EVOLUZIONE DI UN'AZIENDA AERONAUTICA

DA COSTRUIRE A DISEGNO A COSTRUIRE A SPECIFICA

«BUILD TO PRINT» TO «BUILD TO SPEC»

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Definizione

"Build to Print" è il processo attraverso il quale un'azienda (fornitore o «supplier») realizza componenti, equipaggiamenti o sistemi, in accordo alle specifiche tecniche dettate dal proprio committente (cliente o «customer») che specifica i requisiti funzionali, realizza i **disegni** di dettaglio e d'assieme, decide **le metodologie di produzione** e realizza i **cicli di lavoro** e le **istruzioni di montaggio** che saranno utilizzati dal fornitore per produrre quanto richiesto nel documento "SoW" (Statement of Work).

Build to Print (B2P)

L'approccio "Build to Print"

- ✓ Consente al «Customer» di mantenere il controllo della Proprietà Intellettuale, del know-how e dei brevetti associati ("IPR") e quindi di avere **l'abilità** di selezionare il miglior «Supplier» per il prodotto

- ✓ Necessita di un'accurata fase di selezione del fornitore da parte del «Customer» e di continue verifica delle capacità produttive del «Supplier» attraverso periodici "**AUDITS**"

- ✓ Richiede maggior lavoro e costi di sviluppo per il «customer» che rimane **responsabile del progetto** e delle eventuali problematiche di qualità ad esso collegate

Un'azienda "Supplier" strutturata per la realizzazione del prodotto attraverso il processo "Build to Print", sviluppando adeguate competenze e capacità, ha come naturale prospettiva l'evoluzione verso la connotazione di "Supplier" Build-to-Spec

Definizione

Il processo "Build-to-Spec“ si configura quando un’azienda (committente o «customer») seleziona un fornitore o «supplier» per realizzare un componente, un assieme, o un sistema sulla base di specifici requisiti dimensionali, funzionali e prestazionali.

Con la Specifica Tecnica del “customer” e lo *SoW* vengono definiti i vincoli di progetto ed i relativi gradi di libertà, ma in ultima analisi il «Supplier» è libero di utilizzare le proprie “***competenze***“ ed il proprio “***know-how***” per progettare ed produrre quanto commissionato.

Nel processo «Build to Spec» il «Supplier» realizza i **disegni** di dettaglio e d’assieme, decide **le metodologie di produzione** e realizza i **cicli di lavoro** e le **istruzioni di montaggio** in base all’esperienza ed alle proprie competenze per soddisfare i requisiti della Specifica Tecnica secondo l’approccio di lavoro definito nel documento “SoW” (Statement of work)

Build to Spec (B2S)

Con l'approccio "Build to Spec"

- ✓ Il fornitore «Supplier» detiene la piena responsabilità dell'intero progetto incluso qualità, affidabilità e conformità ai requisiti definiti nella Specifica Tecnica.

- ✓ I disegni produttivi, le relazioni tecniche di dimensionamento e i parametri di processo sono di proprietà del «Supplier» che esercita il diritto della Proprietà Intellettuale «IPR», sgravando il cliente della "onere" di mantenere in casa competenze che non costituiscono il "core business" dell'azienda.

Tale approccio ovviamente facilita l'integrazione verticalizzata nel "business" da parte di "Suppliers" intraprendenti, ma soprattutto capaci e competenti

«BUILD TO PRINT» TO «BUILD TO SPEC»

	B2P (Build to Print)	B2S (Build to Spec)
Costi	Più alti per il cliente	Più alti per il fornitore
Competenza/Expertise	Cliente	Fornitore
IPR	Cliente	Fornitore
Responsabilità del Progetto	Cliente	Fornitore
Responsabilità Qualifica/ Certificazione	Cliente	Fornitore

Un'azienda seleziona un fornitore per un progetto "build-to-print" quando non ha le competenze e le specializzazioni disponibili per il prodotto che intende realizzare, o quando non dispone della capacità (risorse, spazi etc.) o delle attrezzature necessarie allo scopo.

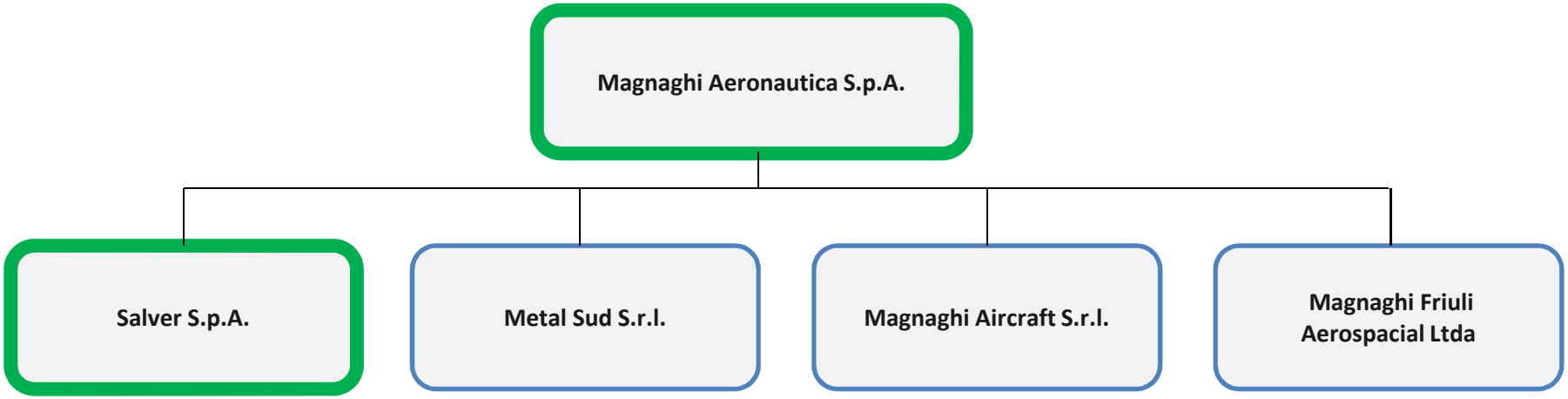
Un progetto "build-to-spec" viene commissionato dal «Customer» per prodotti che non costituiscono le competenze distintive e il "core business" identificative della propria azienda. (i.e. Produttore di Aerei commissiona parti - strutturali e non- e/o equipaggiamenti/sistemi)

…da “build-to-print” a “build-to-spec”

L’evoluzione di Magnaghi & Salver

Magnaghi Aeronautica Group

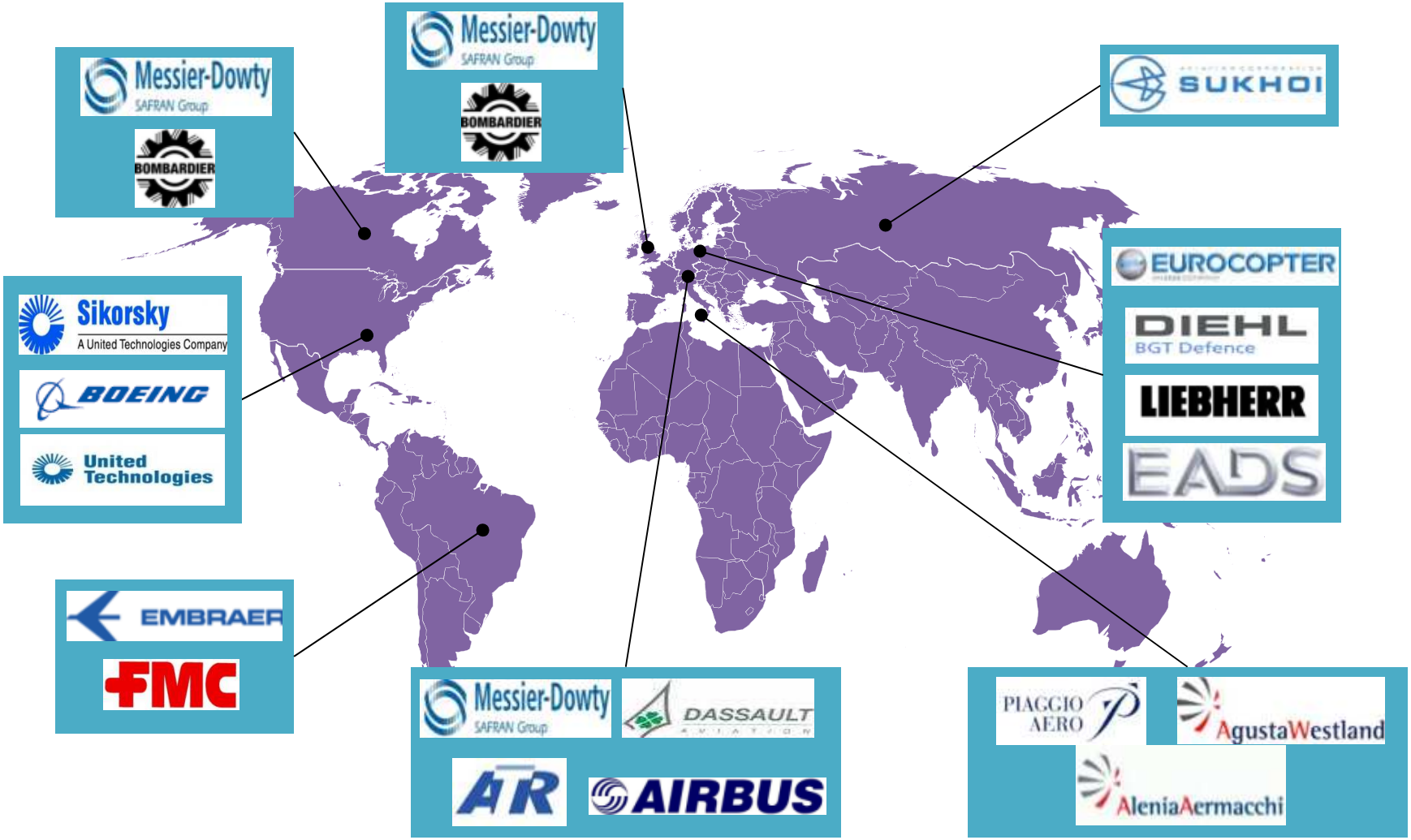
Aeronautical Sector



SALVER

MAGNAGHI AERONAUTICA SpA

The group manages long-term relationships with top customers worldwide (major OEMs in fixed and rotary wing sectors)



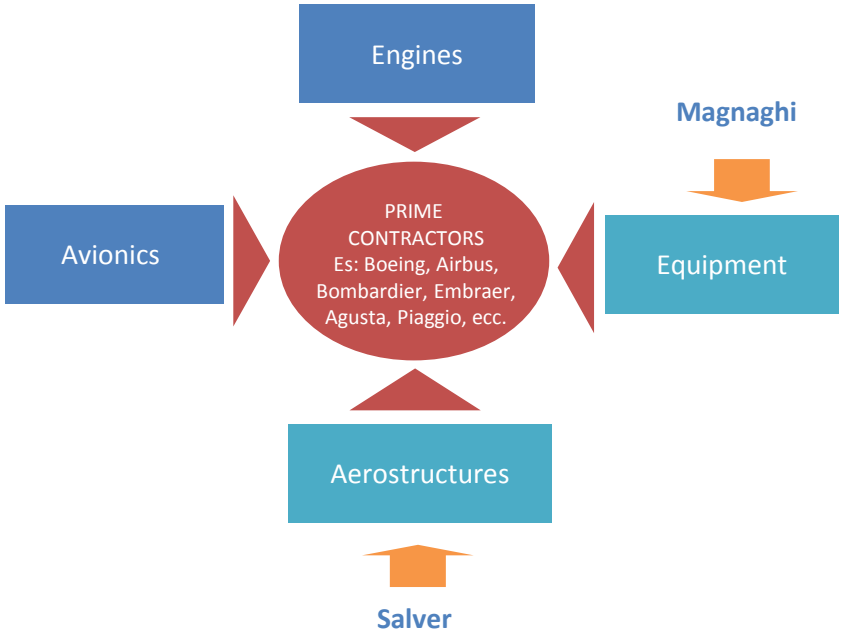
Magnaghi and Salver positioning

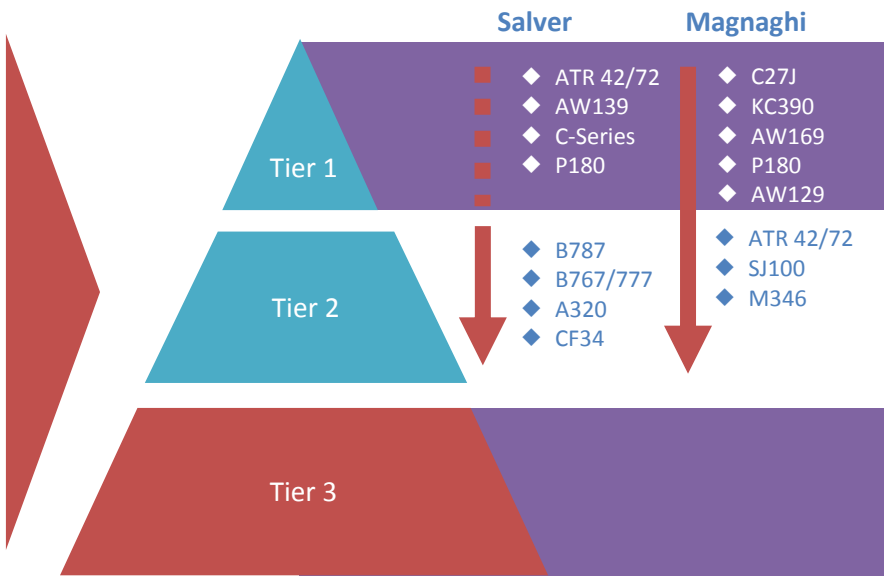
Aeronautical Sector Industry Structure

- The aerospace manufacturing industry is generally divided into four sub-components segments, with integration expertise of sub-components remaining at Prime Contractor level
- Magnaghi refers to the Equipment segment, while Salver is fully focused on composite-based aero-stuctures

Value Chain

- The industry value chain comprises three levels beneath the Prime Contractor/Integrator (the OEM) with increasing value-add activity (and complexity) further up the chain
- Over the last decade, through the development of increasingly sophisticated capabilities (including design), accreditations and approvals, Salver has sought to move up the value chain into higher value-add activities typical of the Tier 1 supplier





Positioning of Magnaghi & Salver

Business Overview

	Magnaghi Aeronautica S.p.A.	Salver S.p.A.
Main Activities	◆ Design, development, qualification, and production of Landing Gear and Actuation Systems, hydraulic and mechanical components ◆ Offered portfolio includes MRO services	◆ Design, development, qualification, and production of composite material components and structures
Key Programs & Customers	◆ Military: EFA, AMX, C27J, G222, A129, NH90, M346, KC390 ◆ Commercial: ATR 42/72, AW169, C Series, SJ100, P180 Avanti III	◆ Military: C27J ◆ Business Jets: Falcon 2000, P180 ◆ Civil: C Series, Boeing (incl. B787), Airbus (incl. A380), AW 139
Production Plants & Staff	◆ ~28,000 sqm Naples site ◆ ~300 employees	◆ ~50,000 sqm Brindisi site ◆ ~290 employees

Magnaghi positioning (selected programs)

Prime Contractor	AleniaAermacchi	ATR	EMBRAER	Eurofighter Typhoon	AgustaWestland	AleniaAermacchi	SUKHOI	DIEHL Defence
Programs	C27J	ATR 42/72	KC390	EFA	AW169	M346	SJ100	IRIS-T
Products	NLG/MLG	NLG/MLG	CDAS Stab Strut	Up Locks and other equipment	LG System	LG Components	LG Components	Motor Case
Tier 1	Magnaghi	Messier-Dowty SAFRAN Group	Magnaghi	Messier-Dowty SAFRAN Group	Magnaghi	LIEBHERR	Messier-Dowty SAFRAN Group	Magnaghi
Tier 2	Magnaghi	Magnaghi		Magnaghi		Magnaghi	Magnaghi	

Magnaghi is generally positioned in the Value Chain as Tier 1/ Tier 2 supplier, developing and manufacturing complete landing gear systems and complex components

Salver positioning (selected programs)

Prime Contractor	BOEING	BOEING	AIRBUS	AIRBUS	GE	BOMBARDIER	AgustaWestland / AleniaAermacchi	AleniaAermacchi	PIAGGIO AERO
Programs	Boeing B787	Boeing B767/777	Airbus A320	Airbus A380	GE CF34	Bombardier C-Series	Agusta Westland AW139	ATR 42/72	Piaggio P180
Products	Nacelle components	Radome and panels	Belly fairings	Nacelle components	Fan cowls	Multiple components	Composite Parts	Multiple components	Multiple components
Tier 1	United Technologies	AleniaAermacchi	eurocopter	Aircelle (Groupe SAFRAN)	AleniaAermacchi	SALVER	SALVER	SALVER	SALVER
Tier 2	SALVER	SALVER	SALVER	AleniaAermacchi	SALVER				
Tier 3				SALVER					

Salver is tipically positioned as a Tier 1/ Tier 2 supplier on the ongoing contracts

Intellectual property programs portfolio

Thanks to highly-skilled engineering dept, Magnaghi Group claims numerous intellectual property programs

Program	Technical Description
Alenia Aermacchi C27J	Landing Gear
	Actuation system
	Steering system
Agusta Westland AW169	Landing Gear Electro-Mechanical Actuation System
NH Industries NH90	Deck lock actuator
	Deck lock hydraulic unit
Piaggio Aerospace P180	Landing Gear Actuation System
Alenia Aermacchi M346	LG Actuation system
Alenia Aermacchi Sky x	Landing Gear Electro-Mechanical Actuation System Steering System
Embraer KC 390	Cargo Doors & Ramp Actuation System
	Stabilizer Strut System
Agusta Westland AW 129	Landing Gear
Agusta Westland AW 109	Landing Gear
ATR 72	Tail Bumper
Bombardier C Series	Wing Structural Components

Magnaghi Production Evolution

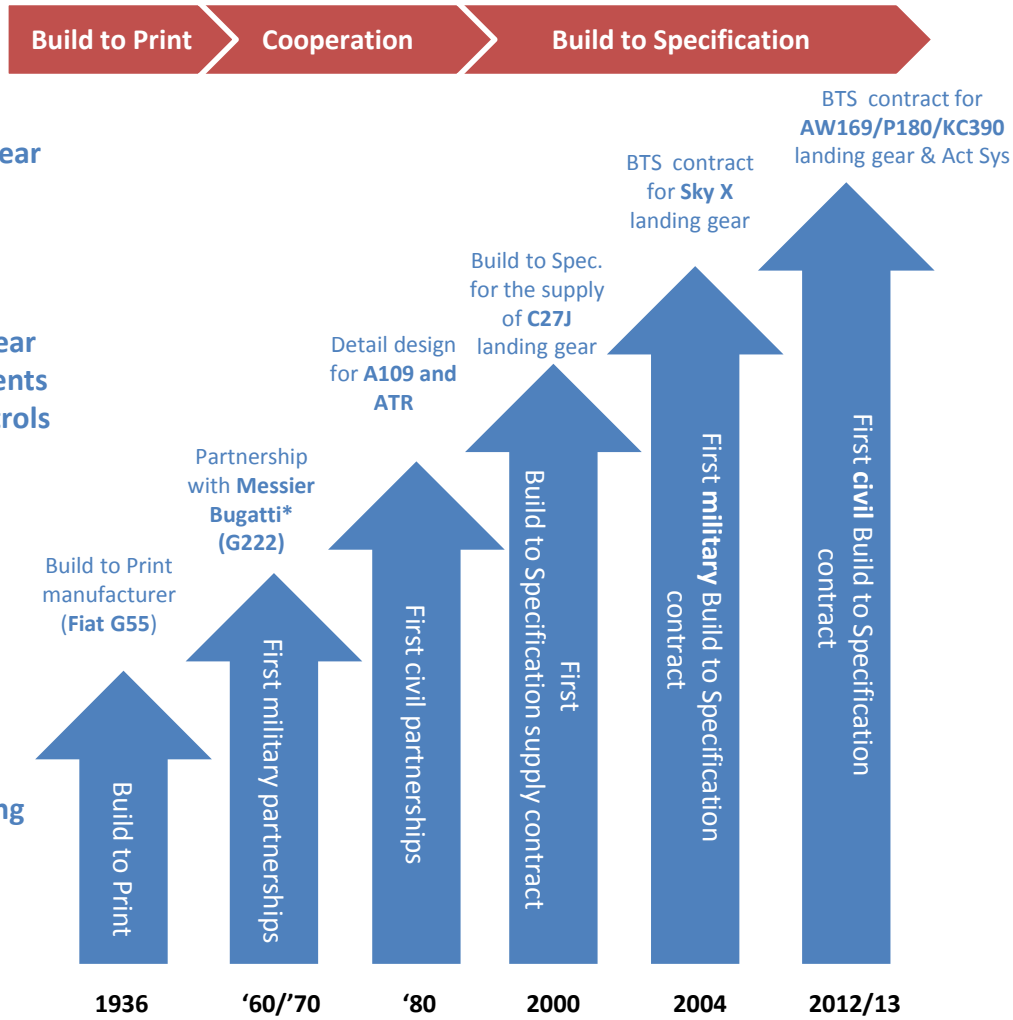
Development & design

Manufacturing

Assembly

MRO

- **Design, analysis, test and qualifications for landing gear and Actuation Systems**
- **Production of all landing gear and actuation sys components**
- **Final tests and quality controls**
- **Landing gear "top assy" e "sub assy" assembly**
- **Assistance and MRO landing systems**

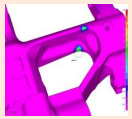


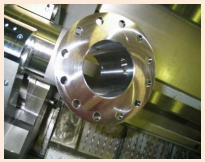
*= today Messier-Dowty

Magnaghi Facilities and production process

- **Product Life Cycle**
  - ❑ Magnaghi is able to follow the entire process from concept to in-service maintainance

Raw material storage → RAW Material cutting and delivery → Rough machine → Heat treatment → Fine machining → Dimensional adn NDT inspection





Special processes → Honings / Bushings Inst. → Paintings → Assembly → Testing → Delivery

In-house → Make or Buy

Progetti Magnaghi Build-to-Print

Fixed Wings - Commercial

Program		System
ATR 72/42		Main and Nose Landing Gears
SJ-100		Main Landing Gear Components

Progetti Magnaghi Build-to-Print

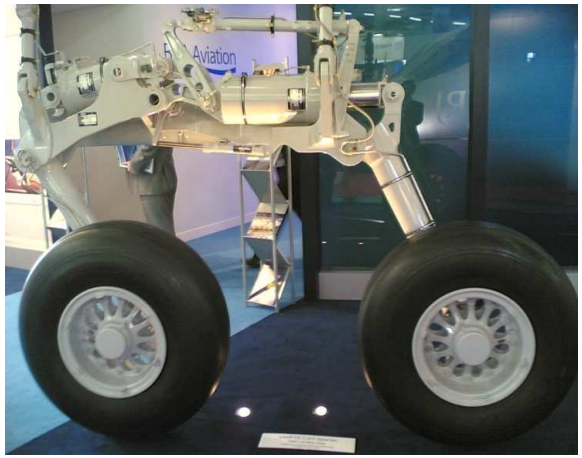
Fixed Wings – Transport & Defence/Trainer

Program		System
EFA		R/E system components
AMX		Nose Landing Gear
G-222		Landing Gear System

Progetti Magnaghi Build-to-Spec

Fixed Wings - Transport

Program		System
C-27J		Landing Gear System



Progetti Magnaghi Build-to-Spec

Rotary wings

Program		System
T-129		Main and Nose landing Gears
AW-109		Main and Nose Landing Gears
NH-90		Deck Lock System
AW-169		Landing gear System

Progetti Magnaghi Build-to-Spec

Fixed Wings - Commercial

Program		System
ATR 72/42		Tail Bumper
P-180		Nose and Main Landing Gears

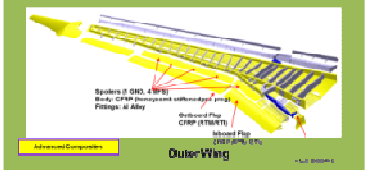
Progetti Magnaghi Build-to-Spec

Fixed Wings – Defence/Trainer

Program		System
M-346		R/E System

Salver Production Evolution

Development & design



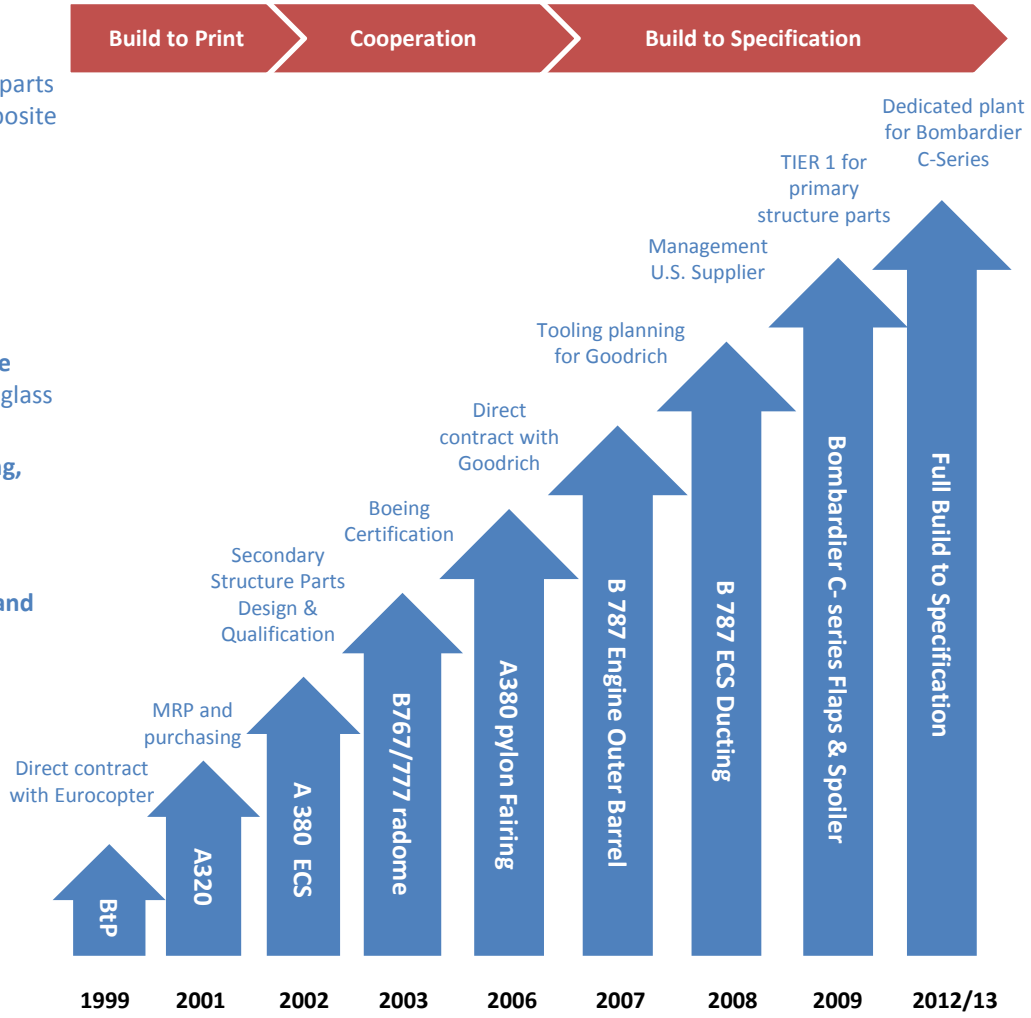
- **Design, analysis, test and qualifications** for structural parts and final assemblies in composite material
- **R&D** of new composite technology

Manufacturing

- **Manufacturing of composite parts** (carbon fiber, aramid, glass fibers, etc.)
- **CNC machines for laminating, drilling, cutting prepregs, contouring using laser instruments**
- **Design and Planning Tools and Jigs**

Assembly

- **Managing entire process of assembling composite complex structures**



Salver facilities and production process

- **Salver retains in-house only high value-added and special process activities, which include**
  - Design engineering
  - Production engineering (tooling and jig design)
  - Prepreg storage, Prepreg cutting, Prepreg lay-up
  - Autoclave cured parts
  - NC machining
  - Manual trimming (high value)
  - NDI
  - Assembly
  - Painting and some surface treatments

- **The company outsources low value-added, commoditized activities including**
  - Sheet metalworking
  - Plaster/fabric separation
  - Manual trimming (low value)
  - Machining of metallic parts and sheet metal
  - Heat treatments for metallic parts
  - Metallic surface protection treatments (galvanic, priming)
  - Some painting

Laboratory

Automatic cut of prepreg "LECTRA"

Clean Room

Controlled Measurement Machine "DEA"

Autoclaves

NDI Machines

Machining

Progetti Salver Build-to-Print

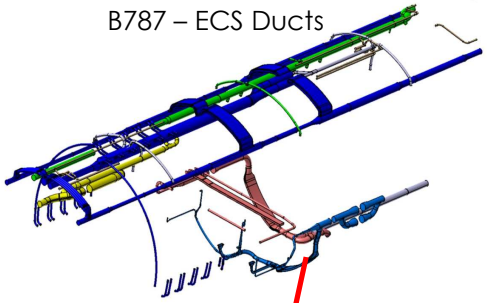
B767 / B777 Radome Assy

Epoxy/Glass sandwich structure

B787 – Inlet Outer Barrel

CFRP laminate & sandwich structure

B787 – ECS Ducts



Kevlar laminate & sandwich structure

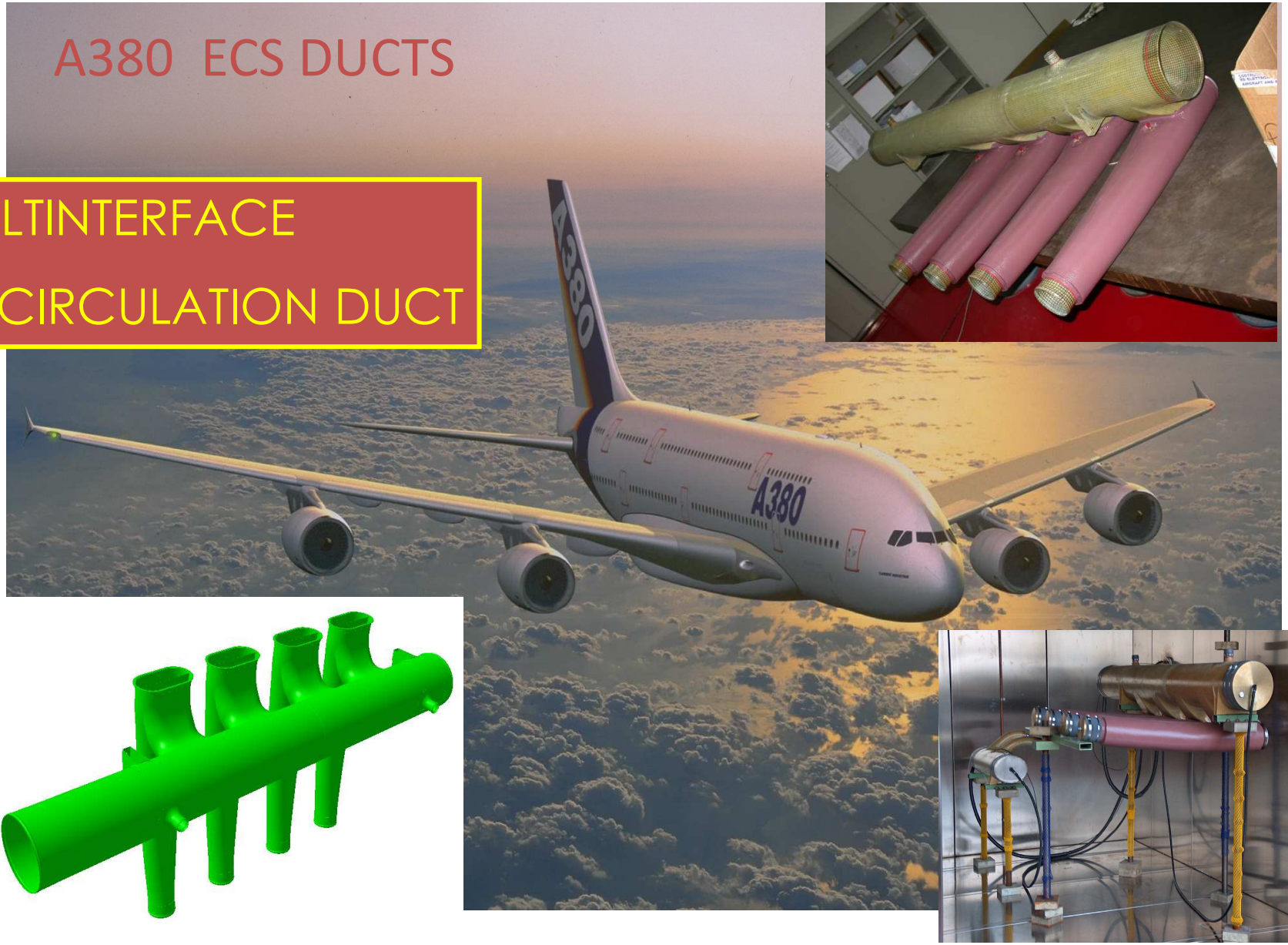
A380 ECS – Fan Cowls

A380 ECS – Composites Ducts

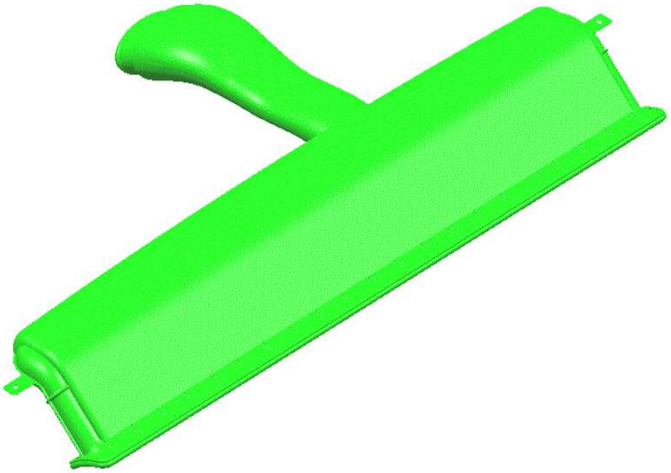
Multinterface, Outlet, Oval Ducts Made of hybrid prepreg

AW139 – Tail Plane

Progetti Salver Build-to-Print



A380 ECS DUCTS

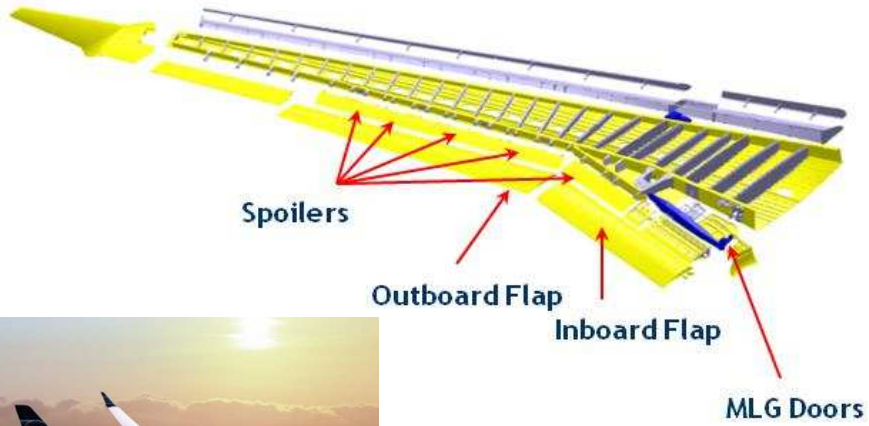


OUTLETS/DIFFUSERS

Salver Project Build-to-Spec

Bombardier C-Series

- Bombardier's new C-Series program consists of two models (C110 and C130) of a commercial, single-aisled regional aircraft designed to carry between 100 and 150 passengers
- Once in operation, the C-Series is planned to have the lowest operating costs in its class
- Salver is a Tier 1, single source supplier to its customer Bombardier
- Assemblies supplied by Salver include
  - Inboard and Outboard flaps
  - Ground and Multi-Function spoilers
  - Main landing gear bay doors

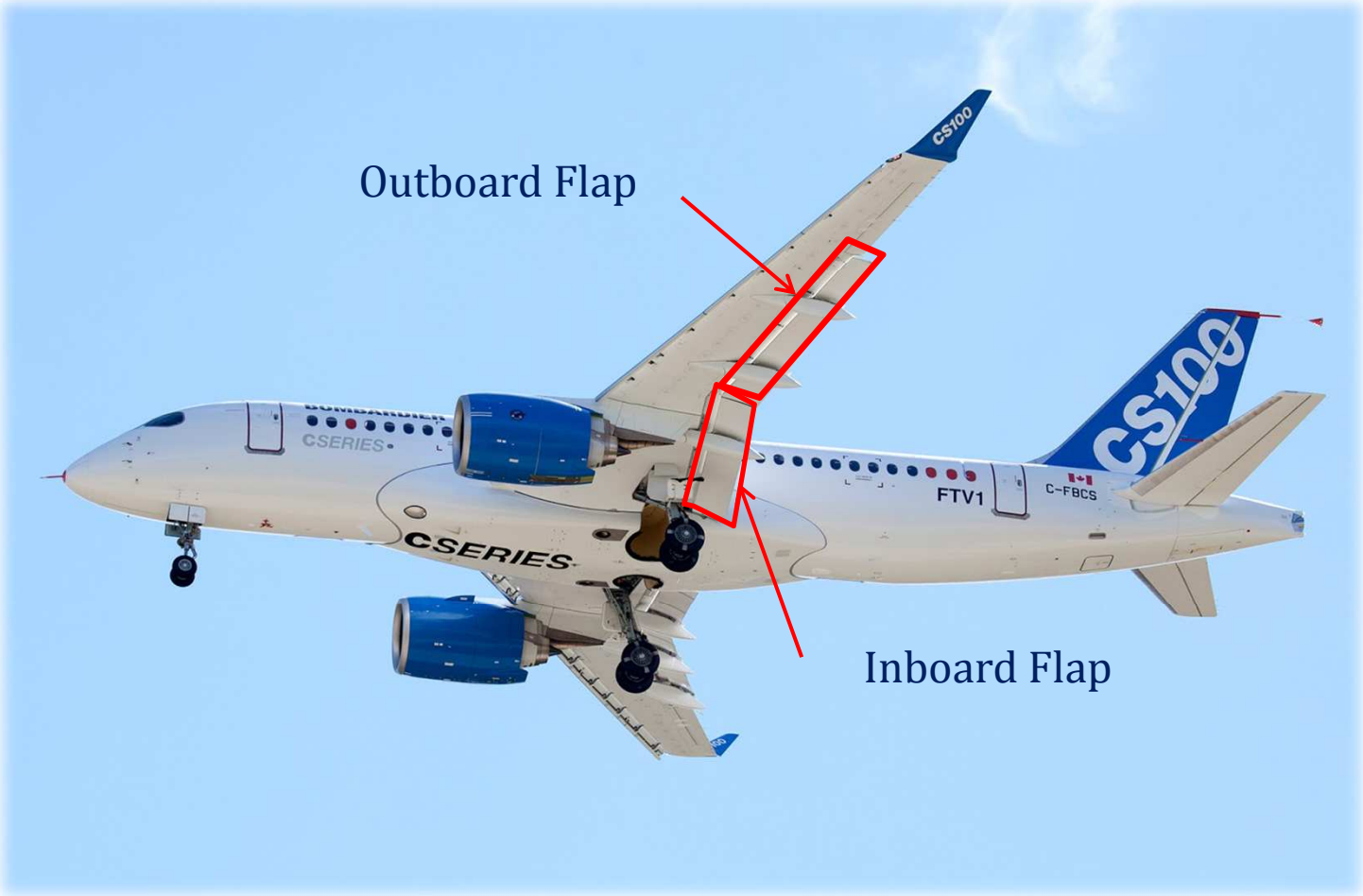


Salver's first BtS program, with full responsibility for design, testing, certification and production

Salver Project Build-to-Spec

Primo volo prototipo sperimentale C-Series avvenuto a Montreal 16 Settembre 2013

La Certificazione per l'ntrata in servizio è attesa per Dicembre 2015



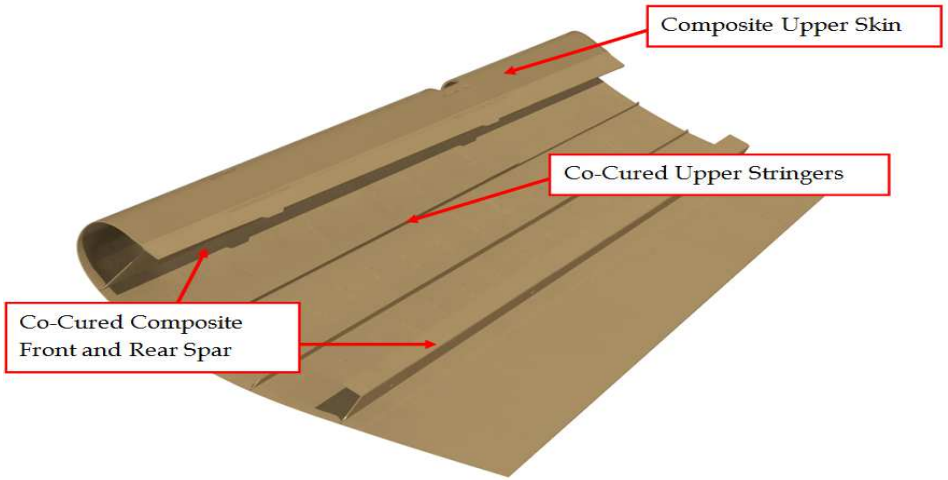
Descrizione dell'architettura del Flap

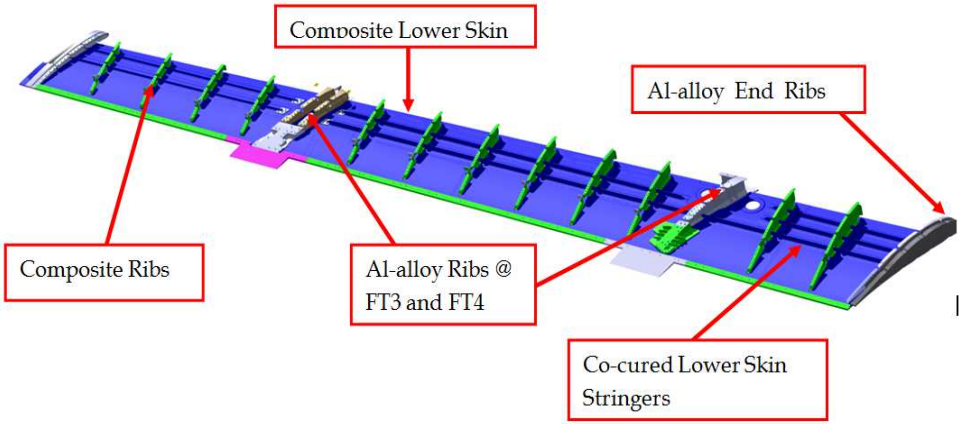
MAGNAGHI AERONAUTICA SpA

STRUTTURA INNOVATIVA IBRIDA DI MATERIALE COMPOSITO IN FIBRA DI CARBONIO E PARTI METALLICHE IN LEGHE LEGGERE

Parti metalliche
#1 Rib di chiusura macchinata in alluminio lato inboard
#1 Rib di chiusura macchinata in alluminio lato outboard
#2 *back to back rib* in corrispondenza degli attachi del track 3
#2 *back to back rib* in corrispondenza degli attachi del track 4

Parti in composito
Upper skin "*cocured*" con il fornt spar il leading edge e gli elementi di irrigidimento longitudinali "*stringer*"
Lower skin "*cocured*" elementi di irrigidimento longitudinali "*stringer*"
#12 rib





…da “build-to-print” a “build-to-spec”

Certifica delle strutture in materiale composito

Part 1

- Il processo di certifica. Controllo e qualità del materiale prodotto
- Certificazione del prodotto.
- Test (Il *Building-block approach* (MIL-HDBK-17-1F)

La fornitura: *“Extended Enterprise” – Supply Chain System*

Part 2

- La struttura della “Supply Chain”; Integrazione e logistica

Project Management

Part 3

- L’evoluzione del *Project management*

Investimenti

Part 4

- *Partener* and *Stakeholder*
- Gestione del rischio. “*Risk sharing*”

Materiali Compositi

Ref. MIL-HDBK-17-3E

…Quality conformance tests are needed to assure the continued integrity of a characterized material system. The tests performed must be able to characterize each batch/lot of material so a proper assessment of critical properties of a material system can be made. These critical properties provide information on the integrity of a material system with regard to material properties, fabrication capability, and usage. Additionally, the test matrix must be designed to economically and quickly evaluate a material system…"

Il controllo qualità in ambiente produttivo richiede l'ispezione ed il test del composito in ogni fase dalla realizzazione del materiale fino alla produzione della parte specifica.

I test di ispezione devono essere effettuati separatamente per la resina, le fibre ed il laminato (fabric o tape)

In particolare per il prepeg sono necessari test di ispezione in tutte le fasi: ricezione, messa in opera e realizzaione della parte mediante test non distruttivi e distruttivi sia su parti campioni che sul componente finito.

Materiali Compositi - Tipici test di ricezione/accettazione

Ref. MIL-HDBK-17-3E

Typical acceptance and revalidation tests required for suppliers and users.

PROPERTY	TESTING REQUIRED			SPECIMENS REQUIRED PER SAMPLE
	PRODUCTION ACCEPTANCE (SUPPLIER)(3)	PRODUCTION ACCEPTANCE (USER)(3)	REVALIDATION (USER)(3)	
Prepreg Properties				
Visual & Dimensional	X	X		-
Volatile Content	X	X		3
Moisture Content	X	X	X	3
Gel Time	X	X	X	3
Resin Flow	X	X	X	2
Tack	X	X	X	1
Resin Content	X	X		3
Fiber Areal Weight	X	X		3
Infrared Analysis	X			1
Liquid Chromatograph	X	X	X	2
Differential Scanning Calorimetry	X	X	X	2
Lamina Properties				
Density	X			3
Fiber Volume	X			3
Resin Volume	X			3
Void Content	X			3
Per Ply Thickness	X	X	X	1
Glass Transition Temp	X	X	X	3
SBS or ±45° Tension	X(2)	X(2)	X(2)	6
90°/0° Compression Strength	X(1)	X(1)	X(2)	6
90°/0° Tension Strength & Modulus	X(2)	X(2)	X(2)	6

(1) Tests shall be conducted at RT/Dry and Maximum Temperature/Dry (See Volume I, Section 2.2.2).
(2) Tests shall be conducted RT/Dry.
(3) Supplier is defined as the prepreg supplier. User is defined as the composite part fabricator. Production acceptance tests are defined as tests to be performed by the supplier or user for initial acceptance. Revalidation tests are tests performed by the user at the end of guaranteed storage life or room temperature out time to provide for additional use of the material after expiration of the normal storage or out time life.

Receiving inspection: l'utilizzatore del material composito prepara le specifiche dei controlli in accettazione del material

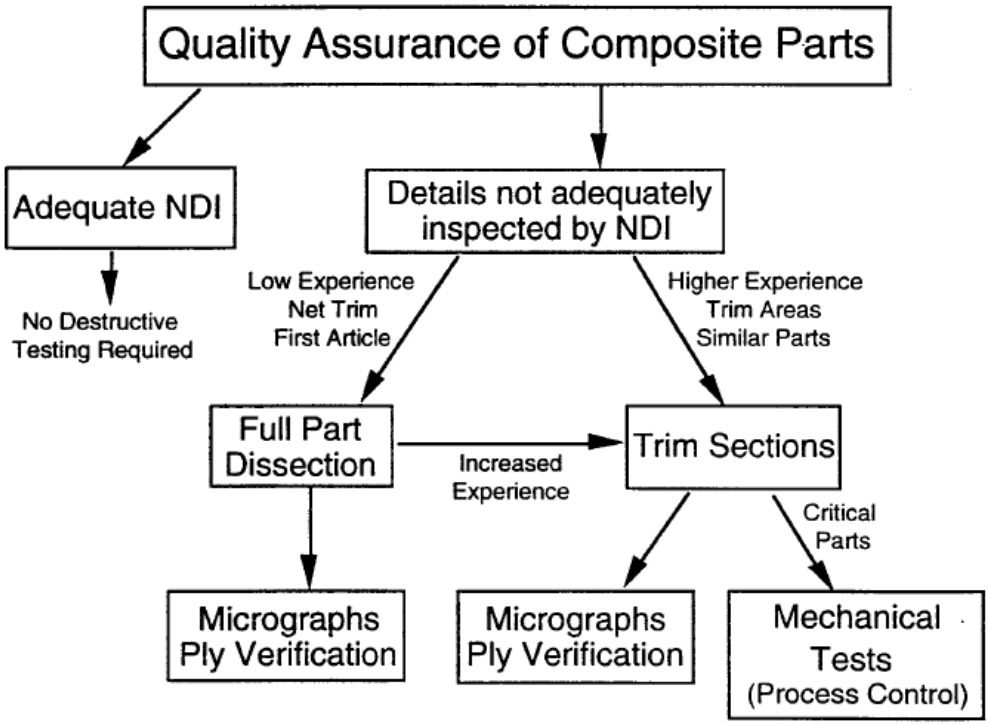
Per assicurare che incontri i requisiti caratteristici definiti dal dipartimento di Ingegneria

Process verification: L'ente Assicurazione Qualità has la responsibilità di verificare che I processi a cui è sottoposto il materiale siano in linea con le specifiche definite dalla Progettazione. Assicura quindi:

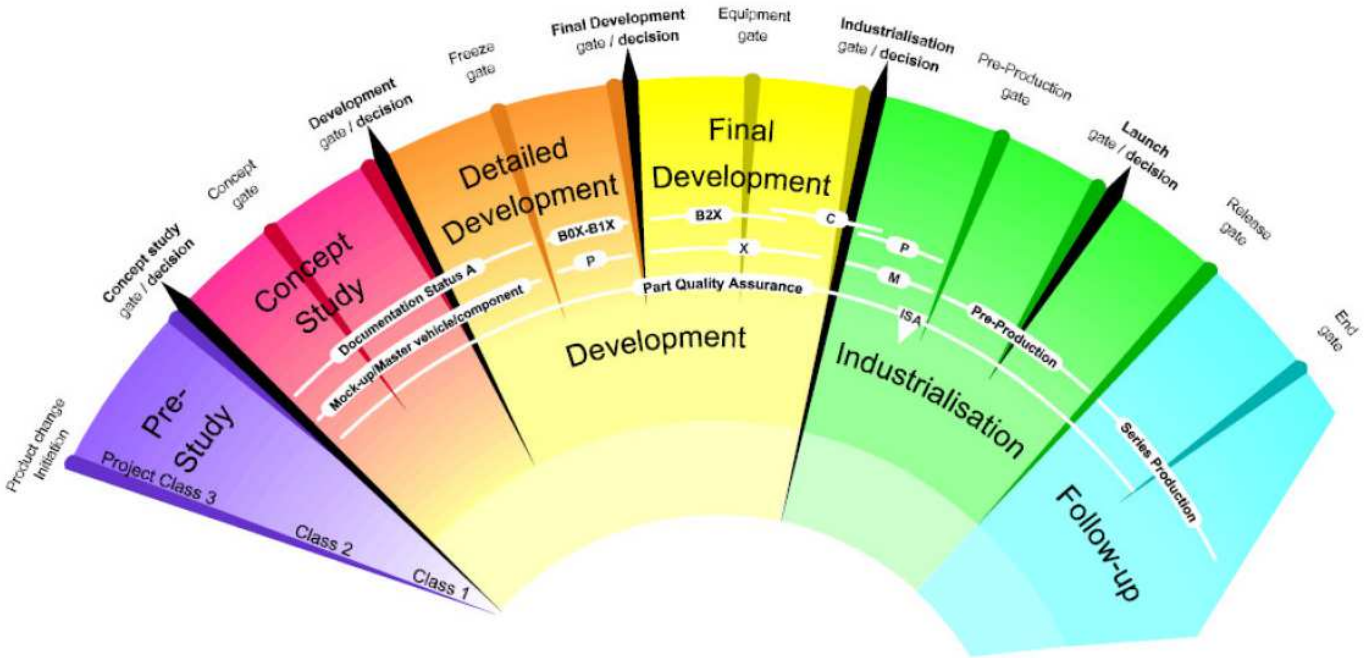
- Handling e conservazione del Materiale
- Idoneità delle attrezzature e degli strumenti con cui si lavora
- La cura delle Parti
- Il Processo di Controllo dei campioni

The Composite Material

Destructive tests: Spesso, quando non è possibile assicurare l'integrità strutturale del material attraverso mezzi e metodi non distruttivi, sono necessarie prove distruttive.
Queste prove prevedono periodici sezionamenti a campione delle parti che hanno struttura complessa.



Global Development Process



Process Certification: Technologies Readiness plan

TECHNOLOGY READINESS LEVEL

		Maturity Stages
TRL 1	Conceptual Idea	TECHNOLOGY READINESS
TRL 2	Patent searches made, Conceptual schemes available, Manufacturing concepts defined	
TRL 3	Materials investigations started, Manufacturing concepts investigated,	
TRL 4	Preliminary Material available (new), Prelim Tooling available, Manufacturing Trials started	APPLICATION READINESS
TRL 5	Manufacturing Trials completed, Limited Material qualification data available (Coupons, T's etc)	
TRL 6	Product concepts frozen, Static & Fatigue testing underway, Material Allowable available, Prototype built and tested in representative environment	
TRL 7	Manufacturing Processes qualified, Production solutions (design & manufacturing) qualified PPV	PRODUCTION READINESS
TRL 8	Production Ready Technology, Requires Certification, Flight trials underway Start with Production	
TRL 9	Fully Productionised Technology, Flight Certified and flying with customer	

Process Certification: Technologies Readiness plan

Development manufacturing plan

- **Verify tooling performances, manufacturing process and method**
- **Validation and optimization of manufacturing phase**
- **Identification of manufacturing process parameter**

Flat charge lamination

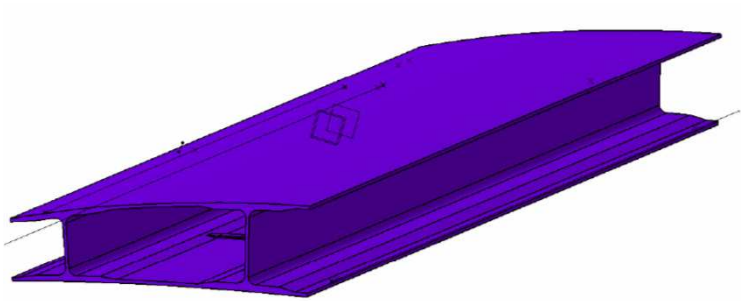
Stringer wet-assy

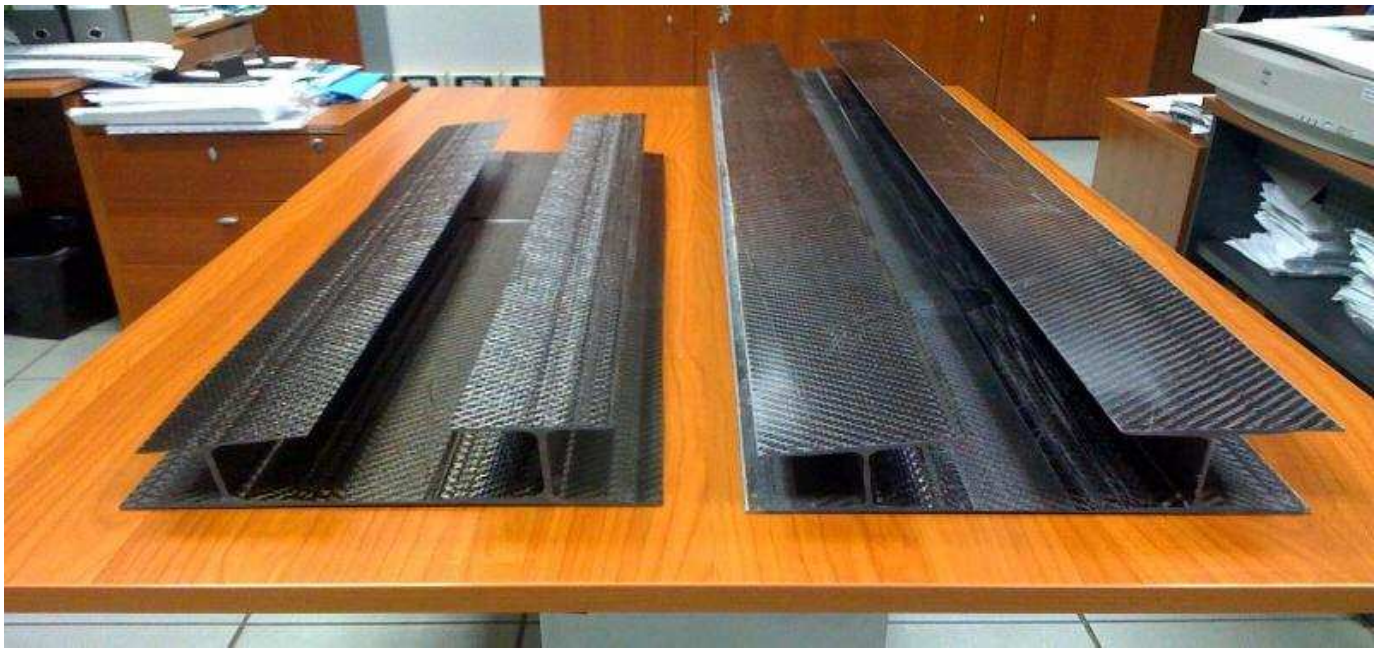
Charge hot forming

Cured “I” shaped Stringer

Process Certification: Technologies Readiness plan

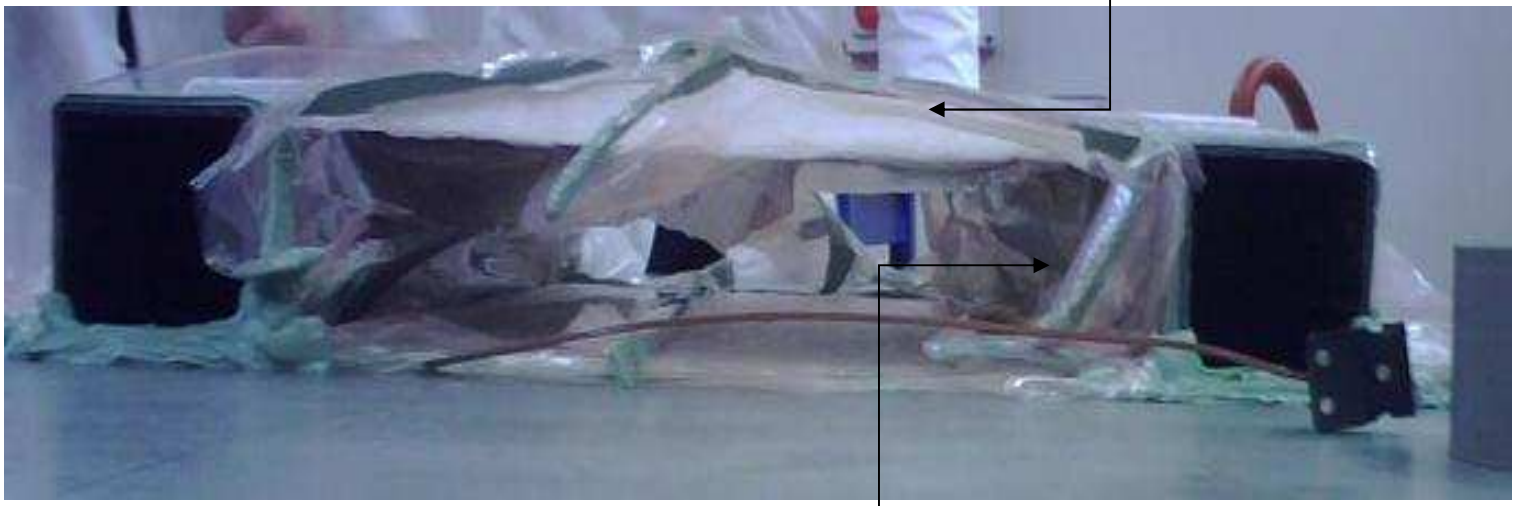
MANUFACTURING DEMONSTRATOR



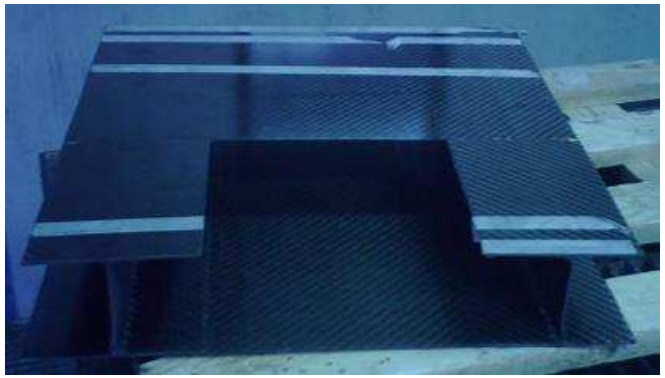


MANUFACTURING DEMONSTRATOR

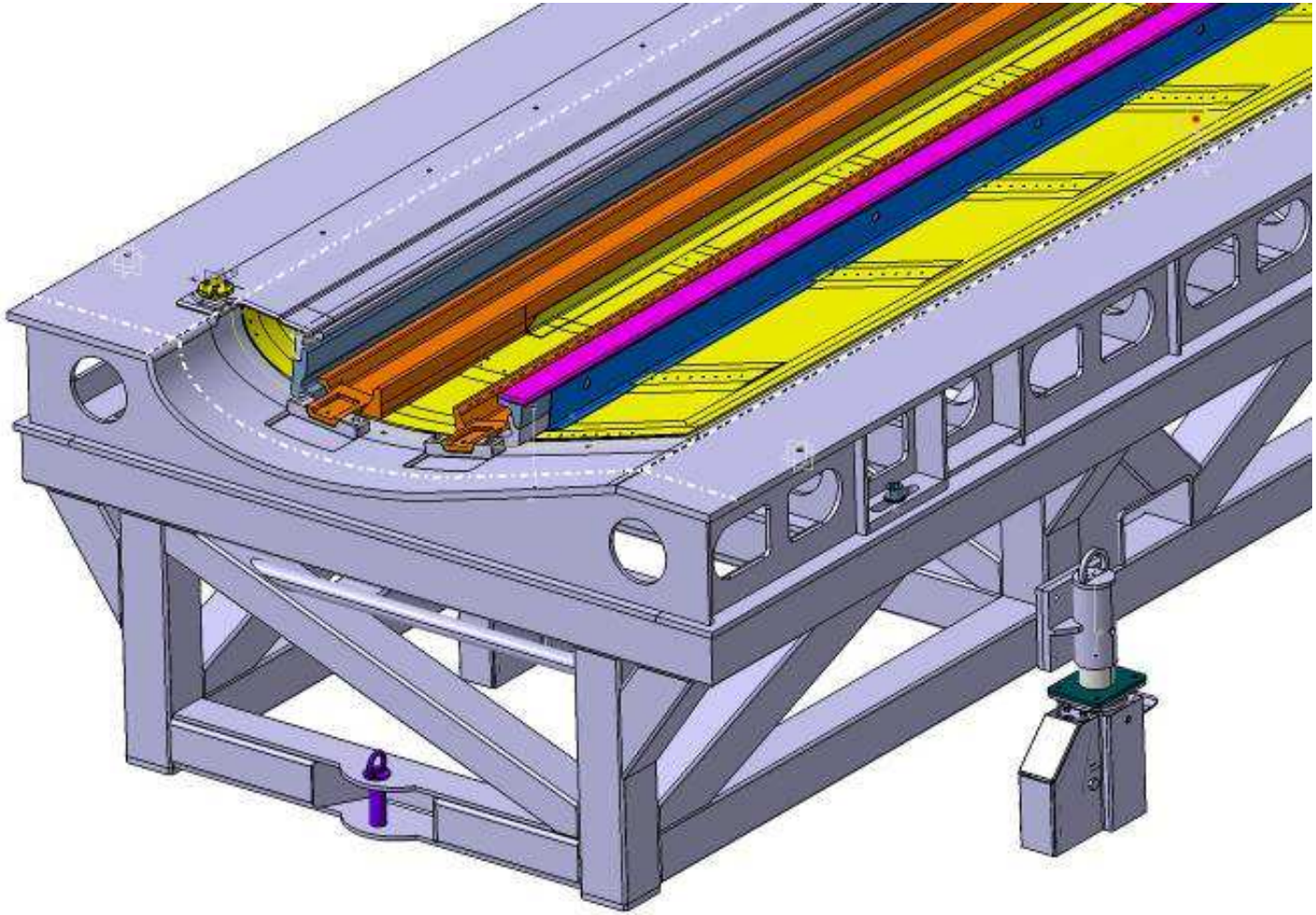
External vacuum Bag



Internal vacuum Bag



Lay-Up Tools Concept Flap



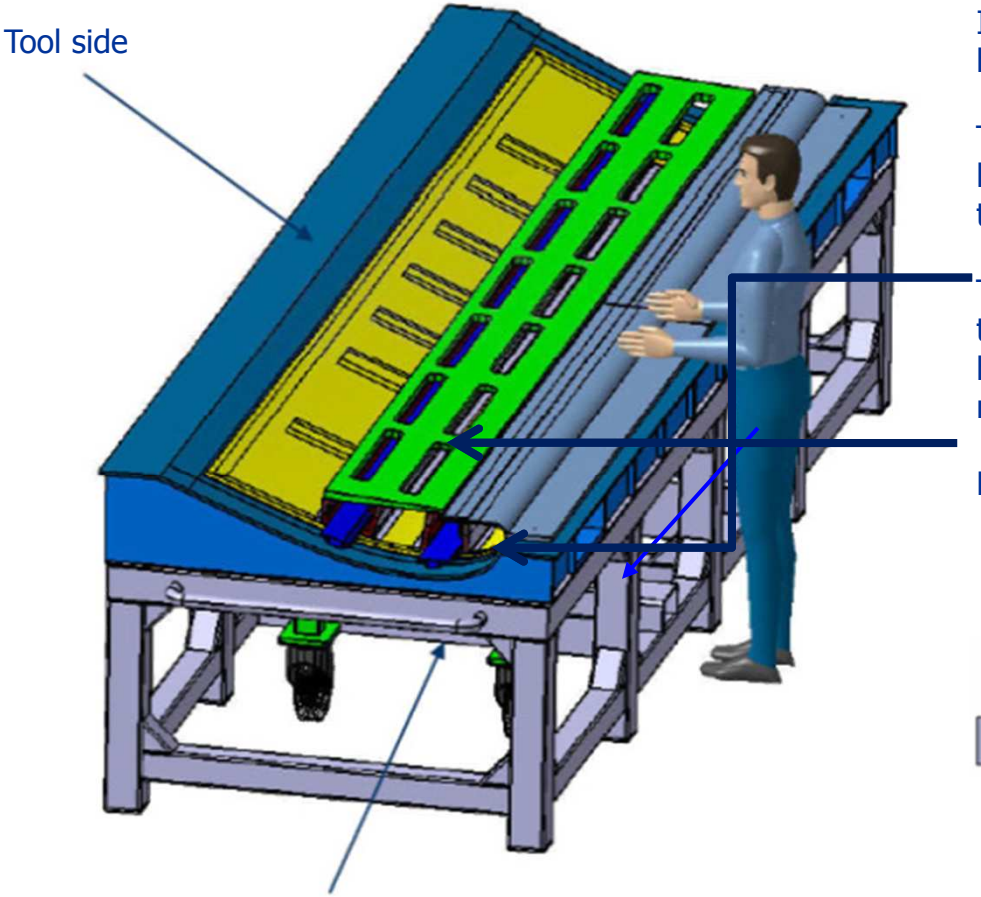
Flaps Lay-Up Tools

Standard Invar Tools Example

Lay-Up Tools Concept Flap

Demonstrator (Vacuum Bag)

3D Example Layup Tools Flap Lower Panel

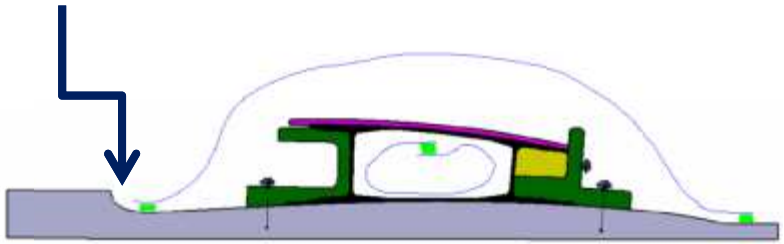


In order to have a good compaction, 2 vacuum bag have been used.

The first one is inside the leading edge (so the plies of the leading edge will be compacted between the bag and the tool)

The second vacuum bag is the final bag that will cover all the tool. In this way, every part section is compacted between vacuum bag and rigid tool (tool skin or removable tools)

Double vacuum bag example



DEVELOPMENT OF CERTIFICATION AND VALIDATION TEST PROGRAM

Testing Schedule & Cert Plan

L'obiettivo del Piano di Certificazione è definire I principi e le regole da seguire per ottenere la Certificazione della parte attreverso un accordo preliminare con le autorità certificanti coinvolte (FAA, EASA, etc.) definendo I "Means of Compliance" nella Qualification/Certification Matrix

Base di certificazione usata per qualificare il progetto C-Series:

- FAA - FAR Part 25 Amendment 25-1 fino a 25-114
- EASA - Certification Specification 25, Initial Issue, Published 17 October 2003.
- AC 20-107A or AMC No1 to CS 25.603

Product Certification: Test

Test Matrix example

	Test Category (sub-test)	Test Article configuration		Parameter of Tests									
Type	Description	Part Shape (Ref)	Qty	Con-dition	Defect, Abuse & Impact Type & Location	Loading - Column I	Loading - Column II	Test Objective	Strain gage chn. Qty	Thickness (Ref)	Dimension (Ref.) TBC (mm)	Test Facility Site	Magnaghi-Salver Activities
Full Scale	INBOARD FLAP Full Scale Tests	Complete assembled part	1	RT/AR	VID, BVID, Mfg defect	Static & CFRP DT justification	saddles + hinges + actuators	To demonstrate load carrying capability of the inboard flap body under limit and ultimate static loads (including Environmental Knock Down Factors) in retracted and deployed positions. To demonstrate the capability of composite structure for durability and damage tolerance. To generate data to support validation of analysis.	16 axial, 4 rosette (TBC)	All	2330 x 678	N/A	Provide the components for the Full Scale Test Articles, Definition of impact locations, test article drawings, Test Setup Drawings (TBC).
Full Scale	INBOARD FLAP Full Scale Tests	Complete assembled part	1	RT/AR	VID, BVID, Mfg defect	Metal Parts Fatigue	saddles + hinges + actuators	To demonstrate durability and damage tolerance capability of inboard flap metallic internal parts and support structure. To generate data to support validation of analysis.	16 axial, 4 rosette (TBC)	All	2330 x 678	N/A	Provide the components for the Full Scale Test Articles, Definition of impact locations, test article drawings, Test Setup Drawings (TBC).
Full Scale	INBOARD FLAP Full Scale Tests	Complete assembled part	1	RT/AR	Mfg defect	Bird Strike Impact		To demonstrate bird strike capability of inboard flap and flap attachment structure mounted in a representative manner. To validate model of damage analysis prediction. To generate data to support validation of residual strength analysis and demonstrate continue structural integrity post bird strike.		All	2330 x 678	N/A	Provide the components for the Full Scale Test Articles, Definition of impact locations, test article drawings, Test Setup Drawings (TBC).
Full Scale	OUTBOARD FLAP Full Scale Tests	Complete assembled part	1	RT/AR	VID, BVID, Mfg defect	Static & CFRP DT justification	saddles + hinges + actuators	To demonstrate load carrying capability of the outboard flap body under limit and ultimate static loads (including Environmental Knock Down Factors) in retracted and deployed positions. To demonstrate the capability of composite structure for durability and damage tolerance. To generate data to support validation of analysis.	16 axial, 4 rosette (TBC)	All	4200 x 512	N/A	Provide the components for the Full Scale Test Articles, Definition of impact locations, test article drawings, Test Setup Drawings (TBC).
Full Scale	OUTBOARD FLAP Full Scale Tests	Complete assembled part	1	RT/AR	VID, BVID, Mfg defect	Metal Parts Fatigue	saddles + hinges + actuators	To demonstrate durability and damage tolerance capability of outboard flap metallic internal parts and support structure. To generate data to support validation of analysis.	16 axial, 4 rosette (TBC)	All	4200 x 512	N/A	Provide the components for the Full Scale Test Articles, Definition of impact locations, test article drawings, Test Setup Drawings (TBC).
Sub-component	Box Skin Panel	Skin + 3 spars flat panel	3	RT/AR	BVID, Mfg defect	Static - Compression	1 Pristine + 2 Impacted	To validate the capability of the analysis method to predict the final strength of skin-Spar configuration under compressive loads and evaluate the knockdown factor for damage and manufacturing defects on complex structure.	8 axial, 2 rosette, 4 EDI (TBC)	1 skin thickness	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Sub-component	Box Skin Panel	Skin + 3 spars flat panel	3	RT/AR	BVID, Mfg defect	Static - Tension	1 Pristine + 2 Impacted	To validate the capability of the analysis method to predict the final strength of skin-spar configuration under tension loads and evaluate the knockdown factor for damage and manufacturing defects on complex structure.	8 axial, 2 rosette, 4 EDI (TBC)	1 skin thickness	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Sub-component	Box Skin Panel	Skin + 3 spars flat panel	3	RT/AR	BVID, Mfg defect	Fatigue Compression	3 Impacted	To validate the capability of the analysis method to predict the final strength of skin-spar configuration under fatigue compressive loads and validate the Fatigue ELF obtained from coupon tests.	8 axial, 2 rosette, 4 EDI (TBC)	1 skin thickness	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Sub-component	Box Skin Panel	Skin + 3 spars flat panel	3	RT/AR	BVID, Mfg defect	Fatigue - Tension	3 Impacted	To validate the capability of the analysis method to predict the final strength of skin-spar configuration under fatigue tension-compression loads and validate the Fatigue ELF obtained from coupon tests.	8 axial, 2 rosette, 4 EDI (TBC)	1 skin thickness	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Sub-component	Box Skin Panel Flailing & Burst Tyre	Skin + 3 spars flat panel	1	RT/AR	High Energy Impact (TBC)	Impact		To evaluate the capability of inboard flap lower skin to resist to discrete event damage caused from flailing tyre or tyre burst events.		1 skin thickness	TBD	Magnaghi Aeronautica Test Lab or External Test Lab (TBD)	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Sub-component		Skin flat panel , Skin flat panel + hinges, Skin panel and relative Al wedge, Skin flat panel + spar+ bolt	4	RT/AR		Lightning Strike		Determine the ability of skin panels and attached fittings to withstand direct effect caused from a lightning striking to an aircraft.		1 skin thickness	TBD	Magnaghi Aeronautica Test Lab or External Test Lab (TBD)	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Element	Front Spar	Double T-section beam	1+1	RT/AR	BVID, Mfg defect	Static	1 for Impact test survey+ 1 Bending load	To establish the impact energy to produce BVID in different location and to generate data to support validation of analysis. To demonstrate the robustness of analysis method to predict failure	8 axial, 2 rosette, 4 EDI (TBC)	1 type	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Element	Middle/Rear Spar	J-section beam	1+1	RT/AR	BVID, Mfg defect	Static	1 for Impact test survey+ 1 Bending load	To establish the impact energy to produce BVID in different location and to generate data to support validation of analysis. To demonstrate the robustness of analysis method to predict failure	8 axial, 2 rosette, 4 EDI (TBC)	1 type	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Element	CFRP Rib	Rib	1	RT/AR	BVID, Mfg defect	Static	Shear	To evaluate the capability of composite ribs with several notch due to mousehole to sustain shear loads and validate analysis method.	8 axial, 2 rosette, 4 EDI (TBC)	1 thickness type	TBD	Magnaghi Aeronautica Test Lab	Definition of impact locations, test article drawings, Test Setup Drawings. Tests Plan definition. Tests conduct. Test correlation
Coupons	Unnotched Tension Strenght & Modulus	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Unnotched Compression Strenght & Modulus	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	ILSS	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	ILTS	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Open Hole Compression	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Filled Hole Compression	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Compression After Impact	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Open Hole Tension	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Filled Hole Tension	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Bearing	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Pull-trough	coupon	TBD	RT+ CTD + HTW	N/A	Static					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Compression After Impact	coupon	TBD	RT+ CTD + HTW	N/A	Fatigue					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods
Coupons	Open Hole Compression	coupon	TBD	RT+ CTD + HTW	N/A	Fatigue					Depends on test method	Magnaghi Aeronautica Lab (TBC)	Data for Salver Material available from ASTM Test methods

BVID to be specified from PAI

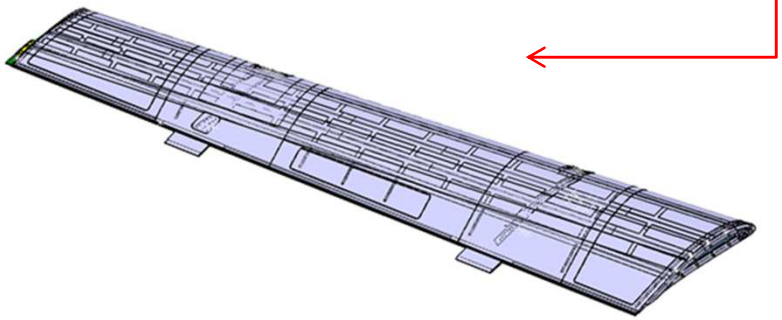
Manufacturing defect are simulated trhough teflon square 0.5" x 0.5" dimension

Product Certification: Test

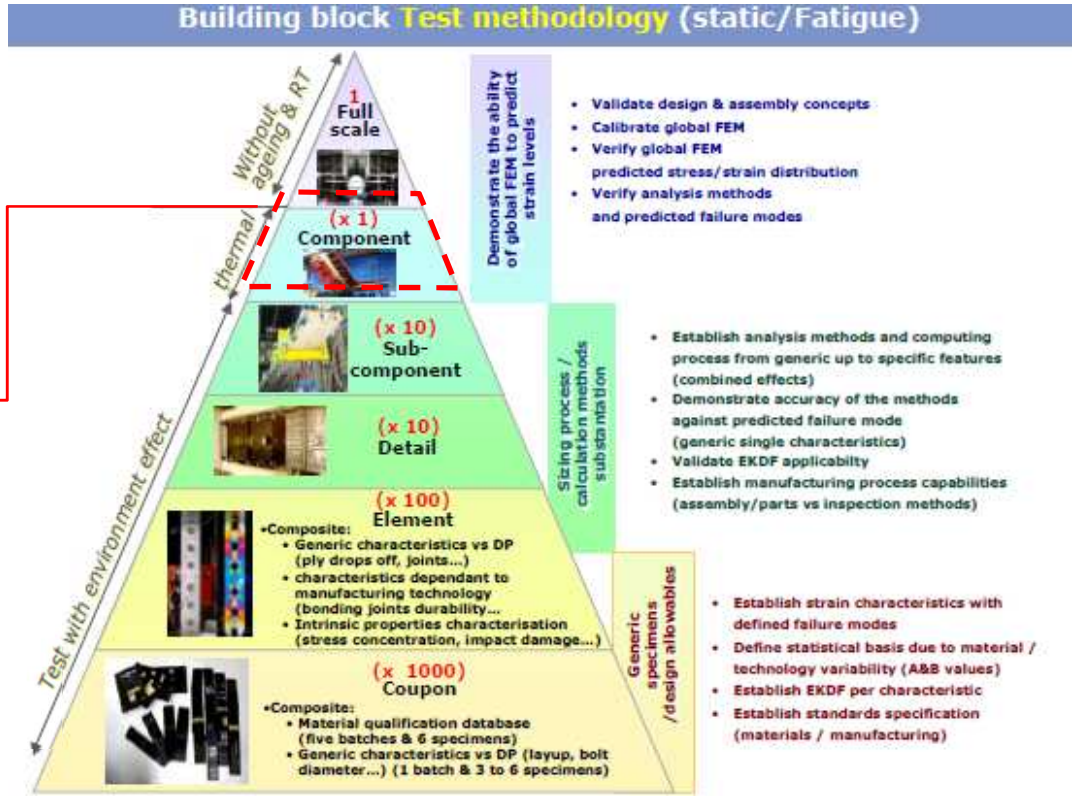
Building block approach

Functional area involved:

- Engineering: Analysis validation
- Laboratory: testing of full and subcomponent test article
- Production: manufacturing of test article

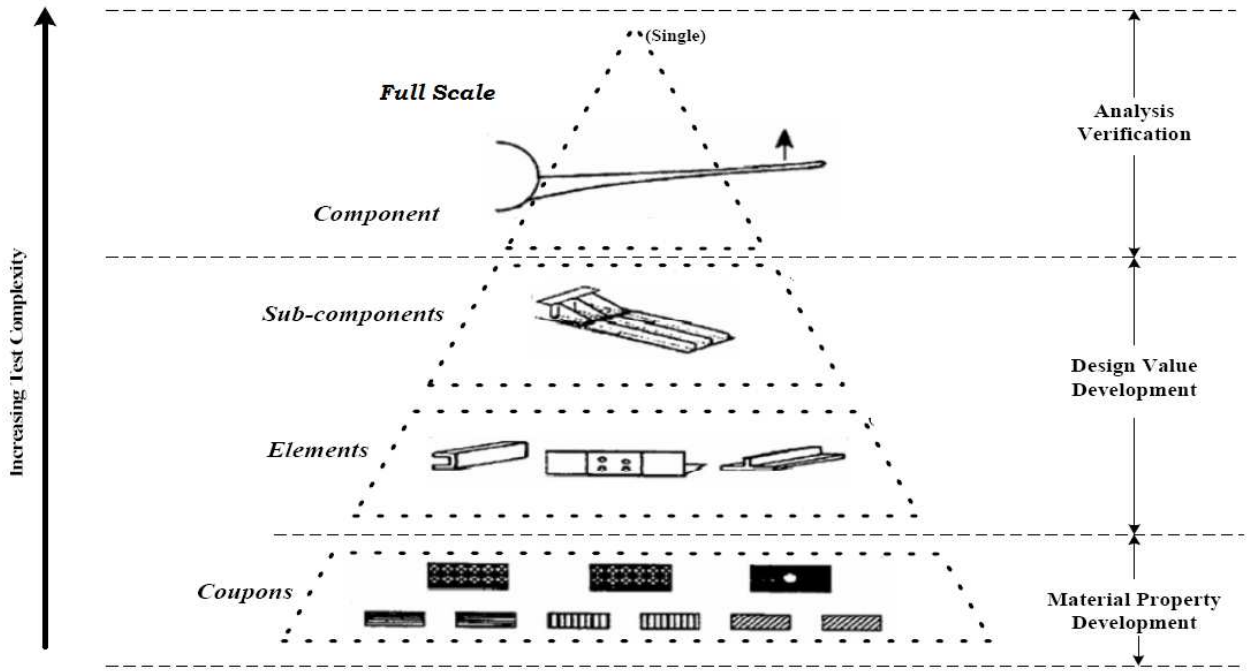


Hybrid CFRP+Metallic
Outboard Flap

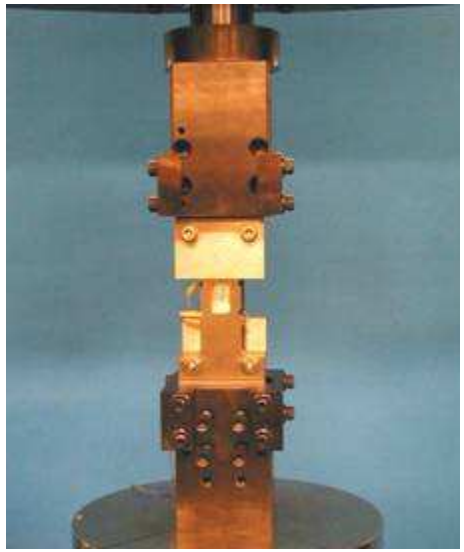


Test Strategy: "Building Block" approach

- Full scale component tests, including static, fatigue, lightning and bird impact tests will be conducted to validate the design and analysis methods
- Element and subcomponent tests are conducted at R.T. to establish point design values and validate analysis methods for panel, spars, ribs and joint.
- Several coupon level tests that will characterize also the environmental effect



Coupons Test

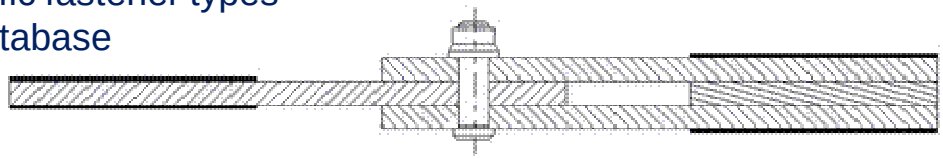


Design allowable testing

- This testing is intended to cover any specific lay-ups with selected material system and confirm or update preliminary allowables used in the current phase.
- Layups tested are selected as representative of the designed structure, with the allowable generated at the critical environmental conditions.

Fastener validation testing

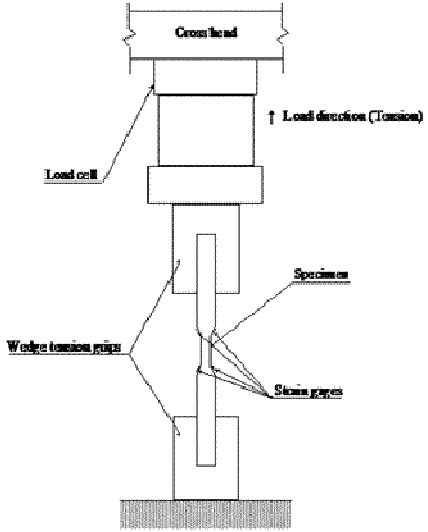
- This testing is intended to cover any specific fastener types or forms that do not exist within current database

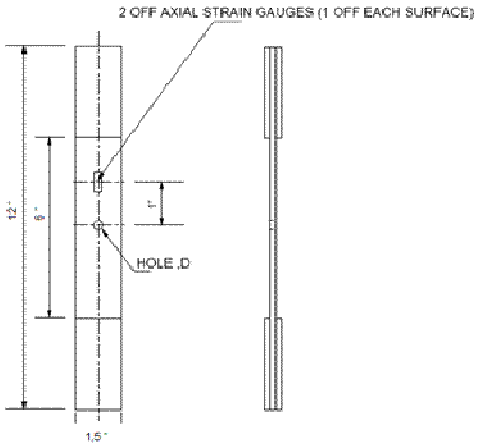


Coupons Test

Coupons have been tested for:

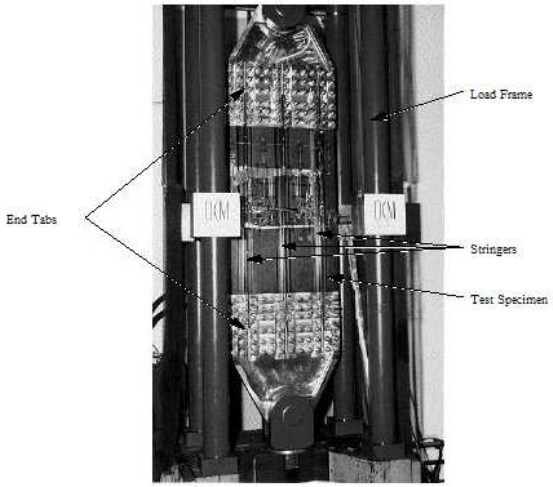
- Un-Notched Compression
- Open Hole Compression
- Compression After Impact
- Un-Notched Tension
- Filled Hole Tension
- Tension After Impact
- Bolted Joints (bearing and pull through)
- Laminate Inter-laminar Shear
- Laminate Inter-laminar Tension
- Compression After Impact Fatigue
- Open Hole Compression Fatigue





Subcomponent and Element Test

- Subcomponent and Element tests established point design values and validated methods of analysis for skin panel, spar, rib, and joints
- Design values accounted for the effects of environment, the presence of barely visible impact damage and manufacturing anomalies
- Scopes of the defined tests are to validate the following critical design values and method of analysis:
  - ✓ Compression and tension ultimate strength design value curve for stiffened skin panels
  - ✓ Evaluation of skin-stringer/spar resistance to energy impact
  - ✓ Lightning strike effect on structure
  - ✓ Analytical methods for rib shear web and chord strength and stiffness



tension test article positioned in the loading frame.

Product Certification: Test

Full Scale Test – Outboard Flap

Product Certification: Test

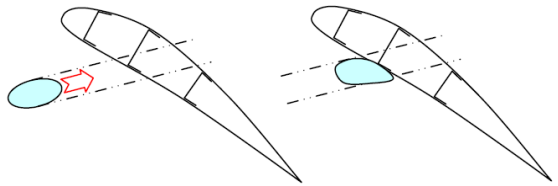
Full Scale Test – Inboard Flap

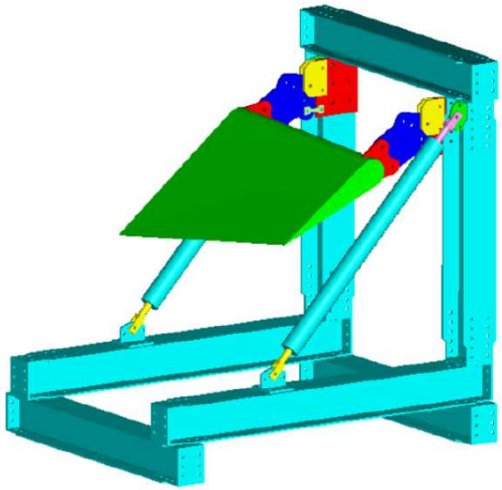
Product Certification: Test

Full Scale Test – Ground Spoiler

Full Scale Test: Bird Impact

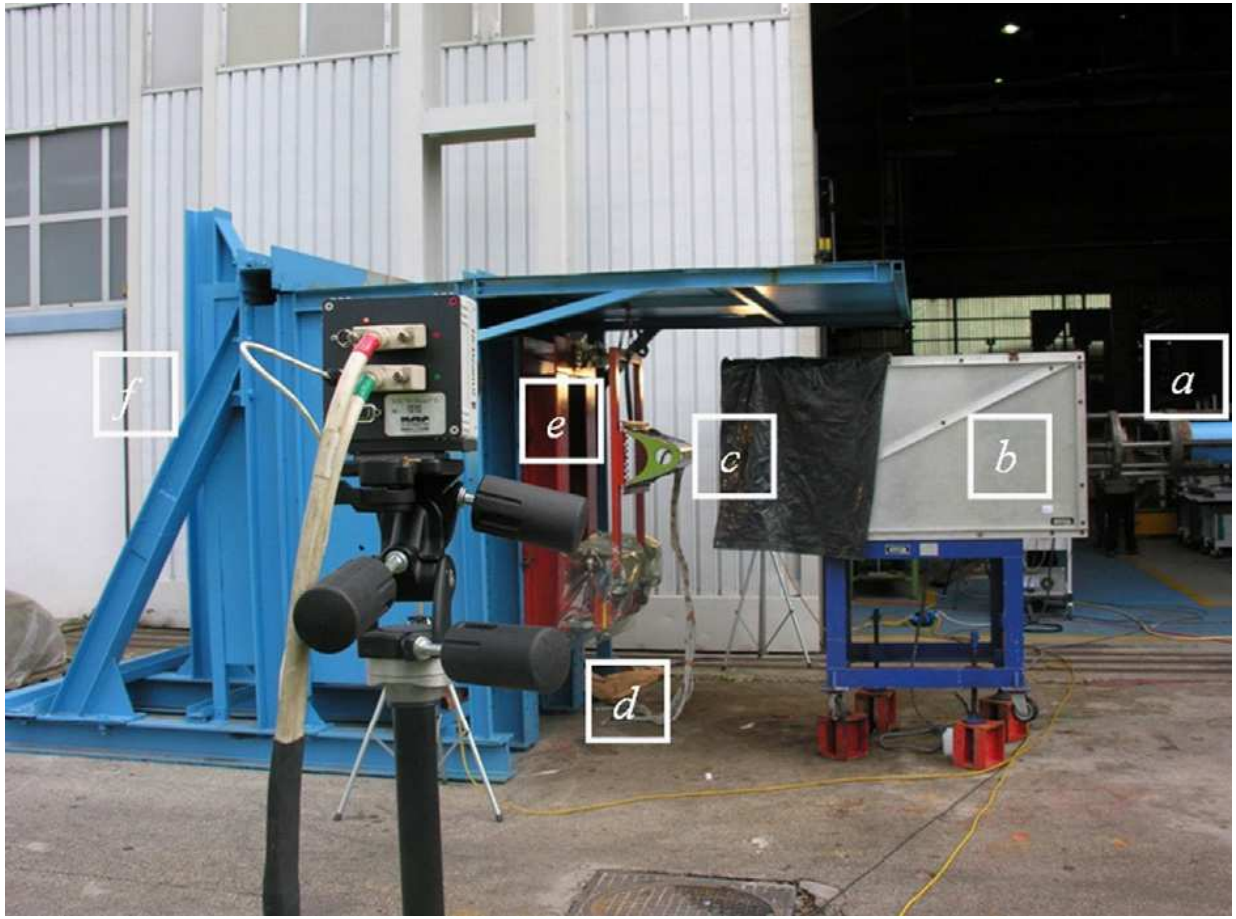
- Complete Full Scale TA and attachment mounted in a realistically representative manner on Bird Strike Test Rig
- Test performed at R.T.
- Selected areas of TA has been impacted by 8lb bird
- The data collected on test about damaged area and type has been used to validate analysis method of damage prediction





Bird Impact Lab Test

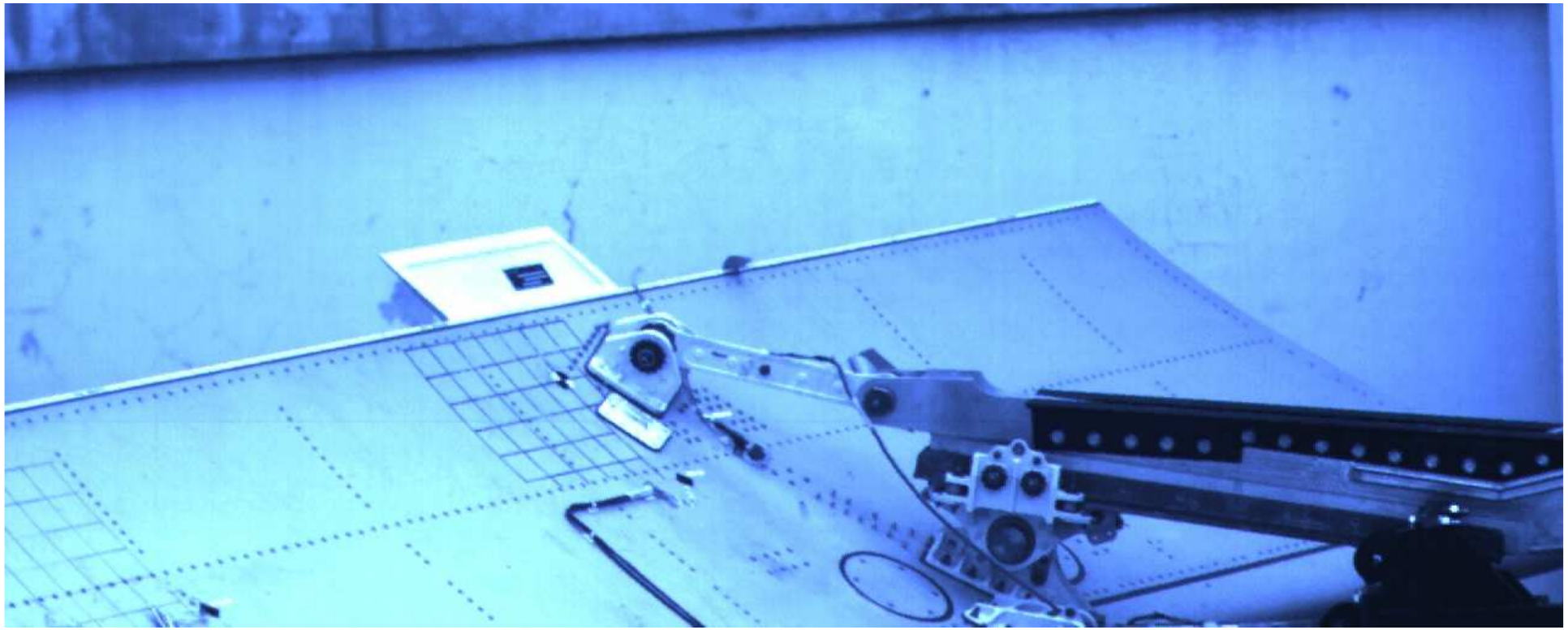
Bird Impact Test: sistema di acquisizione immagini/video ad alta velocità e risoluzione



Fixture and scenario of a bird-strike test.
a – air cannon bore;
b – velocity measure device;
c – test article;
d – high speed camera;
e – test bed;
f - safeguard screen;
g – load cell.

Bird Impact test: Video

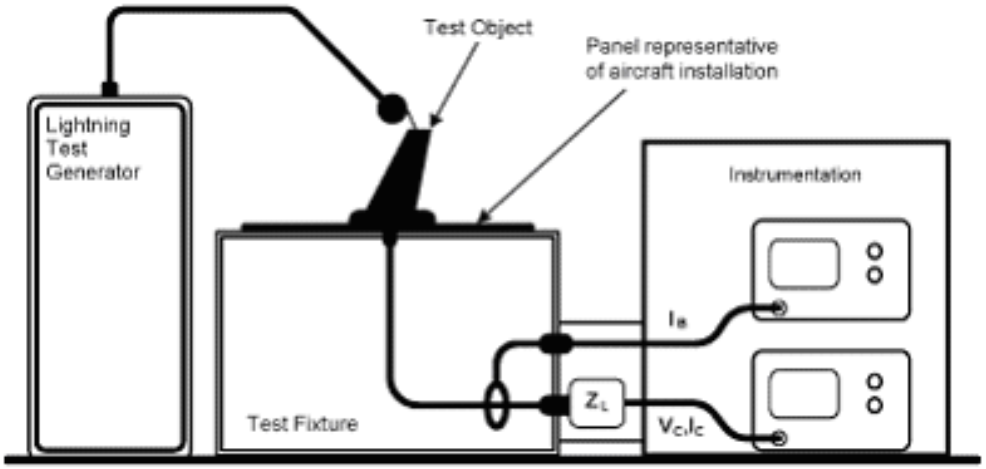
C-Series Bird Impact Test



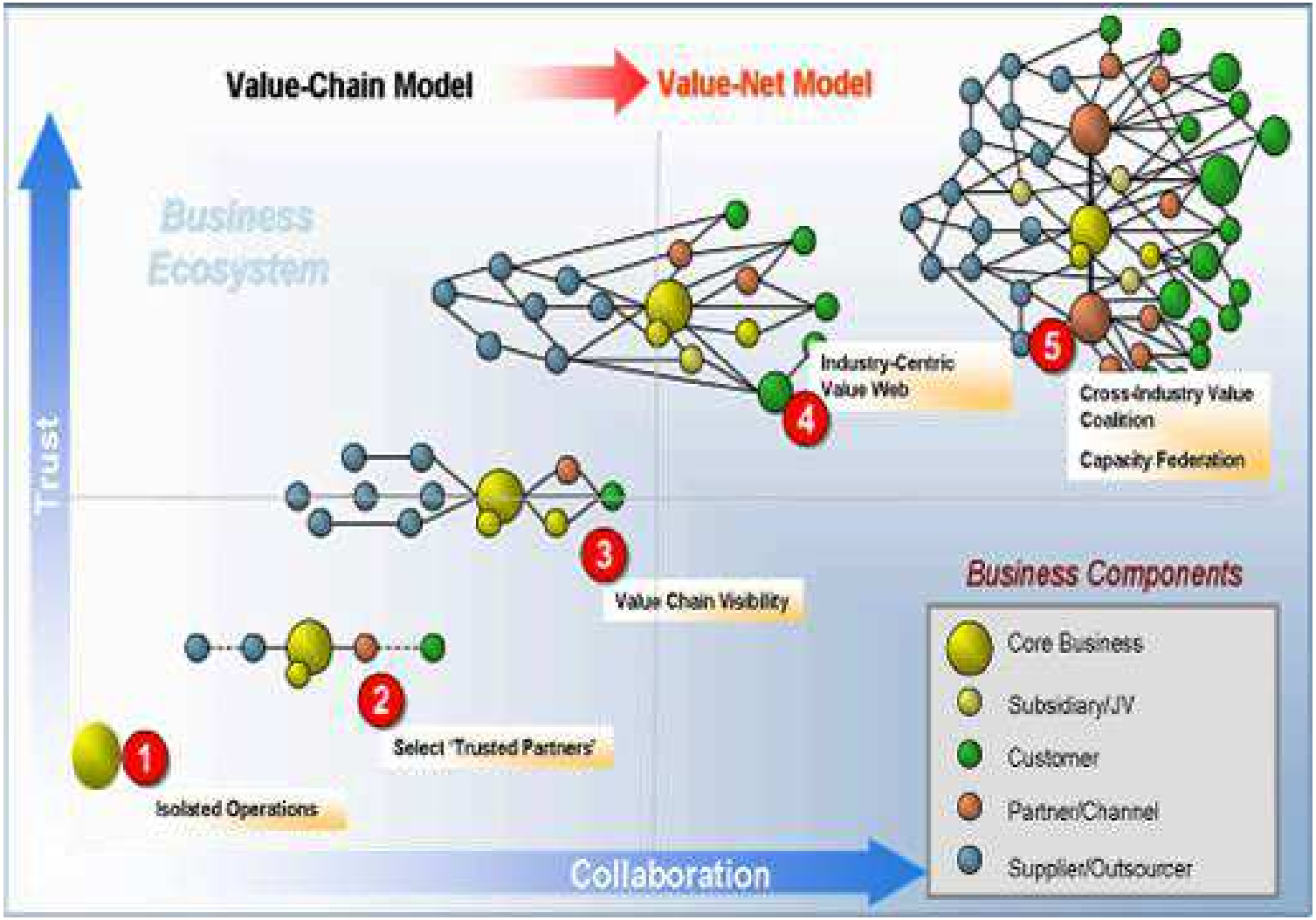
CERTIFICATION AND VALIDATION TEST PROGRAM

Full Scale Test: Lightning Strike

- Test TA capabilities to resist through the thickness perforation due to a lightning strike and capability to conduct current through the structure.
- Test that lightning strike do not produce weld of fitting parts
- To generate data to support validation of analysis.



Supply Chain Structure, Logistic Integration evolution



Project Management

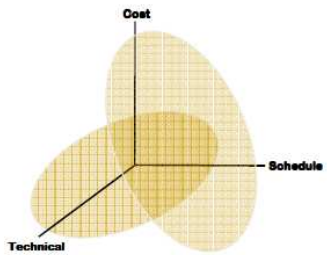
"Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. This application of knowledge requires the effective management of the project management processes." Ref. PM-BOK

Project management scope

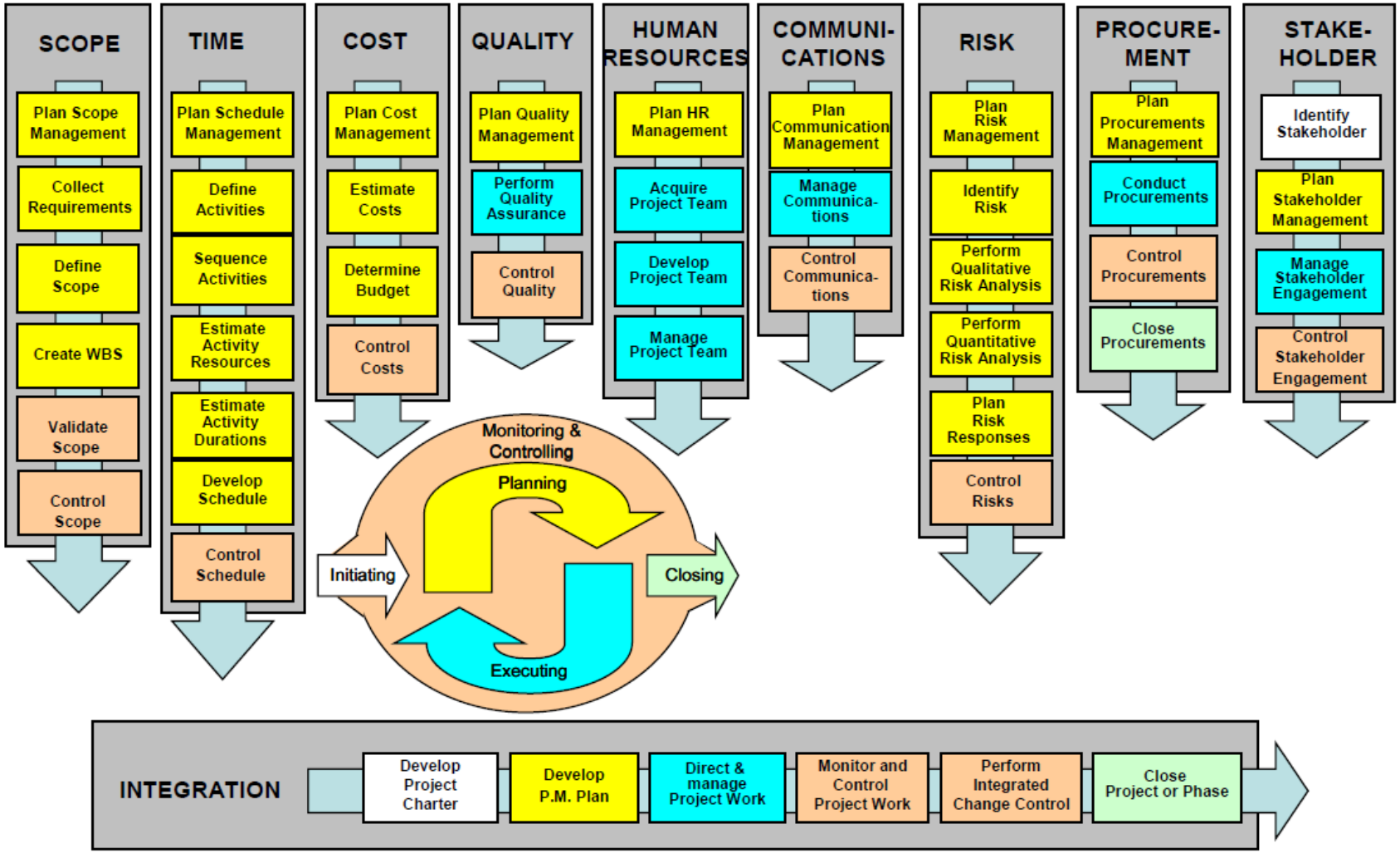
- Select appropriate processes required to meet the project objectives;
- Use a defined approach that can be adapted to meet requirements;
- Establish and maintain appropriate communication and engagement with stakeholders;
- Comply with requirements to meet stakeholder needs and expectations; and
- Balance the competing constraints of scope, schedule, budget, quality, resources, and risk to produce the specified product, service, or result.

Project Management Process

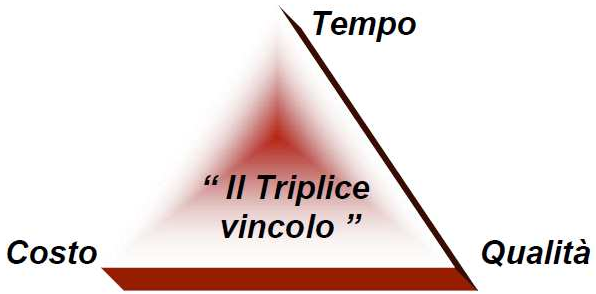
An effective process to develop and control resources to meet the project objectives

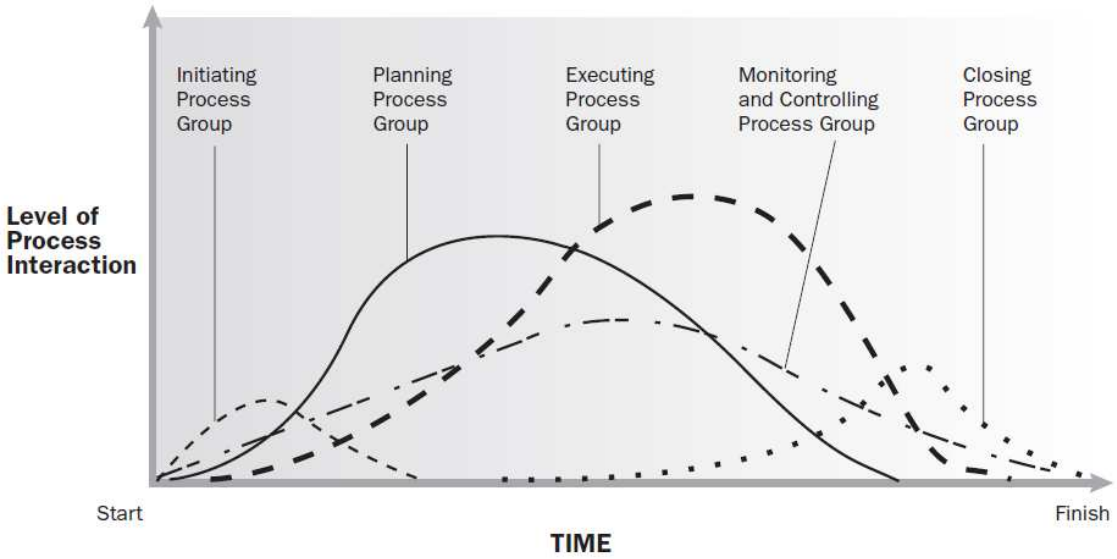


Evolution of Project Management



Evolution of Project Management





During project development all functional area need to be integrated based on TIME-COST-QUALITY.

Investments

Gli investimenti rappresentano il vero punto di forza per un'azienda nel significativo passaggio industriale da «Build to Print» a «Build to Spec».

- Investire nelle **risorse con specifiche competenze ed esperienza**
- Investire nell'acquisto di macchine e impianti per la **lavorazione del composito**
- Potenziare le proprie capacità produttive con l'acquisto di nuovi macchinari per le **lavorazioni meccaniche** per incrementare la capacità o per soddisfare nuovi requisiti di design che richiedono materiali innovativi come il titanio
- Introdurre/potenziare il settore dei **processi speciali** con l'acquisizione di nuove tipologie di trattamenti

Investment Plan	N° Macchine/Impianti
	increm.%
Autoclave	66,7%
Banco di lav.compositi/montaggio/sbavatura	2,5%
Cabina Verniciatura	36,4%
Carrello elevatore/Carroponte	6,5%
Centro di lavoro	10,8%
Clean room	50,0%
Compressore	21,4%
Foratrice	50,0%
Forno/Imp.Trattamenti termici	26,1%
Fresatrice	12,5%
Frigorifero/Refrigeratore/Congelatore	28,6%
Impianto CND	22,2%
Impianto galvanica	50,0%
Macchina di misura	20,0%
Macchina trazione/compressione provini	16,7%
Marcatrice/Stampigliatrice	20,0%
Nuova tecnologia Titanio	100,0%
Pallinatrice	40,0%
Pressa	17,5%
Rettificatrice	10,0%
Stampo termoregolato	100,0%
Tagliatrice/Troncatrice/Taglio al plasma/waterjet	26,9%
Termoformatrice	40,0%
Tornio	8,5%
Trapano	3,3%

CONCLUSIONI

Per un'azienda aeronautica il passaggio a «build to spec»

- *rappresenta il momento della svolta industriale che stravolge l'impostazione e l'organizzazione funzionale ed operativa dell'azienda con approccio «build to print».*

- *richiede investimenti non solo finanziari ma anche di competenze, esperienza e di numero di risorse di gran lunga superiore a quello necessario per la gestione di un processo «build to print»*

- Costituisce il **valore aggiunto** per facilitare l'integrazione verticalizzata nel "business"

THE END

THANK YOU!

SALVER

MAGNAGHI AERONAUTICA SpA