NASA/CR-2001-210847

A Study of the Economic Benefit Potential of Intermodal Transports

J. M. Nelson, R. T. Kawai, and R. D. Gregg
Boeing Commercial Airplane Group, Long Beach, California

April 2001

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Space Administration

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Prepared for Langley Research Center
under Contract NAS1-20267

April 2001

Available from:

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Foreword

This study was conducted under NASA Contract NAS1-20267 Task 25 for the NASA Langley Research Center.

The study was conducted from May through December 1998 by ***Boeing Commercial Airplane Group*** *Advanced Design* personnel in the Long Beach Division and Seattle Engineering. About 30 engineering specialists made contributions. The study was conducted in support of *Pillar One* of the NASA *Three Pillars for Success.*

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Abstract

A conceptual study was conducted to determine the benefit potential of an Intermodal Transport in which quick-change payload modules are used to reduce the cost of air travel by increasing daily utilization. Three basic concepts varying the degree of modularity were investigated for a 122,000 pounds payload 3,000 NM range regional wide body transport. The profit potential for operating as a passenger transport during the day and as a freighter at night was assessed. Assuming current levels of profitability, Intermodal operations could offer an operating cost reduction potential up to 20%. Enabling technology needs are identified as very quiet aircraft for expanded night operations, distributed load-carrying quick-disconnect latching, and configuration-dependent safety issues. Recommendations are made to explore whether additional benefits are possible from alternative mission and usage modules.

1.0 Introduction

A NASA *Pillar One* goal, as shown in *Figure 1*, is to reduce the cost of air transportation by 50%. In order to reduce costs significantly, focus needs to be directed to the major cost element. In the past, the largest element in airline operating cost was for fuel. Through the years, NASA has continuously developed and supported major technology advancements in aerodynamics, structures and propulsion that have improved efficiencies contributing to lowering fuel consumption.

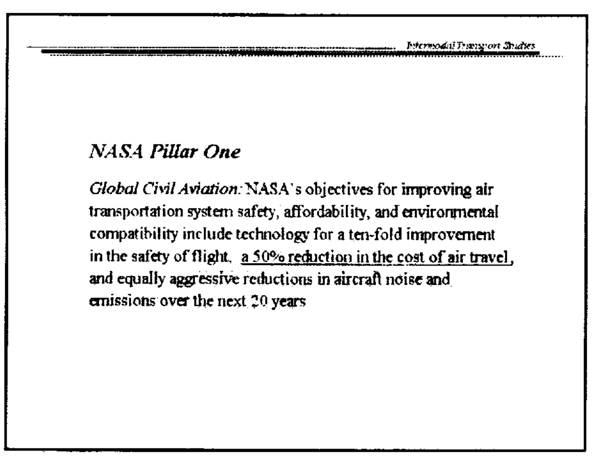

Figure 1

Concurrently, other costs have risen such that, as depicted in *Figure 2*, the cost of ownership has become the largest element of the major contributors to airline operating cost.

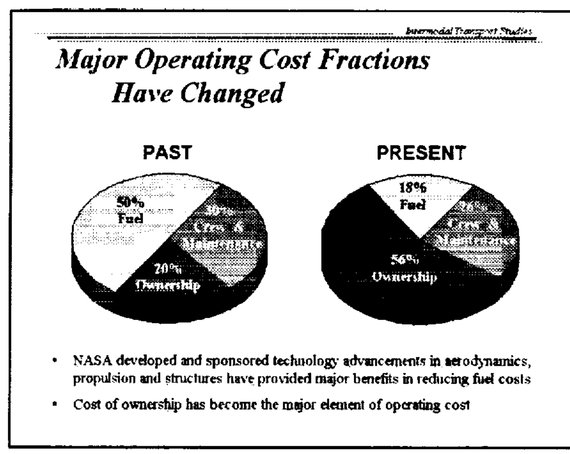

Figure 2

A major reduction in the cost of air transportation clearly requires a reduction in the cost of ownership. Low cost manufacturing technologies and improved production efficiencies are familiar pennants for reducing the hardware product cost. An alternative approach is to improve utilization. Since the ownership cost elements, depreciation, interest, and insurance are annual costs, increasing daily utilization can reduce the share of ownership cost charged to each trip, thus reducing operating cost per trip.

In order to increase utilization in this study, aircraft were conceived to change operating modes from passenger transportation during the day to cargo transportation at night, allowing round-the-clock usage of the transporter. This Intermodal operation was facilitated using large quick-change payload modules.

2.0 Study Results

2.1 Top Level Requirements

Top level requirements are shown in *Figure 3*. The purpose of this study was to make a top-level assessment of the potential benefits

Intermodal Transport Study

Intermodal Transport Top Level Requirements and Objectives

Description	Criteria	Rationale
Technology Level	Consistent with comparison baseline Basic aero, propulsion, structures are current technologies. New technologies applicable to Intermodal are acceptable	Required to identify Intermodal benefit as to generic advancements
Airplane performance and operation	Competitive with economic comparison baseline consistent with Intermodal operations	Requirement for rational comparison
Airport compatibility	May require additions or mods but must operate within current airport infrastructure	Required to facilitate introduction and for intermediate stops
Rules and regulations	Must meet current government rules, regulations, certification criteria	Required to operate in commercial service
Operating cost	Significantly reduce operating cost compared to the economic baseline	Study objective

Figure 3

from modal changes using preliminary design analysis methods. As such, conventional technologies for which performance and weight estimates can be made with confidence were applied. Some unconventional aircraft configurations may enhance Intermodal operations but present too many unknowns, leaving it uncertain whether benefits, if any, came from Intermodal, advanced technologies, or optimism due to oversight.

The airplane performance and operation should have competitive capabilities but the aircraft should be sized for Intermodal operations.

The Intermodal needs to be compatible with the current airport infrastructure in order to facilitate intermediate stops for inter-plane transfers with conventional aircraft. In addition, a new airplane type will be introduced gradually. A large fleet of a new airplane type with new airport infrastructure in place at the onset of operations is not realistic.

Current rules and regulations must also be met.

Minimizing operating cost is a study objective.

2.2 Comparison Baseline and Design Mission

A comparison baseline was selected from an existing family of aircraft in order to recognize the magnitude of weight and drag penalties introduced from incorporating the Intermodal capability. The design mission was established consistent with the expected usage of an Intermodal Transport.

The Intermodal should be a medium range transport. Since the premise is to operate as a passenger transport during the day and a freighter at night, long-range operations that have flight durations of 12 to 16 hours would not leave time for night freighter operations.

For short ranges, airfreight would not be cost competitive with surface trucks in most cases.

A widebody medium-range baseline was selected over a narrow body for space efficiency, carrying LD-3 containers, and the likelihood of having favorable economics (because the cost for incorporating Intermodal would be a fixed cost plus a size-dependent variable cost). The larger size should have more favorable economics.

The medium-range widebody comparison baseline selected was the B767-300, which is available in passenger and freighter versions. The B767-300 is depicted in *Figure 4*.

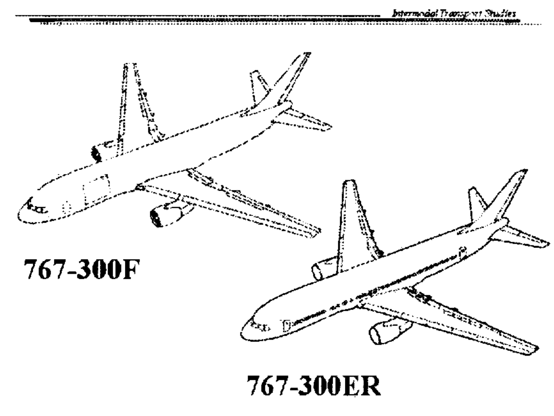

Figure 4

The design range for the Intermodal was selected from a review of worldwide regional transport operations. 3,000 NM was determined to be a reasonable design range covering major city pairs in North America, Western Europe, and the Asia/Pacific region where most of the world's passenger and cargo regional air traffic occurs.

The design payloads were selected to match the B767-300 at 218 three-class passengers and 122,000 pounds freighter cargo.

2.3 Intermodal Transport Concepts

The 767-300ER and -300F Baseline aircraft established payload/range requirements for the Intermodal Transport study mission, which influenced key aircraft design characteristics such as wing geometry and power plant selection. Prior to developing detailed configurations, however, the Intermodal team "brainstormed" concepts for aircraft conceived around Intermodal conversion and how various methods of conversion would impact the configurations.

The underlying premise of the Intermodal concept is that payload modules would be attached or removed from a "transporter" airframe to allow rapid conversion from one mode of payload carriage to another, be that passenger to freight, one shipment of passengers to another, one shipment of freight to another, etc. This multi-mode capability would allow round-the-clock utilization, and rapid conversion between modes would minimize Transporter time on the ground and maximize time in the air, where the aircraft is productive. The direction a module is loaded or off-loaded affects the configuration. If loaded from the tail, for example, the conventional empennage would have to be rearranged or relocated to allow clearance for module transfer. If loaded from the nose, the flight deck would be affected, and so on.

To understand the numerous configuration possibilities, the Intermodal team established a matrix that assessed four types of payload modules:

- Detachable module with upper and lower decks
- Detachable module with upper deck only (belly cargo deck with transporter)
- "Cassette" module inserted into the main deck of a full airframe
- Multiple detachable modules which could be attached/detached separately and transported within and outside of the airport environment

All possible directions from which each module type could be loaded onto a transporter were considered. Subsequently, transporter configuration features that could accommodate each module type and loading direction combination were considered. As part of the process, sketches and layouts were drawn for most of the configurations and their relative merits discussed by a multi-disciplined team at regular design meetings. Some configurations were conventional, while others were novel and "advanced" in relation to current state-of-the-art transport aircraft. Three of the latter are shown in *Figure 5*. At the top is a gulled C-Wing configuration accommodating an aft-loading payload module. In the center is a dual-pod concept with "cassette" modules inserted into each overwing pod. At the bottom is a Canard configuration with aft-loading payload module.

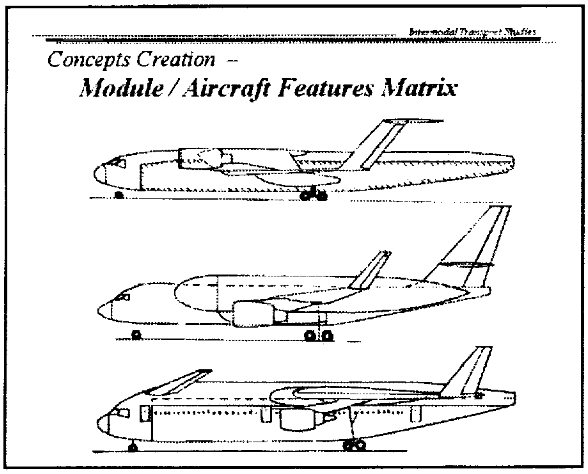

Figure 5

Following a three-month period of concept creation and analysis, the Intermodal team "took a vote" and conducted a macro down-selection process. Each engineering discipline was tasked with doing multi-criteria rating of each configuration from its own perspective. The combined results were not "weighted" because of a lack of appropriate methodology for doing so; as a novel concept, no substantial body of design or operational experience existed for an Intermodal aircraft. The final "scores," however, did match the group consensus on which three configurations should be selected for detailed evaluation.

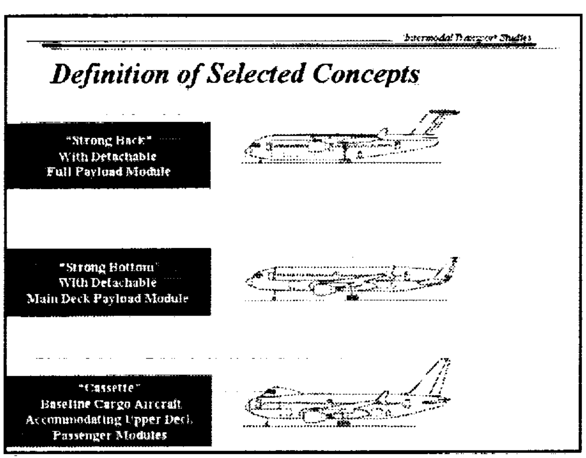

Figure 6

2.4 Evaluation Concepts

Figure 6 shows the three configurations selected. Each accommodates a different module type. The "Strong Back" concept at the top includes a detachable module with upper and lower decks. The "Strong Bottom" concept in the center includes a detachable upper deck module with the lower cargo deck integral to the transporter. The "Cassette" concept at the bottom is a full airframe accommodating insertable main deck modules through an upward-hinging nose door. The detachable multi-module concept was considered but deemed unfeasible for this particular study because of the aircraft size. A passenger capacity of 218 tri-class seats and team-established "market desirable" requirements for using standard cargo containers resulted in a fuselage cross section more than two times wider than the widest loads permitted on public surface streets without the issuance of special permits. Therefore, it would be very difficult to transport these modules outside the airport environment using the current infrastructure.

All three concepts share configurations of conventional appearance. As discussed previously, so-called "advanced" aerodynamic and structural configurations, such as C-Wings and Canards, were considered; however, ultimately they were excluded from detailed study because of the unknown effects those advanced features could have on the overall economic study. If an Intermodal concept using novel aero/structures were to show an economic advantage, how much of that advantage would be attributable to the intermodal productivity gains, versus how much of it from the advanced technology? To keep the comparison with the "conventional" baseline 767 airplanes even, "conventional" Intermodal configurations were selected.

All three concepts were sized to the same mission requirements for performance and economic analyses:

- Freighter Mode Range of 3,000 NM carrying 122,000 lbs. Weight Limited Payload; 218 tri-class passengers plus bags with range a fallout
- 0.80 Mach cruise speed
- Take Off Field Length ≤ 10,500 feet
- Initial Cruise Altitude ≥ 33,000 feet
- Approach speed ≤137 knot

Each configuration had its unique features. The "Strong Back" required conceptual development of a main landing gear more than twenty feet tall. The "Strong Bottom" had a low-mounted horizontal with twin vertical stabilizers. The "Cassette" configuration included an upward-hinging "visor-type" nose door running aft to the fuselage constant section. Schemes for latching the module with the Transporter (especially for the detachable modules) were devised and necessary enabling technologies identified.

As sized for the study, the three configurations had wingspans in the 175-180 foot range and lengths of 162-184 feet.

To minimize investment in Ground Service Equipment (GSE) necessary for Intermodal conversion, specialized mobile trolley concepts were developed for each configuration, which could be used with existing large aircraft tugs. In combination, the trolleys and tugs would provide both module transport to/from the aircraft <u>and</u> transfer of the module on/off the aircraft. The trolleys would include all-wheel steering for maneuverability and "smart" leveling systems to align the trolley with the aircraft for module transfer.

2.5 Mission Analysis

The aerodynamic and weight characteristics were developed for each of the study aircraft using preliminary design methods within the Boeing Computer Aided Sizing and Evaluation System (CASES). A sizing and performance evaluation was then conducted using the CASES program. The resulting performance characteristics are summarized for each of the study aircraft in *Figure 7*. The 767-300 is included for comparison. The Intermodal aircraft were sized to meet 3,000 NM range requirement with a weight-limited payload of 122,000 pounds. Other aircraft requirements included a maximum takeoff field length of 10,500 feet at maximum takeoff weight (MTOW) and a minimum initial cruise altitude capability of 33,000 feet. All Intermodal aircraft satisfied these requirements. The MTOW for the study aircraft are 446,600 pounds, 428,000 pounds, and 421,200 pounds for the V-9, V-10, and V-11 configurations, respectively. The 767 MTOW is 412,000 pounds for comparison and has over a 9% better range capability for a given payload than the Intermodal configurations. The primary cause of this is the higher OEW of the Intermodal configurations compared to the 767.

Intermodal Transport Studies

Performance Capability Comparison

MODEL	B767		V-9		V-10		V-11	
	300 ER	300 F	Passenger	Cargo	Passenger	Cargo	Passenger	Cargo
MTOW	412,000	412,000	445,600	446,600	428,000	428,000	421,200	406,200
OEW	199,408	186,505	237,928	213,754	234,215	209,341	224,634	187,907
Payload	45,780	122,000	45,780	122,000	45,780	122,000	45,780	122,000
Range	6,100	3,270	5,060	3,000	5,300	3,000	5,280	3,000

Figure 7

2.6 Economic Benefit Potential

An economic evaluation was conducted by initially determining the profit potential of the study aircraft. Any significant improvement in the profit generated by an aircraft could result in a reduction in ticket prices; however, the aircraft user must make business decision about how economic improvement is used.

To estimate the profit potential of the Intermodal concept, an economic analysis was conducted using the Boeing OPCOST3 model on the V-9 and V-10 using the estimated performance capability discussed above. Profit is the total revenue generated by an aircraft minus the operating cost of the aircraft. V-11 is not included because this aircraft does not truly utilize the Intermodal concept, but represents a Quick Change (QC) Convertible Freighter configuration for comparison. As a result, the V-11 economics were not evaluated for this study. However the weight and aerodynamic characteristics for this configuration would produce better performance results than the V-9 and V-10 configurations. A QC Freighter would not, however, provide the off-transporter operational benefits possible with the payload modules as described later. This would reduce the utilization benefit associated with the Intermodal aircraft concept.

Intermodal Transport Studies

NASA Intermodal Transport Aircraft Economic Summary

1997 U.S. International Majors and Freighter Rules – 3,000 NM

12-hour passenger, then 8-hour freighter

	Maximum Theoretical Benefit*	"Strong Bottom" V 10 Detachable Passenger Module Only	"Strong Back" V 9 Detachable Passenger and Cargo Module
Total Annual Revenue	$81.25	$82.43	$83.32
Annual Operating Costs	$69.97	$71.72	$74.33
Annual Operating Profit	$11.28	$10.71	$8.99
Relative Profit	Base	- 5.05%	- 20.30%

** Synthesized aircraft based on a 767-300ER passenger and freighter aircraft*

Figure 8

Figure 8 presents the annual operating profit of the study aircraft assuming that each aircraft is utilized 12 hours a day for passenger service and at night would be operated for 8 hours carrying freight. A Maximum Theoretical Benefit level was established for comparisons between the various Intermodal aircraft concepts. The Maximum Theoretical Benefit is based on a 767-300ER used for 12 hours and a 767-300F used for 8 hours just as the Intermodal aircraft were utilized. However, there are no 767's configured to allow this aircraft to operate in this manner, and the weight would be higher than the current aircraft, hence this estimate represents the Maximum Theoretical Benefit that could be obtained for a 767-type aircraft. As is shown on this chart, the Maximum Theoretical Benefit on the annual operating profit is nearly $11.3M per aircraft. The V-10 configuration falls about 5% short of this number (at $10.7M per aircraft) while the V-9 shows approximately a $9M profit per year (a 20% reduction relative to the Maximum Theoretical Benefit) potential.

As a comparison, *Figure 9* shows the profit per aircraft for 10 major airlines during 1996. An average profit per airplane based on this data (removing the highest and lowest performers) was $1.5M per aircraft. 1997 numbers were slightly better. Assuming a higher than average profit level of $2M per aircraft per year and if the remaining economic benefit were applied to lower passenger operation costs, there would be a reduction of up to 20% in the cost of air travel.

Intermodal Transport Studies

Airline Profitability Per Aircraft – 1996

Rank (by RPK)	Airline	Revenues ($ Millions)	Operating Profit ($ Millions)	Fleet	Profit/AC ($ Millions)
1	United	15,781.5	1,130.2	566	2.00
2	American	15,009.4	1,315.5	644	2.04
3	Delta	12,952.3	571.1	545	1.05
4	Northwest	9,651.3	1,107.9	410	2.70
5	British Airways	10,410.6	1,220.6	229	5.33
6	Japan Airlines	8,999.4	124.2	129	0.96
7	Lufthansa	10,477.7	271.7	207	1.31
8	US Airways	7,372.5	368.6	395	0.93
9	Continental	5,310.9	394.4	300	1.31
10	Air France	6,442.3	-581.0	145	-4.00
	Average				1.36
	Average *(minus highest and lowest)*				1.54

Figure 9

2.7 Intermodal Considerations

Some additional considerations for Intermodal Transports include the benefits compared to a Quick-Change Convertible Freighter, disadvantages from additional ground handling and the need to expand night operations.

Past and Present Quick-Conversion Aircraft

The benefit from increasing utilization was recognized in the 1960's when the B727QC, a Quick-Change Convertible, was introduced by major airlines including Braniff, Eastern and United. Conversion could be done within one hour. This earlier experience was unsuccessful because of high operating costs and reliability problems. Overnight shippers offering direct delivery service took over the nighttime freight, including the aircraft, which were then converted to freight-only aircraft. Since then, the fuel burned operating cost fraction due to weight has decreased from 50% to less than 20% and the ownership fraction has more than doubled. There is also a large freighter network carrying an order of magnitude more cargo. The cargo market is predicted to expand at a 6.4% rate compared to a predicted passenger traffic growth rate of 4.9%.

Presently, there are still QC aircraft in operation, but they only number about 100 in a total commercial fleet of over 12,000 aircraft. The largest QC operator is L'Aeropostale which has nineteen 737-300QCs and two 727QCs operated by the French Post Office to carry mail at night and Air Inter for carrying passengers during the day. Other daily converters are Air Alaska, Aloha, the German Postal Service, and Lufthansa. UPS converts for weekend passenger charter flights.

The current QC's allowing daily conversions use seats on pallets. Such an approach on the current study size aircraft would entail large weight penalties as shown in *Figure 10*, which also exhibits the benefits possible with an Intermodal configuration. For freighter operations the cargo module could be bulk loaded at the freighter terminal reducing the weight of pallets.

Intermodal Transport Studies

QC Weight Penalties

	Δ Weight (Lbs.)
Freighter Mode	
Passenger windows and doors, lavatories, galleys, sidewalls, ceiling, overhead bins	15,600
Bulk load Intermodal	6,000
	21,000
Passenger Mode	
Cargo door, cargo floor with cargo handling, seat pallets	12,000
Passenger interior tailored to average load factor	6,800
	18,800

Figure 10

For passenger operations, the interior arrangement and seating could be tailored at night for the next day operation, with reduced seating during low traffic periods. The weight savings possible with Intermodal payload modules compared to a QC are then as much as 21,000 pounds and 18,000 pounds for freighter and passenger operations respectively.

Additional Ground Handling

A disadvantage of Intermodal operations is the need for additional ground handling. Attaching, detaching and surface movement of modules will require new large equipment, storage space, conversion stations, and the personnel to operate the equipment and conduct the conversions. The additional cost for this ground handling was not in the economic analyses. However, the operating cost benefits were not included either.

For passenger operations, as noted above, the interior arrangement and seating can be adjusted nightly to meet daily market demand. Reducing seating and storage bin weight during periods of low passenger loads can save fuel from the lowered operating weight. The passenger interiors can also be cleaned, prepared and serviced during this down time.

For freighter operations, the off transporter modules can be loaded at the cargo terminal minimizing Transporter down time and as noted above using bulk loading to reduce the need for pallets and containers. Cost savings would result from fewer pallets and containers and either increasing revenue payload or reducing fuel burned. The weight of 21 pallets on Model V-10 is 6,000 pounds or 5% of the cargo payload. The increased revenue from deleting the pallets would go almost directly to the bottom line as a 5% increase in cargo operating profit.

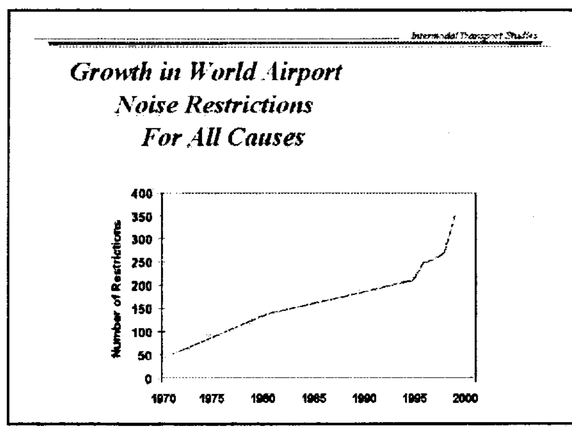

Figure 11

Intermodal Night Operations

The successful development of an Intermodal Transportation system would be expected to increase night operations. Increasing night operations could encounter a high degree of resistance at noise sensitive airports. Noise restrictions are already increasing as shown in *Figure 11*. Some major airports already have limits or curfews on night operations. In order to expand night operations, an Intermodal Transport should be very quiet so as not to increase the perceived noise around airports.

Maintenance is also commonly done at night with routing through airports with maintenance facilities. The Intermodal should be developed under an Early ETOPS type of program to assure a high level of maintenance in the introductory period is not required. In addition, some intermixing with conventional aircraft may be required in order to route through some airports for line maintenance.

2.8 Enabling Technologies

V-9

In order to develop a viable Intermodal Transport, the major enabling technology needs are shown in *Figure 12*. For the Model V-9, the payload module needs to be load sharing with the "Strong Back" to carry the empennage loads. Otherwise increasing the structural depth of the "Strong Back" for stiffness results in excessive weight and drag.

The high wing configuration requires addressing safety issues. The weight of a wet wing with a wheels-up hard landing requires passenger section protection from high crush loads. An energy absorption system on the lower fuselage may be needed. Another issue is protection against inboard fuel tank rupture from a rotor burst.

V-10

The technology for integration of very high by-pass ratio (VHBR) very quiet engines on a low wing airplane is needed. The "Strong Bottom" must also carry cabin pressurization loads in hoop tension to avoid the excessive weight penalty that would result if the flat floor needed to carry the design pressurization load of 1,620 pounds/feet^2. This would entail a quick disconnect latch at each fuselage frame. The module-to-transporter interfaces also require sealing to maintain cabin pressure.

V-11

This is a Quick-Change Convertible Freighter with a large full-width front door such as available on the C5-A and AN-124. Again, the technology for a VHBR engine on a low wing airplane is needed. This concept also requires large quick-change interior modules that include the passenger amenities as well as the seats.

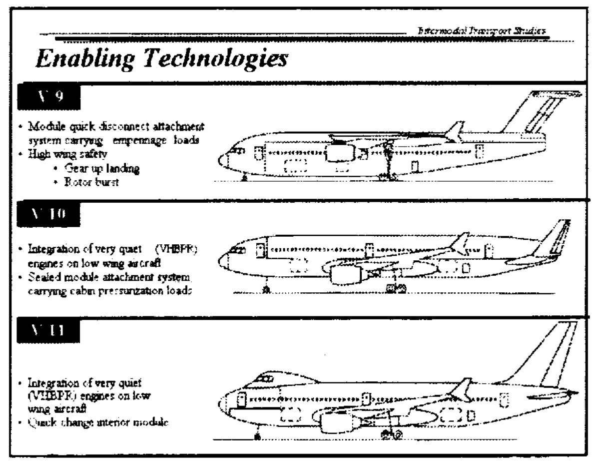

Figure 12

2.9 Expanded Opportunities

An Intermodal Transport offers new business and mission opportunities. The partitioning between flight and payload hardware can allow separation of ownership and addition of new payloads for different missions. This can be extended to shared or partial ownership of the Transporter.

These are not new ideas for common airframe usage but are facilitated by the Intermodal with a separable payload module on a medium sized transport. *Figure 13* shows some possible opportunities.

New Opportunities

- Contract to carry overnight shipper owned module to their hubs
- Contract to carry high priority mail service modules with in-flight sorting
- Charter vacation flights using high density seating modules on slow traffic days
- Shared Transporter ownership for corporate custom modules
- Military mission modules
- Outsize cargo module

Figure 13

Currently, contracted pallet loads are carried overnight. Aloha Airlines, for example, carries pallets loaded with bread from Oahu to the other Hawaiian Islands. Intermodal could expand this concept to loaded payload modules.

L'Aeropostale in France currently does night mail service partnered with daytime passenger service.

Charter vacation flights are done by UPS on a weekend basis. Intermodal aircraft would allow chartering on a daily basis.

Shared ownership is now a common business jet practice. Intermodal aircraft would extend this concept to allow custom interiors.

Many military transports share the design of commercial transports. The utilization of military aircraft is generally low compared to commercial transport operations. The military services continue to fly old, low-efficiency, high-emission transport designs because of because they cannot afford to update their fleets. Intermodal concepts may allow the services to upgrade to modern airframes by repackaging the mission avionics or other functions into the payload modules.

An outsize cargo module as depicted in *Figure 14* could be adapted. The Guppy, Super Guppy and Beluga have been used to transport fuselage sections. The commercially available transport for the fully assembled GE90 engine today is the Russian AN-124, which flies on an uncertified basis in the United States. Development of large very high bypass ratio engines needed to continue reductions in noise and fuel consumption would be facilitated if the engines were air transportable. Intermodal aircraft could create support for the limited market need for outsized airlift.

Expanding the uses for the Intermodal Transporter would increase the production base resulting in reduced non-recurring charges for each airplane, and also reduced unit recurring costs that result from higher production rates.

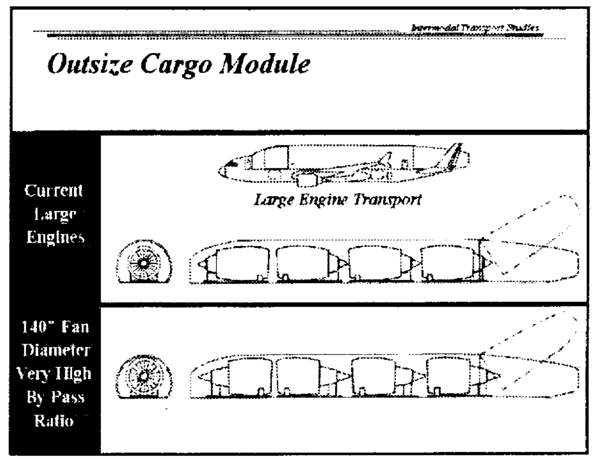

Figure 14

3.0 Conclusions and Recommendations

The study results show that an Intermodal Transport using quick-change payload modules has the potential of improving the profitability of an airplane. Using modularity for passenger operations during the day and freighter operations at night improves the productivity from fixed ownership costs. A profit improvement by a factor of two or more is shown compared to recent airline average level of profitability. If current levels of profit were maintained and the benefit applied primarily to reducing passenger operating cost, the cost of air travel could be reduced as much as 20%.

Achieving this economic benefit is expected to require expanding nighttime operations, which would be facilitated by having very quiet aircraft technology. In addition, the payload module concepts require technology for distributed load-carrying quick-disconnects to achieve low weights.

An airframe designed for carrying passenger and freighter payload modules could be readily adapted to carry other types of modules. Expanding applications for the Intermodal Transport could provide the benefits of a larger spread for non-recurring costs and larger production base for the Transporter. It could also allow development of mission capabilities that would otherwise be unaffordable.

The current study selected a medium-range widebody transport for evaluation. This barred use of off-airport module operations due to maximum size and weight limits for surface transportation. A narrow body short range Intermodal with a smaller payload module might allow beneficial conveniences that were not explored.

Two additional studies are therefore recommended: (1) an assessment of transportable narrow body Intermodal Transports, and (2) a broad application study of Intermodal Transports.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 2001	Contractor Report

4. TITLE AND SUBTITLE
A Study of the Economic Benefit Potential of Intermodal Transports

5. FUNDING NUMBERS
NAS1-20267
Task 25
WU 522-41-11-04

6. AUTHOR(S)
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National Aeronautics and Space Administration
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Hampton, VA 23681-2199

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA/CR-2001-210847

11. SUPPLEMENTARY NOTES
Langley Technical Monitor: Robert E. McKinley, Jr.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified-Unlimited
Subject Category 03 Distribution: Nonstandard
Availability: NASA CASI (301) 621-0390

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

A conceptual study was conducted to determine the benefit potential of an Intermodal Transport in which quick change payload modules are used to reduce the cost of air travel by increasing daily utilization. Three basic concepts varying the degree of modularity were investigated for a 122,000 pounds payload 3,000 NM range regional wide body transport. The profit potential for operating as a passenger transport during the day and as a freighter at night was assessed. Assuming current levels of profitability, Intermodal operations could offer an operating cost reduction potential up to 20%. Enabling technology needs are identified as very quiet aircraft for expanded night operations, distributed load carrying quick disconnect latching, and configuration dependent safety issues. Recommendations are made to explore if additional benefits are possible from alternative mission and usage modules.

14. SUBJECT TERMS
Intermodal, Transport, Economics, Operations

15. NUMBER OF PAGES
17

16. PRICE CODE
A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL