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ABSTRACT

This paper examines Pratt & Whitney's corporate strategy of sustainability in its use of titanium and alloy ores in the manufacturing of its aircraft. It discusses the value chain of titanium and alloy ores from its initial extraction from the earth; it's transformation into metal components and final incorporation as a key component in its aircraft. In addition, a sustainability audit of Pratt is conducted using 3 different audit tools that are accepted in the sustainability community. The sustainability audit is analyzed with recommendations as to how Pratt can improve its sustainability performance as a corporation.

INTRODUCTION

The definition of sustainable development has taken on many forms [1] and was defined in the World Health Organization 1987 Brundtland Commission Report as "sustainability meets the needs of the present without compromising the ability of future generations to meet their own needs" [2]. In terms of our daily lives, it makes sense to behave in this manner for living daily and taking care of the planet for others to benefit. However, when we apply this approach to corporations and large businesses it can get quite cumbersome. How does a company accomplish meeting its needs while leaving the ability of future generations to do the same? When we consider this, three operational criteria arise. First, economic objectives should not be maximized without satisfying environmental and social constraints. Second, environmental benefits should not be maximized without satisfying economic and social constraints. Thirdly, social benefits should not be maximized without satisfying economic and environmental constraints [3]. When we evaluate any sustainable effort we should try to balance all three elements (economic, environmental and social) in parallel with interlocked dependencies.

The determinants of sustainable development are consumption, production and distribution. Consumption must be evaluated in terms of how much is consumed along with the patterns in which they are consumed. Production must be evaluated in term of the triple bottom line (profits, people, and planet) that will satisfy the needs of most of the consumers who are middle-income to low-income to poor category [4]. Distribution of resources across rich and those in poverty must be balanced, not the common income gap found around the globe today [5]. The determinants must be in solved and satisfied in accordance with the operational criteria. Together these form the principles for any successful sustainable development.

To study sustainable development, different measures of sustainability will be applied to Pratt & Whitney, a division of United Technologies. Pratt & Whitney is a major manufacturer of propulsion and energy systems in the aerospace and power generation industries. An analysis will be performed to determine the following conditions: the current sustainability status of Pratt and Whitney, with respect to implementing sustainable practices as compared to where the company should be; what are they doing to get there (if anything); what should they do that they are not planning on currently doing.

SUSTAINABILITY MEASURES

There are sustainability measures found in the literature that give guidance for practices that should be in place for a company to be truly considered a sustainable business. The metrics of interest for this analysis are the sustainability audit, the four point supply chain checklist, the six point perspective with the triple bottom line, innovation as a key driver, sustainability leadership, creative destruction, and servicizing. Each of these measures will be explained and Pratt & Whitney will be evaluated against them. A summary of gaps, closure plans and recommendations will conclude the assessment.

JET ENGINE INDUSTRY

Pratt & Whitney primarily operates within the Air Transportation Industry. The three large jet engine manufacturers have similar characteristics. They are highly diversified corporations, with aircraft engines accounting for less than half of their corporate revenues. They produce jet engines for both military and civil aircraft. They have operations and partners around the world, and they work extensively through international manufacturing joint ventures. Standalone U.S. engine companies have lost significant market share to European competitors and international joint ventures. This has made the jet engine industry extremely competitive [9].

The airline industry has been deregulated since 1978. Overall, airline deregulation has led to positive structural changes including better service to most communities and more competition for most customers. Increased competitiveness of the airline industry has enormous implications for economic growth. Deregulation has had a significant impact on aircraft manufacturing as well. Increasing service has led to increased procurement of new aircraft, engines, and parts. As markets have evolved, new aircraft models have been introduced to meet new market demands. In particular, increasing liberalization of domestic and international markets has been closely linked to declining average size and increasing operating distance of commercial jet transport aircraft, including rapid growth in the use of regional jets [9].

COMPANY OVERVIEW

Pratt & Whitney, a United Technologies Corp. company (NYSE:UTX), is a world leader in the design, manufacture and service of aircraft engines, industrial gas turbines and space propulsion systems. Pratt & Whitney reported an operating profit of \$1.84 billion in 2009 on revenues of \$12.58 billion. The company's 36,000 employees support more than 11,000 customers in 195 countries around the world [6].

Pratt & Whitney was founded in Hartford, CT, in 1925 by Frederick Rentschler, see Figure 1. Pratt & Whitney's first aircraft engine was the 410-horsepower, air-cooled Wasp, which delivered unprecedented performance and reliability for the time and transformed the aviation industry. Pratt & Whitney has been leading change in the industry ever since. Pratt & Whitney builds engines for front line fighters, like the F-15 Eagle, F-16 Fighting Falcon, F-22 Raptor and F-35 Joint Strike Fighter, as well as the C-17 Globemaster III military transport. Pratt & Whitney Canada, a division of Pratt and Whitney, has produced more than 60,000 engines which power corporate jets, regional aircraft and helicopters around the globe. Pratt & Whitney's large commercial engines power more than 30 percent of the world's passenger aircraft fleet. The company continues to develop new engines and work with its partners in International Aero Engines and the Engine Alliance to meet airline customers' future needs. Pratt & Whitney's broad portfolio of businesses includes industrial gas turbines that light cities and power ships. The PureCycle® power system converts heat from geothermal resources, oil and gas wells and other sources into clean electricity. Pratt & Whitney Rocketdyne has been the power behind over 1,600 launches and has been a key engine provider to the U. S. space program since its inception. That service continues today with the Space Shuttle Main Engines and the engines for the current Delta and Atlas launch vehicles. The U.S. return to the moon and innovative missile defense products will also be powered by Pratt & Whitney Rocketdyne engines [6].

FIGURE 1. FRED RENTSCHLER, PRATT AND WHITNEY FLIGHT HANGER, EAST HARTFORD, CT [7]



Pratt & Whitney is developing game changing technologies for the future, such as the PurePower® PW1000G engine, with patented Geared TurbofanTM technology, for next generation of passenger aircraft and hypersonic propulsion systems for aircraft that will travel more than six times the speed of sound. Through Pratt & Whitney Global Service Partners, Pratt & Whitney is also developing innovative new services that will delight customers around the globe. Pratt & Whitney Global Material Solutions is the first Original Equipment Manufacturer to reengineer, certify and manufacture both gas-path and life-limited parts for the CFM56-3 engine [6]. They are one of three large jet engine manufacturers; (Rolls-Royce, General Electric Aircraft Engines and Pratt & Whitney) found on the globe and are highly competitive in every market they participate.

CORPORATE RESPONSIBILITY

"At UTC, profitability and responsibility go hand in hand. These values are fully integrated into the way UTC executes its strategies and serves its customers. Responsibility is more than environmental agenda." It is how they approach everything they do. This is the core of how UTC operates. Its Code of Ethics and employee accountability hold everyone to high standards to meet all of these responsibilities [8]. Key areas that are reported in the 2009 Corporate Responsibility report are: People, Communities, Environment, Products, Customers and Suppliers, and Governance. Within each of these areas, key metrics are reported. These metrics includes the Employee Scholar program investments, Dow Jones Sustainability score, Governance International Accountability Rating, UTC charitable contributions, Greenhouse Gas emissions, Industrial Process Waste, Worldwide Water Consumption, Elimination of materials of concern, Lost workday incident rate, and Energy efficiency. Figure 2 contains the most recent metric performance data. The data shows that significant improvement has occurred in all areas of sustainability and corporate responsibility.



SUSTAINABILITY AUDIT

Knowing the principles, criteria and determinants for a successful sustainable effort to exist, one can develop measures with which to effectively plan, execute and adjust any sustainable effort for a company. One of these measures is the sustainability audit [1]. This audit consists of evaluating a company in 10 statements within 3 areas: framing the sustainability agenda, developing the business case for sustainability and executing the sustainability strategy. The statements are graded on a scale from level 1 agreement to level 4 agreements. Each of the 4 levels of agreement represents how well a company performs in each area up to the point of world class performance.

In evaluating Pratt & Whitney and researching how they evaluate themselves, one finds it is operating at numerous levels and not only evaluates itself in all of the audit areas but also dives deeper into other areas of sustainability (e.g. employee health and wellness, management systems, and safety). Specifically, all 10 statements are evaluated not only for the company itself, but for the supply chain and all its products. Here are the results for all three areas for the audit statements.

Framing the Sustainability Agenda

Statement 1, Our Company has a clearly articulated definition of sustainability and an understanding of how sustainability is or will be affecting business: Pratt & Whitney is operating at a level 4 for the company, flow-down to its suppliers and all products. They have a clearly articulated corporate definition of sustainability that has full consensus and buy-in from the board and across all levels of the organization. The corporate definition is "Sustainability is doing things efficiently to preserve resources and minimize environmental impacts....including human capital...."

Statement 2, Our Company has conducted a thorough assessment of the drivers of sustainability that present the greatest opportunities and potential risks to the business: Pratt & Whitney is at a level 4 for the company and its products and a level 3 for suppliers. Continued cooperation with our global supply chain will drive their supply chain to be at the level 4 of understanding of sustainability drivers to the lowest level of operations. Pratt & Whitney has completed a thorough assessment of all potential drivers of sustainability and have a realistic view of which drivers will affect each business area and market. Pratt & Whitney has conducted a supply chain audit of several key drivers of sustainability for the most critical business areas or markets – but not for all of them.

Statement 3, Our Company has translated analysis into action by defining where and how we will deal with sustainability as a business issue: Pratt & Whitney, products and supply chain are at a level 4 for having a strategy of action for sustainability. They have a clearly articulated sustainability strategy and clear timeline for getting there, and have publicly committed to this timeline and strategy in their annual reports corporate responsibility section [8].

Developing the Business Case for Sustainability

Statement 4, Our Company has developed a clear and compelling business case for our sustainability efforts over the short term (that is, over the next one to three years): Pratt & Whitney and its products are at a level 4 while the global supply chain are at a level 3 as this area is linked to statement 2 for having a full understanding of all sustainability drivers to the lowest levels. They have a clear and compelling short-term business case that exploits all possible value-creation levers to drive competitive advantage and that has been incorporated into their financial plans. Pratt & Whitney supply chain has a clear understanding of the short-term business case that exploits several potential value-creation levers (both economic and intangible).

Statement 5, Our Company has modeled the business case for sustainability investments over the long term (that is, four years into the future and beyond): Pratt & Whitney and its products are at a level 4 while the supply chain is at a level 3 due to statement 2 understanding of all drivers. Pratt and Whitney has a modeled long-term business case for sustainability investments that drive competitive advantage and consider system-wide costs and benefits across the value chain over the life cycle of their products and services for multiyear time horizon. Pratt and Whitney's supply chain has some sense of this.

Statement 6, Our Company has established targets for our sustainability efforts, along with metrics for measurement tracking and reporting: All aspects of Pratt & Whitney, products and supply chain have well defined, measureable and actionable metrics that have to be met in order to ensure sustainable operations and guarantee continued workings. Thus they are at a level 4 for targets, metric measurement, tracking and reporting. Every year, the status to plan of the targets and metrics are reported publicly. They have a defined set of targets and metrics and have integrated the metrics into day to day performance management as part of a holistic sustainability strategy.

Executing the Sustainability Strategy

Statement 7, Our Company's sustainability strategy receives sufficient focus from senior management and all responsibilities and accountabilities are clear: As many companies know, if it's measured, it gets managed. The very deeply institutionalized sustainability targets and metrics get focus along with other critical operating metrics. Accountability at is to the point within Pratt & Whitney that if people are not successful in achieving them, they are replaced, for both internal company and supply chain. This puts the company at a level 4. Discrete individuals with

seniority in the organization are responsible for driving the sustainability agenda, but accountability is spread throughout the global organization.

Statement 8, Our Company's sustainability strategy is integrated with our operations, processes and culture: Linked with statements 6 and 7; targets, metrics and accountability are completely integrated with daily operations, processes and culture. This applies to the company itself, products and supply chain. This puts the company at a level 4. They have fully integrated their sustainability objectives and strategy into the corporate culture, operations and processes.

Statement 9, our Company's sustainability agenda is aligned with the relevant external stakeholders in our business system: Pratt & Whitney is highly integrated with most stakeholders that set regulations, has a strong link to its customers, the public and all other major stakeholders with a vested interest in the company's performance, including competitors. This puts the company at a level 4. They are partnering and working methodically with all relevant stakeholders to solve mutual sustainability issues, drive value from those efforts and proactively change the landscape of the industry.

Statement 10, Our Company has the required capabilities and tools to effectively execute our sustainability strategy: Pratt & Whitney and its products are at a level 4 as all known drivers are being addressed to ensure a fully sustainable strategy is executed. The supply chain has unknowns from statement 2 and thus is not able to know if the full suite of capabilities and tools are in place. They are at a level 3 agreement. Pratt and Whitney have a full suite of capabilities and tools to enable the effective execution of their sustainability strategy. Pratt and Whitney supply chain has most capabilities in place to support them.

All of the above indicate that the strength of Pratt & Whitney's sustainability capabilities is quite high, level 4 for the company and level 3-4 for its supply chain. It reinforces and provides an understanding why they have been on the Dow Jones Sustainability Index for the past 11 years [10].

FOUR POINT SUPPLY CHAIN CHECKLIST

Another measure is the four point supply chain checklist [11]. The checklist highlights packaging, transportation, engagement of suppliers while measuring sustainability and customer and consumer alignment through marketing and sales. The checklist also highlights that in the midst of trying to hit these checkpoints; companies must work through four different pressures to achieve sustainability: regulation, global warming, spike of oil prices and sustainability as a source of competition.

In general the most difficult aspect of the checklist to implement would be engagement of suppliers while measuring sustainability and customer and consumer alignment through marketing and sales. Engaging suppliers can be fairly easy if a company has good supply chain management organization, but measuring sustainability while doing it can be hard. Trying to align supply chains while engaging them with sustainability while measuring them would be a difficult task, but doable. Getting an entire supply chain to support sustainability while measuring it will depend heavily on many other companies across the globe.

Getting customer alignment through marketing on being more sustainable is not as hard for some customers as it is for others. For instance, Pratt and Whitney marketing and sales are working very hard in convincing customers they have a more sustainable product on the market. It is more sustainable (lasts longer than current products, consumes less energy, produces less noise, lower maintenance costs than the current best in class, and is produced by a more sustainable supply chain) and thus a few large customers are delighted with it. Others are more leery and want to wait to see how it fairs after other customers use it or go with another product. So it seems they have early adopters wanting the product while most are not there yet. With this, it has not yet proven very successful.

Packaging of jet engines is simple relative to the product itself. Outside of simple covers and wrapping to ensure handing damage doesn't occur during shipment to aircraft assembly lines or maintenance lines, the main packaging is a trailer that is designed to be re-useable, repairable and rotational across the end customer's facility. Generally,

jet engines are transported on trucks or airplanes, either as complete assemblies or in modules for assembly during aircraft installation.

Similar to the sustainability audit, Pratt & Whitney has sustainability shortfalls in aligning their entire global supply chain. Opportunity lies first getting the critical suppliers necessary to support the sustainability strategies aligned with Pratt & Whitney before bringing in other suppliers. This will not only allow key wins, but it can also ensure critical drivers are being addressed and allow the company to quickly identify suppliers that are not supportive and could potentially need to be replaced.

THE SIX POINT PERSPECTIVE WITH THE TRIPLE BOTTOM LINE

A comparison of each of the six point model of sustainability [12] is shown below. The six perspectives show an evolution from basic considerations of sustainability, regulatory compliance, to the ultimate in sustainability, mission transformation.

Perspective 1 Regulatory Compliance: The regulatory compliance point considers how companies can meet or exceed the laws and regulations established by governing bodies. As it pertains to the triple bottom line, this has a limited scope of sustainability as it just considers what the society has defined as minimum standards for benefit to the people and planet. Companies must define how it can maximize internal profit and not necessarily provide economic value to society. Thus, this is not really a sustainable proposition. Pratt and Whitney considers this a below minimum requirement for all areas of operation, product development, and customer support.

Perspective 2 Incremental Mitigation: This point evolves sustainability to a higher level of sustainability by considering impact measurement and metrics. Companies strive to optimize operations to remain within the metrics while maximizing profitability. Many more areas of people and planet are considered as defined by regulatory and planet/people friendly considerations. Incremental mitigation provides companies with the opportunity to create new business reduce operating costs, prevent fines and other penalties from not considering the metrics. Again this point is low on the spectrum as it relates to providing economic value to society, while providing a higher level of sustainability for people and planet. Pratt & Whitney considers this the minimum operating level for any part of its global operation.

Perspective 3 Value Alignment: Companies that operate at this level of sustainability have aligned what society sees as sustainable with what it values as a company. This helps align employees with company values. This does not necessarily mean the company will operate in a more sustainable fashion but it does allow for company resources (employees, money, capital, etc.) to be aligned and operate towards that goal. This has a very strong people element of the triple bottom line, while it is effectively exploiting the company resources and not as providing a large benefit to them and the whole of society. Depending on what aspects of sustainability (environment, poverty, health, etc.) the company has aligned its value to the planet aspect of sustainability may or may not be improved with this level of sustainability does appear to provide more economic value to society than the previous two levels of sustainability. Pratt and Whitney has clear alignment with stakeholders and is a leader is ensuring feedback from its consumer, legislative representatives and aircraft customers and always ensuring its values are aligned.

Perspective 4 Whole System Design: Whole system design is where companies have not only brought operations to a more sustainable level, but have changed the way they develop products and services and how they are provided to society. The Planet and Profit aspect of the triple bottom line seem to have largely been addressed in this area but possibly at the expense of people. For instance, the green building discussed in the reading highlights how good the operation of the building's in consumption and energy conservation is, but if such a building is placed in the middle of the amazon and require clearing of whole parts of forestry, population and animals, it defeats the purpose of true sustainability. Pratt & Whitney operates this for a majority of operations and considers case by case exceptions to not meeting this perspective.

Perspective 5 Business Model Innovation: This level of sustainability strives for economic and environmental benefits by changing the business model that company uses for operating. They may change from a product

delivering company to a services company to maximize environmental and economic value to itself and society. This seems to be achieved at the expense of people, society, and local community, although the new business model is executed by spreading the sustainable operations through customers and the supply base, new internal processes and scope of company operations. Pratt and Whitney have all new businesses and products operating under this perspective.

Perspective 6 Mission Transformation: The highest level of sustainability in the six point model drives companies to have answers to why they exist and what society they exist within. If companies can answer these questions and operate successfully, then they are capable of existing forever without harming the ecosystem. This level of sustainability is where the triple bottom line system establishes itself. A company fully embracing the triple bottom line and mission transformation have established responsibility to the stakeholders, not shareholders, and strives to benefit them always. Pratt and Whitney consider itself maximizing this where possible but it is not always practical due to the length of time products have been in service. For example, the original WASP engine developed by its founder is still in service throughout most of the world. It is hard to consider sustainable operations for products of this age, but the fact that they are in existence for this length of time is a sustainable proposition unto itself.

Figure 3 shows how a sample titanium rotor value chain for Pratt and Whitney compares to the triple bottom line, people planet, and profit governance. Similar to the sustainability audit and the supply chain checklist, the supporting supply chain is the opportunity of greatest value to Pratt and Whitney.

	Titanium & Alloy Ore	Titanium Billet	Finished Goods	Jet Engine	Customer Usage and End of Life
People	 Long term effectiveness of reclamation efforts are unknown Emissions from cleaning process have unknown impact 	• Kroll process for sponge creation has high chlorine content but EPA and OSHA regulated	 OSHA, MFHAP and NESHAP regulations in place EPA regulations in place for emissions 	• P&W partners with United Way and numerous charities to provide millions of dollars & employees time to their causes	• Engine usage for environmental impacts is world class performance
Planet	• Significant land reclamation has occurred for all titanium mines in Australia	• Significant heat waste is being explored as source of energy used for inputs into each process step	 Material is reverted (used again) during value chain processes Significant consumption in energy and waste has occurred in the aerospace industry over the past decade 	 From 1997 to 2006, P&W has reduced absolute energy use and waste by 49% Continued focus on energy consumption and emissions has yielded similar results 	• Material is reverted (used again) at end of life back to the titanium billet processes
Profit	 NPI reporting remains vague, improved reporting may reduce profit Land reclamation costs increases will reduce profit 	• Kroll process for sponge creation is very inefficient	• P&W is focused on full deployment across the entire supply chain of sustainability goals (logistics and EH&S expectations)	• P&W is focused on full deployment across the entire supply chain of sustainability goals (logistics and EH&S expectations)	• Engine cost effect on airline/warfighter "profit" is fixed capital cost plus variable cost for fuel usage. Fuel burn efficiency drives variability in cost.
Governance	 Federal Law limits titanium usage to that processed in the United States for any Military applications Majority of governance controlled by Australian gov't & Nat'l Pollutant Inventory reporting 	• Only one billet source in the United States, TIMET for P&W. Major player in regulatory and legal requirements definition	• Majority of governance at this stage is limited to general manufacturing laws, EPA, MFHAP and NESHAP etc. Participation varies across global supply chain for involvement	P&W develops regulations/standards with several organizations including International Air Traffic Association (IATA), Federal Aviation Administration (FAA) and numerous others	• Flying airlines develops regulations/standards with several organizations including International Air Traffic Association (IATA), Federal Aviation Administration (FAA) and numerous others

FIGURE 3. TITANIUM ROTOR VALUE CHAIN IMPACT ON THE TRIPLE BOTTOM LINE (P3G) MODEL

INNOVATION AS KEY DRIVER

Another approach to sustainability measurement is how well a company is leveraging sustainability with innovation. According to Nidumolu et al [13], "sustainability isn't the burden on bottom lines that many executives believe it to be. In fact, becoming environmentally friendly can lower costs and increase revenue. That's why sustainability should be the touchstone for all innovation." The authors suggest 5 stages of change that a company goes through to truly use innovation as a key driver of sustainability. Each stage comes with its own challenges and must have necessary capabilities to overcome them.

Stage 1 views compliance as an opportunity. Compliance with the law can be used as an opportunity by maximizing compliance, keeping pace with new legislation and marketing that fact. A company can also leverage its standing by helping to shape and formulate future laws to bring more effective environmental position, reduction in nonrenewable resources, increase in renewable resources and competitive advantage.

Stage 2 views making value chains sustainable. Companies develop sustainable operations by analyzing each link in the value chain. Identification of sources of waste in the supply chain helps define opportunities for improvement. Value Chain analysis needs to focus on supply chain, operations, workplace, and returns

Stage 3 views designing sustainable products and services as additional opportunities. In order to do this, companies have to understand consumer concerns and carefully examine product life cycles. They must learn to combine marketing skills with their expertise in scaling up raw materials supplies and distribution.

Stage 4 encourages developing new business models. This requires exploring alternatives to current ways of doing business as well as understanding how companies can meet customers' needs differently.

Stage 5 creates next-practice platforms. Company leadership must question the implicit assumptions behind current practices. Performing this work enterprise wide usually has the largest impact on company performance. When a company's top management team decides to focus on the problem, change happens quickly. Recruiting and retaining the right kind of people is important for this to happen and continue.

Pratt & Whitney is at stages 1, 2, 3, 4 and 5. This seems like an inappropriate evaluation, but let's examines this situation. Their main products are products that have a 30+ year life span. They have product still in use today that were designed and sold over 80 years ago. These products are maintained and supported for stage 1, sustainability, compliance only. Mid-life products, designed some 20-50 years ago, operate in stage 2, making value chains sustainable. This is the pre-dominant portion of their profit portfolio. Newer products that are early in the production cycle or have yet to be produced were designed 10 years ago or have yet to complete product design. These operate in stage 3, designing sustainable products, services and supply chains. A smaller portion of their business, space and energy products, are operating in stages 4 and 5 but are not significant in the portfolio as of yet. We see these areas as being the test cases for how they can have sustainable business models to carry new and yet to be designed products to be more sustainable. The fact that the products last as long as they do is a sustainable proposition unto itself.

With the above said, it must be pointed out that where higher stages of sustainability are required to ensure company and corporate goals are to be met, Pratt and Whitney make changes to achieve higher levels of sustainability. A specific example is when they went into every product globally to identify the location and quantity of materials of concern and re-designed products to remove them from use and reverted the material to other industries for proper disposal and recycling.

What Pratt and Whitney need to do is to share the good work on the sustainability front that is being accomplished. There is not much marketing in the fact that they are leaders in the sustainability efforts and have made numerous efforts working in these areas. There is a lot of marketing towards highlighting that Pratt and Whitney provides environmentally friendly products and services. The roadblock to success across all of the company is that they have very long life products and bring the operation and support of those products into a stage 3 or 4 of sustainability proves to be very difficult.

To better understand the complexity of Pratt & Whitney's value chain in this sustainability measure, we will examine in detail the titanium rotor value chain. The value chain depicted in Figure 4 represents a simplified value chain of a titanium rotor in a jet engine designed by Pratt & Whitney Aircraft (P&W). Titanium is a lightweight, silver-gray material that is the fourth most abundant metal making up about 0.62% of the earth's crust and is a highly desired material in the aerospace industry. The end product is used in both commercial aircraft, used by the flying public, and military weapon systems. In the realm of sustainability, the product helps enable a global world for public and private endeavors.



FIGURE 4. VALUE CHAIN OF TITANIUM ROTOR IN PRATT & WHITNEY JET ENGINES

The value chain begins with titanium ore being mined from the earth. Labor and fuel are used to extract it with Carbon monoxide (equipment exhaust) and depleted earth being the primary waste of the process. Different forms of titanium ore (ilmenite, leucoxene, and rutile, anatase, perovskite, and sphene) [14] are processed through a Kroll process to extract the valuable titanium whereby various chemicals are added to the ore and heated to result in the titanium sponge and magnesium chloride. The magnesium chloride is extracted and used to process the next batch of titanium ore, significantly reducing waste from the process. Similarly, other alloys (e.g. Aluminum and Manganese) are mined and provided to the second major step in the value chain, the titanium billet supplier.

After shipment of the required materials, including material that is reverted from other steps in the process, to the billet supplier, they are all mixed to the correct proportions. After mixing, the material is compacted into a "compact". Several "compacts" are then welded together with an electrode to enable the melting process. The stacked compacts are then melted three times to provide a very high level of quality, i.e. least amount of flaws in the metallurgic structure. The material is then forged into billet form that is then made available for product use. The primary input during the process is electricity and labor. Throughout all of the billet manufacturing process, the primary waste product is unused heat.

Since jet engines are made to customer order, post-billets processes are started when orders are placed. The billets are forged into the required shapes to support finished goods designs. Advanced material qualification testing, e.g. eddy current inspection, are performed to ensure that the parts meet the desired requirements. Once the material requirements have been met, the parts are then processed through finished goods. The majority of the processes are machine milling, turning and drilling. Other processes include coatings, shot peen and additional material testing. The majority of input into the finished goods processing is electricity and labor. The output of these processes includes heat and material removed during machining that is reverted back into the billet process after melting. The finished goods are then provided to the Jet Engine assembly processes [15].

The jet engines are assembled and tested to ensure they meet customer expectations. The engines are then provided to the aircraft or weapon system company for final installation and deployment to airlines and warfighters. The primary inputs are labor and jet fuel for these processes. The product is used until the useful life is consumed when it is then melted and reverted back to the billet processes for re-use. To examine the sustainability standards that are in place for the value chain, the value chain will be further examined in four sections: Titanium Ore, Titanium Billet, finished goods, and jet engine.

TITANIUM ORE

Titanium ore that is used by Pratt & Whitney titanium rotors is primarily mined in Australia, as illustrated in figure 5. The titanium ore is found in the form of mineral sands. The mineral sands, originally discovered in 1791, are a result of 60 to 120 million years of wind and water erosion of igneous rock from ancient rivers and seas. Minerals leached into beach and dune deposits that occur at varying levels from the present sea level up to 35 kilometers inland. The primary minerals found in these deposits include: ilmenite, zircon, monazite and rutile. Rutile is the mineral that contains titanium and titanium dioxide, which is used for paint and dyes as it is the purest form of white pigment known today. Only 5% of mined ore is converted to titanium sponge, the remainder is used as pigment in paints [16]. There are three possible methods of extraction for rutile mining: suction dredging, where sand is dredged through ponds and separated several times to result in a concentrated form of rutile; open-cut mining, where bulldozers and scrapers dig up the minerals and go through several separation and cleaning processes to result in the minerals of interest; and hydraulic mining, where a water cannon is used to wash down earth to result in ore body which is then further separated and cleaned [17].

FIGURE 5. AUSTRALIAN PROVINCES FOR MINERAL SANDS AND RUTILE PRODUCTION HISTORY [18]



Of primary concern during all of the mining operations is protection and rehabilitation of the environment and, as a result, are highly monitored. Rutile is projected to have at least 116 years of useful production at the current production rates with current exploration and mining technologies. The only mandatory reporting and enforcement of environmental impact of 4 available protocols for Australian mining is the National Pollutant Inventory. The protocol does not require consistent and compulsory reporting of key aspects such as waste rock (rock, sands etc. not captured as the mineral of interest), cyanide, water quality, water quantity and the like. Many mines or companies reporting energy, greenhouse, water, and cyanide data over time fail to explain sudden abrupt increases or reductions in any of these aspects. With these governance/reporting issues, leaving waste rock data outside the scope of reportable NPI emissions remains room for major improvement with respect to mining. With more comprehensive reporting it may be possible to improve the correlations between aspects such as energy, water and cyanide consumption, greenhouse emissions and production variables such as mine type, ore grade, through-put and mill technology. Ultimately, the sustainability of the Australian mineral sands mining industry continues to hang in the balance [18].

There are three major areas of concern related to rehabilitation: a major legacy of mining-impacted land which has not been rehabilitated; a major issue which is not widely acknowledged is that of the long-term effectiveness of rehabilitation measures. Although the engineering and regulatory standards are considerably better at present than in the past, there remains concern over long-term effectiveness; there are not yet uniform standards or criteria for determining 'acceptable' rehabilitation after mining operations have ceased. Outside of these issues (adequate environmental protection, reporting, and rehabilitation), no other governance related issues appear to be prevalent in the Australian mineral sands mining.

TITANIUM BILLET

The titanium billet process for the titanium rotor in Pratt & Whitney begins with the delivery rutile, available at about US \$10 per ton, from the Australian mines to the company TIMET, Titanium Metals Corporation. Billet is produced at a planned volume per year irrespective of specific orders from customers to Pratt & Whitney in order to keep cost fluctuations under control. TIMET processes the rutile through a Kroll process to produce Titanium sponge (so called because of its appearance as illustrated in figure 6). Titanium sponge is the commercially pure, elemental form of titanium metal available at about US \$100 per pound. The first step in sponge production involves the chlorination of titanium-containing rutile ores with chlorine and coke to produce titanium tetrachloride. Titanium tetrachloride is purified and then reacted with magnesium in a closed system, producing titanium sponge and magnesium chloride as co-products. The Company's titanium sponge production facility incorporates vacuum distillation process ("VDP") technology, which removes the magnesium and magnesium chloride residues by applying heat to the sponge mass while maintaining a vacuum in the chamber. The combination of heat and

vacuum boils the residues from the sponge mass, and then the mass is mechanically pushed out of the condensing vessel, sheared and crushed, while the residual magnesium chloride is electrolytically separated and recycled [19]. It is incorporated into the next batch of sponge to be produced.



Once the Titanium sponge has been produced, it is melted and mixed with other available materials, including reverted (scrapped) material from previously used rotors and machined off material during finished good manufacture, to produce the resultant composition required for each jet engine rotor. With the composition created, the material is processed through numerous steps as shown in Figure 4 value chain to produce a titanium billet or ingot [21]. During this process of creating the ingot, significant amount of electricity, labor and water are consumed. The process releases a lot of heat. Although attempts are made to re-use the heat for factory consumption and preheat material for the next step in the process, more effort and efficiencies can be made to reduce the amount of waste.

Due to the chemical stability and inertness of titanium once processed, its corrosion resistance, and stableness at high temperatures, the material does not pose any environmental risks unto itself. Because of this, no additional environmental or sustainable regulations or laws apply to it directly. Most of what is in force is for how the material is processed and ensuring workplace safety in dealing with the sometimes heavy products.

Throughout the billet creation process, several key environmental and sustainability governance items arise. The most predominant is a federal law requires all jet engine titanium products to have the titanium sponge created in the United States, commonly referred to as the Berry Amendment (USC, Title 10, Section 2533a). This law makes TIMET one of a few sole providers of this material in the United States and limits competition from other companies, e.g. VSMPO in Russia. The law also places a large burden of state and federal EPA, OSHA, wages, etc. on the company to ensure all environmental, safety, and employee welfare and wages are appropriate. Typical regulations that apply are related to chemical (those used for sponge creation) control, safety precautions for electrical & heat hazards and control of revert material to ensure it is brought back to the alloy creation step in the process. Additional import restrictions exist due to the Berry Amendment for raw forms of titanium entering the United States, thus giving the exchange of the raw form visibility and monitoring by the World Trade Organization.

One specific area of opportunity is for development of an alternative approach to titanium sponge creation. The current approach of the Kroll process was developed in the 1940's and brought to production in the 1950's. No alternative approach exists that is less costly or cumbersome in chemical control and management than this or the alternate approach used by TIMETs competitors.

FINISHED GOODS

Once billet material is produced, this is the point in the value chain where signals are sent based on sales to start making finished goods. Finished goods start by slicing the required amount of material from a billet and then forging it into the required shape for the desired part. Typical forgings for titanium rotors are created with a closed die, isothermal process. This process is where a die in shape of the outside contour of the forging completely encases the billet slice when closed. The die is pre-heated to a set temperature along with the slice from the billet. The sliced billet is then placed in the die and several high load presses are made on the die to bring the billet to the

required shape. Once the required shape is desired, the die and billet at kept closed until the they are at the same temperature (isothermal), the resultant forging is then removed and cooled by liquid or air methods. The method is predefined based on the required material properties of the finished good. Electricity and labor are main consumptions during this portion of the value chain, while heat is the primary waste. Cutting fluids used to cool cutting tools during metal removal are not generally wasted but must be monitored and routinely cleaned or disposed of as a hazardous material if they are not water based solvents.

Once a forging is created, the primary governance areas come from the Environmental Protection Agency's (EPA) regulation of Metal Fabrication Hazardous Air Pollutants (MFHAP) and National Emissions Standard for Hazardous Air Pollutants (NESHAP). Typical regulations that apply are related to chemical (those used for cleaning, testing, inspection and metal cutting) control, dust (from grinding or sanding of the metal) control, and control of revert material to ensure it is brought back to the alloy (titanium billet) creation step in the process. If the creation of the finished goods is performed outside of the United States or European Union Countries, additional areas of concern as they relate to employee safety, wages and factory efficiency are routinely monitored. This portion of the value chain is routinely competed so specific governance issues are dealt with on a case by case basis but generally risks related to governance or environmental issues are not tolerated by Pratt & Whitney. Other than keeping up the strict enforcement of requirements, areas of governance improvement can be direct engagement with regulatory agencies to ensure that finished goods suppliers remain ahead of requirements.

JET ENGINE ASSEMBLY

Jet engine operation is governed by a litany of regulations and rules around the globe. These rules and regulations cover development, sales, production, safety, noise, emissions, maintainability and operations. Since the large jet engine market is limited to 3 manufacturers globally, there is a lot of trade policy, import/export limitations, and government involvement for all aspects of jet engine development, manufacture, assembly, sales, financing and use. Another aspect to consider is that the average titanium rotor in a P&W jet engine is intended to be used for 8 to 35 years; actual life depends on how the customer uses it. In that time frame, many new rules, regulations, laws, global situations, economic conditions arise and must be managed. Here is a specific example: One of P&W's jet engines was certified and put into use in mid-1980. There is a new emissions regulation going into effect in 2013 that limits the number of these engines that can be used and sold unless the engine is upgraded or re-certified to higher emission standards. Until that time, landing fees may apply at certain airports for airlines to use those kinds of engines. This is an example that highlights the environmental impact of aviation is one of the key constraints on future growth of aircraft operations without additional investment, development and purchase of newer products.

The International Civil Aviation Organization (ICAO) establishes recommended safety and environmental standards and recommended practices. National Authorities (e.g. FAA – United States, EASA-Europe, CAA-China) then make these into standards and regulations for enforcement. Typically, the landing and takeoff fees that a flying passengers pay is related to the type of aircraft/engine combination and how compliant they are with these standards and regulations. Pratt & Whitney is heavily engaged in the ICAO and helps to shape the standards and recommended practices. Environmental regulations have in the past been used to achieve competition-related as well as environmental objectives [9]. Pratt & Whitney is not exception to this approach.

The list of specific standards and regulations that are measured is quite extensive. For all U.S. based carriers, realtime on-board instrumentation measures the performance against these standards and are collected for periodic fee collection and enforcement. Examples of these include fuel efficiency, noise levels, and emissions of nitrous oxides. The one area of improvement would be making changes more shorter term in implementation and enforcement. Typically, from the time of recommendation to the time of implementation of new standards is 5-10 years. Enforcement of violations can be from 1-3 years after the recorded infraction.

The deep dive into the titanium rotor value chain highlights the complexity of the products design, developed, produced and supported by Pratt & Whitney. This one part type is only one of roughly two hundred part types found in a typical jet engine. This evaluation has found the supply chain several layers deep from the end product, has numerous shortfalls in being sustainable. This further substantiates the findings from the sustainability audit that the supply chain is the major gap in Pratt and Whitney having fully sustainable business practices.

SUSTAINABILITY LEADERSHIP

There are three ways that sustainability initiatives are different than typical initiatives: making the case for change with a challenge of creating sustainability vision, the challenge of translating vision into action, and expanding boundaries with a challenge of anticipating future needs [22]. These together make up the sustainability leadership milestones within a roadmap that must be planned and measured by executive leadership to be successful rather than a discussion of 'thought leadership', as illustrated in Figure 7 The three ways highlight goals that sustainability initiatives must achieve and consider in being successful: operational reality first public perception second; sustainability starts with an unclear picture of commercial impact; and most other initiatives are generally a part of sustainability strategy. Using these as goals and considerations, a company can lay out a roadmap to achieving successful sustainability initiatives. Based on several measures and awards provided to Pratt and Whitney, including being on the Dow Jones Sustainability Index for 11 straight years, this places Pratt and Whitney in the early stages of phase 3.

FIGURE 7. THE THREE PHASES OF THE SUSTAINABILITY IMITATIVE [22]



THETHREE PHASES OF A SUSTAINABILITY INITIATIVE As an organization moves through the phases of a sustainability initiative, its capa-

bilities grow: sustainability evolves from a non-issue to a core value, and business

The corresponding executive competencies for the three stages are: change leadership and collaboration and influencing for stage 1; excel at delivering results, i.e. translating the vision into reality, and strong commercial awareness for stage 2; and bringing a strong strategic orientation, often advocating approached contrary to prior business operations. Within Pratt and Whitney, these are six existing competencies within the 12 that they maintain for successful employee and executive growth [23]. For them, it is not a question of whether they develop people for these competencies, but finding the right executive with strong competencies in all areas for sustainability efforts.

Pratt and Whitney has sustainability goals with performance measures to determine effectiveness in the areas of air quality, energy and climate change, health and wellness, legal and regulatory compliance, management systems, product stewardship, resource consumption, waste and recycling, safety, substances of concern and water management. Supporting these goals are metrics for sustainability in the areas of supply chain Environment Health & Safety (EH&S) and energy consumption, sustainable product design including packaging and product efficiency,

elimination of materials of concern for existing products, internal factory EH&S, energy consumption and waste, emissions, regulatory compliance, overall waste generation and recycling. The goals and metrics together give a foundation for measuring if changes are successful or a failure while in progress [8].

To be a successful in bringing the company up in one or more metrics, they need to continue to drive new and more efficient ways to further improve in all areas of sustainability. Specifically, an area of improvement for sustainability is further driving sustainability metric improvement within the supply chain.

CREATIVE DESTRUCTION

Sustainable development innovation requires creative destruction rather than just incremental innovation [23]. This requires radical technologies along with significant consideration of not just primary stakeholders, but secondary stakeholders. Radical technologies not only replace existing technologies with competitive advantage, but generally cause social and environmental disruption. Secondary stakeholders include the public, governments, and other groups with general interest in the impact of the new technologies. These stakeholders have a much higher sense of complexity and ambiguity in understanding and dealing with their interests as well as bring higher levels of pressure for providing a sustainable approach to the innovations.

United Technologies divisions are based on being the innovators in their business segment. They define innovation as not only providing a great technology, but also being able to create a market for it. For instance Pratt & Whitney is based on air-cooled aircraft engines, a novel innovation 85 years ago. Today, Pratt & Whitney provides dependable engines and propulsion systems across the globe with the most leading edge technologies available at the time. They have parts of the business that provide electrical generation from aircraft based turbines, wind power from turbines, solar power from solar collectors combined with deep earth plasma collection, aircraft engine cleaning with environmentally friendly technology and many other sustainable solutions.

Up to about ten years ago, most of Pratt and Whitney's technology innovation has been focused on providing these to primary stakeholders, the direct customer and end users. Today, they have entire organizations and executives focused on managing and leading engagement of secondary stakeholders. They focus on working with communities, governments, and numerous organizations to get alignment and support for the technologies and new legislation to ensure a sustainable solution. We also see how their competition sees some of the radical technology as disruptive to the industry to a point of forcing them to respond. This is consistent with how Hall and Vredenburg see innovating for sustainable development, as illustrated in Figure 8 [24].

FIGURE 8. THE DOUBLE EDGED SWORD OF INNOVATION [24]

The Double-Edged Sword of Innovation

Innovation can be an opportunity for competitive advantage (quadrants 1 and 3) as well as a source of competitive disruption (quadrants 2 and 4). It can also be influenced by market forces (quadrants 1 and 2) and by public policy (quadrants 3 and 4).



The challenges of pursuing these technological challenges include:

- Some primary stakeholders are choosing not buy the technology to wait and see how it turns out
- Having tremendous pull of this technology to get to market for multiple platforms at the same time, thus creating a tremendous strain on our development workforce
- Leveraging the technology capability in the creation in new legislation to maximize the competitive advantages
- Ensuring the supply chain that supports the technologies, drive to a sustainable development innovation

Pratt and Whitney has been able to balance and manage these challenges through its 85 year history and continue to push the boundaries while addressing these challenges and creating new markets for itself.

Three economic perspectives within creative destruction that must be considered for global sustainability are consumer, emerging and survival. To truly become sustainable, a company must have creative destruction to break into new ways of thinking as opposed to just being friendly to the environment, as illustrated in Figure 9 [25]. Pratt and Whitney focuses primarily on the consumer economy due to the product line of the company. With the main product lines being propulsion systems for aircraft, spacecraft and power generation systems emerging and survival economies are not the main customer bases. These products can be considered luxuries within the three economic perspectives. Pratt and Whitney is indirectly involved in supporting all three economic perspectives by supporting air travel, air shipments, satellite communications and electrical power generation to all economies.

FIGURE 9. CONTINUOUS IMPROVEMENT VS. CREATIVE DESTRUCTION [25] Continuous Improvement versus Creative Destruction

Strategies for Greening	Strategies for Sustainability	
Focus on Existing:	Focus on Emerging:	
 Products Processes Suppliers Customers Shareholders 	 Technologies Markets Partners Customers Stakeholders 	
Characteristics:	Characteristics:	
 Incremental continuous improvement rationalizes industry 	 Discontinuous creative destruction restructures industry 	

With that said, Pratt and Whitney is breaking into the emerging market by direct sales or donations. Examples are primarily in the power generation areas. They provide electrical power with the mobile PowerPacTM with basic fuels (e.g. wind, solar, sawdust, propane, natural gas) as a source of generation. The corporation have also provided highly efficient building systems through the sister divisions (Otis, Carrier, Kidde, Chubb) to various organizations, e.g. Habitat for Humanity, supporting the emerging and surviving markets. Pratt and Whitney is not engaged, to any extent found in the literature, in the survival economies directly.

To directly improve life for people in those two economies, Pratt and Whitney could work with local airlines, charter services and other forms of air and space transportation to provide lower cost and even free services for their direct consumption. Another way would be for them to engage those markets to train people to work in the industry: travel, engineering and manufacturing of aerospace products.

Fundamentally Pratt and Whitney need to have executives rethink current strategies, technologies and markets to consider all three perspectives while using existing metrics focused on global sustainability to leverage any new approaches that are developed. These opportunities are listed below [25]:

Consumer -1 billion global customers have the purchasing power to afford anything they desire. Requires seeking to reduce ecological footprint of the firms' activities by reinventing their products and processes

Emerging -2 billion people whose basic consumer needs are met with minimal purchasing power. Outdated practices and technologies from the consumer economy must change.

Survival -3 billion people with unnoticed and unmet basic needs. Must recognize and exploit the inherent opportunity presented by a massive group of potential consumers whose basic needs remain unfulfilled

Managers must fundamentally rethink their prevailing views about strategy, technology and markets. New metrics focused on global sustainability will help managers identify the opportunities that will lead to these innovations.

SERVICIZING

Creative destruction is the development of a radical technology or socioeconomic change in a company that is a departure from present knowledge base and requires different organizations, administrations and infrastructure. Changes in a company to be more operational efficient and more environmentally benign is considered a necessary but not sufficient condition to being sustainable. In order to be truly sustainable, we must consume less. By "servicizing" companies can change the focus of business models from selling products to providing services, thereby turning demand for reduced consumption into a strategic opportunity [26].

There are several not so obvious benefits from making this shift in business models. A company is able to build closer customer relations which results in: customers are less likely to change suppliers, suppliers can expand the

range of products they sell to a given customer, and the attraction of new customers impressed by the company's social consciousness manifested in its array of environmentally friendly services and products [26].

Several factors need to happen to move from a purely product based business to a product and service based business. Rothenberg suggests building on existing strengths, redefining the basis for profit in contractual agreements, communicating the new business model, changing incentives, acquiring new skills, and highlighting the environmental advantage [26]. Pratt & Whitney has transformed themselves from selling very specific products to a combined product and service company with new fundamentals of business decision making. In its transition, they experienced creative destruction and was able to flourish as a result. They did go through all phases suggested by Rothenberg but in an integrated fashion. Service based businesses have always been a part of the company operations so expanding non-product focused business was felt of more an incremental change even though it became a creative destructive change.

Some of the new business segments that have arisen during this era of change have been: more environmentally friendly products, e.g.PurePower® (The PurePower engine uses an advanced gear system allowing the engine's fan to operate at a different speed than the low-pressure compressor and turbine. The combination of the gear system and an all-new advanced core delivers double-digit improvements in fuel efficiency and environmental emissions as well as a 50 percent reduction in noise.); Materials Management Services (manage customers materials for engine maintenance and front line operations; Line Maintenance Services, e.g. EcoPower® (on-wing engine wash as illustrated in Figure 10, blade blending, AOG Services, engine changes & preservation); Aircraft/Engine Operation Services, e.g. EcoFlightTM (a comprehensive service that analyzes airline operations, identifies potential fuel savings, drives implementation, and tracks results). In trying to link the servicing model for Pratt and Whitney, going from an old business model of maximizing product sales to a service model while reducing material goods and bringing other environmental benefits along the way, one can see that Pratt and Whitney is a successful sustainable company that is institutionalizing a sustainable business environment through framing the agenda, developing the business case and executing it. What they can do is to bring the supply chain into these business segments to better leverage the operations and creation of such entities.

FIGURE 10. PRATT AND WHITNEY ECOPOWER® ENGINE WASH [27]



COMPILED FINDINGS

Figure 11 summarizes the results of evaluating Pratt & Whitney in the sustainability measures discussed. The results highly correlate among all 7 measures that Pratt and Whitney can better leverage its supply chain to be more sustainable across all business segments. The most common recommendation is to continue the plans in place and deep dive into the supply chain to better understand the key drivers for sustainability as suggested by statement 2 of the sustainability audit.

Sustainability	Gaps	Plans for Closure	Recommendations	
Measure	-			
Sustainability Audit	Supply Chain is at level 3 for: - assessment of drivers - short and long term business cases - having capabilities to fill in the gap for a sustainability strategy	Continued focus on supply chain improvement for sustainability and overall performance	Continue executing plans for closure	
Four Point Supply Chain Checklist	Alignment with entire supply chain for a sustainable strategies	 Aligning critical suppliers with sustainability strategy Bring non-critical suppliers along with critical supplier improvements 	Continue executing plans for closure	
Six Point Perspective with Triple Bottom Line	 Time products in service provide limitations on perspective level usage Raw Material Ore has long term effectiveness questions and reporting vagueness Titanium sponge process is very inefficient Finished goods have heat and electricity usage that can be improved. 	 Perform full product evaluations to improve sustainability position and eliminate materials of concern Not visible at Pratt and Whitney Not visible at Pratt and Whitney Not visible at Pratt and Whitney 	Continue executing plans for closure and dive deeper into supply chain to better understand key drivers of sustainability	
Innovation as a Key Driver	 Long life of products is roadblock to sustainability across the entire business Protection and rehabilitation of the land where minerals are extracted can be improved Use and import regulatory limitations on use of the most sustainable sources of titanium Environmental impact of aviation is a key constraint on growth of the industry Severe lag of implementation and enforcement of operating standards 	 Better market and sell how sustainable the company is, not just how environmentally friendly the products and services are More comprehensive reporting to allow improved correlations between environmental aspects Develop more sustainable and efficient process to extract pure titanium from minerals Develop more creative destruction within the industry Making shorter term implementation of operating standards 	Continue executing plans for closure and dive deeper into supply chain to better understand key drivers of sustainability	

FIGURE 11. SUMMARY OF GAPS, CLOSURE PLANS AND RECOMMENDATIONS

Sustainability Leadership	- Ability to always find the right executive with the right competencies to lead sustainability initiatives	- Drive sustainability metrics deeper into supply chain	Continue executing plans for closure and dive deeper into supply chain to better understand key drivers of sustainability
Creative Destruction	 No direct engagement with emerging or survival economies Current strategies, technologies, and markets only target the consumer market 	 Work directly with local airlines, charter services and other forms of transportation to bring direct service to the consumer Rethink strategies, technologies and markets to include these other segments in current operating business models and metrics 	Continue executing plans for closure and dive deeper into supply chain to better understand key drivers of sustainability
Servicizing	- Supply chain not engaged with servicizing business segments that have developed	- Engage supply chain in these business segments	Continue executing plans for closure and dive deeper into supply chain to better understand key drivers of sustainability

SUMMARY

In evaluating Pratt and Whitney in the context of being sustainable, it is easy to see that as a company they are very sustainable but need to better understand and align the supply chain to improve the overall sustainability for all aspects of Pratt and Whitney.

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