EUROPEAN METHODS FOR THERMO-ELASTIC VERIFICATION

ECSSMET PRESENTATION 30/03/2023

Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

TOPICS

/// Introduction

/// Structure of the document

/// TEV process

- TEV process terminology
- TEV process
  - Identification
  - Modelling
  - Classification
  - Final verification

/// Conclusion: benefits and final project documentation

Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

INTRODUCTION

///Multi-disciplinary nature

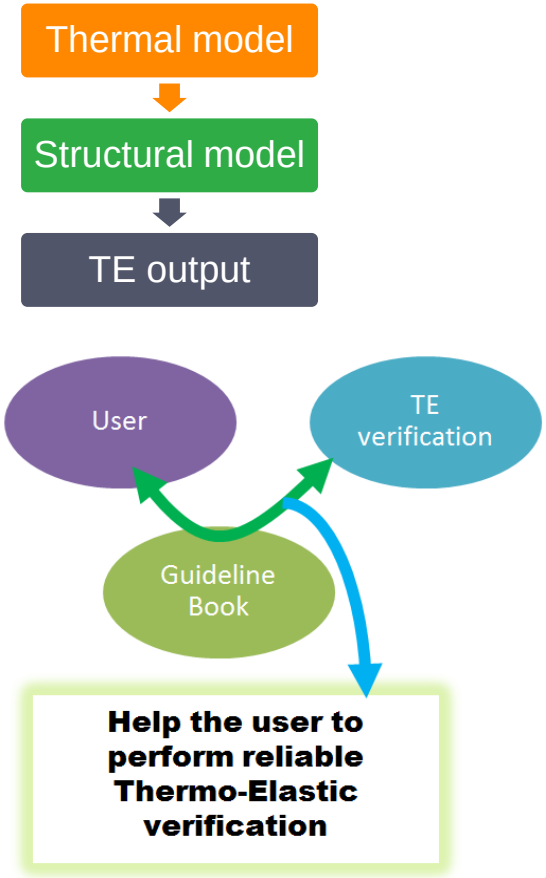
- Thermo-elastic verification: thermal input for the structural mathematical simulation

///No existing standard for performing Thermo-Elastic Verification(TEV)

- In general mono disciplinary ECSS and handbooks
- Many missions -> Many designs
- Each problem is different
  - Difficult to rely on past experience
  - Difficult to define specific guidelines

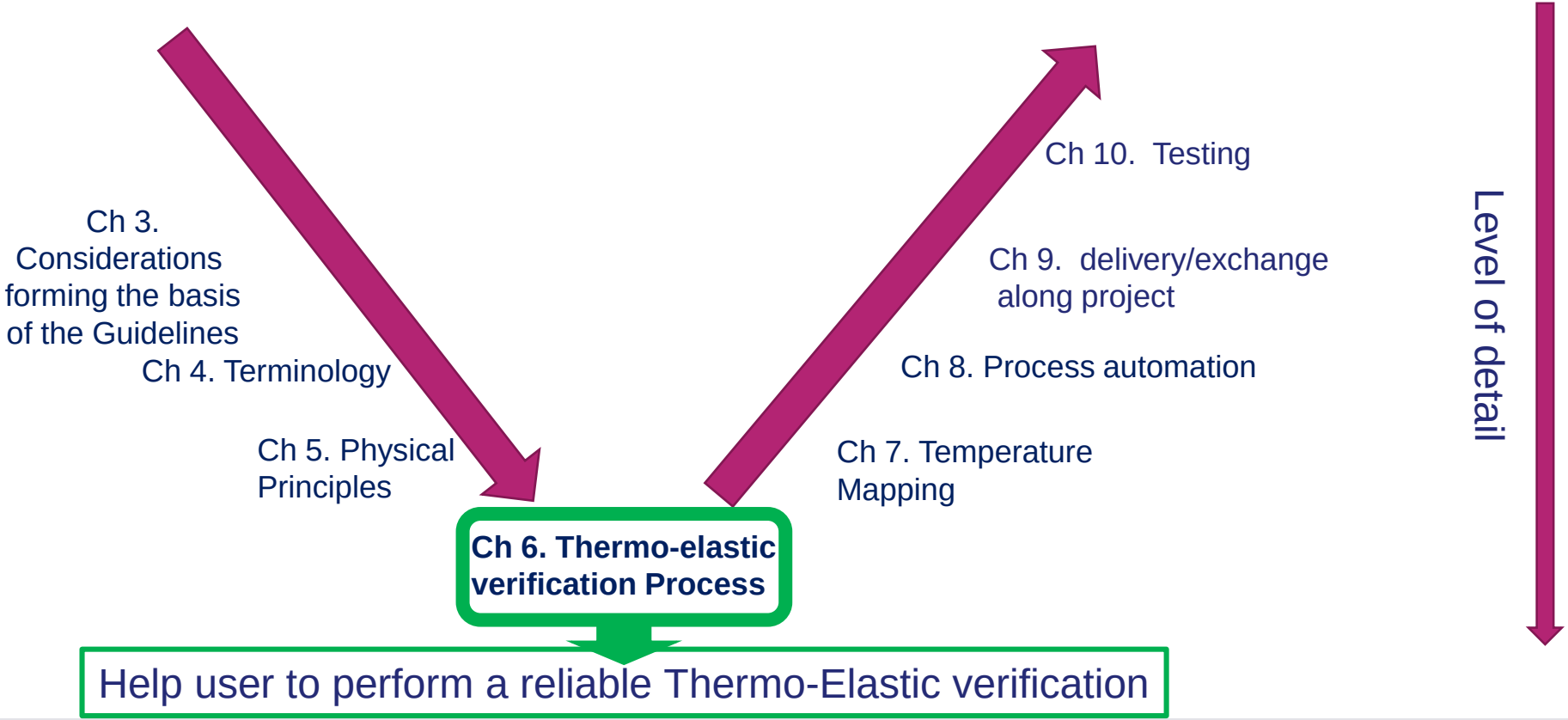
///The Guidelines are not a TEV cookbook

- Not detailed dictating guidelines (models, load cases, etc)
- A global approach: Thermo-Elastic Verification(TEV) process
  - Team involvement (thermal, structural, system, etc)
  - Global concept understanding of all team



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

STRUCTURE OF DOCUMENT



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

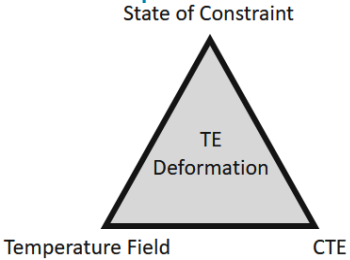
TEV PROCESS: TERMINOLOGY

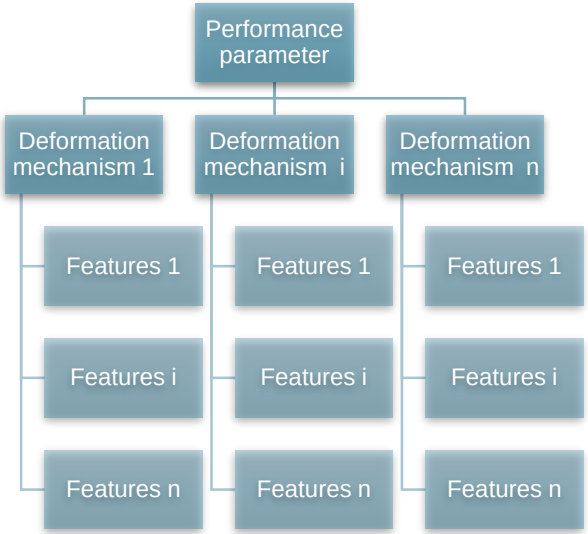
Objective of design is to limit the effect of the environments in space on the performance

→ **Performance parameter (ex: Rotation angle of LoS or maximum stress level)**

Which deformations of the structure can reduce the performance ?

→ **Deformation mechanisms**





Which parts in the model contributed to the degradation of the performance?

Which representation of the part in terms of meshing and geometry is responsible for the contribution level?

Which uncertainties on material and model properties may affect the most the predicted responses of the performance?

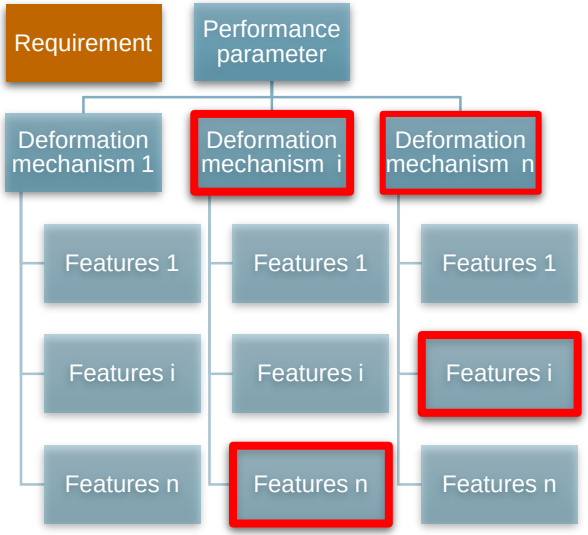
→ **Features**

Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

TEV PROCESS

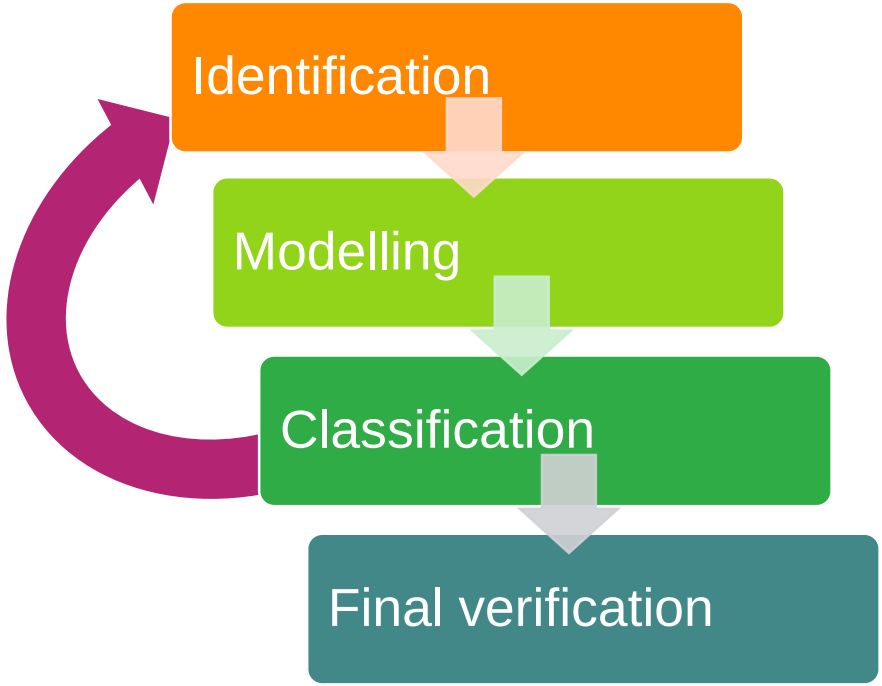
/// Objective of TEV process

- Spend the limited effort available where it is most needed
- Generate models confirmed to be adequate for TEV



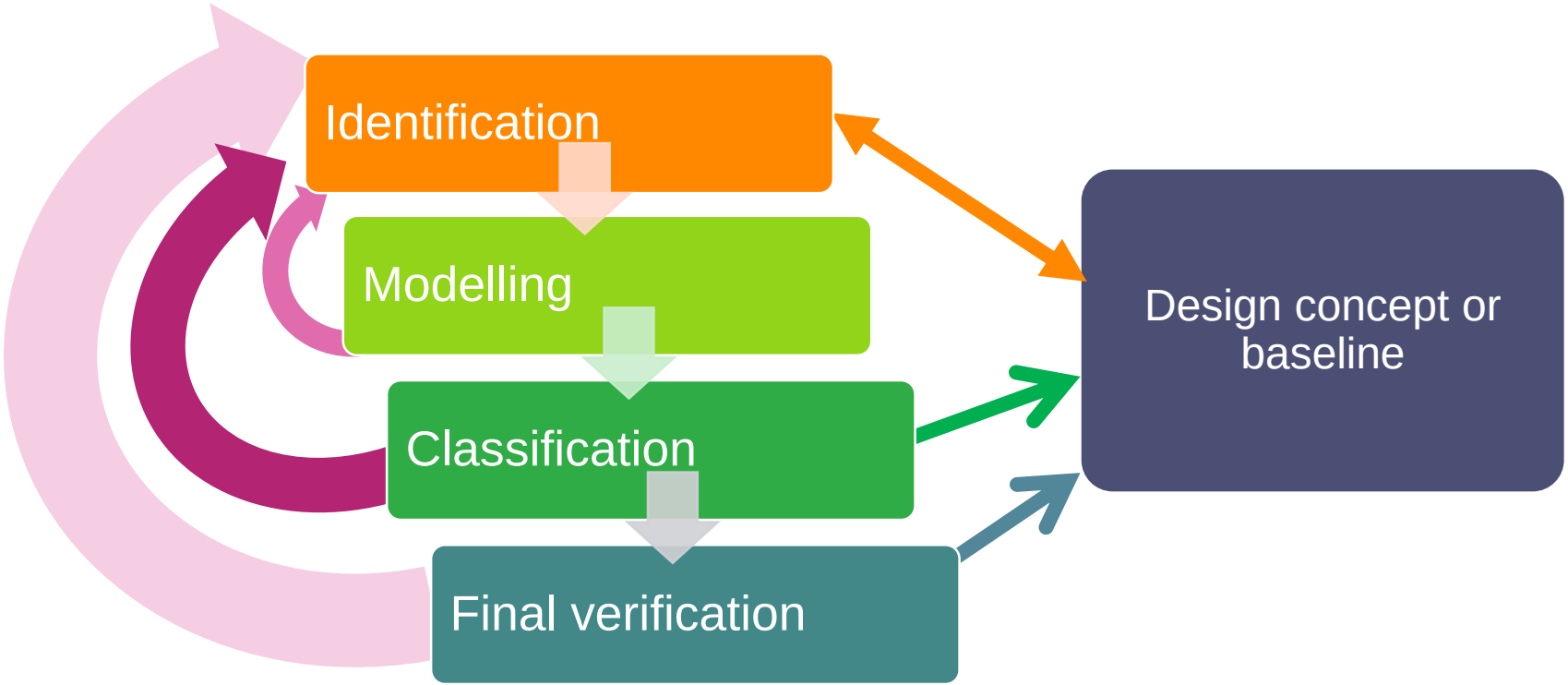
/// TEV process: 4 steps

- ECSSMET 2023: *Practicale Example_of_Thermo-Elastic_Classification_System*



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

TEV PROCESS



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

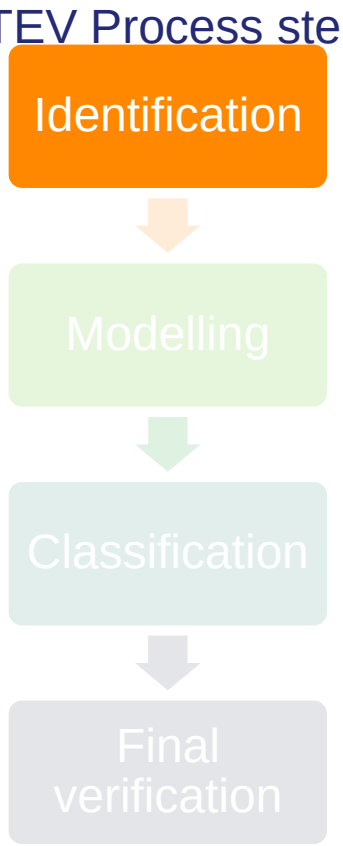
TEV PROCESS : IDENTIFICATION (1/2)

/// TEV-team organisation

- At least design, structural, thermal and systems engineering disciplines
- Performance engineer :
  - Translation of the performance requirement into TE requirements
  - Assures that TEV-team will provide the right data in the right format

/// Starting point of the process: Design concept or baseline

- A design is needed to be built from scratch.
- A design is already defined.

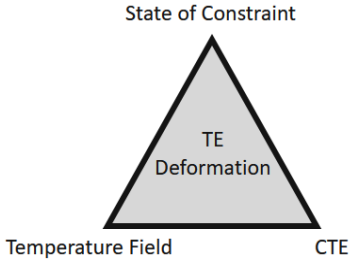


Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

TEV PROCESS : IDENTIFICATION (2/2)

/// Identification of performance parameters and physics to be simulated

- Develop a good understanding of the thermal and structural physics that must be simulated during the next modelling step
- Identification of performance parameters
  - Review of requirements (ideally at system level!)
  - Definition of performance parameter (ex: Rotation angle of LoS or maximum stress level)
- Identification of deformation mechanisms and their associated needed features
  - What physical principles can cause distortions ?
  - What types of deformation are relevant for the performance parameters degradation?



TEV Process step

Identification

Modelling

Classification

Final verification

Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

TEV PROCESS : MODELLING

///Prepare (initial) thermal and structural models

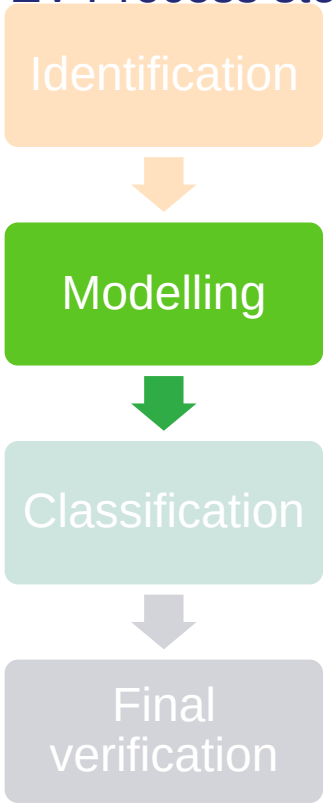
- Performance parameters
- All relevant thermo-mechanical deformation mechanisms, their associated needed features
- Adequate initial mesh resolution for representing the relevant physics

///Mathematical sanity of the modelling

→Good modelling practices will reduce the effort in this step

→Classification step determines if the level of accuracy needs further confirmation

TEV Process step



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

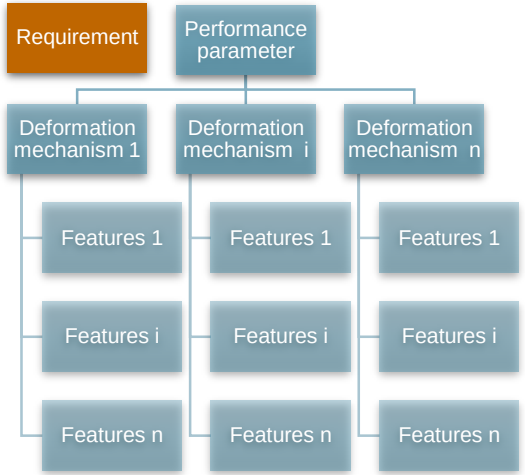
TEV PROCESS : CLASSIFICATION

///TEV classification process

- Set up of analysis and 1st runs
- Thermo-mechanical classification methods

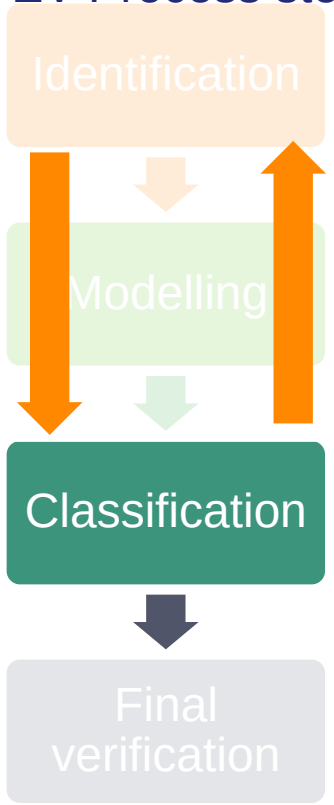
$$\{u\} = \begin{bmatrix} TE \\ Transfer \\ Matrix \end{bmatrix} \{\Delta T\}$$

- Thermal and structural impact assessment
- Conclusion of adequacy of thermal and structural TE models



Performance parameter	Overall Margin of performance parameter	Contribution from feature	Uncertainty of feature	Need for refinement
Features 1		High/Medium/Low	High/Medium/Low	Yes/No
…		High/Medium/Low	High/Medium/Low	Yes/No
Features i		High/Medium/Low	High/Medium/Low	Yes/No
…		High/Medium/Low	High/Medium/Low	Yes/No
Features n		High/Medium/Low	High/Medium/Low	Yes/No

TEV Process step



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

TEV APPROACH : FINAL PERFORMANCE COMPLIANCE VERIFICATION

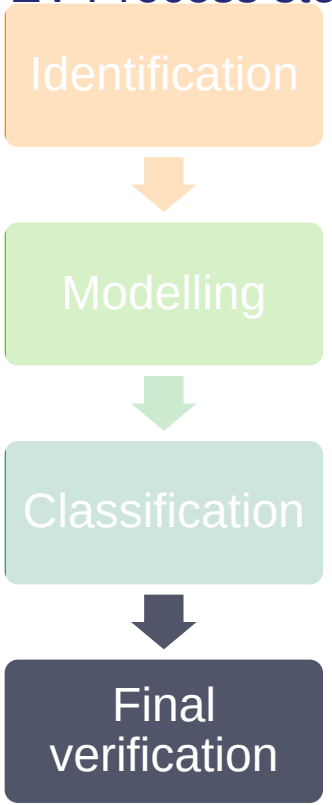
///Best case scenario: during classification, all relevant analyses have already been performed

- Analysis should be performed directly assessing relevant performance parameter with application of thermo-elastic factor of safety

→In practice not always possible:

- Need for stochastic analysis as margins are low, and (physical) uncertainties high
- Requirements cannot be verified efficiently directly during the classification (e.g. expensive optical simulations are needed) → a simplified metric was used to verify the performance parameter (e.g. linear vs non-linear optical model)

TEV Process step



Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

CONCLUSION: BENEFITS AND FINAL PROJECT DOCUMENTATION

/// TEV process

- TEV-team involvement
- Global concept understanding of all team members
  - Avoid wrong impression that a proper TEV is completed
  - Avoid Wasting time on unnecessary analyses

/// Status of the project

- Guidelines are considered beneficial for the upcoming projects
- 1st version of the guideline will be delivered soon
  - European Guidelines for Thermo-Elastic Verification, issue 1, ESA STM-285
  - Available on the European Working Group on Thermo-Elastics, https://tec.esa.int/sites/com-7JaGde/

/// Future project

- Shortcomings and limitations of the current guidelines -> thermoelastic@esa.int for any new feedback
- Based on untreated review points (appendix 2 of the guideline)

Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009

END OF PRESENTATION

THANK YOU FOR YOUR ATTENTION

Any questions?

Date: 30/03/2023
Ref: 0005-0017230807
Template: 83230347-DOC-TAS-EN-009