The CFM56 Engine Family
An International Development

L. M. SPENCE
General Manager
Military CFM56 Programs
CFM International
POB 15514
Cincinnati, Ohio 45215

GEORGES SANGIS
General Manager, Product Support
CFM International
2, Boulevard Victor
75015 Paris, France

INTRODUCTION

During the 1970's General Electric of the United States and Societe Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA) of France took advantage of a unique market opportunity to develop a modern, fuel efficient, quiet turbofan engine in the 20000 to 25000# thrust class. Both companies had confidence that there would be a significant demand for such an engine to warrant the large total investment of both money and resources.

General Electric had the core of the F101 engine being developed for the B1 bomber and SNECMA had a preliminary design of a 20,000 lb. thrust turbofan engine, the M56.

It was SNECMA who precipitated the formation of this project by holding a competition between the 3 major engine companies, Rolls Royce, Pratt & Whitney and General Electric to select a partner. It was this process which joined General Electric and SNECMA into a 50/50 collaboration and led to formation of a joint company: CFM International (CFMI).

The joint company, CFMI, started with a single product, the CFM56-2 -- the so called 10 ton transport engine -- but quickly expanded their product line by developing 2 derivative versions of the engine, the CFM56-3 specifically designed for Boeing's highly successful 737-300 aircraft and the very advanced CFM56-5 for the Airbus A320 and A340 aircraft.

The joint collaboration by GE and SNECMA, started in early '70's, was a pioneering endeavor in the international programs field. Its enduring success is due both to its organization and to its timely products.

CFMI ORGANIZATION & CONCEPT

The program concept was a 50/50 cooperative program between SNECMA and GE. It was structured so that both companies share equally in all work efforts, in all the risks and, potentially and hopefully, in the rewards of the program. It has the full backing of General Electric and SNECMA resources.

Since it would not be practical to market and support pieces of the engine by both companies, a decision was made to form a joint company, CFMI, which would act as the interface with the customer to sell a complete engine, provide one warranty, one set of technical manuals and one integrated product support program.

The logo of CFMI shown in Figure 1 combines those of the General Electric Company and SNECMA. In addition, CFM borrows the "CF" from GE's commercial engine designation (i.e., CF6) while "M" is SNECMA's engine designation (M for Moteur).

FIGURE 1

The CFM program is revenue sharing and not a profit sharing venture. The split of sales revenues is negotiated and the profit or loss that each company makes is based upon its efficiency in
performing its portion of the work. The work, including development, manufacturing and support is split on a 50/50 basis, negotiated and agreed in advance and based on man hours rather than cost.

CFMI is a corporation with a board of directors, 5 of them senior executives from General Electric and 5 from SNECMA, including Mr. B.H. Rowe the Group Vice President of General Electric Aircraft Engines and Mr. B. Capillon, the President and Director General of SNECMA. It is jointly owned; 50% of the stock by SNECMA and 50% by General Electric.

CFMI has a relatively small staff. The company "buys" the services of people from General Electric and SNECMA. It buys the hardware and the assembly/test services from General Electric and SNECMA as well as the product support services. The staff is comprised of full time employees of General Electric and SNECMA and are included in the sharing of work split and responsibilities.

The organization of the company is as shown in Figure 2.

The President and two Executive Vice Presidents form an executive office which, with inputs from the functional director positions, make all of the decisions with respect to the program...except those involving major new long range commitments reserved to an advisory committee of the board of directors. With the two Executive Vice Presidents also being the Project General Managers from General Electric and SNECMA and having responsibility for funding and programs within their companies, the executive committee is fully capable and empowered of making the decisions necessary for the program.

Reporting to the executive offices are functional directors selected by mutual agreement based on qualifications to provide the direction for each particular function.

The headquarters of CFMI is located near the General Electric Company at Evendale, Ohio with the President of the Company at that location. It has been the practice, to this date, that the President of the Company is selected from the ranks of SNECMA.

CURRENT STATUS

The CFM56 Program has enjoyed great success. There are currently 14 aircraft applications (Figure 3) operating or committed. These include transport type aircraft for both military and commercial uses.

CFM56 Applications

CFM56 Engines are Used on a Variety of Aircraft

FIGURE 3

The family currently includes 3 engine models with derivatives providing thrust levels from 20,000 to 30,000 pounds (Figure 4). Over 2,000 engines have been delivered with total orders exceeding $9.0 Billion -- more than 3,700 engines. More than 560 aircraft have been delivered to 89 customers. It is expected that 7,000 engines will be sold by 1992 (Figure 5).

COMMERCIAL PRODUCT SUPPORT APPROACH

The CFM56 was the first engine to receive joint certification from both the Federal Aviation Agency (FAA) and Direction Generale de L'Aviation Civile (DGAC). The prime objective is to provide the customer or user with sufficient parts data, information and technical guidance to ensure that the engine will be maintained in accordance with the agencies' regulations/requirements. This, of course, is paramount to the user because of his obligation to maintain product FAA/DGAC or commercial agency certification as well as reassurance that safety and integrity aspects of the engine are preserved and not compromised.

Services for support provided by the engine manufacturer are varied and many faceted but guided by the awareness of the customer's maintenance resources, needs, and objectives. Understanding these then gives the Product Support group an appreciation of the task so that this support can be implemented.
CFMI Highlights

- Engine models: 3
  - CFM56-2: 22,000/24,000 lbs
  - CFM56-3: 20,000/22,000/23,500 lbs
  - CFM56-5: 26,000/30,600 lbs

FIGURE 4

Commercial Product Support Elements

- Customer support manager
- Spare engine/module requirements
- Field service representatives
- Training
- Technical publications
- Tooling/support equipment
- Spare parts/provisioning
- Warranty
- Product support engineering

FIGURE 6

CFMI Highlights

- Over $9.0B business
  - 3756 engines on firm order
- 2129 engines delivered
  - Approaching 55/mo
- Over 560 aircraft in service
  - Supporting 89 customers
- 7000 engines likely by 1992

FIGURE 5

Long before fleet operation is initiated an Advanced Product Support group works with the airframers and operators on requirements and scenarios such as flight profiles, performance needs, fleet size, utilization, maintenance concepts, and so forth so that a support plan can be established. This support plan develops into a readiness plan from which the elements of support and schedule of support are derived.

Included in this support are the following elements: (Figure 6)

- Customer Support Manager (CSM) - an individual is assigned to be the engine manufacturer’s direct interface with each customer or user. The CSM ensures that the needs of customers are transmitted into the factory support system so that answers and problem resolution can be obtained.
- Spare engine and spare module requirements (such as quantity and configuration) are recommended based on fleet size, utilization, mission profile and such.
- Field Service Representative (FSR) - The engine manufacturer’s representative located on-site at the customer’s facility or station. This individual relates customer questions and concerns to the factory as well as being an excellent on-site source of information regarding the product to the customer.
- Training - to ensure that the customer is prepared as well as kept current, engine familiarization as well as maintenance courses are taught. The maintenance courses can include on-wing, shop or overhaul instructions for the basic engine and are taught either at the engine manufacturer’s or the customer’s facility.
- Technical Publications - produced to ATA specifications these engine manuals primarily consist of Maintenance Manual (geared for on-wing for aircraft manufacturer use), Engine Shop Manual and Illustrated Parts Catalog. Other manuals helpful in maintenance include NDI, Component Maintenance Manuals, Consumable Products, Standard Practices and Tooling Manuals. Revisions to these manuals are provided by the agency approved Service Bulletins as well as periodic scheduled updates/revisions to the basic manuals.
Tooling/Support Equipment - is designed by the engine manufacturer for use at all levels of engine maintenance. Designed to commercial practices these tool drawings are supplied to the customer/user and can, if desired, be procured from the engine manufacturer. Advisory counseling is also available for customer engine test cell and shop facility application/refurbishment/procurement to meet the requirements of the engine.

Spare Parts/Provisioning - significant features of this service includes initial provisioning of parts, availability of parts worldwide, complete warehouse of parts and order/invoicing administration. In addition, an AOG/Emergency Service is provided so that engine spare parts can be shipped within 4 hours.

Warranty - to provide further customer satisfaction warranty of both the procured engine and spare parts is provided. Level of coverage normally is tailored to meet the individual customer’s needs.

Product Support Engineering - a staff of knowledgeable engineers is available to respond to technical questions and provide assistance. This support could include technical response in areas of maintenance, engine performance, reliability trends, problem anticipation, etc. In addition, this staff is responsible for engine part and component repair development as well as an operations section, trained to respond to engine operational concerns and questions.

The Commercial Product Support approach covers all the necessary aspects of engine support/maintenance. It is intended and the personnel are dedicated to provide satisfaction and fulfill the expectations of the customer.

MILITARY PRODUCT SUPPORT

Transport engines are developed to carry people and/or cargo efficiently. The engine would see a commercial or a military flight as identical. But the airline or military Air Force would view the engine from very different perspectives.

The management objectives are quite different (Figure 7). For an airline it is revenue generation while an Air Force is providing for national defense. The airline goals (Figure 8) will be to maximize utilization while minimizing training, maintenance, and the number of operational sites. The Air Force in peace time will try to maximize training and maintainability while minimizing utilization and number of operational sites. During times of conflict the Air Force will need to maximize utilization and number of sites while minimizing training and maintenance.

The utilization goals vividly portray these differences (Figure 9). The commercial user desires the highest utilization rate possible while the Air Force strives for the lowest possible utilization rate. If all training and maintenance have been completed and there are no conflicts the Air Force has no need to fly. That would be perfection from the military view.
Lessons Learned

Providing the commercial CFM56 engine for a military transport/tanker application such as the KC-135R established some interesting and complex issues and concerns. However, as is the case with a majority of problems and challenges, solutions are achievable (Figure 10). Perhaps the longest difference is in the contracting/purchasing area.

Lessons Learned

• Know and understand customers system
• Configuration management by engine manufacturer
• Use commercial spare parts catalog
• Look for innovative solutions/can-do attitudes

FIGURE 10
COMMERCIAL CONTRACTING

Although the majority of procurement actions initiated by the Federal Government in any one day are for commercial products or services, most involve general or wholesaler items including such things as building and maintenance material, consumer goods, cars, medicines, administrative goods and grocery products. Many are purchased by the General Services Administration for the public agencies of Government or by base procurement activities for DoD using simplified purchasing methods. A small number of procurement actions in DoD, however, involve weapons systems and those small number of actions account for the majority of the DoD budget. These actions are usually conducted using complicated acquisition techniques that involve detailed cost or pricing data, audit activity, source selection criteria and a host of rules generated over the years for buying systems whose development was conceived by DoD research funds and whose use is generally restricted to DoD applications. When DoD senior managers made the decision to use commercially developed and sold transport type engines for military applications, the traditional “commercial” methods of contracting and the specialized “weapons systems oriented” methods first came together in the KC-10 tanker program. The result was initially chaotic and while a contract was finally hammered out many difficulties had to be overcome. Major General Charles Wilson, Commander of the AF Acquisition Logistics Command at WPAFB called it “coping with conflicting goals in Government contracting”. In a speech to the NCMA Fall Regional Symposium held in Dayton, Ohio on October 25, 1979, he stated that one of the problems involved was that “people are so entrenched in their way of doing business that they are unwilling to break the shackles of tradition that restrain us (DoD) from innovation and initiative”.

Taking a lessons learned approach from KC-10 was a key factor in the KC-135R Program. Both CPMI Contracts personnel and their USAF counterparts agreed early on to take the best of the KC-10 acquisition methods and avoid the pitfalls of what General Wilson termed “conflicting goals” by being innovative and creative in those areas.

A few of the things we did are described below to illustrate how the marriage of the two systems was accomplished.

• Quality Assurance - Inspection and Acceptance

Typical military programs are done under the MIL-Q-9858A system where an APPO or DCAS inspector performs in process checks, monitors the line, and at the end of the process signs off a Material Inspection Receiving report called a DD Form 250. Because there is no difference between an engine for the USAF vs. one for an airline customer and, therefore, only one production line exists, the DoD inspection system just wasn’t appropriate. We solved the problem by having the FAA’s Material Inspection Representative designated as the “Government inspector”. His very thorough system already in place (FAA Reg. Part 21) was accepted by DoD and he signs off all shipments on an FAA Airworthiness Certificate that the USAF receives. Since the information on the certificate is as detailed as the DD 250 it satisfies the DoD’s needs while not upsetting the FAA/DOAC system in existence for the commercial production line. The contract is written so that this signed certificate constitutes acceptance and permits payments – just like commercial.

• Component Improvement Programs (CIP)

CIP is usually funded separately by USAF and tackles problems after they are encountered in service. A mini bureaucracy manages and directs the work effort as funds and time are available. Since the commercial engine was already in service and was serving as the fleet leader and since the commercial engine manufacturer controls the configuration, the need for dozens of reports and CIP managers at the depot with the supporting bureaucracy was unnecessary. The contractors commercial product improvement program, already in place, was handling all problems very effectively and these improvement programs were paid for by the contractor. The possibility existed, however, that problems unique to a tanker aircraft could be encountered. The USAF and CPM agreed to a price for handling these unique problems and added it incrementally to the first 1040 engines shipped for payment purposes. This effort will cover all unique fleet problems using the commercial Product Improvement Program. Since the nature of commercial PIP’s and resulting
manufacturing changes take, on the average, about one fifth the time to implement as do traditional military CIP’s. the USAF, for less than a year’s normal CIP cost, got the benefit of this efficiency on its unique problems for the life of the program, and also saved the cost of 25 years of a mini-bureaucracy.

The contracting effort was successful because both parties were able to be innovative and agreed up front on what the real objectives were. We agreed on a commercial business structure, tailored where necessary to be acceptable within the general framework of the Government’s Acquisition regulations, and kept the efficiencies and strengths that had originally prompted the DoD senior management decision to “buy commercial”. This decision was supported by a three engine competition and the lowest life cycle cost product selected.

NEEDS VS. WANTS

For either a commercial or military customer the prime consideration that needs to be highlighted is that the engine manufacturer must know and totally understand the customer’s support system. Understanding is a key ingredient. With that knowledge it is then imperative to determine how the customer’s requirements will be satisfied; can this military requirement be satisfied by substituting a commercial or ATA method or can it only be satisfied by full military specifications? Additionally, the military customer, within its own commands, needs to reach an agreement on the program’s wants vs. absolute requirements. Then, with the help of the commercial seller, he needs to establish what the additional cost will be to the program. Do the additional requirements justify the added costs? Only the military customer can determine this.

This consideration needs to be resolved early in the program since prolonging it leads to poor customer relationships and increased difficulties in successfully launching the program.

CONFIGURATION MANAGEMENT

Commercial engines are normally designed and developed by private capital. Therefore, the data rights and configuration management of the engine are retained by the seller. This is contrary to the normal method of military procurement where the military pays the cost of development. One of the important benefits of the contractor maintaining configuration control is the speed with which component improvements can be incorporated into the engine. The proof of this is the outstanding performance and reliability of the engine in service.

COMMERCIAL CATALOG

With the commercial approach the cost data for the engine, spare parts and commercial services are not available to the military customer. The prices are established by the highly competitive commercial market. Again, this may seem to be a deterrent to the military customer’s pricing analyst. The lesson learned is for all parties to be cognizant of the situation and understand that this is a requirement of the commercial sale and is an acceptable although slightly unusual method of doing business with the military. The procurement of parts and services is much quicker with orders frequently being placed by computer terminal in seconds instead of several months for a typical military procurement. The administrative savings for both buyer and seller are significant.

ACCEPT CHANGE

The above issues seem to identify problems and cite inabilities to do business between a commercial seller and a military customer. However, all issues have solutions and, as previously stated, the key to resolution is to understand each other’s needs. While it may seem troublesome, the overall benefits of such an arrangement far outweigh the deterrents.

We must understand each other’s position and requirements - provide innovative approaches and solutions to old standards which may be roadblocks and barriers to success. The F108 commercial engine married to the military KC-135R aircraft is an example of this; although difficult at first, we believe success has arrived (Figure 11).

FIGURE 11

CONCLUSION

The CFM56 engine program started as a unique pioneering effort in international cooperation, and has become the model for many others.

There can be little doubt as to the success of this international program...the results (Figure 12) speak for themselves.

The development, marketing and supporting such a technically sophisticated product as a turbofan engine is no simple task. The efficient integration of the varied resources and technical expertise is difficult enough for a single company...it becomes more complex and challenging as more partners are involved. The successful international collaboration of SNECMA and GE did not occur overnight...it evolved. It has taken effort and
F108 Signs of Success

- Shop visit rate: 0.04/1000 hrs
- In-flight shutdown rate: 0.07/1000 hrs
- Dispatch reliability: 99.975%

FIGURE 12

time for General Electric and SNECMA personnel to develop the mutual trust and respect required for any successful international program, to learn how to effectively communicate and work with each other and establish the comradeship for a unified team. The key ingredients for the specific success of CFMI are these:

- Absolute dedication of top management
- Commonality of interest between partners
- Mutual trust and respect
- Shared "revenues", not costs
- Recognize/accept added cost of integration and communication
- Keep it simple

Last, but not least, is that the international cooperation, as in the GE/SNECMA/CFMI case provide a product that meets the customer's needs.