AIRPORT COMPATIBILITY CONSIDERATIONS FOR HIGH-SPEED CIVIL TRANSPORT (HSCT)

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The High-Speed Transport contract that Douglas Aircraft Company is currently performing for NASA is a two-year $4.5 million study that will provide:

- Technology assessment from Mach 2 through Mach 25
- Commercial-value study
- Most promising vehicle concepts
- New technology requirements and plans
- National Aero-Space Plane (NASP) commonality.

The ability to sustain supersonic cruise has been the basis of many different aircraft concepts. These include the B-70 at Mach 3 and the SR-71 at Mach 3+, then on to the Concorde at Mach 2.07 and the Douglas AST at Mach 2.2, and finally to the Douglas concept of the High-Speed Civil Transport (HSCT) or "Orient Express." Each design, whether civilian or military, has evolved to meet a new mission. For the purpose of this presentation, a generic Mach 5 model, is being used as a reference.

Basic Characteristics

Basic characteristics of the generic HSCT aircraft are:

- A speed of Mach 5
- A range of 6,500 nautical miles
- Fueled by liquid natural gas, or methane as it also is known
- Cruises at 80,000+ feet
- Carries 300 passengers in a mixed configuration.

The three-view drawing of the generic HSCT shown in Figure 1 has the following dimensions:

o	overall length	227 feet
o	wingspan	108 feet
o	tail height	51 feet
o	wheelbase	104 feet

For a general dimensioning of the HSCT grouping of aircraft,

- overall lengths are expected to vary between to 200 to 250 feet,
- wingspans vary from 100 to 130 feet,
- tail heights of approximately 50 feet,
- wheelbase will vary from 80 to 105 feet.

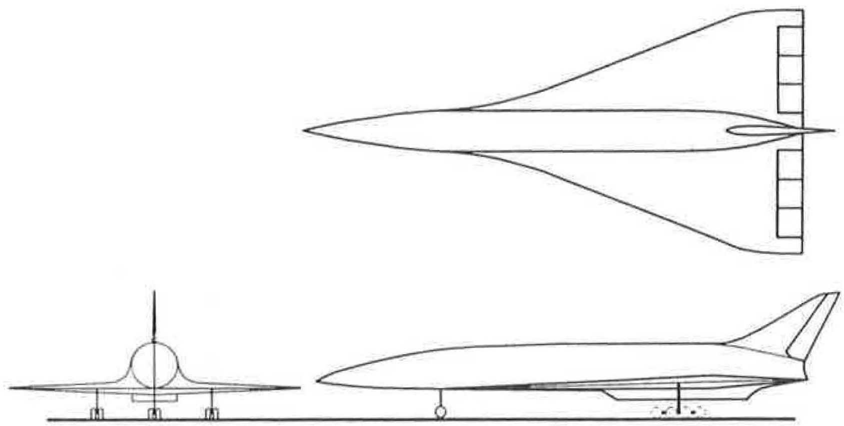

FIGURE 1. Generic Mach 5 High Speed Civil Transport (HSCT)

For comparison, the general characteristics for the two current widebody aircraft are:

		DC-10-30	747-200B
o	Overall length (feet)	181.6	229.2
o	Wingspan (feet)	165.3	195.7
o	Tail height (feet)	57.6	63.5
o	Wheelbase (feet)	72.4	84.0
o	Passengers (mixed class)	227	452

The overall length of the generic HSCT is less than that of the 747. This will affect the ground maneuverability of the aircraft, a situation that is addressed later in this presentation.

Figure 2 is a side-view comparison of the generic HSCT, the DC-10, and the 747. It provides more of a feel for the three aircraft and how they relate to each other in size.

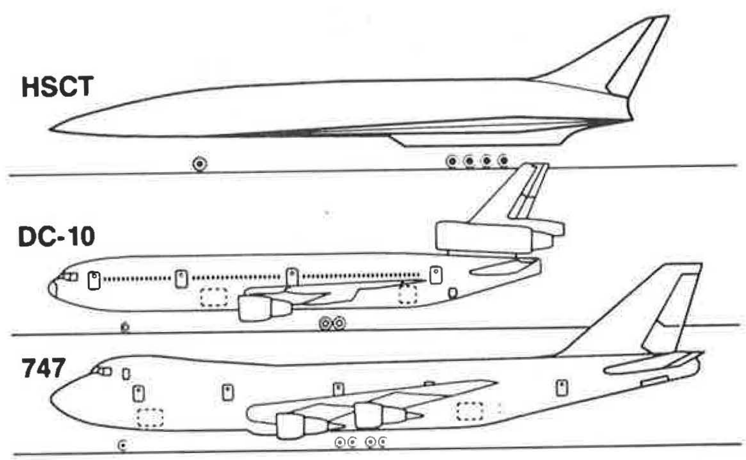

FIGURE 2. Side View Comparison of HSCT, DC10, and 747

Figure 3 is a plan view comparison of the generic HSCT superimposed on the DC-10-30. The DC-10 is much shorter than the generic HSCT, yet has a much greater wingspan.

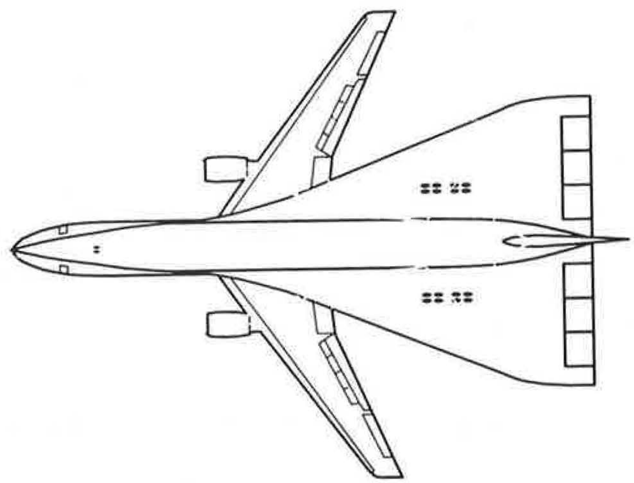

FIGURE 3. Plan View Comparison of DC-10 and HSCT

In the plan view (Figure 4) the generic HSCT is superimposed on the 747-200. The 747 has a similar length yet a much wider wingspan, just as the DC-10-30.

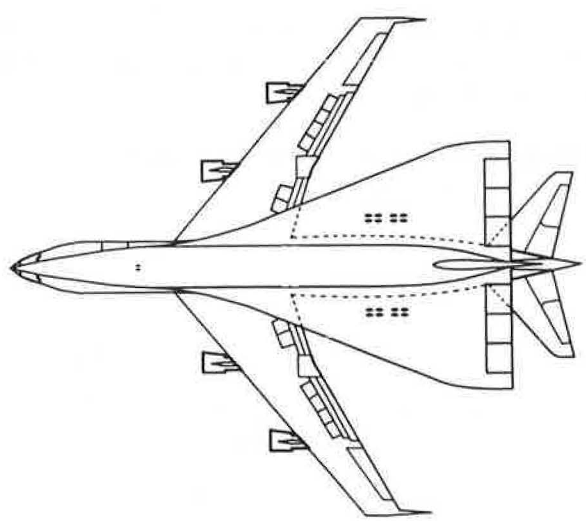

FIGURE 4. Plan View Comparison of 747 and HSCT

Airport Compatibility

Nose-in gate spacing requirements for the generic HSCT, as shown in Figure 5, are such that if the aircraft is powered in and pushed out, resizing of the gate areas is necessary. Wingspan of the generic HSCT results in less required terminal length than for either the DC-10 or the 747. No more distance out from the terminal would be required than for a gate capable of supporting 747 operations.

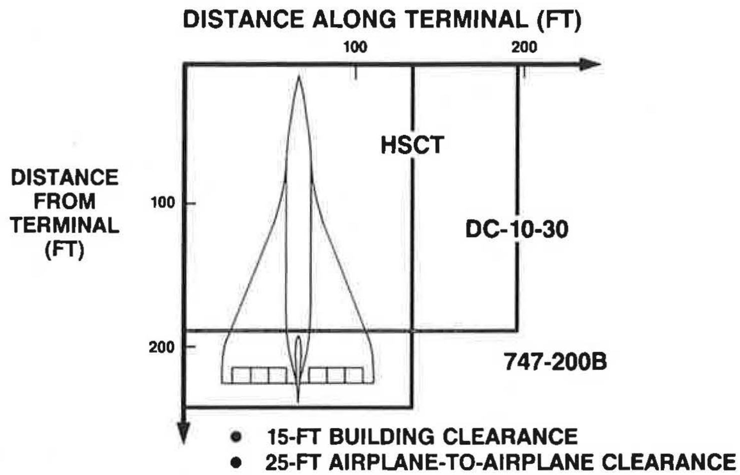

FIGURE 5. Nose-in Gate Spacing Requirement - Power In/Push Out

Footprints of the three aircraft can readily be compared in Figure 6.

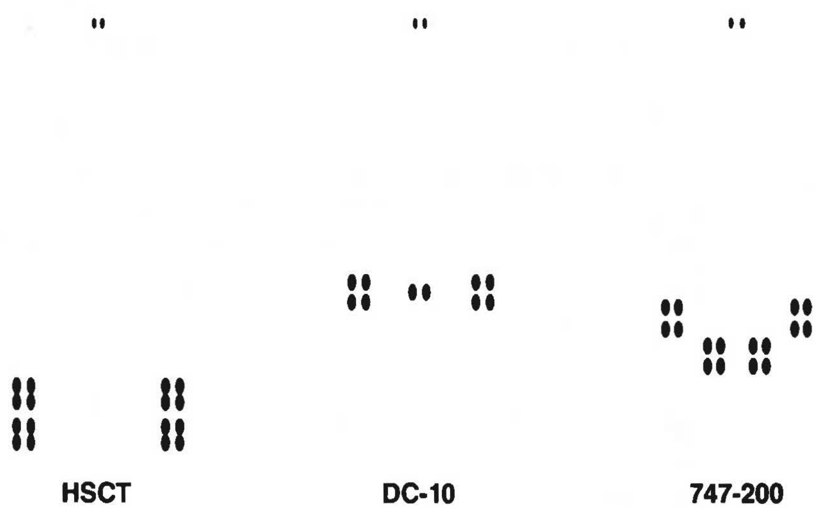

FIGURE 6. Footprint Comparison - HSCT, DC10 and 747-200

Maneuverability of the generic HSCT may present problems at airports designed for aircraft with a much shorter wheelbase. The wheelbase could be up to 20 feet longer than that of the 747 though it may also be comparable length. A steerable main landing gear similar to the body gear used on the 747-200 series would improve the turning capability of the aircraft.

The landing gear configuration will be required to distribute the aircraft weight sufficiently so that the aircraft does not exceed the pavement strength capability of existing airports.

The longer wheelbase would require modifications of a large number of taxiway turn fillet areas. When making a 90-degree turn, the arc of the main gear requires move pavement area. The pilot technique of judgmental oversteering is predominantly used in the United States and involves the cockpit projecting past the taxiway centerline prior to initiating the turn. This technique requires a high level of pilot proficiency.

The pilot technique of cockpit-over-centerline steering is predominately used in Europe and the Middle East. Most airports in these area have the larger fillets that enable this technique to be used. However, the larger areas requires additional construction and therefore greater construction cost.

One of the most important considerations that will affect how the generic HSCT, or any of its group, is handled after landing is the question of airframe heat. Whether the aircraft on landing will retain sufficient skin heat to warrant holding in a cool-down area prior to handling is still to be determined based on studies of thermal management system concepts. If required, the cool-down apron should be located near the runway so that it can be used for both cool-down operations and as a holding area for departures. (See Figure 7.) If heat retention is not a factor, then the apron can be used in a holding-apron mode with fuel top-off capability for the HSCT.

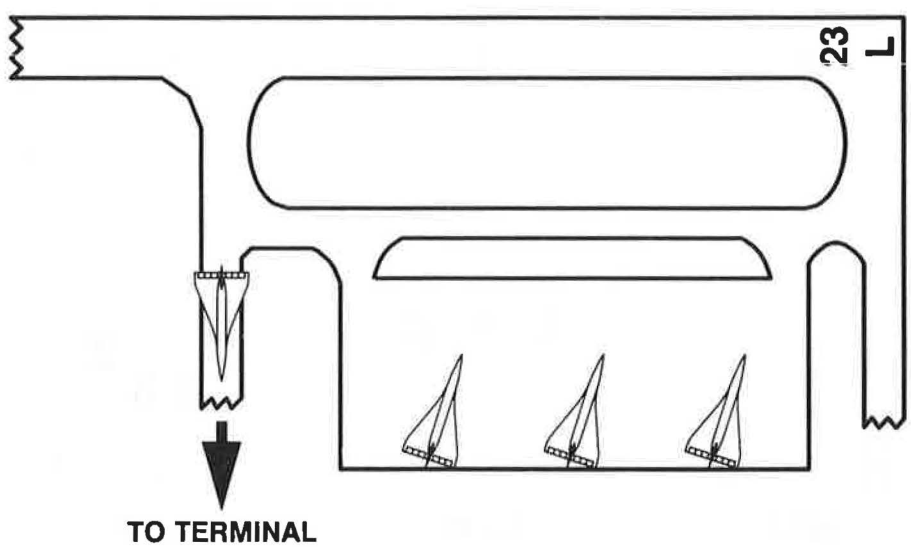

FIGURE 7. Cool-Down and Holding Apron

As shown in Figure 8, wing clearance for aircraft passing on parallel taxiways is not a problem. The generic HSCT wingspan is less than either the DC-10 or the 747; in fact, it is similar to such current standard-body aircraft as the MD-80 and the 727.

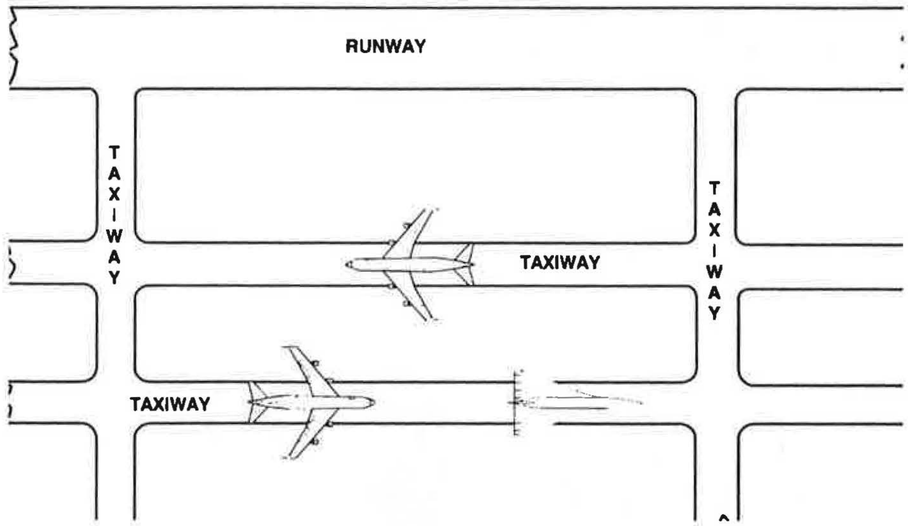

FIGURE 8. Parallel Taxiway Clearance

Fuselage height above the ground for the generic HSCT is higher than for either the DC-10 or 747, but the main passenger door height is about the same for the 747. Access by loading bridges designed for 747 operations should be possible, yet the use of existing loading bridges may place the generic HSCT too close to the terminal due to a longer nose-to-nosegear distance than for the 747 on that specific type of gate.

With the delta wing of the generic HSCT running virtually the length of the fuselage, there is very little easy access to the main deck. Only the forward door is usable with present loading bridges and other passenger loading equipment.

Turnaround time, which has been projected at 1.5 to 2 hours, is affected since passenger enplaning and deplaning can only take place through the single door. If passenger loading equipment is designed to provide access to a second door, enplaning and deplaning time will be reduced.

New concepts will be required for emergency evacuation of passengers. These will include heatproof emergency slides, new door designs, and new egress methods.

The height above the ground of the generic HSCT fuselage is greater than that of either the DC-10 or 747, as shown in Figure 9. Thus, the fuselage height is out of reach of the ground and some service trucks.

New service equipment and service methods will also be needed. For servicing the aircraft, a single drop-down unit might be developed. It would contain service points for potable water, electrical, pneumatic air, air conditioning and lavatory.

The fuel service point will be located separately due to the possibility of contamination, and interference with other operations, during the cycle. Fuel service time for LNG or LH_2 onloading should be similar to that for hydrocarbon fuels during a short-turnaround operation. However, if the aircraft has been sitting overnight or for an extended period of time, the fueling operation will require the additional steps of purging and cooling down prior to bulk-fuel loading. The new fuel types will require additional steps and different safety considerations for operations on the ground.

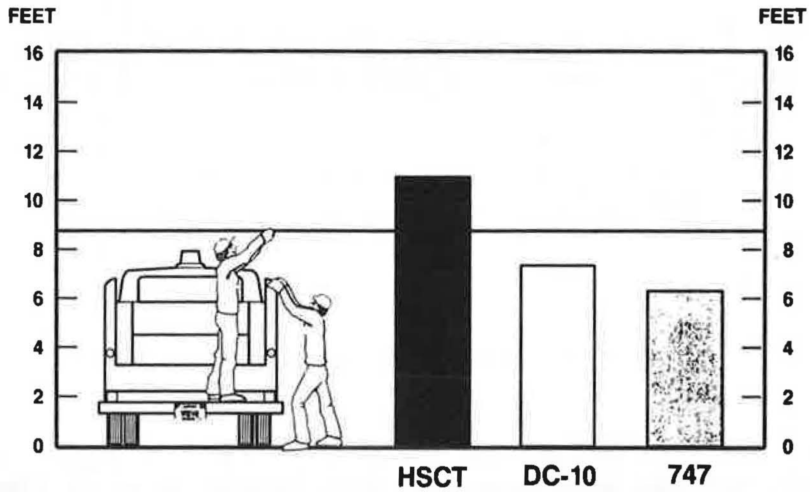

FIGURE 9. Fuselage Height Above Ground

Ground Servicing

The low-aspect-ratio, or delta, wing requires that service vehicles go under the wing to access most of the fuselage.

Cargo handling for the aircraft might also require an innovative approach. There is only one area on this generic model -- aft of the galley service door and forward of the wing -- that is available for a widebody cargo compartment door and baggage handling (Figure 10). A DC-8 type of cargo door in the bottom of the fuselage might be the most efficient for this aircraft.

In addition, the potential heat of the aircraft may be a consideration in handling the aircraft and require thermal protection for ground personnel.

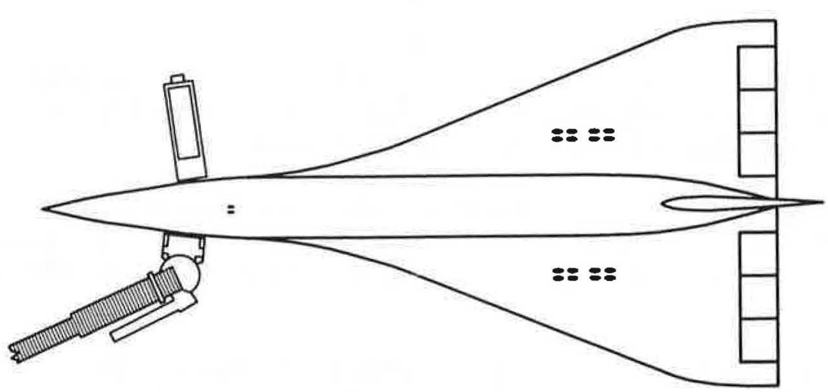

FIGURE 10. Ground Servicing HSCT

Possible Fuel Types

There are three possible fuel types considered for the HSCT series of aircraft: Hydrocarbon (JP), Liquid natural gas (LNG), and Liquid hydrogen (LH_2). Hydrocarbon fuels include both conventional and endothermic fuels which, combined, could have the properties of designer fuels.

Commercial supersonic transports with speeds up to Mach 3 will probably utilize JP fuels similar to those being used today. This would incur a minimum amount of change for facilitation and for procedures. The fuel used for the generic HSCT is liquid natural gas.

The fuel use ranges are shown in Figure 11. Hydrocarbon fuel, used mainly throughout the lower Mach ranges, is viable up to Mach 3+. It is available worldwide as either Jet A, A-1, or B and is the fuel used predominantly by existing commercial turbine-powered aircraft.

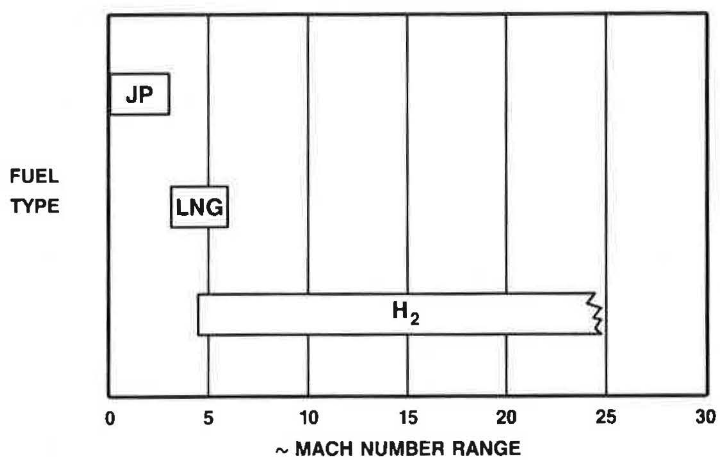

FIGURE 11. Fuel Use Range

Liquid natural gas (LNG), as methane is also known, is available worldwide in commercial quantities. The fuel is used for approximately the Mach 3+ to Mach 6+ range. The fuel is not presently used in commercial aircraft, but it is being used for commercial automotive application. In addition, the existing large-scale production and distribution facilities providing LNG for the industrial sector make it an attractive alternative.

Liquid hydrogen is suitable for use in the ranges of Mach 4.5 to Mach 25+. This fuel is presently in use for commercial space-launch applications. Domestic production capability is limited, and it is produced in only a few countries abroad. The fuel does have the advantage that it can be produced as a by-product of nuclear power generation and by other methods that could make it available in commercial quantities in the next few decades.

A typical schematic for either a LNG or LH_2 airport fuel system is shown in Figure 12. The fuel is either brought to the airport in liquid form or transformed into the state at a liquefaction plan on-site. It is then moved to the service ramp area, distributed, and dispensed into the aircraft. At various points in the system, the ability to vent the boiloff gasses will be required. Flare stacks will be necessary for certain areas. In addition, a captive system will have to be provided as vent for the aircraft in order to purge the fuel system during the cool-down process and to trap any type of overflow.

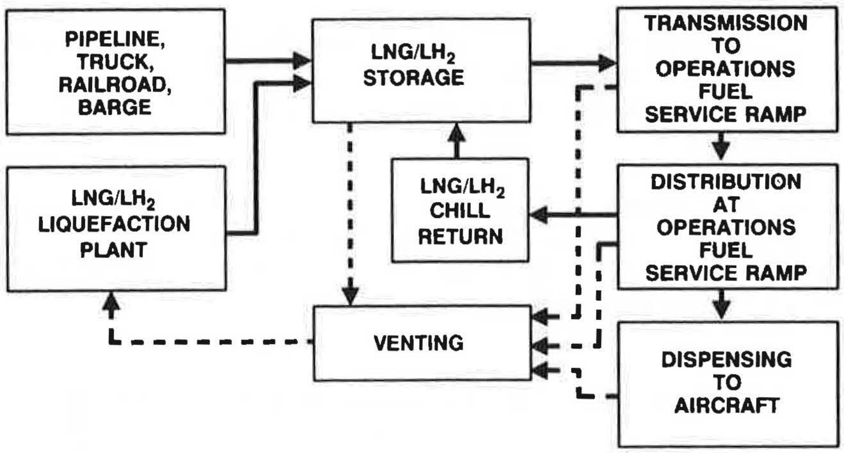

FIGURE 12. Typical Airport LNG/LH_2 System Schematic

Fire protection will include devices such as ultraviolet (UV) light detectors and fuel sniffers. As the flame of LH_2 is difficult for the human eye to see, crash, fire and rescue, ramp, and in-flight personnel will require portable flame detection devices to ensure rapid identification and containment of a fire once it is located. Due to the rapid evaporation rates of both LNG and LH_2, it is felt that the fire danger of these fuels is roughly equivalent to that hydrocarbon fuels.

Figure 13 is a schematic for a hydrocarbon (Jet A) fuel system. It is a much simpler system than that illustrated for LNG and LH_2 fuels in Figure 12.

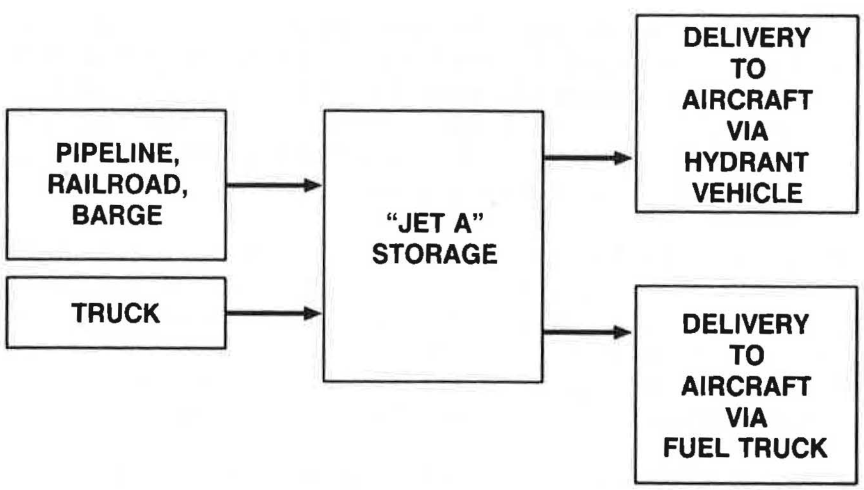

FIGURE 13. Typical Airport Hydrocarbon Fuel (Jet A) System

Fire protection is provided by deluge systems and requires either sensor or visual confirmation to identify the fire. Fire suppression is provided by existing crash,fire, and rescue services.

The principal handling characteristics of conventional JP fuel are

- It is loaded by either pumping or pressure-feed.
- Jet A requires storage above -104^{o}F, and has a 100^{o}F flashpoint.
- It has toxic by-products in a closed environment.
- The flame is visible.
- The liquid clings to surfaces and evaporates slowly.
- Airline and airport handling practices are well-established.

The handling characteristics of LNG and LH_2 are:

- Loading is by either pumping or pressure-feed.
- It must be stored at temperatures to maintain a liquid state: Below -259^{o}F (LNG) or -423^{o}F(LH_2).
- LH_2 flame is difficult to detect by the naked eye thus causing problems in passenger evacuation and personnel locating the flame source.
- As a liquid it evaporates rapidly, but vapor clouds may linger, especially with cold temperatures, thus causing a further problem with both fuels on the ground in the gate area. This is especially so with an inboard gate that may trap a vapor cloud against the terminal for possible ignition. This will require new practices by the airlines and airports.

Operation in Airport Traffic Pattern

An approach speed of 130 knots is the goal for the HSCT in order to ensure its operability within the airport traffic area. This speed will enable the aircraft to operate with current commercial aircraft on approach to the airport. However, due to the fuel-burn requirements of the aircraft, landing sequence priority over subsonic aircraft may be required.

Air traffic control considerations for the terminal area may consist of greater spacing intervals for aircraft following the HSCT during landing approach due to wake turbulence. Also a possibility is the need for special missed-approach procedures for the aircraft due to its low-speed characteristics.

Special climb-out corridors may also have to be provided depending on the altitude at which the aircraft transitions to supersonic flight.

In order for the aircraft to be accepted at airports, especially those that are noise-sensitive, the goal is for the aircraft to meet Federal Air Regulations Part 36 - Stage 3 noise requirements.

Also to be considered is the possibility that by the time the HSCT becomes operational, it should be expected that noise levels possibly lower than those of Stage 3 will be the standard and will need to be met.

Summary

The HSCT dimensions, either the generic model or as a grouping, should not present any unresolvable operational problems at major airports.

The aircraft length and wheelbase can affect parking area and maneuverability requirements, such as size of taxiway fillets.

Heat retention by the HSCT aircraft skin may affect the ground-handling requirements of the aircraft.

Supersonic transports using JP fuels are expected to present the least change for airports. High-Mach supersonic and hypersonic aircraft using either LNG or LH_2 fuels will require new airline procedures (with specific regard for passenger safety) and may cause significant impact on the airport infrastructure.

The ability to operate in the future by using today's airports, updated to the 2005 time period, it the goal for the new HSCT aircraft. The minimum need for facility change will allow the easiest integration of the HSCT into the airport environment.