# International Cooperation in the Development of New Technology for Commercial Transports

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## Abstract

*There is a new paradigm emerging in which the technology for new airplane programs is developed in many different countries. The subject of this paper will be to investigate the different models of international cooperation, giving examples of several programs Boeing now has in work.*

## 1.0 General Introduction

In the past, the technology required for a new Boeing commercial airplane program was largely developed in the USA by Boeing and it's key suppliers. Over the last ten years, this has begun to change, as Boeing seeks to utilize the talents and capabilities of technology developers around the world. A listing of the suppliers providing components for the 777 shows participation from around the globe. (slide 1) In the course of developing the 777, the expertise of Japan Aircraft Industries, Alenia of Italy, Hawker deHavilland and ASTA of Australia, and others was utilized to create the premier commercial transport in service today.

## 2.0 Research and Development work done under contract

As Boeing takes the next step beyond 777, the challenge is to use these worldwide talents to create the underlying technology needed for the next generation of airplanes. There are several models of cooperation, which can be applied to this task. The first we will discuss is **Research and Development work done under contract.** Two examples of this type of arrangement will be examined.

- The first example is the work that IPTN (now known as IAe) of Indonesia has done under contract to Boeing Product Development in the prototyping of low cost fuselage concepts. IPTN and Boeing have been collaborating for many years, during the period of time in which Indonesia was developing its own indigenous aircraft design and manufacturing capabilities. As Boeing looks to develop new low cost design and manufacturing technology, IPTN has played a part by prototyping a new concept under contract to Boeing. (slide 2) In this model of cooperation, IPTN design and manufacturing personnel are used to try out new processes by building a structural test article, which is then tested by Boeing in Seattle. As the work is done under contract to Boeing, the intellectual property created in the process of doing the work is solely owned by Boeing.

- The second example is the work done at the Boeing Technical Research Center in Moscow, Russia, on flow physics and Computational Fluid Dynamics (CFD). (slide 3) During the development of the 777, many hours were expended in running computer simulations of wing shapes, in an effort to optimize the performance of the airplane. In general these simulations were run overnight in a batch mode on a Cray supercomputer. The goal for the future is to run some of these simulations in a more interactive mode using less expensive computer workstations. The Boeing Technical Research Center (BTRC) was formed in 1993 to engage the aeronautical talents of the former Soviet Union for Boeing tasks. One of the first tasks of BTRC was to work on the creation of a quick, workstation based, CFD program. BTRC approached TsAGI (Central Aero-Hydrodynamics Institute) in Zhukovsky, Russia, to see if work done there could be applied to the Boeing task. TsAGI provided experts under contract to Boeing who used research done at TsAGI as the basis of a new BLWF34 computer code. This BLWF34 code proved to be much faster than the codes in use at Boeing, and capable of being run on the equivalent of a Pentium PC. TsAGI retains the intellectual property rights for the original work that they did independently, but Boeing owns the rights to work done jointly in creating the BLWF34 code now in use at Boeing. It should be pointed out that BLWF is one of a suite of many tools used for CFD at Boeing.

Several issues were identified in these two examples, which should be rectified for future cooperation. The use of "technical English" can be a challenge when working with cultures using English as a second language. It is important to use terminology that is readily understood by both parties. Agreement on the system of measurement to be used is also an issue, as conversion from the metric system to English units can cause errors and extra expense. It has been found that insistence on the use of the English system of measure can double the cost of drawing preparation for an organization normally using the metric system. The use of 3D graphics systems such as CATIA can help here, in that they can be "toggled" between the two systems of measure. One last issue is that of effective communications, especially when dealing with a partner 14 time zones away from the home office. It is vitally important that a communications infrastructure be in place that allows for quick transfer of computer datasets, and for video-conferencing to allow face-to-face meetings without the time and expense of physical travel. In the future, it is anticipated that everyday engineering tasks will be performed at locations far away from Seattle, using engineering partners so well electronically linked that an engineer in Moscow, Madrid or Bandung can be tasked interchangeably with one in Seattle.

## 2.1 Coordinated Research and Development

A second model of cooperation used by Boeing is that of **Coordinated Research and Development**, in which commercial entities agree to mutually beneficial work, funded by the respective parties. The example illustrated will be work done between Boeing and the JAI (Japan Aircraft Industries) companies in Japan to investigate low cost structural design concepts. Boeing and the JAI companies have been working together for many years, and have been researching low cost fuselage structural design concepts for a new small airplane. One of these concepts is CAPS, or Cast Aluminum Primary Structure. (slide 4) Boeing and the JAI companies jointly decided to fund the design, fabrication, and testing of several examples of a cast aluminum fuselage bulkhead. A division of tasks was decided upon, and design and analysis work was performed both in the USA and in Japan. After fabrication of the test parts, tests were performed at the Boeing laboratories in Seattle and JAI laboratories in Japan. Because both JAI and Boeing funded the work, the intellectual property was jointly owned by Boeing and JAI. Contractual terms stipulated the terms under which the jointly developed technology could be applied to commercial airplanes.

## 2.2 Coordinated Research and Development that is partially or completely funded by government organizations

A third model of cooperation is **Coordinated Research and Development that is partially or completely funded by government organizations.** The example shown involves work done on High Speed Civil Transports (slide 5) between Boeing, NASA, the JAI companies in Japan, and the NAL national laboratories in Japan. A key issue to be addressed in this, and other types of cooperation is the technology export rules of the US Government. There are strict rules in place known as EAR (Export Administration Regulations) which control the level of contact between US aerospace companies and foreign nationals. Many technologies such as composite structures are controlled under the EAR, and this limits the type of cooperative work, which can be considered.

The effectiveness of this effort has been compromised by the need to comply with strict US technology export rules. Funding for some of the US efforts has come from NASA, and funding for a portion of the Japanese work has come from the Japanese government. As a result of the nature of government funded research in the US, distribution of the work done is on a limited basis. In addition, technology export rules limit the amount of discussion that can take place between US nationals and foreign nationals on a wide range of technologies.

## 2.3 Establishment of global research and technology centers

Reference has been made to the Boeing Technical Research Center in Moscow, Russia, established in 1993. This was Boeing's first step in establishing a series of centers outside of the United States aimed at making the development of new technology a global enterprise. In July of 2002, the Phantom Works branch of The Boeing Company opened the Boeing Research & Technology Center in Madrid, Spain. This center, incorporated in Spain as a wholly owned subsidiary of Boeing, will focus Boeing's new technology efforts in Europe in the areas of the environment, air traffic management, and safety. The center will establish areas of core competency, engaging EU nationals as Boeing employees. It is anticipated that more centers of this type will be opened around the world in the years to come.

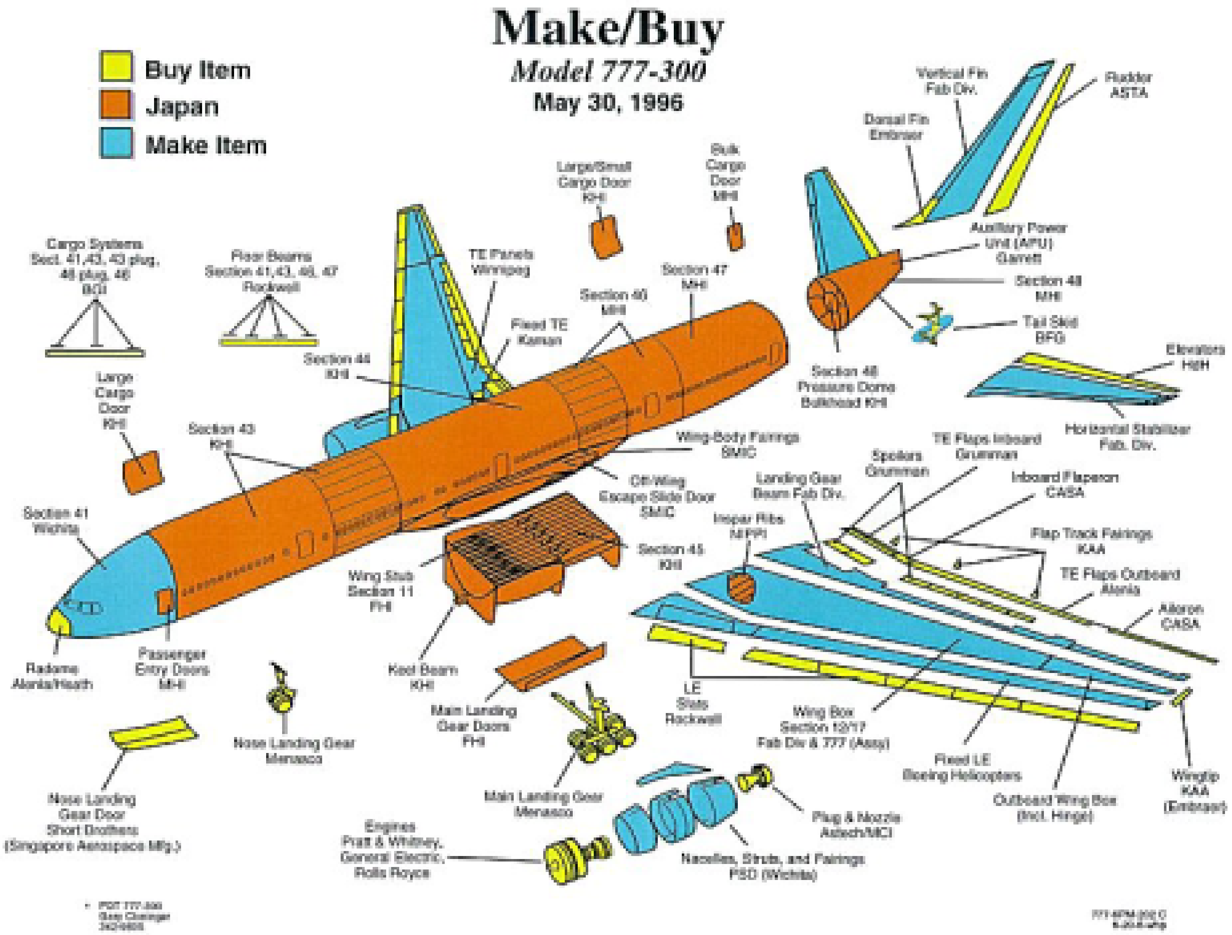
An example of the type of work to be performed in this new center is the Fuel Cell Demonstrator Airplane. (slide 7) This demonstrator is the first step in investigating the effect of emergent fuel cell technologies on the efficiency and architecture of a "more electric airplane". Fuel cells offer the promise of dramatically improving the efficiency of electrical power generation while virtually eliminating pollutant emissions. They also provide useable water as a byproduct. Starting with a small aircraft powered by a fuel cell, this program will investigate the incremental increase in electrical power efficiency, and resultant decrease in fuel burn, that might be achieved through eventual replacement or augmentation of the gas turbine Auxiliary Power Unit (APU) by a fuel cell. It is intended that the Madrid center will work with a variety of European research organizations and universities to demonstrate the potential of this exciting new technology.

Another type of work to be performed in the center is in the area of noise technology. A quick look at the program for any aircraft noise seminar will show a large number of efforts in noise technology in which Boeing and European research organizations are cooperating. The Madrid center will expand on this heritage of international cooperation to continue reducing the environmental impact of our products.

The Madrid center, as well as other Boeing international efforts, will focus on meeting the challenges of the next generation of commercial transports (slide 6).

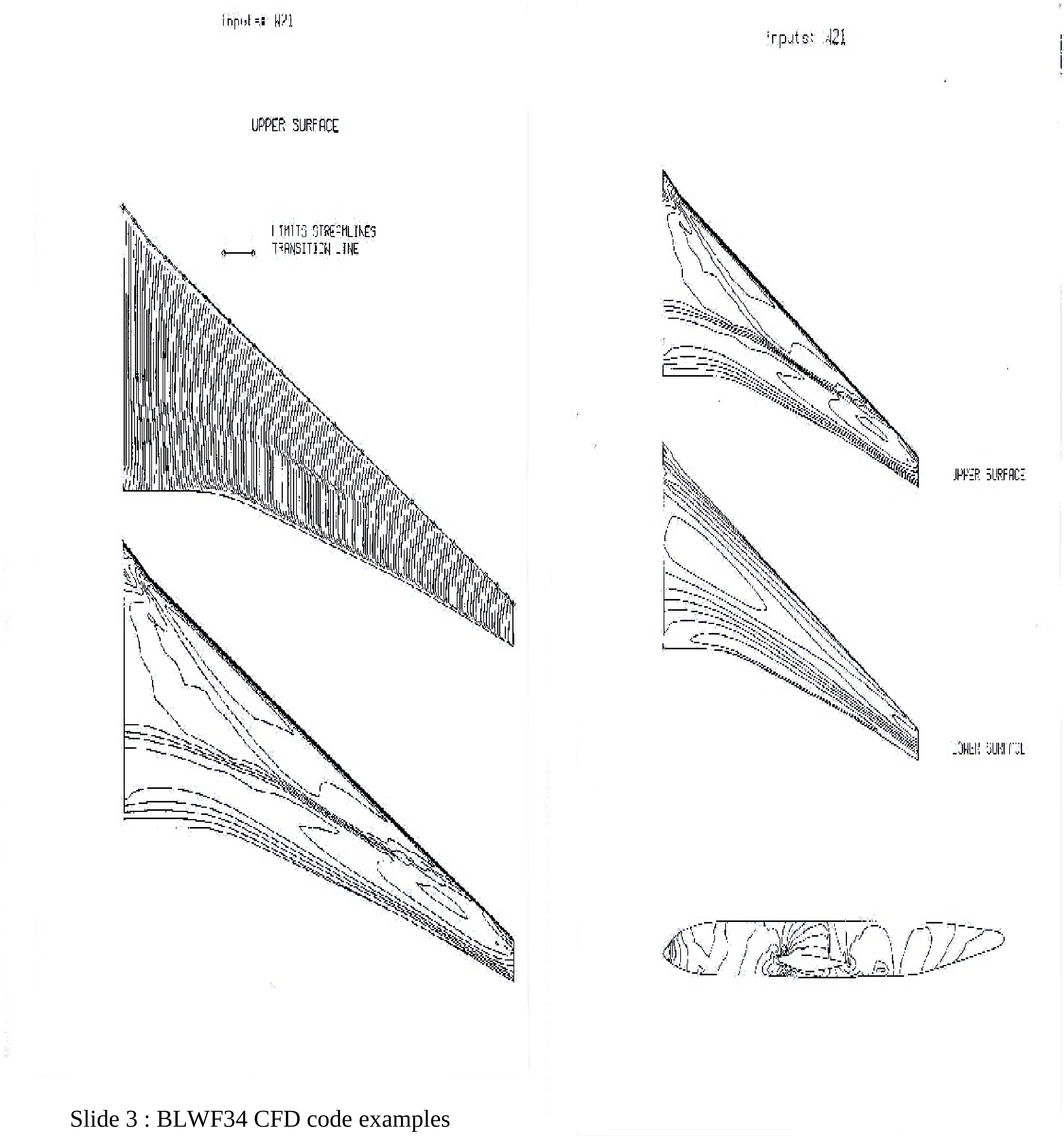
## 2.4 Conclusions

In summary, the nature of technology development for commercial transports has changed in a fundamental way. The creation of a new commercial transport requires the intellectual and financial capital of many nations. Boeing has explored many different models for international cooperation, and found value in applying each one of them in a strategic manner. There are advantages and drawbacks to each form of international cooperation. In total, they represent the new way of doing business in the commercial aviation sector. While Boeing will retain its core role of large-scale integrator, the business of creating the technology to support new programs will take on an increasingly international flavor.




Slide 1: The Make/Buy strategy for the 777-300

Slide 2: Low cost Fuselage Barrel Test article




Slide 3 : BLWF34 CFD code examples

Slide 4 Large Complex Structural Fatigue Casting Test Item

Slide 5  High Speed Commercial Transport Boeing Concept

Slide 6  The Sonic Cruiser- the next challenge


Slide 7 Boeing Fuel Cell Demonstrator Airplane