

CRITICAL NATIONAL NEED IDEA  
WHITE PAPER

**Survivable Modular Transport Aircraft (SMTA)**

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A Survivable Modular Transport Aircraft (SMTA) architecture is needed that will meet future aviation needs to assure fast reliable airline passenger safety and is adaptable to various commercial, military, and homeland security missions. Through the use of unique aircraft architecture components the evolving threat of 'carry-on' terrorist bombing can be mitigated while providing infrastructure growth elements needed to broaden the future of the critical US aircraft industry. The SMTA project will demonstrate processes and material research applications that provide versatile threat mitigation architectures and revolutionary growth paths for an emergency-quick-response-industry. The SMTA system is a projection of applied research that demonstrates advanced materials and concepts to provide aircraft passengers with a survivable protection from explosive and chemical / biological weapon threats and general failure modes.

To assure US industrial security; modern commercial and military transport aircraft must provide a safe environment for their passengers while treading a narrow economic path based on passenger miles traveled. This economic calculation includes such things as passenger handling time (loading / unloading) and customer satisfaction (i.e. while shoving as-many-people-as-possible into as-small-a-space-as-possible satisfies the immediate cost / income calculation, passenger dissatisfaction will eventually cut into the long term income side of the calculation). Add to this the burden of anti-terrorism measures and the need to meet increasingly complicated regulations and it becomes evident that the current airline solution is marginally tenable. The SMTA system proposes research to address these issues through a revised aircraft configuration that not only improves passenger safety but speeds the loading / unloading process, and improves baggage accountability. The system will mitigate the risks of 'carry-on' weapons / explosives and emergency clutter control while providing strict baggage tracking and modular adaptability to diverse civil and military missions.

The societal challenge associated with this critical national need is overcoming the long standing air traveler protocol of multiple 'carry-on' items (i.e. while the vacation traveler is normally willing to 'check' his larger bags, the business traveler frequently insists on 'carry-on' baggage to facilitate rapid retrieval and departure). Due to the increased threat of chemical, biological, and explosive terrorist weapons the future must address separating all passengers from their baggage so that it can be carried in an external compartment that segregates covert weapons from human occupants. The separation of hard cargo from soft cargo (passengers) is the standard safety paradigm for ground based handlers and not only prevents dangerous human / material interaction but potentially speeds up the passenger loading / unloading process.

The SMTA topic requires definition of a major structural change to the existing 'man-in-a-tube' commercial transport aircraft architecture concept that has dominated the industry since the 1950's. The key element of the SMTA concept is the modular compartments that are easily attached / detached to the aircraft structure while conforming to aerodynamic requirements and remaining within overall structural and weight constraints. The concept of having modular cargo / passenger compartments enables multiple vendors to construct standardized components, handling systems, and innovations to address unique cargo constraints (e.g. commercial cargo pallets that are pre-loaded, inspected, and queued for next available transport could be constructed and handled differently than pallets that must accommodate last minute business travelers). While externally the cargo pallets must fit a standard aircraft interface and aerodynamic constraints, the individual compartments can be configured to accommodate specific payloads such as emergency response medical units or general use baggage containment that would disgorge its content in a controlled manner should an

explosive discharge occur. The ability of an individual compartment to rupture its external skin to discharge its contents without damaging vital aircraft components or significantly disrupting aerodynamic performance would minimize threat effects to the point that it is unlikely that the terror tactic would be attempted. Through electronic ticket tracking during the loading process it would be possible to focus post incident investigation on a relatively small group of travelers (i.e. each bag placed in the subject compartment would be positively tracked to the individual boarding the aircraft and would thereby reduce the number of suspects). By tailoring the pre-flight baggage handling process the need to x-ray each bag would be removed (i.e. each passenger would need only to place his 'carry-on' bag in a compartment as he boards the aircraft). When the compartment is full, it would be sealed by an attendant, and subjected to bomb / chemical 'sniffers' prior to being attached to the aircraft. Likewise upon arrival the baggage pallet would be made quickly available to the passengers as they disembark. By modifying the passenger gate area within the airport terminal the congestion and danger caused by 'over-head' storage of baggage would be removed thus speeding the boarding / arrival process while eliminating the possibility of luggage falling into the passageway during an emergency (i.e. an empty cargo pallet would be made available prior to the aircraft arrival and through the use multiple identical assets would remain available after aircraft re-boarding and departure thus enabling passengers to take whatever time and space they need to deal with their bags). The modular pallet concept is extended to include passenger pallets that can be pre-boarded at the passenger's leisure and loaded onto the fuselage just prior to flight. The passenger pallets also provide a survivability capability through module ejection and parachute deployment when commanded in emergency situations. The flexibility provided by the modular nature of the cargo / passenger compartments would enable unused cargo capacity to be exploited via shared carrier leasing agreements or 'as available' space utilization for non-perishable queued cargo pallets etc. It also opens up a new market of leased or privately owned custom purpose or luxury pallets to be transported on demand via commercial carriers while still retaining the luxury of a privately owned aircraft but without the cost of maintaining the aircraft or crew.

The high risk to the aircraft manufacturing paradigm and changes to passenger / baggage handling would be offset by the higher rewards of safer passenger transport, flexible cargo manifesting, and faster embarkation / debarkation cycles. The research necessary includes materials and methods required to re-structure transport aircraft architecture to provide a 'strong-back' undercarriage that could accommodate modular pallets, the pallets themselves, and the pallet handling systems required to support quick secure passenger / cargo transfer.

The expected new outcomes and capabilities of the SMTA research would include flexible aircraft configurations and associated modular pallets of various configurations devised to fit the needs of a diverse customer market while providing the ability to accommodate an in-flight explosive discharge without impact to primary aircraft structure. The SMTA research would also define a new handling process that expedites the embarkation / debarkation process through pre-configured pallets that can be quickly attached to the airframe for rapid turn-around dispatch.

The problems addressed by the research effort include the aircraft manufacturer's bias to existing methods, materials, and technologies (i.e. re-tooling to build anything other than a stress-structure 'tube' style aircraft body will require that the basic design paradigm be changed). The socialization of this change involves not just the major aircraft manufacturers, but the flying public, and the airport support infrastructure must be revised. People will be required to think about where they keep their pills and books rather than rely upon digging through an overstuffed roller-bag shortly after take-off.

The perceived inconvenience that the new system would cause must be combated through an educational program that stresses the benefits of aircraft safety.

While the major aircraft manufacturers would be the primary target participants for the structural research, many smaller aircraft modification organizations are likely to express interest in retrofitting existing vehicles, and all levels of special interest manufacturing organizations are likely to be interested in participating in the design and development of modular pallets (i.e. it may be possible to deploy, either via normal ground detachment or via parachute assisted air-drop, special interest modules such as emergency medical facilities, humanitarian shelters, logistics shelters such as vehicle repair shops, food preparation facilities, food stuffs including liquids, sanitization facilities, command control and communication centers, and even marine applications such as emergency surface craft for flood response may be conceived. In this way organizations such as the Department of Homeland Security can commandeer the use of commercial air-carriers during times of need and by simply uploading the appropriate special purpose modules, quickly deploy the necessary infrastructure to create a fully capable emergency response facility. Likewise the military, the scientific community, and special interest organizations can define unique cargo pallets with sensors or possibly even weapons that can be deployed as needed to monitor borders or events using the same basic commercially available aircraft platforms.

This broad agenda should attract many companies, academic institutions, and government organizations to define needs and solutions that pave the way for a more flexible ‘next-generation’ survivable modular transport aircraft that fits into a newly defined emergency response market.

#### **A. Mapping to Administration Guidance**

The societal challenges identified by the SMTA fit within the area of critical national need expressed in Executive Order 13479 of November 18, 2008, Transformation of the National Air Transportation System. As stated in Section 1. Policy. “It is the policy of the United States to establish and maintain a national air transportation system that meets the present and future civil aviation, homeland security, economic, environmental protection, and national defense needs of the United States, including through effective implementation of the Next Generation Air Transportation System (NextGen).” The term “Next Generation Air Transportation System” means the system to which section 709 of the Vision 100—Century of Aviation Reauthorization Act (Public Law 108–176) refers.<sup>1</sup> The executive order stipulates involvement of the Secretary of Transportation in collaboration with the Secretary of Defense, the Secretary of Homeland Security, and the Secretary of Commerce to take appropriate account of the needs of the NextGen in trade, commerce, and other activities, including those relating to the development and setting of standards.

#### **VISION 100 – CENTURY OF AVIATION REAUTHORIZATION ACT PUBLIC LAW 108-176 SEC. 709.**

States in part:

“(1) The Secretary of Transportation shall establish within the Federal Aviation Administration a joint planning and development office (JPDO) to manage work related to the Next Generation Air Transportation System.

(2) The responsibilities of the Office shall include:

(E) coordinating goals and priorities and coordinating research activities within the Federal Government with United States aviation and aeronautical firms;

(F) coordinating the development and utilization of new technologies to ensure that when available, they may be used to their fullest potential in aircraft and in the air traffic control system;

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<sup>1</sup> VISION 100 – CENTURY OF AVIATION REAUTHORIZATION ACT, PUBLIC LAW 108-176 SEC. 709

(G) facilitating the transfer of technology from research programs such as the National Aeronautics and Space Administration program and the Department of Defense Advanced Research Projects Agency program to Federal agencies with operational responsibilities and to the private sector; and

(3) The JPDO shall develop and Integrated Plan.—The integrated plan shall be designed to ensure that the Next Generation Air Transportation System (NGATS) meets air transportation safety, security, mobility, efficiency, and capacity needs beyond those currently included in the Federal Aviation Administration's operational evolution plan...

(c). The integrated plan shall include--

(2) a description of the demand and the performance characteristics that will be required of the Nation's future air transportation system, and an explanation of how those characteristics were derived, including the national goals, objectives, and policies the system is designed to further, and the underlying socioeconomic determinants, and associated models and analyses;

(c) Goals.--The Next Generation Air Transportation System shall--

(1) improve the level of safety, security, efficiency, quality, and affordability of the National Airspace System and aviation services;

(4) leverage investments in civil aviation, homeland security, and national security and build upon current air traffic management and infrastructure initiatives to meet system performance requirements for all system users;

(5) be scalable to accommodate and encourage substantial growth in domestic and international transportation and anticipate and accommodate continuing technology upgrades and advances;

(e) Authorization of Appropriations.--There are authorized to be appropriated to the Office \$50,000,000 for each of the fiscal years 2004 through 2010."

## **B. Justification for Government Attention**

As can be seen by the executive order and associated public law, the subject effort is a recognized critical national need that while it is well identified and subject to many improvement efforts, the majority of the improvements are focused on adding communication and navigation aids on top of a largely unchanged infrastructure.

Within the ongoing NGATS effort a great deal of money has been spent yet the overall system improvements have been marginally effective; resulting in a congressional assessment being performed. The assessment determined that a great many 'experts' from industry and government were involved and that they seemed to have an agenda related to specific technological products lines such as en-route navigation aids rather than focusing on root-cause issues. The assessment of the INTEGRATED PLAN for the NEXT GENERATION AIR TRANSPORTATION SYSTEM (NGATS)<sup>2</sup> was provided to congress by Mr. S. Michael Hudson, Vice Chairman (retired) Rolls-Royce North America, Chair of the Committee on Technology Pathways Aeronautics and Space Engineering Board Division on Engineering and Physical Sciences National Research Council and is summarized as follows:

"Transforming the air transportation system is essential to meet the needs of the traveling public and other system users, to sustain the nation's economic growth, and to help the United States maintain continued global aviation leadership... The assessment committee considers the timely preparation of the first edition of the Integrated Plan to be a positive first step. Even so, substantial improvements in the Integrated Plan and the method by which it is being implemented are essential..."

"The assessment committee's overall guidance is summarized in the following recommendation:

The secretary of transportation, the FAA administrator, the rest of the Senior Policy Committee, and the JPDO should invigorate development, implementation, and operation of the Next Generation Air Transportation System, especially with regard to the development of core technologies and processes, as follows:

- Focus the work of the JPDO on development of a systematic, risk-based approach for achieving the primary objective, which is to resolve demand issues and increase capacity while also satisfying enabling, interrelated requirements for safety, security, environmental effects, consumer satisfaction, and industrial competitiveness.

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<sup>2</sup> US Government Accountability Office Testimony Before the Subcommittee on Aviation Operations, Safety and Security, Committee on Commerce, Science and Transportation, U.S. Senate

- Restructure the JPDO as a product-driven organization with three coordinated operational concepts and three IPTs focused on (1) **airport operations**, (2) **terminal area operations**, and (3) en route and oceanic operations.”

The research outlined in the SMTA effort has a strong potential to advance the state-of-the-art by directly addressing airport and terminal area operation issues with emphases on increase capacity through improved passenger and cargo processing while also improving safety, security, consumer satisfaction, and industrial competitiveness.

The cost of not meeting the air transport challenges can be measured not only in dollars associated with unused cargo space and delayed departures due to mishandled people and baggage, but in lives lost due to terrorist activities such as a low yield chemical or biological bomb, hand-carried as a harmless cosmetic canister, or mechanical failure of a crowded commercial flight. The current system of hand inspecting every carry-on parcel is rife with opportunities to smuggle such a device and when it happens the news media will be wringing their hands asking why we didn't do something about it before it happened. By performing the research and development outlined in the SMTA effort we are setting the stage for the development of an air transportation system that will be safe, scalable to growing demand, and responsive to evolving business and threat models.

The following information was excerpted from GOA testimony<sup>3</sup> to emphasize the financial cost estimates for the current NextGen technical efforts (note: it does not account for the re-direction advocated by the ‘Assessment Committee’ in the testimony reference above nor does it accommodate cost estimates for possible terrorist activities):

“The numbers currently show that during peak periods of operation as many as 5,000 general aviation, business, and commercial airplanes will be in the air. Currently, the system handles 750 million enplanements each year. We expect this number to reach one billion by 2015. Forecasts indicate a significant increase in demand, ranging from a factor of two to three by 2025. The system is already straining in some areas, and the current system design will not provide the relief required. Unless new technology, development of key infrastructure, and improved procedures are put into place now, particularly given that system capacity will reach its maximum by 2015, the ability of aviation to continue to play its traditionally dynamic role in our economy will be substantially diminished.

In an industry that currently generates 5.4 percent of America's GDP, and over 9 percent when this is expanded to include aviation related industries, as well as \$640 billion in revenues and 11 million jobs, it is a blueprint that can ill afford to miss the mark. Over the next five years, we estimate that FAA's NextGen investment portfolio, key investments that will enable the transition to NextGen, will require \$4.6 billion. That is \$4.3 billion in the Air Traffic Organization Capital appropriation and \$300 million in Research, Engineering, and Development. Of the \$4.3 billion, an estimated \$1.3 billion would be directed to ongoing programs that directly support NextGen. An estimated \$3 billion is for efforts that will be rolled out over the next five years. The JPDO is also developing preliminary estimates of the future requirements of the other contributing agencies to NextGen. In FY08, they are investing a total of about \$300 million in NextGen, primarily in research and development. Based on the current five year picture, we can anticipate major FAA investment areas for the period from FY13 through FY17. Total federal requirements for the first ten years (FY08 through FY17) range from \$8 billion to \$10 billion. Estimates for the end state, or through 2025, range from \$15 billion to \$22 billion.

The MITRE Corporation has developed a preliminary estimate for the cost of equipping aircraft with NextGen avionics. It concludes that a wide range of costs are possible, depending on the bundling of avionics and the alignment of equipage schedules. The most probable range of total avionics costs to system users is \$14 billion to \$20 billion. This range reflects uncertainty about equipage costs for individual aircraft, the number of very light jets that will operate in high-performance airspace, and the amount of out-of-service time required for installation.

Recently our European counterparts released a preliminary cost estimate for the Single European Sky Air Traffic Management Research (SESAR) initiative. SESAR is a system that, while smaller in scope and size, has similar air traffic management goals to those of NextGen. They consider different system scenarios and, accordingly, a range of

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<sup>3</sup> US Government Accountability Office Testimony Before the Subcommittee on Aviation Operations, Safety and Security, Committee on Commerce, Science and Transportation, U.S. Senate

total costs from \$25 billion to \$37 billion (U.S.) through 2020. They further estimate that 60 percent of those costs will be associated with avionics and 40 percent with ground infrastructure.

SESAR, like NextGen, has a lot of work remaining to refine assumptions and better define the system. Further, it is important to note that European aviation does not share the same characteristics as U.S. aviation. There is, for example, a much larger general aviation presence in the U.S. than in Europe. And while SESAR focuses on air traffic management, NextGen takes what is called a “curb-to-curb” approach, including not only air traffic control, but also airports, airport operations, security, and passenger management.”

It should be noted here that while ‘NGATS’ pays homage to the ‘curb-to-curb’ concept that would include infrastructure issues, it can be seen in the following testimony that the majority of planned research is concentrated in the ‘en route and oceanic operations’ areas not in the airport or terminal operations:

“Some of the demonstrations and infrastructure development planned for the next eighteen months include: Oceanic Trajectory-Based Operations: Aircraft flying over oceanic airspace currently use designated routes. Sometimes these are not the most efficient in terms of time and fuel consumption...”

“The following outlines some of these critical near-term and longer focus areas:

- 1) Required Navigation Performance
- 2) Automatic Dependent Surveillance-Broadcast (ADS-B), Traffic Information Service-Broadcast (TIS-B), and Flight Information Service-Broadcast (FIS-B)
- 3) Capstone Program  
The Capstone Program in Alaska is a long-term, highly successful application of ADS-B in a non-radar environment.
- 4) Safety Management System (SMS)  
The safety programs of NextGen must evolve from the traditional post-accident data analysis to an integrated forensic and prognostic evaluation and management of hazards and their potential risk.
- 5) Implementation of the National Aeronautics Research and Development Policy  
On December 20, 2006, President George W. Bush signed an Executive Order calling upon the Departments of Commerce, Defense, Energy, Homeland Security, State, and Transportation, NASA, the FAA, National Science Foundation, the International Trade Commission, and the Executive Office of the President to develop a National Aeronautics Research and Development Plan
- 6) Continuous Descent Approach (CDA)  
A Continuous Descent Approach is a procedure that optimizes the aircraft approach from the beginning of its descent to the touch down on the runway.”

So while the NGATS research and development plan acknowledges the need for vehicle and infrastructure improvements, the bias of the current efforts is summarized in the testimony as “Avionics play a key role in transforming the U.S. air transportation system.” With the assumption that; “New air vehicle designs will increase the level of crash survivability by incorporating design features that reduce the effects of the crash on the airframe and occupants. The use of new materials, fuels, and design processes will make aircraft more resistant to impact damage and flammability.” And that “The Airport Infrastructure needs to be revised to Meet Future Demand Strategy”. The testimony then resorts to a sort of ‘shopping list’ of things that should be done at some time in the near future, but fails to define how or when these issues will be addressed:

“• Airport infrastructure must address the need to expand in a way that meets future capacity while satisfying the other objectives.

Research areas:

- Develop requirements and concepts for servicing a variety of future demands, from maximizing overall metropolitan area capacity to servicing smaller communities. Groundside questions include airport access alternatives and associated transportation, security, and information systems requirements, such as regional airports and city check-in by specific location. Establish an Effective Security System Without Limiting Mobility or Civil Liberties Strategy:
- Establish a global security system to ensure reservation to-destination security for travelers and the stream of commerce. Travelers and shippers will be confident that no undue security or health risks exist in the transportation system, and that movements and civil liberties are not unduly impeded by security measures.

Research areas:

- Explore integrated, scalable security methods and implementation to mitigate potential threats to the air transportation system.

- Develop advanced sensors, information systems, and mitigation strategies for identifying threats and recovery from attack.
- Develop automated security screening of passengers, baggage, and cargo integrated into the normal flow of people and items.
- Improve chemical, radiological, biological, and health sensors, including automation for detection and recognition of hazardous items

#### Transformation Strategies

- Prepare for new and varied security threats
- Increase the speed and predictability of air travel
- Reduce aviation system security costs
- Instill high public confidence in the aviation security system IPT Mission

#### Transformation Direction

Develop reliable means to identify and mitigate security risks.

- Ensure real-time aviation security situational and domain awareness for all security stakeholders to eliminate security breaches or mitigate impact to lessen the need for blanket flight restrictions
- Develop and integrate technologies into aircraft/airborne vehicles to prevent the use of aircraft/airborne vehicles or other missiles as effective weapons
- Collaborate with industry and other government agencies to develop and apply appropriate procedures and higher accuracy and sensor technology to identify aviation threats including chemical, biological, radiological, nuclear, and explosives
- Implement techniques to positively identify and rapidly screen air travelers and air cargo for threats to, or conveyed by, the air transportation system
- Passengers and baggage screening will not add significant time to the curb to gate transit
- Terminals will have an effective physical security design that minimizes vulnerabilities while facilitating passenger and baggage flow
- Cargo will be pre-screened and assessed for risk with all higher risk cargo subject to physical screening or exclusion from the system
- Facilities and sites for inter-modal connections will maximize transfer efficiency with standardized and non-redundant security processes
- Minimize health and security risks within the global transportation sector”

As can be seen from the supporting references, the magnitude and nature of the problem has received high level government involvement, however, while a great deal of concern has been expressed related to aircraft safety and passenger / baggage handling the narrow technical bias of the current NGATS effort has focused on navigation aid avionics. The magnitude of the societal challenge of dealing with isolating potentially dangerous cargo / baggage from the passenger compartment and providing passenger survivability has not been addressed by any of the concepts put forth by the current NGATS efforts. The momentum of the NGATS effort is unlikely to be redirected to address the areas of research / technology needed to address the unmet societal challenge outlined by the SMTA effort without alternative research sponsorship. The technical inputs from aircraft structural and materials manufacturers as well as the exploration of sociological structures necessary to define ways to introduce the flying public to modular compartmentalized cargo is needed as part of the research. The outcomes of successful SMTA research will include a path to revitalize the aircraft manufacturing industry by specifying new design criteria for safer future transport vehicles as well as a re-definition of airport designs and cargo handling that will speed passenger processing while reducing inconvenience and improve safety.

#### C. Essentials for TIP Funding

The scientific frontiers of commercial transport aircraft structural design with advanced materials and concepts to accommodate airborne hazard containment and mitigation will be advanced and will result in stimulating the nations capabilities to deal with dynamically changing, diverse, terrorist

threats. Composite structural material technology will be leveraged to retain necessary vehicle strength while accommodating the revised architecture that supports modular cargo / passenger containment. The success of the SMTA concept pivots on the ability of the flight vehicle to survive explosive discharge of a moderate sized bomb as might be contained in a typical 'roller' carry-on passenger bag. The technology necessary to enable a 'shaped charge' type wave-front to rupture a modular cargo container exterior skin without jeopardizing flight performance must be developed, tested, and evaluated along with passenger escape modules to provide survivable recovery of personnel. The end products of the research effort will include a standardized aircraft interface and modular cargo / passenger containers that can be integrated by any new or existing aircraft manufacturer. The development of these standard interfaces will meet an unacknowledged need that is currently not being addressed by any other research effort. As can be seen from the NGATS testimony, the bias of their effort will continue to focus on 'big ticket' avionics improvements that, while they will marginally improve the current system, will not conducted the research necessary to formulate a paradigm shift in aircraft design within a reasonable time period without TIP funding. The research outlined by the SMTA effort could impact the nation in a transformational way by providing a new way of dealing with potential threats that defuses the ability of would-be terrorists to intimidate or significantly impact normal air traffic. The success of the SMTA research would provide dramatic benefits to the nation by providing safer air traffic and by invigorating private aircraft industry and support organizations with new design concepts that would open the market to new businesses able to manufacture modular components that can be marketed worldwide.