Kinematic simulation in the aircraft landing gear design and optimization process

Jakub Suszyński[1)]

[1)]Warsaw University of Technology,

The paper focuses on supporting the mechanical design process of the landing gear for a general aviation aircraft using available simulation modules and CAD/CAM/CAE software. The article is based on the analysis, modification, and optimization of the landing gear system of the AT-5 aircraft. The AT-5 is a three-seat, low-wing metal aircraft designed for both training and tourism purposes. Its retractable tricycle landing gear system features two main legs attached to the wing structure, which retract outward toward the wingtips, and a nose gear that retracts rearward into the fuselage. The nose gear is equipped with a dampened, steerable leg that is retracted through an electric actuator system. This system also includes an emergency extension mechanism that mirrors the functionality of the main landing gear emergency extension system.

A wide range of kinematic simulations and structural analyses were conducted using NX Motion and NX Nastran software, with a specific focus on the landing gear's retraction and deployment mechanisms. These analyses were carried out under conditions outlined by CS-23 regulations. Through these simulations, the study enabled identification of the loads acting on the landing gear extension system during various operational phases. The results enabled the selection of appropriate actuators and the determination of the necessary strength for key components and connections.

Following the initial design phase, modifications were introduced to optimize the system further. These modifications aimed not only at improving functionality but also at reducing the overall weight of the landing gear. Through an iterative process of simulation-driven optimization, significant reductions in the mass of the landing gear components were achieved without compromising the structural integrity or performance of the system. The lighter landing gear improved the overall efficiency and performance of the AT-5 aircraft, demonstrating that weight reduction can be achieved.

The post-modification analyses confirmed the success of these design changes, with the landing gear system performing efficiently in both normal and emergency modes of operation. The system met all required parameters and safety standards, further validating the approach. The strength analysis of the modified components was conducted using both analytical methods and advanced Finite Element Analysis (FEA) via NX Nastran. The results showed that the modified elements possessed adequate strength, ensuring that they could withstand operational stresses with sufficient safety margins.

The success of this approach underscores the immense value of incorporating kinematic simulations and advanced CAE tools into the design process. By using simulation software, system behaviour can be predicted more accurately, enabling to make design decisions early in the development cycle. This leads to a more efficient and streamlined design process, minimizing the need for costly physical prototyping and testing. Moreover, the methodology allows for more precise optimization, not only reducing weight but also ensuring that systems perform reliably under all operating conditions.

The methodology presented in this paper can be effectively applied to various stages of aircraft landing gear design and optimization, as well as in other areas of aviation engineering. It is especially beneficial in scenarios where weight reduction, reliability, and system optimization are critical factors. By facilitating early validation and refinement of designs, this methodology can lead to superior performance, reduced development costs, and enhanced safety across a wide range of engineering disciplines.

Ultimately, this paper highlights how the integration of simulation tools such as NX Motion and NX Nastran into the design process enables significant improvements in critical aspects such as weight, functionality, and reliability. This approach exemplifies the power of simulation-driven engineering in advancing modern mechanical design practices, delivering tangible benefits that extend well beyond the scope of the project.

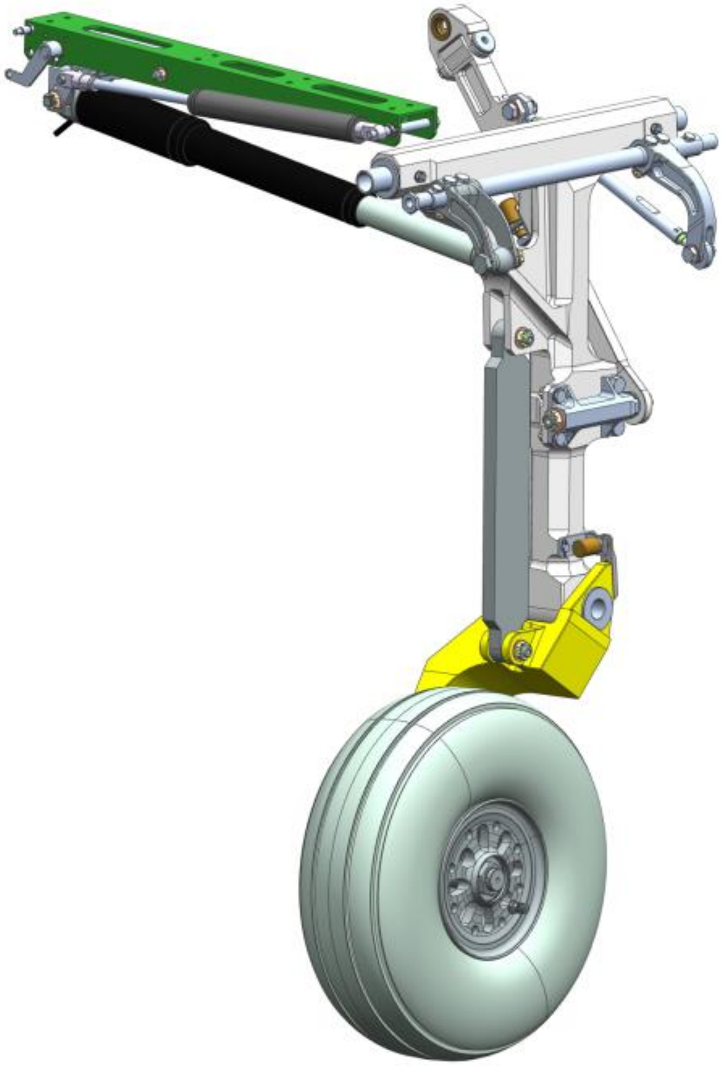

Fig. 1 The render of 3D model of modified AT-5 main landing gear