HEALTH MONITORING OF AIRCRAFT

BY NONLINEAR ELASTIC WAVE SPECTROSCOPY

AERONEWS

EC SIXTH FRAMEWORK PROGRAMME
PRIORITY 4: AERONAUTICS AND SPACE
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Deliverable 17 and Milestone M6

Decision on the choice of the full scale testing object and testing site

(Sub-Task WP5.1)

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Final version (confidential)

Confidential

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Contents

1 Introduction

The objective of the Work Package 5 (WP5) is the implementation and validation of the complete NEWS system on a full scale model of a chosen aircraft structure.

The aim of Workpackage 5 is to combine the results of WP1-WP4 and to validate the operation of the NEWS technology based inspection system for the monitoring of critical components of structures on a full scale object at a chosen testing site. WP5 will display the power and the potential of nonlinear methods when applied under real operational conditions. WP5 was scheduled to start at month 18 with subtask WP5.1 "Choice of an appropriate site and testing object" for validation of the efficiency of the proposed NEWS system. This includes Deliverable 17 which results in Milestone 6 at month 30. This report contains the final decision by the consortium on the testing site and the testing objects.

The lead partner in this WP, VZLU, decided to plan the actual validation well in advance. For that reason, two technical workshop meetings were organized. For the scientific and technological support of WP5 issues, a special Topical Workshop was organized in Prague. The Workshop was devoted to 1) the introduction of the facilities of VZLU, and 2) the preparation of NEWS tests as a part of WP1 and WP5. The AERONEWS Topical Workshop on "Preparing full-scale NEWS testing of aircraft parts" was organized by ITASCR, VZLU and DAKEL in Prague on November 18-19, 2005 in the presence of 32 participants. The program of the workshop agreed with the objectives planned in WP1 and WP5.

The consortium members at the AERONEWS General Assembly in Tenerife on 10th March 2006 decided to organize a second special workshop devoted to real hands-on NEWS testing of typical aircraft structure models as a part of WP1, and in preparation of the final full-scale real aircraft parts in WP5. From the point of view of the WP5 objectives this meeting was of great importance to WP5.1.2 which deals with the choice of the testing model of aircraft structure for validation of the efficiency of the proposed NEWS system. This workshop was called "*Prague experimental week*" and was jointly organized by Bodycote, ITASCR and VZLU. The Prague experimental week took place at VZLU in the 21st Week on 22nd – 26th May 2006 in the presence of 26 participants. Each participant/partner was responsible for his experimental set-up, and prepared and organized his own measurements. The purpose of that week was to examine realistic samples subject to progressively increased damage. This experience serves as a stage between pure laboratory tests and the final full scale tests. Several samples were available for inspection of fatigue damage - a wing lower surface aluminium panel, a model of wing attachment lugs, and impact damaged CFRP single skin samples.

The choice of an appropriate testing object, fatigue load procedures, choice of suitable NEWS techniques and of the proposed NEWS inspection system constitute a complex problem that must be taken into consideration within WP5.1. This subtask is closely linked with WP5.2 and WP5.3 tasks.

2 Overview of the Tasks, Deliverables and Milestone of the WP5.1

Overall participants in WP5:

Workpackage leaders	VZLU	
Person-months per participant:	15	

Participant id	KU Leuven	DAKEL	ITASCR	NDTE	BR&TC
Person-months per participant:	3	7	3	5	3,5
Participant id	BODY-COTE	UNIV-BRIS	GIP-U		
Person-months per participant:	10	2	4		

2.1 Overall objectives of WP5

- Validation of the efficiency of the NEWS inspection method in operational conditions.
- Installation and testing of a complete inspection system at a testing site.
- Defining requirements for operating the NEWS inspection method in particular environments.
- Formulation of recommendation for the implementation of NEWS for on-ground and in –flight non-destructive testing

2.2 Description of WP5.1 tasks

WP5.1 Choice of an appropriate site and testing object for validation of the efficiency of the proposed NEWS system.

- WP5.1.1 Choice of the testing site
- WP5.1.2 Choice of the testing model of aircraft structure

2.3 Deliverables, Milestone and expected result of WP5.1

D17: Choice of test objects and industrial test site
Delivery Date**:** month 30

- D17.1 Choice of testing site
- D17.2 Choice of testing model of aircraft structure

D17 results in **Milestone 6** at month 30 in the form of a decision on the choice of the full scale testing object and testing site.

3 Report on the accomplished activities in Work Package WP5.1, constituting Deliverable 17 and Milestone M6

3.1 WP5.1. 1 Choice of the testing site

VZLU, with its 2 700 m^2 laboratories for full scale testing and 50-year experience in the field of full-scale fatigue testing of aircraft structures, has been chosen as the testing site for the implementation and validation of the complete NEWS system on a full scale model of a chosen aircraft structure . This choice was confirmed by the AERONEWS consortium at General Assembly held in Ghent on 15th September 2006.

VZLU is the major centre for aeronautic research development and testing in the Czech Republic. VZLU is a member of the Association of European Research Establishments in Aeronautics (AREA) associating seven national research institutes of EU countries.

Using long-time experiences the VZLÚ Strength of aircraft Division performs full scale rigidity, static and dynamic proof tests of aircraft and their parts. For validation of the NEWS methodology VZLU offers its laboratory and testing facilities:

- Load systems
  - MTS 250 kN and Instron Schenck 250 kN fatigue load machines
  - MTS and IST Schenck digital multichannel servo-hydraulic load systems
- experimental stress analysis
  - VISHAY 4000 and VISHAY 6000 strain gage measurement systems
  - SPATE 4000 non-contact measuring system for stress pattern analysis by thermal emission
  - Q 100 – ESPI non-contact measuring system for deformation and strain analysis
  - ARAMIS HS non-contact photogrammetry measuring system for deformation and strain analysis
- NDT devices
  - MASTER SCAN 400 ultrasonic system
  - FOERSTER DEFECTOMETER 2.837, HOCKING PHASEC 2200 eddy currents systems
  - DAKEL XEDO BOX-16 acoustic emission system
  - Q 800 shearography system
  - OLYMPUS industrial video analyzer

The following figures illustrate the ability of VZLU to perform full-scale tests of aircraft structures.

Full-scale fatigue tests of commuter and light combat aircraft completed by VZLU

3.2 WP5.1. 2 Choice of the testing model of aircraft structure

The principal goal of WP5.1.2 is to select appropriate aircraft parts for testing, and to identify the available NEWS procedures, which could be used for damage detection within WP5.3.
As an outcome of the two technical meetings organized at VZLU, several aircraft parts and models of component structure in damage or intact state were selected for testing, and the potential NEWS procedures for damage detection were identified together with their requirements on device and transducers, their advantages and disadvantages. Suitable structures were available at VZLU, NDTE, BODYCOTE and ASCO. At first VZLU offered a rear part of a fuselage with a horizontal tail plane of a light combat aircraft for the implementation and validation of the complete NEWS system. This structure features a typical aluminum riveted aircraft structure. For the *Prague experimental week* VZLU selected a wing lower surface test panel and a clewis attachment with two and tree lugs. These structures were also made from aluminium. The issue of testing model choice was widely debated with support of experience obtained within WP1 testing on one side and resulting from the *Prague experimental week* on the other side. Finally, a quite different testing model was chosen and confirmed by AERONEWS consortium at General Assembly held in Ghent**: a nose landing gear** of a commuter.

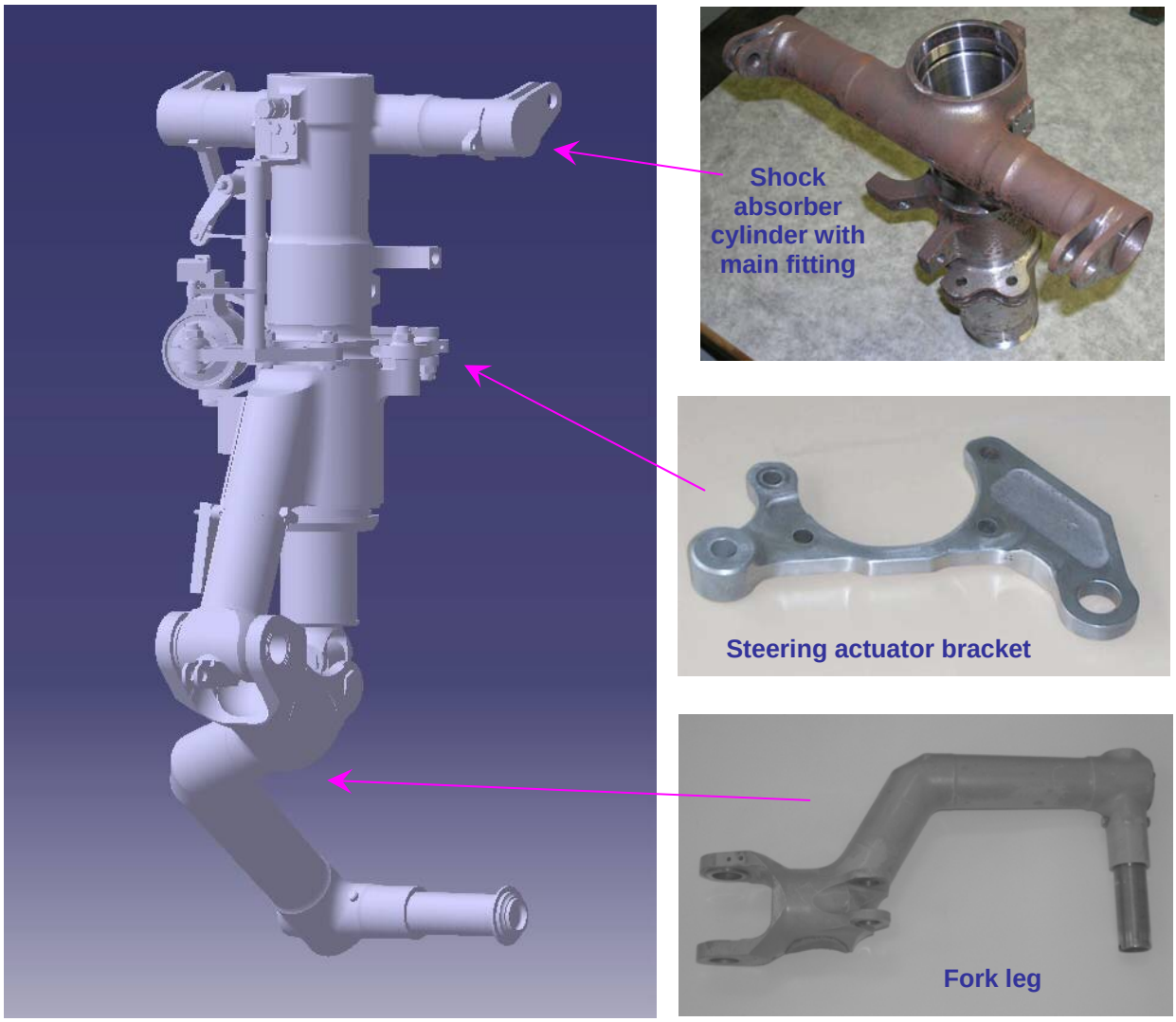
The P*rague* e*xperimental week* showed very promising results on massive structure with complex geometries. The nose landing gear gives the possibility to evaluate the performance of both global and local NEWS techniques on a critical structure. The evaluation of this structure using classical NDT procedures (eddy-current and ultrasonic) requires to dismount the components of the structure. One of the objectives of the testing on the nose landing gear will then be to evaluate the possibilities to use global techniques to test the different components still mounted in the structure.

The nose landing gear represents massive structure made from high strength steel and contains several principal structural elements which are fundamental to carrying ground loads during take off, landing and taxiing. The stresses induced by ground loads are usually at high stress ratios and contribute significantly to damage growth once fatigue cracks are formed. Failures, which remained undetected, lead to a loss of safety of aircraft operation. Several locations of high stress concentration provide areas for NEWS methods application. Each of these areas features different structural geometry (bearing surface) and critical fatigue crack length. The principal structural elements of the chosen nose landing gear are accessible for all NEWS inspection techniques.

It should be noticed that the nose landing gear is a typical example of an aircraft structure that might not be conductive to damage tolerance design (Advisory Circular 25.571-1 Section 3, Paragraph 2). The regulation allows a safe-life design concept in this case. But due to life extension of ageing aircraft landing gear the damage detection procedures are inevitable. From the point of view of implementation and validation needs, the full scale fatigue test of the nose landing gear is suitable.

The following pictures show the chosen nose landing gear and its main critical parts.

Nose landing gear of L-410 Commuter



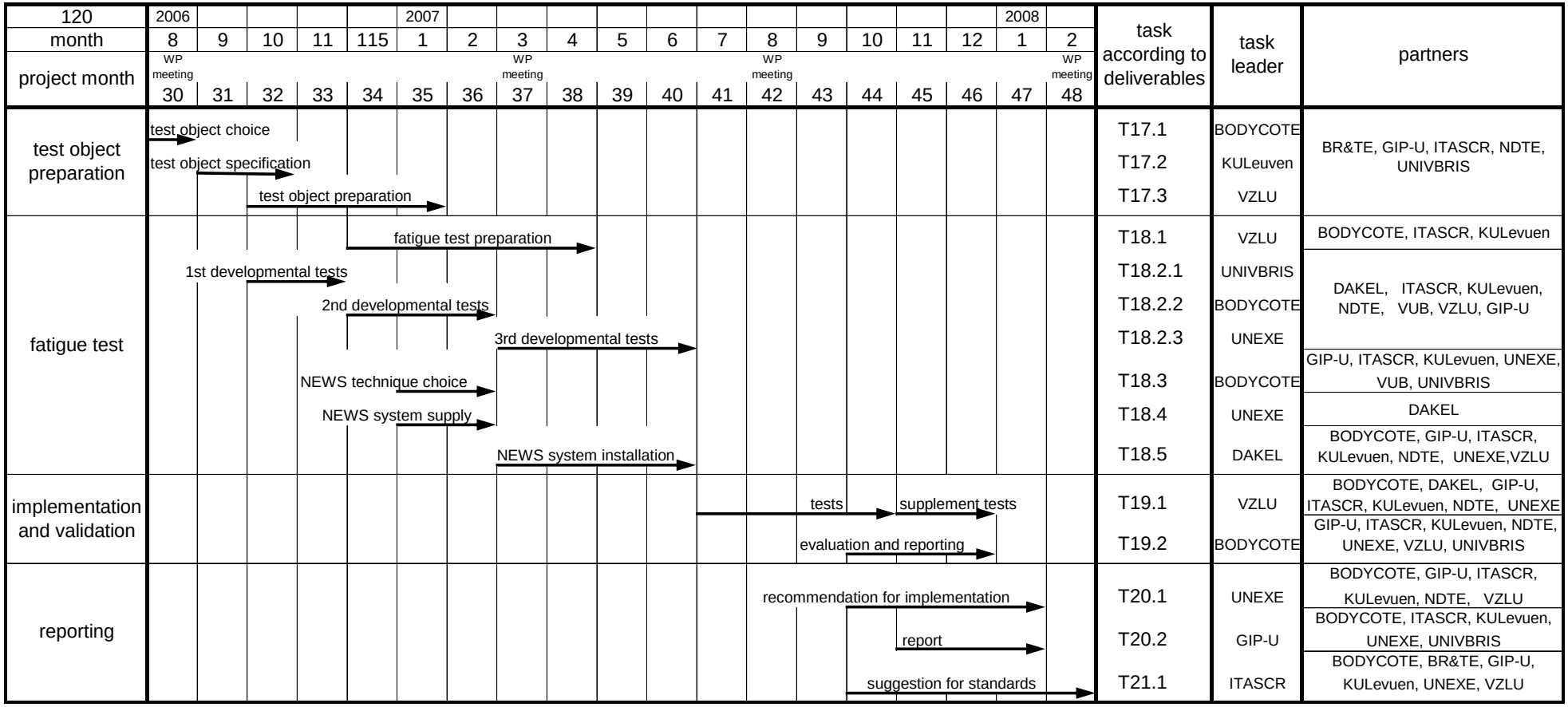
Model of the nose landing gear and main critical parts of the gear

4 Working Flow-diagram for future WP5 activity

After having agreed on the testing site and the structural testing model for implementation and validation of the complete NEWS system, the WP5 members have decided to follow the plan displayed in the table below for the future WP5 activities concerning the strategy of the fatigue test and the validation phase.

The working flow-diagram carefully lists the WP5 tasks with timing and partners involvement. It is also important to note that the scientific and technological support of WP1 through WP4 will remain.

WP5 Working Flow-diagram



5 Conclusion

The AERONEWS consortium at its General Assembly in Ghent on 15th September 2006 confirmed:

- VZLU as the testing site
- the nose landing gear as the testing object

for validation of the efficiency of the proposed NEWS system.

With this, Deliverable D17 (D17.1 Choice of testing model of aircraft structure and D17.2 Choice of testing site), together with Milestone 6 (formal decision) were accomplished at month 30.