NASA Technical Memorandum 78724

PROSPECTS FOR A CIVIL/MILITARY TRANSPORT AIRCRAFT

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SUMMARY

The similarities and disparities between commercial and military payloads, design features, missions, and transport aircraft are enumerated. Two matrices of civil/military transport aircraft designs have been evaluated to determine the most cost effective payloads for a projected commercial route structure and air freight market. The probability of this market developing and the prospects for alternate route structures and freight markets are evaluated along with the possible impact on the aircraft designs. Proposals to stimulate the market and increase the viability of the common aircraft concept are reviewed and the possible impact of higher cargo demand on prospects for common civil/military freighters is postulated. The implications of planned advanced technology developments on the aircraft performance and cost are also considered.

The minimum payload considered is constrained to the approximate weight of one main battle tank. Matrix one is based on a 6667 km (3600 nmi) range mission while matrix two is based on a 6667 km (3600 nmi) radius mission. Payloads of 0.489, 0.979, and 1.334 MN (110,000, 220,000, and 300,000 pounds) are included. Two military cargo transport designs for the 0.489 MN (110,000 pound) payload are also considered for commercial passenger applications. The changes in penalties due to commonality are correlated with changes in payload and range and the costs of extending the aircraft design range are evaluated.

Irrespective of the commonality proposition, the USAF will require replacements for the aging fleet and to meet proposed increased airlift requirements. These needs are projected to determine possible future military aircraft acquisition programs.

THE COMMONALITY CONCEPT

Commonality refers to interchangeability between and/or joint usage of civilian and military transport aircraft subsystems, ground equipment, spare parts, maintenance facilities, airports, crew training and aircraft.

The desire for commonality in transport aircraft is primarily economic although the concept has important implications on the nation's total strategic mobility posture. The economic motivation stems from the following considerations. The increasing costs of all weapon systems developments, and the constraints upon the defense budget make it extremely difficult to embark upon a major new aircraft system development and acquisition program. Nevertheless, the nation's strategic airlift fleet is aging and will require replacement early in the next century, assuming that all the proposed modernization programs are accomplished. Since more than 35% of the nation's total strategic airlift capability resides in the Civil Reserve Air Fleet (CRAF), a joint military/civil cargo aircraft would represent a significant national asset in enhancing CRAF contributions to our strategic mobility posture, and in maintaining U.S. leadership in the development and production of civil transport aircraft. However, current projections of the growth of the civil air freight market are not sufficient to persuade commercial manufacturers and carriers to invest the capital needed to develop and produce a dedicated cargo aircraft. A joint military/civil venture would lower acquisition and operational costs to both parties and thereby increase the chances for new aircraft development.

Commonality between civil and military cargo transports has been a subject of Defense Department and Congressional interest dating back to at least 1960 and was attempted during the development of the C-141 aircraft with the certification of that aircraft for civil use. A civil version of the C-130 has been successfully marketed in the commercial world. The current emphasis stems from the Military Airlift Command's (MAC) Airlift Enhancement Studies and the initiation of Project INTACT in 1973. The MAC studies lead to the formulation of a joint military/civil aircraft system first described in the C-XX Concept Paper in 1974 (ref. 1) and subsequently revised in 1978 (ref. 2).

The C-XX story from its inception to the present is summarized in figure 1. The following is a brief description of each of these activities:

Project INTACT

Project INTACT (Intermodal Air Cargo Test) was a joint DOD, DOT, industry effort to demonstrate intermodal transportation of commercial containerized air cargo. The project was successfully accomplished during October 8 and 9, 1975 using an Air Force C-5A aircraft. The demonstration was conducted between Nashville, Tennessee and Oakland, California with fresh lettuce from the Salinsa Valley loaded directly aboard the aircraft in a refrigerated over-the-road trailer. On the return flight, six intermodal 2.4m x 2.6m x 12.2 m (8' x 8 1/2' x 40')

THE C-XX STORY

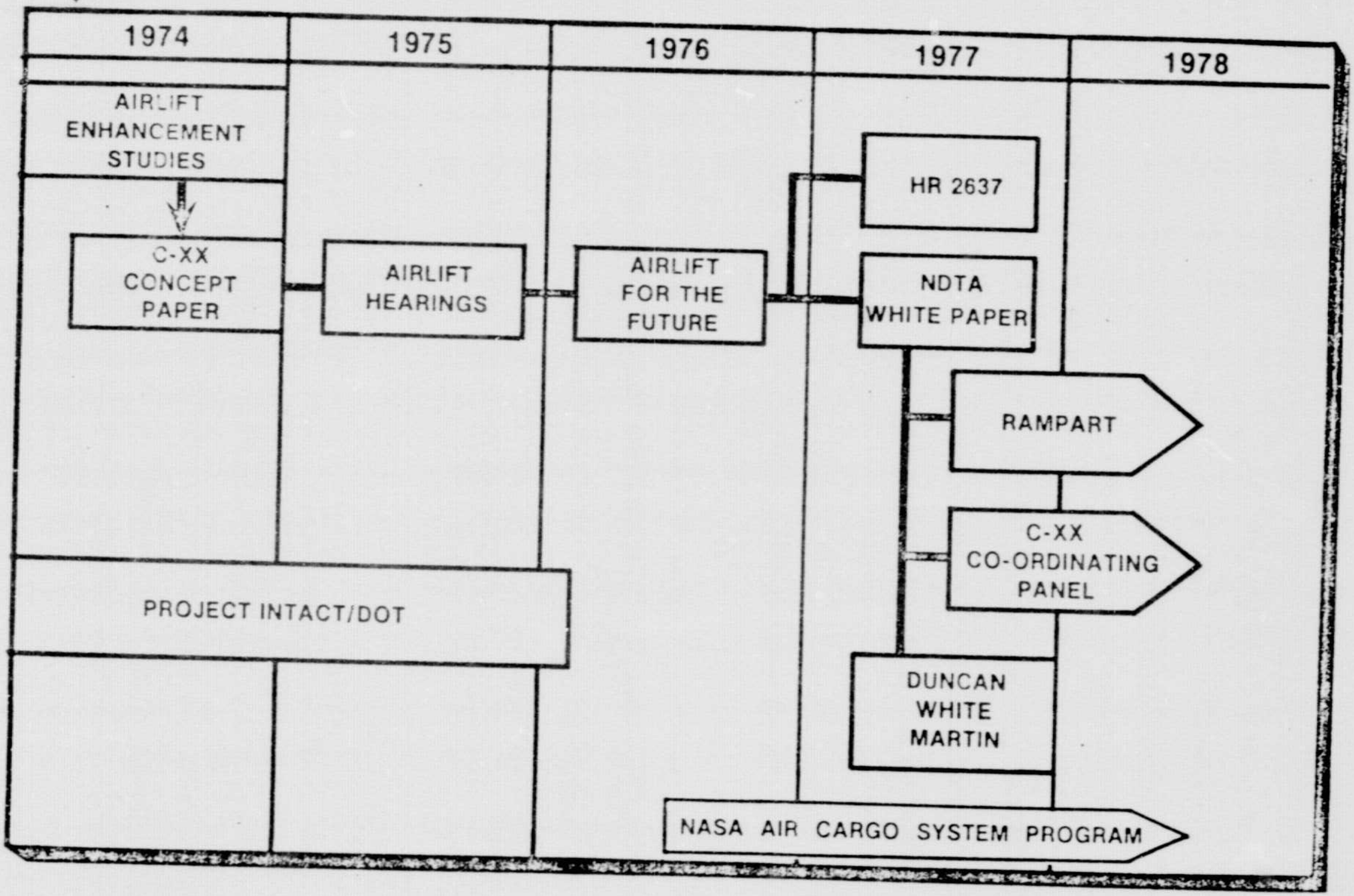

Figure 1.

containers containing shoes, automotive parts, chemicals, and a marine container destined for Tokyo were loaded. In both instances, the domestic cargo was distributed to the retail outlets for sale the following morning. These results (ref. 3) indicated that an intermodal air cargo system can be developed within the next decade. It is feasible from an operational standpoint and such a system can be economically compatible with surface transportation modes.

C-XX Concept

As originally envisioned, the C-XX concept provided for carrier-owned, freight configured aircraft of advanced design. The airplanes would be on call for military use. This concept has evolved somewhat as information has been developed until it is no longer viewed as a purely commercial aircraft but will include military design features and be acquired by both the civil sector and the military. More will be said about this later.

NDTA White Paper

In 1976, the National Defense Transportation Association (NDTA) tasked its Military Airlift Committee to consider the national security and commercial transportation aspects of the question:

> "Is it in the public interest for both the U.S. Government and U.S. industry to provide funds and other support towards the development of a new generation of cargo-capable aircraft with both military and commercial applications?"

Following an 18 month study, the committee concluded that the question could only be answered in a broader context than simply consideration of the transportation issues. They recommended that DOT and DOD pursue the question in a much more rigorus and in-depth manner.

RAMPART

The concept of commonality is developed further by Hq MAC with a planning program entitled RAMPART, an acronym for Route to Airlift Mobility Partnership. This effort lays out a detailed time-phased roadmap for the introduction and approval of the policy decisions and legislation needed to accomplish a joint military/civil aircraft development program.

C-XX Coordination Panel

Interagency cooperative efforts were formally initiated in October 1977 with the establishment of the C-XX Working Level Coordination Panel. The panel is made up of representatives from various elements of DoD, NASA, DoT, and FAA. The objective of the panel is "...to establish courses of action that will define the feasibility of, and obstacles to, common or closely coordinated development of aircraft systems to satisfy commercial cargo and military airlift requirements in the 1990s and beyond, with particular emphasis on the "C-XX" Concept ....".

Issues

The commonality concept introduces a number of important issues which have never before had to be considered in an aircraft development program. The issues span the range of national affairs including economics, sociopolitical considerations, foreign relations, and national security. These issues are in addition to the normal acquisition processes of design, fabrication, test, production, deployment, maintenance, and support. These topics will be discussed in more detail within the context of other topics.

CIVIL MARKET FOR MILITARY AIRCRAFT

This section and the following section consider some cases of commonality that have occurred. The aircraft have been designed and developed for either military applications or the civil market. Design for commonality with equal participation by both the military and civil users will be considered later.

The unique case of a military transport aircraft converted to civilian use is the C-130 Hercules as shown in figure 2. The U.S. Air Force contract for the design and production of the C-130 medium multi-purpose transport was awarded in 1952 and deliveries began in December 1956. The L-100 commercial configuration of the Hercules was first certificated in 1965. In addition to the initial L-100 configuration, two stretched versions have been produced, the Model L-100-20 (2.54m (100") stretch) and the Model L-100-30 (4.57m (180" stretch)). There are over 50 items of equipment and systems on the L-100-30 Super Hercules commercial version that are different from the current C-130 Military Hercules Airplane. As shown in figure 2 517, or one-third of the total of 1536 aircraft sold and ordered to date, have been for commercial or export use. The commercial and export sales are considered together; however, over two-thirds of the foreign commercial airlines are owned or controlled by the governments of those nations. Commercial operations of the L-100 Hercules primarily involve scheduled and non-scheduled commercial and military cargo. Flights often involve delivery of large and unusual items to

CIVIL MARKET FOR MILITARY TRANSPORTS

AIRCRAFT	FIRST FLIGHT	MILITARY	CIVIL	TOTAL
C-130 HERCULES	1955	1019	517	1536
C-141 STARLIFTER	1963	285	0	285
C-5 GALAXY	1968	81	0	81

Figure 2.

underdeveloped areas.

The C-141 Starlifter pioneered a novel concept in aircraft development. It was planned from the beginning to serve both military and commercial applications, and was the first program of its kind requiring any aircraft to meet FAA commercial transport criteria as well as military requirements simultaneously. The FAA Administrator, N. E. Halaby, on the occasion of the C-141's civil certification on January 29, 1965 stated that "... this airplane, now a reality, has had more civil-military cooperation than any other aircraft in history." Although the C-141 was certificated, the commercial L-300 version was never produced, due to lack of; engineering personnel, factory space after the C-5 contract award, and sufficient market demand. A total of 285 military C-141 aircraft were produced before the aircraft went out of production.

The C-5 Galaxy entered service in 1969 to provide the Military Airlift Command with a new measure of heavy logistics capability. The principle mission of the C-5 is to provide a rapid, reliable, and efficient means of airlifting combat or support units of all services under general or limited emergency conditions, and military logistics supplies, including ballistic missiles. The Galaxy has many unique loading features; a visor nose that opens upward exposing the full width and height of the cargo compartment, full-width aft doors, integral full-width ramps at each end, and a kneeling landing gear.

The C-5 was designed to be certificated and considerable effort went into the civil C-5, or L-500; however, the program was never launched. The L-500 program was abandoned when the USAF cancelled a portion of the follow-on C-5 Run B production order and in light of the overall financial position of the Lockheed Corporation at that time. The commercial market demand for this airplane was also insufficient at that time for a production go-ahead. The C-5 is also out of production; however, the major tooling is still in position.

The prospects for developing a civil market demand for a new military airlifter with design payload of 1.78 MN (400,000 pounds) and a range of 11482 km (6200 nautical miles) were considered by Barber (ref. 4). A commercial derivative of this configuration was designed by removing the military cargo floor, tiedowns and rails, forward and aft ramp, and military cargo handling ramp. This produced an operating weight savings of 0.28 MN (62,580 pounds) or about 10 percent after the commercial cargo handling system was installed. The direct operating costs of this commercial derivative are compared with those of the 747-200F and a commercial freighter configuration on figure 3. A family of design points at different ranges is shown for the commercial derivative (dashed line). By designing to 9630 km (5200 nmi.) rather than to a more commercially desirable 5093 km (2750 nmi.), the DOC was increased by about 3.4¢/Tonne-km (0.5¢/Ton-mile). The figure indicates that the commercial derivative resized for 5093 km (2750 nmi). has superior operating economics compared to the commercial freighter. However, when the differences in technology (1980 versus 1985) and design cabin area pressurization are accounted for (solid arrow on figure), the

Commercial Commonality Direct Operating Costs

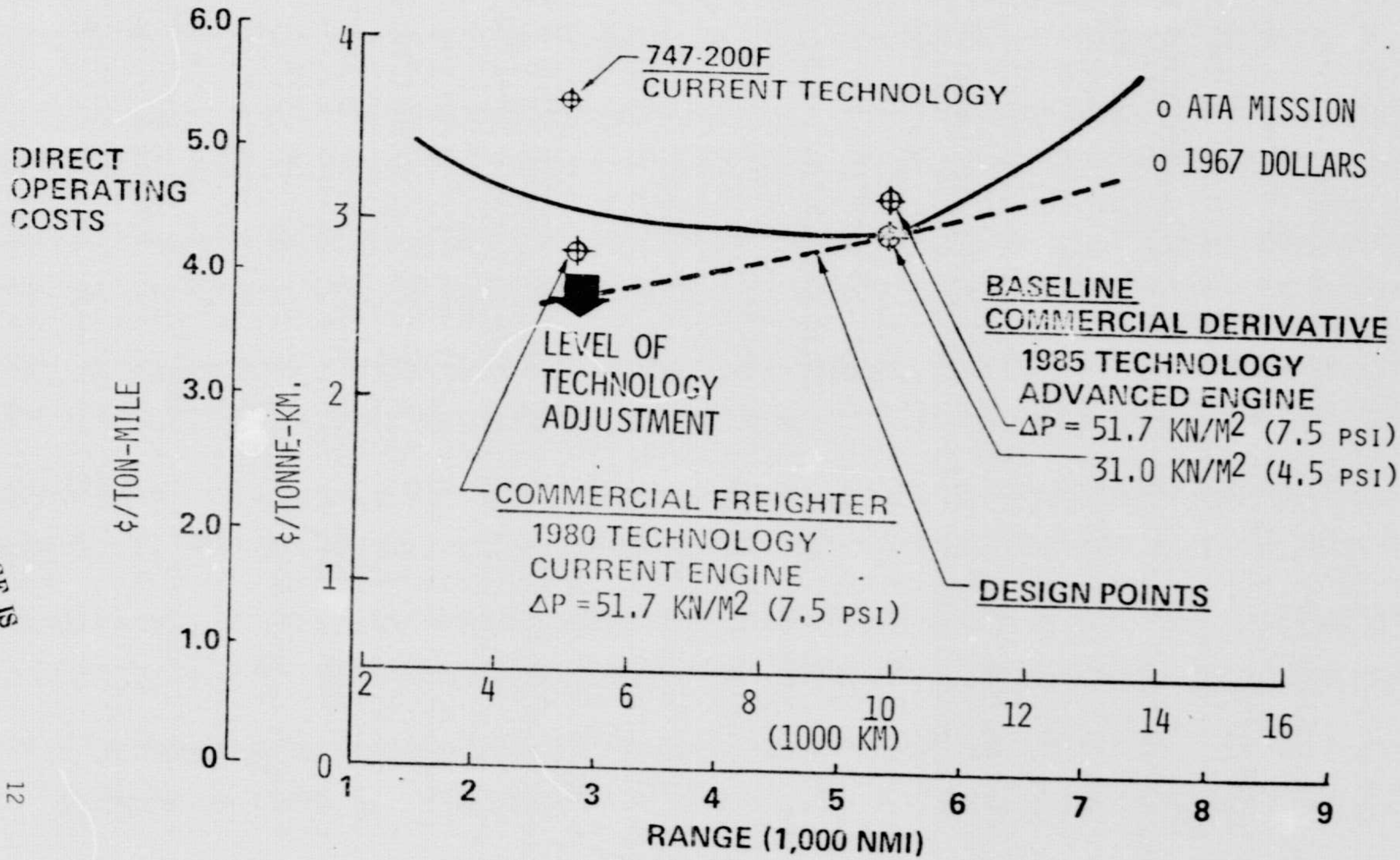

Figure 3.

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DOC of the commercial design drops below that of the derivative. This comparison assumes that the development of the commercial derivative was sponsored and funded by the military. Note that either of these advanced designs would offer at least a 20 percent DOC reduction over the current technology airplane. Figure 3 shows that the aircraft design requirements required by military operations could impose significant economic penalties compared to a competitive airframe designed to commercial rules.

In addition to the primary use of civil transports for military airlift type missions, other proposed applications include airborne missile launching, advanced strategic tanker, military cargo airlift, navigational trainer, intelligence mission, theater command and control, airborne instrumentation platform, laser weapon platform, and other special missions (The latest being the Cruise Missile Carrier and launcher mission).

A list of current civil jet aircraft and their respective military and civil sales are shown on figure 4; however, many of the older, notable civil aircraft that have found military applications are not included. Nearly 11,000 "Gooney Birds" known as the DC-3 in the commercial version and primarily as the C-47 in the military version were built by the Douglas Aircraft Company. There were twelve versions and designations of this aircraft, the latest being the AC-47 Attack Cargo airplane (Gunship), also known as Puff the Magic Dragon. The DC-3 (1936) was followed by the DC-4 (1939) that was designated the C-54 and ordered in large quantities as a long range military transport for troop and cargo handling, and for medical evacuation missions.

The Convair 240 commercial airliner was designed as a DC-3 replacement and first delivered in 1948. The military derivative was the T-29 military aircrew trainer, used for navigation and bombardment training. The Convair 340 was delivered in 1952, and

MILITARY APPLICATIONS OF CIVIL TRANSPORTS

AIRCRAFT	FIRST FLIGHT	MILITARY	CIVIL	TOTAL
B-707	1957	30 (700 KC-135)	750	780
B-720	1959	0	154	154
B-727	1963	0	1491	1491
B-737	1967	21	519	540
B-747	1969	16	353	369
DC-8	1958	0	556	556
DC-9	1965	40	932	972
DC-10	1970	20	285	305
L-1011	1971	0	215	215

Figure 4.

the C-131 military transport derivative was used for air evacuation and electronic equipment testing and training. More than 460 of these aircraft were built for the Air Force and Navy.

Other similar military conversions of commercial aircraft designs including the Lockheed Constellation (C-69), the Lodestar, and the Electra (in military use as the P3V-1). The Curtiss commercial CW-20 passenger transport derivative was used as the C-46A Commando Military Transport.

The first U.S. jet transports were derived from the Boeing funded Model 367-80 prototype. This program produced about 700 KC-135 military tankers and the 707 and 720 commercial transports. As shown on figure 4, 780 B-707s and 154 720s have been produced in many commercial versions. The military derivatives of the Dash 80/B-707 are the Boeing VC-137A VIP personnel transport, the VC-137C high-priority cargo transport, and the E-3A AWACS (Airborne Warning and Control System) aircraft. The B-727 has enjoyed the largest commercial market and several are in non-commercial operation with the Federal Aviation Administration and International Telephone and Telegraph; however, military uses of this aircraft are nonexistent. Several B-737 aircraft are in service with foreign governments while 19 are used by the U.S. Air Force in the T-43 Navigation Trainer configuration. Of the 369 B-747s, 16 are in service with the military - 12 cargo versions with the Iranian Air Force and 4 E-4A/B Advanced Airborne Command Post (AABNCP) versions with the U.S. Air Force.

The Douglas DC-8, although available in cargo configuration, has not found military use except in charter service. The DC-9 has been in use with the U.S. Air Force since 1968 as the C-9A Nightingale aeromedical airlift aircraft. These twinjets transport injured and ill military personnel and their dependents between medical facilities within the United States, Europe and Asia. The C-9B Fleet Logistics Support Transport is a U.S. Navy and Marine Corps. version of the DC-9 convertible passenger/cargo jet transport, incorporating supplementary fuel tanks for long range operation. The VC-9C is the third government version and is outfitted for service with the Military Airlift Command's Special Air Missions Wing at Andrews AFB. The twenty DC-10s shown in the military column are the DC-10 Advanced Tanker Cargo Aircraft (ATCA) derivative of the basic DC-10CF. The ATCA cargo role is secondary and intended to provide a margin of airlift capacity that may be needed for certain contingencies. The DC-10 ATCA is sized to primarily accept oversize cargo and in tactical deployments, for example, can airlift personnel and appropriate ground support equipment while, at the same time, tanking the tactical aircraft.

The Lockheed California Company's L-1011, the newest of the basic jet transports, has not been used for military missions.

In summary, the larger jet military transports have not found a commercial market even when they have been designed to be compatible with civil regulations. The military design specifications impose too severe an economic penalty for economical civil operation. On the other hand, derivatives of commercial jet transports have been used in a variety of military applications, but not the strategic airlift mission. The slight trend toward military use of the newer civil jet transports reflects the large and increasing development costs of large aircraft and the decreasing military budgets available for new aircraft procurement.

DESIGN FOR COMMONALITY

The case histories of commonality in the previous sections indicate that a successful design for commonality must be compatible with the commercial market requirements. Strong, active commercial participation during the early design phases is required since overemphasis on military features could prohibit commercial acceptance and sales.

The Boeing Company, under Air Force contract, is currently studying transport aircraft designed primarily for the commercial market but with several important military features. The minimum range must be intercontinental and the minimum payload is the heaviest single piece of air-transportable military equipment.

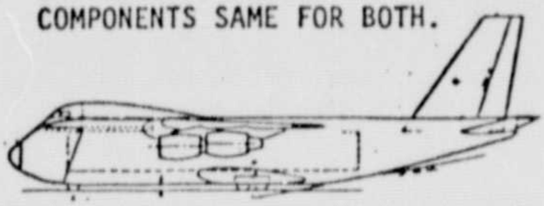
The commonality concept assumed by Boeing for the dedicated military/commercial freighter family is shown on figure 5 in which two different aircraft are produced at one production line. The aircraft's exterior configuration and most of the components are the same for both versions. The dedicated military freighters are produced by adding the military peculiar items necessary to carry heavy concentrated payloads, while the dedicated commercial freighters are produced by adding the lighter weight structure necessary to carry the lower density and distributed commercial payloads.

The high wing military/commercial freighter concept, shown on figure 6 was sized for a range and a radius of 6667 km (3600 nmi) and payloads of 0.512, 0.890, 1.33 MN (115,000, 200,000, and 300,000 pounds). The radius mission consists of the range mission plus a return trip of 6667 km (3600 nmi.) without the usable payload. The six aircraft were

COMMONALITY CONCEPT
DEDICATED MILITARY/COMMERCIAL FREIGHTER FAMILY

DESIGN COMMONALITY

- o SAME TOGW AND ZFW FOR MILITARY AND COMM'L VERSIONS
- o EXTERIOR CONFIGURATION AND MOST COMPONENTS SAME FOR BOTH.



PARTS COMMONALITY

IDENTICAL COMPONENTS (USED IN BOTH VERSIONS)

- o WING, EMPENN. LANDING GEAR, ENGINES.
- o MOST BODY COMPONENTS INCLUDING NOSE CARGO DOOR.
- o MOST SYSTEMS AND EQUIPMENT.

ADD MILITARY -PECULIAR ITEMS

- o HEAVY BODY FRAMES, FLOOR SUBSTRUCTURE, SILL, FWD SKIN.
- o HARD FLOOR
- o TIEDOWN SYSTEM
- o MIL. CARGO LOADING SYSTEM
- o FRONT RAMP
- o MILITARY NACELLES
- o IN FLIGHT REFUELING
- o MIL. AVIONICS.

DEDICATED MILITARY FREIGHTER (ORGANIC)

ADD COMM'L-PECULIAR ITEMS

- o LIGHT WEIGHT BODY FRAMES, FLOOR BEAMS, SILL, FWD SKIN.
- o COMM'L CARGO LOADING SYSTEM
- o COMM'L NACELLES (NOISE TREATMENT)
- o COMM'L AVIONICS

DEDICATED COMM'L FREIGHTER

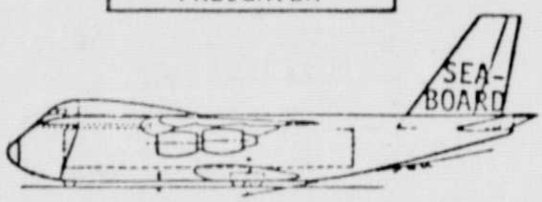
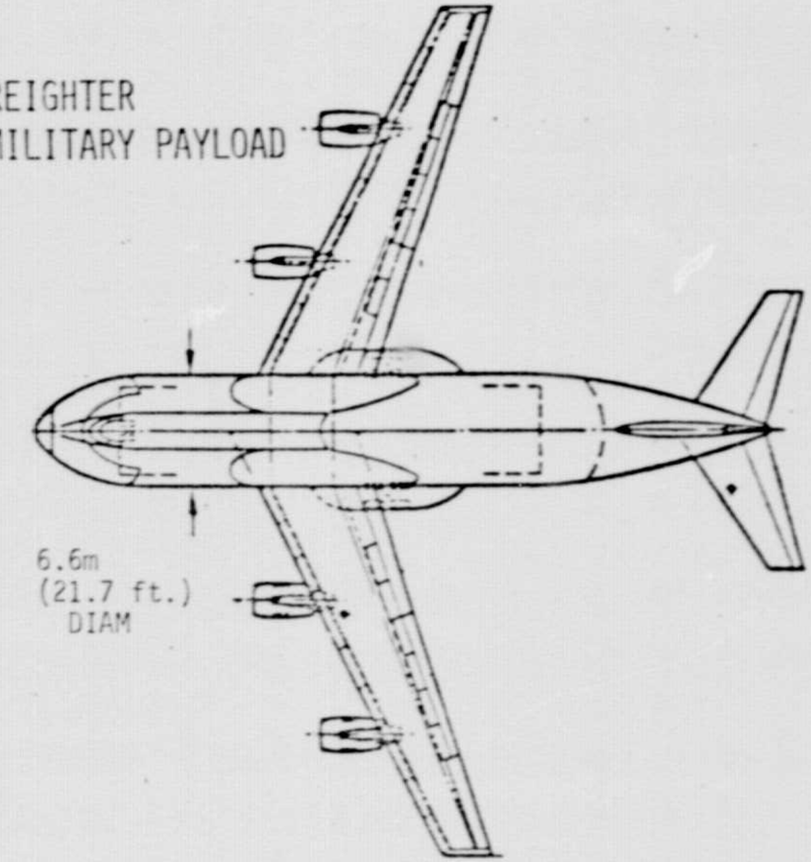


Figure 5.

MILITARY/COMMERCIAL FREIGHTER
TWO LAND; 0.512 MN (115,000) MILITARY PAYLOAD

RANGE, MILITARY		6667	km	3600	NM
TOGW		1.62	MN	365,000	LB
ZFW		1.15	MN	260,000	LB
PAYLOAD, MILITARY		0.51	MN	115,000	LB
CRUISE SPEED	M.77 @	12.23	km	35,000	FT
WING AREA		$261 m^2$		2,810	FT^2
SWEEP		25°		25°	
AR		9.5		9.5	
ENGINES (SLST)	4 @	90.1	kn	20,260	LB
TECHNOLOGY LEVEL		1985		1985	



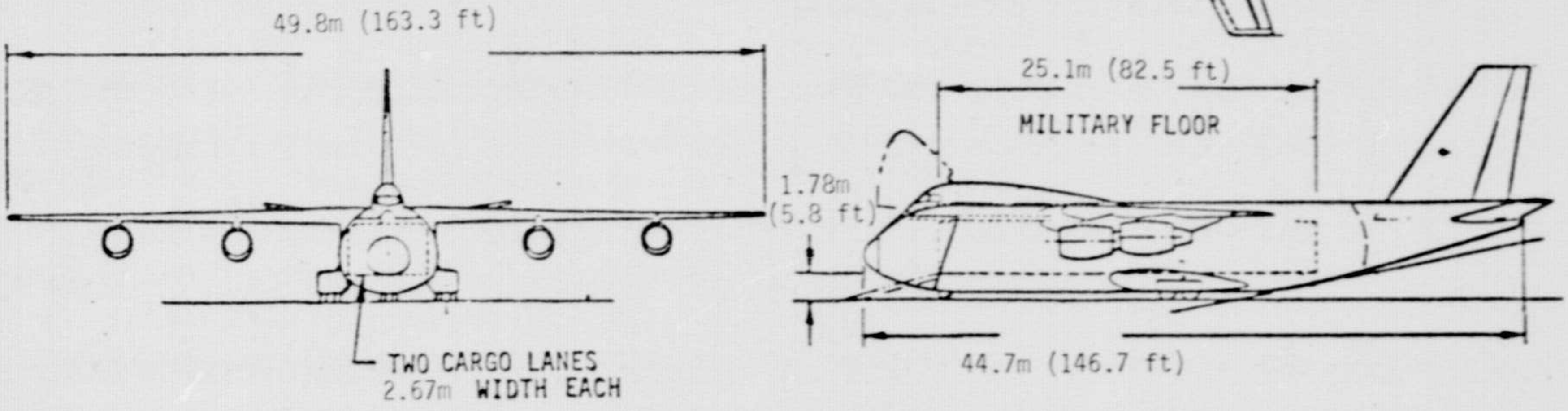


Figure 6.

then tested against Boeing's projected commercial market for long range aircraft to determine the design payload that offers the largest sales potential. The basic assumption was that the design would not penetrate the market unless the total transportation costs were lower than current wide-body airplanes. The closed loop analysis balanced the air freight market demand, aircraft price, fleet productivity and operating economics to determine the commercial market potential for the 6667 km (3600 nmi.) range configurations, as shown on figure 7. The radius, equivalent to about 11482 km (6200 nmi.) range, configurations did not have a significant market for any of the payloads considered. The life cycle costs of the combined organic military and CRAF fleet were estimated by assuming the development costs were prorated to each airplane, and that one-half the commercial aircraft would be available for CRAF use. The cost results indicate that the optimum payload for a commercial freighter is between 0.9 and 1.3 MN (200,000 and 300,000 pounds), increasing with the requirement for airlift, and that signficant improvements in operating cost are required to have a viable joint military commercial freighter program.

Because commercial freighter sales projections were not optimistic, two additional configurations were defined with commercial passenger as well as cargo commonality; a conventional low wing configuration of 0.89 MN (200,000 pounds) payload and the configuration shown in figure 8 of 0.512 MN (115,000 pounds) payload. This over-the-wing engine configuration offers an effective compromise to the low cargo deck military requirement versus the low wing to satisfy civil safety and ditching requirements. The potential requirements

HI-WING FREIGHTER COMMERCIAL SALES POTENTIAL 1990-1999

ORGANIC MILITARY BUY ↓ / PAYLOAD →	0.525 (MN) 118,000 (LBS)	0.903 (MN) 203,000 (LBS)	1.357 (MN) 305,000 (LBS)
100	N.S.*	N.S.	N.S.
200	N.S.	N.S.	283
400	N.S.	431	300

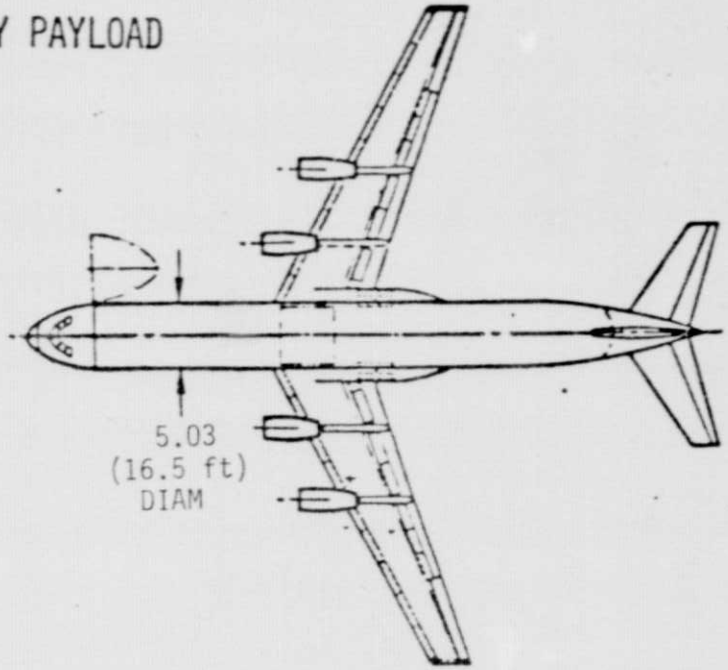
* N.S. = NOT SIGNIFICANT < 50 A/P

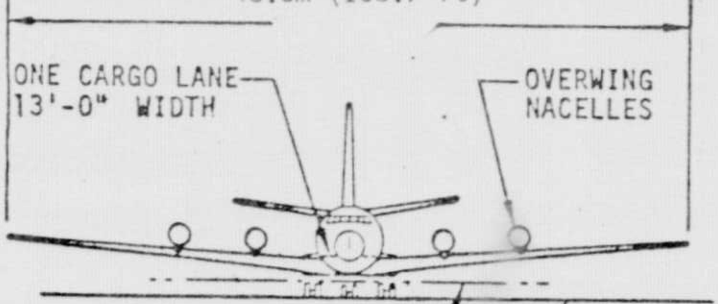
Figure 7.

MILITARY/COMMERCIAL FREIGHTER/PASSENGER TRANSPORT
1½ LANE; 115,000 LB MILITARY PAYLOAD

- CONSTANT ZERO FUEL WEIGHT ALL VERSIONS

RANGE, MILITARY	6667 km	3600 NM
TOGW	1.57 MN	345,000 LB
ZFW		
PAYLOAD, MILITARY	0.51 MN	115,000 LB
CRUISE SPEED M.78 @	12.23 km	35,000 FT
WING AREA	246 m^2	2,650 FT^2
SWEEP	25°	25°
AR	9.5	9.5
ENGINES 4 @	85.2 kn	19,150 LB
TECHNOLOGY LEVEL	1985	1985





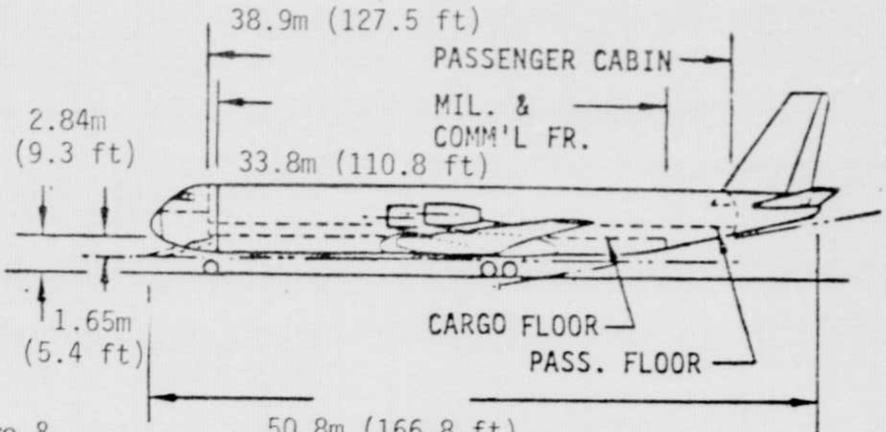


Figure 8.

(passenger plus combi) for these aircraft range from 1100 to 1400 units through the year 2000. Assuming that all the current wide body airplane types remain competitive throughout this time period, these new configurations will be directly competitive with the B-747 and DC-10. In order to meet this competition, the new models must offer an improvement of about 20% in direct operating costs (DOC) to account for improvement in return on investment and model changeover costs. The economics that are required to penetrate the current model sales and fleets may not be realizable unless increased use of advanced technology, particularly in the composite primary structures area, is available at design start. A 1985 design start, or technology availability date, is assumed for all aircraft in this section and could be late enough to accommodate composite primary structures.

Alternatively, increased government participation through funding during the development and acquisition phases and subsequent subsidies could produce the DOC reductions necessary to create a viable common aircraft. The problems arising out of possible funding arrangements are addressed in the final section.

CHARACTERISTICS OF THE PROJECTED CIVIL MARKET

The NASA-sponsored Cargo/Logistics Airlift Systems Studies (CLASS) can contribute to the definition of future civil markets for air cargo. These studies are currently in progress under separate contracts with the Lockheed-Georgia Company and the Douglas Aircraft Company. There are five major requirements set forth in the Statement of Work:

1. Characterize current air cargo operations.

2. Survey shippers, carriers, and airport operations to determine nature of demand.

3. Develop air-eligibility characteristics.

4. Determine sensitivity of demand to improved efficiency of the airplane and supporting infrastructure.

5. Identify research and technology requirements.

Most of the CLASS study results are currently available and preliminary implications of the impact on the C-XX concept can be postulated. Because the CLASS project ran concurrently with the Boeing commonality study discussed in the previous section, the CLASS findings did not impact the Boeing work.

On the basis of a yield/penetration correlation and the response of the shippers to an advanced air cargo system assumed to be operational by 1990, the Lockheed CLASS team found a higher 1990 growth potential than assumed in the Boeing commonality study (figure 9). The Douglas cargo flow estimate, derived independently, is also seen to be above

1990 ALL CARGO FREIGHT MARKET FORECAST

(U.S. Domestic, U.S. International, & Foreign International)

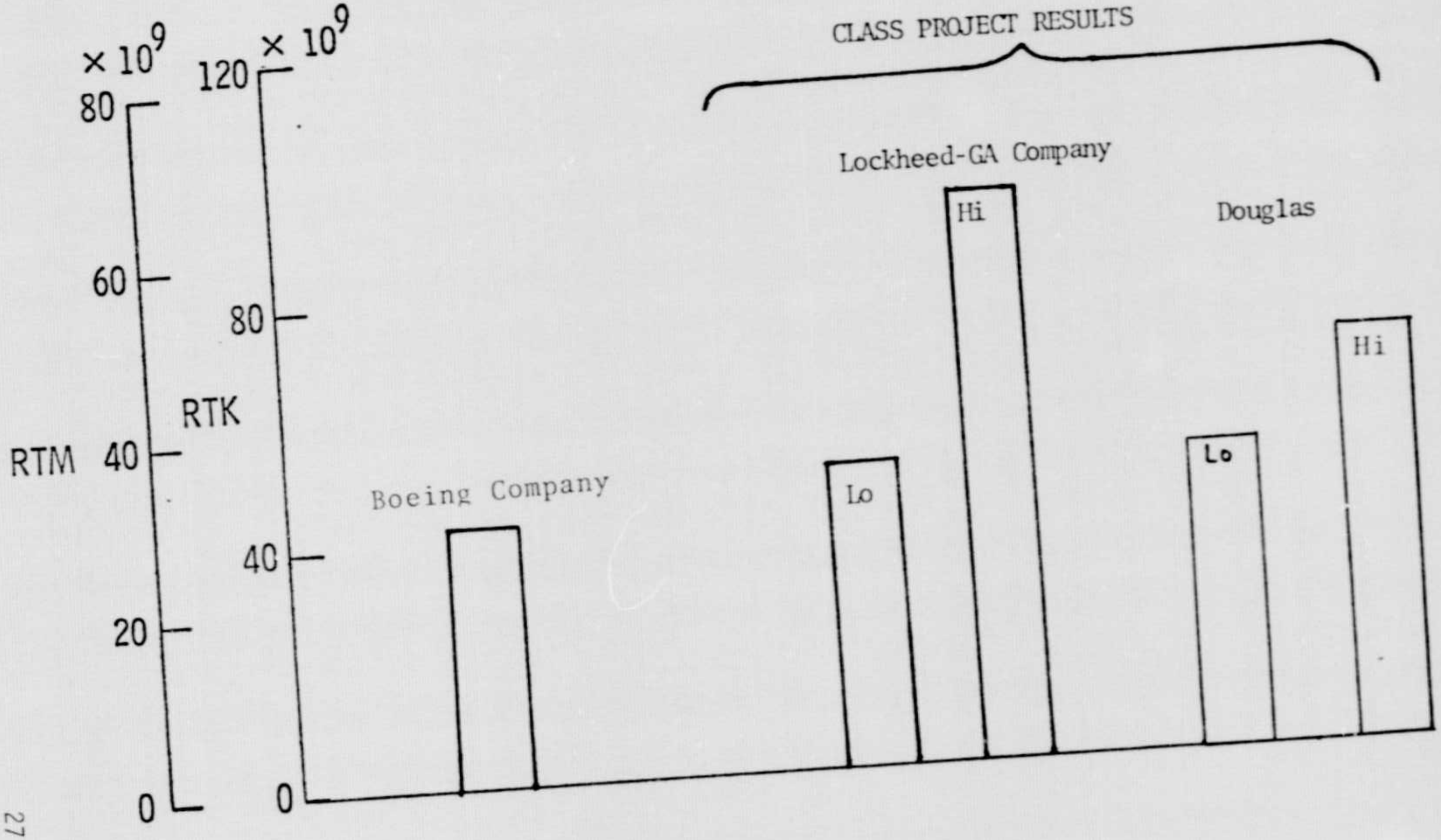


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Figure 9.

the Boeing projection. The introduction of a higher cargo demand into the Boeing analysis would have a substantial impact on the conclusions. The Lockheed study shows that fleet mix and choice of aircraft design payload are very sensitive to the assumed demand. When larger cargo flows are input to the optimization or simulation programs used in the CLASS project, larger payload aircraft are selected. Thus, while the Boeing analysis in figure 7 shows a 0.903 MN (203,000 pound) payload to be optimum for commercial freighter sales, both the CLASS teams suggest the need for a design payload around 1.47-1.51 MN (330-340,000 pounds) for the 1990-2000 market. Further analysis of the optimum payload for the large, long-range freighter is being considered by NASA since the CLASS results for that phase of the project were based on limited resources. Another iteration of the Boeing closed loop market analysis would be desirable with more refined demand projections.

The timing of the civil demand for the new freighter is likewise affected by the postulated cargo volume. Boeing concludes that the most promising freighter markets in the 1990's will be occupied by current equipment and derivatives. Since there is currently a shortfall in military airlift capability, the earlier civil freighter demand date shown in the CLASS results would improve the chances for a common aircraft design. Additional work beyond the CLASS project is needed to better define future payload density and external payload dimensions, two critical potential incompatibilities between civil and military design criteria.

One of the key CLASS objectives was to review the regulatory statutes for the impact on future air cargo operations. In addition, the contractors offered their judgment on impacts of possible future changes in regulations. These institutional and regulatory issues will have a direct impact on future civil freighter acquisitions, and hence will influence the prospects for commonality. Information has been gleaned from both CLASS contractors in constructing figure 10 that identifies three major C-XX "issues". Here it is assumed that if civil operating costs increase or capital becomes more difficult to acquire due to an "institutional" change (U = strongly unfavorable), then the viability of a new aircraft purchase by the civil carriers diminishes. Likewise, a regulation can also affect the prospects for joint tenancy or all-cargo airports.

Five institutional issues have been defined on the left side of figure 10. Under curfew restrictions, if modifications to existing aircraft are required and new designs are forced to meet the newer, challenging noise restrictions, then the fuel efficiency will be degraded. If flight schedules are dictated by worldwide curfews aircraft will have lower utilization, thereby increasing operator's cost. These environmental pressures will diminish the appeal of carriers in the capital markets when new aircraft funding is required. On the other hand, the threat of curfews would have a favorable effect in justifying the concept of joint tenancy or an all-cargo airport removed from some or all of the environmental restraints imposed on current passenger airports.

The effects of deregulation can only be surmised at this point, but educated guesses can be offered. Free entry of carriers into the

IMPACT OF INSTITUTIONAL ISSUES ON C-XX CONCEPT

Institutional Issue ↓ / C-XX Issue →	Civil Operating Costs	Capital Acquisition for New Equipment	Joint Tenancy or All-Cargo Airports
Curfews/Night flight rules			
• Lower aircraft noise	U	} U	} F
• Limited delivery "windows"	M		
Deregulation			
• Free entry	U	U /MF	F
• Pricing freedom	N	MU/MF	N
• Aircraft size freedom	MF	N	MF
Airport Growth Restriction	MU	MU	F
Vertical Integration	F	F	MF
Horizontal Integration	F	F	N

KEY: F - Strongly favorable to C-XX; N - Neutral to C-XX; U - Strongly Unfavorable; MF - Moderately favorable; M - Moderately Unfavorable

Figure 10.

market will undoubedly lower load factors and raise operating costs for existing carriers, at least in the near future. The unstable environment introduced by free entry will discourage lenders due to their increased risk. Capital, when available, will be priced according to the risk. Douglas Aircraft projects, however, that capital scarcity will be a short-term problem, and that once equilibrium is established, following initiation of free entry, the competitive environment will attract investors. Without regulation, the carriers can tailor their service to the customer. Finally, free entry will increase congestion in major hub cities and force some carriers to reconsider dedicated airports. Pricing freedom and the removal of aircraft size limitations for commuter carriers will have mixed effects which are difficult to gauge.

Many communities have placed restrictions on the growth and/or improvements to their airport facilities. This action is seen to lend more credence to the establishment of new locations for cargo terminal operations.

Either vertical integration (multi-mode ownership and operation) or horizontal integration (one carrier absorbing others of the same mode) will increase total system efficiency by improved utilization of aircraft, reduced terminal costs and higher route optimization. A favorable effect is noted for operator costs and capital acquisition where regulations are eased to permit either vertical or horizontal mergers. The cause of commonality might further benefit in such an environment since larger and less diffuse points of contact would evolve. Coordinating selection of aircraft design criteria, for example, would be greatly simplified if the Air Force could deal with one or two carriers rather than ten to fifteen.

ISSUES AND PROSPECTS

The prospects for a joint military/civil aircraft development program are strongly influenced by factors other than civil market demand. Among the more important of these are:

1. The timing for the initiation and the duration of the development effort.

2. Consideration of the role of the federal government during each phase of the program.

3. The impact that near-term alternative aircraft options have on the requirement and the availability of funding for a new aircraft program.

4. The impact that diminishing fossile fuel reserves and escalaing fuel prices have on energy intensive transportation systems.

5. The possible emergence of major roadblocks in formulating policy, and/or legislation, obtaining funding support, and/or reaching timely compromises/agreements.

We shall consider each of these factors in more detail in the following paragraphs.

Program Timing

The timing desired for the introduction of a new military strategic transport does not appear to coincide with that foreseen for the introduction of a dedicated air freighter. At the latest, a new military strategic transport will be needed in the first decade of the next century. Civil cargo market forecasts vary considerably with estimates for new freighter introduction. The Boeing studies suggest a date of 2020, whereas the CLASS contractors indicate a date nearer the year 2000.

A similar mismatch occurs even when one considers a hybrid aircraft program wherein derivatives of a basic airframe are configured for each application; i.e., an outsize cargo capable version for the military, a containerized cargo capable version for the freighter market, and a passenger version. Projections of the civil passenger market indicate that the next generation passenger aircraft will be introduced in the early to mid 1980's - too early for a new military or civil cargo transport. For example, the Boeing Company is near a design start for a new 180/200 seat passenger transport. The seven abreast seating configuration that is currently favored cannot carry two standard LD-3 containers back-to-back in the lower deck (ref. 5). That design would, therefore, not be an efficient cargo carrier. After this transport development, the next passenger aircraft "window" will occur too late for the initiation of the next generation strategic airlifter program.

Historically, a typical development cycle for a major military weapon system has been seven to ten years. Recent experience indicates that this cycle is lengthening and is now closer to fifteen years; particularly when a new engine development is involved as a part of the total system development effort. This contrasts markedly with the typical commercial aircraft development of three to four years duration. The military development time is driven primarily by the extensive testing and verification required to meet stringent military specifications. In contrast, the time for commercial development is driven by the need for minimizing investment capital and the market requirement for higher equipment performance. A joint development effort must find a satisfactory way of pacing the development to meet the needs of both parties. A lengthy joint development program would entail large capital investments by industry for long periods at high interest rates. This would impose added cost on the civil user and could restrict some of his equity servicing flexibility. Since it is unlikely that a joint development program could be accomplished within the normal commercial development time, the commercial producers and users must be prepared to accept a somewhat higher level of risk in return for the higher profits a new dedicated aircraft would produce. This comes about because industry must commit itself to a new aircraft at a time when the definition of market conditions will be less precise than would normally be the case.

Role of the Federal Government

A consideration of the proper role of the U.S. Government in such a development program is very complex. An overly active role would inject the government into the commercial aircraft business and impinge upon the free enterprise system. On the other hand, a very remote role would jeopardize program success and risk being interpreted as a government subsidy for a commercial venture. Between these two ends of the spectrum lie many potential compromise positions; however, what position(s) are desireable depend heavily upon the degree of civil participation volunteered; the magnitude of government expenditures; the urgency of the aircraft need; public opinion; international trade agreements; condition of the national economy and the air transportation industry; and the nature of the organization charged with carrying out the total program.

Impact of Alternatives

A number of military airlift programs are now under consideration by Congress and the Air Force which potentially could have a major impact upon any future decision to initiate a new military aircraft development program.

Among the programs already being considered by Congress are the C-5A rewing, the C-141 stretch, and the Civil Reserve Aircraft Fleet (CRAF) enhancement. Also under consideration is the need for a new intratheater transport for the tactical airlift role. Each of these programs place heavy demands upon the R&D resources available for the airlift mission area, and there is little opportunity for new program initiatives until the mid to late 1980's. Each of these programs is structured to meet an existing airlift need and is expected to satisfy that need through the end of this century. Thus, only the emergence of additional mission requirements and/or the opportunity to significantly reduce system operating and support costs can be expected to provide the incentive necessary to launch a new military aircraft development program. However, the emergence of additional mission requirements can be so rapid and so critical that a new aircraft can not be considered because of the development time involved. Under these urgent conditions only derivatives of existing aircraft are viable options, and a decision to pursue such an option could negate the need for a new system well into the next century. As an example, if a requirement for greatly increased outsized cargo capability were to suddenly emerge, only derivatives of existing commercial widebody aircraft or a reopening of the C-5 production line are viable options. A decision to pursue either one of the options would virtually eliminate the need for a new strategic airlifter for the succeeding 20 odd years.

In a similar vein, other approaches to solving the need for rapid shipment of goods and materials may become more attractive and reduce the need for a new aircraft system. In the military sector, perhaps some form of rapid long distance surface transportation will emerge to compete with air freight shipments. Prepositioning of the larger, heavier military supplies also reduces the airlift requirement, particularly in the outsize freight category.

Impact of Diminishing Fuel Reserves

Thus far, projections of the nation's energy future have not been definitive enough to adequately assess the impact of escalating fuel costs and diminishing fuel supplies on the civil air transportation industry - other than to predict increasing emphasis upon fuel efficient technology. Questions of priority in fuel allocations, national policy regarding mass transportation systems, the development of alternative fuels, and the state of international relations have not been resolved to the point where a clear perception of the future is possible, and yet each could potentially have a major impact on the development of a new cargo aircraft.

It is possible, however, to postulate that decisions and policies may emerge which are not favorable to the continued growth of the civil air cargo market or to the development of a dedicated air freighter. For example, a strict "minimum energy consumption" policy would mitigate the U.S. government's participation in a joint development of an energy intensive cargo transport system.

Emergence of Roadblocks

Given the uncertainty of energy, economic and political conditions in the future, it is conceivable (perhaps even probable) that roadblocks will emerge to delay (or terminate) the progress towards a truly joint military/civil cargo aircraft development program.

The only comparable joint aircraft development venture was that undertaken in the 1960's when government and industry undertook the development of the ill-fated supersonic transport (SST). Although never completed, the program did successfully blend together the various government agencies and industrial organizations into a functioning development team; and the concept of government/industry cooperation was proven to be workable.

Even with the precedent-setting supersonic transport program experience, there remain several important differences between it and a joint military/civil transport. The most important difference is the design compromises that must be accepted by both parties in order to have a viable program. In the SST program, the configuration was chosen on the basis of commercial economics and both parties were seeking the lowest cost configuration. However, a military transport must provide the minimum essential design features to accomplish its military mission. Such features are not necessarily consistent with the lowest cost commercial transport configuration and compromises must be made. Because of this, it is conceivable that some form of government assistance may be needed to encourage commercial use of the aircraft and to compensate the user for the added cost of operating a less than minimum cost aircraft. Obtaining approval of the Legislative Branch for such assistance may entail more effort and time than is presently anticipated.

Prospects

For the past three years, the Air Force, NASA, and industry have been studying, at a low level, various aspects of the commonality c ncept. Because these efforts have been limited in scope, the accumulation of a sufficient data base on which to base conclusions has been slow. However, the data base is now approaching the point where trends can be discerned and overall direction of movement indicated.

Figure 11 presents a cryptic summary of the overall prospects as we currently view them.

Only under the favorable scenario developed in the CLASS project will the civil cargo market growth be rapid enough between now and the year 2000 to generate the demand needed to stimulate development of a dedicated civil air freighter. Projections of such a demand improves markedly by 2010; however, the influence of many factors will undoubtedly influence the response to this demand.

If one assumes an equal cost-sharing arrangement between government and industry, under the Boeing analysis and assumptions, the prospects for a dedicated freighter improve only slightly by the year 2000; but they appear good by 2020. The difficulty with this situation is that the military strategic transport fleet is aging, and a new aircraft will be required prior to 2020. The prediction of civil demand is seen to be critical.

- PROSPECTS -

NEW CARGO AIRCRAFT

FUNDING	TO 2000	TO 2020	COMMENTS
CIVIL ONLY	NONE	POSSIBLE	KEYED TO MARKET DEMAND
EQUAL SHARING	POOR	GOOD	CIVIL MARKET GROWING, MILITARY FLEET AGING
INCENTIVES	POSSIBLE	GOOD	AMOUNT REQUIRED TO STIMULATE MARKET
MILITARY ONLY	UNDESIRABLE	REQUIRED	AIRLIFT FLEETS ATTRITED DUE TO AGE.C-141 IN 1996, C-5 IN 2011

Figure 11.

If the government were to provide development funding support and agree to some form of additional incentives - either direct monetary or indirect through policy - the prospects improve to the point where a joint program becomes a distinct possibility by the year 2000, and even appear probable by 2020.

Finally, when one considers the development of a new military transport without civil participation the life cycle costs appear prohibitive in today's environment. Nevertheless, a new military strategic airlifter will be required by 2010, providing that one of the near-term alternatives has not exercised prior to 1995. Both the C-141 and C-5A fleets (assuming the proposed modernization programs are approved) will be attriting because of age by 2010. If the modernization programs are not pursued, both fleets will be attrited prior to 2000.

In conclusion, the prospects for commonality are highly dependent on the assumed civil market demand. Several projections of this demand, based on various assumptions, are now available. Additional effort is required to resolve the differences and chart a course to achieve a common civil/military transport aircraft.

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