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February 7, 2011

Regulatory Policy Division
Bureau of Industry and Security
Room 2705
U.S. Department of Commerce
Washington, D.C. 20230

Attn: Notice of Inquiry – CCL

Re: Commerce Control List: Revising Descriptions of Items and Foreign Availability (75 Fed. Reg. 76664, December 9, 2010)

Dear Mr. Mooney:

United Technologies Corporation ("UTC")[1] appreciates the opportunity to submit these comments in response to the Bureau of Industry and Security's ("BIS") advance notice of proposed rulemaking on revisions to the Commerce Control List ("CCL"), Supplement No. 1 to Part 744 of the Export Administration Regulations ("EAR"). BIS seeks comments on how to clarify descriptions of items on the CCL to make them more "positive," and on how these items should be "tiered" consistent with the Administration's guidelines and control list criteria.

UTC strongly supports the Administration's Export Control Reform Initiative, and its stated goal of strengthening national security and the competitiveness of key U.S. manufacturing and technology sectors by focusing on current threats and the changing technological landscape. Of paramount importance in achieving this goal is reforming both the U.S. Munitions List ("USML") and the CCL, and aligning associated export licensing policies, to achieve a more positive, transparent and tiered list structure that concentrates munitions and dual-use export controls on the items most critical to national security. The proper "tiering" of dual-use items pursuant to the control list criteria, working in conjunction with revised licensing policies such as the proposed License Exception STA, will speed legitimate dual-use trade and technology exchange among trusted allies and other parties while preserving and focusing export licensing controls on the most sensitive items.

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[1] UTC is a global, diversified corporation based in Hartford, Connecticut, supplying a broad range of high technology products and services to the aerospace, power generation, security, transportation, and building systems industries. UTC's companies are industry leaders, among them Hamilton Sundstrand aerospace and industrial systems; Pratt & Whitney aircraft engines, space propulsion systems and industrial turbines; Sikorsky helicopters; Carrier heating, air conditioning and refrigeration systems; Otis elevators and escalators; UTC Fire & Security electronic security and fire safety systems; and UTC Power fuel cell and power systems. With 2009 revenues of $52.9 billion, UTC is the 18th largest U.S. manufacturer and 37th largest U.S. corporation. In 2009, *Fortune* named UTC its "Most Admired" aerospace and defense company for the 9th time in the past 10 years. UTC has been named to *Forbes* Platinum 400 list of Best Managed Big Companies in America and the Dow Jones Sustainability Index every year since 1999, and a Global 100 most sustainable corporation in the world by Corporate Knights, Inc. each year since 2005.

Of particular importance to UTC, Export Control Classification Numbers ("ECCNs") 9A001 and 9E003 cover a wide range of aero gas turbine engines and technologies, not all of which meet the stated criteria for treatment under Tier 1. We recommend below specific revisions to these ECCNs to differentiate among commodities and technologies that merit different tiers of control. We also recommend consideration of a revision to ECCN 9A101. A summary of these proposed CCL revisions is included in separate comments by UTC in response to the proposed License Exception STA in §740.20. *See* UTC Comments, Export Control Modernization: Strategic Trade Authorization License Exception, dated Feb. 7, 2011.

1. Overview

Within CCL Category 9, ECCNs 9A001 and 9E003.a/h control aero gas turbine engine items that span a wide range of sensitivity. 9A001 controls aero gas turbine engines capable of extended supersonic operation, and commercial aircraft engines in certification. 9E003.a/h controls single crystal turbine blades, engine control law algorithms, and a simple flap in the engine bypass duct. We propose a tiered approach to 9A001 and 9E003.

Developmental commercial engines are classified under 9A001, yet become 9A991 once certified by the civil aviation authority in a country listed in Supplement No. 1 to EAR Part 743. There is no technology or performance difference between a pre- and post-certified engine. We propose that engines destined to be commercially certified and intended for use in non-military manned aircraft be treated, at a minimum, as Tier 2 and be eligible for the STA exception in §740.20(c)(1). The mechanism to achieve this would be to create a sub-entry (9A001.a.1) that could be specifically eligible for the STA exception.

9E003.a/h controls "development" and "production" "technology" for a wide range of aero gas turbine components. Within "production" "technology" is a wide range of items, with production know-how being the most sensitive and a simple blueprint being the least sensitive. According to the proposed §740.20, "technology" "required" for the "development" or "production" of 9E003.a.1 through a.5, a.8, and 9E003.h is not eligible for the full scope of the STA exception. We propose that both "development" and, particularly, "production" "technology" in those subparagraphs be tiered among Tier 1, 2 and 3 based on the sensitivity and availability, and that this structure maintain widespread eligibility of technology for various categories of authorization under the STA exception.

2. Proposed Tiering of ECCNs 9A001, 9E003 and 9A101

A. 9A001 – Aero Gas Turbine Engines

ECCN 9A001 controls at a NS1 level developmental aero gas turbine propulsion engines incorporating any of the technologies controlled by 9E003.a or 9E003.h, and engines designed for aircraft capable of prolonged supersonic flight. An engine is no longer controlled by 9A001 once it is civil certified in a participating Wassenaar member state and intended to power a non-

military manned aircraft that has been civil certified. There is no technology or performance difference between a pre- and post-civil certified engine, and there is no critical military or intelligence advantage provided by pre-certified development engines that warrant treatment at a Tier 1 level. We suggest two different approaches to revising ECCN 9A001 for consideration:

(1) The first approach assumes 9A001.a captures primarily developmental commercial engines. We propose 9A001 be amended to add an STA exclusion paragraph (proposed new language underlined):

9A001 Aero gas turbine engines having any of the following:
* * *
License Exceptions
* * *
<u>STA: Paragraph (c)(2) of License Exception STA (Sec.740.20(c)(2)) of the EAR may not be used for any commodity in 9A001.b.</u>

This approach would restrict the STA exception for supersonic-capable aero gas turbine engines in 9A001.b. Any engines captured under 9A001.a having characteristics listed in 9A101, and therefore subject to MT controls, also would not be eligible for STA, as STA cannot to be used to export items controlled for MT reasons. <u>*See*</u> 740.20(b)(2)(iii). Therefore, developmental commercial engines that do not meet 9A101 would be eligible for the full STA exception.

(2) The second approach is to identify specifically those engines destined to become part of a civil-certified aircraft. Under this approach, 9A001.a would be split into 9A001.a.1 and 9A001.a.2, where a.1 would be eligible for the §740.20 STA exception, and a clarifying note would be added (proposed new language underlined):

9A001 Aero gas turbine engines having any of the following:
* * *
License Exceptions
* * *
<u>STA: Paragraph (c)(2) of License Exception STA (Sec.740.20(c)(2)) of the EAR may not be used for any commodity in 9A001.a.2 or 9A001.b.</u>

a. Incorporating any of the technologies controlled by 9E003.a or 9E003.h and;
<u>a.1 Intended to power non-military manned aircraft planned for civil certification; or</u>
<u>a.2 Does not meet the requirements of a.1, or</u>
b. Designed to power an aircraft designed to cruise at Mach 1 or higher, for more than 30 minutes.

* * *

Note: 9A001.a.1 controls:
a. Development or test engines for non-military manned aircraft, where the aircraft has been offered for commercial sale, or
b. The engine has been certified by a civil aviation authority in a country listed in Supplement No.1 to Part 743

Lastly, to ensure clarity and precision on the scope of control of 9A001, we recommend specifying that aero gas turbine non-propulsion engines, e.g., auxiliary power units, are not controlled under 9A001.a. This can be accomplished through addition of an exclusionary note – "9A001.a does not control engines not used for propulsion"– or a change to the ECCN chapeau to add the term "propulsion."

B. 9E003.a/h – Gas Turbine Engine Technology

(1) Summary

ECCN 9E003.a and .h covers a wide range of technology spanning single crystal turbine blades to engine control law algorithms. It covers "development" and "production" technology, which range from design methodology, to production know-how, to simple build-to-print drawings. Not all of this technology rises to the level of Tier 1 control.

We propose a tiered structure for selected 9E003 "technology." In order to implement this Tier structure, it is necessary to define a hierarchy of "technology" consistent with the tiering criteria set forth in the Administration's guidelines for revising the CCL and USML. Under this hierarchy, "technology" would be divided into "Development Methodology" (DM), "Production Know-How" (PK), and "Production Data" (PD). Similar to the tabular structure of ECCN 2E003.f, the control of various items within ECCN 9E003 may be defined as follows:

9E003 Control Table

9E003		Tier 1	Tier 2	Tier 3	Note*
a.1	DS/SC blades, vanes, tip shrouds (BVTs)	--	DM, PK	PD	1
a.2	Combustors	--	DM, PK	PD	2
a.3	Composites	--	DM, PK	PD	3
a.4	Uncooled BVTs	--	DM, PK	PD	4
a.5	Cooled BVTs	DM	PK, PD	--	5
a.8	Damage Tolerant Powd'd comps	DM	PK	PD	6
a.10	Adj flow path Geom.	DM	--	PK, PD	7
.c	Hole Drilling	--	DM, PK	PD	8
.h	FADEC	DM	--	PK, PD	9

Key:
DM – Development Methodology
PK – Production Know-How
PD – Production Data

* The Note column links to the rationale for each item, provided in section (3) below.

(2) Background

9E003 controls "technology" for the "development" and "production" of a variety of components. There is an hierarchy within "development" and "production" that roughly corresponds to the Tier structure:

Technology Hierarchy *	Tier Structure
Development Methodology (DM) Enables the recipient to create new products and improve or change the characteristics of existing products.	Tier 1 Items **almost exclusively available** from the United States and that provide a **critical** military or intelligence advantage
	Tier 2 Items almost exclusively available from Regime Partners/Adherents and that: provide a **substantial** military of intelligence advantage, or make a **substantial** contribution to the indigenous development, production, use or enhancement of a Tier 1 or 2 item
Production Know-How (PK) Enables the recipient to develop, broaden, and improve their manufacturing base	Tier 3 Items more widely available that provide a **significant** military or intelligence

Production Data (PD) Enables the recipient to replicate an item	advantage, or make a **significant** contribution to the indigenous development, production, use or enhancement of a Tier 1, 2 or 3 item
	Outside of Control (*e.g.*, EAR99)

* See Appendix for proposed definitions in Technology Hierarchy.

Note that there is not an exact one-to-one relationship between the proposed Technology Hierarchy and the Tier Structure. The overlap is due to differences in the foreign availability and the technical sophistication required to develop, produce, use or enhance an item. This variation is captured on an item-by-item basis in the 9E003 Control Table.

Within the definition of the Tiers, production capability only appears in Tier 2 and Tier 3. From this definition, it is inferred that unless production data (including know-how) provides significant insight into design methodology, "production know-how" should be Tier 2 or lower.[2]

(3) Tier Selection Rationale

Note 1

9E003		Tier 1	Tier 2	Tier 3	Note
a.1	DS/SC blades, vanes, tip shrouds (BVTs)	--	DM, PK	PD	1

9E003.a.1 controls "development" and "production" "technology" for gas turbine blades, vanes, or tip shrouds made from directionally solidified (DS) or single crystal (SC) alloys meeting a stress-rupture life threshold. There is an overlap of control with a.4 (uncooled components) and a.5 (cooled components), so only components not caught by those controls due to performance are captured in a.1. Therefore, these are 'low performance' components that still use a sensitive technology construction method.

The key to the successful manufacture of a DS/SC item is the "production know-how" of growing the crystal structure. This know-how is not evident through examination of the

[2] A key concept is that a commodity inherently contains some technical data, and that technical data should not be controlled at a higher level than the item itself. In a sense, an item (e.g. turbine blade) is a perfect 3D model that also contains data about acceptable variation. If someone has a 9A991 turbine blade, they can examine it (including dissection) and create a blueprint. Through statistical analysis, a small number of the same turbine blade will provide allowable production variations to a good confidence level. Because this technical data is available to any determined entity with access to commercially available items, technical data discernable through examination of an item cannot effectively be controlled at a level higher than the item itself.

A corollary is that there is technical data not readily available through physical examination. This would include processes used to make a component. Examination may show the turbine blade to have been heat treated, but the heat treatment parameters would not be readily apparent. This type of production data should be controlled at a higher level than the data available through examination.

component. Therefore, a simple print of the component (PD) is insufficient to reproduce the component, and should be treated as Tier 3.

Since the critical technology in the production of DS/SC is the "production know-how", it should be at the same level as the "design methodology". Although this is a sensitive technology, it is readily available outside of the United States, notably in countries from the former Soviet Union. This puts the "development methodology" and "production know-how" at Tier 2. Note again that more sophisticated components will be controlled under a.4 and a.5.

Note 2

9E003		Tier 1	Tier 2	Tier 3	Note
a.2	Combustors	--	DM, PK	PD	2

9E003.a.2 controls "development" and "production" "technology" for gas turbine engine combustors. Although combustors provide a critical capability to the performance of gas turbine engines, the technology is fairly widespread. The key performance aspect of combustors – exit temperature – is primarily limited not by the combustor capability, but by the temperature capability of the High Turbine stages. Combustor design is concerned with fuel economy, emissions, and component life. Although important to commercial operators, these characteristics do not provide a critical military advantage. Therefore, the "development methodology" of combustors should be placed in Tier 2.

The actual construction of combustors is not highly sophisticated. Many combustors are constructed of sheet metal and/or interlocking plates or rings. Many of the construction techniques are readily apparent through examination; however, there are several sophisticated production processes associated with the fabrication of cooling features and sliding joints. Given the sensitivity of the technology, although it is available outside the United States, the "production know-how" should be Tier 2 as several processes would provide a substantial contribution to indigenous production capabilities abroad.

Since the combustor is essentially a simple arrangement, the production data (as in a build-to-print drawing package) contains little technical information beyond what would be apparent through careful examination. However, there may be certain process parameters (heat treatment, peening, etc.) on a production drawing that are not readily apparent from physical examination, and would contribute to indigenous production capabilities. Accordingly, combustor "production data" should be Tier 3.

Note 3

9E003		Tier 1	Tier 2	Tier 3	Note
a.3	Composites	--	DM, PK	PD	3

9E003.a.3 controls "development" and "production" "technology" for gas turbine engine components manufactured from specified Category 1C "composite" materials. This control is essentially a "use" technology for the referenced 1C materials. As a composite passes from raw material through semi-finished part to finished part, it will transition from 1C to 9A. The material cure requirements are controlled under category 1E. The layup order and pattern, thickness, etc., are part specific, and therefore controlled under category 9E. The "development" and "production" aspects specific to the material would be controlled under 1E, and the "development" and "production" aspects specific to the finished component would be controlled under 9E.

Due to composite material temperature limitations, composite parts find their use in the 'cold' section of aero gas turbine engines, *e.g.*, large structures such as fan exit guide vanes and early low compressor stages, nose cones, fan cases, and miscellaneous small items such as bushings, brackets, covers and tubes. Although important to engine operation, these items do not provide a critical military advantage. The primary performance advantage is weight savings; there is no increased gas path performance (*e.g.*, higher thrust) over conventional materials. The only other 'cold' section items listed in 9E003 are hollow fan blades (a.11), which subcategory is available for the STA exception.

The end items "developed" or "produced" under this control do not provide a critical military advantage, and both the Development Methodology and Production Know-How should be placed in Tier 2. Because the layup and configuration of the item is part specific, the Production Data does not make a substantial contribution to indigenous development or enhancement, and therefore should be treated as Tier 3.

Note 4

9E003		Tier 1	Tier 2	Tier 3	Note
a.4	Uncooled BVTs	--	DM, PK	PD	4

9E003.a.4 controls "development" and "production" "technology" for uncooled blades, vanes, tip-shrouds, etc., that meet a temperature performance threshold. Because of the absence of cooling, these components meet the performance threshold primarily through materials and coatings. The technology of uncooled components has reached a plateau. As turbine temperatures increase, instead of trying for better uncooled components, designers turn to cooling (a.5). Because this capability is available outside the United States and does not provide a critical military advantage, the design methodologies to determine the blade shape, metallurgy and coatings should fall within Tier 2.

These components are almost exclusively made from DS/SC materials, so the "production know-how" is a key technology. However, similar to 9E003.a.1, this know-how is not exclusive to the United States but is present in the industrial base of other regime partners

and adherents. Because this know-how would make a substantial contribution to the indigenous production of a Tier 2 item, "production know-how" should be Tier 2.

Because of the relatively simple construction of an uncooled component, the "production data" does not provide a substantial contribution to indigenous production. The "production data" would allow reproduction of the component, but this data would not be easily extended to other components. Given the sensitivity of turbine technology, "production data" for uncooled components should be Tier 3.

Note 5

9E003		Tier 1	Tier 2	Tier 3	Note
a.5	Cooled BVTs	DM	PK, PD	--	5

9E003.a.5 controls "development" and "production" "technology" for cooled blades, vanes, tip-shrouds, etc., that meet a temperature performance threshold. These components meet the performance threshold through materials, coatings and cooling features. The ability to operate at high temperatures in a turbine section is critical to engine performance and life. The design methodologies to determine the blade shape, metallurgy, coatings, and especially cooling features as an *integrated system* are Tier 1.

In addition to these components being almost exclusively made from DS/SC materials, the processes to form and maintain the cooling holes through the manufacturing cycle are key technologies. However, similar to 9E003.a.1, this know-how is not exclusive to the United States. Because this know-how would make a substantial contribution to the indigenous production of a Tier 2 item, "production know-how" should be Tier 2.

Unlike the relatively simple construction of the uncooled components in a.4, components controlled under a.5 require numerous, complex processes. Each of these processes is critical to a usable product. The "production data" would provide a substantial contribution to indigenous production outside the United States. Given the sensitivity of turbine technology, "production data" for cooled components should be Tier 2.

Note 6

9E003		Tier 1	Tier 2	Tier 3	Note
a.8	Damage Tolerant Powd'd comps	DM	PK	PD	6

9E003.a.8 controls "development" and "production" "technology" for damage tolerant rotating gas turbine engine components controlled by 1C002.b, which controls powered metals. Damage tolerant components are designed using methodology and substantiation to predict and limit crack growth. Because of the stresses the components (typically disks) experience, and the criticality of the components on safety, this is a highly sophisticated methodology. The essence of this control is the methodology is to account for inevitable flaws in the finished product. Because turbine disks are key to engine performance, "design methodology" should be placed in Tier 1.

While "production know-how" is important to producing the components, the critical technology is in the design of the part to account for production compromises. There is no significant insight into "design methodology" provided, so "production know-how" should be treated as Tier 2.

Although "production data" in the form of blueprints and processes are the result of the "design methodologies" of powered metal components, there is no direct link between the design processes and the resultant component features. Replication of those features on another component for another application will not provide the same fault tolerance, and may even degrade the fault response of the part. Therefore, "production data" should be Tier 3.

Note 7

9E003		Tier 1	Tier 2	Tier 3	Note
a.10	Adj flow path Geom.	DM	--	PK, PD	7

9E003.a.10 controls "development" and "production" "technology" for gas turbine engine adjustable flow path geometry. This functionality is tightly coupled with the FADEC control laws controlled under 9E003.h. Because of this sensitivity (see FADEC), the "design methodology" for adjustable flow path geometry is Tier 1. Note that the control of this geometry is implemented in software, and the algorithms in source code or higher level language are considered to contain 'technical data' that provides insight into the design methodology. The control laws for adjustable flow path geometry are also Tier 1.

The actual implementation of adjustable flow path geometry is very simple. This usually consists of simple vanes or blockers in the flow path, very similar to either thrust reversers or adjustable stator or guide vanes. The "production know-how" for simple actuators and airfoils is commonly available, and would not make a substantial contribution to the production of Tier 1 or 2 systems. Therefore, the "production know-how" is Tier 3.

The physical implementation of adjustable flow path geometry is simple, and easily determined with simple measuring devices when an engine is available. As a result, this is a case

where the physical hardware is a representation of the "production data." Because the physical hardware in a commercially certified engine is 9A991, "production data" should fall to Tier 3.

Note 8

9E003		Tier 1	Tier 2	Tier 3	Note
.c	Hole Drilling	--	DM, PK	PD	8

9E003.c controls "technology" for the "development" or "production" gas turbine engine components using specified hole drilling methods, where those holes meet certain criteria. This control is primary a process control. The design methodology of any components that would use these holes (*e.g.*, 9E003.a.2 and 9E003.a.5) is already controlled at a high level (Tier 1). Therefore, all that is left is the "design methodology" for hole drilling processes. This technology is widely available throughout the world, and used for many non-export controlled commercial items. For this reason, any "design methodology" is not unique to the United States and is not a critical technology, and therefore should be Tier 2.

"Production know-how" is important to the production of 9E003.a.2 and 9E003.a.5 components, and does make a substantial contribution to indigenous production, and therefore would also be Tier 2.

The location of cooling holes is evident from physical inspection of a part. However, the "production data" may also include tolerances and other acceptance criteria that is not readily evident by inspection. Given that this is an enabling technology for Tier 1 items that could contribute significantly to production capabilities outside the United States, "production data" should be Tier 3.

Note 9

9E003		Tier 1	Tier 2	Tier 3	Note
.h	FADEC	DM	--	PK, PD	9

9E003.h controls "technology" for the "development" and "production" of gas turbine engine "FADEC systems." There are two aspects to "FADEC Systems" – the system hardware and the system software.

"FADEC system" hardware, while technically sophisticated, is not significantly different than any other computer and input/output processing system designed for a harsh environment. For example, it can be argued the technology that goes into designing and building an under-hood automobile engine control is the same as that used for an aero gas turbine engine control. "FADEC system" software is the key enabler for gas turbine engine performance. This is limited to software that contains "technology," which is source code, logic diagrams, and other detailed requirements. Object code is controlled by 9D003.

The "design methodology" for "FADEC system" algorithms is a critical differentiator in aero gas turbine engines, and is Tier 1. The "design methodology" for "FADEC system" hardware, as noted, is fairly common. However, because of the tight integration between

algorithms and processing, and the practice of combining algorithms and hardware (firmware), it is difficult to perfectly split out "design methodology" from "FADEC system" hardware. Therefore, all "FADEC system" "design methodology" should be Tier 1.

As noted, "FADEC system" hardware "technology" is widespread. There are no special "production know-how" issues with the hardware, so it should be place within Tier 3. There is no "production" technology for software – the duplication of software is EAR99 at best. Most technical data for "FADEC system" hardware is evident upon examination; the exception would be custom circuits, but "production data" would not include the internals of custom chips. Therefore, both "production know-how" and "production data" should be placed in Tier 3.

C. 9A101 - Turbojet and Turbofan Engines

ECCN 9A101 covers small, fuel-efficient aero gas turbine engines, other than those controlled by 9A001, and is controlled by Missile Technology (MT) reasons. There are several engines in the small business jet market that are caught by this regulation, with one example being the PW610, which powers the Eclipse 500 aircraft. An engine installed on an aircraft does not require an export permit, but the regulatory burden of selling and supporting commercial aircraft engines controlled under MT is significant.

We understand that 9A101 controls are based on Missile Technology Control Regime (MTCR) commitments. In addition to encouraging the U.S. Government to seek revisions to this control within the multilateral regimes, in the spirit of the CCL reform we suggest that those civil-certified engines falling under 9A101.a whose intended end use is for civil-certified commercial aircraft be excluded from this control. The civil certification exclusion used in 9A001 is an example of such a carve-out. The exclusion could be implemented with addition of a note to 9A101:

> *Note: 9A101.a does not control aero gas turbine engines which meet all of the following:*
> *a. Certified by the civil aviation authority in a country listed in Supplement No.1 to Part 743; and*
> *b. Intended to power non-military manned aircraft for which any of the following has been issued by a Participating State listed in Supplement No. 1 to Part 743 for the aircraft with this specific engine type:*
> *b.1 A civil type certificate; <u>or</u>*
> *b.2 An equivalent document recognized by the International Civil Aviation Organization (ICAO)*

* * *

UTC appreciates the opportunity to present its comments on how to revise and tier ECCNs 9A001 and 9E003 of the CCL to differentiate among Tier 1, 2 and 3 items based on current state and availability of the technology, and its significance to maintaining U.S. military and intelligence advantage. Information concerning foreign availability and indigenous development or production capabilities outside the United States may contain or be based, in whole or in part, on proprietary information. We are willing to provide such supporting information to BIS upon request.

For additional information, please contact the undersigned at (202) 336-7467 or, with regard to technical proposals for ECCNs 9A001, 9A101 and 9E003, Ari Novis at Pratt & Whitney at (860) 557-2353.

Sincerely,

Peter S. Jordan
Director, Senior International Trade Counsel
United Technologies Corporation

Appendix

Hierarchy of technology sensitivity:

1. Development Methodology. Enables the recipient to create new products and improve or change the characteristics of existing products.

2. Production Know-How. Enables the recipient to develop, broaden, and improve their manufacturing base.

3. Production data. Enables the recipient to replicate an item.

Development Methodology consists of the (analytical) tools, methods, processes, and other information and "technology" necessary to design the system and components from the high level requirements. The inputs are the system performance requirements, and the outputs are detailed specifications for the individual components.

> An example of Development Methodology would be the technology to take the general core performance requirements, and determine the HPT blade configuration, including the location and size of the cooling holes and necessary material properties.

Production Know-How consists of the (analytical) tools, methods, processes, and other information and "technology" necessary to produce or manufacture items from the detailed specifications, with an acceptable cost, yield, and cycle time. The inputs are the detailed component specifications, and the outputs are the component drawings, process steps and parameters, test requirements and acceptance criteria.

> An example of Production Know-How would be the technology to create the process to drill the blade cooling holes, determine the Hot Isostatic Densification (HIP) and heat treat parameters to meet the material properties, and calculate acceptable component variation to manufacture the turbine blade noted above. Production Know-How also includes the technology to vary the production processes to bring an out-of-conformance process back into conformance, and to improve yields and turn-times.

Production Data is the information necessary to replicate a component with existing production know-how. The inputs are component drawings, process steps and parameters, test requirement and acceptance criteria, and the output is a component that meets the acceptance criteria.

> An example of Production Data is the information on a build-to-print drawing. It will show the location of the blade cooling holes, provide the HIP and heat treat parameters (pressure, temperature, cycle time) and acceptable variation and tolerances. Production Data is typically specific to the component.