-14</td>
<td>Jan-15</td>
<td>Jan-16</td>
<td>Aug-17</td>
<td>Sep-18</td>
</tr>
<tr>
<td>Honeywell</td>
<td>Jun-14</td>
<td>Mar-15</td>
<td>Apr-15</td>
<td>Mar-15</td>
<td>Aug-17</td>
<td>Sep-18</td>
</tr>
<tr>
<td>MTU</td>
<td>Jan-16</td>
<td>Mar-15</td>
<td>Oct-15</td>
<td>Jan-16</td>
<td>Aug-17</td>
<td>Sep-18</td>
</tr>
<tr>
<td>PCC Structurals</td>
<td>Aug-15</td>
<td>Jan-16</td>
<td>4Q16</td>
<td>Jan-16</td>
<td>Aug-17</td>
<td>Sep-18</td>
</tr>
<tr>
<td>Safran</td>
<td>Dec-14</td>
<td>Oct-15</td>
<td>Jan-15</td>
<td>Jan-15</td>
<td>Aug-17</td>
<td>Sep-18</td>
</tr>
</tbody>
</table>
AESQ is now well established and is gathering momentum

Supplier feedback is very positive & they want us to move faster

Broader supplier engagement is being sought to apply more resources

Stronger links with IAQG & PRI are being developed

Stakeholder engagement essential for progress & direction
PUBLISHED STANDARDS

BARRIE HICKLIN, HONEYWELL
Feedback Questions

1. Has the Standard been flowed down by your Customer(s)?
2. Do you have any problems with or suggestions for the Standard?
3. Have you had problems flowing down the Standard to your suppliers?
4. Are there any commodity specific considerations?
AS13000 PROBLEM SOLVING

OLIVIER CASTETS, SAFRAN
AS13000 Problem Solving

Original State

Future State

AESQ Principles

- Standardise
- Simplify
- Adopts Existing Industry Standards
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits

- Reduced need for Customer training & support
- Improved access to training & consultancy
- Removal of complexity of reporting
- Improved problem solving skills

GLOBAL 8D

Rolls-Royce GE Aviation Pratt & Whitney SAFRAN

7-Step Apollo DIVE/Red-X® 8D

Supplier

Supplier

DIVE/Red-X® 7-Step 8D

8D

AS13000 Problem Solving

This document slide does not contain ITAR or EAR technical data. The content of this presentation slide is proprietary and confidential information of the AESQ. It is not permitted to be distributed to any third party without the written consent of the AESQ.
AS13001A DPRV TRAINING

EARL CAPOZZI, PRATT & WHITNEY
AS13001A Delegated Product Release Verification Training

Original State

- GE Aviation
- Pratt & Whitney
- Safran
- Rolls-Royce

Future State

- One Common Training Requirement
- Industry-wide DPRV database through SAE
- Delivered globally by SAE
- Refresher training every 3 years

Total 12 days

AESQ Principles

- Standardise
- Simplify
- Adopts Existing Industry Standards*
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits

- Reduced costs for customers & suppliers
- Reduced training time for DPRV personnel
- Training provided in region of DPRV personnel
- Customer training limited to on-site

* Rev A aligns with AS9117 - DPRV
AS13002 INSPECTION FREQUENCY

ERIKA GRIMM, GE
AS13002 Inspection Frequency

Original State
100% Inspection
REDUCED Sample
Error Proof AQL

Future State
- Common Method for Inspection Planning
- Guidance on commodity specific planning

AESQ Principles
- Standardise
- Simplify
- Adopts Existing Industry Standards
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits
- Standardised Process
- Improved compliance
- Improved Product Quality
AS13003 MSA

DR IAN RIGGS, ROLLS-ROYCE
AS13003 Measurement Systems Analysis

Original State

Future State

<table>
<thead>
<tr>
<th>Method</th>
<th>Feature Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Critical</td>
</tr>
<tr>
<td>Resolution</td>
<td>≤10% of total tolerance***</td>
</tr>
<tr>
<td>Accuracy ratio**</td>
<td>Requirement = 10:1</td>
</tr>
<tr>
<td>Accuracy Error / Bias</td>
<td>≤10% of total tolerance</td>
</tr>
<tr>
<td>Repeatability</td>
<td>≤10% of total tolerance</td>
</tr>
<tr>
<td>Gauge R&amp;R</td>
<td>≤10% of total tolerance</td>
</tr>
</tbody>
</table>

AESQ Principles

- Standardise
- Simplify
- Adopts Existing Industry Standards
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits

- Improved knowledge of Measurement Capability
- Clarification of minimum acceptance standards
- Mandates replaces guidance
- Adopts Automotive Industry Action Group ‘Blue Book’ on MSA
- Improved Quality Performance
AS13004 PFMEA & CONTROL PLANS

DR IAN RIGGS, ROLLS-ROYCE
AS13004 PFMEA & Control Plans

Original State

Future State

Varying standards and approaches

**AESQ Principles**

- ✔ Standardise
- ❌ Simplify
- ✔ Adopts Existing Industry Standards
- ✔ Prescriptive, Auditable
- ✔ Common Language
- ✔ Supported by 3rd Party Training & Consultancy

**Expected Benefits**

- Standardised process
- Increased pace of adoption
- Improved compliance to a better standard
- Reduced quality risks
- Ultimately improved quality & delivery

**In Scope:** Risk Mitigation requirements with execution guidance & recommended timing, supporting AS9145

**Out of Scope:** DFMEA requirements, any duplication of related Aerospace Standards (e.g. AS9145)
AS13006 PROCESS CONTROL METHODS

PETER AMSDEN,
PRATT & WHITNEY
AS13006 Process Control Methods

Original State

- Varying standards & approaches
  - PC requirements not clearly defined/understood
  - Inconsistent application/flowdown to sub-tiers
  - Lack of commitment/belief in benefits
  - Belief low volume environments not applicable

Future State

- Common standard & approach
  - Aligned with AS13002, 13003, 13004, AS9103, AS9145 & AIAG “Blue Books”

- In scope: Process Control for all characteristics
- Out of scope: Foundational requirements

AESQ Principles

- ✔ Standardise
- ✔ Simplify
- ✔ Adopts Existing Industry Standards
- ✔ Prescriptive, Auditable
- ✔ Common Language
- ✔ 3rd Party Training & Consultancy

Expected Benefits

- • Improved variation control & reduction techniques, broad-based belief in benefits
- • Common prescriptive standard fully aligned with AESQ, AS9103 & AIAG Blue Book Stds
- • Focus on accurate data analysis and proactive problem resolution
- • Improved Quality Performance, reduced risk
AS13006 designed to align and work closely with other industry standards
AS13004 & AS13006 Standard Relationships

Related Standards

**AS13000**: Problem Solving Requirements (8D)
**AS13002**: Developing & Qualifying Alternative Inspection Frequency Plans
**AS13003**: Measurement Systems Analysis Requirements
**AS9103**: Variation Management of Key Characteristics
**AS9145**: Advanced Product Quality Planning & Production Part Approval Process
BENEFITS OF THE STANDARDS & SUPPLIER CONTRIBUTIONS TO AESQ
AS13001 DPRV TRAINING
REDUCING NON QUALITY EVENTS BY DEPLOYING DPRV AT SAFRAN SUPPLIER FACILITIES

CATHERINE CATARINA-GRACA, SAFRAN
**DPRV Certification** following AS9117 DPRV & AS13001

**PROCESS TO BECOME A DPRV**

2017 Update

**3 MONTHS**

**1 MONTH**

**Setting up the function**

On site audit
By Safran QE

Granting the SAFRAN DPRV stamp
And the SAFRAN certificate if the audit is conclusive
DPRV DUTIES

1. Check the documentation. (Mainly consistency between the routing sheet and the delivery documents)

2A. Perform a physical check. (Marking, visual, ...)

2B. Check the consistency between the packaging and labeling with the specifications of the item ordered by Safran.

3. Record monitoring in the DPRV log.
## RECORD MANAGEMENT

On Safran Aircraft Engines Quality ERP
Check over more than 1000 claims

<table>
<thead>
<tr>
<th>FAULT</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>C00</td>
<td>CONDITIONING PACKAGING</td>
</tr>
<tr>
<td>P00</td>
<td>DOCUMENTATION</td>
</tr>
<tr>
<td>T00</td>
<td>MARKING / IDENTIFICATION / TRACEABILITY / MANAGEMENT (GENERIC)</td>
</tr>
<tr>
<td>V00</td>
<td>APPEARANCE / VISUAL / FINISH (GENERIC)</td>
</tr>
</tbody>
</table>
Safran Aircraft Engines Claims: DPRV Deployed

Diminishing despite the LEAP ramp up
Comparing deployed and non-deployed sites

83% of DPRV deployed sites

17% of DPRV undeployed sites
WHAT ABOUT MARKING EVENTS?
• Communicating on metrics: going ahead with DPRV Deployment

• Specific improvement action plan on « top 10 » SAFRAN impacting suppliers

• Raising awareness on SAFRAN and Safran Aircraft Engines requirements for DPRV managers (8 workshops worldwide) focused on SAFRAN & AESQ standards

• SAFRAN and Safran Aircraft Engines Communication kit are updated twice a year

• Promote Benefits of DPRVs as 9 SAFRAN companies are going live
BENEFITS OF AS13004 – PFMEA & CONTROL PLANS

DR IAN RIGGS, ROLLS-ROYCE
Core Product Defect Prevention Tools

- Product Design
- Process Design
- Production & Service

Advanced Product Quality Planning (APQP) & Production Part Approval Process (PPAP)

- Design FMEA
- Process FMEA
- Control Plan
- MSA
- Capability
- Error Proofing
- Process Control (SPC)

- 8D Problem Solving

Must be applied as a ‘system’ of tools
Must be applied at part number level
Effectiveness relies on Cross Functional working

AESQ - Aero Engine Supplier Quality Strategy Group

This document slide does not contain ITAR or EAR technical data. The content of this presentation slide is proprietary and confidential information of the AESQ. It is not permitted to be distributed to any third party without the written consent of the AESQ.
Defect Prevention  Key Quality Tools for Zero Defects

“Strive for perfection in everything. Accept nothing ‘nearly right’ or ‘good enough’.”

TRUSTED TO DELIVER EXCELLENCE

Inspection is never 100% effective

Advanced Quality Planning & Process Control

PRODUCT DESIGN

1. Customer Meeting
   - Customer meets requirements

2. Design Process
   - Design meets customer requirements

3. Design Failure Mode & Effects Analysis
   - Potential Design Risks Identified
   - Risks Identified, Understood
   - Risks & Mitigated

PROCESS DESIGN

- Process can make defect free parts

PROCESS FAILURE MODE & EFFECTS ANALYSIS

- Process Design

CONTROL PLAN

- Process Design
- Risks Identified, Understood
- Risks & Mitigated

INSPECTION CAPABILITY

- Variable gauge repeatability & reproducibility
- SPC
- Inspection & Target Setting
- Audit
- Total Quality

MANUFACTURING CONTROLS

- Process Capability
- Process Capability CPK

PROCESS CONTROL

- Initial Process Capability
- Process Control
- Process Improvement
- Process Capability

8D PROBLEM SOLVING

- Accept nothing ‘nearly right’ or ‘good enough’

# jointheMovement

Rolls-Royce
What’s New

1. A Process FMEA for every part number

2. A Process FMEA that covers all Process Steps (those that transform the product)

3. A Process FMEA that covers all design features / characteristics*

4. Failure Modes that describe how the PRODUCT can fail to meet Design Intent

5. A Control Plan for every part Number

* Rolls-Royce Deployment Requirement
DON’T PANIC!
It is an achievable task, thanks to;

Computer Software e.g. xFMEA, DataLyzer, etc.

The use of Reference PFMEAs (see later)

Being part of a Large Network – sharing lessons learnt
SAM SUZHOU CASE STUDY

Deploying AS13004 to Achieve Zero Defects

Honglei Zhu
Production Manager
SAM (Suzhou) Co. Ltd.
Agenda

Introduction of SAM Group and SAM Suzhou

Zero Defect and PFMEA (AS13004)

RFT improvement

Benefits

Lessons learnt
SAM is a subsidiary of Accuron Technologies and headquartered in Singapore. With nearly 2,000 employees across Asia and Europe servicing the precision and equipment markets, we are equipped with the design and cutting edge manufacturing capabilities to service leading global companies.

Our precision business segment focuses primarily on niche products such as engine mounts, airfoils, engine cases and structural parts. Our equipment business segment is vertically integrated to offer unique engineering solutions from collaborative design and development, to finished equipment assembly.

As an AS9100 certified company, our quality system conforms to the quality requirements of major companies in the aerospace and industrial industries. Our products are supplied from our facilities in China, Germany, Malaysia, Singapore and Thailand to customers world-wide.
Geographical Presence

Sitec Aerospace
Germany – Bad Tölz/

SAM Aviatron

SAM Suzhou
China / Suzhou

SAM Aviatron

SAM Aviatron

SAM Precision

Malaysia – Penang

Meerket Precision

Headquartered in Singapore

Staff Strength

<table>
<thead>
<tr>
<th>Country</th>
<th>Staff Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>410</td>
</tr>
<tr>
<td>Europe</td>
<td>264</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1027</td>
</tr>
<tr>
<td>Singapore</td>
<td>259</td>
</tr>
<tr>
<td>Thailand</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>2,010</td>
</tr>
</tbody>
</table>

(non-Aerospace)
SAM Suzhou Business

AEROSPACE

Contract Manufacturing

EQUIPMENT

OEM Products
SAM Suzhou

- Geographical Location: Suzhou, China, 2 hours to Shanghai
- Incorporated in 1995, 2004 relocated in EPZ
- Factory Size: 150,000 sq ft
- Land Size: 250,000 sq ft
- Location: Export Processing Zone, SIP
- Manpower: 410
- Machine capabilities:
  - 5 Flexible manufacturing system Lines
  - Milling 49, Turning 9, Grinding 4, CMM 5, others(SP) 35

Production: 294
Engineer: 60
Manager: 9
Support Staff: 47
In Dec, 2016 SAM was invited to join the movement. Working together... to deliver a competitive supply chain.

DRIVE FOR ZERO DEFECT

Join the movement
PFMEA Drives RFT & Scrap reduction & Productivity Improvement

DfZD Work Stream PFMEA using AS13004

Error Proofing
Awareness
Training
...

PFMEA output

Achieve:
100% RFT
0 Escape
Concession Reduction

PFMEA Drives RFT & Scrap reduction & Productivity Improvement
PFMEA Roadmap to XWB Engine Mounts

On 5th April, 2017
High Level PFMEA Training
at Rolls Royce Singapore Facility

On 6th April, 2017
AESQ Forum
PFMEA AS13004
In Singapore

On 7th – 10th March, 2017
PFMEA workshop @ SAM
Facilitator: T.Slater / R.Kelsey

By end of September, 2017
PFMEA completed
Part Number:
KH41762 (11)
KH17503 (12)

By end of October, 2017
PFMEA completed
Part Number:
KH34690 (13)
KH28378 (14)

By end of July, 2017
PFMEA completed
Part Number:
KH28383 (7)
KH17500 (8)

By end of August, 2017
PFMEA completed
Part Number:
KH28379 (9)
KH11711 (10)

In Dec, 2016
Invited to join the movement

By end of December, 2017
PFMEA completed
Part Number:
KH63599 (15)
KH34693 (16)

By end of May, 2017
PFMEA completed
Part Number:
KH41760 (2)
KH28381 (3)
KH17496 (4)

By end of June, 2017
PFMEA completed
Part Number:
KH28382 (5)
KH34695 (6)

By end of May, 2017
PFMEA completed
Part Number:
KH17504 (1)

By end of May, 2017
PFMEA completed
Part Number:
KH17504 (1)

31st July, 2017
“Zero Defect” part
(KH17504) delivery
kick off event

On 20th April, 2017
Team Celebrated
1st Feature PFMEA completed
Part Number:
KH17504 (1)

On 5th April, 2017
High Level PFMEA Training
at Rolls Royce Singapore Facility

On 6th April, 2017
AESQ Forum
PFMEA AS13004
In Singapore

On 7th – 10th March, 2017
PFMEA workshop @ SAM
Facilitator: T.Slater / R.Kelsey

By end of September, 2017
PFMEA completed
Part Number:
KH41762 (11)
KH17503 (12)

By end of October, 2017
PFMEA completed
Part Number:
KH34690 (13)
KH28378 (14)

By end of July, 2017
PFMEA completed
Part Number:
KH28383 (7)
KH17500 (8)

By end of August, 2017
PFMEA completed
Part Number:
KH28379 (9)
KH11711 (10)

In Dec, 2016
Invited to join the movement

By end of December, 2017
PFMEA completed
Part Number:
KH63599 (15)
KH34693 (16)

By end of May, 2017
PFMEA completed
Part Number:
KH41760 (2)
KH28381 (3)
KH17496 (4)

By end of June, 2017
PFMEA completed
Part Number:
KH28382 (5)
KH34695 (6)

By end of May, 2017
PFMEA completed
Part Number:
KH17504 (1)

By end of May, 2017
PFMEA completed
Part Number:
KH17504 (1)
RFT improvement case study

RFT Tracking for p/n: KH17504

1. ZD delivery part kick off event end of Jul, 2017;
2. Achieve the 100% RFT by end of Q3, 2017;
3. Achieved 100% RFT in Sep 17 – Apr 18 (7 months) & Jun 18 – Aug 18 (3 months)

Recommend Actions:
1. Change cutting method to Reaming;
2. Move to H M/C (with RFID, less human touch, close door machining);
3. Enhance 5S management; Handling Trolley Improvement Project;
4. Enhance Supplier Engagement;
5. Case study for cutting tools improvement;

Cutting Tool Broken
Go back PFMEA review
Lessons learnt from AS13004

P/N: KH17504 Pareto Chart by NON-Conforming Chart

P/N: KH17504 Pareto Chart by Rejection Code

The cause of non-conformance effect are the input of PFMEA.

Action & Action Result
### Process Failure Mode and Effects Analysis (PFMEA)

**Part Number:** KH17504  
**Core Team:** Custom  
**Date (Orig.):** 2017/3/9  
**Date (Rev.):** 2018/4/19

<table>
<thead>
<tr>
<th>Operation Step</th>
<th>Process Function/ Description</th>
<th>Feature Num (A3)</th>
<th>Dim (B1)</th>
<th>Tol (+) (B2)</th>
<th>Tol (-) (B3)</th>
<th>Potential Failure Mode</th>
<th>Potential Effect(s) of Failure</th>
<th>Potential Cause(s) of Failure</th>
<th>Severity</th>
<th>Classification</th>
<th>Prevention Controls</th>
<th>Detection Controls</th>
<th>RPN</th>
<th>Recommended Action</th>
<th>Action Results</th>
</tr>
</thead>
</table>
| SH3 38 & 45 170 | Reaming | E | CCF Ø 37.0215 | 0.0125 | 0.0125 | Above top limit | Customer Effect: Increased wear of pin - early scrappage/repair  
Manufacturing / Assembly Effect: A proportion of production run may have to be reworked off line and accepted | CCF | wrong tooling | 5 | CCF | tool ID visual check, tool presetting check, | 3 | bore gauge in station by operator | 5 | 75 | Action Owner: Xu Hua  
Target date: December 2018 | | |
| SH3 39 & 46 170 | Reaming | E | CCF j | Ø 0.10m | A | 0.1 | | wrong tool setting | 6 | | tool presetting routine, qualified operators, | 3 | in station dimensional check | 5 | 90 | Move to Heller M/C to implement automated tooling control routine | Action Owner: Xu Hua  
Target date: December 2018 | | |

---

**Key success factors:**

- Supporting from Design engineer for Design Risk Analysis
- Update PFMEA frequently (nonconformance data as an input)
- Create action plan to mitigate risks
- Refer to previous product history, customer feedback, etc
Lessons learnt from AS13004

Key success factors:

- Control the process inputs to obtain the desired product outputs
- Use of error proofing
- Verify output at the earliest possible operation within the process
SAM SUZHOU CASE STUDY
Deploying AS13004 to Achieve Zero Defects

Honglei Zhu
Production Manager
SAM (Suzhou) Co. Ltd.
HOW TO BE EFFICIENT BY USING REFERENCE PFMEA

How to Create and Manage Part Specific Process FMEAs using a Reference FMEA Database
Using Reference PFMEAs

<table>
<thead>
<tr>
<th>Process</th>
<th>Requirements</th>
<th>Potential Failure Modes</th>
<th>Potential Effects</th>
<th>S</th>
<th>E</th>
<th>V</th>
<th>Potential Causes</th>
<th>Prevention Controls</th>
<th>O</th>
<th>C</th>
<th>C</th>
<th>Detection Controls</th>
<th>DET</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP10 CNC Drilling</td>
<td>Drill Fuel Hole</td>
<td>Hole too Big</td>
<td>Fuel leak leading to explosion</td>
<td>9</td>
<td></td>
<td></td>
<td>Oversize tool</td>
<td>Tool presetting</td>
<td>4</td>
<td></td>
<td></td>
<td>Bore mic at OP 50</td>
<td>7</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>50mm Diameter +/- 1.0 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scrap part</td>
<td>6</td>
<td></td>
<td></td>
<td>Spindle alignment error</td>
<td>Asset Care &amp; Calibration</td>
<td>3</td>
<td></td>
<td></td>
<td>Weekly ball bar check</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OP20 CNC Drilling</td>
<td>Drill Air Hole</td>
<td>Hole too Big</td>
<td>Slight increase in noise level</td>
<td>3</td>
<td></td>
<td></td>
<td>Oversize tool</td>
<td>Tool presetting</td>
<td>2</td>
<td></td>
<td></td>
<td>Bore mic at OP 50</td>
<td>7</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>50mm Diameter +/- 3.0 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concession</td>
<td>4</td>
<td></td>
<td></td>
<td>Spindle alignment error</td>
<td>Asset Care &amp; Calibration</td>
<td>1</td>
<td></td>
<td></td>
<td>Weekly ball bar check</td>
<td>8</td>
<td>32</td>
</tr>
</tbody>
</table>

Blue Boxes show the (partial) content of a Reference PFMEA for Hole Drilling where the Failure Mode is ‘Hole Too Big’
Creating a Part Specific PFMEA using Reference FMEAs

Reference PFMEA Database
- CNC Drilling
- CNC Milling
- CNC Grinding
- E Beam Welding
- TIG Welding
- Casting
- Part Marking
- Cleaning
- Chemical Etch

Part Specific Design and Process Documentation

‘Shell’ Part Number PFMEA

<table>
<thead>
<tr>
<th>Process</th>
<th>Requirements</th>
<th>Potential Failure Modes</th>
<th>Potential Effects</th>
<th>S</th>
<th>E</th>
<th>V</th>
<th>Potential Causes</th>
<th>Prevention Controls</th>
<th>Detection Controls</th>
<th>DET</th>
<th>R</th>
<th>P</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNC Drilling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OP20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNC Milling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OP30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNC Grinding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A ‘shell PFMEA is created for each operation and every feature / specification required to produce a specific part number using the Process Flow Diagrams, Characteristics Matrix and Drawing / Specifications.
### Completing the Part Number Specific PFMEA

<table>
<thead>
<tr>
<th>Process</th>
<th>Requirements</th>
<th>Potential Failure Modes</th>
<th>Potential Effects</th>
<th>Potential Causes</th>
<th>Prevention Controls</th>
<th>O C C</th>
<th>Detection Controls</th>
<th>D E T</th>
<th>R P N</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP10 CNC Drilling</td>
<td>Drill Fuel Hole 50mm Diameter +/- 1.0 mm</td>
<td>Hole too Big</td>
<td>Fuel leak leading to explosion</td>
<td>Oversize tool</td>
<td>Tool presetting</td>
<td>4</td>
<td>Bore mic at OP 50</td>
<td>7</td>
<td>252</td>
</tr>
<tr>
<td>OP10 CNC Drilling</td>
<td>Drill Air Hole 20mm Diameter +/- 3.0 mm</td>
<td>Hole too Big</td>
<td>Slight increase in noise level</td>
<td>Oversize tool</td>
<td>Tool presetting</td>
<td>2</td>
<td>Bore mic at OP 50</td>
<td>7</td>
<td>56</td>
</tr>
</tbody>
</table>

The team may need to add in additional Failure Modes, Potential Causes and/or Control information based on their knowledge of the specific part numbers. Some information in the Reference PFMEA may not be relevant so can be deleted.
How long does it take to complete an AS13004 Process FMEA?

Estimates are for a medium complexity machined part (1000 features)
Reference PFMEAS once created will be used for all future PFMEAs and only updated when necessary. This is a ‘one off’ activity.
Initial Part Specific PFMEAs will take longer as the cross functional team discuss issues for the first time e.g. what would happen if....?
Initial PFMEAs should be treated as a learning exercise.
It will probably take 3 – 5 PFMEAs for the team to optimise the process.
How Rolls-Royce can help

Process PFMEA Practitioner Guide for developing PFMEAs & Control Plans to AS13004 including the creation and use of Reference FMEAs is available free of charge (electronically or hard copy) from Rolls-Royce.

Rolls-Royce will make its Reference PFMEAs available to external businesses to promote the deployment of AS13004.

We recommend that suppliers invest in a suitable FMEA software tool to manage the level of data created efficiently.

We have developed Global PFMEA training to support this approach with Smallpeice Enterprises and Industry Forum (see AESQ website for details).
Supplier Success Examples

SAM Suzhou
XWB Engine
Mounts
Defect Free

GKN Newington
Trent 7000 Fan Case
Defect Free at Product Introduction
It *really* is that easy.....

It *really* is that effective.....

Good luck.
AS13003 MSA

MARTIN SCHAEFFNER, MTU
MSA@MTU

Experiences from using the Measurement System Analysis method at MTU

4/4/2017
Proprietary Notice

This document contains proprietary information of the MTU Aero Engines AG group companies. The document and its contents shall not be copied or disclosed to any third party or used for any purpose other than that for which it is provided, without the prior written agreement of MTU Aero Engines AG.
## General Approach

### What is the intent?

The goal is to make sure that every measurement system (gage + outside influences) used is suitable for the intended task → representing “real” part quality!

The AS13003 method summarizes different tools and delivers a standardized approach. Mainly used in: PPAP; approval of new measurement technology; stabilizing production processes.

### Guiding Questions

<table>
<thead>
<tr>
<th>“Method 1”</th>
<th>“Method 2”</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Is the gage precise and accurate enough to rely on it?</em></td>
<td><em>What happens in real production line conditions?</em></td>
</tr>
<tr>
<td>How big is the variance of my measurement?</td>
<td>What happens if the same inspector measures the same part without knowing the results from his last measurements?</td>
</tr>
<tr>
<td>Is there a systematic error in the measurement?</td>
<td>What happens when a different inspector measures the same part without knowing the results from his coworker?</td>
</tr>
<tr>
<td>Calculation of the value cg &gt;1,33</td>
<td>% GR&amp;R Total Variance</td>
</tr>
<tr>
<td>Calculation of the value cgk &gt;1,33</td>
<td></td>
</tr>
</tbody>
</table>

© MTU Aero Engines AG. The information contained herein is proprietary to the MTU Aero Engines group companies.
Hands-on Example

Background

- Thin-walled part with tight tolerances
- The measurement results were suspected to be unstable due to issues with the fixture and clamps.

→ MSA performed according to AS13003

Approach

- Definition of Key characteristics by manufacturing engineers, metrologists, and designers
- Independent reference measurement (new program)
- 20 CMM measurements under production line conditions
- Evaluation of systematic errors and variances.
- Optimization of the measurement process to eliminate errors which were found until values can be accepted.
- R&R Study to evaluate influences from different inspectors
**Actions defined due to results from the MSA**

- Characteristics showed problems with accuracy and repeatability
  - A test on a more accurate CMM showed a huge improvement

- Form tolerances problems with repeatability even though the machine was changed
  - The cause was found in changing the measuring fixture

- The parallelism tolerance between the upper and lower flange was still not in
  - Together with engineering the reference plane was changed

---

**Case, Turbine**

- Standard CMM for this part family
- New CMM
- Rework of the measuring fixture
- Change made to the drawing
Lessons Learned up to now

• By using the MSA method you get a reliable and understandable statement if you can rely on your results or not
  → don’t touch your production processes before you are sure about your measurement
• Cg & Cgk database is a great support to discuss drawing requirements with the design organization
• An MSA helps to eliminate influences coming from different measurement strategies
• A CMM measurement is not always reliable – accuracy and inspector variance matters
• High quality of existing measurement programs as in most cases only a few characteristics show a significant variance
• A comparison to an independent reference measurement gives a valuable insight into the production line measurement;
  → not easy to achieve due to the small tolerances and the expectation to be more precise
• For tighter tolerances the method is very challenging and even a difference of 1/10 µm between reference & production results can be the reason for an incapable system -> Rules for these special cases are necessary
FUTURE INITIATIVES

BARRIE HICKLIN, HONEYWELL
What topics would you like us to work on in the future?
FUTURE INITIATIVES

DAN EIGENBRODE,
PRATT & WHITNEY
Product Life Cycle & Document Interaction

AS9145 (APQP/PPAP) & AESQ Standards

1. Planning
   - AS9145 (PDP)
     - Kick Off
     - End of Concept (PDR)
   - AS9145 APQP Phases
     - 1. Planning
     - 2. Product Design & Development
     - 3. Process Design & Development
     - 4. Product & Process Validation
     - 5. Ongoing Production, use and Post Delivery Service

2. Product Design & Development
   - Design
   - Records & DRA
   - Process Flow Diagram
   - PFMEA
   - Control Plan
   - Packaging, Preservation & Labelling
   - MSA
   - ICS
   - FAI

3. Process Design & Development
   - AS9145 Key PPAP Events
     - Design Release (CDR)
     - End of Concept (PDR)
     - Initial Prod. Approval
     - Production Launch
     - PPAP Approval

4. Product & Process Validation
   - Production Readiness Review
   - AS9102 FAIR
   - Production Process Run

5. Ongoing Production, use and Post Delivery Service
   - AS9145 (PDP)
     - Initial Prod. Approval
     - Production
     - Launch

AESQ 2nd Level Documents

- AS13004 – PFMEA & Control Plans
- AS13003 – Measurement Systems Analysis
- AS13006 – Process Control Methods
- AS13002 – Inspection Frequency

AESQ Systems Documents

- AS13000 – Problem Solving Requirements for Suppliers - 8D
- AS13001 – Delegated Product Release Verification Training Requirements
- AS13005 – Quality Audit Requirements
- AS13007 – Supplier Management

AESQ – Aerospace Engine Supplier Quality Strategy Group

This document slide does not contain ITAR or EAR technical data. The content of this presentation slide is proprietary and confidential information of the AESQ. It is not permitted to be distributed to any third party without the written consent of the AESQ.
Existing & Future Workstreams

**Quality Planning**
- IAQG APQP & PPAP – AS9145

**Process Control**
- IAQG APQP & PPAP – AS9145
- Ppk / Cpk
- SPC incl. short run
- Tooling / fixture mgmt
- KPIs incl. RFT

**Quality Assurance**
- Audit
- NC Material
- Supplier (Subtier) Management
- Customer / 3rd party audits
- Problem Solving
- Counterfeit Parts / Ethics Compliance
- DPRV Training
- NDT

**Process Planning**
- Process Flow
- PFMEA
- Control Plan

**Process Control (Variation Management)**
- Inspection Frequency
- Source & Method Change

**Published Standard**
- AESQ working in IAQG Team
- Current Workstream
- Potential future workstream

---

AESQ – Aerospace Engine Supplier Quality Strategy Group

This document slide does not contain ITAR or EAR technical data. The content of this presentation slide is proprietary and confidential information of the AESQ. It is not permitted to be distributed to any third party without the written consent of the AESQ.
Assimilation & prioritization of future AESQ initiatives for standardization and step improvements in quality
White Paper Projects

Work in Progress

FAI Study Topics

- Interpretation (partial / full FAI)
- Form 3
- Ballooning
- Submission
- Planning FAIR

Non-Conforming Material Study Topics

- Guidance (8D)
- Standardize Forms
- Common IT Hub
- Common processes for repair and repetitive concession requests
AS13100 AS9100 Supplemental Requirements

Original State

- Regulator
- Customer Requirements
- IAQG
- SCMH Guidance
- AS Standards
- Unique Aero Engine Manufacturer Requirements
- Common Aero Engine Manufacturer Requirements
- Supplier

Future State

AESQ Quality Standards (AS13xxx series)

- AS13100
- AS9100 Supplementary Quality Requirements

- AS13000
  8D Problem Solving
- AS13001
  DPRV
- AS13002
  Inspection Planning
- AS13004
  MSA
- AS13005
  Quality Audit
- AS13006
  Process Control
- AS13007
  Supplier Management
- AS13008
  Future Initiative

AESQ Principles

- Standardise
- Simplify
- Adopts Existing Industry Standards
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits

- Reduces/Eliminates top level OEM Requirements
- “Raises the Bar” for Quality Expectations
- Common Aero-Engine Manufacturer Language
SUPPLIER CONTRIBUTION TO AESQ WORK
How You Can Participate

- Attend our AESQ Supplier Forums
- Provide feedback on current standards & those in development
- Share best practice deployment stories and impact of standards via the AESQ Website
- Help identify new areas of standardization & future work

aesq.saeitc.org/

Challenge your customers about deployment of standards
AESQ members are committed to deploy
AS13005 QUALITY AUDIT REQUIREMENTS

HELEN DJÄKNEGREN, GKN
AS13005 Quality Audit Requirements

Original State
Internal and supplier audit requirements in many documents

Future State
Every Customer Audits Every Supplier

AESQ Principles
- Standardise
- Simplify
- Adopts Existing Industry Standards
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits
- Lean & effective internal audit process provides confidence in state of compliance throughout Aero-Engine supply chain
- Improved rigor of audit approach
- Suppliers chosen for audit based on performance and risk
- Reduced and/or eliminated unnecessary and/or duplicate audits => Cost reduction / resources liberated by customer and supplier.
- Reduced supplier audits for performing suppliers (low risk) that demonstrate compliance to internal audit requirements
- Recognizes existing 3rd party certification

Risk Based Supplier Audit
One Common Requirement for Internal Audit

Internal Audits for Many Requirements

Aerospace Standard AS13005
- Audit types & checklists
  - System
  - Production process
  - Product
  - Special process
- Auditor qualification, KPI’s
- Supplier Surveillance Audit
  - Selecting suppliers
  - Selecting scope, approach
- Audit outcome
AS13007 SUPPLIER MANAGEMENT

BARBARA NEGROE, GE AVIATION
AS13007 Supplier Management

- Lots of sub-tier surprises?
- Is the variation and risk understood?
- Is the risk owned?
- How is it managed?
- How will it be improved?
AS13007 Supplier Management

Original State

Varied Customer-Specific Requirements

In scope: Raw material & finished hardware

Out of scope: Distributors & MRO suppliers

AESQ Principles

- Standardise
- Simplify
- Adopts Existing Industry Standards
- Prescriptive, Auditable
- Common Language
- Supported by 3rd Party Training & Consultancy

Expected Benefits

- Simplify language for organizations to manage suppliers
- Ability to use the standard throughout all tiers of the supply chain
- Standard will simplify and reduce the number of methods the suppliers must use to meet Customer requirements (i.e. simplify/make common the “how to”)
CLOSING REMARKS
MARTIN SCHAEFFNER &
TETSUYA MIZUTANI
AESQ Vision

To establish and maintain a common set of Quality Requirements that enable the Global Aero Engine Supply Chain to be truly competitive through lean, capable processes and a culture of Continuous Improvement
AESQ Vision

In detail

• Create common standards within the engine manufacturers (OEM’s) in regard to quality
• Deploy together the written standards throughout our supply chain
• Establish capable quality processes and a culture of continuous improvement

Main targets

• To improve quality within the supply chain
• Improve on time delivery and minimize costs through a reliable quality performance
• Gain efficiency by standardized processes
AESQ Will Drive Progress

Spread the Word

Provide feedback on the AESQ website
RETURN HOME SAFELY