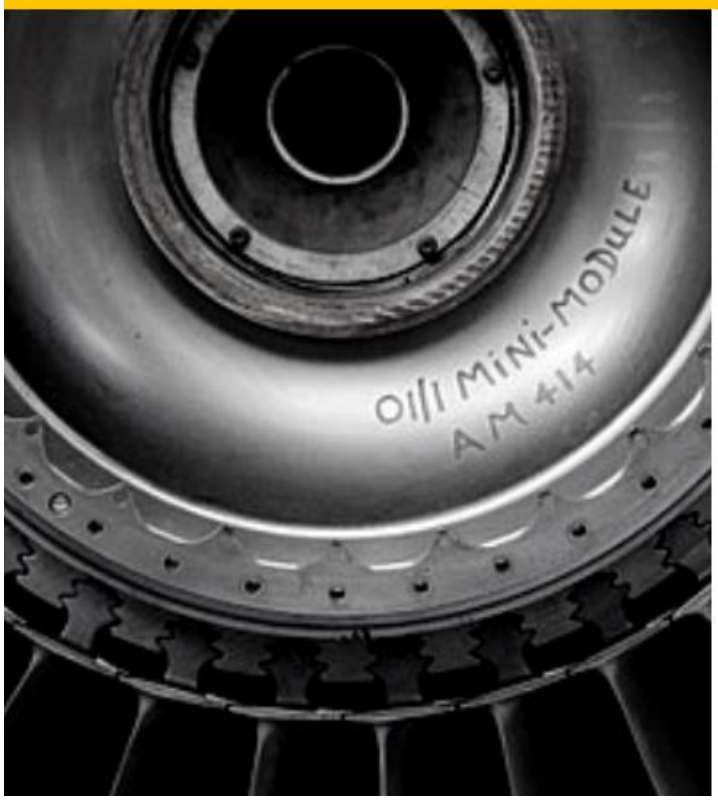
AEERO

IO1. RESEARCH, CONTEXTUALISATION AND NEED ANALYSIS

GENERAL REPORT



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About this document

This document is part of Intellectual Output 1 (O1) of **AEERO: Aerospace Engineering ECVET Resources Online**. The project AEERO is co-funded by the European Commission through the ERASMUS+ programme, KA2.

Following the methodological guidelines and tools provided by the leader of O1, the results of primary and secondary data collection and analysis of each partner country (UK, Italy, and Portugal) are compiled in a global European Report. National Reports are the basis for the Global Report which sets out the main conclusions of O1 - Research, Contextualisation and Needs Analysis, which aims at providing background and contextualisation for the project, to ensure quality and that the platform, the learning objects and the content are fit for purpose, relevant to the market and of a high standard.

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Acronyms list

AGP	Aerospace Growth Partnership	IT	Italy
BIT	Business Improvement Techniques	PT	Portugal
EC	European Commission	R&D	Research and Development
ECVET	European Credit system for Vocational Education and Training	SME	Small and Medium Enterprises
EU	European Union	UK	United Kingdom
GDP	Gross Domestic Product	VET	Vocational and Educational Training

Contents

1. Introduction

The aerospace industry is one of the most technologically advanced in the modern economies. It also benefits from state-of-the-art research and pioneering technology leading to devices, materials and systems that are intensively used within the sector targeting client's needs. Business models and market approaches perform well with profitable turnovers for the different stakeholder groups involved in the entire value-chains.

Consequently, with its highly skilled workforce, comprehensive research and development programmes, and deep emphasis on innovative technology, the Aerospace and Defence industries play a pivotal role in the European Union (EU) economy.

The European Aerospace sector is a key part of the EU economy. Highly dynamic and innovative, it is a world leader in advanced engineering, in civil air transport and in space technology, delivering a myriad of economic and social benefits for Europe.[1]

The industry is highly concentrated, both geographically (in some regions of the EU countries) and in terms of the few large enterprises involved, although it also includes large numbers of small suppliers operating in tiers 3 and 4. Furthermore, employment in the aerospace sector is particularly significant in the United Kingdom, France, Germany, Italy, Spain, Poland and Sweden. Productivity is also noteworthy and despite the high employment costs, the sector is quite profitable with a substantial share of value added being spent on research and development (R&D), which reflects in an increasing number of patent applications.[2] It is one of the most R&D intensive sectors in Europe, dedicating more than 12% of its turnover to research and development: 16% of its employees work in R&D, often in close partnership with universities and research centres.[3]

Currently, the EU is a world leader in the production of civil aircraft, including helicopters; aircraft engines, parts and components which are exported all over the world, producing a trading surplus.[4] The aerospace sector is a major contributor to the EU trade balance: around three-quarters of Europe's civil aviation output is exported outside of the EU.[5]

The main challenges facing the European Aerospace industry are:

- International competition from different regions of the world
- Competitors subsidised by the USA (Boeing)
- Congested skies and air traffic control systems stemming from the 50's which are functioning, but soon will be needed to be improved due to the expected annual growth rate of air traffic until 2030 (5% per year) and increasing numbers of passengers using airports[6]
- Congested airports
- CO2 emissions reduction
- Skilled workforce operating in demanding and stressful jobs/profession highlighting social issues
- Maintaining high safety standards

In this context, EU actions in the following areas are also needed:

- Reinforcing the social agenda and creating high quality jobs in aviation;

[1] http://www.asd-europe.org/?id=9
[2] https://ec.europa.eu/growth/sectors/aeronautics_pt
[3] http://www.asd-europe.org/?id=9
[4] https://ec.europa.eu/growth/sectors/aeronautics_pt
[5] http://www.asd-europe.org/?id=9
[6] https://ec.europa.eu/transport/modes/air_en

- Protecting passenger rights;
- Embracing a new era of innovation and digital technologies;
- Contributing to a resilient Energy Union and a forward-looking Climate Change Policy.[7]

Different countries have established several measures to accomplish this strategy and meet these requirements.

1.1 United Kingdom

The Aerospace Growth Partnership (AGP), a strategic partnership between the UK Government and industry[8] was set up in 2010 in order to tackle barriers to growth, boost exports and grow high value jobs in the UK helping to create a sustainable, long term future for the industry.

The UK demonstrates a good model where Aerospace strategy is focused on improving productivity and competitiveness by investing in next generation skills, radical technologies, and increased productivity throughout the supply chain. It is supported by £1.95bn of Government Research and Development funding for 2013-26 which is being matched by the industry to provide a total investment of £3.9bn through the Aerospace Technology Institute.[9]

Nonetheless, a 2015 survey of the UK supply chain[10] commissioned by the UK Government found that many companies have shortages in advanced technology and manufacturing skills and experienced shortcomings in advanced manufacturing and lean supply chain management which impeded global competitiveness and (particularly in lower tier companies), lacked the management structures and processes required to achieve growth. The strong engineering tradition in the UK is supported by top ranking University courses (currently 69 courses at 47 different Higher Education Institutions are offered)[11] which produce highly knowledgeable graduates in the field of aeronautical engineering; however these graduates take longer than desired for their first-rate skills to be adapted to the practical work environment of an aerospace company.

1.2 Portugal

Traditionally, the industry in Portugal has been primarily focused on activities with lower added-value associated with manufacturing and commercialization. A new strategy based on a combination of measures and policies such as substantial investment in R&D, an excellent level of FP7 funding success, a strong cluster organization, wide participation in European projects, establishing relationships with critical partners and knowledge acquiring, as well as the presence of large international players in the country has allowed the Portugal to gain the competences and competitiveness to place the aerospace sector amongst the most technologically advanced in the world.

The next steps devised to continue pursuing this type of strategy will lay in taking critical advantages from the existing knowledge of advanced manufacturing technology present in Portuguese SME's that are already working in the aerospace industry enlarging, services supply for this sector. In the long run, the country wishes to assure the development of entire aircraft and is already partially doing this, helping Europe to be a worldwide leader in the sector.

[7] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0598&from=EN
[8] http://www.theagp.aero/the-agp/
[9] http://www.ati.org.uk/
[10] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536903/bis-16-310-aerospace-supply-chain-study.pdf
[11] http://search.ucas.com/search/providers?CountryCode=&RegionCode=&Lat=&Lng=&Feather=&flt99=2011&Vac=1&AvailableIn=2017&SubjectCode=20
https://www.thecompleteuniversityguide.co.uk/courses/search?s=Aeronautical+engineering

1.3 Italy

With a long history in mechanical engineering alongside innovation and research supported by many institutions and universities, Italy's aerospace industry demonstrates vast capabilities. Among the large players and SME network it is possible to find competences across the entire aeronautics value chain and in every aspect of aerospace activity, from components and services to data collection and handling.

At national level, the Aerospace Sector is characterized by the presence of several clusters and regional districts. Industrial and technological knowhow of these aggregations is wide and is built on local excellences ranging from fixed and rotating wing systems, software, propulsion and engine, fuselage components, projecting and installation of specific parts (made of aluminium, titanium and other composite materials), steel, mechanics and electro mechanics production to plastic, rubber and other high standard materials for complex applications. In this sense, the trend, in recent years, shows the increasing of inter-regional clusters, with the aim of rationalising the supply chain and linking local competencies with universities and research centres.

The Italian aerospace industry has the fourth highest turnover at European Level and the seventh worldwide. One of the most important features linked with this performance, is the relevance of exports, as it represents the seventh highest share of a total income of €13 billion[12].

[12] "Il settore aerospaziale resiste alla crisi: dal 2008 +43% di fatturato – Newspaper article- Il sole 24 ore 04-09-2015"

2. Market size and characteristics

In 2015, the International Airports Council estimated the total economic impact of airport and aviation-related activities at €338 billion across the EU representing 2.1% of the total European GDP. A recent study for the Commission shows the strategic weight of the sector makes a vital contribution to the economy, estimating that up to 2 million people are employed directly in the EU aerospace sector and that it directly contributes more than €110 billion to the European GDP. 900 million air passengers travel each year to, from and within the European Union, making up one third of the world market.

Aviation can also act as an 'economic multiplier' generating wider economic activity, positively influencing job creation and retention. Overall, the sector directly employs between 1.4 to 2 million people and directly or indirectly supports 4.7 to 5.5 million jobs.

Since the creation of a single market for aviation in 1990 the entire sector has been affected by strong business dynamics not previously seen in such a complex market; prices have fallen dramatically, new business models appeared and the offer of services and routes has grown significantly. European policy has fundamentally reformed the air transport industry and created the conditions for competitiveness while ensuring both quality of service and the highest level of safety.[13]

The increasing global demand for new aerospace and aeronautic products is expected to grow during the next decades. It is expected that passenger traffic will be grow annually at a rate of 4.8% in the coming years. The aerospace sector of EU requires general improvements to be ready to meet the rising demands for fleet enlargement, reduction of environmental impacts, increased aircraft size, safety and security standards, airport saturation and opportunities and threats from emerging markets. The importance of passenger air transportation is expected to grow stronger with a simultaneous increase in air cargo business. Aeronautics is already one of the EU's key high-tech sectors on the global market, but to maintain the high competitiveness levels achieved, the sector must guarantee considerable investments in the R&D sector. In light of this, the EU has already launched a "Clean Sky" initiative in 2008, which is a public-private partnership worth € 1.6 billion aimed at helping the aerospace industry to develop and build environmental friendly aircraft. [14]

The European ASD industry[15] has experienced improved performances such as growth in revenues, export and market competitiveness. The ASD KEY FACTS & FIGURES 2015[16] states that 2015 was another year of growth for the industry which remains sustainable and competitive, against the uncertainties and slowdown of the European economy and manufacturing.

This report confirms a continued stability of investments in R&D, in the range of €20 billion, equally split between civil and military activities allowing a valuable return which needs to be preserved in the a future where the industry is facing increased competition from third country government investments and competitors.

In line with the global military demand, a similar trend has taken place in Europe in respect of military exports which experienced a 50% increase of value of orders in 2014-15 (continuing in 2016); higher than

[13] https://ec.europa.eu/transport/modes/air_en

[14] ADS Industry Facts and Figures 2015 (www.adsgroup.org.uk/Facts2015)

[15] In 2015 ASD member associations were spread across 19 European countries: 16 of them in the EU plus Norway, Switzerland and Turkey. The EU countries are: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Poland, Portugal, Spain, Sweden and UK.

16 ADS Industry Facts and Figures 2015 (www.adsgroup.org.uk/Facts2015)

the average of the last 5 years. Deliveries are forecast to reach the level of €40 billion, with a 60:40 ratio between extra and intra-EU sales. This includes final items and parts to industries.

Aeronautics (including civil and military activities) turnover level represented €161.7 billion compared to €140.5 euro in 2014. Civil aeronautics demonstrated a significant increase of 23% with turnover amounting to €113.4 billion, compared to €91.6 billion in 2014. Military aeronautics shows stability with a turnover amounting to €48.3 billion in 2015 and 848k workers.

2.1. United Kingdom

The UK's Aerospace industry is the largest in Europe and globally is second only to the United States. It is the powerhouse of the Advanced Manufacturing sector in the UK. In 2015, it generated an annual turnover of £31 billion including £27 billion of exports, representing a 39% growth in productivity since 2010. There are almost 3000 companies within the UK Aerospace sector directly employing 128,000 workers including 4,100 apprentices and indirectly supporting a further 154,000 jobs.[17]

A highly-skilled workforce, historical institutional expertise and an advanced science and research base has ensured the UK has a strong position in many current aircraft programmes. This success draws heavily on the investment made in developing technologies in the 1970s and 1980s, and the UK is now at the forefront in three high-value, highly complex areas of modern aircraft; engines, aero-structures and advanced systems.[18]

Despite strong core aeronautical skills, there is also a shortage of skilled manufacturing and advanced technology skills in the UK. Due to this lack of available talent there is strong competition from the prime contractors and major Tier 1 suppliers as well as from other industries that require similar skillsets (e.g. automotive).[19]

Overall, this large-scale UK supply chain survey indicates reasonably strong growth in the UK aerospace supply chain and for lower tier suppliers, an optimistic view of future growth. However, there is a disparity between this view and that of prime contractors and Tier 1 suppliers which is contributing to a reducing UK share of global aerospace market in the face of lower costs and higher productivity in many emerging and advanced economies and a strong willingness for some overseas governments to invest in this area.

2.1. Portugal

To place the country as a supplier of higher added-value products and services different policies have followed in order to encourage more complex activities such as assemblage, outsourcing, co-manufacturing and production of components. To change the fact that Portugal represented a relatively small portion of the gross investments within the EU countries members of the European Space Agency (ESA), in 2012, and despite being hit by a severe financial crisis, the Portuguese government undertook a strategic investment commitment for the following three years (2013-2015), pledging a subscription to the ESA Optional Programs, which would best adapt to the national space industry's requirements and improve response capabilities.

The sector was assured a strong presence in international aerospace R&D and Innovation programmes, through active participation in R&D and Innovation Framework Programmes, of the European Space Agency (ESA), European Aviation and Safety Agency (EASA), and a direct involvement in some of the major

[17] ADS Industry Facts and Figures 2016 (www.adsgroup.org.uk/Facts2016)
[18] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536903/bis-16-310-aerospace-supply-chain-study.pdf
[19] ibid

aeronautical programmes worldwide such as the Embraer KC-390, AugustaWestland AW609 tilt-rotor or EADS-CASA C-295.

In respect of the Labour Market, the whole aeronautic industry in Portugal comprises some 7,000 jobs and involves highly-skilled, experienced professionals from different fields and areas ofexpertise. At first glance, the whole workforce is divided between R&D and R&I (universities, research centers) and industry (organisations of different size and position in the supply chain)[20]. In Portugal, due to several factors, the general level of investment (as a percentage of GDP) has been decreasing steadily since 2010.[21] Portugal's greatest asset is probably the technical expertise and competence of Portuguese professionals in structures and materials, advanced manufacturing, industrial engineering, system integration and simulation and technology application for existing and next-generation aerospace systems.[22]

According to José Marcelino, chairman of the Portuguese Aerospace Industry Association, the aeronautic industry accounted for 1% of Portuguese GDP in 2015 and, by 2025 it will have doubled its sales, reaching 2% of national GDP through the capitalization generated by EU funds and the maturity of the automobile sector, connected to aeronautics. The manufacturing industry is primarily focused on exporting and is a niche, highly innovative and profitable industry; despite being a relatively small sector.

2.2. Italy

The Italian aerospace sector is an industrial catalyst for high technology, generating positive effects for cross fertilization of related industries. Italy is investing significantly in the development of new technologies in both products and processes (up to 12% of total R&D expenditure for the country). This has been well justified by its results: one euro invested in R&D has generated up to 7 euros of GDP and €10 billion creating 300 new jobs.[23] The Aerospace industry has always outperformed the national manufacturing sector even during periods of economic crisis. At national level, the total turnover is €10 billion and the size of the Aerospace industry is 1% of national GDP. Enterprises belonging to the Aerospace industry employ up to 60.000 workers of which one third are engineers involved in research and productivity.[24]

Among the main stakeholders are **CTNA** (Aerospace Technological National Cluster) a trade association including, among the others, Leonardo, Avio Aero, Campania Aerospace Technological District, Regione Lazio Financial regional agency, Promoting Committees for Aerospace industry in Lombardia and Piemonte Regions, Italian Space Agency (ASI), Italian Federation of companies in Aerospace, Defense and Security and CNR – National Board for Research. CTNA is the key organization unifying all different actors within the aerospace sector, from the various regions, ranging from large companies and SMEs, to academic institutions and other entities.

There is a wide presence of small and medium enterprises, universities and research centres. Many companies have been able to draw on their experience in other sectors, transferring knowledge from the automotive industry. Small and medium enterprises employ 10% of the whole workforce in the Aerospace sector, and also benefits from an extended network of specialized subcontracting companies (focusing on selected fields, such as precision mechanics, optic, advanced materials etc.), all contributing to the

[20] EC, Horizon2020 country performance, 2016
[21] http://ec.europa.eu/regional_policy/en/projects/portugal/kickstarting-portugals-fledgling-aerospace-industry
[22] http://ani.pt/wp-content/uploads/PortugueseProfiles.pdf
[23] "Cluster Tecnologico Nazionale Aerospazio Piano di Sviluppo Strategico 2013-2017 28 Settembre" www.ctna.it/ITA/team/shareholders/CTNA_Rapporto_20120927.pdf
[24] "DATI E APPUNTI SU FINMECCANICA E IL SETTORE AEROSPAZIALE" http://www.fiom-cgil.it/web/aziende/grandi-gruppi/gruppo-finmeccanica/documenti/dati-e-appunti-su-finmeccanica-e-il-settore-aeronautico?device=desktop

national aerospace economy. Due to their smaller size and market presence, SMEs face strong competition and challenges that larger companies overcome more easily. The speed at which the aviation industry is evolving, and the obstacles that national SMEs are facing, are forcing them to look abroad for business opportunities. Many believe that their capacity to survive will depend on whether they are able to enter the European and international markets or not.

Aerospace industry is now facing, a series of contrasting challenges; on one side, the commercial sector is in a period of growth forecast to continue, on the other side, governments, particularly in Italy, are limiting investments especially in the military sector. This tendency is leading to strong pressures on the supply chain, together with the volatility of fuel prices and general weakness of Western economies.

We are able to draw some general conclusions about the Aerospace industry in Europe:

- Competences in the sector are shared with the automative sector and many developments result from joint research and well-aligned policies
- It has a strong investment in the R&D sector, with rates much higher than other sectors
- The all sector has a high rate of exports
- The value-chain is complex and extensive leading to different levels of specialization
- Traditional leading countries in the industry are facing competition from other emerging economies in the supply of services for the big players, especially competing with the players positioned in the tier 3 and 4; those countries companies are turning their strategies towards being more exporting oriented.

Therefore, it is essential to encourage a sustained and productive dialogue with industry stakeholders and policy makers in these key sectors.

3. Training offer and routes to market

This report, intends to account for Vocational Education and Training (VET) related to the aerospace industry activities and Business Improvement Techniques (BIT) that includes any type of education and training which aims to equip people with knowledge, know-how, skills and/or competences required in aerospace related occupations or more broadly in the labour market. This is in line with the definition of VET provided by the EU Quality Assurance in Vocational Education and Training (EQAVET)[25]

It encompasses education and training at higher qualifications levels (6-8 of the European Qualifications Framework) generally available at Higher Education Institutions. In line with the clear distinction made between VET and academic higher studies by the European education system, HEI provision within this report is discussed in separate sub-sections.

In the countries assessed, the term BIT – Business Improvement Techniques – was not equally well known, but is used in similar ways. The HEI and VET providers were revealed to be more aware of if than companies and other stakeholders. Apart from UK, where the awareness of training in BIT is relatively high; in the other countries, a few Institutions of Higher Education make it available during training, but not a significant amount. Amongst private companies BIT is relatively unknown, but these organisations clearly express an interest in knowing and having access to this genre of training or similar.

While the terminology Business Improvement Techniques (BIT) is not familiar for most of the aerospace industry stakeholders, the subjects it covers are known and sometimes used. This is further discussed in section 5 – Needs Analysis.

3.1. Training courses and certification

3.1.1 United Kingdom

BIT are included in different types of learning in United Kingdom, such as:

- Apprenticeships
- Vocational education and training
- Higher education institutions
- Aerospace growth partnership support programmes

Apprenticeships

An apprenticeship can be described as a job with an accompanying skills development programme designed by employers in the sector. It allows the apprentice to gain technical and real practical experience, along with functional and personal skills required for their immediate job and future career. These are acquired through a mix of learning in the workplace, formal off-the-job training and the opportunity to practice and embed new skills in a real-world context.

Level 2 Apprenticeship Framework – Improving Operational Performance[26]

Developed and issued by the Science, Engineering and Manufacturing Technological Alliance (SEMTA)[27], an NGO responsible for engineering employer led skills solutions in the UK's most advanced sectors; this framework includes a new learning pathway specifically focused on Business Improvement Techniques. It

[25] http://www.eqavet.eu/qa/gns/glossary/v/vocational-education-and-training.aspx
[26] http://www.afo.sscalliance.org/frameworkslibrary/index.cfm?id=FR04049
[27] http://semta.org.uk/

provides an industry standard programme centred on the proven tools and techniques of lean process and quality improvement activities. It is designed to support continuous improvement by promoting effective team working and developing lean skills across the wider workforce.

The B-IT2 NVQ is delivered by high-achieving lean process practitioners and is described within the framework guide as 'a down to earth, hands-on programme designed for operators in companies that have lean systems in place but are looking to engage the wider workforce in continuous improvement activities'. It teaches learners how to identify and eliminate waste, create flow and improve quality, leading to greater efficiency and increased profitability. The programme is also considered essential in ensuring UK companies can compete against strong international competition.

Qualifications available to learners undertaking this pathway include:

- Competence Qualifications:

C1 – Level 2 NVQ Diploma in Business Improvement Techniques[28]

- Knowledge Qualifications:

K1 – EAL Level 2 Certificate in Business Improvement Techniques[29]
K2 – Pearson BTEC Level 2 Certificate in Lean Organisation Management Techniques[30]
K3 – City and Guilds Level 2 Certificate in Improving Business Performance[31]
K4 - PAA/VQSET Level 2 Certificate in the Improvement of Business Performance
K5 – EAL Level 2 Certificate in Applying Business Improvement Techniques[32]
K6 – NCFE Level 2 Certificate in Lean Organisation Management Techniques[33]
K7 – Pearson BTEC Level 2 Extended Certificate in Engineering (Specialist: Manufacturing Engineering)[34]
K8 – HABC Level 2 Certificate in Lean Organisation Management Techniques[35]
K9 – HABC Level 2 Certificate in Business Improvement Techniques[36]
K10 – City and Guilds Level 2 Certificate in Manufacturing Practices[37]
K11 – FAQ Level 2 Certificate in Business Improvement Techniques
K12 – ETCAL Level 2 Certificate in Business Improvement Techniques
K13 – BIIAB Level 2 Certificate in Lean Organisation Management Techniques [38]

[28] http://www.cityandguilds.com/qualifications-and-apprenticeships/manufacturing-industry/business-improvement-techniques/7576-business-improvement-techniques#tab=information
[29] http://eal.org.uk/PDF/B-IT/501_1495_5_fs.pdf
[30] http://qualifications.pearson.com/content/dam/pdf/btec-specialist/BA025217-BTEC-Cert-in-Lean-Organisation-Management-QCF-L2-011110.pdf
[31] http://cdn.cityandguilds.com/ProductDocuments/Manufacturing_Industry/Business_Improvement_Techniques/7576/7576_Level_2/Centre_documents/7576-02_L2_Qualification_handbook_v2.pdf
[32] http://eal.org.uk/images/SPEC_601_1686_9.pdf
[33] https://www.ncfe.org.uk/media/432228/ncfe-level-2-certificate-in-lean-organisation-management-techniques-qan-60125305-fixed.pdf
[34] https://qualifications.pearson.com/content/dam/pdf/BTEC-Specialist-Qualifications/Engineering-(Specialist---Manufacturing-Engineering)/2010/Specification/9781446924983_BTEC_Splt_Eng_SpltME_L2_Iss2.pdf
[35] https://highfieldabc.com/Assets/DownloadArea/QualificationDownloads/[14062017_1558]_9_L2_Certificate_in_Lean_Org_Mgt_Techniques_specification_v2.pdf
[36] https://highfieldabc.com/Assets/DownloadArea/QualificationDownloads/[10022017_1336]_9_L2_Certificate_in_Business_Improvement_Techniques_specification_v1.1_published.pdf
[37] http://cdn.cityandguilds.com/ProductDocuments/Manufacturing_Industry/Manufacturing/5938/Purpose_and_Recognition/19_Plus/Purpose/60130362_L2_Certificate_in_manufacturing_Practice_Purpose.pdf
[38] https://www.biiab.org/fileadmin/content/Documents/Qualifications/Business_Improvement_Techniques/Handbooks/biiab-level-2-certificate-in-lean-organisation-management-techniques-handbook-v1.0.pdf

The pathway also includes information on:

- Employee rights and responsibilities
- Functional skills

The Business Improvements Techniques Pathway is designed to ensure that business practices are planned and executed as efficiently as possible, identifying and minimising waste whilst ensuring highest quality.

Learners can progress through the following higher level apprenticeships:

- Operations and Quality Improvement Advanced Apprenticeship Framework Level 3[39] which has a single learning pathway on Business Improvement Techniques
- Higher Apprenticeship in Advanced Manufacturing Engineering Framework Level 4[40] equates to a foundation degree and includes an aerospace specific learning pathway.

Vocational Education and Training

Many of the vocational training courses focusing on BIT form part of the apprenticeship frameworks, but can also be completed as courses in their own right outside of a formal apprenticeship.

A City and Guilds National Vocational Qualification (NVQ) in Business Improvement Techniques, is available at Levels 2, 3 and 4[41] and has the learning objective of improving business performance through the delivery of Quality, Cost and Delivery (QCD) benefits. This suite of qualifications provides the learner with all the skills (from basic to advanced) to effectively monitor and make improvements to production and manufacturing processes. The learner is assessed in the workplace and on completion of this qualification the learner is well placed to work in a variety of business improvement roles in their chosen industry.

The City and Guilds Level 2 Diploma in Aerospace and Aviation (Foundation Competence[42] and Knowledge[43]) is a qualification designed for the Aerospace Manufacturing Fitter apprenticeship standard. The standard has been developed by Employers including BAE Systems, Airbus UK, Rolls Royce, GKN, Marshalls Aerospace and Defence Group and AgustaWestland. The competence qualification is undertaken in the foundation phase (first year) of the apprenticeship and includes an optional unit on 'Conducting Business Improvement Activities'. This unit of competence identifies the training and development required in order that the apprentice can demonstrate that they are competent in being able to conduct a business improvement activity using a systematic plan, do, check, act approach for an engineering operation or process, which will prepare them for entry into the engineering industry or engineering manufacturing sector, creating a progression between education and employment and acting as a basis for the development of additional skills and occupational competencies in the working environment. They will be expected to adopt a systematic approach to conducting business improvement activities on an engineering/manufacturing operation or process to identify opportunities for the elimination of waste.

[39] http://www.afo.sscalliance.org/frameworkslibrary/index.cfm?id=FR03680
[40] http://www.afo.sscalliance.org/frameworks-library/index.cfm?id=FR04082
[41] See 18
[42] http://cdn.cityandguilds.com/ProductDocuments/Engineering/Mechanical/4605/4605_Level_2/Centre_documents/4605_L2_Qualification_Handbook_v2-0.pdf
[43] http://cdn.cityandguilds.com/ProductDocuments/Engineering/Mechanical/4705/4705_Level_2/Centre_documents/4705-02_L2_Diploma_Qualification_handbook_v1.pdf

They are required to conduct a 5S/5C audit and identify wasteful or non-added value activities in the operation or process. They also need to produce a new standard operating procedure (SOP) or contribute to improving an existing SOP. These activities include creating the appropriate visual management systems required, calculating key performance indicators required and the quality control requirements and presenting records of the business improvement activities and how they will meet their aims. Their underpinning knowledge will provide an understanding of their work, in order to safely apply appropriate engineering principles to business improvement activities. Learners will understand the tools and techniques used in business improvement activities and procedures used, and their application, and will know about the process, materials and consumables, to the required complexity to provide a sound basis for carrying out the improvement activities and producing project plans that will lead to a successful project outcome.

The knowledge qualification also includes a unit on '**Business Improvement Techniques**' which aims to provide the learner with the knowledge of lean business process and quality improvement in order to effectively monitor and make enhancements to production, manufacturing and maintenance processes. Topics covered include continuous improvement, workplace organisation, visual management and problem-solving techniques.

These and other similar courses are available from a wide range of public and private VET providers.

Higher Education Institutions

Undergraduate

According to UCAS in the UK there are over 60 Higher Education providers of Undergraduate Aerospace related courses. 51 in England, 5 in Scotland, 4 in Wales and 1 in Northern Ireland. Details of all the courses and providers can be seen here:
http://search.ucas.com/search/providers?CountryCode=&RegionCode=&Lat=&Lng=&Feather=&Vac=1&AvailableIn=2017&Query=aerospace&ProviderQuery=&AcpId=&Location=&IsFeatherProcessed=True&SubjectCode=

Specific course titles cover a range of descriptors including:

- Aerospace/Aerospace Engineering/ Aerospace Engineering Manufacturing
- Aviation/Aviation Management
- Airport Management
- Metallurgy
- Automotive Engineering/Technology
- Aeronautical Engineering
- Air Transport/Air Transport with Commercial/Private Pilot Training
- Aerothermal Engineering
- Aerospace Systems Engineering
- Aerospace Technology
- Travel Operations Management
- Mechanical Engineering
- General Engineering

Most of the courses are single subject, although some courses have the options of a joint, minor/major or triple subjects. The vast majority of the courses are at undergraduate level with a small number described as HND's, DipHEs or Foundation Degrees. There are a small number of 1 year top up courses.

Undergraduate courses are generally 3 or 4 years in duration: more if they include a sandwich/placement year in the UK or abroad. UK HEIs have degrees awarding powers recognised by the UK authorities (UK and Scottish Parliament, Welsh and Northern Ireland Assemblies). The QAA (Quality Assurance Agency for Higher Education) is an independent body who monitor and advise on standards and quality in UK higher education. A number of courses are linked to the Engineering Council accreditation standards. Entry requirements vary depending on the provider and course. 2 examples can be seen below:

- University of Wolverhampton
    - Aerospace Engineering Degree requires BCC at A Level or BTEC Level 3 in Engineering;
- University of Glasgow
    - Aerospace Systems Degree requires AAA at A Level and in Mathematics and Physics (along with other equivalents);

Course Content:

Example 1: Aviation and Airport Management, University College Birmingham

The Aviation and Airport Management course has been developed in response to these trends, specifically in partnership with Swissport, the aviation ground operations specialist, and Airport Placements Ltd., both of whom have a continual demand for appropriately trained personnel.

Year 1: Understanding the Air Transport Business, Understanding Airport Passenger Operations, Understanding Finance, Understanding People, Tourism Destinations, Aviation Marketing Studies.

Year 2: Managing Aviation Operations, Airport Planning, Pricing & Revenue Management, Research in Practice, Managing People. One option from: International Travel Operations, Social Media in Tourism, Retail Operations Management, Modern Languages, Summer Work Experience.

Year 3: Aviation Risk Management, Strategic Management for Tourism, Aviation Futures, Aviation Project (double module). One option from: International Marketing, Financial Strategy, Strategic Human Resources, Destination Management.

Example 2: Aeronautical Engineering, Loughborough University

This department is one of very few that brings together the excitement and challenge of both Aeronautical and Automotive Engineering. Their reputation for excellent teaching and topical research is built on a long and successful history. Automotive engineering started in 1919 and Aeronautical in 1935. The department enjoys close working links with Rolls-Royce, Ford Motor Company, BAE Systems, Jaguar Land Rover, Caterpillar, JCB, Airbus, Lotus, Bentley and many others. Strong industry links benefit research and keep the department up to date with the latest industry developments. A large proportion of students start their careers with organisations they have got to know as a student while on their placement. The extensive laboratories house state of the art equipment which supports a lively research programme and also provides undergraduate students with the opportunity to pursue projects at the cutting edge of technology. Part A (Year 1) – Part B (Year 2) – Placement Year (Year 3) – Part C (Year 4) – Part D (Year 5). Each year is divided into a series of modules, which make up a total number of credits for the year. As students' progress through the course there are a series of core modules as well as the opportunity to tailor studies through a range of optional module choices.

Example 3: Cranfield University

Cranfield University is the only European university with its own airport and runway. Through the strong links with industry built over the past 70 years, they focus on defining and delivering the aircraft, airport and airspace management of the future. 'Using our expertise in propulsion, aeronautical engineering, intelligent automation, autonomous systems, and computational engineering we are creating tomorrow's air vehicles and businesses here today. Our blue-sky research generates concepts that, through then building and testing, we actually put into practice in physical flight demonstrations. Using our airport at Cranfield we show how our ideas are more than theories but work on the ground and in the air. Because our work starts with ideas and culminates in actual delivery Cranfield offers something for industry partners and also people at all stages of their career. We have more than 200 doctoral students and 400 MSc Aerospace students drawn from universities around the world. We are the UK's top destination for aerospace engineering postgraduate students and the largest provider of accredited aerospace degree courses.' (Cranfield University, 2017). https://www.cranfield.ac.uk/themes/aerospace

Postgraduate

According to UCAS there are 7 providers of Postgraduate Aerospace related Masters degrees in the UK, which offer 37 courses. These are all either full or part time and are all taught courses. Most courses include the terms 'Aircraft' or 'Aeronautical' in their descriptions. Entry requirements are a relevant degree and some providers stipulate and minimum classification (2:1, 2:2 etc.).

Course content:

Example 1: Aircraft Design (Taught) Glyndwr University, Wrexham

The course equips students with the required knowledge and understanding of typical aircraft systems their power requirements and how they interface with other on-board and ground based systems. With common taught elements of the programme including: advanced materials, design, and stress and fluid dynamics analysis, candidates use state of the art commercial software: CATIA V5, ABAQUS and ANSYS. Modules include: Engineering research methods and postgraduate studies; sustainable design and innovation; engineering systems modelling and simulation. Optional modules: advanced composite materials; aircraft structures; airframe systems design; dissertation.

Example 2: Aeronautical Engineering (Taught) Staffordshire University

This programme covers a broad range of areas including fixed wing and rotary aircraft, subsonic and supersonic flight regimes, aircraft propulsion systems, aircraft control systems, materials, etc. As well as taught classes, students use an extensive range of laboratories which include industry standard design and analysis software, including Pro Engineer, Phoenix CFD, ANSYS FEA, etc. Modules include: Technical and study skills; research methods and project management; control systems for aeronautics; structural integrity; aircraft propulsion systems; advanced aeronautics; advanced vehicle aerodynamics.

Degree Apprenticeships

In the UK Degree/Professional Apprenticeships have recently been introduced and allow apprentices to achieve a full bachelor's or master's degree as part of their apprenticeship. Entry requirements can require at least five GCSEs grades A — C/National 4s or 5s, and Level 3 qualifications, including A levels/Highers, NVQ/SVQ Level 3, or a BTEC National. Some employers also have specific entry requirements, and this is particularly the case for degree apprenticeships. ''Degree Apprenticeships are a new government development. Apprentices will split their time between university study and the workplace and will be employed throughout – gaining a full bachelors or masters degree from a top university, while earning a wage and getting real on-the-job experience in their chosen profession. Higher Apprentices are already able to study to degree level as part of their apprenticeship but Degree Apprenticeships will go further.

They will involve a degree as an integral part of the Apprenticeship, co-designed by employers to make sure it is relevant for the skills that industry is looking for.'' (Career Pilot, 2017).

According to HEFCE (2017) ''There are currently around 1000 degree apprenticeships. Government has made a pledge to increase the number of apprenticeships starts to 3 million by 2020''. ''Providers of apprenticeships at any level must be registered with the Skills Funding Agency (SFA) via its Register of Training Organisations (ROTO). Once registered, they can enter a procurement round to offer a course that conforms to an approved Apprenticeship Standard or Framework. Higher education providers can also work with employers to develop new apprenticeship standards, called Trailblazers, for which they would have influence over the content and shape of the apprenticeship.'' (HEFCE, 2017).

Higher and Degree Apprenticeships being offered or under development in the Aerospace sector include: aerospace engineering; aerospace software development; automotive engineering.

According to Prospects.ac.uk (2017):

'Some of the most high-profile universities currently involved include:

- Aerospace engineering and Aerospace software development - University of Central Lancashire (UCLan) and Lancaster University'

Some of the most high-profile employers currently involved include:

- Aerospace engineering and Aerospace software development - Airbus, BAE Systems and Rolls Royce
- Automotive - BMW Group UK, Toyota Manufacturing UK and Vauxhall Motors''

Two examples can be seen below (The Scholarship Hub, 2017).

Companies offering Degree Apprenticeships in Aerospace Engineering:

Airbus Aerospace Engineering Degree Apprenticeship	**A 3 year programme which leads to a degree in Aerospace Engineering delivered in partnership with either Bangor University, Swansea University or the University of the West of England.**
BAE Systems Aerospace Engineering Degree Apprenticeship	**A 5 year programme leading to a degree in Aerospace Engineering from Blackpool and Fylde College accredited by Lancaster University.**

Aerospace Growth Partnership Support Programmes

The AGP, supported by Government funding matched by the aerospace industry have put in place several support and training programmes for organisations working in the sector; including Supply Chains for the 21st Century (SC21) and Sharing in Growth (SiG) which focus on continuous improvement and contain elements of BIT.

SC21[44]

SC21 is a change programme designed to accelerate the competitiveness of the aerospace and defence industry by raising the performance of its supply chains. International competition, together with the challenges posed by the defence industrial strategy, necessitates rapid improvement in the effectiveness

[44] http://www.sc21.org.uk/

of supply chains. At the same time, industry must ensure that it delivers competitive solutions for customers whilst maintaining profitable business growth.

Benefits, which have been documented in a benefits brochure[45], include:

- Reduced overheads from implementing business excellence and lean principles through the Bus Ex and Man Ex tools,
- Operational improvement with minimal costs to the business
- Increased competitiveness
- Leaner production,
- Cost reduction
- Lower set-up times

SiG[46]

To capitalise on the opportunities for growth in the aerospace industry, suppliers need to constantly invest in their ability to deliver competitive performance. To support this, Sharing in Growth UK Ltd was set up in 2013 specifically to deliver a £250 million programme of intensive supplier development over four years to 30 to 40 UK suppliers. The main funding support for this ambitious and innovative programme has come from a successful Regional Growth Fund application. SiG is already effective, having delivered over one million training hours. With tranche two funding of another £30 million, SiG can now support more than 60 beneficiaries. The lead companies have already secured around £2 billion of total contract value through improved competitiveness.

SiG provides over £1 million of grant funded training per business unit. This provides the necessary breadth and depth of support to drive globally competitive performance in the aerospace sector. With a strong focus on leadership, culture and operational excellence, it is designed and led by industry to remove barriers to growth and secure long term contracts from UK and overseas customers. It provides access to world class training throughout a four year intensive programme tailored to and targeted at enablers for growth. The training support comes from some of the sector's leaders and experts who can draw on their companies' knowledge of substantial change over many years, supplemented by professionals from expert delivery partners.

The aim of the programme is to secure over 10,000 jobs in the UK aerospace and related high value manufacturing sectors.

3.1.2 Portugal

Taking in consideration the width of the concept of BIT which includes alternative teaching methods, business policies, management practices, etc., we can find a multitude of training modules, curricula, subjects and topics in different type of aerospace training providers. Mostly, they are not called or officially categorized as BIT, but they can undoubtedly be considered as such. They can be found in:

- Vocational Education and Training
- Higher Education Institutions
- Specific Professional Training Programs

<u>Vocational Education and Training</u>

[45] http://www.sc21.org.uk/wp-content/uploads/sites/23/2015/07/SC21-Benefits-Brochure-v1.pdf
[46] http://www.sig-uk.org/

The training of specialized technicians takes place in different training centres according to the needs and aims of knowledge required. Aircraft Maintenance Technicians receive training in Organizations of Training in Maintenance Technicians certified by INAC (National Institute of Civil Aviation of Portugal), which is the civil aviation authority of Portugal and oversees all aspects of civil aviation within the Portuguese territory and all its dependencies. This hierarchy of norms is designed according to the European Aviation Safety Agency (EASA). You can find in Portugal 6 organizations providing that type of training. In the end of 2011 there was 1493 graduate mechanics in the country.[47] Recently, there are four professions in large demand from the Portuguese aerospace industry. The approach to training in these professions encompasses BIT. We briefly describe the main topics for the training of each one:

Technician of CNC machining EQF Level 4

Course with a total workload of 1200 hours. According to their training program we can determine that BIT is addressed in the following units:

- Quality and organization of production (40 hours)
- Advanced machining operation and Techniques (25 hours)
- Technologies and properties of materials (25 hours)

Technician of aeronautic production - Structures assembling EQF Level 4

Course with a total workload of 1250 hours. According to their training program we can determine that BIT is addressed in the following units:

- Human Factors (25 hours)
- Quality and reliability (25 hours)
- Criterion of excellence - Lean (25 hours)
- Special Processes (75 hours)
- Product Quality (25 hours)
- Aircraft assembly (100 hours)

Technician of production and transformation of composites EQF Level 4

This is a course with a total workload of 1250 hours. According to their training program we can determine that BIT is addressed in the following units:

- Human Factors (25 hours)
- Quality and reliability (25 hours)
- Maintenance Management (25 hours)
- Project management (25 hours)
- Draft structures (150 hours)
- Basic composites manufacturing in aeronautics (50 hours)
- Project Structures (100 hours)

Technician of Metal Treatment EQF Level 5

This is a course with a total workload of 1250 hours. According to their training program we can determine that BIT is addressed in the following units:

- Human Factors (25 hours)
- Quality and reliability (25 hours)

[47] http://www.anac.pt/SiteCollectionDocuments/Publicacoes/anuarios/AAC_2011_V1.pdf

- Manufacturing Process (50 hours)
- Laboratorial Techniques (75 hours)
- Industrial waste management (25 hours)
- Technology of materials (50 hours)
- Product Quality (25 hours)
- Criterion of excellence - Lean (50 hours)

The following courses are very small (between 25 and 50 hours) including many topics. We believe that in general the BIT are addressed, not as a specific topic, but rather through a general approach throughout the various topics.

Human Factors

See detailed program here

Duration: 25 hours

Main content:

- General issues: The human factor in the work environment; Incidents attributed to human factors/human error; Murphy's Law.
- Human performance and limitations: Vision/audition; Information processing; Attention, perception and memory; Claustrophobia and physical tiredness.
- Psychological and social aspects: Individual and collective sense of responsibility; Motivation and demotivation; Pressure exerted by colleagues; Cultural problems; Teamwork; Management, supervision and leadership.
- Factors affecting performance: Health/physical condition; Stress caused by family and professional factors; Pressure caused by time and job factors; Workload: overload and under load; Sleep and tiredness, work shift; Abusive consumption of alcohol, medicines and drugs.
- Physical environment: Noise, smoke and illumination; Climate and temperature; Motion and vibration; Work conditions.
- Work: Physical work; Repetitive tasks; Sight inspection; Complex systems.
- Communication: Communication inside teams and among teams; Work registry; Update and fluency; Information broadcast.
- Human error: Error models and theories; Types of error in maintenance tasks; Implications of error (accidents); Prevention and management of errors.
- Risks in workplace: Risk identification and prevention; Procedures in emergency situations.

Aeronautic Culture

See detailed program here

Duration: 25 hours

Main content:

- Aeronautic culture – introduction
- Quality tools (Pareto, Ishikawa, 5 "Why's", 5W1H, Brainstorming)
- Hangar culture
- Human factors and quality
- Advisements regarding documentation

- FOE (Foreign Object Elimination) program
- 5S Programme
- Aircrafts production – general aspects

Criteria of aeronautical excellence – Lean

See detailed program here

Duration: 50 hours

Main content:

- Introduction to excellence criteria (roles and responsibilities)
- Integrated management system
- Business planning
- Management indicators and panel
- 5"S" concept; Sight control; Process certification
- Economic viability analysis; Value Stream Mapping (VSM)
- Standard work
- Quality improvement team – Problem solution analysis; "Poka Yoke" concept
- SMED (Single-Minute Exchange of Die) – Reducing Set Up time
- TPM – Total Productive Maintenance
- Just-in-time – Kanban
- Kaisen concept
- MFA – Market Feedback Analysis; Benchmarking.

Higher Education Institutions

Undergraduate

In Portugal there are three Universities who offer a degree in Aeronautical subjects. These are the principal schools where Business Improvement Techniques' are taught within courses, as topics related to normal, engineering subjects. Unfortunately, it is still quite difficult to determine with certainty that BIT is openly addressed in class.

Nonetheless, we have hereby selected some curricula from the three aformentioned universities, where it is possible to assess that Business Improvement Tecniques are explicitly or implicitly addressed witin the Aerospace field.

IST- Higher Technical Institute – link to the course here

Instituto Superior Técnico (IST) is a school of engineering, part of the Universidade de Lisboa (University of Lisbon). Founded in 1911, IST is the largest and most prestigious school of engineering in Portugal. It is a public school with a large degree of scientific and financial autonomy. Its alumni have held prominent positions in both the private and public sectors of Portuguese society, having produced numerous CEOs, government ministers, 2 Prime Ministers of Portugal, and 1 Secretary-General of the United Nations

UBI- University of Beira Interior – link to course here

The University of Beira Interior (Universidade da Beira Interior or UBI for short) is a public university located in the city of Covilhã, Portugal. It was created in 1979, and has about 6,879 students distributed across a multiplicity of graduation courses, awarding all academic degrees in fields ranging from medicine

and biomedical sciences to aeronautical engineering to mathematics. The university is named after the historical Beira region, meaning Beira Interior the most interior area of Beira, mainly composed by the district of Guarda and the district of Castelo Branco, in today's Centro region.

Portuguese Air Force Academy, website link here (link to aerospace engineering curriculum here)

The Portuguese Air Force Academy (AFA, Academia da Força Aérea in Portuguese) is a Portuguese military higher education institution whose aim is to provide all its students with the training and the experience that will enable them to graduate having gained the knowledge and the character qualities that are essential for leadership, and the motivation to become Portuguese Air Force officers. It comprises both university and polytechnical academic programmes.

Specific Professional Training Programs

Postgraduate

We have also identified some postgraduate study programs which are **executive education** and **professional training** that we believed to be interesting for the purpose of this research and may perform some of the BIT goals. Although, they are not exclusive to the aeronautic sector, they have the interesting option of customization upon request from the company. It is a kind of training aimed at top executives, managers, supervisors and administrators, focused on creating, developing and fostering efficient and collaborative team dynamics.

Católica Lisbon Business and Economics

- Management and Leadership Development Program for SME Leader (Duration: 56 hours) - aims to provide SME with up-to-date skills, tools and techniques in the various functional areas, using an approach which is rich in concepts but with a strong emphasis on practical aspects.
- Leading and Energizing Teams for Performance: (Duration: 50,5 hours) – the aim is to aid the participants in infusing their environment with positive energy, taking full advantage of the potential of their colleagues and staff and energizing dynamic teams - without additional resources.

Specific Training for Leadership, Managing, Sales, Technical And Soft Skills

A number of independent training institutions offer courses and classes aimed at developing Leadership, Team Management Project Management and other related skills.

Management and Talent Retention

The aim is to understand the concept of talent and how to manage it in organisations. The program focuses on practices concerning mobility and retention of talent, particularly for talent audit, development and succession planning.

Developing Strong teams

Develop skills to work in good team environments and contribute to the organisation being more competitive through:

- Efficient Production lines
- Better Communication
- Better sales
- Workplace environment

- Soft Skills improvement
- Project Leadership – focus on Team Building

Build and maintain high-performance project teams by enhancing leadership skills; develop a strong identity in a team, leading others to act through the Organization, Vision, Mission and Values; Foster communication within the team in a positive, productive and effective way, promoting conflict management; Increase productivity, challenging processes to motivate teams; Manage internal and external factors affecting the team's performance; Maximize project leadership skills as a member of an organisation.

All the courses listed above are included in a certification system, common to all training and education programs of the same kind. Higher education, naturally, reflects an ECTS system that is recognized worldwide categorises qualifications at an EU level. Vocational Education Training programs, are clearly structured and labelled according to a QNQ (Quadro Nacional de Qualificações - *National Qualification Framework*) and to the European Qualification Framework (EQF). The former, mirrors the latter, therefore we are able to assess that the two frameworks are equivalent.

The VET training described above is all certified by INAC, following the regulation from the European Aviation Safety Agency (EASA). It is awarded by IEFP (Portuguese Employment Office).

3.1.3 Italy

The apparent asymmetry and fragmented structure of the Italian aerospace industry is a peculiarity when compared to other national markets, which have seen a greater amount of consolidation and therefore are home to fewer niche companies. Compared to other countries, Italian companies are more accustomed to relying on private capabilities and investment, and the Italian system has allowed the industry to develop in this way.[48]

In Italy, there is an increasing interest in Aerospace field, but because Business Improvement Techniques (BIT) is not a very well-known or clearly defined, it is difficult to unite all the cases under a unique category. Examples presented below are drawn from the following education sectors:

- Vocational Education and Training
- Higher Education Institutions
- Post-graduation

Vocational Education and Training

UNAVIA

This is a free, non profit, association established in 1946 by the main aeronautical manufacturers and the Ministry of Defence (via Costarmaereo) for standardization in the aeronautical sector. Nowadays the Association has expanded its activity into aerospace and defence sector and its members are the Ministry of Defence (via Armaereo), the Ministry of Economical Development, ENAC (Italian Civil Aviation Authority), UNI (Italian National Body for Standardization) and AIAD (Italian Industries Federation for Aerospace, Defence and Security). UNAVIA operates in three different fields: Standardization, Training and Non- Destructive Testing Personnel Qualification (ITANDTB).

UNAVIA training, taking advantage of its competence in Standardization Area, consists of development and continuous support of improvement in organizational policies in order to provide qualified services

[48] Cluster Tecnologico Nazionale Aerospazio Piano di Sviluppo Strategico 2013-2017 28 Settembre" www.ctna.it/ITA/team/shareholders/CTNA_Rapporto_20120927.pdf

to organizations. A particular focus of the training is Quality Management Systems involving the entire company and the relationships between customers and suppliers, the specific tool to create an adequate culture and a solid base for operational activities. UNAVIA training is strictly related to its standardization activity, in accordance with the standard requirement in aerospace and defence field. It designs and provides courses focused on regulations and standards and on quality management methodologies.

In order to provide a priority service that is more practical and more appreciated, UNAVIA, which is expanding its training, works with highly significant partners in specific areas. For example, an agreement was established with Plexus Systems Management, the Italian version of Plexus International, as the company chosen by IAQG to design and deliver the course aims to optimize the training of auditors of the aerospace and defence sector.[49]

UNAVIA is accredited by the national body (CBMC) from IAQG (International Aerospace Quality Group) as a Training Provider and is one of the few training institutions in the world authorized to provide special courses in the aerospace sector.

IMEX.A

This company is an engineering enterprise that was founded in Turin in 2009 to deal with space applications and design. Thanks to a network of highly specialized collaborators it spread to other areas in which it still operates, such as aeronautics, space, automotive, industry. iMEX.A offers consulting, training and design services in the mechanical and structural fields, fluid dynamics, electrical and electronic fields to all sectors. In particular, iMEX.A is able to support the customer from the early stages of definition and design, through technical and economic feasibility studies, to the final product completion, helping with definitive design and supplier management.[50]

QUANTA COMPOSITE LEARNING & TRAINING

This is the first output of the CSD (Composites Skills Development) network: a vocational training school, created from the involvement and cooperation of highly qualified partners, which due to connections with higher institutes and university faculties allows the identification of young talents and provides information about internships during school time to guide vocations and expectations. It is a highly specialized advanced vocational training course for individuals and companies. It provides customizable courses, that analyse the training needs and the processes that are used (or are to be acquired) in the client companies. The needs analysis is conducted directly by the technical / teaching staff of Quanta Composite Learning & Training at the production sites of the contracting companies and on the production operations of the customer.[51]

In addition to those VET providers we have identified a wide array of industry operators, which provide training for business processes. The main key operators in funded education, that is Fondimpresa [52], are:

- Adecco Formazione srl
- Assoform Romagna scarl
- Civita srl
- Conform Consulenza Formazione e

[49] http://www.aiad.it/en/unavia.wp
[50] http://www.imexa.it/formazione.php
[51] https://www.quanta.com/blog/quanta-composite-learning-training/
[52] http://www.fondimpresa.it/images/documento20130611/regolamento_qualificazione_proponenti/Elenchi_agg.07.06.17/riepilogoSoggettiProponentiqualificati_agg07.06.2017.pdf

- Management scarl
- Consilia CFO
- Consulman spa
- Consvip s.c.ar.l.
- ECOLE – Enti Confindustriali Lombardi per l'Education Società consortile arl
- Ergon Srl
- Eulab consulting
- E- Work
- Forema
- Form & Atp
- Formamentis
- I.F.O.A. Istituto Formazione Operatori Aziendali
- Istituto Italiano Saldatura
- Il Sole 24 ore
- Insi SPA
- Poliedra
- Protom Group
- Randstad
- Riconversider
- Risorse in Crescita srl
- Saip formazione
- Servizi e Promozioni Industriali
- Sistemi Formativi Aziendali srl
- Soges
- Solco Srl
- Step Srl
- STOA' S.C.p.A. Istituto di Studi per la Direzione e Gestione di Impresa
- Talentform spa
- Tecfor
- Unindustria Servizi&Formazione Treviso Pordenone scarl

These bodies also have training catalogues recognized by the fund, among which there are training elements related to BITs. For example, Consilia[53] and ECOLE – Enti Confindustriali Lombardi per l'Education Società consortile arl[54], offer specific classes on Lean. Although not specifically designed for the aerospace industry, courses are directly applicable in different operating environments and the fund also finances contextual adaptation activities.

Higher Education Institutions

In Italy there are a large number of universities that offers these kind of courses.

- **Università "La Sapienza" di Roma;** in addition to courses the university houses CRAS, an inter-departmental center for aerospace research.
- **The Polytechnic University of Turin** in Turin offers undergraduate (bachelor) and graduate (masters) programs in the field of Aerospace Engineering

[53] http://www.consilia.net/catalogo/schedacorsoincatalogo.php?idcorso=238
[54] https://www.myecole.it/doc/wp-content/uploads/2015/03/Catalogo-ECOLE-2015-MILANO-LODI-2.pdf

- **Università degli Studi di Bologna –branch located in Cesena** The University of Bologna (UNIBO) in Bologna, Italy is the oldest university in Europe. The Faculty of Engineering at the Bologna University offers undergraduate (bachelor) and graduate (masters) programs in the field of Aerospace Engineering.
- **Università degli Studi di Napoli "Federico II"**
- **Università degli Studi di Padova,** offers undergraduate and graduate programs in the field of Aerospace Engineering.
- **Università di Pisa**, offers undergraduate and graduate programs in the field of Aerospace Engineering.
- **Seconda Università degli Studi di Napoli**
- **Politechnico di Milano** in Milan, Italy is the largest technical university in Italy.

The curricula are fully described in the Annexes. They have a common methodology that is based on: face to face, workshop and laboratory based classes in order to have a deeper understanding of the subject. Usually the aim is the acquisition of a high level of competences required to carry out innovative research and/or state of the art advanced applications in: industry, research centres, universities and service companies operating in the aerospace industrial and research area, including all fields having any connection with aerospace. The level of the programmes should allow graduates to compete successfully in both the European and International aerospace environment.

Sadly, in the aformentioned universities, it is not possible to assess if **Business Improvement Tecniques** are explicitly or implicitly addressed witin the Aerospace field. During the interview's process, professors stated that contents regarding BIT are part of master degrees such as Mechanical Engineering, so they are provided but on a superficial and generic level.

Postgraduate

This is Executive Education that refers to academic programs at graduate-level business schools for executives, business leaders and functional managers. These programs are generally non-credit and non-degree-granting, but sometimes lead to certificates. Once again, they are not necessarily exclusively for the aeronautic sector, but can be customized for each company, depending on its need.

Universities (especially private ones) are very relevant, since they are important for Lean organization, but not closely related to the sector. Some interesting examples are:

- the **Università Bologna**[55] : Offers the **Master in Supply Chain and Operations**, which aims to support the strategic positioning of a business and to improve operations and supply chain management by favouring a systemic view of the activities related to the product and the process: from supplying materials to delivery of products
- **SDA Bocconi - EXECUTIVE PROGRAM IN OPERATIONS & MANUFACTURING MANAGE**MENT[56], Addresses people in key industrial positions (Operations Director, Plant Manager, or Young High Production Leaders). This intervention, structured around multiple technical modules, contains a large part on management, economic and related elements, with great focus on Lean production.

[55] http://www.bbs.unibo.it/hp/master-executive/supply-chain-and-operations/?gclid=CNjhvvKGvdQCFUOfGwodLaQEmQ
[56] http://www.sdabocconi.it/it/formazione-executive/executive-program-operations-manufacturing-management

3.2. Target groups

The target groups of the different training courses will vary according to the specifies of the training and its associated objectives. In Europe, these type of instruction, change according to national strategies for the sector, ages of trainees, employment needs, regions, HEI idiosyncrasies; although there are many similarities across the continent and in a sector that is mainly international and highly competitive we see a trend of convergence.

3.2.1. United Kingdom

Apprenticeships

Level 2 Improving Operational Performance Apprenticeship target learners are primarily school leavers who have completed their GCSE studies and in some cases relevant vocational activity such as a Diploma in Engineering, Pre-Apprenticeship programme or extended work experience.

Level 3 Operations and Quality Improvement Advanced Apprenticeship target learners include school leavers who have completed their GCSEs and in some cases relevant vocational activity such as a Diploma in Manufacturing or other related activity, Pre-Apprenticeship programme or extended work experience. Also, older apprentices aged 18-24 and adults post 25 who have worked in a process driven context and are considering an Advanced Apprenticeship. It is also likely that intermediate apprentices completing the Level 2 Improving Operational Performance framework will progress onto this level 3 framework.

Level 4 Advanced Manufacturing Engineering Apprenticeship target learners include those who have A or AS Levels in Science, Technology, Engineering or Mathematics (STEM) subjects and GCSEs in English, Maths and Science at grade C or above. Also, learners who have completed an Advanced Engineering Apprenticeship or completed a 14-19 Advanced Diploma in Engineering or Manufacturing or those that have previous work experience in engineering at Level 3.

Vocational Education and Training

City and Guilds National Vocational Qualification (NVQ) in Business Improvement Techniques:

Level 2 is aimed at new and existing employees who have undertaken some BIT training and are now acquiring experience within a team as well as other people involved in a business at all levels who require a fundamental understanding of business improvement practices.

Level 3 is aimed at staff employed as supervisors, team leaders, change agents or facilitators and who are responsible for carrying out business improvement activities as well as people who through Continuing Professional Development (CPD) are being prepared to take on management responsibilities in a business improvement environment.

Level 4 is aimed at managers who have overall responsibilities for business improvements with specific responsibilities for achieving business objectives as well as people who (through CPD) are being prepared to take on management responsibilities in a business improvement environment.

Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Competence and Knowledge) is aimed at anyone over the age of 16 who would like to progress in a career in the Advanced Manufacturing and Engineering sector and who typically has achieved 4 GCSEs at Grade C or equivalent, including Mathematics, English and a Science.

The NVQ Diploma in Business Improvement Techniques is for anybody whose work involves business performance or who wants to work in this sector. The qualification is open to existing workers or new entrants - you don't need any previous experience to take the course.

Higher Education Institutions

Target groups for HE providers are generally those aged 18+ who meet the entry requirements of the specific provider for the specific course. Generally, for HE study applicants will have to have A levels or equivalent. For mature students, Accreditation of Prior Achievement, work experience etc. may be eligible. For EU and International applicants, HE providers will have equivalent entry requirements and often a minimum English language level.

HE UG: Entry requirements vary depending on the specific provider and course. See above for examples.

HE PG: Entry requirements are a relevant degree and some providers stipulate a minimum classification (2:1, 2:2 etc.).

Many HEIs have links with industry and support graduates in finding relevant employment after they have completed their course. As described above, a number of providers offer placement/sandwich years so students gain industry experience.

3.2.2. Portugal

Vocational Education and Training

The target groups of the Vocational Education Training courses, mentioned above, are mainly apprentices, medium-level long-term employees either directly working on the assembly line or workers whose job is indirectly dependent on production procedures. These are people aged around 40 years old, who have working experience on the field. They are mostly looking to gain new competences for their jobs or to refresh their knowledge.

Another group of attendants of this kind of courses are Aircraft Maintenance Technicians. We can find a considerable percentage of these trainees looking for improvement of specific professional competences and soft-skills adapted to their functions.

Higher Education and Institutions

The aerospace engineering higher education institutions provide education to young people, normally between 18 and 30 years old, whose objective is to become aerospace and aeronautical engineers, project managers, or to continue as researchers in the field. Other types of target group in these schools are professionals from companies that work in the area with previous education in mechanical engineering.

Specific Professional Training Programs

Alternatively, some of the training focuses on managerial, organizational and other aspects related to industry culture. This type of training is designed to improve production through a better understanding of human resources and cultural capital, rather than by re-thinking the organization of the production line. Henceforth, the target groups for such training are higher level employees: supervisors, executives, head of units, managers, etc.

3.2.3. Italy

Training, as highlighted in section 5, is directed at every level of worker in the industry, in different ways. As far as apprentices are concerned, there are mainly two pathways. Firstly, the Vocational Training Centers. A vocational training centre (in italian Centri di formazione professionale, abbreviated to CFP) in Italy is an institute that help young people and adults to perfect their vocational training and help them enter the work environment or improve their job performance. Courses can be of four main types[57]:

- professional qualification courses: they are commonly aimed at students that are finishing their compulsory schooling; they have a duration of two to three years and end with an examination that certifies the achievement of the professional qualification.
- specialization courses: they are aimed to young adults and/or adults who, having already obtained a professional qualification, intend to deepen their knowledge and skills in the professional sector of their interest; they generally have a duration of one year.
- post-graduate courses: they are aimed at people who have, through a state exam, a high school diploma and want to complete their vocational training; they generally have a duration of one year.
- higher education and technical training.

The Vocational Training Centres are run by training bodies who have their work controlled by the Regions or, in certain cases, are directed by the Region itself. Alongside the CFPs, it is envisaged, at regional level, to create specific training and apprenticeship training courses by private training institutions, generally through public calls based on market research and training needs. [58] The initiative is often combined with the definition of emerging training elements from companies entrusting training bodies to provide staff guidance and training / job placement.[59]

For both modes, although there are no specific courses for the Aerospace industry, the issues discussed and the skills which they provide (especially at production techniques) are compatible with the sector. In both cases support is given to job placement (or reinstatement if you are unemployed/over 50) by means of specific financial measures or partial tax exemption on workers. As far as apprentices are concerned, a three-year period of work placement is envisaged, in which there is a training obligation for the company to improve the worker. The financial resources associated with apprenticeships, especially those related to regional initiatives, come from the European Social Fund.

Regarding training for "established workers", besides the formalized courses, the role of inter-professional funds is very important in Italy. The National Interprofessional Equal Funds or Continuing Education are associative organizations promoted by the companies representing the Social Partners through specific Interconfederal Agreements concluded by employers and employees' representatives of organizations at national level. There are currently 19 Funds (of the 22 authorized by the Ministry of Labor) of which three are dedicated to Executives. The funds receive directly from the companies part of the contributions paid to their employees (0.30%) and manage them by financing corporate, sectoral and territorial training plans, which single or associate companies will decide to implement for their employees. They may also finance individual training plans, as well as additional preparatory activities or related training initiatives, and from 2011 (Law No.148 of 14/09/2011), training plans may also involve apprentices and project workers. The most important fund is Fondimpresa, in terms of the number of workers and businesses. It

[57] ITALY European inventory on NQF 2016 - Cedefop http://www.cedefop.europa.eu/en/publications-and-resources/country-reports/italy-european-inventory-nqf-2016
[58] https://www.laformazioneprofessionale.it/formazione_professionale.html
[59] http://www.regione.liguria.it/argomenti/conoscere-e-vivere-il-territorio/istruzione-formazione/occupazione/apprendistato-professionalizzante-e-contratto-di-mestiere.html

receives approximately 50% of the total annual payments made by companies registered in the Interprofessional Funds for Continuing Education. From 2007 up to now, it has enabled the training of over 4,500,000 workers. 175 million companies join in with a total of 4.4 million workers.

Interprofessional funds are the main tool for vocational training especially for small and medium-sized companies. In this sense, interventions tailored to individual training needs are defined on companys' initiative or on the initiative of the training body involved. As regards the certification of courses and the implementation of European tools for vocational education and training, especially for professional courses, the catalogue of national professional profiles (29 profiles) is identified as described in the Inter Ministerial Decree 7 September 2011, laying down general rules on ITS diplomas and relevant national reference figures, verification and certification of competences, as supplemented by the Ministerial Decree of 5 February 2013 (Decree 82/2013)[60]. These professional profiles were subsequently implemented and adapted in all Italian regions becoming characteristic elements for certification (through specific examinations and procedures established for each Region) of professional courses or courses of shorter nature (working, in that case, on some skills which define the whole professional figure)[61].

At present, ECVET, even though is not widely known in companies, is increasing in Italy which is facing the challenge of introducing a common methodological framework.[62]

3.3. Training resources available

3.3.1. United Kingdom

Higher Education

http://search.ucas.com/search/providers?CountryCode=&RegionCode=&Lat=&Lng=&Feather=&Vac=1&AvailableIn=2017&Query=aerospace&ProviderQuery=&AcpId=&Location=&IsFeatherProcessed=True&SubjectCode

General BIT

https://leaninkingcounty.com/lessons-and-resources/

Government Supported Initiatives

http://www.sc21.org.uk/wp-content/uploads/sites/23/2015/07/SC21-Imp-Guide-2014-v11.pdf

http://www.sig-uk.org/wp-content/uploads/2017/06/SIG-brochure-interactive.pdf

3.3.2. Portugal

Higher Education

Mestrado integrado com Licenciatura em Ciências Militares Aeronáuticas na especialidade Engenharia Aeronáutica (ENGAER) -

[60] Relazione sull'istruzione e la formazione professionale (IFP) in Italia, Cedefop, 2014
[61] http://nrpitalia.isfol.it/sito_standard/sito_demo/repertorio_nazionale_qualificazioni.php
[62] http://librettocompetenze.isfol.it/validazione-delle-competenze.html
http://www.programmaleonardo.net/ecvet/download/Leaflet%20ECVET.pdf

http://www.emfa.pt/www/po/unidades/includes/10D00/conteudos/galeria/novosite/cursos/mestrado-integrado/engaer-pe-v1_826.pdf

Mestrado integrado com Licenciatura em Engenharia Aeronáutica - http://www.ubi.pt/PlanoDeEstudos/73

Mestrado integrado em Engenharia Aeroespacial - https://fenix.tecnico.ulisboa.pt/cursos/meaer/curriculo

Government Subsidized Initiatives

Human Factors - http://www.catalogo.anqep.gov.pt/Ufcd/Detalhe/5113

Aeronautical Culture - http://www.catalogo.anqep.gov.pt/Ufcd/Detalhe/5112

Criteria of aeronautical excellence - http://www.catalogo.anqep.gov.pt/Ufcd/Detalhe/5114

3.3.3. Italy

As stated in the previous paragraph, some reports are available to show the current situation in Italy. Unfortunately, it cannot be stressed enough the fragmentary nature of resources in this field.

Higher Education

Aerospace engineering -Federico
http://www.universitaly.it/index.php/public/schedaCorso/anno/2016/corso/1531561

Aerospace engineering - Politecnico of Turin

https://didattica.polito.it/pls/portal30/sviluppo.offerta_formativa.corsi?p_sdu_cds=32:11&p_lang=EN

Aerospace engineering, University La Sapienza - Master degree
http://www.masteraviation.it/_content/services/brochure_MAC_2017.pdf

Government Subsidized Initiatives

Ecole Milano - responsible of business planning and production planning

https://www.myecole.it/doc/wp-content/uploads/2015/03/Catalogo-ECOLE-2015-MILANO-LODI-2.pdf

Production managers, planning managers, industrial designers and technicians, purchasing managers, business managers.

http://www.consilia.net/catalogo/schedacorsoincatalogo.php?idcorso=238

4. Good practices

4.1. United Kingdom

4.1.1. AEB LTD

A Journal article[63] and Conference paper [64] by A.J Thomas, M. Francis, R. Fisher and P. Byard (Cardiff School of Management at Cardiff Metropolitan University) documents the implementation of a new Lean Six Sigma Framework (SLSSF) that attempts to create a more balanced and integrated approach between the Lean and Six Sigma elements and one that is capable of achieving greater efficiency of production whilst also ensuring variation reduction and Critical To Quality (CTQ) issues are eradicated from the production process.

The case study chronicles the application of this framework in a medium sized UK aerospace manufacturing company (AEB Ltd) a specialist manufacturer of internal aircraft structures which had suffered from significant issues with production capacity and capability for many years.

The application of the new SLSSF achieved significant improvements in business performance. Key improvements were: build time reduction of 20.5%, improved on-time-in-full delivery to customer by 26.5%, reduced value added time by 5% and reduced non-value added time by 44.5%. In addition, estimated financial savings of £2 million were forecast.

4.1.2. An Advanced Composite Materials and Technology Company

The Industry Forum[65] delivered two 1 day 5S (a lean manufacturing tool) workshops that consisted of a mix of theoretical training, short example and practical activity. Staff at the company who were making a transition from a traditional manufacturing model to becoming a leaner organisation learned about, then were able to implement the key principles of 5S.

The team were led through the 5S teaching points and played the 'numbers game' before carrying out a assessment of the current 5S condition in their target areas. The 5S numbers game is a simple but practical example that presents the 5S concepts to the team and demonstrates how to practically apply it. This interactive example clearly highlights the efficiency improvements that can be gained by applying 5S.

All participants then went into the target area and worked together to remove all unnecessary items from the area (Sort) and arranged the work space to ensure that it was safe, organised, and promoted an efficient, clean workplace (Simplify). Coaching was given to the team to develop visual standards in the form of 5S check sheets (Standardise) to help maintain the standard of the activity and guidance on how to sustain 5S across the organisation (Sustain).

The Benefits:

- Improved visual management in the target areas means teams can easily and quickly identify abnormal conditions and act on them before they manifest into key issues;
- All excess consumables were returned to stores, freeing up valuable space lineside and reducing the clutter. Items are now easier to find in the area;

[63] Production Planning and Control Volume 27, 2016
http://www.tandfonline.com/doi/citedby/10.1080/09537287.2016.1165300?scroll=top&needAccess=true
[64] Proceedings of the 15th International Conference on Manufacturing Research (ICMR2015) Paper 44
http://www.academia.edu/17369357/ICMR_2015_Paper_44
[65] https://www.industryforum.co.uk/

- Better organisation in the target area(s) means that the team can ensure time isn't lost searching for key equipment and materials;
- Identification of overproduction and countermeasures put in place to eliminate it. This led to a reduction in inventory;
- Obsolete plant equipment removed from area. This not only decluttered the area, but also meant that essential items could to be stored closer to point of use, and improved safety.

4.1.3. ZODIAC INTERCONNECT UK

(Part of the global Zodiac Aerospace group) [66]

Zodiac engineers and delivers innovative and cost-effective interconnect products and systems for harsh and safety-critical environments in the aerospace, defence, industrial, and energy industries. In the UK the production, engineering and design plant is in Slough, where Zodiac Interconnect UK has around 125 employees. The formal implementation of lean began in 2012 because the business acknowledged the benefits of lean such as reducing lead-times by identifying waste, the elimination of defects by developing a culture of problem solving and the reduction in variation by making processes predictable and stable through standardisation.

The lean tools are helping in the effort to make Zodiac Interconnect UK a facility that is recognised for operational excellence and the Business Improvement Techniques training is empowering staff with the essential techniques to deliver on this core objective. During six, half-day sessions in the first part of BIT training, five employees learnt key theories and developed their knowledge in areas including organisational safety, effective team working, 5S workplace organisation techniques, visual management systems and continuous improvement techniques using the Japanese Kaizen approach to problem solving and process improvement.

During the second phase of the bespoke training the employees worked in three teams to identify and tackle three individual workplace related projects on Quality, Cost and Delivery. Having completed their training, the team leaders are coaching their individual teams in the business improvement techniques and are auditing each other's 5S+1 audits. They have also identified and are working on new projects focused on safety, reducing the lead time of processes on the assembly line and on improving production efficiency by reducing rejections.

4.2. Portugal

As we have mentioned it is possible to find some good practices inside Portuguese companies related with BIT, although companies do not refer to these policies, methods or procedures as BIT. As such we can only report some general descriptions, associated to companies and related to their management policies:

4.2.1. EMBRAER

It was previously mentioned that Brazilian Embraer invested in Évora, implementing two new plants. The units have been dedicated, respectively, to manufacture machined metal structures and composite material assemblies. The site has started operating in 2013.

Although BIT is never mentioned in the production strategy and planning, Embraer's management have been using LEAN concepts to help bring new paradigms in several stages of the production process of the new wing assembly line in Évora.

[66] http://skillstraininguk.com/bit-empowers-zodiac-team-to-problem-solve

Starting from the design for manufacturing principles in the product, full application of Production Preparation Process (3P) concept for the line early design planning, through to designs for automation assembly tooling, intense application of manufacturing simulation tools like ergonomic analysis and dimensional management as well as state of the art digital manufacturing execution systems for shop floor management Embraer intends to create a highly efficient work flow. All these developments ultimately ensure product quality, continuous and stable production rates and a highly efficient use of all available resources.

4.2.2. OGMA

OGMA's business policy aims for the optimization of the Quality/Cost ratio, the lasting relationship with its customers and suppliers, the penetration into new markets and the continuous improvement of its Quality System's efficiency and effectiveness.

OGMA's strategic view requires a constant search for customer satisfaction, the maximization of return on investment for shareholders and the benefits for society, thus requiring greater focus on its business results with clear impact on productivity and competitiveness. The company has professional training as an ever-present consideration towards improvement of people's individual competencies and of the capability of the company as a whole.

OGMA organises and manages its business activity, providing all means as necessary to meet the customer's contractual requirements, in accordance with the applicable laws and regulations. The organization values partnerships with suppliers in order to create added value and potential benefits for both partners.[67]

4.2.3. CEiiA

CEiiA focus a great part of its efforts in innovation as a key method to leverage business process improvement. The institution promotes collaboration with other companies to achieve and conceive innovative processes, products and services. Furthermore, as innovation is a collaborative process, CEiiA connects companies, universities and other knowledge centres, and public entities in different countries.

CEiiA invests more than 10 million euros in R&D every year. As a result, CEiiA has been consistently ranked among the most innovative organizations in Portugal. According to the latest official data, CEiiA ranked 13th in total R&D investment among all the organisations in Portugal, holding the first position among the not-for-profit entities. Additionally, it participates in many different innovation and R&D projects.

Besides that, it holds different qualifications/certifications from Embraer, AugustaWestland and Nato, as well as EN9100 | ISO9001 Certification concerning its methods of production, being a recognized engineering supplier to some global manufacturers[68]

4.2.4. AEROMEC

The company has the ISO 9001:2008 that specifies the requirements for a quality management system of a company that needs to demonstrate its ability to consistently provide products that meet customer and applicable statutory and regulatory requirements; and aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer.

[67] http://www.ogma.pt/index.php?page=quality_en
[68] https://www.ceiia.com/

In the logistics department Aeromec has a well-organized and practical operation in order to optimally manage the material resources, always seeking the best solutions.[69]

4.2.5. EVOLEO

EVOLEO Technologies provides high-end and differentiated electronic engineering solutions, and seeks continuous improvement, flexibility, quality and customer oriented innovation.

The strategy for this is to promote partnerships and networking with centers of knowledge and industry players. They have gained international recognition as a technological company for leveraging partnerships, added value enhancement and sustainable growth.[70]

4.2.6. CRITICAL MATERIALS

Critical Materials delivers high value consulting services, making usage of a unique combination of skills, ranging from multi-physics to composite materials properties validation.

Critical Materials combines different skilled people, with a high count of PhDs in Mechanical Engineering and Physics. Their service capacity provides clients with custom tailored responses to requirements ranging from structure health monitoring, to analysis of advanced materials to electronics & instrumentation.[71]

4.3. Italy

It is possible to find some good practices inside Italian companies related to BIT, although no company in the country refers to these policies, methods or procedures as BIT. As the case studies were gathered with the support of an engineering consulting society, we were not given permission to publish the names of customers.

4.3.1. METODI Engineering S.r.l

The company, located in Genoa Area develops, constructs and maintains aircraft, aero-engines and aircraft structural components. It has a subsidiary in the United States, located at West Palm Beach, Florida. A global provider of excellence, the company is dedicated to cutting edge aviation technology. Among the leading industry players to design, develop and support unmanned aerial systems, business, special missions and ISR aircraft and aero engines this company is an industry leader in business aviation and Defence and Security. The company decided to move toward a Lean manufacturing operation, in order to comply with a low investment cost and a high return in terms of production efficiency and customer satisfaction.

METODI Engineering S.r.l. an engineering company operating in aeronautic, aerospace, automotive and railway fields and for the development of industrial production tools since 1985, was selected to guide the process. The support from Metodi Engineering was concentrated on applying Lean production operating to existing processes.

The focus was then placed on

- Okuma Lathes: standardisation of the turning operations to allows the employment of a single worker per shift

[69] http://www.aeromec.pt/
[70] http://evoleotech.com/
[71] http://www.critical-materials.com/en/homepage

- Morando Lathes: Recovering of productive capacity on Morando Vertical Lathe 615-415/418 by eliminating wastefulness
- High Vacuum Furnaces: standardization of work operations optimizing the bathes to avoid producing non-requested stocks
- MRO Department: 5s integration activity and operation to set a visual department
- Breton Machinery: Detailed Analysis for workflow to standardize the operation in order to improve production capacity
- TIG Welding Robot: average set up and welding process time reduction

After a period of support/consultancy the results achieved are

- Okuma Lathes: decrease of process time (-18.5%), decrease of worker per shift (-50%), improvement of available space (m2 + 18%)
- Morando Lathes: decrease of set up time (-79%) and diminution of average process time (-21%)
- High Vacuum Furnaces: definition and implementation of a standard work and elimination of non-requested stock production
- MRO Department: improvement of available space (+ 9 m2), definition and implementation of a standard work process, rationalization and replacement of tools (+ 40%)
- Breton Machinery: still in progress
- TIG Welding Robot: average set up and process time – 60% (min – 84%)

4.3.2. MRO CRU

This company is a diversified global provider of highly engineered innovative flight critical products to the aerospace and defence industries specialising in flight control and utility actuation and environmental control systems utilising state-of-the-art technologies. System integration capabilities give the company the possibility to offer turnkey system solutions meeting the most challenging requirements.

The company decided to move toward a Lean manufacturing model, in order to address a period of financial difficulties as well as the new management approach linked with the American ownership.

Lean production approach was provided in the three productive sites in Italy.

- MRO CRU Cell– Site 2
- Time Observation Standard Work definition for MRO activities on CRU devices, KPI, transit time reduction and spaces rearrangement.
- Machinery Bodies Cell - Main productive site:
- Standard Work analysis for a redistribution of the loads on machinery with an increase on efficiency. Kanban system implementation. KPI, TAKT production program, WIP to SWIP.
- PCM Cell – Site 3
- Setting up of a spare area outside the PCM cell where to stock monthly needs freeing the working area from WIP and warehouse from PCM stocks. Daily collection (and construction) of PCM.

Results achieved were:

MRO CRU Cell– Site 2

- average process time – 24%
- average p/n movement – 64%
- p/n transit time - 40%

Machinery Bodies Cell - Main productive site:

- work in process – 40%
- on time delivery + 45%

PCM Cell – Site 3

- average process time - 21%

4.3.3. Genoa

The company is a high-tech private engineering SME based in Genoa, Italy. Due to its experience in Aerospace, STAM has decided to invest resources in the active debris removal field and, in order to support these activities, has established a business collaboration with Mr Franco Malerba, the first Italian astronaut, in order to maximize the visibility of the project and push the developed technology to the market. The business innovation coaching (Funded through EASME - Executive Agency for SMEs, under the SME Instrument) strengthened their capability to deal with growth, and aspects such as strategy, organisation, management, financing and resource development.

The total number of hours was 96 divided as presented below:

- 4H: Assessment of business development strengths Meeting with company managers, discussing the space debris capture system, designing a preliminary methodology to assess market value and potential customers; deciding on paths to connect with potential partners and customers.
- 4H: Articulation of a vision and a mission
- 8H: Business architecture and market segmentation
- 36H: Connect to potential partners and customers
- 10H: Preparation of negotiations with partners
- 10H: Estimation of sales and business potential
- 24H: Support in the development of a detailed business development plan

The connections developed through this coaching helped the company to prepare new proposals and to reach new targets.

5. Needs Analysis

An analysis of the need for improved and enhanced vocational training, particularly in respect of teaching BIT techniques, within the Aerospace Manufacturing Sector has been carried out. This has included primary research, in the form of **questionnaires, interviews** and focus groups with representatives **of four**

key stakeholder groups; complemented by secondary research focusing on existing case studies, academic enquiry and the findings of recently published larger scale sector specific surveys.

BIT programmes provide the training and knowledge for employees to drive positive improvement within a company, this can be achieved with a range of tools which aim to minimise waste and cost as well as maximise profits and performance. Although they are key for aerospace engineering apprentices and workers, competences developed through BIT are currently under-used in the aerospace industry.

In the context of the project, BIT is a term used comprehensively, to include any systems or techniques adopted by organizations to improve services, increase efficiency and productivity.

The main purpose of this initiative is to provide employees, trainees or students with the tools and competences, skills and know-how to enhance the impact and competitiveness of their work performance.

The four key stakeholder groups identified were **Aerospace Manufacturing Enterprises, Vocational Education and Training Providers, Higher Education Institutions and Other Sectoral Organisations, including clusters, industry and trade associations, certifying authorities, regulators and other bodies.**

In this enquiry, these groups answered the questionnaires and the interviews were conducted with experts from the four types of stakeholders defined as belonging to the aerospace industry. This research (interviews and questionnaires) focused on awareness on BIT, ECTV, training needs and training conducted in the organizations.

We have received the following answers according each stakeholder group and country

Questionnaires					
	Companies	Higher Education Institutions	Clusters	VET Providers	Total
UK	4	15	2	0	21
IT	13	5	15	7	40
PT	13	3	1	2	19
Total	30	23	18	9	80

Interviews					
	Companies	Higher Education Institutions	Clusters	VET Providers	Total
UK	3	3	1	0	7
IT	17	5	13	0	35
PT	3	2	2	1	8
Total	23	10	16	1	50

The answers provided were grouped according to the stakeholder type and the data concerning each question is presented jointly, independent of the country where respondents are from. Nevertheless, the composition of each chart is made with information from each country.

This data has also been analyzed separately in each national report.

5.1. Vocational Education and Training

Questionnaires

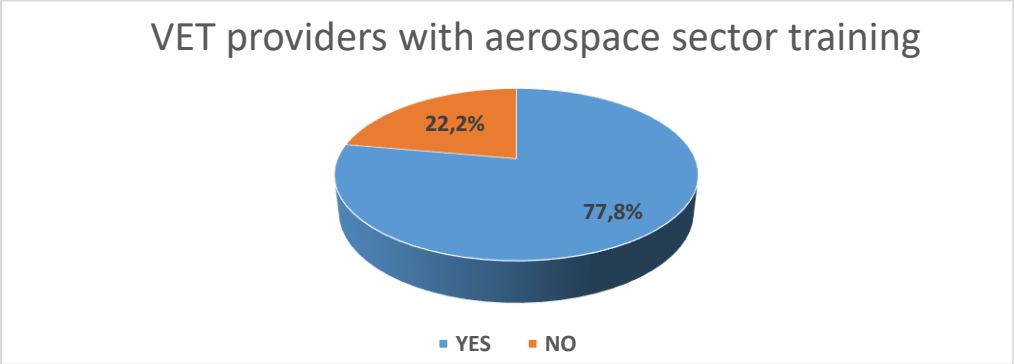
Responses from and participation in this research by **UK** VET providers was negligible, due in part to the strongly competitive and commercially driven environment in which VET providers (particularly those working in high value manufacturing sectors such as aerospace operate). However, their training provision is driven by the availability of skills funding and industry need which has been discussed in depth elsewhere in this report.

The training from the Vet providers in **Portugal** and **Italy** was considered adequate to the needs of the professionals and consists in certified courses part 147, development of specific competences and soft-skills progress. The people that engage in this mode of training are professionals from companies in the aerospace sector with an age around 40 wishing to refresh their competences or to acquire a new set of skills.

Training organizations play an important part in promoting the development of aerospace companies and, more importantly, in the spread of BIT. In this sense, although not always known under the name of BIT, Lean Production or continuous improvement, these themes are well known by training bodies (not just those involved in interviews / questionnaires) that often offer more or less customized training interventions on these topics to industries. The data highlighted during our desk research have been validated during the VET Providers involvement phase.

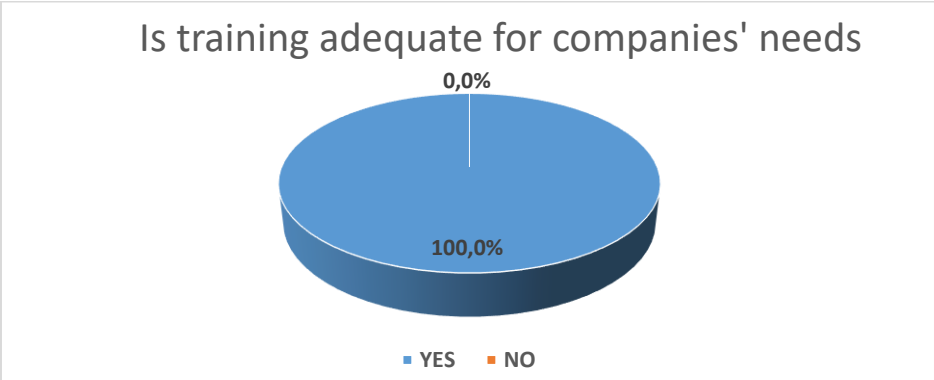
The VET providers involved all have deep experience in enterprise affiliation and definition of targeted interventions, and are widely credited for courses, with a large portfolio of Aerospace clients, more than 70% of respondents. Knowledge of the ECVET system is wide but its application - as discovered during our desk research - is not active.

Question - Does your organization provide courses for the aerospace sector?



Most part of the VET providers assessed offers training courses in this area.

Question - Is the course(s) for use in the aerospace sector suitable for training workers in one or more enterprises?

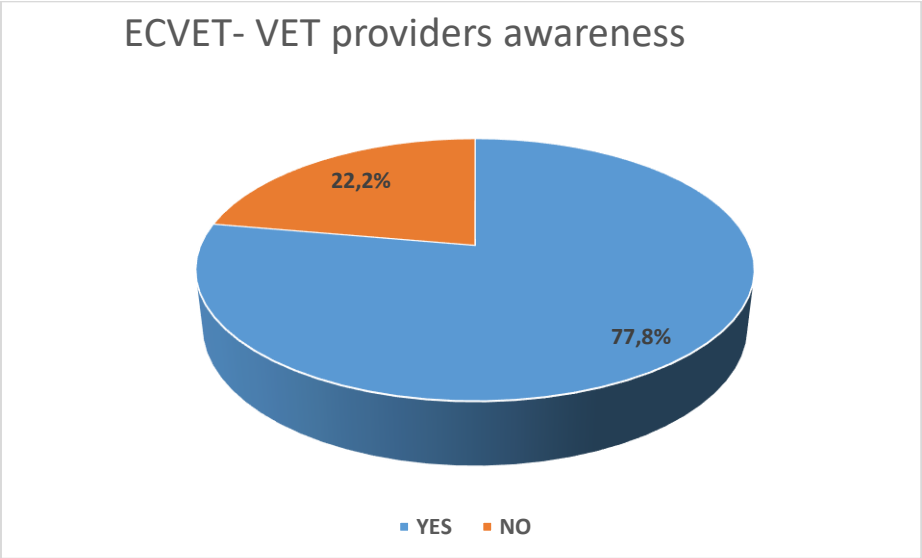


They consider it suitably to the needs of the companies and their professionals.

Question - Are you accredited by a certifying authority to provide any specific course(s)?

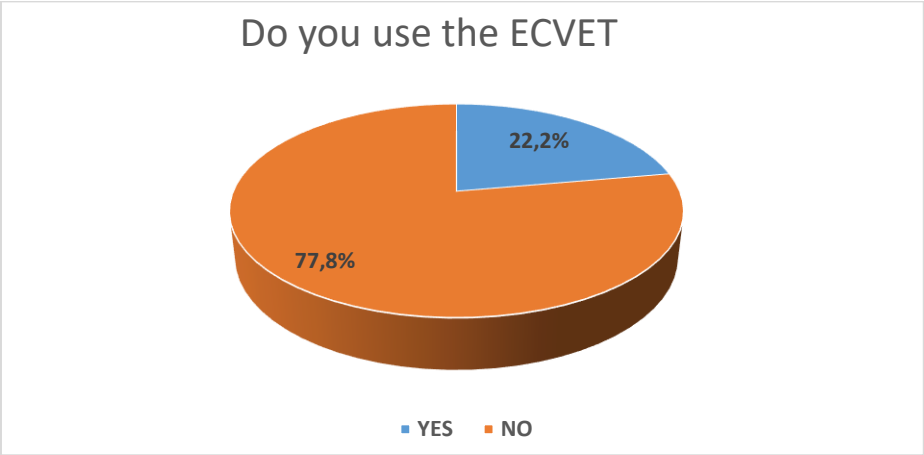
They all are certified for giving this genre of training by an official certifying authority.

Question - Are you familiar with the concept of ECVET?



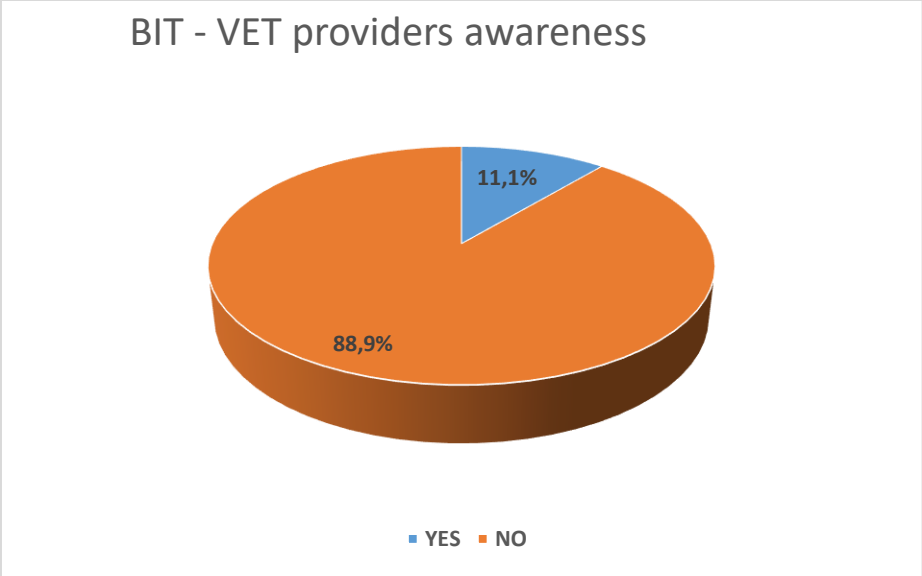
77,8% of the inquired are familiarized with the concept of European Credit system for Vocational Education and Training.

Question - If Yes, does your organization use such system?



Just 22,2% is using the ECTV System.

Question - Are you familiar with the concept of BIT (Business Improvement Techniques)?

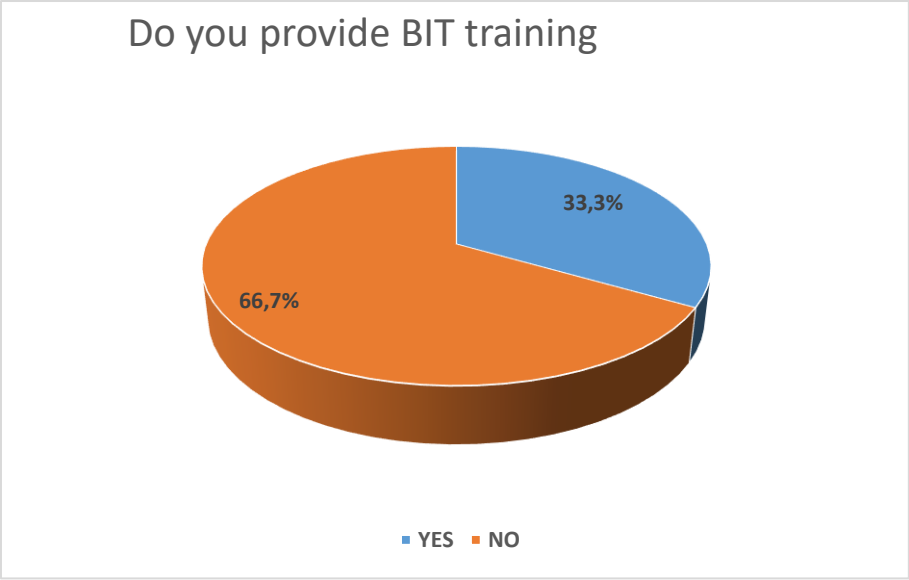


Regarding the BIT courses promoted by VETs involved, they generally arise on direct customer business initiatives, often with independent trainers and, above all, with a high customization of the interventions. The most recurring theme is that of the Lean Organization in its application in the context of the medium-sized company both with spot and multi-art campaigns, lasting several months and specific training sessions on the job and of support.

Portuguese VET Providers revealed a similar knowledge that other stakeholders did about BIT. **In this case, we believe, as well, that <u>some are not familiar with the terminology</u>**. In fact, some provide training where BIT are a central issue meeting some of the real needs of the professionals in the field.

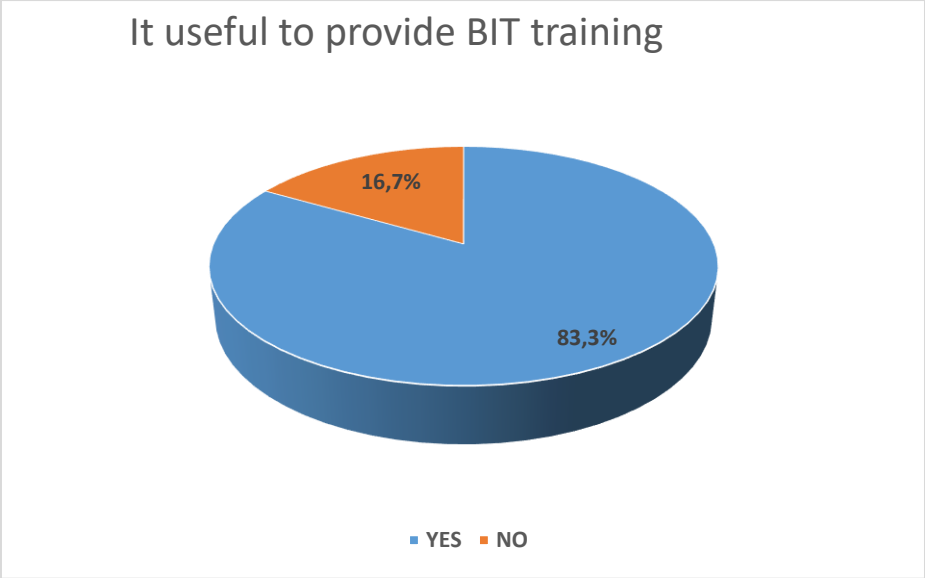
Italian VET Providers revealed **that they are not totally familiar <u>the concept, but though they had not heard about it, they provide</u>** BIT in their training.

Question - Does your institution provide training for professionals on Business Improvement Techniques or similar (Lean, six sigma, etc.)?



A third do not supply this type of training

Question - Do you think it would be useful for your organization to provide training/information/support about BIT or similar?



A vast majority of the VET provider organizations consider it advantageous for them to provide training in BIT. They offer courses on a wide range of issues: innovation in the organization (part of which involves BIT), digitization and technical production skills, business start-ups, and emerging activities from specific business demands. The target groups of these training actions are practically all workers, obviously taking into account both the business size and the type of courses. In this sense, since SMEs are the main focus of intervention for these bodies, often the whole workforce is involved in training processes. In less formalized contexts (i.e. without large hierarchy schemes, staffing offices and executives for the definition of human resource policies), the direct involvement of the entrepreneur is crucial for the definition of BIT related interventions.

The customization of training courses also offers a very fragmented view of the duration of targeted training campaigns for industry companies, even though the trend is to have either a limited time-to-action (generally headed by managers / executives) or different windows of activities with the

participation of a large percentage of corporate population (sometimes 100%) in more complex projects. No instances of reward for participation in training have been reported

As far as the BIT techniques are concerned, practically all VET operators are aware of them but with little direct application, while the total number of respondents who do not offer initiatives on these issues, consider their eventual development useful.

Interviews

The genre of training available in the VET providers entities are: **Certified Aviation Technical Training** (Part-147) and **Behavioral Training** (Leadership Development, Project Management, Career Management).

5.2. Higher Education Institutions

Questionnaires

The different Portuguese Universities surveyed answered that a deeper cooperation between companies and universities would be desirable for a better preparation of students regarding their professional life.

UK Higher Education representatives, including Lecturers, Senior Lecturers, Professor, Researcher, Course Leader and Head of Aerospace Teaching Programme contributed to research findings which indicate that the typical HE course offerings at UK Universities are Aerospace or Aeronautical Engineering at Degree and Masters levels (usually leading to a BEng or MEng qualification). More specialised courses such as Aircraft Maintenance Engineering (BSc) and Space Systems Engineering (MSc) are also offered at a limited number of institutions.

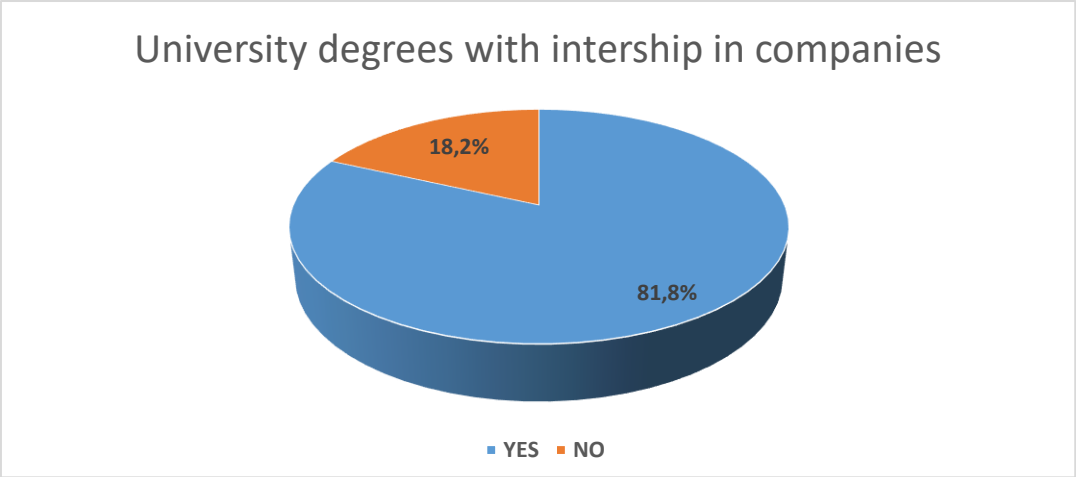
As previously highlighted, a big part of education and formation in Italy is performed from Higher Education Institutes. The **questionnaires** and **interviews** provided more or less the same response.

- Most of the interviewed/questioned institutes have dedicated courses on Aerospace
- The students number is slightly increasing in the last few years
- The main aim of the institutes is to create a contact among the students and the enterprises, so there is a greater collaboration with sector enterprises
- The percentage of graduate students that enters the Aerospace sector is very small (around 1%). The number is stable, since the Italian companies working in this sector are not so many and the turn-over is quite low.

Main envisaged challenges:

- Technological development
- Development of the competences of workers
- Lowering of costs
- Transfer of the knowledge of new tools for design, production and organization of work.

Question - Do your courses include a component where students work with an aerospace manufacturing company (or similar)? e.g. through an internship, project, apprenticeship, etc.

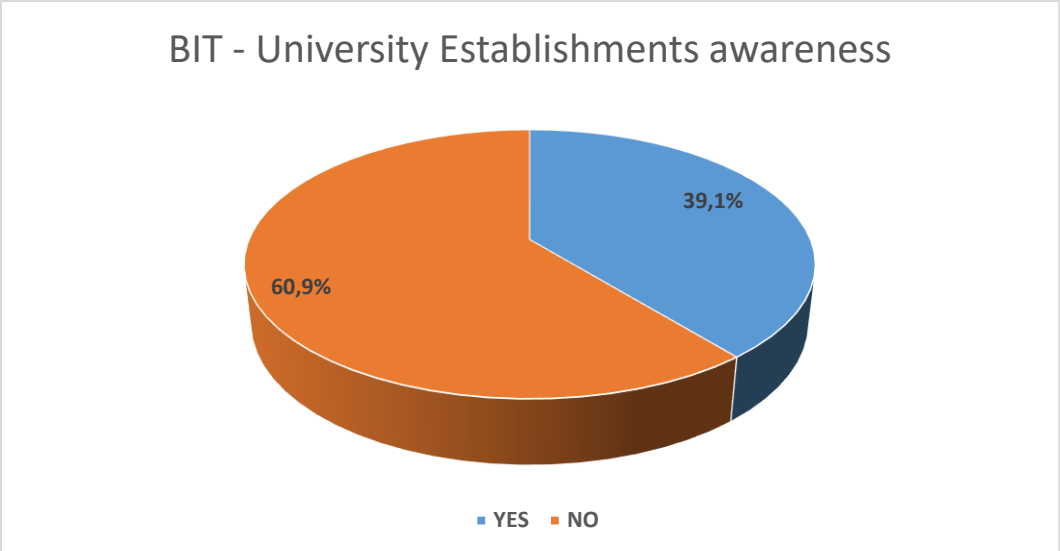


More than 80% of the Institutions in our enquiry include an internship period in its degree.

Examination of course syllabi and information gleaned through interview also indicate that the majority of undergraduate aerospace engineering courses offer an optional additional yearlong industry placement. The national percentage of undergraduates pursuing this option is not clear, however; the University of South Wales estimates that 10% of their degree students undertake this. Factors discouraging higher take up of this option include the negative implications of increased costs and time spent by students to complete their degree.

In terms of **BIT, Universities** are not fully engaged with Business Improvement Techniques and do not consider it relevant to have subjects or topics concerning this issue. Although, after a careful analysis to the different master degree curriculum considered in this study, (see 3. Training offer and routes to market) it is possible to ascertain that there are several disciplines about this theme. **We are lead to believe, as we have referred, that many of education providers are, merely, not familiar with the jargon BIT (Business Improvement Techniques)**. In fact, the Master Degrees scrutinized have a strong component of BIT, several subjects of science regarding innovation, management, marketing, optimization and sales are included bestowing fundamental knowledge to drive positive improvement within a company.

Question - Are you familiar with the concept of BIT (Business Improvement Techniques)?



Most HEI's in the UK are familiar with BIT, due to the higher profile this concept has in UK.

As previously underlined, in Italy, the contents of many of the courses included in the Master's Degree in Mechanical Engineering - Energy and Aeronautics refer to the industrial sector in general and are therefore not focused on the aerospace industry. For this reason, some issues are treated superficially.

In UK 98% of institutions who responded indicated that student numbers on aerospace related courses were either growing or stable. There was some confusion over a question regarding 'Probable professional developments for students', primarily due to the slightly unclear wording, however when interpreted as referring to the type of employment students move into, responses suggest that likely career destinations include aerospace design, development and manufacturing, EASA Certified Engineer, and commercial sector. These findings are supported by potential career information included in the majority graduate and undergraduate marketing materials such as prospectuses published by UK HEI's.

The percentage of graduates who progress into the aerospace manufacturing industry is not clear. While various national surveys[72] and other guidance websites[73] in the UK can provide an indication of the percentage of employment achieved by graduates from degree course subject area, this employment information is not broken down by sector. Survey respondents were not able to provide accurate figures and estimates range widely from 2% to 80%.

Various challenges facing HEI's involved in aerospace engineering provision were identified by respondents, which broadly tally with more widely available commentary and information. While some of these issues are aerospace sector specific, others relate to the HEI sector or UK political climate as a whole; nevertheless it is reasonable to assume that the effects of these wider factors may be felt and potentially addressed at individual subject level.

Challenges ranged from lack of time and resources placing excessive demands on staff through to Brexit. The importance of genuine partnership with industry, from understanding and meeting their ongoing and new demands to the need for industry experienced staff to work in academia was clear from responses received. Risks of falling standards, lack of good quality students and preparation in relevant subjects at school level were also highlighted.

[72] https://www.gov.uk/government/statistics/graduate-outcomes-by-degree-subject-and-university
[73] https://www.whatuni.com/degree-courses/search?subject=aerospace-engineering&sort=empd

Solutions to these challenges were less clearly articulated, though better collaboration with industry was the most commonly suggested. Other approaches suggested the need for investment in staff, students and infrastructure. The responses to some challenges, such as minimising the negative effects of Brexit were considered to be outside the control of respondents.

A recommendation that HE provision in Maintenance Engineering seems to offer a solution to meeting the demands of the industry; clearly, as numbers of new aircraft increase, so will the global demand for skilled aerospace maintenance.

Views on whether there were important skills that were not currently being taught were also mixed. 35% of respondents did not identify any areas not taught. The remaining 65% identified a number of skills either not being taught, or requiring increased provision ranging from emotional intelligence, big data, engineering management (which may include BIT), multidisciplinary learning to Maths, Physics and Programming. The importance of responding to industry focus and increased input from industry into defining educational provision was also highlighted.

Opinions regarding whether BIT should be reinforced in HE curricula were mixed. Almost 70% either thought this wasn't necessary, were not familiar with BIT or did not know how this could be implemented. 15% thought that BIT should be reinforced with the remaining 15% commenting that they though students already had relatively good exposure to BIT through commercial, business and management focused lectures as well as pointing out that Engineering Management is required by accrediting bodies. The need for more team working, design based and self-thinking modules rather than more lectures was also emphasised.

An interview[74] and academic research[75] from a HEI perspective, focused on the need for new skills for future aerospace professionals and how this could be translated to the (university) classroom. This study used 'The Assessment and Teaching of the 21st Century Skills Project'[76] as a baseline for the definition of the future 'critical' skill set. This framework is considered well aligned with the future needs of the aerospace industry and could be translated to a range of learning environments through an effective redesign of existing teaching and learning philosophy and practices. It is clear that 'an industrial-age curriculum will not fully equip students for living and working in an information-age society'. [77]

Interviews

There has been an increase in demand for this type of degree and the implied knowledge, especially in public Universities. This is as a result of the high quality technical and scientific knowledge that it entails; this high level of requirements demanded by the companies means well paid careers, professional stability, furthermore there is the traditional magnetism that people have for this sector and the evolution observed in the sector during in the last few years, making it more attractive. The search for the degrees granted by the Air Force has remained stable and highly popular as it was in the past.

A close cooperation between the two types of institutions (higher education Institutions and companies) is desirable and could lead the sector to a better acceptance of recent graduate Human Resources as well as to later fruitful incorporation in the labour market. Other recommendations devised were joint collaborations in research and scientific projects and partnerships for other types of collaboration where

[74] Ilias Lappas, Aerospace and Defence Professional and Academic currently working as a Senior Lecturer and Course Director of Aeronautical Engineering at the University of South Wales
[75] http://www.jatm.com.br/ojs/index.php/jatm/article/view/616/512
[76] http://www.atc21s.org/
[77] http://www.jatm.com.br/ojs/index.php/jatm/article/view/616/512

students could participate in problem solving and applying new methods to assessing companies' challenges.

Besides the good technical and scientific learnings, soft-skills are competences that could be more detailed and have a deeper focus in the curriculums. **BIT** are a subject of strong relevance for the industry and may bring clear benefits in the future, although the institutions are afraid that it may lead to prejudices in the technological and technical preparation of the students due to the time limitations.

It was concluded that **Higher Education institutions** educational contents are totally satisfying the training needs for the future professionals

5.3. Aerospace Manufacturing Enterprises

Questionnaires

Additional needs identified by survey respondents included the need for Technical College based provision for less academic personnel, investment in new equipment, culture change throughout all levels of the business and further reference to the need to develop new technology and improve productivity.

While increasing productivity was considered key, responses indicated that it would be possible to do this with the existing labour force if there were more qualified staff, by reducing waste and improving processes and taking a more disciplined approach encompassing greater attention to detail, better procedures and work instruction and a clear line for management responsibility as well as structural changes (once more, there is a clear opportunity for the utilisation of BIT here).

Some of these challenges translated directly into areas or themes where it was felt that training was required or would be useful which included specific needs for training around the programming and setting of Computer Numerical Control (CNC) machines and operation of new equipment to more general requirements for management and leadership training based around business transformation.

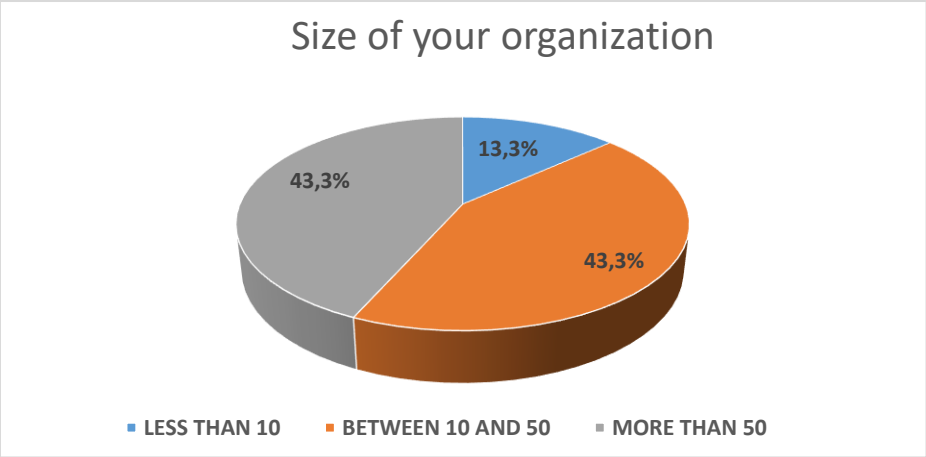
The majority of enterprises stated that their main concern and challenge is to find the right Human Resources, train them suitably and achieve a good return from these actions. Additionally, to hire more people with specific training, with the right skills and preparation is decisive. More specifically, they highlighted the training needs in general management, marketing and sales, and procurement.

A training element that should be developed is the internal communication and associated procedures to avoid redundant work. These good practices are referred to as needed to improve internal process management and planning.

The majority of enterprises stated that they consider it useful for all employees to take advantage of BIT courses, perhaps with different duration and depth depending on the role.

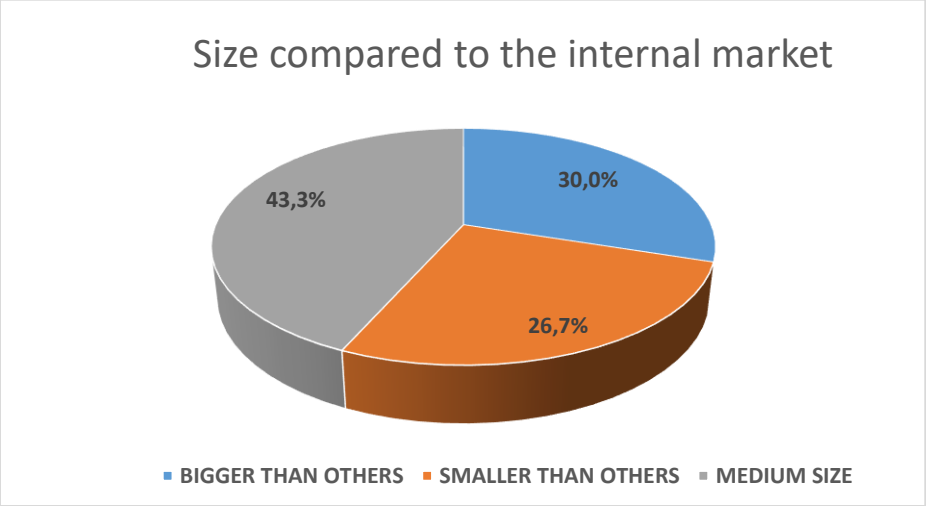
Questionnaires and interviews saw the participation of companies in the sector of various sizes (especially SMEs, but also large companies) and with different areas of intervention, ranging from real production to design, consulting and engineering to the chain, with companies active in the production of industrial valves, sheet metal, radio and telecommunication equipment, defence systems and electronic systems and specific software.

Question - What is the size of your company in terms of number of employees



43,3% of the companies has between 10 and 50 workers and an equal amount has more than 50 employees. 13,3% has less than 10 workers.

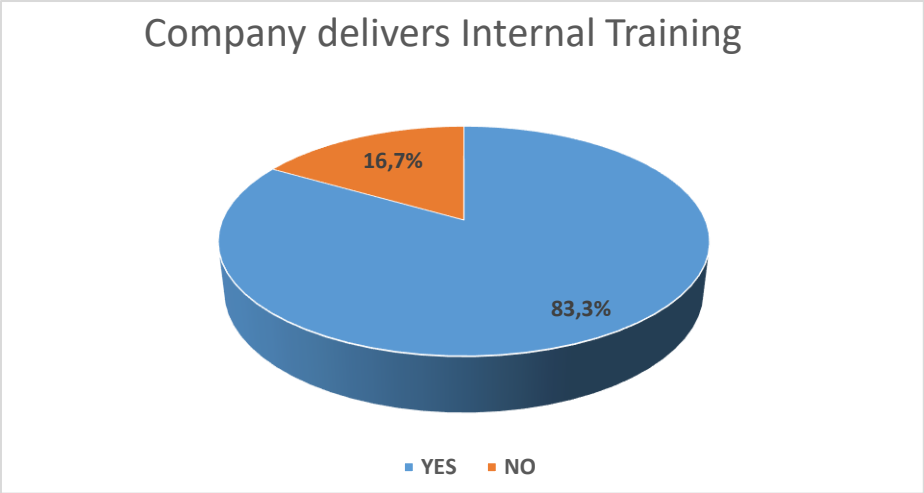
Question - How would you consider your company's size, in comparison to other similar organizations active in the national market?



A majority believes it has an average size in the domestic market.

One of the biggest challenges is definitely to find the people with proper competences and promote their growth within the organization. In terms of industry training needs, the quality and productivity of HR is a central issue.

Question - Does your organization put in place in-company training or another type of training for the employees?



Most part of companies delivers training to their collaborators:

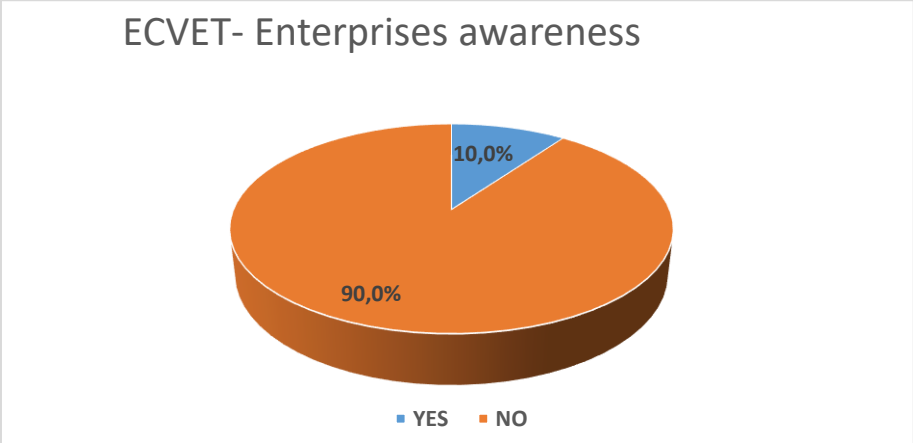
Factors adversely affecting workplace learning included the time and cost implications of freeing up skilled and experienced personnel to train others and training needs being determined on an ad hoc rather than career development basis.

Examples provided of training dislikes were the lack of infrastructure in place to support the activity required and training being too generalist.

The majority of enterprises stated that the main challenges for the future are:

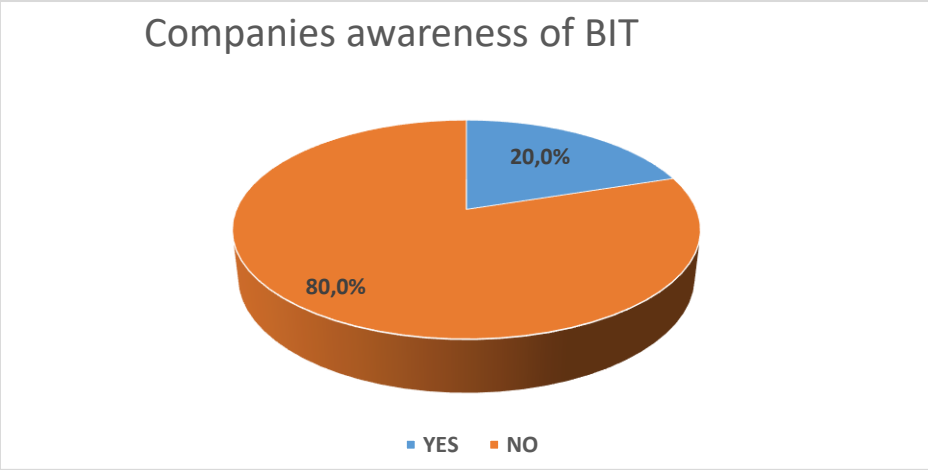
- deeper research for greater efficiency in production
- reducing production costs
- competition from abroad
- maintaining competitiveness and innovation
- structure reliability
- remaining competitive in a declining market,
- Improving business potential

Question - Are you familiar/have you heard about the concept of ECVET?



A small minority of the respondents were familiar with the concept of European Credit system for Vocational Education and Training.

Question - Are you familiar with the concept of BIT (Business Improvement Techniques)?

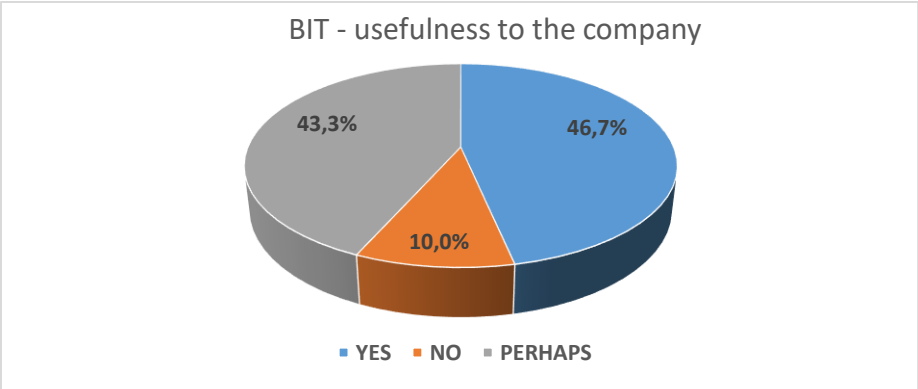


Amongst the **companies of the sector**, BIT was relatively unknown, but companies' performance in the market is supported by a strategy and preparation of its professionals according to the principles associated with this kind of training. Once again, the term is not familiar, but companies are aware of its practical relevance.

Despite many companies not being aware of the advantages of BIT, they are totally focused in developing it inside the organization, the methods and approaches already employed by some of the players (see section 4. Good practices), follow several of the principles of BIT.

The awareness of this component does not match other levels of excellence and competitiveness showed in other departments or aspects of the businesses.

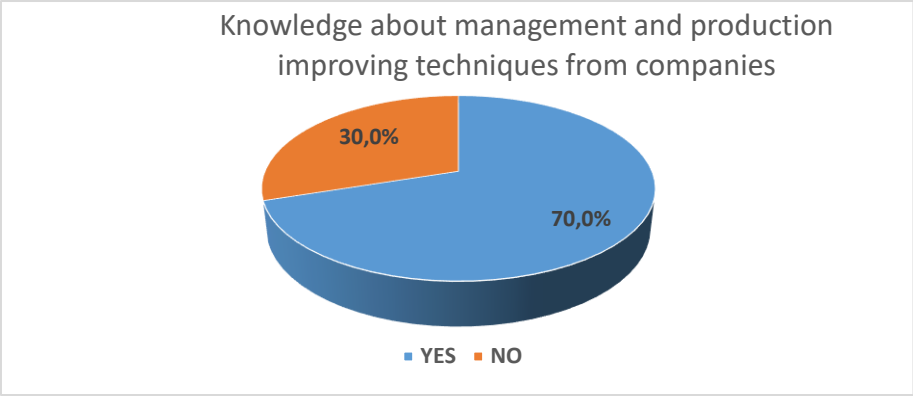
Question - Do you think it would be useful for your company to receive training/information/support about BIT or similar (Lean, six sigma etc.)?



A vast majority answered that either their company would find BIT useful or were not totally sure about the need to have training in BIT or similar techniques.

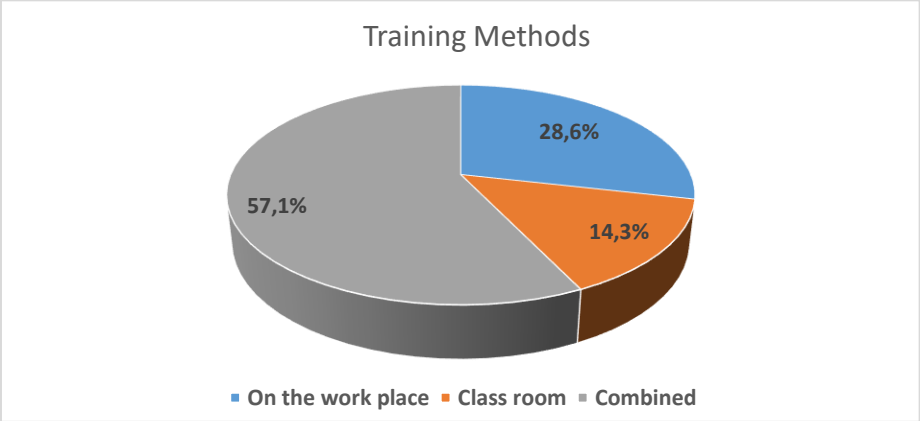
The majority of the companies stated that is familiar with other training methods for production or business improvement:

Question - Are you aware of any training/mentoring about techniques to improve production or business in general?



When questioned about the training methods, companies responded as follows:

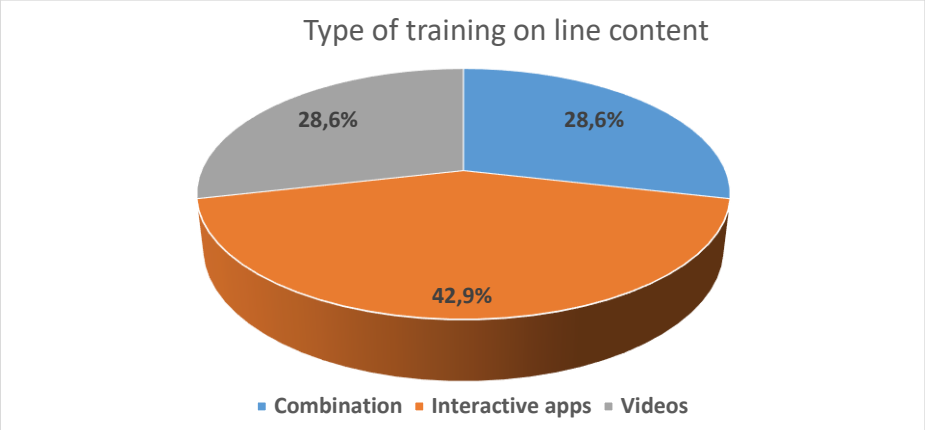
Question - What training method would you recommend?



The majority of respondents favoured a combined classroom and workplace approach.

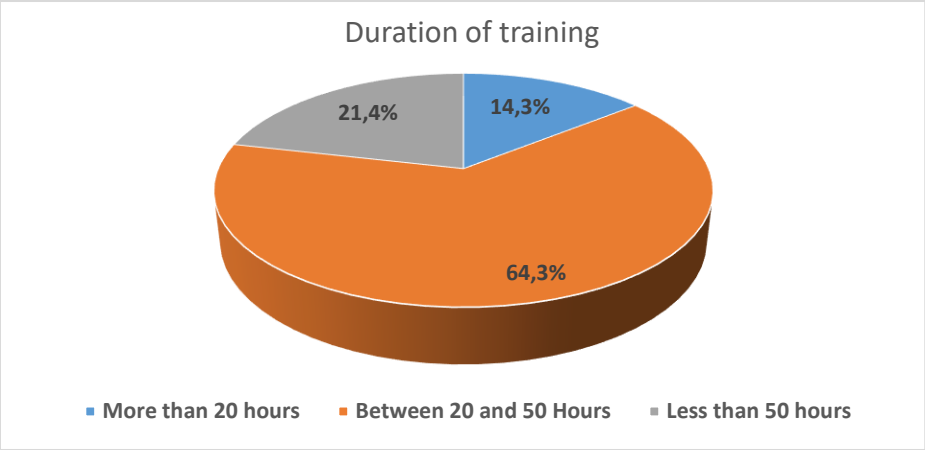
When asked about online based training, respondents selected the following types of content:

Question - If online, what kind of content would you prefer?



Almost half chose interactive applications.

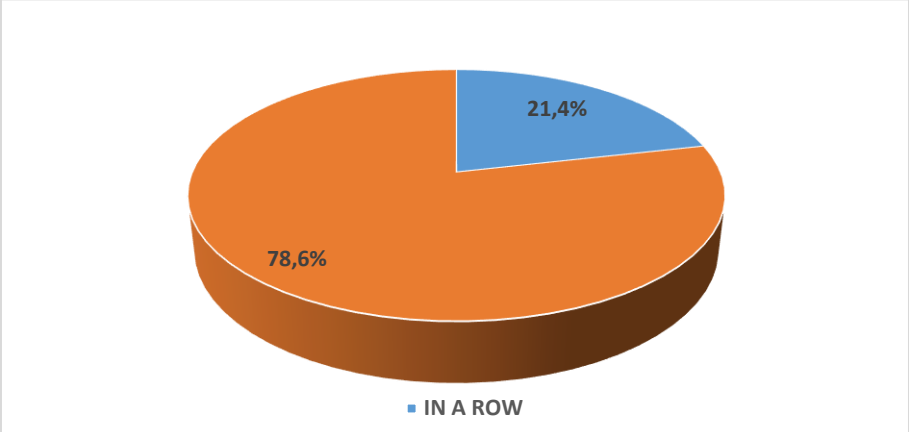
Question - How long do you think a course should last?



Almost a third of the respondents told us that the training should last between 20 and 50 hours.

Regarding the period of time for training:

Question - Time span: the training should be



Again, there was possibly some confusion as to the meaning and definition of BIT, as, in UK, 75% actually described having attended courses or training containing elements of BIT, though not all identified learning and using lean manufacturing, cellular manufacturing and other tools and techniques could be classified as BIT.

Reference was made by several organisations to their participation in sector wide and competitiveness and continuous improvement programmes, Supply Chans for the 21st Century (SC21) and Sharing in Growth (SiG) which are discussed elsewhere in this report.

Other comments received emphasised concerns that the skill levels within Aerospace SME's will soon be in crisis and there is a need to consider infrastructure for personnel who are not necessarily academic, but who have the potential to become good engineers. SME's struggle to free up resources to train others and colleges often do not have the equipment or lecturers to fill this void.

Findings from a round table discussion involving a focus group of aerospace industry professionals identified that there was a need for the type of learning platform that the Aeero project was proposing and that there were gaps in the type of online training available in the sector, as well as a noticeable variation in quality standards and generally not much online training specifically aimed at the aerospace sector is available.

The group felt that it was important that the learning platform be authentic in order to be effective. It would need to be engaging, user friendly and incorporate of reward and recognition of progression in order to motivate learners.

Other key factors to ensure that the training was effective would be non-patronising, have some level of interaction and including working examples relevant to the audience undertaking the training.

The group also emphasised that it was important to overcome as many barriers to entry as possible (such as avoiding classroom based lectures which many workplace based learners are put off by).

In terms of flexibility and accessibility, an internet browser based platform would probably be the best format to adopt and it was also suggested that a Process Mapping focused 'module' may be a good starting point as this could fit anywhere in any tier of business.

In the UK, response rates to our survey were relatively low; however it is reassuring that the findings generated broadly match with other similar recent surveys of the sector carried out by other organisations, for example the BDO Group, who in 2015 partnered with the Institution of Mechanical Engineers (IMechE) to analyse the sentiments, challenges and changing macro landscape for UK aerospace companies.[78]

The resulting report indicated that there had been strong growth in the sector for several years and that this was likely to continue, resulting in demands for productivity being ramped up and also notes that how suppliers respond to new technologies will be crucial to their future success, especially given the competitive threat from China who will develop domestic competitors as it is already doing in the automotive sector.

Overall, this survey revealed a strong positive sentiment in the UK aerospace sector but also serious concerns about the UK's continuing position as the world's second biggest source of aerospace equipment. There are serious issues with long-term agreements, productivity levels, availability of correctly skilled people and the rise of Asia as an aerospace powerhouse which represent threats to the UK industry.

Key survey results[79] showed 62% of companies had an issue with productivity, 62% of companies were setting up overseas facilities with 35% of these located in China and 15% of companies indicating that local incentives that de-risk overseas investment make it easier to create a foreign base. 63% thought that the UK should invest strategically in through-life engineering services and product service systems with the same percentage believing that the UK needs more home grown, mid-size companies to strengthen the UK aerospace sector.

64% were positive about prospects for their civil aerospace order book in the next 5 years, with only a slight decrease when considering the next 10 years.

There were a mixed range of concerns and challenges identified, with the need to invest in research and development to remain competitive and fulfilling new, higher production rates required by prime contractors scoring highest.

The BDO report also pointed out that the lack of technical skills and the high displacement f trained personnel from SME's to larger companies is frequently cited as a common inhibitor to manufacturing growth. 53% of the companies surveyed had experienced difficulty with recruiting people trained in the disciplines they needed, with mechanical and aeronautical engineers in greatest demand. Other jobs

[78] https://www.bdo.co.uk/en-gb/insights/industries/manufacturing/the-aerospace-report
[79] ibid

where a skills gap existed were software engineers, systems integration engineers and experienced machine tool operators. 21% said they needed more engineers with an understanding of through-life engineering, showing that design for repair is seeing a market pull which the engineering education sector should heed.

Apprenticeships are seen by most stakeholders as key to the future of the industry. Survey results showed that 20% of companies responding had no apprenticeship scheme, 10% of apprenticeship schemes were not cost effective, however 42% had taken on 50 or more apprentices in the last 2 years, demonstrating what a substantial part of overall headcount in larger aerospace firms that apprentices form.

Future developments will also influence needs and challenges facing the sector. Organisations such as the Aerospace and Defence Security Group (ADS), the Engineering and Physical Sciences Research Council (EPSRC) and the EPSRC Centre in Through-life Services predict that the global maintenance, repair and operations (MRO) sector is about to take off.

As local skilled labour costs in India and China are much lower than in Europe and the US the UK will need to fight hard to retain and win MRO services which will mean better training coupled with an understanding of Big Data, the Internet of things and how companies use the immense volumes of data they generate. [80]

The UK Government is supportive of the industry (as described earlier in this report) and there are several well-funded and often industry match funded programmes and initiatives[81], which more than half of the BDO survey respondents received benefits from; however 18% said they were unaware of most of these programmes and 22% though aware, had received little tangible benefit. 25% of companies responding said that Government sponsored activities had helped them with innovation and research and development, but just 4% said that Government programmes had helped them access the supply chain of bigger companies, calling into question the efficacy of the AMSCI.

Despite new government supported training initiatives and the aspirational status of the sector, nearly 25% of companies said these activities would probably not address their company's recruitment issues over the next 10 years. Companies also wanted to see more government support in some key areas of activity; including Apprenticeships (25%), channelled support for smaller companies (23%) and a National Strategic Productivity Review (20%).

An overwhelming 87% also thought that the UK should develop a National Strategy in Through-life Engineering Services (TES) and create a global centre of excellence for TES.

It was interesting to discover that, in Italy, 100% of the interviewed enterprises answered positively to the question: "Are there internal training campaigns for your company's employees?", but only 7% were aware of ECVET and only 23% had heard about BIT.

The answers that emerge from questions related to the training campaigns carried out in the company give very different results, however some relevant factors emerge. Firstly, it appears to be of little relevance the certification/accreditation of courses; instead the importance of direct applicability of learnt competences is underlined.

[80] ibid

[81] Aerospace Growth Partnership (AGP), Advanced Manufacturing Supply Chain Initiative (AMSCI), Aerospace Technology Institute, National Aerospace Technology Programme, SC21 (ADS), National Composites Centre, other Catapult Centres

Likewise, VET results also reveal heterogeneous feedback regarding the workers involved in these campaigns that may be executive resources (especially for limited interventions) or all workers in the company. Even in this case, there is little presence of training reward systems.

With regard to attending Lean courses only in one case there is a direct experience, linked to Lean production in particular. Most respondents find it useful to have a BIT-related training program, with a mixed teaching approach and with limited duration work (especially between 20 and 50 hours) and available for a long period of time.

Interviews

Companies reinforced the importance of R&D to support the innovation. R&D has to be well-conducted to be productive and lead to innovation achievements meeting costumers' requirements and desires; employees' training should be planned with this in mind. Findings specifically referred to were innovative engineering solutions for clients' needs in a range of multidisciplinary sub-areas such as robotics, signal processing and software.

The importance of the quality of human resources was emphasized, as well as procedures and internal processes. One common wish is to grow sales and a solution suggested was to develop strategic partnerships for that.

The need for good practices in digital platforms and software usage were mentioned in the context of helping to execute complex projects. Efficiency can be attained with process optimization and automation through CBTs. Designers and engineers would reduce the time to complete tasks and final product would be better conceived with less people participating in the operations.

A clear majority of the Portuguese **Enterprises** from this industry provide regular training to their employees. Some complaints are associated with the fact of not being able to find the proper trainers, the training not being well conducted or is not being specific enough to be fruitful.

Findings from most parts of the survey indicate that is vital to have some form of certification at the end of the training. The majority state that training in BIT or similar learning is pertinent for their company and it is important that the training happens in the work place.

Some companies referred to the need for better facilities because of the complex and demanding tasks that come up day-by-day.

5.4. Sectoral Organizations Clusters, Industry and Trade Associations, Certifying Authorities, Regulators And Other Bodies

Questionnaires

The **sectoral organizations, clusters, industry and trade associations, certifying authorities, regulators and other bodies** do not seem to know about BIT and do not include this issue in their priorities or strategies.

The main envisaged challenges that were reported were the ability to adapt to the European market and to anticipate technological and operational trends before they become commonplace and need to be swiftly adapted.

The key drivers for innovation that need to be targeted are:

- better operating efficiency of production
- Development, market analysis and partnership research
- a higher level of technological mastery
- Constant technological analysis
- reduction in resources required for development
- spin off
- credit access
- Different commercial policies, open to SMEs
- Environmental impact and safety

Many of these organisations have commissioned their own research into the challenges and needs facing the sector as well as acting as points of contacts for all organisations operating within the sector and encouraging collaboration and cooperative behaviours aimed at addressing these needs.

Findings from these types of organisations identify a number of key major challenges facing the sector. These include a shortage of qualified and experienced personnel with core engineering skills (exacerbated by an ageing work force) as well as skills shortages in key technologies. The uncertainties of Brexit were also cited as a major challenge.

There is also a perceived need for a holistic approach between industry and academia to generate interest in both engineering and the aerospace sector specifically in schools to help with the recruitment of Aerospace Engineering graduates.

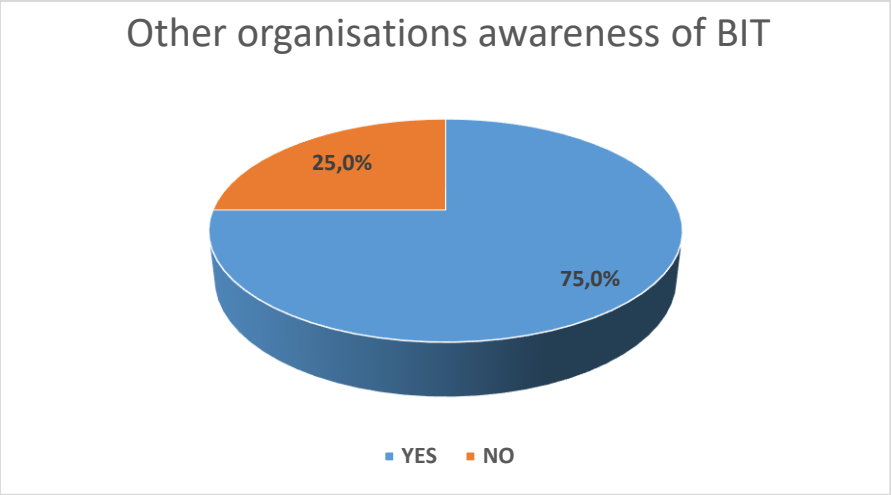
There is demand for there to be certainties over trade regulation and movement of personnel following the UK's renegotiated relationship with the EU. Although the outcomes and possible negative impact of any Brexit agreement are currently unknown, it is clearly a major potential challenge facing the sector as evidenced by the large amount of commentary, expert opinion and research available, much of which has been commissioned and/or provided by other sectoral organisations such as trade associations, clusters and governing bodies and will be further discussed below.

Possible contributions identified that these types of organisations could make towards addressing these challenges were included working in partnership with organisations in the sector, as well as public bodies such as RAeS to support recognition of this skills shortage and to influence methodologies to attract and educate the next generation of aerospace professionals. Regional Aerospace Alliances, such as the West of England Aerospace Forum[82] (one of our survey respondents) can also contribute by facilitating contact between influential personnel; encouraging collaboration and cooperative behaviours.

We focused our research on levels of BIT awareness and collated the following findings:

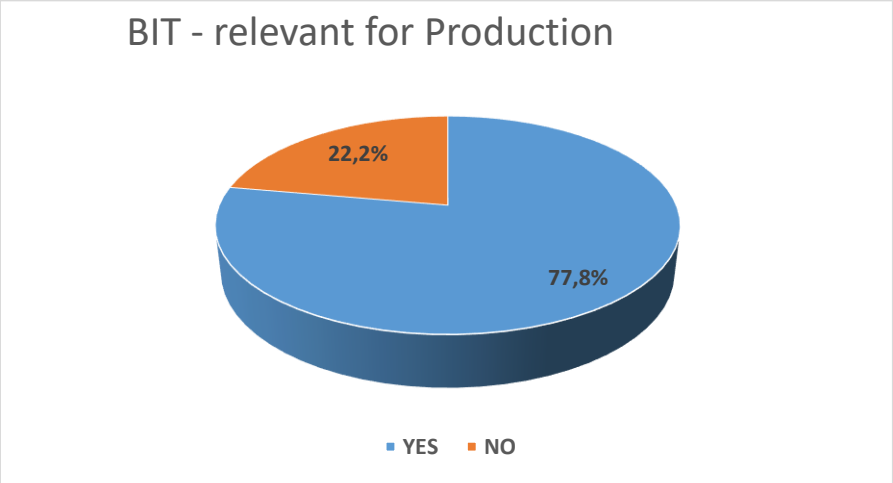
Question - Are you familiar with Business Improvement Techniques?

[82] http://www.weaf.co.uk/



Just a quarter answered that they were aware, although, when asked about the eventual impact of BIT for leveraging innovation in the production process the general opinion is that it might bring advantages and benefits.

Question - Would you say that BIT is an interesting/important field for innovation in the production process?



More than three quarter say that BIT is relevant for innovation in the production process.

Interviews

Representatives of these 'other' organisations indicated as major challenges the general ability of the sector to supply international tier 1 and 2 players maximizing the exports that follow the fast-growing demand in the world industry; to enlarge the Portuguese participation in international R&D projects boosting collaboration in international and profitable ventures; to create favorable conditions to maintain the technological evolution attained and promote the improvement of processes to reduce costs, rise quality and to have better working conditions in thesector.

They understand that the Portuguese aerospace sector needs better access to funding in order to invest in innovation, international market promotion, more specialized training and knowledge sharing between the industry and academia.

6. Conclusions and recommendations

The European aerospace industry benefits from innovative and advanced technology. This is a result of advanced research, high rates of investment in R&D; and devices, materials and systems that are intensively used in the sector targeting clients' needs that represent state-of-the art tools. Business models are well-developed, ensuring high performance in an extremely competitive sector worldwide.

The European Aerospace industry is vital for the European economy and leads to innovation in other sectors by combining efforts for development in common areas. It was measured that, in 2015, airport and aviation-related activities reached a value of €338 billion across the EU representing 2.1% of the European GDP. The strategic significance of the sector brings a vital contribution to the economy with up to 2 million people employed directly in the EU aerospace sector. Air passengers travelling to, from and within the European Union represent one third of the total world market.

The concept of BIT is relatively well known within the UK, but not so much in the rest of the European continent.

Some companies have shown good practices connected with BIT that have been utilised in order to drive improvement in processes and procedures within their organizations and to make some strategical changes that may lead them to a better market approach, higher sales and healthier management. Nonetheless, most part of the practices identified are never referred by the companies as BIT. We have concluded, that the terminology is not widely known and that there is some confusion regarding the plethora of terms which can be used to describe BIT concepts.

There are examples of companies who have demonstrated varying scales of Quality Cost and Delivery (QCD) benefits through the use of BIT tools and it is accepted that BIT and training in BIT will be helpful for companies and the aerospace sector.

There is not much training offered with the subject title of BIT, although we can find some related courses, normally referred to by other terms such as LEAN, 5S, Kaisan etc.

We were able to conclude that the need to address skills shortages, respond to new technological developments and increase competitiveness to ensure growth and ward off threats from emerging markets are well recognised throughout the sector. Simultaneously, there is a common understanding amongst the different stakeholders in the aerospace sector that specific training in different areas of knowledge would be beneficial for such an internationally competitive industry. Moreover, continuous training is needed due to the growing rates of the industry and its status as a KIBS.

More precisely, organizations have indicated the need to find skilful people, to train them in line with business specific needs and make them productive. Other issues regard the need for R&D and innovation to be aligned due to the importance they have in making companies more competitive. VET providers and Universities, already, make available training for some of these specific needs, but the interaction between training entities and Companies must be more profound for that training to be more fruitful. Companies mentioned that good practices in digital platforms and software usage would help in the execution of complex projects with efficiency being attained sustained by process optimization and automation through CBTs.

Due to the complexity and heterogeneity of the sector, that requires highly specialized knowledge, a useful approach suggested was an even tighter collaboration between Industry and Institutions (in particular academia), in order to optimize the training of highly specialized personnel in the fields where there is greater demand.

Governments have contributed towards research, development and innovation as well as supply chain competitiveness. The industry is spread all over Europe with some regions and clusters supporting the competitiveness worldwide.

It is clear that the market would benefit from a specific training course or other type of training focused on BIT. The results assessed and opinions expressed indicate to us the value of this genre of training with specific issues addressed and attention paid to the companies' needs.

Following our enquiry all genres of stakeholders provide suitable training for the market needs and are aware of ECTV, but they do not use the European Credit system for Vocational Education and Training.

In addition, as mentioned the concept of BIT is not recognized by most suppliers, except in UK, although the training provided in Europe widely covers this theme.

VET providers make available specific certified training to help professionals to be prepared for their daily activities, but it could be more appropriate to management and market approaches.

Most of the Companies deliver training to their collaborators. There is a clear need for higher education courses to be closely linked to companies. The methods employed and subjects covered should be reviewed and there should be higher levels of participation by students in internships in organizations operating in the market prior to their graduation.

It was concluded that **Higher Education institutions** educational contents are generally satisfying the training needs for future aerospace professionals.

Other stakeholders (Organizations Clusters, Industry and Trade Associations, Certifying Authorities and Regulators) indicated that major challenges are to qualify the sector to supply international tier 1 and 2 players and increase exports in light of the fast-growing demand of the sector worldwide.

Responses to our survey from Aerospace Manufacturing Organisations indicate that some of the main challenges facing the sector include finding suitable and well trained staff (such as machine programmers and setters), increasing global competition, paradigm shifts in technology and the ability of businesses to grow, which needs to be supported by continuous improvement in business processes, driving cost, quality and delivery to be competitive in the market as well as the need to develop superior products and new manufacturing methods. The need to improve processes represents a key challenge that the application of BIT could play an important part in addressing.

'The aerospace industry has always been at the forefront of excellence and innovation, attracting and retaining highly-skilled employees.' This means that skills shortages will adversely affect the capacity of the sector to develop and maintain existing and future platforms and systems. 'New skills have to be identified for the future workforce of the aerospace industry which then needs to be translated to the classroom'.[83] A possible response to this is to place more emphasis on professional and occupational education and training; which could also usefully incorporate an increased focus on BIT which is already included in some of the UK accreditation standards. One approach would be to reinforce this type of training with through more specific courses equipping learners with a solid and relevant knowledge base.

[83] http://www.jatm.com.br/ojs/index.php/jatm/article/view/616/512

7. Annexes

See separate documents:

7.1. Annex 1 – Sources

7.2. Annex 2 – List of stakeholders

7.3. Annex 3 – Training description

7.4. Annex 3 – Good practices description