How do you drop a Tank from a moving Airplane?

In 1997, eight NATO air forces issued a Request for Proposal for a new generation military airlifter. To respond to the proposal, a new consortium for the development and industrial production of airlifters was established as the prime contractor and single point of contact between the customers and industry. The consortium manages the overall program and distributes the development and manufacturing of aircraft sub-assemblies.

The consortium selected leading U.S. and European suppliers for the design and manufacture of in-aircraft cargo loading systems. Realizing that current air delivery technology did not meet the performance and supportability requirements of the next generation air lifter, the primary partners selected Intent Design for their global engineering design and systems integration know-how.

The development partnership relied on the expertise and innovation of Intent Design to perform a complete overhaul of the Cargo Hold System (CHS) and Aerial Delivery System (ADS) within a compressed timeline. Intent Design's first class systems integration team achieved a rapid scale-up, reduced cycle time and manpower hours, and met the critical deadline for a ground up design concept of the cargo lock system in three months.

Industry:
Aerospace

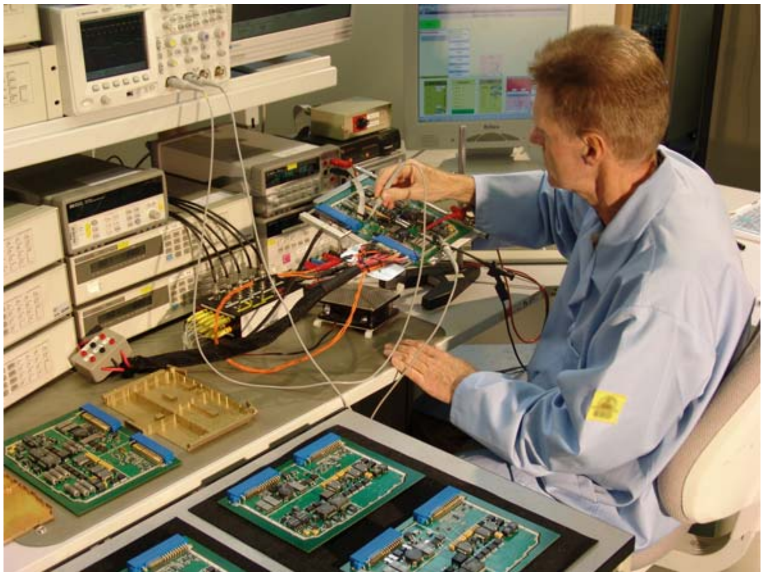
Project Type:
Cargo Hold and Arial Delivery System

Challenge

Armed forces today are equipped with airlift equipment dating back to the 60's and 70's. Transport aircraft were designed for the Cold War era of known threats and pre-defined response plans. Today's armed forces are faced with new demands

- Conflicts have become more regional. The armed forces of the USA, Europe and other regional powers have been called to intervene more often than at any time during the Cold War.
- Peace-keeping and humanitarian interventions are the order of the day, often against ill-defined threats or natural disasters and with less than well prepared response plans. Today's need is for crisis response through rapid intervention, at short notice, often over longer distances, with greater amounts of bulky and varied equipment, both military and civil/humanitarian - but within strict financial limits.

These military and humanitarian needs create demands new on military air transport for which today's transport aircraft are both technically and operationally obsolete. The current fleets provide today's forces with inadequate payload and range capability, lack of commonality and interoperability between different forces, and low fleet availability (reliability) by modern standards. The next generation of equipment must fulfill a wider set of roles - the emphasis is now on reliability and availability, versatility and flexibility, commonality, and interoperability.



The next generation military airlifter is setting new standards and changing the way in which future military programs will be managed. The next generation airlifter will have the highest payload density of a single drop as well as increased flexibility and responsiveness. It will play an essential role in enhancing NATO's airlift capabilities, while enabling the establishment of common support, training and operational procedures and greater interoperability in multi-national humanitarian and peace-keeping missions.

The demands of the next generation air lifter include

- delivering large amounts of payload over long distances and at high speed
- supporting tactical missions that require operation into an out of semi-permanent runways and aerial delivery
- receiving as well as dispensing fuel.

The existing design of the Cargo Hold and Aerial Delivery Systems were not robust enough to meet such stringent requirements. The new design needed to

- ensure cargo stability during take-off and landing on unprepared landing strips under adverse meteorological conditions
- facilitate loading and unloading independent of ground support, and
- air drop equipment via parachute or gravity extraction, including Very Low Level Extraction (VLLE) - 15 ft above ground.

Meeting the performance and supportability guarantees required a holistic design approach and the invention of new technology to ensure a more precise timing of the cargo delivery while allowing higher tolerances to optimize the manufacturing process.

Solution

Intent assigned an integrated team of designers, engineers, and project managers to the development. To meet the compressed timeline, engineers from the aircraft manufacturer, the Cargo System suppliers, and Intent were co-located at facilities in three countries on two continents.

The development of an integrated system for the precise movement of heavy payloads in the cargo bay of a moving aircraft required a top-down system-level approach. Before starting any component designs, the team

- Analyzed the problem
- Documented the complete requirements for the aerial delivery system
- Quantified system performance requirements
- Defined repeatability, backup and redundancy features.

The team further developed extensive computer simulations to precisely model the preparation, execution, delivery and monitoring of an air cargo delivery sequence. Simulations characterized the overall deployment process, timing, speed, parachute deployment sequence, and the behavior of cargo deployed by parachute.

Complex control systems were needed to efficiently load and unload cargo on the ground, and to safely drop cargo in flight. In-flight cargo delivery has to accommodate “nose up” (gravity extraction) and timed extraction of cargo in level flight using parachutes. Once the problem and requirements were clearly defined, the team

- Developed a complete and integrated system architecture
- Specified each component and part used in the system
- Designed and developed the individual sub-systems and component parts to meet the system specifications and performance requirements, and
- Planned validation and testing of the performance and reliability of each component.

In an air drop sequence, pallets are restrained by a system consisting of guide rails, rollers, latches, actuators, and electronic control units to direct the precise pallet release timing and movements. Multiple sets of parachutes are used.

- Extraction parachutes create the pulling force to extract the cargo from the aircraft.
- Stabilization and glide parachutes slow the cargo speed of descent to prevent damage on landing.

The use of an extraction parachute creates a danger to the aircraft and crew if the extraction chute is deployed without a release of the cargo. A second major risk with cargo extracting systems is the “zipper effect”. This phenomenon occurs with other designs which result in a gap between the anticipated release point and the actual release point. These systems can result in an unpredictable release sequence when latches are not evenly engaged or when parachute loads vary due to the aircraft speed, weather, or the parachute size. The consequence can be the release of a pallet before the parachute is fully deployed and the cargo could tumble, causing lost cargo and flight instability of the aircraft.

Existing designs combat the zipper effect with hydraulic locks that vary the force required to release the pallet. The use of hydraulic locks and actuators adds complexity and weight, requires additional maintenance, and did not meet the more challenging requirements of the next generation air lifter.

To eliminate the zipper effect and ensure a very precise cargo delivery, Intent Design invented a new and unique motion control system consisting of custom-engineered locks and actuators. The new design uses multiple locks and actuators on both sides to hold the cargo in place securely. The aircraft’s avionic system interfaces with the cargo release control units to control the exact timing of the pallet release. In-built redundancy features ensure a high degree of reliability and safety.

The key to a safe and successful cargo release is the complete integration of the X-Locks, Lock Control Units and Network Interface Module with the aircraft’s avionic systems. Intent Design cooperated closely with the developer of the avionics systems and the targeting control computer. This integration is controls the release timing of payload with millisecond precision. To validate the design, Intent developed kinematic and dynamic 3D models that simulate the geometry of cargo motion in and out of the aircraft in a real world application. Extensive Finite Element Analysis (FEA) was used to simulate mechanical dynamics and stress points. Every computer-generated model was cross-validated with standard manual engineering tools as a backup safety measure.

Results

Intent Design engineers and project managers worked on-site with the aircraft and Cargo System manufacturers to closely integrate the Cargo Release System with the Cargo System supplier's overall logistics solution. Research, modeling, development, and testing were completed in time for the release of the design to prototype manufacturing. In the next phases, the Cargo System manufacturers will test the cargo lock and release with actual loads applied to simulate operational conditions. The teams will continue to support the program through the MSN4 and 5 stages, operational flight testing, and production sign-off expected in 2009.

Customer Feedback

"Intent's structured planning, innovation, experience, in-depth knowledge of engineering principles and electromechanical systems and placement of key people in key places made this project successful."

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