4.0 Possible Future Mobility Systems

The Mobility Panel complied a list of nineteen possible future systems which they felt could improve mobility operations utilizing advanced technologies. These systems were based on the New World Vista study guidelines as stated in Section 1, the mobility mission shortfalls as identified in Section 2, and the technology needs as summarized in Section 3. A listing of the systems selected is provided in Table 4.0-1.

Table 4.0-1: Possible Future System

1*	**Global range transport**
2	**Supersonic military transport**
3*	**Information dominance system**
4	**Wing in ground effect transport**
5	**Global navigation system**
6	**Advanced material handling equipment**
7*	**Precision/large scale airdrop**
8*	**Virtual reality training**
9*	**Directed energy self-defense system**
10	**Unmanned transport**
11	**Containerized, intermodal system**
12	**Rocket transport**
13	**Air refueling transfer craft**
14	**Stealth transport**
15	**Twin fuselage transport**
16	**Modular transport aircraft**
17	**Improved refueling system**
18	**VTOL special operations**
19	**Sea-based transport**

Sections 4.1 through 4.19 provide a description of each possible system, discuss their applicability to the mobility mission, list possible benefits, and state the technology status or challenges to fielding the new system. These systems are used as the basis for ranking in Section 5. Finally, those with highest (*) ranking are discussed in detail in Section 6.

4.1 Global Range Transport

This system takes advantage of major advances in propulsion and materials technology. The result is a transport airplane of less than a million pounds take-off gross weight, capable of carrying 150,000 pounds of payload 12,000 nautical miles. With this performance capability the transport will be able to have unrefueled global reach. This airplane would support cargo and passenger airlift, aeromedical evacuation, and could be the basis for use as a tanker. Thus it would have broad application to air mobility.

Benefits

The benefits to the Air Force associated with the Global Range Transport (GRT) are many. Its unrefueled global range provides great flexibility in mobility operations. All the enroute support associated with inflight refueling or ground base staging can be focused on other missions. Further, use of modern design and commercial type subsytems should result in major reliability improvements. These reliability improvements in turn result in greater availability and fewer airplanes required to support the mobility missions. Finally, the technologies envisioned will be extremely attractive to commercial cargo carriers. Thus commercial development of such a transport is a distinct possibility - in which case a military adaptation would be possible. Such an approach would result in an extremely affordable global range Air Force transport.

Technology Needs

A number of technology advances are needed to develop an unrefueled GRT. Such an airplane represents a major technology advance over any existing airplane. Four needed key technologies are:

- Improved propulsion efficiency (advanced engines based on improved materials, higher cycle temperatures and bypass ratios). The IHPTET initiative should be pursued to bring this capability to the design of the global range transport.
- Improved aerodynamic efficiency (advanced wing design and innovative configurations)
- Light weight and low cost advanced materials
- Innovative concepts for design and build of the airplane utilizing digital technology and teaming

4.2 Supersonic Military Transport

Continued advances in supersonic aerodynamics, high temperature turbojets and advanced materials will make it possible to have a military supersonic transport. This vehicle will cruise at Mach number 2.4 and carry 50,000 pounds (150 personnel) for 5,000 nautical miles. The vehicle take-off weight will be approximately 500,000 pounds.

Benefits

Future warfare will require much quicker reaction times and smaller payloads. A supersonic military transport would provide the capability to deliver military personnel, advanced precision weapons, and appropriate resupply within hours to almost anywhere in the world. This fast reaction capability could be critical to deterring or containing potential conflicts. These vehicles would also have great value for special air missions.

Figure 4.2-1 Supersonic Military Transport

Technology Needs

A key requirement is for an advanced turbojet engine with high turbine inlet temperatures (+300° from today).

Continued aerodynamic development of efficient supersonic cruise configuration is needed. Development of laminar flow control would enhance the capability. Sonic boom problems must also be minimized.

Development of low cost, high strength, light weight materials is a must. These will probably be advanced composites - but not necessarily boron/epoxy.

4.3 Information Dominance System

The revolution in information technology led by the United States provides the US Air Force an unequaled opportunity to exploit and seize the next vista in aerospace employment on the 21st century battlefield. The information spectrum is composed of numerous critical elements which in combination will strongly enhance Air Mobility Command effectiveness in future operations, from peacekeeping through warfighting. The information spectrum has direct applicability across all the AMC mission areas of cargo airlift, passenger airlift, air refueling, medical evacuation, special operations and airdrop and will increase efficiency in all these areas.

The proposed system should consist of worldwide communication networks that are timely, accurate, and dependable. Their purpose should be to provide autonomous broadcast, or mission-coordinated information, in this case to all elements of the mobility system. The system would be composed of satellites in various orbits as well as fiberoptic nets. Available information should include, for example: surveillance/reconnaissance, command and control (C2), combat identification, communications/computer nets, intelligence, weather and precision navigation.

In-transit visibility of aircraft cargo, passengers and patients is another benefit. This must be accomplished in a seamless DoD transportation system consisting of sub-systems that not only communicate with each other but with system-supporting civilian entities to include the Civil Reserve Air Fleet. The global network must contain a sub-network core that is totally reliable and protected in warfighting situations, connects aerospace vehicles (manned and unmanned) with command nodes and employs embedded computation with trusted fusion capability. Terrestrial (fiberoptic, optical, wireless) and satellite communication architectures will be necessary.

Near-perfect real-time situational awareness provided to the aircrew is another plus. Relevant information should include for example: threat updates, weather, airfield information (delays, base loading, fuel availability, runway composition etc.) and air refueling rendezvous data/offload. Accurate and timely intelligence information not only aids preflight planning but must be tailored to specific mission needs ranging from humanitarian relief, to a ground threat situation update for an airborne unit prior to paradrop.

The vision is assured communications connectivity coupled with providing the right information to the right person at the right time. To accomplish this, timely, automated direct-feed collection and fusion, improved imaging intelligence and multi-level security technology is required. Information from cyberspace provided through globally connected computer networks is central to meet the warfare acceleration of the next century. Command and control assistance provided by computer-generated-automated planning/decision tools is imperative to enhance mobility force efficiency.

Information dominance must include the technological ability to conduct C^2 Warfare by denying any adversary the ability to paralyze or exploit the information spectrum, thereby insuring preservation of the tactical initiative. Conversely, interfering with the adversary's decision process is a needed military capability.

The above-mentioned capabilities must always be measured against the constants of affordability, survivability, supportability, mobility, commonality, interoperability, standardization, and user friendliness while exploiting commercial off-the-shelf technologies.

Promising technologies that require exploitation to satisfy the requirements stated above include integration of national/airborne/commercial surveillance resources, integration of the wired/wireless global grid, core bitways (ground/sea/air) and services, automatic coordination, data fusion and planning applications, small massive parallel processors and multi-level security/access applications. There must be both doctrinal and technological advancement.

Worldwide communications will increase mobility efficiency by providing instantaneous connectivity, quick problem resolution and greater C^2 flexibility. Also, it will make available much needed in-transit visibility and situational awareness.

4.4 Wing in Ground Effect (WIG) Transport

WIG aircraft rely on the increased lift generated by an airfoil moving over a surface at very low altitudes (generally not exceeding one chord length). Fuel economy is increased by as much as five times. This effect rises steeply at altitudes less than 1/10 of the wing span, so practical transport systems relying on WIG are very large, with cruise heights of 10-20 feet, largely limiting them to over-water operation. One current concept (Figure 4.4-1) transports 250,000 pounds of cargo over 6,000 miles at 400 to 450 knots. Other versions have been designed to carry payloads up to five million pounds - equivalent to forty C-141 loads or fifteen C-5 loads.

Benefits

WIG aircraft provide a high speed air supplement to the sealift component of the mobility triad (air, land, and sea). WIG aircraft provide true fast sea-based lift capability,with flexible terminal options. Speed is ten times that of the fastest transport ships. WIGs can load and unload at virtually any location on water and can fly over land at altitudes up to several thousand feet (although less efficiently) to land at aerial ports. Speed and water landing capability supplement prepositioning for sustainment in sea-based airlift during expeditionary, over-the-shore, and littoral operations.

Technology Needs

Low-drag hulls, cargo transfer system for water-based operations, saltwater corrosion protection, obstacle detection and collision avoidance, propulsion (including takeoff lift augmentation), as well as research on effects of sea state and weather on lift and control feasibility.

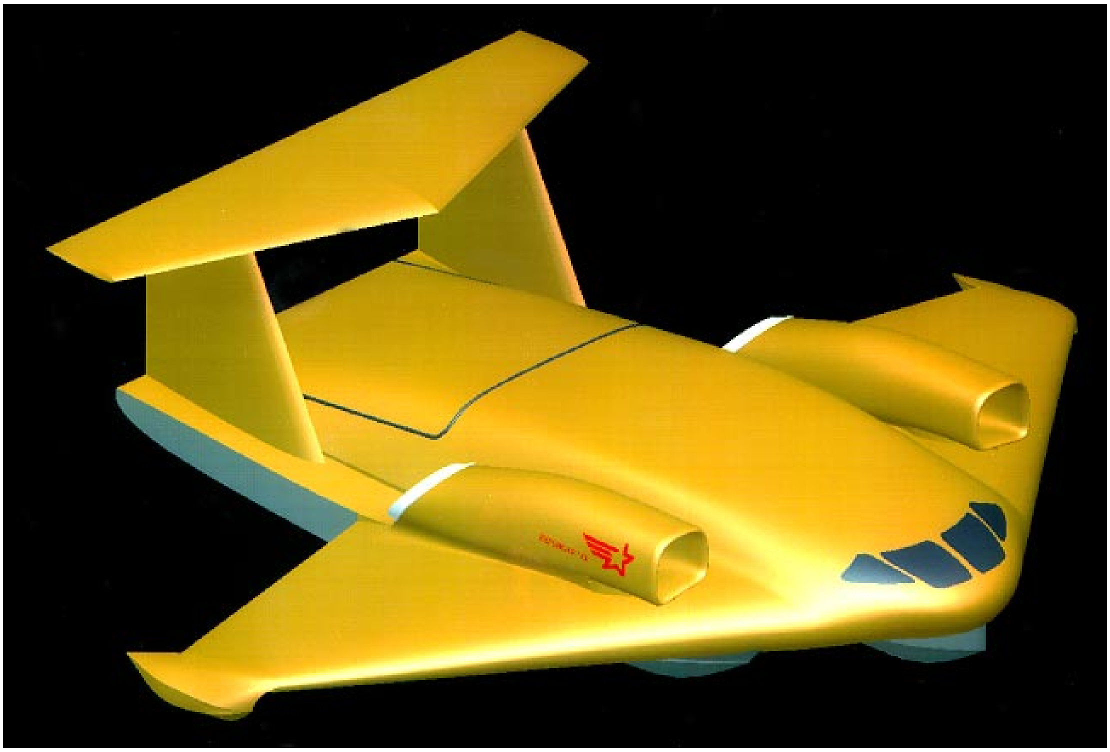

Figure 4.4-1 Wing in Ground Effect Transport Concept

4.5 Global Navigation System

A navigation system for aircraft operating anywhere in the world with an accuracy of one meter is envisioned based upon geostationary satellites, advanced communication networks, and enhanced computer capability. This will greatly improve economics and safety for all mobility missions.

Benefits

It will be technically possible to control the world's air traffic from eight centers—both enroute and on approach. Tests to demonstrate the feasibility of controlling aircraft enroute in remote areas or over the oceans have been conducted. Pilot's radio reports of position to ground controllers, which take from 5 to 45 minutes, can be eliminated. Uncertainty of position, which means the 20 minutes or 15,000 square mile safety zone, could be reduced over some routes. Choke points could be minimized to triple capacity and shorten delays into major air hubs. Digitized radio transmissions could streamline communication between the flight computer on board and the air traffic control computer located on the ground. One benefit is the reduced fuel burn and flight time by optimizing flight plans for different weather conditions. A second benefit is to lessen spacing and increase the capacity of crowded skies. The navigation and communication tools would allow the AMC fleet to fly direct, take advantage of winds, not be constrained by altitude and speed, and avoid delays getting into the airspace to increase mission effectiveness.

Technology Needs

The Air Force should take a leadership role in advocating the use of the global navigation system as the international enroute and landing approach solution. Augmented GPS signals can provide the accuracy, integrity, availability and continuity for precision approaches. A decision on the method to communicate the data through a satellite data link is necessary to enable many aircraft to communicate their GPS positions to one another and to ground stations. This has particular significance for the mobility mission, particularly reducing the need for radio communication. Anomalies in the signal pattern and jamming susceptibility must be completely understood and mitigated to give full confidence to the international user.

4.6 Advanced Material Handling Equipment

Currently, the positioning of material handling equipment (MHE) by airlift to global destinations presents a heavy demand on early airlift capacity. Further, the on-ground mobility of the current MHE fleet is inadequate for current and future needs.

Marginal ideas such as magnetic levitation were discussed as potential solutions to the problem of loading and unloading transports (particularly commercial derivatives). No realistic potential solution was uncovered, the need persists.

Benefits

If a new system could be invented, it would reduce the number of airlift loads required and improve cargo delivery times particularly in the early days of a conflict.

Technology Needs

No technology demonstration programs exist to reduce dependence on MHE. USAF Wright Laboratories is contemplating an Improved Methods for Airlift Cargo Handling (IMACH) demonstration program. Joint Force Power Group is engaged in a first step - identifying common cargo handling concepts. New technology concepts are needed to support the mobility mission.

4.7 Precision/Large Scale Airdrop

More robust airdrop systems enable broader use of airdrop instead of airland operations for rapid force insertion and direct delivery while providing increased aircraft/air crew survivability. This capability comprises two components: new or improved airdrop systems (ADS) and improvements to aircraft equipment used to perform airdrop. Precision airdrop technology increases the mission success rate of cargo airdrop. New airdrop systems (ADS) extend airdrop to larger loads, higher altitudes, and substantial standoff. Enhancements to airdrop attack all components of the air delivery error budget, benefiting directly from the development and testing of precision munitions delivery systems. Widespread use of GPS means both intended impact point and aircraft position are known within the accuracy of GPS-based techniques. GPS leads to highly reliable "drop on coordinates" capability. Ballistic winds measurement using dropsondes or LIDAR reduce uncertainty by providing wind models to simulation of trajectory.

Benefits

The greatest advantage of precision airdrop is the greater survivability of aircraft and aircrews afforded by high altitude and long standoff releases. Another direct benefit would be a broader use of airdrop for rapid force insertion and direct delivery. Also, precision delivery of material would lead to wider use of airdrop. Highly mobile forces would be more economically supported with large scale airdrop than by building temporary air bases. Extension of precision cargo drop technology to paratroop operations would lead to use of smaller drop zones and more immediate ground force battle readiness.

Technology Needs

New airborne sensors and offboard imagery and targeting data feeds establish accurate slant ranges in the absence of GPS, or can be used in concert to refine location accuracy. Development of higher load-carrying parasails is needed, lower cost devices are desired. Precision airdrop of paratroopers depends upon a new paratrooper guidance system.

4.8 Virtual Reality Training

By combining computer-generated imagery with advanced three-dimensional holographic displays, simulators can be constructed for almost all air mobility functions. The first application could be for flight simulators (some motion cues may also be required). Similar software could be generated for maintenance training and operational training (such as loading and unloading the transport). Refueling operations could also be simulated. Once the software, computer systems and displays were available they could also be used to evaluate different operational procedures. A major advance will be the combining of these simulators through secure datalinks to other services and remote locations. Thus networked simulation training will be possible. With adequate data links crews could be prepared to fly into very austere fields and better understand their full missions. Rehearsal training will be very realistic.

Benefits

One big advantage of the system would be in keeping up with configuration and operational changes. These would be in software rather than in hardware. Another advantage will be in increased realism. These applications should result in reduced training costs and improved efficiencies for all mobility missions.

Technology Needs

Development of these concepts should be in parallel with many similar commercial projects. This shared costing for the development is a distinct possibility.

The technology developments required are: higher definition, three-dimensional holographic displays, advanced computer-generated 3D imagery, and high speed (parallel processing) computer power to integrate all these elements.

4.9 Directed Energy Self-Defense System

This system is proposed for large air mobility-sized aircraft, and would encompass the use of a missile attack warning system to alert a directed energy (i.e. a laser, high-power microwave (HPM)), or Self-Protection Missile (SPM) to destroy or confuse an approaching missile.

Surface-to-air, or air-to-air missiles, are a major threat to mobility aircraft performing cargo airlift, passenger airlift, airdrop operations, medical evacuation, special operations and refueling missions. The proliferation of these missiles gives hostile nations and unfriendly faction groups an opportunity to employ weapons against air mobility aircraft, who on a routine basis, use the world's airfields. Threats range from handheld ground-launched IR missiles to SAMs and fighter-launched missiles. Mobility aircraft must have warning of an impending attack through: Real-Time-in-Cockpit (RTIC) situation awareness system; on-aircraft passive/ active missile approach warning sensors; and, systems that defeats approaching missiles. A directed energy defensive system would enhance air mobility-sized aircraft's survivability substantially and provide assurances of primary mission success.

Approach

1. The development of a sensor(s) system to ensure spherical (4 pi steradian) coverage around the aircraft which alerts the crew when under attack and defines a relatively accurate azimuth resolution track file for counter missile activity.

2. The employment of high speed computation to provide a fine resolution pointer-tracker to precisely orient an on-board directed energy counter measure system at approaching missiles.

3. The development of a directed energy (laser/high power microwave) counter measure system capable of engaging (destroying or confusing) an approaching missile at sufficient range to ensure protection of the host aircraft. Also, under consideration is a SPM with either a HPM or small warhead.

Missile warning systems have been developed that provide relatively good azimuth and range information for RF acquisition and tracking systems. However, missile warning systems for IR-guided, ground and air-launched missiles, is sorely lacking. Two recent USAF/Navy programs attempted to address this shortfall. Both the Missile Attack Warning System (MAWS) and Silent Attack Warning (SAW) systems both focused on the IR missile threat, but have not matured due to insufficient funding. The Advanced Threat IR Counter Measure (ATIRCM) program is the latest joint initiative to solve the IR missile warning problem. This Army-led program inherited the MAWS program and schedule. However, to keep people on their toes they renamed it Common Missile Warning System (CMWS). The contractors bidding for the ATIRCM/CMWS contract may propose full coverage IR search air track (IRST) sensor systems, single or array detector systems, UV, MMW and other sensor ideas that will acquire and track incoming IR (or other passive seeker) missiles.

Correspondingly, massively parallel computing processors begin to offer the capability needed to predict an on-coming missiles' flight trajectory and impact points. Next generation fast computing will be required to solve the difficult pointing and tracking problem for a directed energy defensive system to be successful. As this capability is developed countermeasure system can be employed to confuse or destroy threat missiles. Flares and decoys are of some value, but offering the most promise are the following three initiatives:

1. A laser weapon that is both adequately lethal and sufficiently compact to be practical as a self-defense weapon. The laser would be located so that it has full coverage of both hemispheres around the aircraft. The power requirements should be reasonable and consistent with what the airplane can supply. A potential light-weight system operates at the kilojoule laser level.

2. A high-power microwave system that is capable of destroying an attacking missile without degrading the aircraft's basic mission is another option. However, the problem of degrading the basic mission is severe.

3. A small Self-Protection Missile (SPM) capable of intercepting an approaching missile.

Benefits

A directed energy system would provide active protection for air mobility aircraft. Since they are not able to take evasive action, an active system is needed. The transports have much more space and power available than tactical aircraft and hence it is more feasible.

Continued technology developments of on-board missile sensors and computers must continue to support the concept. Also, the small laser system technology needs to continue with special emphasis toward accomodating a complete system within the weight, space, and power requirements of air mobility aircraft.

4.10 Unmanned Transport

This concept involves using modern control technology together with worldwide communications to eliminate the transport crew. It would be most practical when used as a flight of several transports where one had a pilot, copilot and loadmaster and the other craft were slaved to the lead ship. He would remotely land each before landing his own vehicle, or ground control of the landing could be done by telepresence. This concept would be initially applicable to cargo airlift, but with additional development could be applied to airdrop operations.

Benefits

Flight personnel are expensive and vulnerable. The number of flight personnel at risk and in total would be reduced.

Technical Needs

Major technology advances in reliability are required in all aircraft systems, particularly controls. In addition, secure, dependable communications are required.

4.11 Containerized, Intermodal System

Economical long haul cargo transport using surface transportation modes (truck, rail, or ship) increasingly relies on packaging of cargo into standard intermodal containers that are transferred from one mode to another. The container is only "broken" at its destination or a planned redistribution point. Today, military cargo transportation needs are increasingly being met through intermodal containerization to take advantage of the cost economies and distribution system available using commercial carriers and equipment. Many military trucks and ships differ from their commercial counterparts only in ownership. Intermodal ports have an air component enabling direct transfer of standard containers between surface and air transportation systems.

Benefits

Adding an intermodal dimension to air cargo capabilities facilitates both rapid deployment and readiness. The intermodal system for air mobility (ISAM) concept recognizes the integral character of airlift in the mobility triad (air, land, and sea) by inserting container handling capability into aircraft material handling systems.

Many studies of intermodal freight emphasized potential commercial applications of military airlift aircraft. Now, the emphasis is just the reverse - exploiting commercialintermodal technology to improve military airlift. One of the foremost limiting factors turned out to be the inherent difference between the Air Force's 463L cargo handling system and the International Standards Organization (ISO) intermodal container configuration standard. No common interfaces exist between 463L pallets and ISO containers, meaning additional port and material handling equipment is needed to transfer cargo to and from transport aircraft.

In the 1970's, Project INTACT Intermodal Air Cargo Test culminated in the first practical demonstration of complete intermodal compatibility between air and surface freight transportation. The program evolved from the consensus that an expanded air cargo fleet would meet the need to enable air freight to evolve from a premium specialty service keyed to small shipments to an economical prime large-volume distribution service. Project INTACT showed that large, advanced technology aircraft would provide an economical air component for container-based intermodal transport.

Tomorrow's transportation network must recognize the interlocking relationships of the mobility triad: airlift, sealift, and overland transportation. Adapting air cargo to include intermodal containers emphasizes total distribution system economies. Although containers contribute higher tare weights than palletized (breakbulk), the advantage comes in the form of end-to-end distribution economies - reductions in manpower and equipment needed for transfer between air and surface modes of transport.

Technology Needs

Aircraft and cargo tracking (point of sale) system inputs for container identification systems, aircraft-compatible intermodal (container transfer) material handling equipment.

4.12 Rocket Transport

The system envisages accurate delivery of non-explosive payload by rocket from US bases to points around the globe. The system would complement existing payload delivery systems of Air Mobility Command for extremely high priority items.

The challenges to developing a viable system are numerous:

1. Limited volume and weight of payload

2. Requires modular payload compartments, preferably preloaded, for rapid attachment to rocket.

3. Reentry heat protection for a relatively large payload compartment will impact payload.

4. Specific payload compartment shape required for stability during reentry may impact volumetric efficiency.

5. Requires programmed rocket ready to fire as soon as payload module is in place.

6. Final reentry - soft landing stage - would be the least accurate phase of delivery if parachutes were necessary. Retro-rockets would improve accuracy. Work is needed to evaluate the payload penalties involved.

7. Feasibility of a shock-absorbing target area in selected areas overseas would reduce payload penalties if higher impact velocity could be tolerated. Research would be required. Use of such technologies would reduce the number of delivery points worldwide, and raises the competitive concept of pre-positioned stockpiles.

8. Local mapping of delivery points needs to be compatible with global coordinate system.

Benefits

1. Very short transit time - under one hour to any location worldwide. A two hour order to receipt may be feasible.

2. High accuracy of delivery.

3. Valuable as means of delivering extremely high priority items.

Technical Needs

1. Technical assessment to evaluate the points raised in the technical assessment above. Initial study on net weight and net volumetric capacities practicable as add-ons to existing solid fuel rockets such as Titan and Minuteman. Weight and volumetric studies should include initial feasibility design of stable reentry freight compartment with reentry heat protection.

2. Determination of demand for system on basis of outcome of 1.

3. Review of 1 and 2. Determination of need and decision on next step.

4.13 Air Refueling Transfer Craft (ARTCraft)

The ARTCraft concept is unmanned high-speed air vehicles that fill with fuel from a tanker “mothership,” then fly out to refuel fighters at higher speeds while flying with the receiver aircraft (fighter), then return to the mothership. Each would contain enough fuel to enable loiter, flight, and recovery in addition to that required to refuel one fighter. Multiple ARTCraft would operate with each mothership, say up to 20, where command and control (C^2) is based. C^2 would also be shared among motherships, fighters, and theater C^2 air assets. Fuel transfer can be accomplished with conventional “probe and drogue” or receptacle systems or, for future systems, by actual attachment to the receiver. In the latter configuration, a high rate transfer system would enable minimum flight time in the refueling configuration but also allow maneuver while mated. This could be as simple as a “married” control system to enable two craft to fly as one. More aircraft could be refueled at one time, over a wider area and at a range of altitudes. ARTCraft could either be deployed from the mothership or fly together with it.

Benefits

ARTCraft could support the Air Refueling mission area, including all key processes within the mission area.

The use of multiple autonomous fuel transfer craft enables as many fighters to be refueled simultaneously from a single tanker as there are ARTCraft associated with it. Refueling takes place at fighter cruise speeds, rather than tanker speeds. The aircraft are refueled at a distance from the tanker.

Technology Needs

Unmanned air vehicle guidance and control, coordinated control systems, high rate fuel transfer.

4.14 Stealth Transport

The need for special operations is envisioned to dramatically increase in the future. Vulnerability of airlift aircraft presents a constantly growing weakness of mobility operations in hostile areas. All transport aircraft are vulnerable to proliferating low-cost hand-held IR missiles. Tactical and special operations transports must face even higher threats from air defense radar and other sensor systems, as well as small arms fire. The Special Operations Command has a long recognized need for a low-observable transport aircraft, reflected in a Mission Need Statement.

Rapid advances in stealth made in fighter and bomber aircraft have not been implemented in the transport community. Today’s special operations workhorses, the MC-130, AC-130, MH-53J and MH-60G fall short of SOCOM mission needs. The Air Force’s newest airlifter, the C-17, began development prior to the recognition of the need and capability to implement stealth. Today, transport aircraft can be readily developed that feature low observables and a broad range of other survivability enhancements.

Benefits

A survivable transport, well-suited to forward tactical transport missions, will directly benefit from stealth technology now in the fighter community, including geometric shaping, composite structures, and radar-absorbing materials. In addition, integrated propulsive high-lift systems meet the demand for short-field operations. Survivable transports also benefit from built-in defensive systems and use of off-board navigation and information data feeds, including all-weather operations.

Technology Needs

Affordability is the key issue due to the small quantity of aircraft needed to meet Air Force theater lift capacity. Although commercial aircraft and derivatives thereof also require survivability improvements, aircraft capable of operating in high-threat environments pose a military-specific need. A new military acquisition would be needed.

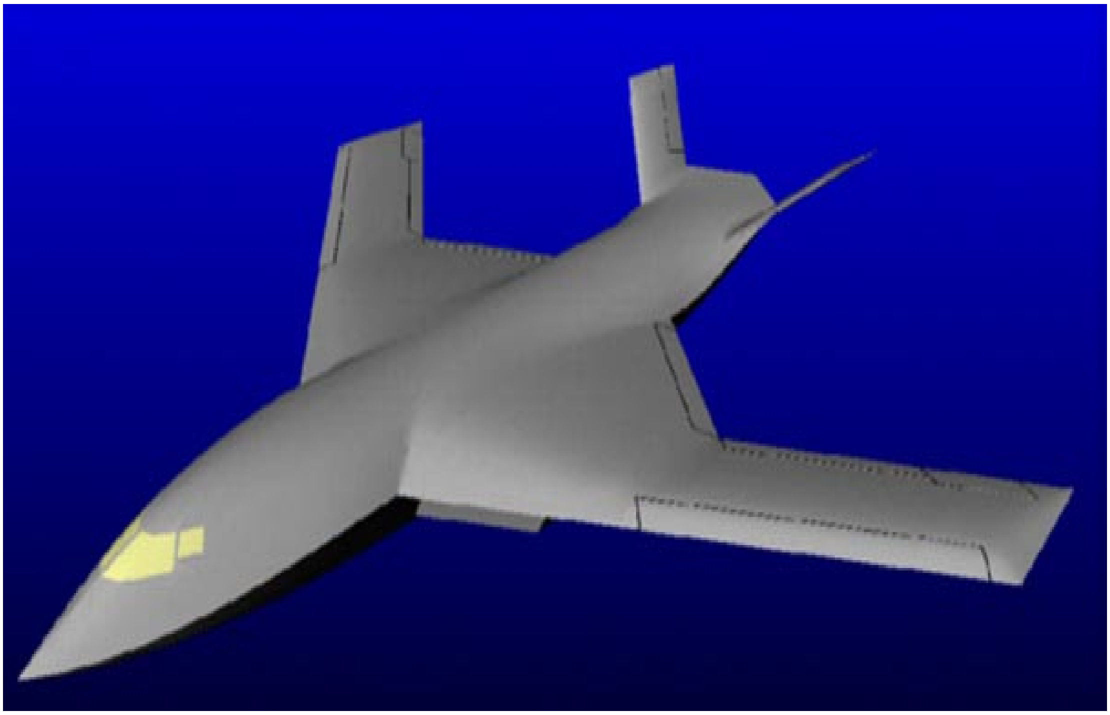

Figure 4.14-1 Stealth Transport Concept

4.15 Twin Fuselage Aircraft

Concept

The concept advanced here is that of an airplane configuration having twin fuselages that are separated by straight wing and tail surfaces. The underlying problem being addressed is that of finding a way to increase the wing aspect ratio of an airframe without incurring the associated structural weight penalties. and at the same time to realize the increased L/D (lift over drag) benefits that higher aspect ratios provide.

In the analysis of airplane performance from a range and payload point of view, three fundamental parameters appear, namely: zero lift drag coefficient (C_{do}) specific fuel consumption (c) and wing aspect ratio (AR). To obtain good range, (or low fuel consumption) the aim is to keep C_{do} and c small, and AR large. Much has been done to make the airplane clean (that is to make C_{do} small) and much has been done to reduce the specific fuel consumption of the engines. Practical design considerations, however, constrain the desire to have large aspect ratios. For the conventional type airplane configurations - those with a single fuselage - wing bending moment increases dramatically with aspect ratio, and causes the wing weight to grow excessively, precluding a more practical design. As a result, aspect ratio in conventional design has been generally limited to the 7 to 9 range.

Benefits

The use of a twin or dual fuselage configuration is a way that aspect ratios can be increased. This arrangement allows a dramatic reduction of wing bending moment, hence a way to achieve lower wing weights while obtaining high aspect ratios. Analysis indicates, for example, that an aspect ratio of 12 can be obtained with a wing weight less than that of a conventional design. At the same time a synergistic improvement is found throughout the airframe design:

1. The fuel consumption is lowered.
2. The skin friction area of a twin fuselage configuration may be less than a corresponding single fuselage design.
3. The gross weight, engine thrust requirements and airplane size are reduced.
4. Aeroelastic effects are reduced.
5. The flap system may be simplified.

The resulting payoff offered by the twin-fuselage concept can be seen by the typical results shown in Table 4.15-1. Values are given for a base or reference configuration, and for

Table 4.15-1. Comparison of Single vs Twin Fuselage

Number of Passengers = 300
Range = 6000 nautical miles

		Gross Weight	Total Max Engine Thrust	Wing Area	Wing Span	Seat-miles per pound
Base	Single	652,700	145,400	6101	214	7.21
	Twin	499,100	113,000	4596	224	10.64 +47.6%
With -10%c	Single	555,900	128,600	5009	194	8.95
	Twin	444,400	103,600	3971	209	12.72 +42.1%
With -10%W	Single	523,500	119,400	4783	189	8.83
	Twin	489,400	96,400	3800	204	12.49 +41.4%

technology reductions in specific fuel consumption and for structure weight, considered separately. The configuration parameters, gross weight, engine thrust required, and wing area, are all noted to be decreased in the range of 20% for the twin concept relative to the single fuselage configuration. The basic operational parameter, seat-miles per pound of fuel, as given by the right-column numbers, is noted to increase by a remarkable 40-50%, further indicating the marked gains to be realized by the twin-fuselage concept.

Technology Needs

Items to consider include: landing gear tread, ground handling and turning and pilot offset. Developments needed include wind tunnel tests to verify L/D increase, proceed with a prototype to gain operational experience (note: construction can proceed by simply applying present day technology and assembly processes).

4.16 Modular Transport Aircraft

The key to achieving dramatic improvements in airlift efficiency may still be achieved by exploring innovative new concepts. The modular airlifter illustrates this potential in a concept that combines aspects of mobility operations and innovative aircraft concepts of the past with deliberate investment in new technology.

The modular airlifter attempts to create an aircraft system analogous to surface modes of transport, such as trains or barges, by linking multiple cargo mobilizing units (boxcars) together to achieve efficiencies not available to separate air vehicles. However, rather than separate the locomotive source from the cargo units, the air train joins multiple, otherwise independent aircraft wingtip to wingtip, achieving higher combined efficiency by reducing drag due to tip losses and exploiting the aerodynamic benefit of high aspect ratio. The units take off under their own power, then maneuver into position once aloft and complete a connection at the wingtip during steady climb or once cruise altitude and speed have been established. The connection may be mechanical or electromagnetic. The joint transfers sufficient load to hold the air train together in its joined configuration, yet separates under sudden application of large load excursions.

One concept of the modular airlifter exploits a span loading all-wing shape and integrated propulsive lift shown in Figure 4.16-1. The engine is buried within the airfoil shape and draws air through a spanwise slot inlet to augment circulation lift and maintain laminar flow, achieving high lift-to-drag and permitting use of a very high thickness ratio. A 100 foot span and a 40-50 foot chord encompasses a cargo compartment able to carry four 20' ISO containers, weighing up to 200,000 pounds, with sufficient thickness behind the rear beam for four transversely mounted engines with a fan diameter of more than 8 feet. The engines exhaust through a full-span, vectoring trailing edge jet flap.

Benefits

Unprecedented advantages can be gained. A modular airlifter comprising six units as in Figure 4.16-2 attains an aspect ratio of 24, carries 1.2 million pounds, and weighs 3 million pounds, yet operates from the same airfields as a C-130 or C-17. The all-wing shape doubles the maximum number of aircraft on the ground (MOG), quadrupling throughput. Laminar flow and possible elimination of tail surfaces reduce drag. Structural weight is minimized by achievement of high volumetric efficiency, minimizing the fuselage, and high section properties. Sophisticated automatic flight control, tightly linked among all units, enables operation with a much reduced crew complement. Possibly, only one unit would be manned, with the others operated under supervised autonomy.

Operationally, a modular airlifter can be assembled from multiple aircraft departing from geographically dispersed air ports of embarkation, fly together for efficient long range cruise, then deliver to one or multiple air ports of debarkation.

Technology Needs

Key technologies include integrated propulsive lift, transverse propulsion systems, in-flight coupling and coupled flight, atmospheric monitoring systems, and robust autonomous control.

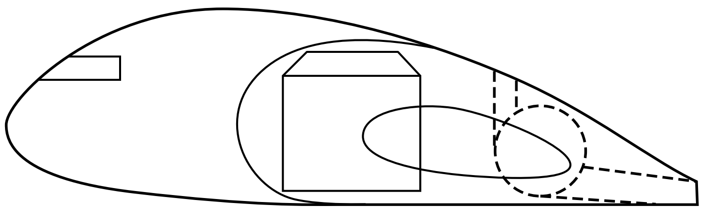

Figure 4.16-1 Span Loading Wing Design

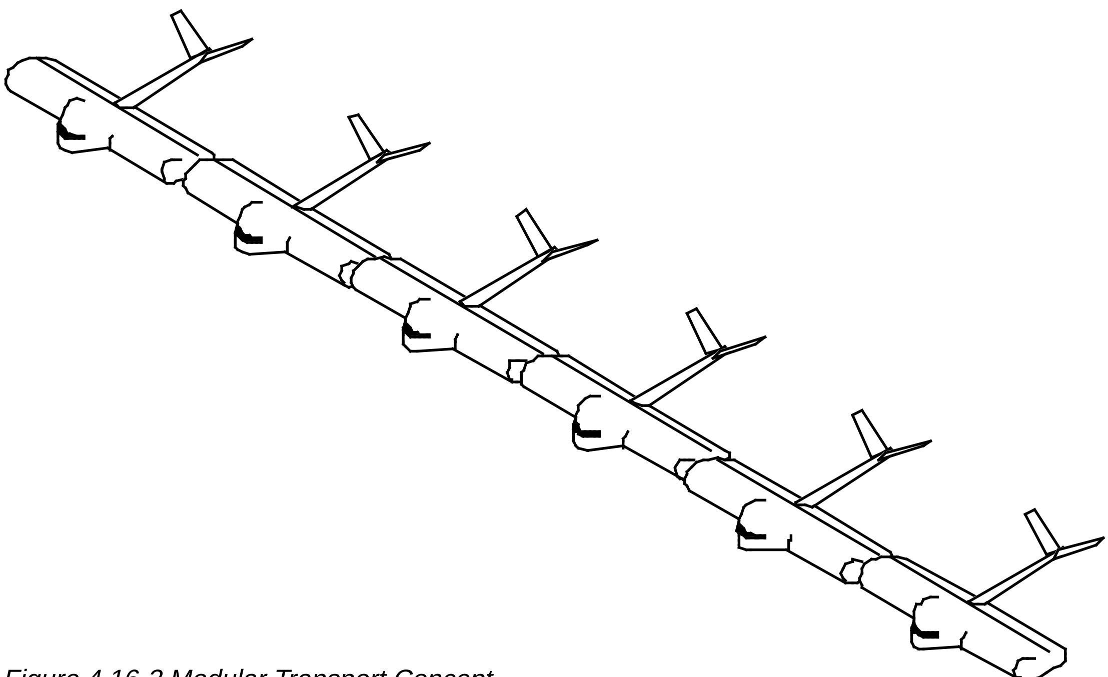

Figure 4.16-2 Modular Transport Concept

4.17 Improved Refueling System

A key element in the ability of the US Air Force to provide Global Reach is the Air Mobility Command tanker force. Aerial refueling is essential to rapid world-wide force projection. Operational requirements frequently demand rapid fuel off-load to multiple receivers. At this time, only two methods are available for fuel transfer, boom/receptacle or probe/drogue. Each of these options has drawbacks. Boom refueling provides a higher fuel transfer rate but is limited to one receiver aircraft per tanker, which impacts critical target timing for large fighter strike packages. Drogue refueling permits two receiver aircraft per tanker, however, off-load transfer rate is reduced. Tanker/refueling system limitations are but one part of the fuel transfer equation. Fighter aircraft internal fuel systems are limited in size due to fighter dimensions and constrain receiver on-load rates. Further, only US Navy fighter aircraft are probe-equipped and therefore compatible with drogue-equipped tanker aircraft.

This situation logically leads to the question of whether some technically improved refueling system can be devised that is compatible with existing multi-service aircraft configurations and will satisfy the operational requirements of rapid off-load to multiple receivers.

A review of technological opportunities to find such a concept proved unsuccessful. The realistic improvements would appear to involve improved boom control systems and remote boom operators. The remote boom operator could be extended to telepresence so that the crew size could be reduced. A better control system would result in a larger breakaway envelope and hence fewer inadvertent disconnects - resulting in shorter and safer refueling.

Continued technical development of advanced control concepts is required to expand the boom envelope. Virtual reality developments with displays, computer controls and sensors will be needed for the remote boom operator. The development of a remote boom operator station will make it possible to develop and install pod-mounted refueling booms for large tankers. There are other developments needed in station-keeping, sensory, etc to permit true all-weather refueling.

Refueling of small aircraft takes too long. Efforts should continue to get higher pressure systems with higher flow rates.

4.18 VTOL Special Operations

Variable bypass engines can be developed in the near future which provide high thrust to weight for vertical takeoff and landing and also provide efficient cruise performance for transport aircraft. This concept would utilize such engines to power a small transport to support special operations. It could also be used for search and rescue. The vehicle would be capable of carrying a squad of troops for 500 to 1000 miles and then effecting a vertical landing to insert the troops. After insertion it would take-off vertically and return to its base. It could also be used for search and rescue and would have a hover capability as well.

Benefits

The primary benefits from such a system would be: 1) ability to operate into very small spaces, 2) faster insertion and recovery and 3) reduced vulnerability due to higher to higher cruise speeds (than helicopters).

Technology Needs

The technical challenges for this concept are formidable. Low cost composite materials are needed to keep the airframe weight low. Development of a variable by-pass engine with very high thrust to weight ratio (15:1) is required. It should have a cruise specific fuel consumption no higher than today's commercial transports. It is assumed that the technology for stability and control functions will be minor extensions of stability augmentation systems which exists today.

4.19 Sea Based Transport

Sea-based airlift could enhance force projection in the future. The USMC is exploring new operational concepts that dramatically reduce the "footprint" of expeditionary forces by airlifting 8'x8'x20' containers from a new series of combat service support team ships to inland 900'x50' landing zones. These new ships are envisioned to provide decks that accomodate airlift aircraft takeoffs and landings.

Sea based airlift relies on aircraft operating from water to perform air mobility operations. Aircraft concepts include those confined to takeoff and landing on water (seaplanes), those that can operate on either water or land (amphibians), or those that can operate from the deck of specially configured ships or floating air bases. Prepositioned materiel is transferred from the prepo ship to aircraft which then transport the cargo over the shore for airland or airdrop delivery.

One concept of sea-based airlift adapts the C-130 by attaching floats (Figure 4.19-1), retaining 23,000 to 25,000 pounds payload capacity. Advances in hydrodynamics leading to new hull and float designs promise to enable a renaissance of new seaplanes. Alternatively, aircraft with short takeoff and landing capability can operate from ships configured with decks shorter than 1,000 feet. A new, Super-Short TakeOff and Landing (SSTOL) aircraft will be needed to fulfill this role. USAF studies in the 1980's concluded that a tilt-wing medium transport could best achieve this needed performance. While seaplanes and amphibians may operate in weather up to sea state 3, the ability to transfer cargo to and from the aircraft is made more difficult.

Benefits

Sea-based deployment supports rapid response and rapid force projection using float prepositioning of equipment and supplies. Many potential regional and contingency conflicts occur within easy reach by air of coastal continental boundaries. Though aimed at cargo airlift, sea based airlift conceivably can perform a broad range of airlift and air refueling missions in conjunction with suitably configured ships or land-based facilities. Sea-based airlift provides a forward air component of the land-sea-air mobility triad.

Sea based airlift increases the flexibility and range of air delivery options, speeds response by enabling prepositioning rather than CONUS basing, and reduces the land footprint of amphibious operations. This capability is especially attractive for special operations.

Technology Needs

Key technologies needed include: float and hull design (reduced drag and improved stability), stable ship-to-aircraft transfer systems, corrosion protection (especially salt-water), and large payload precision airdrop.

Figure 4.19-1 Sea Based Transport Concept