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March 27, 2000
2358 PeachParkway
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Department of Transportation, Dockets
Docket No. FAA 1999-6411-32
400 Seventh Street SW.
Room Plaza 401
Washington, DC 20590

Gentlemen,

Long before the Flight 800 disaster many of us were concerned about the design of fuel systems in general, so we are excited about the opportunity to get something done about the problem.

In meetings with FAA Atlanta, Jerry C.Robernette Senior Engineer, Propulsion, David Crews, Senior Engineer, Flight Test: Robert Bosak, Aerospace Engineer Propulsion, Paul C. Sconyers, Associate Manager, Atlanta Certification Office sat down with our team and went over our schematics in great detail. We have been encouraged by their help and interest and will continue to work with them. We have also received help from Mercer University Engineering Department (Proof of Concept Research) and Doctor Bill Nease, Economics Department joined our team. We received our Patent Pending about a year ago and are still working toward our final Patent.

In response to your Docket 1999-6411, SHN Aeronautical Technologies submits the enclosed proposal. If you have any questions regarding any part of our proposal please contact Frank Smisson, President. We commend the FAA, NSTB and others who are dedicated to resolving the "Fire Triangle" problem that is endemic to all large commercial certificated planes. We believe our proposal goes a long way in resolving the issue.

We are excited about this project and are looking forward to hearing from you.

Please accept our solution to this problem so that we can get started with the task of making flying safer for us all.

Respectfully,

L. Frank Smisson

L. Frank Smisson
President SHN Fuel Systems

RESPONSE TO DOCKET 1999 64-1 1

BY

SHN AERONAUTICAL TECHNOLOGIES

FORT VALLEY, GEORGIA, USA

SUBMITTED: 26 MARCH 2000

INTRODUCTION

Fuel tank explosions in airplanes have been of concern to air crews, airlines, the military, aircraft manufacturers and their component suppliers, and government air safety oversight agencies for many years. Fuel tank explosions first became a significant issue during World War II when aircraft were exposes to enemy fire with the potential of "hits" in fuel tanks.

Since World War II the potential for catastrophic fuel tank explosions has increased dramatically. This increased potential is driven by several factors related to growth of the airline industry.

1. The tremendous increase in the numbers of airline passengers planes in the skies. Large U.S. air carriers increased enplanements 23.32 percent from the beginning of 1990 through 1996, and are forecasted to increase enplanements another 54.44 percent from the beginning of 1997 through 2008. Overall, this is a 99 percent increase from the beginning of 1990 through 2008, and average of 5.49 percent a year. (See Table I, Appendix.)

2. Increased capacities of large turbojet aircraft (large aircraft-more than 30 seats), increased 37.7 percent from 1987 through 1996. (See Table II, Appendix.)

3. These larger certificated planes are operating ever longer flights in terms of miles flown increasing the opportunity for empty fuel tanks and/or unsubmerged pumps, monitoring equipment and other electrical components. For example, revenue aircraft hours flown by the large certificated air carriers from 1987 through 1996 increased from 3.485 hours to 4.015 hours per flight, an increase of over 30 minutes on each flight. (See Table III, Appendix.) If international flights could be segmented out of these figures the time per flight would probably see a much greater increase. This issue, more time in the air per flight, is being exacerbated today by the growing number of flight delays. Flight delay problems are sure to worsen before being resolved.

4. Life-cycles of large certificated passenger planes are continuing to lengthen in terms of age and total hours flown (e.g., TWA Flight 800 was a 20 year old 747). Hours flown increased 26.7 percent from 199 1 through 1999, and are projected to increase another 44.6 percent from 1999 through 2008. (See Table IV, Appendix.)

5. All of the above will require increased inspections and maintenance which has potential for human error. As is well known, inspection and maintenance of pumps, monitoring equipment and other electrical components being inside the fuel tanks is no simple task. Quite to the contrary- Physical limitations of access, the need to use artificial light, and the hazards of gas fumes all contribute to a difficult and serious task.

6. Because of the inherent design flaw in large airplane fuel systems (electrical pumps, metering equipment, including wiring, insulation, seals and other electrical components being located inside the fuel tanks) combined with the 5 factors mentioned above compound the problem.

7. Consumer demand, the driving force of commercial air traffic, has experienced significant increases over the past decade and is predicted to show even larger gains through 2008. In Senate hearings for FAA funding, Senator Kent Conrad (D-ND) commented that there are 600,000,000 passengers today and this figure is expected to rise to 1,000,000,000 in the next decade. (C-Span, 3 February 2000.) FAA's own forecasts confirm these figures. (See Table V, Appendix.)

Even though air passenger flight safety has a remarkable record of improvement the potential for catastrophic fuel tank explosions is increasing because improvements are being overwhelmed by the growth factors mentioned above. The probability of a fuel tank explosion is very low but when it does occur it is most often catastrophic with many lives lost. Economic costs, both direct and indirect, will also continue to escalate on a per accident basis as seating capacities increase, load factors increase (FAA Forecasts 1997) and as commercial air carriers take more responsibility in settling disputes in a timely manner. (Wall Street Journal, 15 February 2000: Swiss Air FL 111 and Alaska Air Line FL 261.)

It is time to correct the ful system design flaw and eliminate the consequences of the "Fire Triangle". The following paragraphs describe a fuel system concept that resolves the "Fire Triangle" problem, saves lives, and significantly reduces operating and long-term costs.

EARLY HISTORY AND BASICS OF THE SHN FUEL SYSTEM

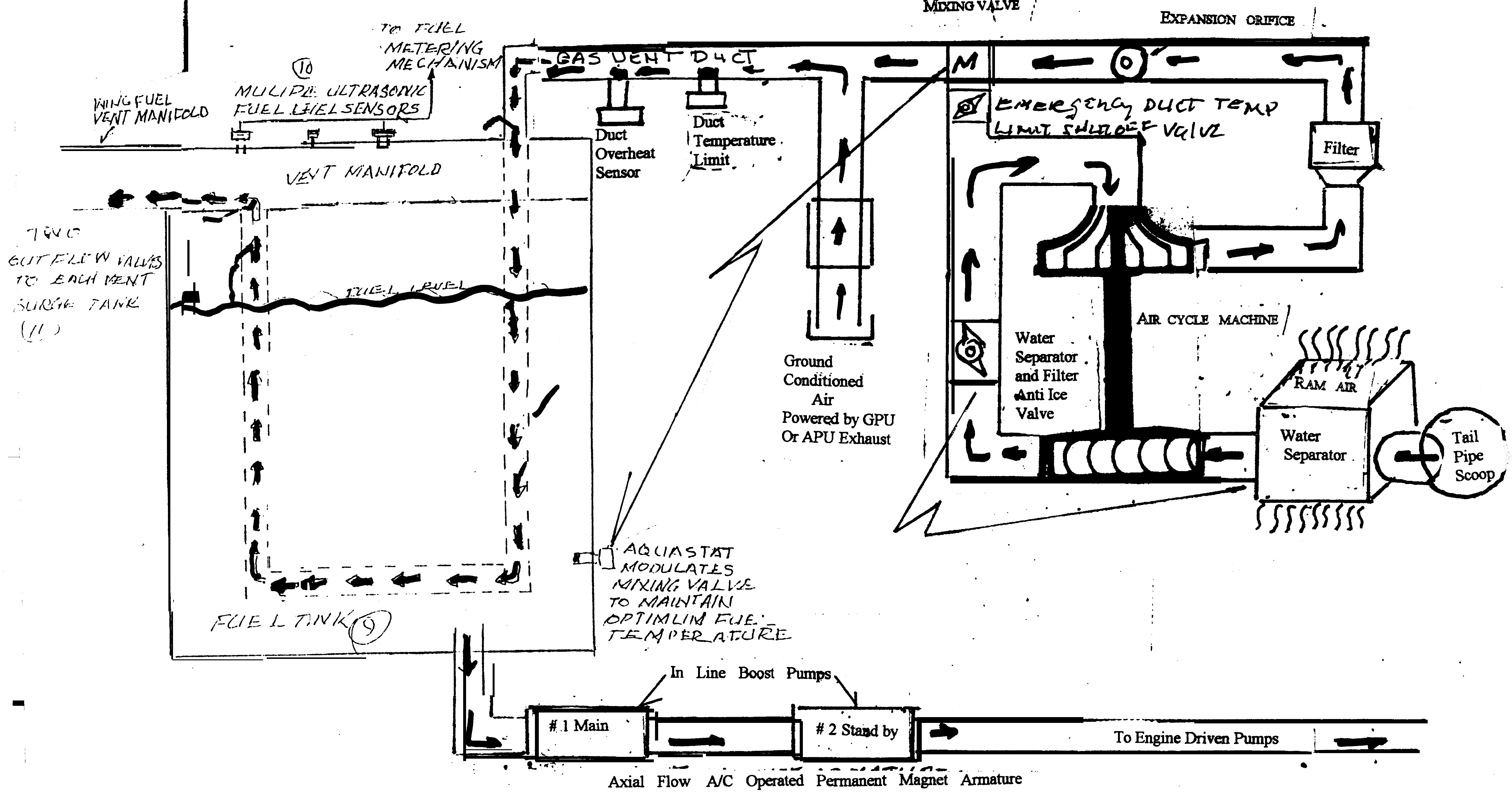
During World War II, (as early as 1938), the Russians developed a fuel tank safety procedure (used in their LN-7 and LN-8 fighters, and other ground attack aircraft) of pumping exhaust gases into and around fuel tanks to reduce fuel tank explosions by purging explosive fumes. The exhaust of an operating jet engine contains carbon monoxide, carbon dioxide, nitric oxide plus several other non combustible gasses, as well as ten parts of water in the form of steam, with more than ample pressure and continuous flow to operate an air cycle machine.

The SHN fuel system is unique in that it uses this flow of non combustible gases to provide a continuous flow of these gases after they have been dried, chilled and filtered to flush all fuel fumes from the tanks and overboard through the outflow valves located in the fuel vent surge tanks in the wing tips. The air cycle machine along with its water separator, expansion orifice, mixing valve and other associated units provide a 2.7 pounds pressure differential and a continuous out flow of fuel fumes and excess non combustible gases that have been chilled or heated to the optimum temperature. An accosted in the fuel tank modulates the mixing valve to provide this temperature control.

The air cycle machine, built to SHN specifications, will incorporate a quick disconnect to the air cycle machine turbine inlet so that the exhaust of the GPU can provide the power and non combustible gasses for safe refueling and chilling of potential overheated fuel. (See NTSB Comment: Docket No. FAA-1999-64-11; Notice No. 99-18, pp 4-5.)

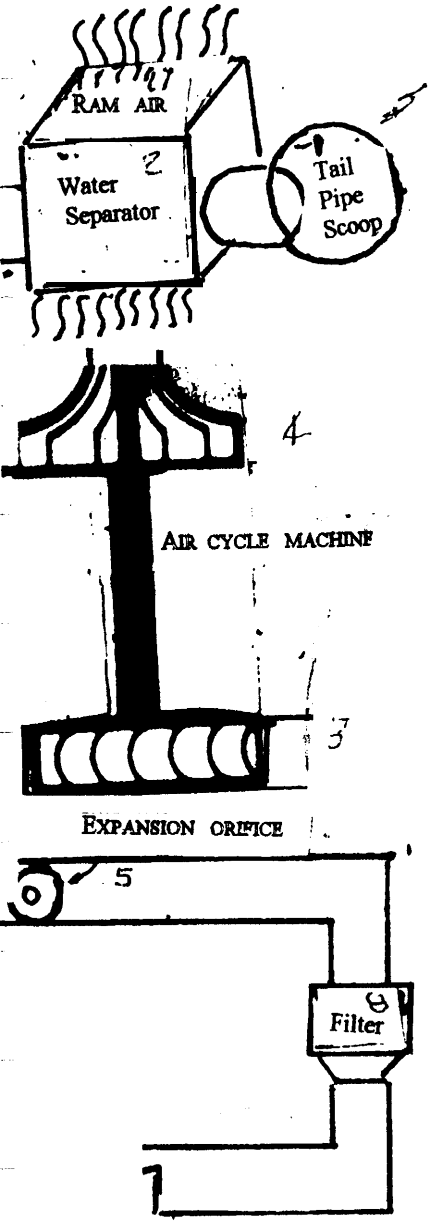
RESPONSE TO FAA DOCKET 1999 64-11

In several readings of your Docket 1999 64-11, the three principals of SHN Aeronautical Tehnologies have developed specific objectives to resolve the problem of potential fuel tank explosions. First, those objectives are identified and the relationship of the SHN fuel system to each of those objectives is made evident. Second, an overview scheme of the SHN fuel system is presented with a summary description of its primary characteristics. Detailed discussion of the system is integrated into the discussions of the objectives with specific reference(s) to particular components or multiple componelnts as appropriate. Third, each objective is discussed clearly showing and/or illustrating how the SHN fuel system satisfies, and in many cases exceeds, FAA's desired requirements. During these discussions the SHN fuel system is presented as both a total unti and its various system elements as an integrated interdependent holistic system whose purpose is to satisfy the objectives in Docket 1999 64-1 1 and eliminate the inherent design flaw now endemic in all large commercial certificated jet aircraft. Where appropriate references are made to the overview model of the SHN fuel system or to a drawing of the system subset.



2 or Stand by boost pump operates as a fuel flow generator during normal operating conditions. In the event of a drop in fuel pressure indicating a possible failure of the # 1, or Main Boost Pump, the # 2 or Stand by Pump will be turned on. The Pump Vanes will be designed and spaced so as to allow ample fuel flow through booth pumps so that full engine power can be maintained with only the engine driven fuel pumps operating.

SHN FUEL SYSTEM



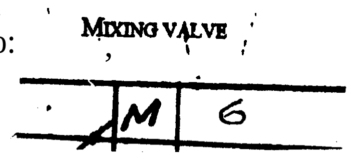
1. Scoop in tailpipe picks up flow engine exhaust and directs it through duct work to:

2. Water separator where steam is condensed into water carrying some contaminates with it overboard. Sicne the outside air temperature at cruise altitude is most often minus 55 degrees C, the water separator must be heated to keep the water from freezing. Approximately ten percent of the exhaust is water in the form of steam. The dried gases is routed through duct work to:

3. The turbine side of the air cycle unit and the exhaust coming from the turbine side of the air cycle unti is routed to:

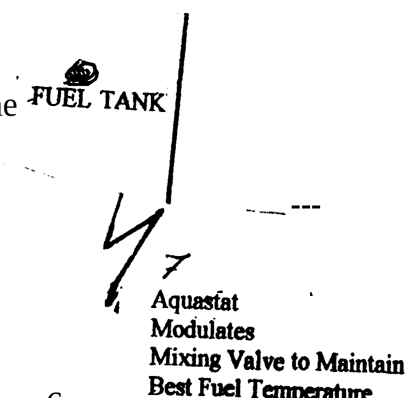
4. The compressor side of the air cycle unit where it is compressed and routed through:

5. The expansion orifice where it expands and chilled to a very low temperature and routed to:



6. The mixing valve that is modulated by:

7. Aquastats located in the fuel tank to control temperature by mixing hot air from the turbine side of air cycle unit with the chilled and dried inert gases. Gases from the mixing valve, adjusted to the required temperature, are routed through duct work that contains:



8. A cotton sleeve which filters out remaining contaminates before reaching the:

9. Fuel tank with:

10. Multiple ultra-sonic fuel level sensors located in top of each fuel tank. An average of all readings gives very accurate readkings of fuel quantity in any aircraft attitude.

11. There are two outflow valves in each vent surge tank that are adjusted to maintain an appropriate positive pressure and to allow gas fumes and excess

inert gases to esacpe. For example, the 767 burns an average of 10,000 pounds an hour (which is 22.5 cubic feet per hour) and the outflow valves are calibrated accordingly to provide a constant out flow. The calibrations are adjusted to meet the requirements of each model aircraft.

OVERVIEW OF OBJECTIVES

1. How the SHN fuel system eliminates all three sides of the "Fire Triangle".

2. All requirements in the Docket 1999 64-aa are met or exceeded with adoption of the SHN fuel system.

3. The SHN fuel system is being prepared for submission and approval as an STC.

4. Catastrophic failure conditions in fuel systems will not occur in fleets that have incorporated the SHN fuel system and are properly inspected and maintained.

5. Proper inspection and maintenance key elements in the desing and operation of the SHN fuel system.

6. Redundancy and fail-safe procedures are built in to all critical components and processes of the SHN fuel system to ensure adequate fuel system operation if a malfunction were to occur.

7. The SHN fuel system has a warning mechanism for the detection of failures or failure indications of critical components.

8. Functional verification of various components' condition is one of the operational capabilities of the SHN fuel system.

9. Proven reliability and integrity to ensure that multiple component failures cannot occur in the fuel system during the same flight, built-in damage tolerance that limits effects of a failure, and a design failure path that controls and directs failure by design to limit failure impacts.

10. Flight crew manuals are an integral part of the total package of every SHN fuel system, describing, among ogther things, procedures to use in the event of a fuel component malfunction or failure to assure continued safe flight by specific crew actions. Built-in redundancy will automatically be activated in most caases of a malfunctio or failure.

11. Error tolerant design that recognizes the possibility of human error in the operation, inspection, maintenance, and replacement of the SHN fuel system.

12. Margins of safety that allow for undefined, unforseeable and adverse flight conditions.

OBJECTIVE # 1

THE FIRE TRIANGLE

For a fire/explosion to occur three objects must be present:

1. Combustible material: in this case, fuel fumes.

2. Oxygen (02): in the fuel tank.

3. Ignition: which can come from a hot motor bearing, a lightening strike, a spark due to the buildup of static electricity, a dropped metal tool striking another piece of metal, or due to auto ignition because of rising temperatures in the fuel tank as the plane is on the ground.

Combustible Materials

The SHN fuel system continuously removes all combustible gas fumes from the fuel tanks. It does this by scooping CO2 and other inert gases exiting jet engines and using these high pressure flows which are pressurized, chilled and filtered, to operate air cycle units to remove all fuel fumes from the tanks. SHN outflow valves are calibrated to maintain 2.7 percent differential (usually the same as cabin differential). Outflow valves are also installed in the vent surge tanks. During ground operations air cycle units are operated by the exhaust of an auziliary ground power unit (GPU), or an auxiliary power unit (APU).

Fuel temperature is controlled by an aquastat in the fuel tank that modulates a mixing valve for purging gases to maintain fuel temperature at desired levels. Docket 1999 64-11, notes on p5, "Vapors from Jet A fuel (the typical commercial turbo jet engine fuel) at temperatures below approximately 38 degrees C are too lean to be flammable at sea level; at higher altitudes the fuel vapors become flammable at temperatures above approximately 7 degrees C, (at 40,000 feet altitude). However regulatory authorities and the aviation industry have always presumed that a flammable fuel air mixture exists in fuel tanks at all times and have adopted the philosophy that the best way to ensure aircraft fuel tank safety is to preclude ignition sources within fuel tanks. It should also be noted that on a typical day (and at operating altitudes) outside temperatures are usually a minus 55 degree C plus or minus IS. Therefore, since the SHN system controls fuel temperature, at no time will fuel approach temperatures that support combustion. Additionally, this philosophy considers only one side of the "FIRE TRIANGLE", ignition. The SHN fuel system by controlling fuel temperature, take ignition and therefore combustibility of fuel and fumes out of technical possiblity.

Oxygen

A significant feature of the SHN fuel system is that it continually purges fuel tanks of all fumes, using inert gases so that the level of O2 never reaches a volume where combustion can be supported.

Ignition

The most insignificant feature of the SHN fuel system compared to present fuel systems in use and the source of the inherent desing flaw, is the removal of all ignition sources from the fuel tanks. By design, two SHN in-line axial flow boost pumps are mounted in series in the main from fuel tanks to the jet engine driven pumps. All SHN in-line boost pumps are designed, constructed and installed to be impact proof (See Figure 2.) The downstream pump serves as the stand by pump in event of main pump failure. In normal operation the stand-by pump operates as a fuel flow generator. In the unlikely event the main pump malfunctions, triggering a drop in fuel pressure, the stand-by pump automatically starts, and without interruption continues supplying fuel at the required pressuer.

All SHN in-line boost pumps are a/c operated, using permanent armatures with field coils positioned external to the carbon fiber housing and made a part of the air frame structure. (See Figure 2.) Ione lamination of the carbon fiber housing contains a copper screen mesh to provide shielding for the purpose of preventing statis pickup by avionic equipment, as well as a bonding connect.

The capacitance type fuel quantity measuring devices along with their associated wiring are eliminated. These present in-use devices and their associated wiring are removed from inside the fuel tanks and replaced with SHN ultrasonic fuel level measuring instruments. There will be multiple SHN fuel level measuirng instruments in the top of each fuel tanke depenidng on its size and configuration. An average of the multiple readings provides very accuragte measures of fuel levels regardless of an aircraft's attitude. The SHN fuel measuirng units use a concept that has a long history of measurement reliability and accuracy. Additionally these units weigh only a fraction of the present capacitance type fuel measuring devices. The SHN fuel system requires no wiring inside any fuel tank thereby eliminating the major source of ignition inside fuel tanks.

Since the SHN fuel system has no wiring in any fuel tank there are no electrically operated boost pumps and fuel measuring devices in any tanks. The SHN system not only eliminated the ignition problem it also reduces weight, increases fuel measurement accuracy, and lowers the cost of inspection, maintenance and replacement.

The SHN fuel system expurgates combustible materials, oxygen and ignition sources from the present fuel system thereby eliminating all three sides of the "Fire Triangle".

OBJECT #2

MEETING REQUIREMENTS OF DOCKET 1999 64- 11

We commend the Federal Aviation Administration for their determination to resolve the "Fire Triangle" problem in large commercial aircraft which will result in the saving of many, many lives over the years. Fior SHN Aeronautical Technologies the process of finding an answer to this problem actually began within a few days after the catastrophic accident of TWA FL 800. Two of the principals of SHN Aeronautical Technologies concluded that an explosion of that magnature could have only resulted from a center wing tank explosion. That was the begining of creating the SHN fuel system. This proposal is the result of our efforts from that day. We strongly believe this system rsolves the "Fire Triangle" issue.

We have ready Docket 1999 64-11 many times and appreciate FAA's focus on all three legs of the "Fire Triangle". Our study of the Docket led to the creation of twelve objectives, when taken in total, do four things:

1. First and foremost, resolve the "Fire Triangle" problem.

2. Create a very reliable, fail-safe fuel system.

3. Incoporate FAA's concerns for a fuel system that is economical in terms of initial costs of components relative to present systems in use, and also in redesign, retrofitting and long term operating costs that include inspection, maintenance, repair and replacement. Indirect long term costs, such as legal and insurance, will also be significantly reduced because of the reliability and fail-safe design of the SHN fuel system, and

4. Recognizing that the SHN fuel system is just one of many sub systems, in which all are interconnected to make up, holistically, an airplane that carries passengers.

All of the objectives are fully discussed and includes a schematic draawing of the SHN fuel system. Our desires mimick those of the FAA, design a fuel system that has little or no opportunity to explode, therefore saving many lives. SHN Aeronautical Technologies has worked toward that goal and we believe that goal has been accomplished.

OBJECTIVE # 3

BASIS FOR STC

After several meetings with FAA officials in Atlanta, Georgia, we have been advised to apply for an STC for the SHN fuel system. The process has begun. A positive response by FAA to our proposal will spur our efforts to attain an STC.

Preliminary evaluations of the SHN fuel system confirm that the SHN fuel system concept is valid and has the potential to save many lives. No doubt the transition to a more efficient fuel system will be time consuming and costly during the retrofitting phase. But eliminating this design flaw is long overdue and in the long run will not only save lives, it will be less costly operationally and reduce indirect costs. SHN Aeronauticl Technologies has taken the first steps in putting this problem behind us.

OBJECTIVE # 4

CATASTROPHIC FAILURE CONDITIONS WILL NOT OCCUR DURING LIFE OF FLEETS USING SHN FUEL SYSTEMS.

The probability of failure in an SHN fuel system is very remote. The strategic partners that supply the variojs components have a history of quality that has led us to work with them to create a fail-safe fuel system that no only meets SHN standards but meets the requirements of FAA's new policy of fuel system safety as specified in Docket 1999 64-11.

The SHN fuel system is designed with in-depth redundancy dramatically reducing catastrophic failure conditions. Since all large certificated passenger aircraft have a minimum of two turbo engines, the SHN fuel system, by design, has built-in redundancy in addition to the on-board APU. For example, a Boeing 767 would hae it's prinmary fuel system powered by the exhaust from one engine and the second engine's exhaust would power a stand-by system in the event the primary system were to malfunction. An additional benefit of the SHN fuel system is the components, by design, weigh significantly less than components presently in use, therefore the addition of a stand-by fuel system does not add weight to the aircraft.

The on-board APU could also be used as the power source for a stand-by fuel system as it has sufficient exhaust to operate the SHN fuel system.

OBJECTIVE # 5

INSPECTION AND MAINTENANCE A MAJOR FACTOR TO SUCCESS OF SHN FUEL SYSTEM.

Fuel system components that contribute to the "Fire Triangle" are inside fuel tanks making proper inspection and maintenance very difficult. The physical demands made on persons responsible for these crucial tasks is severe to say the least. As long as this design flow exists adequate inspection and maintenance will always be suspect. (See Docket for quote.)

The SHN fuel system resolves the desing flaw by removing all electrical components from inside fuel tanks. By design, fuel boost pumps, quantity measuring devices, wiring and other assocalted components are positioned external to fuel tanks. This design feature not only negates the major cause of fuel tank explosions, but these components are now easily accessible to inspectors and maintenance personnel. Accessibility enhances effectiveness and efficiency.

The inspectin and maintenance section of the SHN fuel system operations manual can now be "at the side" of inspection and maintenance personnel as they perform these crucial tasks. Present fuel system design makes the physical presence of manuals during inspections impractical, detracting from effective and efficient inspection and maintenance raising the potential for human error. The SHN fuel system eliminates this problem, leading to improved inspection and maintenance and therefore significantly reducing the potential for human error.

OBJECTIVE # 6

REDUNDANCY OR BACKUP SYSTEMS THAT PROVIDE SYSTEM FUNCTION AFTER THE FIRST FAILURE.

As mentioned in Objective # 4, built in redundancy of the SHN fuel system could be produced to have a primary system plus two back up systems. However, this is an overkill considering the reliability of components in the system.

Our recommendation, is to use one engine to power the primary system and the APU to provide cooling and filtering while refueling or in the unlikely event that there is a failure of the main system use the APU powered system. If our recommendation is followed it would be a saving in cost and weight without sacrificing safety.

Several years ago aircraftr at New York International were lost due to main tank explosions during single point refueling. Gulf Oil Company investigated the explosions and ran detailed studies that revealed the problem to be mixing Jet A and JP-4 fuel and the fact that during single point refueling (approximatley 1,000 gallons in 12 minutes) six to eight inch spark gaps were occurring in the fuel tanks. Jet A fuel would not expode because it was too lean. JP-4 wold not explode because it was too rich. But when mixed there was a point where the mixture was just right for ignition and the spark gaps set the stage for an explosion. In Canada they were using JP-4 at that time. In the States Jet A had already become the standard for civilian carriers.

Purging of fuel fumes during refueling adds afety to the refueling process. There are outflow valves in each vent surge tank. In the unlikely event one of the valves sticks the other two can adequately accommodate any overflow. In the event of a stuck mixing valve causing an overheated situation, an overheat sensor activates a mechanical drive that modulates the mixing valve to the full cold position.

In the event of an over-pressure situation in the ducts and fuel tanks a pressure sensor opens a bypass gate that will bypass the fuel tank to the surge vent tanks until pressure is reduced to normal at which time the bypass will be driven back to normal. (See Figure.)

In event the water separator freezes, a water separator heater will be activated automatically.

There are multiple ultra sonic fuel level sensors in each tank. Actual number depends on size and configuration. They are mounted in the top of each tank. The average of all the sensors gives a very accurate rading of fuel remaining regardless of the attitude of the aircraft. In the event one sensor fails the average of the remaining four will still give a reliable reading of fuel level. If four fail, which is extremely unlikely, an accurate measurement of fuel can still be obtained on straight and level flight.

In the event of failure of one of the in-line boost pumps, a drop in fuel pressure automatically activates the stand-by boost pump.

OBJECTIVE # 7

DETECTION OF FAILURES, OR FAILURES INDICATION

As discussed earlier, all but one of the component concepts in the SHN fuel system have a sixty year record of proven, almost maintenance free service in all environments. All of these component concepts have been upgraded to meet the evermore rigorous requirements of FAA AD's. Additionally, new materials and technology have been incorporated when research and field testing have proven that performance is enhanced. For example, as indicated in Objective # 7, some failures will require action by the crew, and some failures will be corrected automatically by design. For example, a drop in fuel pressure will activate a switch to the stand-by fuel boost pump. Since decisions of whether to flight to it's next destination or make an "emergency" stop for a quick change replacement would be based on crew knowledge that the plane is operating using the stand-by pump.

The SHN fuel system is designed to allow for quicl change out of components, enhance flight safety, and reduce costs of maintenance and down time.

A fuel system indicator light, switch, reset accuator is incorporated into the annunciator panel. This set of acuators, dedicated tothe SHN fuel system, will assist the flight crew to determine the operational efficacy of the fuel system. (See Figure 2.)

If acuator is red flight crew required to take immediate appropriate action. An amber acuator indicates a precaustionary posture and flight crew should examine situation to ensure thaat the backup, or redundancy, system has activated. Green light indicates normal operting conditions. Detailed informatin on flight crew procedures regarding the SHN acuator switches is available in the operations manual. For exampel, a power surge in # 2 boost pump circuit activates the amber light in # 2 boost pump acuator. The pilot would push the # 2 boost pump acuator. In this case the acuator light would become green indicating the # 2 boost pump circuit is normal.

TABLE IV. HOURS FLOWN BY LARGE CERTIFCATED U.S. COMMERCIAL AIR CARRIERS: HISTORICL (1991-1996) AND FORECAST (1997 - 2008)

Year	Number of aircraft	Airborne Hours	Average Airborne hours per aircraft
HISTORICAL			
1991	4,244	10,554	2,487
1992	4,202	10,728	2,553
1993	4,254	11,206	2,634
1994	4,421	11,538	2,610
1995	4,605	12,020	2,610
1996	4,775	12,343	2,585
FORECAST			
1997	4,916	12,690	2,581
1998	5,069	13,042	2,573
1999	5,197	13,375	2,574
2000	5,315	13,802	2,597
2001	5,560	14,443	2,598
2002	5,796	15,101	2,605
2003	6,027	16,778	2,618
2004	6,281	16,518	2,630
2005	6,508	17,198	2,643
2006	6,762	17,948	2,654
2007	6,987	18,617	2,665
2008	7,226	19,335	2,676

Source: <www.api.faa/forcast/foac1697.htm (16 February 2000, Tables 16 & 17.)

TABLE V. U.S. COMMERCIAL AIR CARRIERS: SCHEDULED PASSENGER TRAFFIC - 1991 - THROUGH 2008

Year	Revenue Passenger Enplanements (Millions)			Revenue Passenger Miles (Billions)		
	Domestic	international	Total	Domestic	International	Total
HISTORICAL*						
1991	413.3	39.7	453.1	333.6	113.5	447.1
1992	430.3	42.6	472.9	346.7	128.5	475.2
1993	434.0	45.2	479.2	348.6	134.8	483.4
1994	472.1	46.3	518.4	371.4	138.6	510.0
1995	496.3	48.6	544.8	392.5	144.3	536.9
1996E	523.6	50.3	573.9	418.6	151.1	569.6
FORECST						
1997	546.2	53.1	599.3	439.5	159.4	598.9
1998	569.4	56.1	625.5	459.3	168.3	627.6
1999	591.0	59.2	650.2	477.9	177.9	655.8
2000	613.5	62.6	676.1	497.3	188.2	685.5
2001	636.8	66.5	703.3	517.5	200.2	717.7
2002	661.1	70.8	731.9	538.5	213.3	751.8
2003	686.2	75.5	761.7	560.4	227.0	787.4
2004	712.3	79.8	792.1	583.1	240.1	823.2
2005	739.4	84.2	823.6	606.8	253.8	860.6
2006	767.6	88.9	856.5	631.4	267.8	899.2
2007	796.8	93.6	890.4	657.0	282.5	939.5
2008	827.1	98.5	925.6	683.7	297.6	981.3

Source: <www.apr.faa.gov/forcast/foac 1297.htm (16 February 2000.

OBJECTIVE # 9

PROVEN RELIABILITY AND INTEGRIGTY THAT MULTIPLE COMPONENT OR SYSTEM FAILURES WILL NOT OCCUR ON THE SAME FLIGHT

The various component concepts of the SHN fuel system, but one, have been in use for over sixty years. They have excellent track records of rugged reliability and functional accuracy. Where appropriate SHN upgraded the operating characteristics to enhance reliability for performance and flight safety.

In the event a failure occurs that would shut down the system, (such as an engine), a complete independent stand-by system, powered by the exhaust of the on board APU is available,

In event of failure of one of the stand-by systems, such as the in-line boost pumps, the aircraft will still fly normally, because of the built-in SHN redundancy system (which in this example icnludes a stand-by pump as well as the engine driven pumps).

SHN fuel system components are manufactured to standards that improve the safety factor of each unit. For example, in-line fuel boost pumps are axial flow, permanent magnet armatures with field coils as part of the structure, mounted exterior to the pump barrel. This design feature enhances safety of the fuel system.

The turbine side of the air cycle machines housing has been upgraded with the latest, proven, light-weight rugged materials to protect surrounding units in the unlikely event of a turbine failure.

Since aircraft will continue to fly safely with most components of the SHN fuel system inoperative, the best procedure is to shut down the failed fuel system component. The exception to this is a stuck mixing valve in the "hot" position. First the flight crew would try opening the fuel tank bypass valve to unstick the mixing valve. If all efforts to unstick the mixing valve fail and the bypass valve cannot be opened the emergency duct overheat shut-off valve automatically by duct emergency switch, or can be actuated by the pilot.

At cruise altitude, chances are the otuside air temperature will keep fuel temperatures within limits. If this is the situation the flight crew should monitor fuel temperature and continue on to destination.

Built in redundancy will take care of failures, however, understanding the system and good common sense will ensure a safe flight.

OBJECTIVE # 10

FLIGHT CREW PROCEDURES FOLLOWING FAILURE DESIGNED TO ASSURE CONTINUED SAFE FLIGHT BY SPECIFIC CREW ACTIONS

In event of failure of a complete primary system, i.e., the SHN fuel system, the pilot would switch to the secondary system which is powered from the exhaust of the on-board APU. If it is necessary to start the APU use normal cehck list for starting APU in flight.

A check list is provided with installation of the SHN fuel system. Check lists are modified dto each particular model aircraft. Instructions for operation of the SHN fuel system is provided which includes the fuel panel enunciator.

The SHN fuel system has been automated as far as practical, and in most cases, the system will take care of itself Switching to an alternate system, repositioning valves to alternative operating positions are accomplished automatically when a pressure or heat sensor senses the need.

The SHN fuel system panel includes override switches, providing the pilot with final control. From a practical approach, we have reviewed every possible situation, with Murphy's law firmly in mind.

OBJECTIVE #11

ERROR TOLERANT DESIGN THAT CONSIDERS PROBABLE HUMAN ERROR IN THE OPERATION, MAINTENANCE AND FABRICATION OF THE AIRPLANE.

Only components that have proven track records of reliability and history of practical maintenance economy are used in the SHN fuel system. Aircraft will continue to fly safely with the loss of any or all of the components of the SHN fuel system.

For example, the in-line axial flow fuel boost pumps are designed with ample space between impeller vanes so that adequate flow through the pump continues in event of failure. For exampel, in the 767 more than ten thousand pounds, or twenty two and one half cubic feet per hour, can continue to flow in the event of failure of either pump. In the unlikely event that both pumps fail the engine driven fuel pumps will supply the necessary fuel for safe flight to destination . (See Figure.)

The pumps are designed taking into consideration Murphy's Law: it is impossible to install the SHN pumps backwards. The intake end of the pump has left hand threads while the pressure or outlet end of the pump has right hand threads. In addition, color coding with arrows indicting direction of flow are used with a circuit diagram of the wiring on the barrel of the pump. The accompanying SHN fuel system operations manual not only provides direction for installation of fuel boost pumps and other components, it also provides procedures for inspections, maintenance, replacement and trouble shooting considering a variety of scenarios.

For example, since SHN boost pumps are A/C pumps, inspection and maintenance procedures are significantly simplified over present boost pumps presently in use. All components and installed units are color coded with date of installation and scheduled date of next inspection including th date/hours when replacement is due.

In event of a failure that could affect safety of flight all fuel system valves woudl be driven to normal flight position, unless overridden by the pilot.

OBJECTIVE #12

MARGINS OF SAFETY THAT ALLOW FOR UNDEFINED AND UNFORSEEABLE ADVERSE FLIGHT CONDITIONS

The SHN fuel system is designed to withstand greater stress and adversity thatn the aircraft in which it is installed. No aircraft operations are compromised because of the isntallation of our system. Table V provides several illustrations of the veracity of the SHN fuel system.

TABLE VI. IMPACE OF SELECTED ADVERSE FLIGHT CONDITONS ON SHN FUEL SYSTEM AND FLIGHT SAFETY

Flight Conditions	Affect on SHN fuel system	Affect on Safety of flight
Clear Air turbulance	None	Normal
Lightning strike	All components well bonded	Normal
Icing	Water separator heater turns on	Normal
Excessive Negative "G" forces	None, unless extended inverted flight	Do not exceed published aircraft limitations
Excessive positive "G" forces	None. (Do not exceed published limits.)	Stay within published limits
Engine fire	None or catastrophic	Isolate fuel system

SUMMARY

At the NBAA conference in Atlanta in 1999, we spent many hours examining fuel systems on display. We were pleased to find, upon comparision of these systems with the SHN fuel system, that ours was better designed, more fail safe with superior built-in redundancy. Ruggedness and the historic reliability of the various components of the SHN fuel system left no doubt in our mind of the superiority of the SHN fuel system in it's ability to negate all three sides of the "Fire Triangle".

Throughout this response we have referred to the reliability of the components used in the SHN fuel system. At the heart of our fuel system are the air cycle units and outflow valves. For example, a similar air cycle unit to the SHN unit on a UPS 767 was changed out at 78,000 hours, No inspection is required. Our outflow valves operate 24 months before a required inspection.

In summary the SHN fuel system eliminates the "Fire Triangle", is rugged, reliable and accurate, light weight, simple to inspect, maintain, and replace. The SHN fuel system is both effective and efficient meeting all the requirements contained in Docket 1999 64-11.

APPENDIX

SUPPORTING INFORMATION AND TABLES

TABLER II. TOTAL TURBOJET AIRCRAFT REPORT IN OPERATION BY AIR CARRIERS 1987 - 1996

YEAR	NUMBER OF TURBOJETS	ACCUMULATED PERCENTAGE INCREASE
1987	3,575	
1988	3,915	9.5
1989	3,942	10.3
1990	4,148	16.0
1991	4,167	16.6
1992	4,446	24.4
1993	4,584	28.2
1994	4,636	29.7
1995	4,834	35.2
1996	4,922	37.7

Source: <www.api.faa.gov/forcast/fortab.htm (15 February 2000, Table 5.1)

TABLE III. HOURS FLOW PER LARGE CERTIFICATED CARRIERS 1987 - 1996.

Year	Revenue Aircraft Departures	Revenue Aircraft Hours Flown	Hours Flown Per Flight
1987	308,484	1,075,187	3,485
1988	353,892	1,258,489	3,556
1989	392,028	1,446,188	3,687
1990	419,472	1,556,575	3,711
1991	418,146	1,644,475	3,933
1992	439,046	1,825,202	4,157
1993	460,518	1,933,046	4,198
1994	481,781	1,973,473	4,096
1995	504,572	2,019,103	4,002
1996	525,268	2,108,695	4,015

Source: <www.apr.faa.gov/forcast/fortab.htm (15 February 2000, Table 6.4.)

TABLE IV. HOURS FLOWN BY LARGE CERTIFCATED U.S. COMMERCIAL AIR CARRIERS: HISTORICL (1991-1996) AND FORECAST (1997-2008)

Year	Number of aircraft	Airborne Hours	Average Airborne hours per aircraft
HISTORICAL			
1991	4,244	10,554	2,487
1992	4,202	10,728	2,553
1993	4,254	11,206	2,634
1994	4,421	11,538	2,610
1995	4,605	12,020	2,610
1996	4,775	12,343	2,585
FORECAST			
1997	4,916	12,690	2,581
1998	5,069	13,042	2,573
1999	5,197	13,375	2,574
2000	5,315	13,802	2,597
2001	5,560	14,443	2,598
2002	5,796	15,101	2,605
2003	6,027	16,778	2,618
2004	6,281	16,518	2,630
2005	6,508	17,198	2,643
2006	6,762	17,948	2,654
2007	6,987	18,617	2,665
2008	7,226	19,335	2,676

Source: <www.api.faa/forcast/foac1697.htm (16 February 2000, Tables 16 & 17.)

TABLE V. U.S. COMMERCIAL AIR CARRIERS: SCHEDULED PASSENGER TRAFFIC - 1991 - THROUGH 2008

Year	Revenue Passenger Enplanements (Millions)			Revenue Passenger Miles (Billions)		
	Domestic	International	Total	Domestic	International	Total
HISTORICAL*						
1991	413.3	39.7	453.1	333.6	113.5	447.1
1992	430.3	42.6	472.9	346.7	128.5	475.2
1993	434.0	45.2	479.2	348.6	134.8	483.4
1994	472.1	46.3	518.4	371.4	138.6	510.0
1995	496.3	48.6	544.8	392.5	144.3	536.9
1996E	523.6	50.3	573.9	418.6	151.1	569.6
FORECST						
1997	546.2	53.1	599.3	439.5	159.4	598.9
1998	569.4	56.1	625.5	459.3	168.3	627.6
1999	591.0	59.2	650.2	477.9	177.9	655.8
2000	613.5	62.6	676.1	497.3	188.2	685.5
2001	636.8	66.5	703.3	517.5	200.2	717.7
2002	661.1	70.8	731.9	538.5	213.3	751.8
2003	686.2	75.5	761.7	560.4	227.0	787.4
2004	712.3	79.8	792.1	583.1	240.1	823.2
2005	739.4	84.2	823.6	606.8	253.8	860.6
2006	767.6	88.9	856.5	631.4	267.8	899.2
2007	796.8	93.6	890.4	657.0	282.5	939.5
2008	827.1	98.5	925.6	683.7	297.6	981.3

Source: <www.apr.faa.gov/forcast/foac 1297.htm (16 February 2000.

TABLE I. U.S. AIR CARRIERS, LARGE AIR CARRIERS, ENPLANEMENTS: HISTORIAL (1990-1996) AND FORECAST (1997-2008)

Emplanements	**HISTORICAL**			**FORECAST**		
(Millions)	**1900**	**1995**	**1996**	**1997**	**1998**	**2008**
Domestic	**424.1**	**496.3**	**523.6**	**546.2**	**569.4**	**827.1**
International	**41.3**	**48.6**	**50.3**	**53.1**	**56.1**	**98.5**
System	**465.4**	**544.9**	**573.9**	**599.3**	**625.5**	**925.6**
Percent Increase	**-----------23.31------------**			**---------54.44---------------**		
	------------------------98.88			**------------------------------**		

Source: <www . api. faa.gov/forcast/vol 297. htm (14 Februay 2000 Tables I-2)