Aerospace Technology 2016

GRÖN FLYGTEKNISK DEMONSTRATION

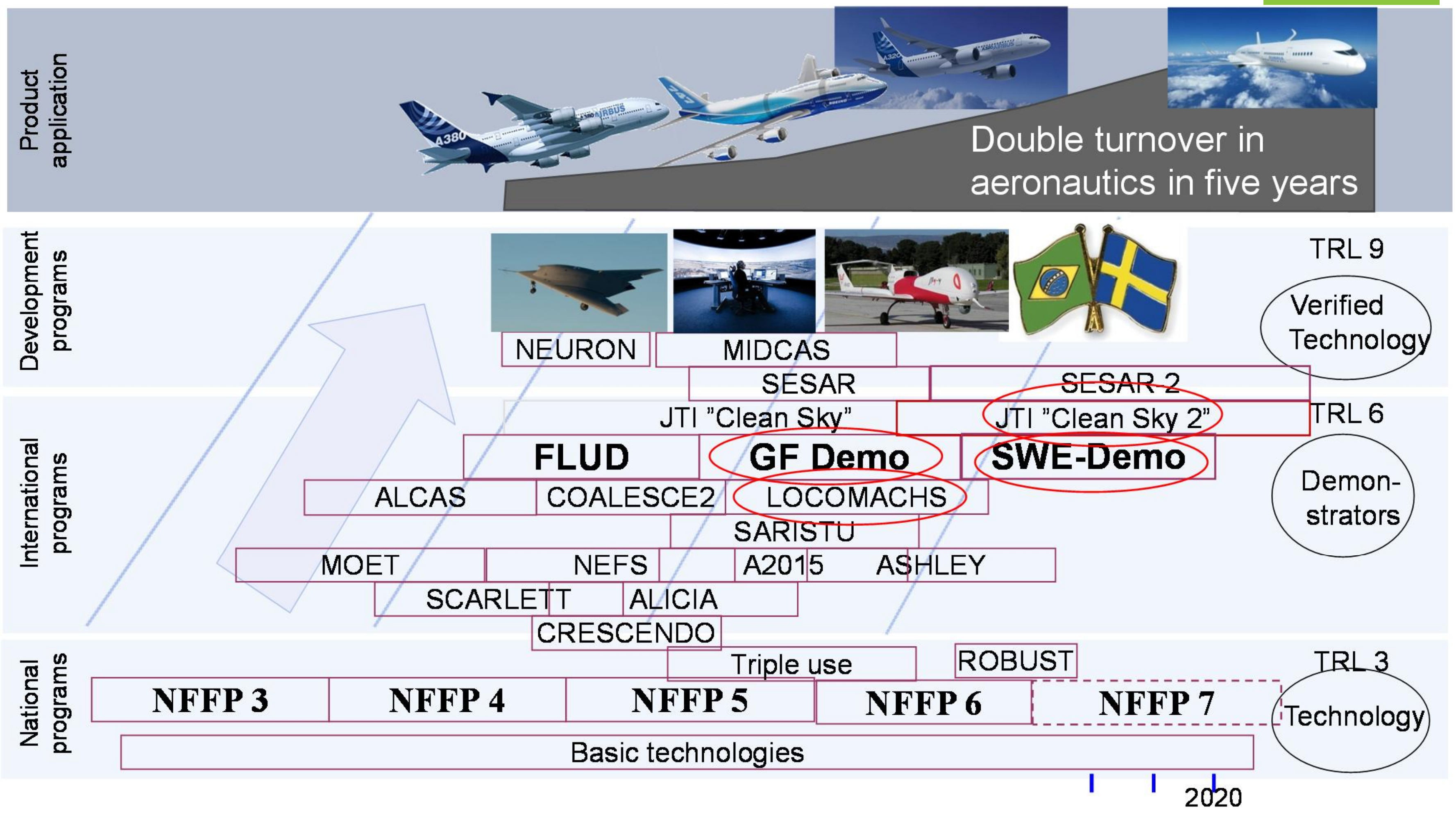
Maria Weiland
Saab AB
Aerostructures

Maria.weiland@saabgroup.com

Next Generation Composite Structures for Commercial Aircraft

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

SAAB RESEARCH ROADMAP



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OBJECTIVES IN GFDEMO

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ACARE

- Reduce fuel consumption and environmental impact in the next generation of civil aircraft
- Reduced structural weight
- Develop upon the knowledge gained in Clean Sky
- Engage national partners with new knowledge
- Develop and mature radical new technologies
- Manufacture a demonstrator that
    - Raises international attention
    - Puts Saab in a strong position for participation in Clean Sky 2
    - Provides strong future business opportunities

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PROJECT PARTNERS AND VINNOVA FUNDING

46,1 MSEK

8,5 MSEK

GF Demo 1 including additions

GF Demo 2

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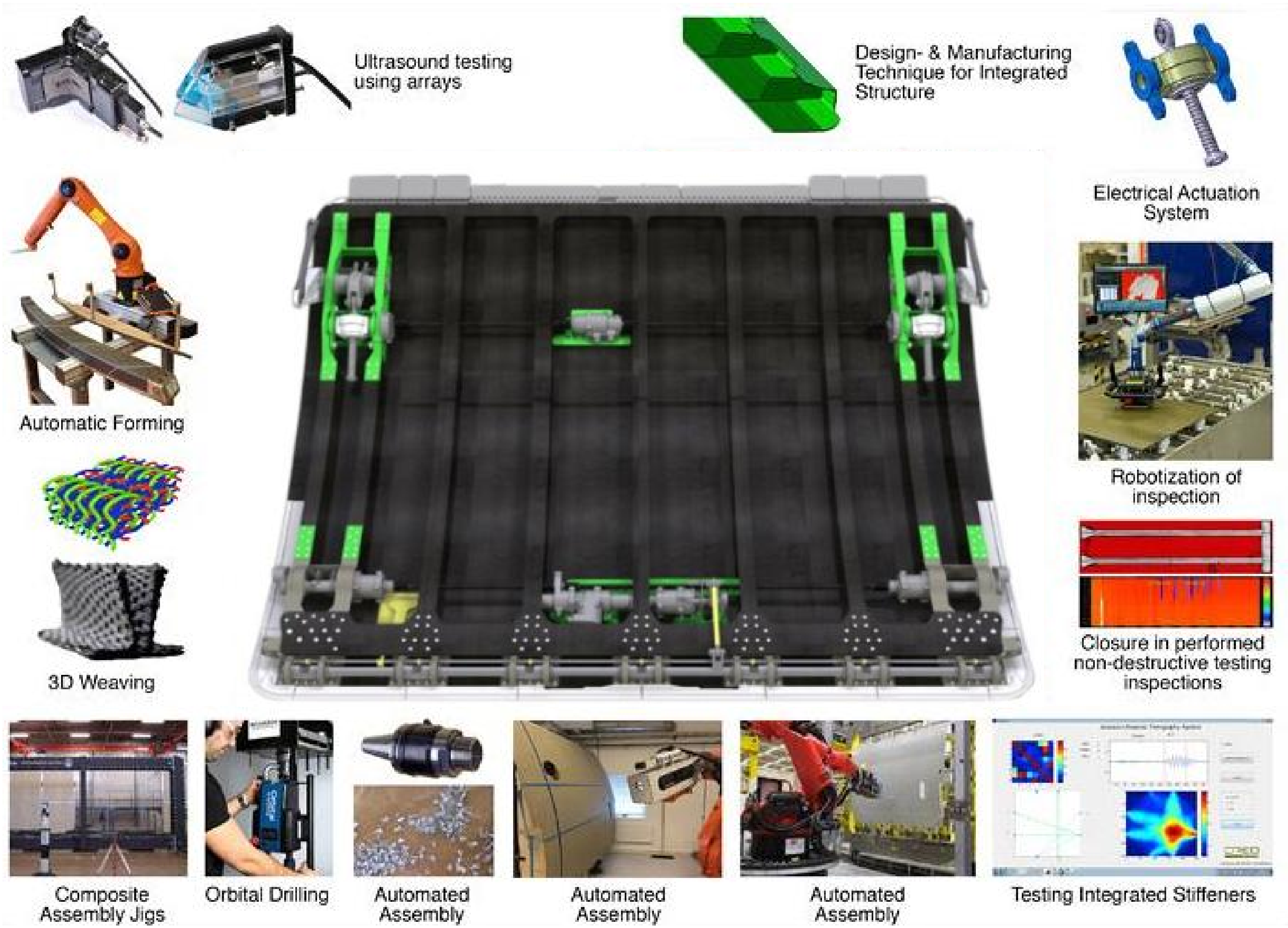

www.gfdemo.se

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INTEGRATED CARGO DOOR DEMONSTRATOR

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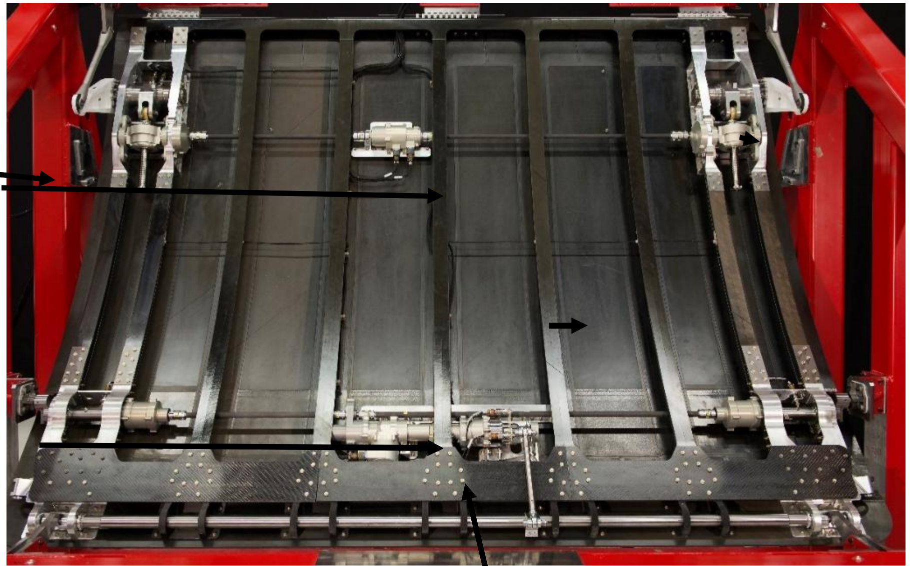
Reliable, efficient lightweight actuation system
* The lifting functionality is provided by a centrally located electrical motor connected to composite drive shafts and ball-screw units at each side of the door
* The latch & pull-in functionality is provided by a common electrical motor via a differential gear. Planetary gears are used for final reduction.
* Trapezoid motor drive with relatively few components increases robustness while maintaining high efficiency



Mechanical attachments
* Optimized metallic attachments for Lift, Pull-in and Latch systems

Integrated Composite Door
* Skin, Frames, Upper Beam and part of lower beam integrated into one co-cured composite part
* Reduced no. of fasteners XX%
* Process: UD-prepreg, 180°C autoclave cure

3D-weaved lower strap
* 3D-woven carbon textile reinforcements

Innovative Ultrasonic NDA Techniques demonstrated

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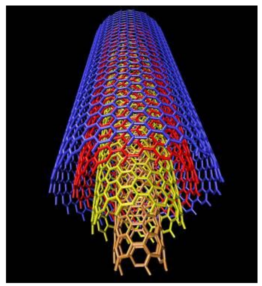
WP 3.1 MULTI-FUNCTIONAL MATERIAL

- Development and definition of materials- and processing technology for multifunctional airframe materials is carried out in this work package
- New technology for prepreg materials with multifunctional properties has been introduced and coupon testing is used to study processing and forming properties of uncured prepreg and mechanical properties of cured laminates
- Multifunctional properties in this WP means mechanical properties in combination with electrical - , thermal - and other physical properties as well as combinations of improved mechanical strength, stiffness and fracture toughness that will allow future airframe materials to outperform currently used materials based on carbon fiber and epoxy
- Industrial size material samples (sqm scale) are used
- TRL 3 to 4 is expected in this WP



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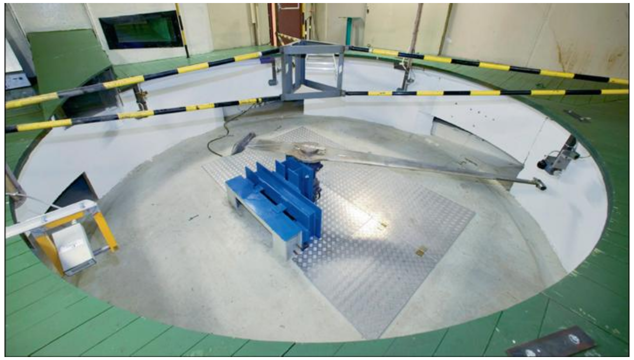
WP 3.2 FUNCTIONAL COATING

- Development and definition of materials- and processing technology for functional coatings is carried out in this work package
- Electrical function for efficient airframe de-icing, anti-icing and other applications is developed
- Future functional coatings must meet all relevant operational requirements for aerodynamic surfaces designed for improved laminar flow conditions, e.g. surface smoothness, erosion resistance, lightning strike effects and adhesion
- Different coatings are studied
- TRL 3 is expected in this WP



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WP 3.3 3D-WEAVES

- Within WP 3.3 there has been activities on finding applications for 3D reinforced composite material
- A peel loaded T-profile is selected as test article to study properties with and without 3D-weaves
- A test program is ongoing together with the GFDemo partners Biteam, KTH and Elitkomposit to study interlaminar strength in the T-profile
- TRL 4 is expected to be met
- A 3D-weaved composite part is proposed to be part of the door demonstrator
- Development of manufacturing equipment for impregnated 3D-weaves is ongoing within GFDemo

Image from peel test of a T-section with 3D-weaves

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

WP 3.4 INNOVATIVE TOOL DESIGN

- Two initial projects have been performed within this WP
  - Studies on sacrificial milling as an alternative to liquid shim
  - Studies on using female tools to improve manufacturing tolerances for C-frames
- These two initial projects are now completed and part results from them will be implemented in the door demonstrator
- The continuation of WP 3.4 will be concentrated on door demonstrator tools
- It is a challenge to develop a tool concept for the highly integrated door demonstrator. This will be performed together with Compraser Labs

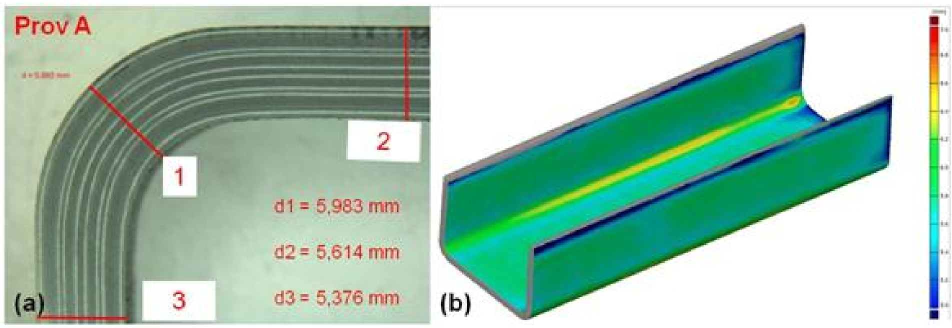

Image from the female test to the left and the sacrificial milling test to the right

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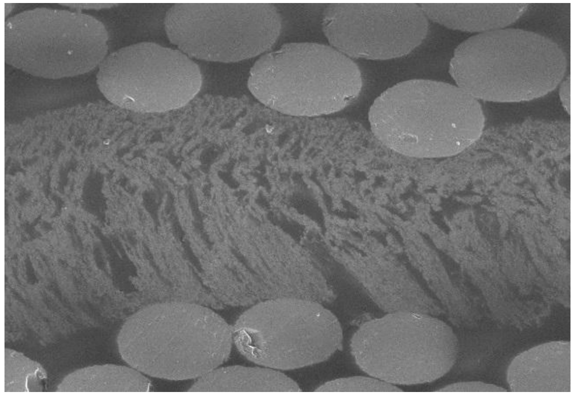
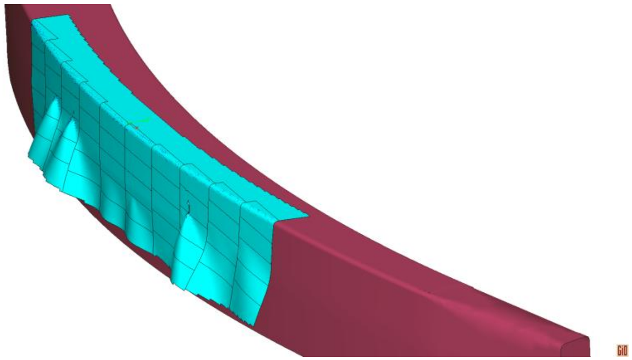
WP 3.5 AUTOMATIC FORMING

- Increased knowledge on prepreg forming mecanisms
- Visualizing local forming phenomena
- Increased knowledge on material characterization
- Verifying numerical methods on forming
- Increased knowledge on ”tailor made” forming methods





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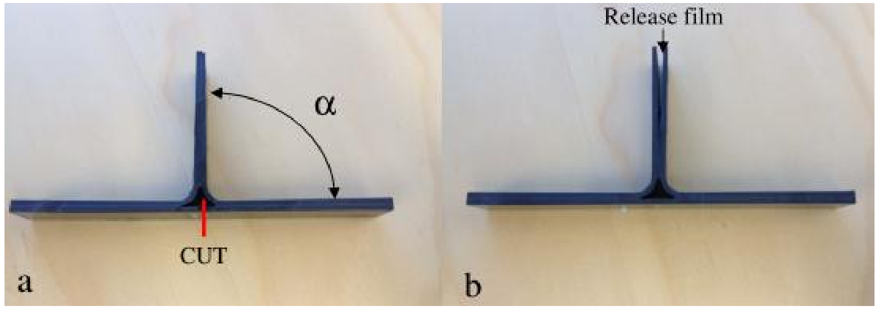
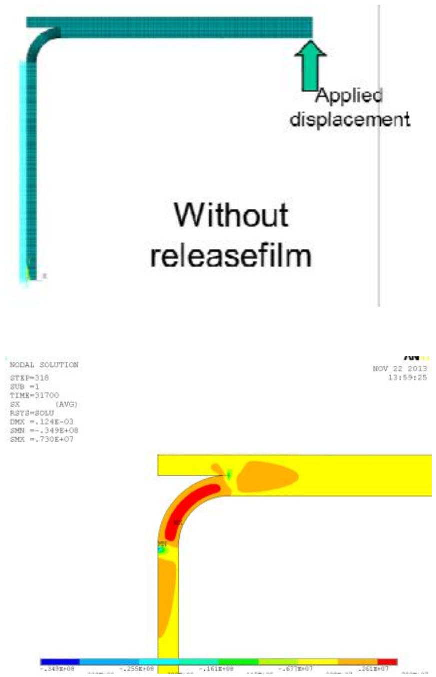
WP 3.6 SPRING BACK AND RESIDUAL STRENGTH

- Stress relaxation study is completed and reported by SICOMP
- A literature study is performed about Tool Part Interaction also by SICOMP





Images from analysis and test of relaxation in a T-profile

swerea | SICOMP

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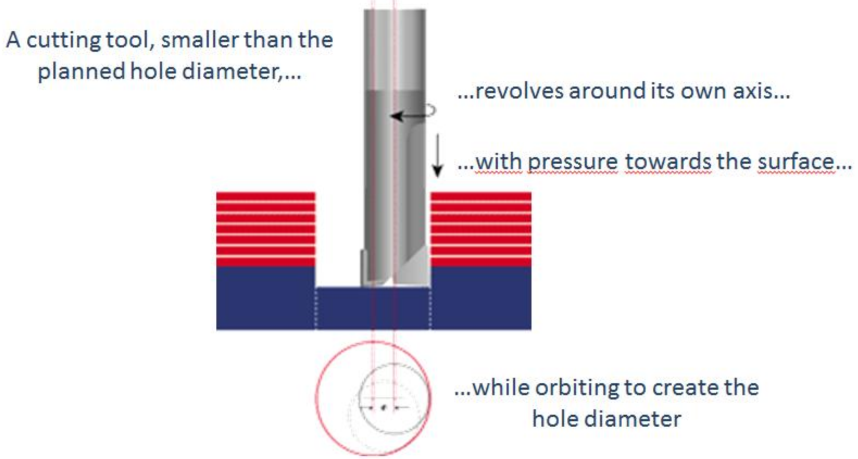
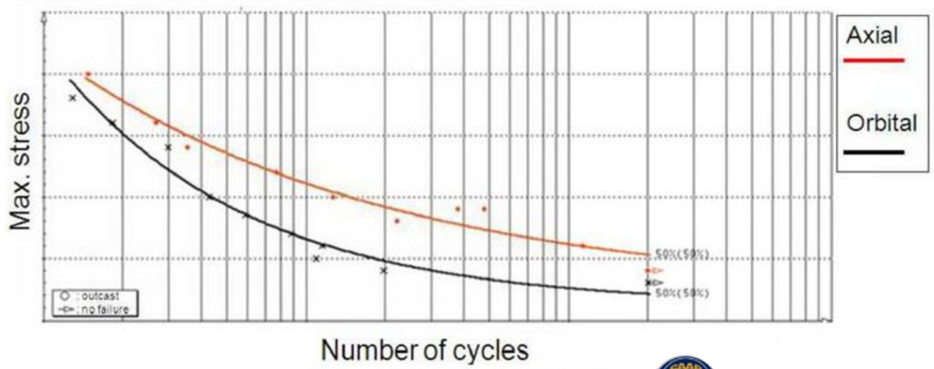
WP 4.1 ORBITAL DRILLING

- Study for increase of fatigue stress performance in aluminum holes which has been made with orbital drilling. Reference is conventionally drilled and reamed holes.
- Fatigue stress trials of aluminum coupons which are orbital drilled with optimized cutting data and cutting tools.
- Definition of a model for assembly cost analysis.





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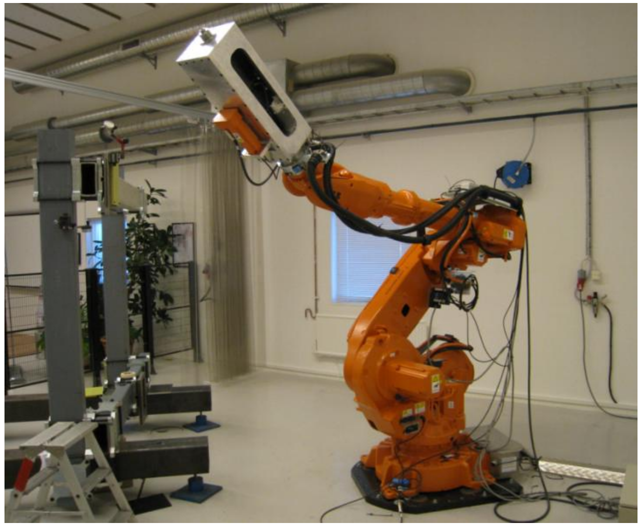
WP 4.2 OCH 4.8 AUTOMATED ASSEMBLY

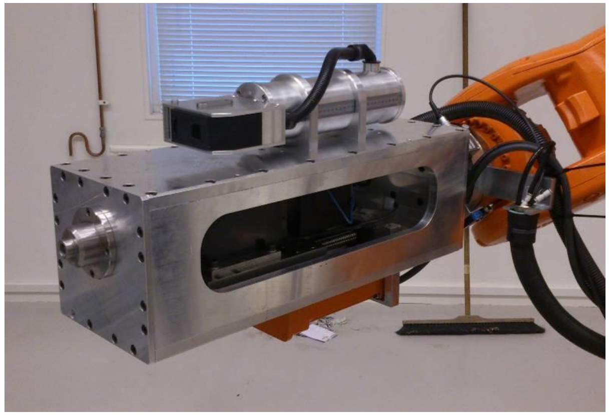


Objectives in GF-Demo

Develop cost effective solutions for robotic drilling which use new sensor technologies to maintain highly accurate robotic positioning and which use new cutting technologies to increase the drilling performance

Result 1.

ÅF Industry and LIU has developed a solution which uses a force sensor to control process forces and maintain the accuracy of the robot positioning.
The solution minimizes the number of movable parts in the process tool, hence also the price for the overall solution.

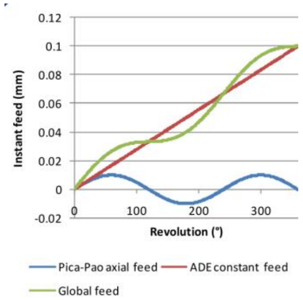


Result 2.

X-Laser system has developed a solution for quick and accurate calibration of the robot positioning relative to the product.

Result 3.

By using robotic vibration drilling SAAB develops the cutting process in hybrid materials towards higher quality and performance.



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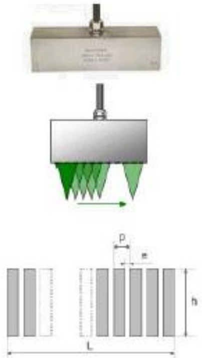
WP 4.3 ULTRASOUND INSPECTION BY PHASE-ARRAY TECHNIQUE

- The purpose of this work package was to streamline the inspection process by the usage of phase-array technique.
- Special interest was put towards the inspection of radius sections, having the antecedent of Saab inspecting flat surfaces by phase-arrays. The radii are inspected by single transducers which are oriented to various angles to cover the radii's area.
- The deliverable verification of radius array, TEK14-0056 has been reported.
- The deliverable optimization of the door demonstrator's inspection, TEK14-0155 has been reported.

enkelsökare



arraysökare

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WP 4.5 – ACOUSTO-ULTRASONIC INSPECTION OF COMPLEX STRUCTURES

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OBJECTIVE:

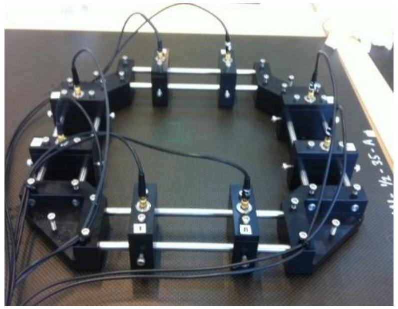
- Development of an innovative technique for rational inspection of 3D CFRP structures: Acousto Ultrasonic Tomography (AUT).
- The AUT technique gives an instantaneous image of the integrity of a 20cm x20 cm zone and can handle non-planar structures.
-

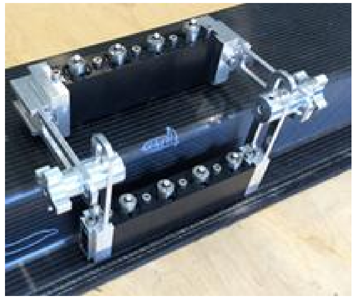
APPROACH and BENEFITS:

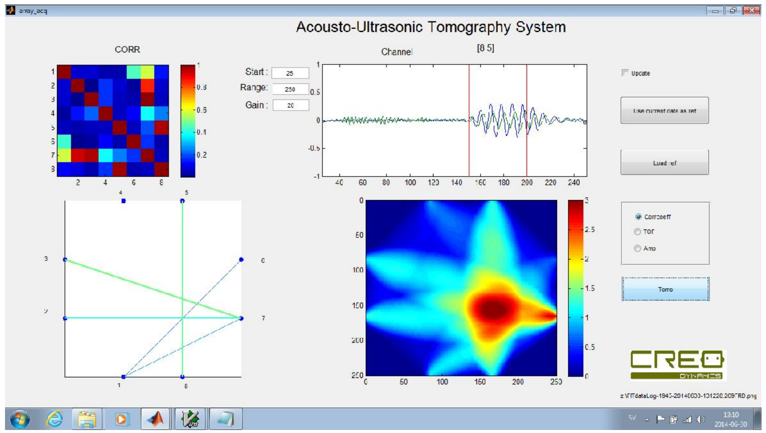
- The proposed technique uses guided waves (“Lamb waves”) propagating in the laminate, eliminating the need for scanning.
- The main benefit is shorter inspection time.
-

ACHIEVED RESULTS

- Development of method and procedure. Development of Hardware and Software
- Validation on plane laminate and stringers.
- 2 patents pending.







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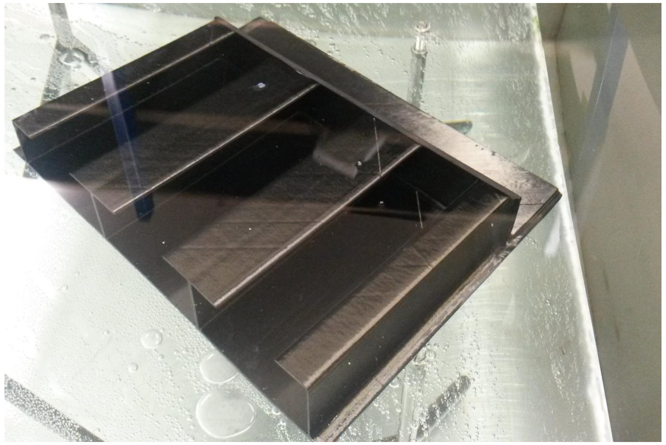
WP 4.6 AUTOMATED INSPECTION



Komplexa geometrier

http://www.boeing.com/boeing/defense-space/support/maintenance/commercial/auss/AUSScatalog.page

- The purpose of this work package was to compare gantry systems, robots and other types of equipment for its implementation into the inspection of composite panels at Saab. Benchmarking study that comprised software/algorithms and equipment has been performed.
- Real solution possibilities have been studied for three composite products: c-frame, bulk-cargo door and door demonstrator.
- The deliverable automated inspection, TEK14-0373 has been reported.
- The deliverable inspection by ultrasound of the door demonstrator is on-going.

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WP 4.7 ADVANCED 3D TEXTILE REINFORCEMENTS

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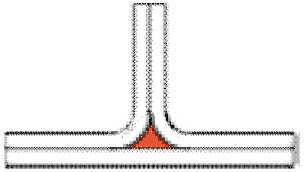
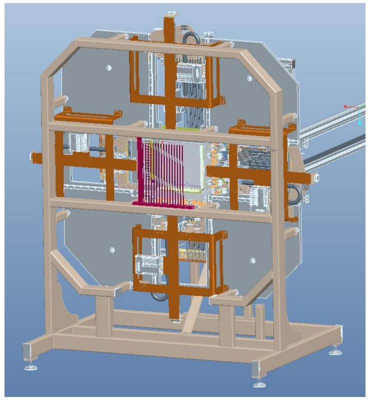
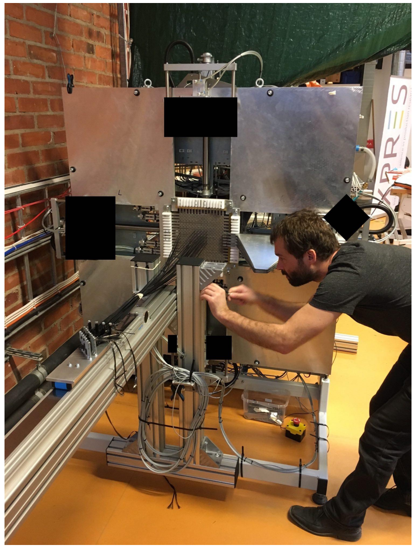
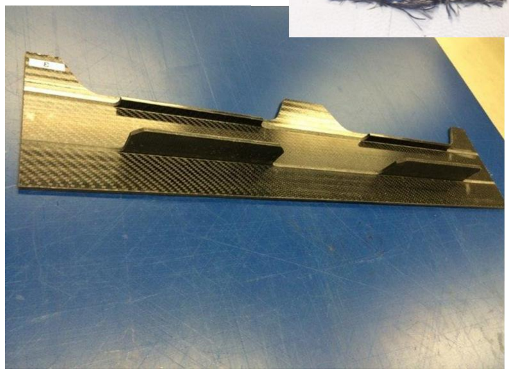
The objective is to develop and manufacture equipment to produce 3D-woven profiled materials developed in work-package 3.3.









BITEAM

elitkomposit

KTH
VETENSKAP
OCH KONST

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WP 4.9 ASSEMBLY JIGS IN CFRP

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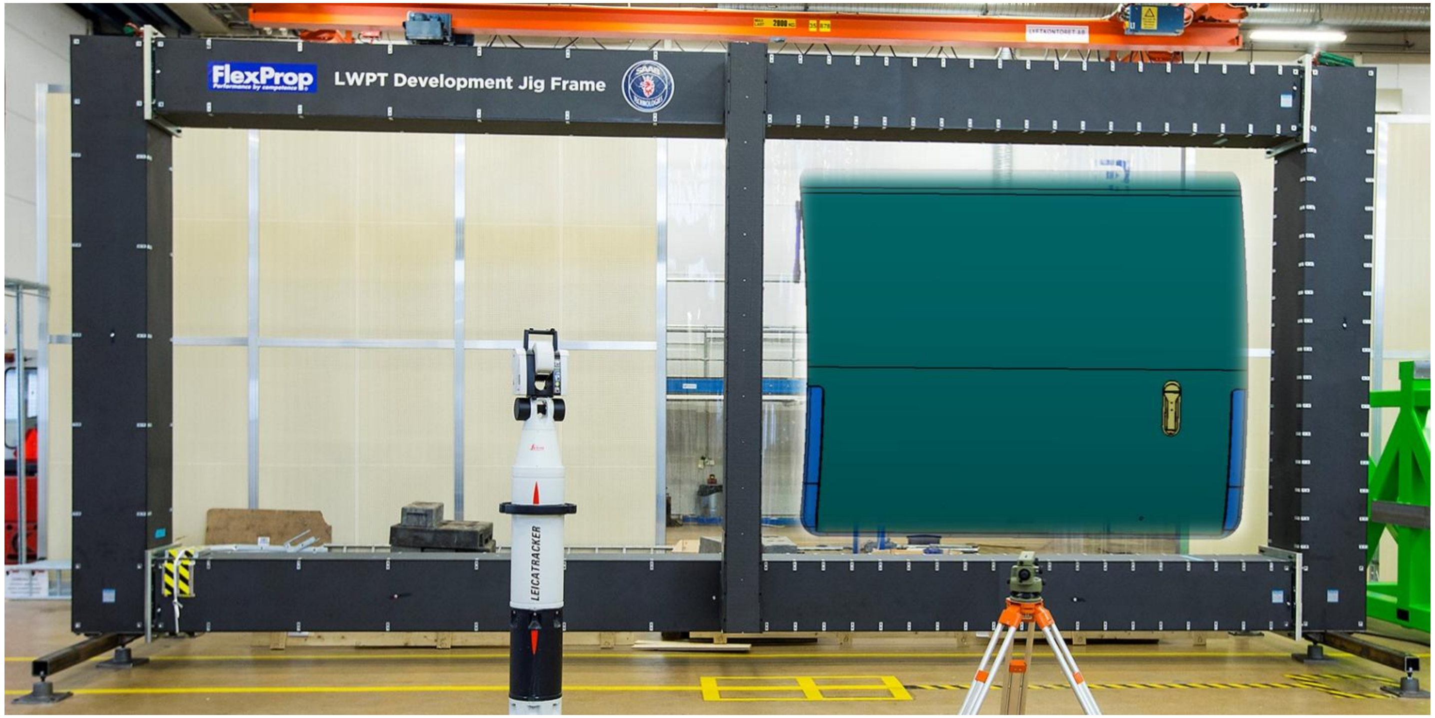
The CFRP Jig is manufactured for two purposes;

- To enable assembly of Airframe structure of a size that at least representing a Boeing 787 LCD (Large Cargo Door). The jig frame of 9x4 m can handle the size of 2 LCD's.
- To demonstrate a movable generic jig frame to be used for pules production of airframe components/structure. It requires a lighter jig with higher accuracy then a traditional jig in steel.



SAAB

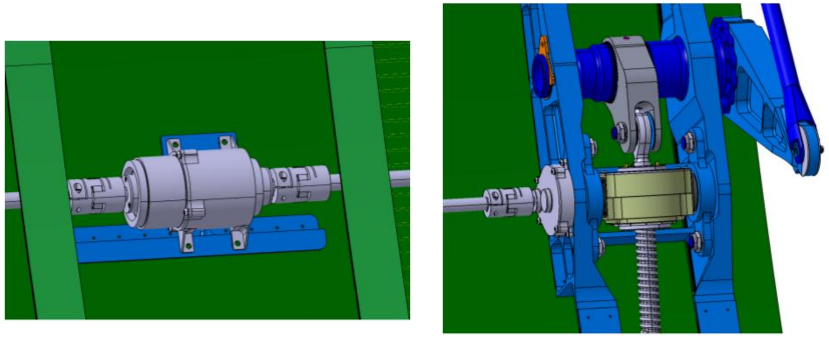
FlexProp

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

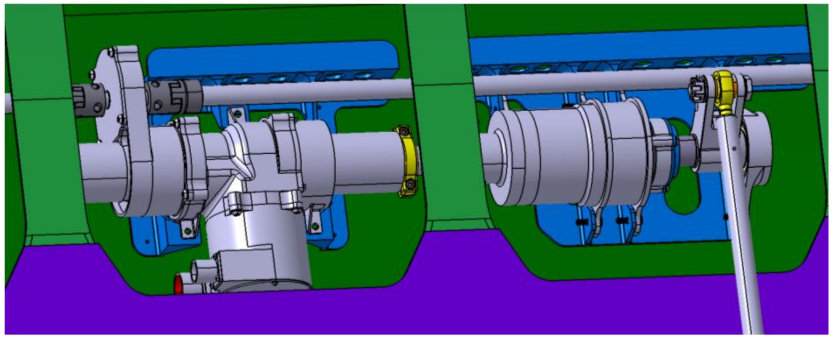
WP 5.1 ACTUATION SYSTEM FOR OPENING/CLOSING OF CARGO DOOR

- Opening/Lift of the door is done with an electrical motor that drives shafts connected to a ball-screw unit at each side of the door.
- Functions for Latch and Pull-in are driven with a common electrical motor via a differential. Planetary gears are used as final reduction.

Lift, right side with motor



Combined Pull-in/Latch



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WP 5.2 Trapezoidal drive of Stritorque®-motor

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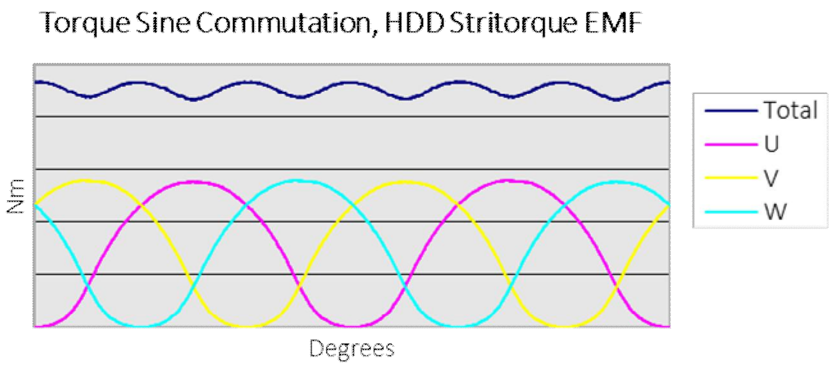
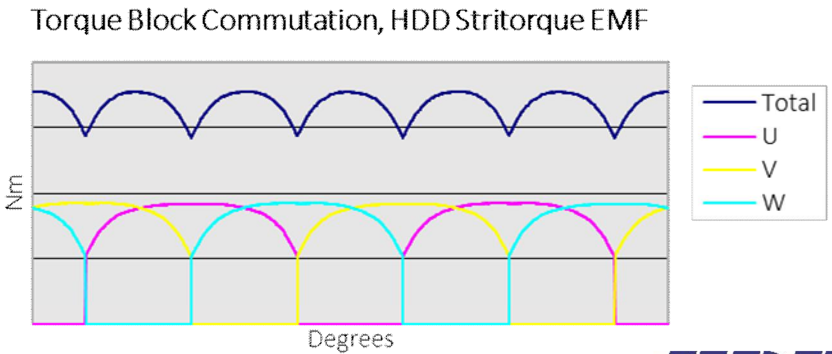
- To investigate possibilities to use Stritorque®-motor with trapezoidal drive instead of sinuszoidal drive. This is done by HDD Servo Motors AB.
- This technical solution will provide a robust, lower-cost and lower-weight door-actuation system.
- Theoretical study has presented that trapezoidal drive of a Stritorque®-motor only gives 2.6% torque loss in comparison with sinuszoidal drive at same copper losses.





High Density Drives

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WP 6.2 DOOR DEMONSTRATOR

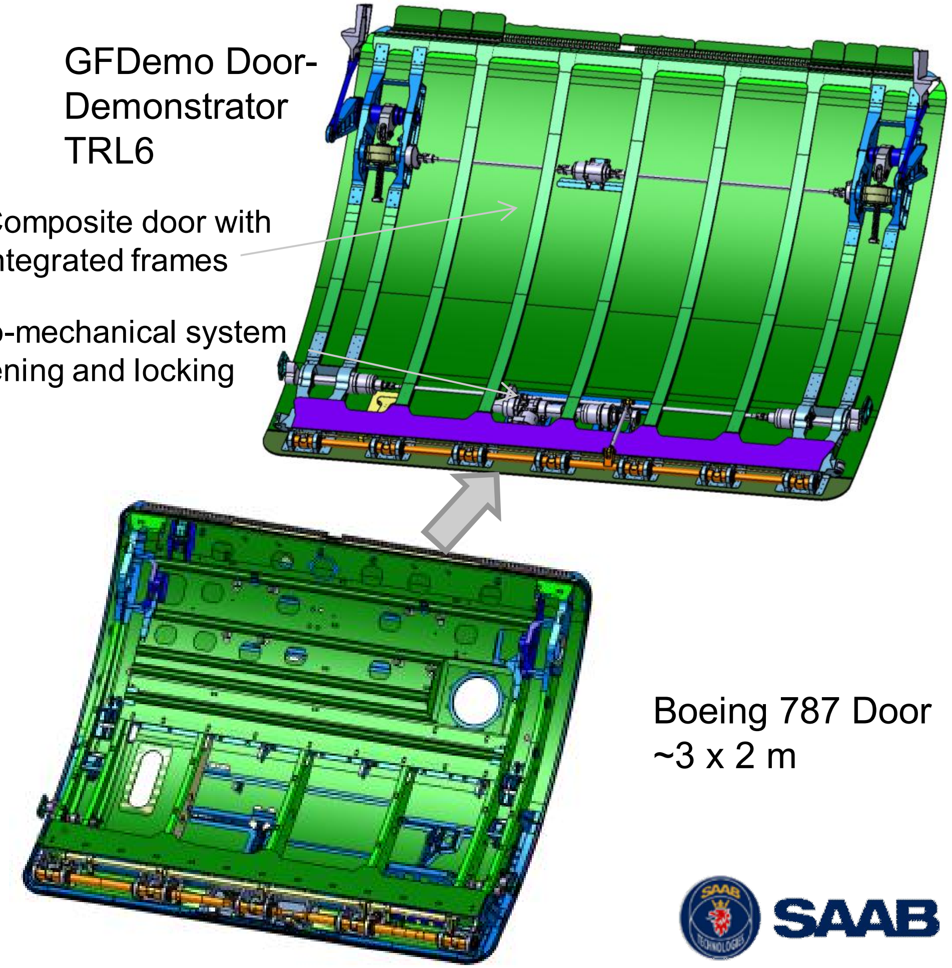
Goal:

Develop and demonstrate a door with respect to the structure and system as an integrated unit with:

- Low weight
- Low production costs
- Reduced environmental impact

Technologies to achieve the objectives:

- Integrated construction of curved door structure of carbon fiber composites
- Reduce environmental impact by completely removing the hydraulic fluids and greatly reduce the use of liquid shim
- Improve the design and production technology related to DFM-criteria



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WP 6.2 DOOR DEMONSTRATOR CONTINUED

Mechanical attachments to Composite box

a) Load transfer to Latch 2-6
- Stress analysis completed
- Construction base line

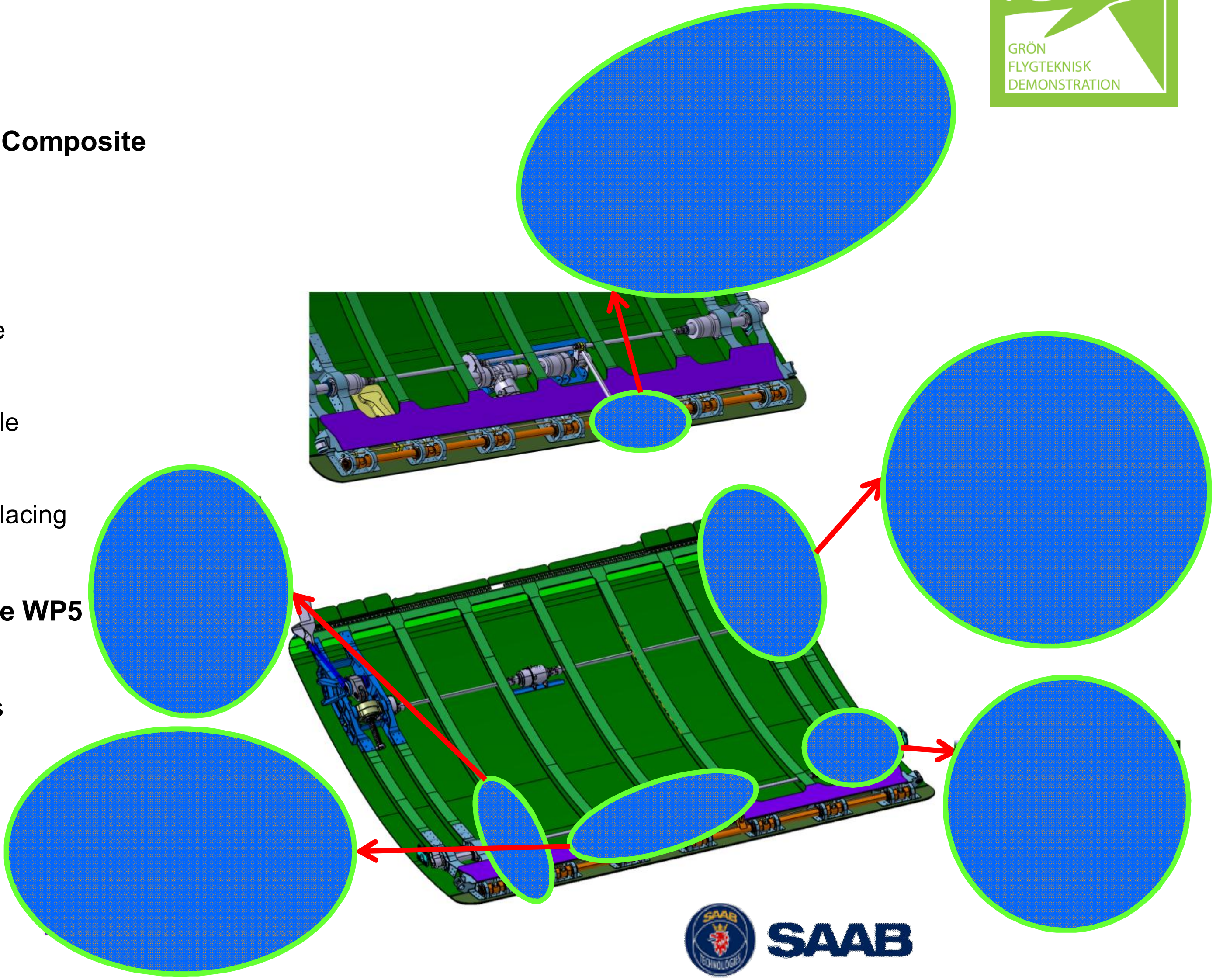
b) Shear force fitting and failsafe
- Optimized placement

c) Latch, Pull In, Lock and Handle
- Integration Latch / Pull In
- Lock system
- Smaller Handle Box central placing
- No Vent-door on Demo-door

Mechanical system interface WP5 and Composite box:

d) Lift system
- Load paths and internal loads
- Build-philosophy sealant

e) Latch and Pull In
- Ongoing



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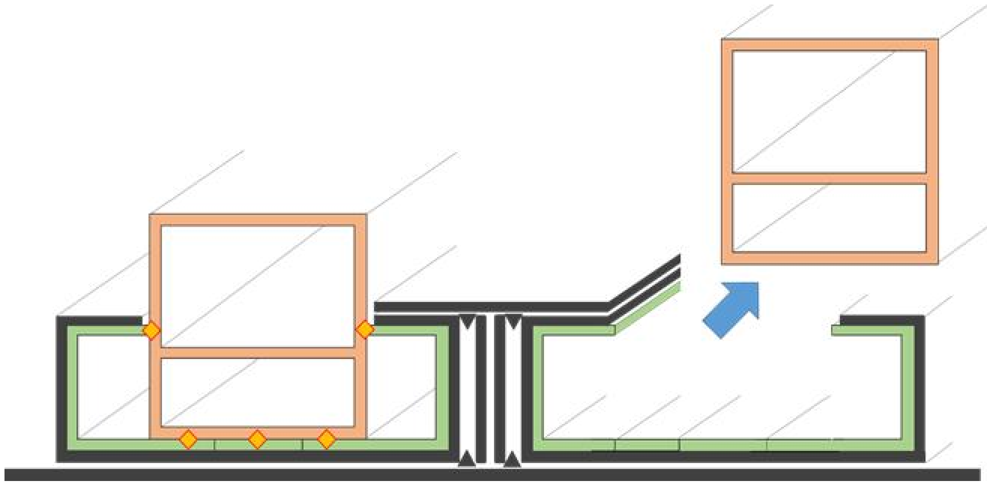
WP 6.3 MANUFACTURING SYSTEM FOR THE DOOR DEMONSTRATOR

- A door demonstrator will be manufactured within GFDemo
- The demonstrator door contains several parts e.g. integrated curved frames
- Compraser Labs will contribute within this WP
  - Frame hot drape forming
  - Manufacturing of composite parts
  - Furthermore, will Compraser Labs be the arena where the final assembly and systems integration of the demonstrator door will take place



Door demonstrator tool concept

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WP 6.3 MANUFACTURING SYSTEM FOR THE DOOR DEMONSTRATOR

Hot Drape Forming → Manufacturing System → Arena for final assembly

Status

- Plan project work together with SAAB
- Hot Drape forming project startup
- Manufacturing system project startup
    - (Manufacturing) Simulation will be performed by a Master Thesis

Study of the demonstrator and the Boeing 787 Cargo door

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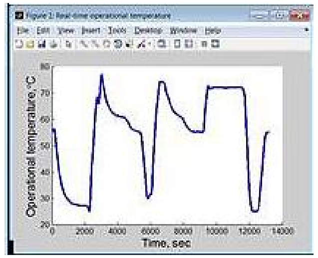
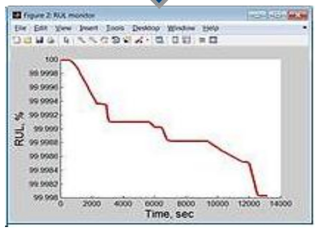
WP 7.1 PROGNOSTICS OF REMAINING USEFUL LIFE (RUL) OF LEAD-FREE ELECTRONICS

Aim:

- To evaluate the feasibility of embedded prognostics of RUL for lead-free electronics, and pave the way for potentially continued actions in the form of a demonstrator project



Measured Environmental loads



Remaining useful life

Work packages in four main areas:

- Statistical analysis of uncertainties of life predictions, depending on various parameters, such as material variations and modeling assumptions
- Life prediction of printed circuit board assemblies (PCBA)
- Calculation of thermomechanical fatigue of solder joints
- Requirements definition for logger hardware

Spin-offs:

- Our understanding of physics of failure will increase, both for lead-free and lead-containing electronics. Furthermore, parts of the result of the pre-study will be immediately applicable in the context of reliability predictions.

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

WP 7.2 POTENTIAL IN ULTRASONIC DRILLING

Source: SAUER GmbH / Ultrasonic (DMG MORI)

Properties

Piezo-electric generation of axial vibrations over 20 kHz in the cutting tool gives improved cutting conditions, reduced cutting forces and reduced temperature in the cutting zone.

Potential (ref Acoustech systems)

- Existing machinery and cutting tools can be used.
- Feed rates can be doubled with maintained cutting forces. Alternatively with maintained feed rates the cutting forces can be cut to half.
- Wear of life can be increased up to 4 times.
- Increased quality in hole cylindrical surface
- Reduced burrs.

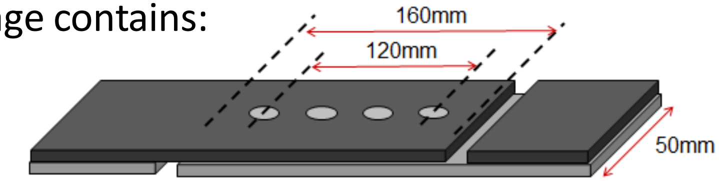
Source: ACOUSTECH systems

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

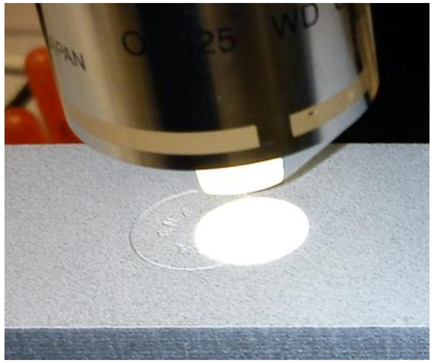
WP 8 SURFACE RECOVERY OF LAMINAR FLOW SURFACES WHEN REPAIRED AND AT LOCAL REINFORCEMENT

To reduce drag and thereby environmental impact from aircrafts there are very high demands on surface finish for all surfaces in contact with air.

There is a need for methods to recover the finish for all types of imperfections at the surface. In WP8 robust investigations will be conducted to restore the surface finish at fastener locations for various fillers. The work package contains:



- Evaluation of different fillers
- Manufacturing of 30 specimens
- Static testing in various environmental conditions (hot and cold)
- Develop and verify a FE-simulation model that capture the deformation of the fastener during loading.



Microscopic image of a mounted fastener, Emil Hedlund, Sicomp

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

WP 9 SPRING-BACK ANALYSES ON COMPOSITE ARTICLES WITH TOOL PART INTERACTION

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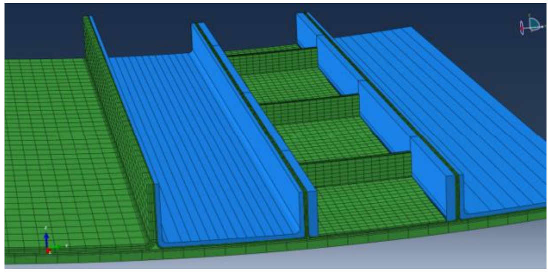
Objective:

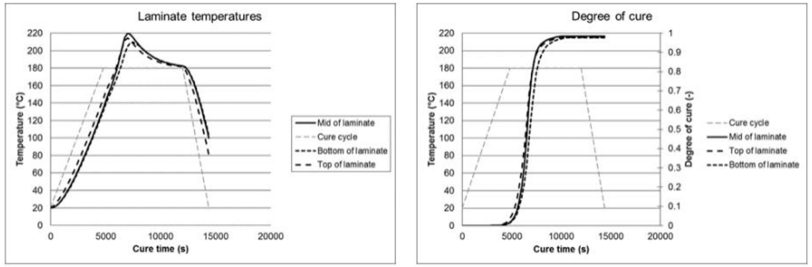
Further development of process modelling tools to enhance and refine the ability to perform manufacturing process simulation of composite structures and related stress issues.

Work packages two main objectives:

- Develop simulation methods for analysis of the interaction between tool and article before de-molding
- Simulation of the curing with respect to the temperature inside the laminate and degree of cure.



Fe-model for simulation of tool-part interaction. Article in green and aluminum tooling in blue.
By K. Giannadakis, Sicomp



Cure simulation showing maxmum inner temperature and degree of cure as function of cure time.
By Jesper Eman and Rolf Lundström, Sicomp

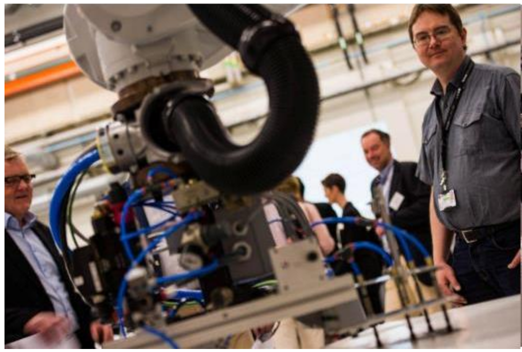
SAAB swerea|SICOMP

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

NATIONAL ARENA –
BUILDING UP COMPRASER LABS

- Building up the laboratory
  - Moving in March 2014, inauguration May 2014
  - Swerea SICOMP and Swerea IVF invest with their own funds and resources
- Prioritized list of equipment
- Competence mapping
- Equipment inventorying within the network
- Initiate strategy for development of Compraser Labs

Results in the project



The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

PROJECTS BENEFITS OCH EXPLOITABILITY

GRÖN
FLYGTEKNISK
DEMONSTRATION

Contribute to new civil business, growth within Swedish aircraft industry

- Support concept work for new products
- Increased competitiveness for new business
- Increased employment in Sweden as a result of the new business

Contribute to new technologies demonstrated in products and systems

- Bring forward step change technologies which will contribute to Saab future product range

Strengthen Swedish role in future international demonstrators

- Create a solid platform for Saab and partners to participate in international projects

Strengthen the competence for small/medium businesses/suppliers and also universities, colleges and institutes

- Collaborate with academic institutions and Swedish small/medium companies in an important technical development phase of future products, they will also gain experience of international collaboration

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667

THANK YOU

Key Project Results:
* ~20% Reduction in weight
* Reduced manufacturing cost
* Reduced environmental impact

www.gfdemo.se

The research leading to these results has received funding from VINNOVA under program n*2012-01031 and n*2013-04667