PPAP Process Implementation in Aerospace Industry

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Abstract

OGMA Industrialization Project Management division is a dedicated unit responsible for the industrialization process of aeronautical manufacturing products. It was recently established, therefore, some processes were not thoroughly developed. By the time of the official presentation to begin working, area leaders should sign the industrialization contract to ensure that everyone understand and agree with the information presented. Thus, it is recommended that the industrialization contract includes all the information gathered at that point. Along these lines an update was needed. Monitoring tools, such as, the industrialization checklist, key performance indicators, risk analysis methodology and the Obeya meetings operational procedure, required an update. Afterwards it was possible to make official the underlying documentation on OGMA internal website. Due to increasing demand of production process verification activities in the aerospace industry, one of the objectives was to establish the set of deliverables that must, when applicable, be part of OGMA PPAP (Production Part Approval Process). Furthermore, basic methodology of PPAP elaboration was required. In line with the concept of continuous improvement, associated with the lessons learned significance in the organization context, namely in spreading good practices and preventive actions, it was necessary to define lessons learned record methodology. The developed work led to the industrialization process internal norm full revision, ensuring conformity with the current practices and an official record of the main activities, responsibilities, monitoring tools and industrialization project deliverables, comprising, thus, all the activities developed.
Keywords: Project Management, Industrialization Process, Monitoring, Lessons Learned; PPAP

1. Introduction

OGMA - Indústria Aeronáutica de Portugal S.A., based in Alverca, is a Portuguese aerospace company that provides MRO (Maintenance Repair and Overhaul) services and solutions to the aerostructures market. Its share capital is retained in 65% by Airholding SGPS consortium, part of Embraer, and the remaining 35% are owned by EMPORDEF, retained by Portuguese government [1].

As a supplier of integrated services to OEMs (Original Equipment Manufacturer) and a first tier supplier, OGMA Aerostructures contemplates the assembly and sub-assembly of aircraft aerostructures, covering a broad spectrum of products, namely metallic and composite structures, avionics, structures with harness integration and machine and sheet metal parts.

This study was developed in OGMA Industrialization Project Management division that is a dedicated unit responsible for industrialization process of aeronautical manufacturing products. The goal of every industrialization project is to assure customer requirements, to accomplish deliveries on time, assure budget, and with no quality escapes.

The main goals to achieve with the present work are: revision of documentation used along industrialization projects, such as, the industrialization checklist, the Obeya meetings operational procedure, and the industrialization contract; establishment of standard key performance indicators; establishment of the set of deliverables that comprises OGMA PPAP; development of lessons learned methodology; industrialization internal norm full revision [2].

The remainder of this paper is organized as follows. Section 2 defines some project management related concepts. The industrialization process main activities are presented briefly in Section 3. The responsibilities attributed to the interdisciplinary team are presented in Section 4. Section 5 is about the monitoring tools used in industrialization projects. The project deliverables are provided in Section 6 and the PPAP deliverables in Section 7. In section 8 some conclusions are made.

2. Project Management

According to [3], a project is a temporary endeavour undertaken to create a unique product, service, or result. A project has a definite beginning and end. It can end when its goals are reached, or when its objectives will not, or cannot, be met, or when the need for the project no longer exists.

Project Management is all about accomplishing the project requirements through the application of knowledge, skills, tools and techniques to plan activities. The activities are integrated into five categories: initiating; planning; execution; monitoring and controlling; and closing.

Generally, managing a project includes balancing the several project constraints, which include, for instance: scope; quality; schedule; budget; resources; and risk. The factors are related in a way that if one changes, some other factor is likely to be affected. In order to illustrate this relation, take for instance, the case where the project schedule is shortened. To accomplish the same amount of work in less time, typically the budget needs to be increased to include more resources on the project. Other alternative would be to compromise the quality levels in order to prevent a budget increase.

The project manager is responsible for leading the project team and for accomplishing the proposed goals. Project managers have the duty to satisfy task needs, team needs, and individual needs. Also, taking into account that project management is a critical strategic disciple, project managers take the position of link between the strategy and the team.

The project team includes the project manager and the group of people that performs the activities needed to achieve the project objectives. Due to the diverse nature of the tasks, the team is comprised by individuals with a specific skill set to carry out certain functions.

A project life cycle is the series of phases by which the project passes between the beginning until its end. Typically, the phases are divided in terms of objectives, results or milestones and are time bounded with a start and ending. The life cycle is considered to be the framework by which the project is managed.

Risk and uncertainty are greatest at the project start. As decisions are made and deliverables are accepted, the project course becomes clearer and these factors decrease over time.

At the project start, it is cheaper to change a product characteristic, but the ability to influence the product final characteristics, without increasing the price, decreases over the project life cycle. The underlying notion is that the cost of making changes increases substantially towards the project end.

Project Management operates in a context broader than that of the project itself. In order to assure conformity with the organization objectives and current practices, it is imperative the understanding of this broader environment. When the project involves external organizations, the project will be influenced by more than one organization.

There are ten project management knowledge areas: Project Integration Management; Project Scope Management; Project Time Management; Project Cost Management; Project Quality Management; Project Human Resource Management; Project Communications Management; Project Risk Management; Project Procurement Management; Project Stakeholder Management.

Each knowledge area represents a complete field of specialization and the project successful depends on the mastery of each one of them.

3. OGMA Aerostructures Industrialization Process

The industrialization process of aeronautical manufacturing products is the set of activities which aims to define the needed resources to manufacture the product in a standardized way and according to applicable regulations.

This process is developed by an interdisciplinary team, comprising individuals with specific expertises (namely, engineering, quality, acquisition, logistics, production, planning, commercial), focused on ensuring the implementation of the necessary, and sufficient, tasks to fulfill the project requirements.

The project manager has an integrated vision of the process as a whole, and manages the interdisciplinary team during the project life cycle.

Ultimately, the industrialization process main goal is to ensure production at the lowest price, delivers on time while satisfying quality and guaranteeing the process reproducibility.

Every time a new product, or a modified product that required more than 500 engineering hours, is to be manufactured, an industrialization process development is mandatory.

Subsequently to a potential client request for quotation, if OGMA proves to be the best available opportunity and is chosen to be the supplier, the industrialization process begins after project handover to the project management division.

The industrialization process is comprised by a set of activities briefly described in the following subsections.

3.1. Pre Kick-Off Alignment

This is an initial stage where relevant information is gathered, namely: the product description; deliveries forecast and milestones; need of raw materials and tooling; and need of certifications and training.

A meeting between the project manager, directors and division leaders, in order to present the product description, the project scope and the need of operational team, marks the end of this stage.

3.2. Kick-Off

Between pre kick-off alignment and kick-off stages, the project schedule is elaborated, and to assist in critical tasks identification, a risk analysis at operational level is performed.

The technical features, such as, part numbers, drawings, bills of materials, processes and technologies are verified. Also, based on the budget, man-hours by process or technology are analyzed and the make or buy decision is reassessed.

Internal and external deliverables and the corresponding milestones are defined. Additionally, industrialization monitoring methodology, namely, Obeya meetings are scheduled. The project internal contract, that should comprise the most relevant information in the scope of the project, is elaborated.

This stage ends with the kick-off meeting where is presented the operational team, the Obeya room, the technical and economical reassessment, and the industrialization contract is signed to ensure that everyone understands and agrees with the information presented.

3.3. Technical Documentation Management

The technical documentation supporting the industrialization process is comprised by information, in any format, related with one of the following groups [4]: customer norms and technical specifications, including product features and work instructions; part-lists and drawings (3D and 2D models); technical sheets and related documentation supporting directly the manufacturing process.

The customer technical documentation is kept at a database allowing its consultation during the project life cycle.

This stage aims to assess the technical documentation availability in order to ensure sufficient resources to begin defining the product structure.

3.4. Product Structure Definition

Customers define the product characteristics and underlying information, such as, bills of materials, drawings, models and specifications.

The preliminary product structure is defined based on customers documentation and comprises, part numbers, the application coefficient, materials quantities, drawings and the associated index, a list of tooling and a list of special processes.

Based on the product structure it is possible to: begin searching for raw materials and hardware suppliers; determine selling part numbers; define the tooling nature; identify process limitations and enhance the product characteristics control.

3.5. Manufacturing Processes Definition

This stage aims to ensure the availability of the resources required to the manufacturing process, such as: process and materials certifications; tooling; and technical documentation.

When stated, manufacturing processes may have to be certified, according to the customer specifications. On the other hand, all specials processes, due to its high complexity, must be certified. Special process refers to a process that can change or affect the product mechanical, chemical or physical properties, which cannot be verified after the process without specific inspections [5].

Due to lack of tooling, OGMA availability to manufacture the tooling is assessed and compared to the price of subcontracting its production. Based on these two criteria a make or buy decision is reached. Whenever the option is subcontracting, this procedure can only be carried out by suppliers certified by OGMA. For each supplier a technical specification is prepared comprising all the information needed to manufacture the tooling.

When is stated in the contract that the customer is responsible for supplying the tooling, the customer should sent a list comprising the tooling required to the work package, along with technical documentation (drawings, part-list and models).

The manufacturing methodology definition encompasses the establishment of the following documentation: manufacturing technical sheets; special processes support technical sheets; procedures, work instructions and technical manuals; items, nomenclatures and work orders sets.

3.6. Supply Chain Management

When OGMA isn't able technically or procedurally (dimensions, technologies, equipments...), isn't able to certify special processes or to manufacture at a competitive price, activities to search for suppliers are initiated.

Subsequently, a market analysis is conducted and the supplier that presents the best final offer is selected. If the selected supplier is not an OGMA certified supplier, the first step, before the service beginning, is to certify the supplier.

A follow up plan is then defined, specifying deliverables, milestones and product FAI (First Article Inspection) manufacture monitoring throughout the project stage.

After FAI product acceptance, a set of activities aiming to follow up the supplier mass production stage is triggered. Essentially, nonconforming product management and continuous improvement activities.

3.7. Logistics Management

Logistics management is a supply chain management component that aims to fulfill the applicable requirements through the planning, control and implementation of efficient movement and storage models. This stage comprises the entire process from raw materials acquisition to shipping of final product.

Logistics management includes, essentially, the following elements:

- supplying/acquisition external logistics - packaging and handling conditions, external routes flow and transport models;
- handling and internal movement - storage and handling, product movements through the plant and line supply conditions;
- handling, packaging and final product shipping - the packaging development is based on the product weight and volume, the required movement and storage conditions, the material fragility and customer specific requirements.

3.8. Configuration Management

Product configuration management aims to ensure that the product configuration is always updated and available for consultation.

Configuration management comprises, fundamentally, the following activities [6]: control of changes/revisions in the product associated documentation; changes in the technical documentation and in the manufacturing process; product changes/revisions approval.

3.9. Manufacturing and Process/Product Approval

Before mass production, and after completion of the activities described throughout section 3, the manufacture of the FAI product is initiated.

The main goal of the FAI product is to ensure that all the product features were considered, documented and checked, in order to approve the methodology underlying the manufacturing process [7].

The entire FAI process is followed by the Engineering, Quality and Production divisions. It is triggered by the respective work order release together with the FAI assessment sheet.

The FAI assessment sheet aims to: identify deviations of materials, process, tooling and others; promote and trigger corrective actions ensuring product conformity.

The FAI inspection outline the product conformity to the technical definition. Additionally, the PPAP deliverables are also approved at this stage.

3.10. Production Handover

In order to ensure the industrialization proper performance and validate the project costs, at least the first five ships sets are carried out by the project management division.

Before delivering the project to the production division, an internal audit should be done to verify the entire process and all the assumptions previously held.

Subsequently, a technical report comprising the most significant information about product and process features is developed by the industrialization project management division and delivered to the production division, transferring, also, the project responsibility.

Lastly, lessons learned are recorded in order to document preventive and corrective actions, as well as, good practices.

4. Responsibilities

A strong project planning is a keystone to achieve success. Taking into account that there are several operational areas and the work flow amongst them is high, it is necessary to standardize tasks. Therefore, responsibilities are assigned to the operational areas.

4.1. Industrialization Project Management

The main responsibilities of industrialization project management division are:

- gather core information within the project scope (make or buy analysis, costs, deliveries forecast, due dates);
- promote the 'pre kick-off alignment' and 'kick-off' meetings;
- identify the need of operational team;
- ensure the elaboration of the project schedule and the industrialization contract;
- perform a risk analysis;
- define the critical project tasks, milestones and deliverables;
- supervise the project progress and ensure tasks accomplishment;
- promote and lead Obeya meetings;
- be the customer focal point to project timing issues;
- promote the record of lessons learned;

4.2. Aerostructures Engineering

The main responsibilities of Aerostructures Engineering division are:

- reassess technical and economical features;
- manage the project technical documentation;
- define the product structure;

- certify materials, manufacturing processes and special processes;
- identify the need for tooling and define those which require periodic control;
- identify lead times and the technical capacity of each operational area;
- carry out CAD models and bills of materials
- define the manufacturing methodology;
- develop technical specifications to suppliers;
- manage product configuration ensuring the latest version is always available;
- be the customer focal point to project technical issues.

4.3. Aerostructures Quality

The main responsibilities of Aerostructures Quality division are:

- analyze quality features stated on the customer technical documentation;
- audit suppliers, approve the FAI product and manage nonconformities;
- perform and document the first article inspection;
- audit the industrialization process according to the project schedule;
- be responsible for the project PPAP.

4.4. Acquisitions

The main responsibilities of Acquisitions division are:

- search for suppliers and assess each one capacity;
- develop request for quotation processes;
- select suppliers after market analysis and according to the project manager budget;
- define deliverables and milestones that suppliers must meet;
- provide the subcontracting products according to the project schedule;
- request progress evidences of suppliers critical activities.

4.5. Logistics

The main responsibilities of Logistics division are:

- define handling and packaging conditions for supplier products, as well as, external routes and transport models;
- define internal handling, movement and storage conditions;
- project packages according to the optimal product quantity to be exported;
- define external shipping routes and transport models.

4.6. Production Areas

The main responsibilities of Productions Areas are:

- manufacture tooling and the product according to the technical documentation;
- ensure the availability of all the required manufacturing resources;
- ensure the continuity of the project after the industrialization stage.

4.7. Commercial

The main responsibilities of Commercial division are:

- ensure technical documentation availability;
- be the customer focal point to project commercial issues.

5. Monitoring

In virtue of constant project monitoring it is possible to identify the need of taking corrective actions, when the project development diverge from how it was planned.

In this chapter the different monitoring methodologies, followed on the industrialization process, are addressed

5.1. Industrialization Checklist

A checklist is used in order to reduce failure, helping to ensure consistency and completeness in carrying out industrialization tasks.

The industrialization checklist is a control tool comprising a detailed list of the activities to be performed to accomplish the industrialization process. The following parameters are associated to each task: description; main area; responsible for deliver; input; output; mean by which the task is carried out; normative, if applicable; progress (done/ not done/ not applicable); indication if it is a mandatory task; planned schedule; corresponding milestone; comments.

Additionally, aggregates features that allow to track the project progress.

All the industrialization process stages are comprised in the checklist, therefore a continuous use throughout the project is recommended.

5.2. Key Performance Indicators

A Key Performance Indicator (KPI) is a measurable quantity that displays how effectively the industrialization project objectives are being achieved.

The following KPI's are standard, and for that reason, must always be adopted:

- Industrialization Plan Completion - aims to depict the completion degree of the industrialization plan, it is calculated through the ratio between the number of tasks performed and the number of tasks planned; The goal is to achieve a value of 100%;
- Recurring Costs (Hours) Variance - aims to assess the variation between the number of hours budgeted for processes execution and the number of hours taken to perform those processes, it is calculated through the formula [(RC hours planned – RC hours actual) / RC horas planned] x 100; The goal is to achieve a value equal or lower than 0%;
- Recurring Costs (Material) Variance - aims to assess the variation between the material costs budgeted and the actual expenses, it is calculated through the formula [(RC material planned – RC material actual) / RC material planned] x 100; The goal is to achieve a value equal or lower than 0%;
- Non Recurring Costs Variance - aims to assess the variation between the non recurring costs budgeted and the actual expenses, it is calculated through the formula [(NRC planned – NRC actual) / NRC planned] x 100; The goal is to achieve a value equal or lower than 0%;
- FAI On Time Delivery - aims to assess if FAI's are delivered according to the schedule negotiated with the customer, it is calculated through the formula (Number of FAI's delivered on time / Number of FAI's delivered) x 100; The goal is to achieve a value equal to 100%;
- FAI Approval - it is not enough to deliver FAI's on time, it is also necessary to get their approval, therefore, this KPI aims to asses FAI requirements achievement; it is calculated trough the formula (Number of first time FAI's delivers approved / Number of FAI's delivered) x 100; The goal is to achieve a value equal to 100%.

Nevertheless, the operational team may use other key performance indicators if necessary, such as the following:

- Buffer - the buffer prevents project delays enhancing the probability that the project deadline will be met; when a buffer is added to the project schedule, any delays on the critical chain will consume the buffer, not affecting the project completion date; the goal is to add a thirty days buffer to the project schedule;
- RAC's Lead Time - RAC's are Reports of Anomalies and Corrections, that arise from product nonconformities throughout the manufacturing process; the RAC's Lead Time KPI is defined to assess the nonconforming product control efficiency; the goal is to not exceed three days of lead time; this KPI counts the number of active RAC's with a lead time superior to three days;
- Scrap - scrap consists of recyclable materials left over from the manufacturing process; this KPI accounts for the number of items scrapped over the project life cycle; A goal is defined taking into account related project and establishing a scrap ceiling by analogy.

5.3. Audits and Control Points

The use of control points aims to evaluate the industrialization project progress. In each control point, a "GO - NO GO" decision is taken based on applicable risks. If the task completion percentage is higher than 85% and no critical tasks are delayed, the planned project course is followed. If a "No GO" decision is reached it necessary to reassess the project and establish an action plan and a task force to ensure the delayed tasks accomplishment.

There are four control points, CP 01, CP 02, CP 03, CP 04, and the required set of activities to fulfill each control point is described in the industrialization checklist. The control points are scheduled accordingly to the project schedule and the critical deliverables per milestone are defined in the industrialization contract.

At each control point the process is audited by someone external to the operational team, but internal to OGMA. Subsequently, project strengths and weaknesses are analyzed, and an action plan is defined in order to adjust the project status to the planned schedule.

5.4. Risk Matrix

Risks identification, evaluation and treatment processes are developed accordingly to the methodology described in [8]. The analysis is recorded in a risk matrix that comprises the following elements: risk description; initial classification; identification date; action plan; responsible foe each action; achievement date; achievement status; and current classification.

This process begins at the kick-off stage and is followed until production handover in order to track the risk classification and the efficiency of the actions taken to decrease the risk. Nevertheless it is possible to identify new risks in the project course.

The risk matrix updates are monitored in Obeya meetings, every two months, or more frequently if defined by the project manager or a hierarchical superior.

5.5. Industrialization Obeya

The operational follow up is led by the project manager, with the participation of the project multidisciplinary team, in the project Obeya room.

An Obeya room aggregates crucial information regarding the project status, namely, key performance indicators, the project schedule, quality requirements and an action plan.

Prior to the meeting, the project manager should update the key performance indicators and the PPAP deliverables status. At the meeting, unresolved actions are analyzed with respect to the action plan and to the project schedule, and corrective, or new, actions are defined, when necessary.

An Obeya room should be the closest possible to the main industrialization operational area and the meetings frequency is defined according to the project stage and needs.

6. Deliverables

In this section, internal and external project deliverables are explored according to the industrialization phase. The industrialization process can be split in six phases: kick-off phase; CP 01; CP 02; CP 03; CP 04; and Production Handover phase.

6.1. Kick-off Phase

The kick-off phase comprehend all the activities prior to the kick-off meeting milestone.

The deliverables of this phase are: validated budget; operational team appointed; customer purchase order registered; make or buy decision taken; project schedule established; industrialization contract completion; kick-off meeting held.

The industrialization contract is the project internal contract and its goal is to record the initial project assumptions/informations. Since it is an official document ensures that everyone acknowledged the project details and are committed to develop the required actions to achieve a successful project.

The first contract section should include overall project information, such as: project type and designation; customer identification; kick-off date; first delivery date; product images; and area leaders signatures.

The second contract section is linked to the project statement and should include the following information: project scope and description; operational team identification; deliveries forecast; main risks (according to the risk analysis performed); and project KPI's.

The third contract section comprises a technical review, related with: part numbers drawings; raw materials; tooling; the process flow diagram; and a suppliers list.

The fourth contract section comprises an economical review aggregating non recurring cost and recurring costs. The recurring costs are divided in material costs, internal processes costs and subcontracting costs. It is expected that the internal processes cost decrease over time due to an increase of know-how. Non recurring costs are broken down into: engineering activities; manufacturing; logistics; quality (tooling approval); processes and materials certifications; other costs (subcontracting, travels, training and investments).

In the fifth contract section a macro level project schedule is attached. It should include the main project activities, the start and end dates and the critical chain.

In the sixth contract section the industrialization process audit responsibility is assigned to one or more individuals that guarantee audits execution in the planned dates.

The seventh contract section comprises the project deliverables and the corresponding milestones.

The eighth contract section depicts the product configuration, containing the following information: part number description; quantity; drawing, partlist and 3D model indexes; customer code; technical sheets type and number.

The ninth contract section is a list of the manufacturing instructions identifying its reference, structure level and a description.

The tenth contract section is a tooling list comprising: a description; part numbers manufactured; the calibration process; type; and quantity;

The eleventh contract section aims to document the tooling project in its initial stage, indicating: part numbers; maximum dimensions; costs; and 3D models.

The twelfth contract section aims to document the manufacturing time of each part number. The maximum manufacturing rate should be compared to the deliveries forecast in order to identify possible constraints.

The thirteenth contract section depicts the logistics project related to the industrialization process. It is comprised of: internal logistics (handling and movement conditions); supply logistics (packages and transports); shipping logistics (optimum shipping package and transport).

The fourteenth contract section comprises a SIGMA overview demonstrating that the information loaded to the system is according to the project specifications, namely: deliveries forecast, purchase orders and acquisitions lead times.

6.2. CP 01 - Product Structure Review

The first control point is linked to the product structure. At this phase, all activities of technical documentation management, product structure definition and suppliers searching should be concluded. Additionally the tooling project is developed.

The deliverables of this phase are: customer documentation received; articles defined; engineering technical specifications completion; market analysis carried out; tooling project concluded.

6.3. CP 02 - Manufacturing Resources Review

The second control point is linked to manufacturing resources. At this stage the support documentation to tooling manufacture is prepared. If tooling manufacture is subcontracted, then purchase orders are sent out. Simultaneously, activities of suppliers selection and certification are completed. Related to logistics management, the supplying/acquisition external logistics are defined.

The deliverables of this phase are: economic lot, transports and external routes defined; tooling manufacturing orders released; tooling purchase orders sent out; purchase orders for products acquisition sent out.

6.4. CP 03 - Manufacturing Outset Review

The third control point aims to ensure that all the required resources are available to begin the manufacturing process. At this stage, suppliers FAI products are followed and approved. Tooling acquisition or production is completed. The manufacturing process methodology is defined and processes are certified when required. Internal storage, handling and transport conditions are defined.

The deliverables of this phase are: special processes certified; manufacturing technical documentation defined; manufacturing orders approved; tooling available; raw material available; suppliers FAI's approved; workforce trained and certified; line supply defined; work security evaluated; manufacturing orders sent out.

6.5. CP 04 - FAI Manufacturing Review

The fourth control point is linked to the FAI product manufacturing. At this stage, the FAI product is manufactured and subsequently submitted to approval by means of FAI inspections and PPAP deliverables. Additionally, activities of suppliers mass production stage follow up and product shipping are defined.

The deliverables of this phase are: FAI product manufactured; FAIR's approved; PPAP deliverables approved; FAI product shipped.

6.6. Production Handover Phase

This phase aims to approve the industrialization process and comprises production handover activities and suppliers mass production stage follow up.

The deliverables of this phase are: FAI/PPAP improvements applied; recurring costs (hours) variance evaluated; recurring costs (materials) variance evaluated; non recurring costs variance evaluated; on time delivery variance evaluated; lessons learned recorded; technical report comprising the most significant information about product and process features delivered to production.

The lessons learned concept is part of the continuous improvement processes. Through the identification and documentation of past experiences, current and future projects can benefit, namely, avoiding past failures as a result of spreading good practices.

Every team member should contribute with his knowledge enhancing the lessons learned process. In order to more easily identify lessons learned, taking into account the following perspectives is a good starting point: project relevant events; goals and deadlines achievement; successful events and the respective root causes from an internal and customer perspective; unsuccessful events and the respective repercussions from an internal and customer perspective; positives and negatives unforeseen actions.

In collaboration with the Information Technology division a lessons learned database was developed that comprises the following fields: project designation; project stage; project manager; SIGMA project identification; customer; source division; technology; event description; root cause; corrective and preventive actions; impact.

The database is intended to aggregate lessons learned from all industrializations processes and presents the following advantages:

- record directly at OGMA internal website or by uploading an excel file - it is possible to record the lessons learned throughout the project and, when required, upload all to the website;

- filter searches - it is possible to select information by each one of the fields;

- share more easily - tacking into account that the database was developed at OGMA internal website, lessons learned consultation is available to everyone related to aerostructures manufacturing;

- download particular lessons learned to an excel file - typically, customers request the project lessons learned, so after searching by project, lessons learned can be download to a file ready to be sent.

7. Production Part Approval Process

According to [9], PPAP is an output of APQP (Advanced Product Quality Planning) confirming that the production process has demonstrated the potential to produce products that consistently fulfill all requirements while operating at the customer demand rate.

In this chapter the deliverables that should comprise OGMA PPAP are approached.

7.1. DFMEA

The DFMEA (Design Failure Mode and Effects Analysis) is a methodology applied by the organization responsible for the product design to identify potential failure modes in the design and to define preventive actions. The customer is responsible for performing the DFMEA and should deliver it to OGMA simultaneously with the product drawings. The DFMEA should be reviewed when performing a PFMEA (Process Failure Mode and Effects Analysis), or a control plan, in order to enhance the respective output.

7.2. Process Flow Diagram

The process flow diagram depicts all the operations required to manufacture the product, from receipt of raw material through shipment of finished product.

The process flow diagram should comprise: measurements, inspections and handling activities; machine and tooling descriptions; list of released and approved part drawings and operation work instructions.

7.3. PFMEA

The PFMEA is methodical approach, similar to DMFEA, but applied to the process. The goal is to identify potential failure modes in the process and to define preventive actions. The engineering division is the main responsible for applying the FMEA methodology to the process, but this should be a team activity including all the divisions linked to the process.

7.4. Control Plan

The control plan is a document that describes actions (measurements, inspections, quality controls and monitoring of process parameters) required in each process stage in order to ensure the achievement of the project requirements.

The control plan should comprise: manufacturing methodology; product or process features to be checked; key characteristics; outsourced operations; process equipments; test equipments used to measure each characteristic; sampling strategy; and control and reactions methods.

7.5. Measurement Systems Analysis

The measurement systems analysis (MSA) is, essentially, the study of certain effects (people, machines, tooling, methods, materials, environmental conditions) on the measurement process (precision, accuracy and uncertainty).

The most common MSA methods are: bias studies; Gage Repeatability and Reproducibility (Gage R&R); repeatability study; measurement uncertainty analysis; attribute agreement analysis.

7.6. Process Capability Studies

Process capability studies compare the output of an in control process with the product specifications. Essentially, the study compares and tries to align the process output with the requirements.

Process performance can only be established for statistically stable processes. The sampling size shall be statistically valid and, in some cases, established together with the customer.

The report should comprise: product identification; process phase; operator; measurement system; sampling size and strategy; gathered data; calculations; graphics; capability indices; remarks;

7.7. Logistics Plan

The logistics plan aims to ensure that the methods of packaging, preservation, labeling of production materials and products are in conformity with internal and/or customer requirements. It should also ensure that the product will not be damaged in the course of transportation, delivery and storage.

The logistics plan should comprise: supplying/acquisitions external logistics plan; handling and internal movement logistics plan; handling, packaging and final product shipping logistics plan.

7.8. FAIR

The first article inspection aims to validate that the manufacturing process is capable of producing products according to the contract requirements.

The First Article Inspection Report is an output of the FAI process, aggregating all the documents and records required to provide evidence that the first product manufactured is in conformity with the requirements.

7.9. Weight Report

The weight report aims to record the parts weight and respective deviations from the expected values.

The weight report should comprise: part number; 3D model weight; upper and lower tolerances; measurement system; actual weight; maximum and minimum allowable weight; and remarks.

7.10. Tooling Project

When it is necessary to develop tooling to the industrialization process, it is required to provide evidences of the tooling project progress.

In the project schedule are established two tooling project milestones, the preliminary design review and the critical design review.

7.11. Dimensional Inspection
Dimensional inspections assess the geometrical characteristics of the product aiming to ensure that the design specifications are met.

The dimensional report should comprise: dimensional inspection plan; inspection procedures; measurement systems; tolerances; and results.

7.12. First Part Qualification
Qualification procedures of composite parts are denominated FPQ. This procedures consists, essentially, in a set of tests and inspections defined according to the product features and customer requirements.

The FPQ report should comprise: procedures schedule; identification of part numbers and tooling; description of the tests and inspections performed; and the respective results.

7.13. Sub Tiers Management
Sub tiers management is the set of activities that aims to ensure the supplying conformity with the applicable specifications.

The sub tiers management plan should comprise: visiting schedule; plan of audits; KPI's; flow down of requirements; qualification status.

7.14. Product Structure
The product structure comprises the identification of part numbers, the application coefficient, materials used and respective quantities, drawings and respective indices, a tooling list and a list of the special processes involved.

7.15. Special Processes
Certification of special processes is the official action that approves and documents the fulfillment of the applicable requirements. The documentation should comprise all the records of the performed analysis and tests.

7.16. Tooling, Checking Aids and Fixture Approval
This deliverable should comprise a list of the tooling and the equipment, used to manufacture and inspect the product, identified in the control plan. Additionally, it should comprise: inspection procedure and dates; tooling certification.

7.17. Workforce Qualification Plan
The workforce qualification plan is the training plan to obtain or, to renew, the required workforce skills, assuring the proper qualification.

7.18. Qualified Workforce
This deliverable comprises a list of the qualified workforce, including: worker identification; operational area; certification code and designation; certification dates (emission and expiration).

7.19. Layout
The layout should comprise the floor plan of the entire manufacturing process.

7.20. PPAP Approval Form
Both the supplier and the customer should sign the PPAP approval form to state that the PPAP documentation is in accordance to what was initially agreed.

8. Conclusions

The main goal of the present work was to review OGMA aerostructures industrialization process and to improve certain aspects.

The industrialization contract, the industrialization checklist and the Obeya meeting operational standard, were updated and made available at OGMA internal website.

The project standard key performance indicators, the risk analysis methodology and the lessons learned record methodology were established.

The set of PPAP deliverables that must comprise OGMA PPAP was established and basic methodology of PPAP elaboration was defined.

The developed work led to the industrialization process internal norm full revision that was outdated regarding the current process. When an internal audit is performed, this norm must be in conformity with the industrialization process, thus justifying the value of the developed work.

As future work it would be helpful to study other industrialization methods in order to compare them and establish advantages and disadvantages of each one.

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