Dept. Aerospace Engineering

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▣ Introduction

Aerospace Engineering is an engineering field that studies aerospace vehicles operating in atmosphere and space and related systems. It is a system-oriented area where both of mastery in fundamentals of various disciplines and understanding on their interactions are required.

Department of Aerospace Engineering at KAIST have been fostering the world leaders in aerospace field since it was founded in 1979 (graduate) / 1991 (undergraduate). The department is training students as globally competent engineers by providing strong fundamentals in essential disciplines and encouraging interdisciplinary system-centric research in strategic areas such as unmanned aerial vehicle (UAV), space systems, and hypersonic vehicles.

▣ Research Areas

The research activities in our department can be grouped into six major areas as follows:

1) Unmanned and Guided Aerial Systems (UAV)

UAVs are designed to be operated without a human crew on-board the vehicles. They should be equipped with advanced autopilot systems to replace a human pilot that serves as a controller, a navigator, and a mission coordinator. Although many UAVs are similar to their manned counterparts in terms of flight mechanics and control, some UAVs are designed to be very small, or to adopt novel types of propulsion and energy source. As they can operate as long as the power remains and other onboard systems function well, alternative energy resources such as solar power or fuel cells are used for electric-powered UAVs. In Korea, medium-altitude surveillance UAVs, unmanned combat aerial vehicles (UCAV), and division-class reconnaissance UAVs are under active development.

2) Space Systems Engineering

Space systems engineering research includes attitude control systems and flight software design for small satellites and nano-satellites systems. Guidance, navigation and control for a lunar exploration and deep space missions are also pursued: an obstacle detection and avoidance are investigated using cameras and laser sensors for lunar and planetary surface landing objectives. Satellite formation flying is one of our strategic research areas, and is a new mission concept of coordinating multiple satellites. A lunar landing spacecraft prototype model having mono-propellant thrusters is developed and tested for performance verification of a in-house thruster module. Thruster system for a national future lunar exploration mission are analyzed and the requirements are identified to meet the needs of associated core technologies. Spacecraft degradation in space environment and collision with space debris is another important research area that is currently under investigating. Test facilities for emulating space environment and a high-speed collision with space debris are currently operational.

3) Aviation and Avionics

Avionics is associated with the electronics aspects of the aircraft and spacecraft technologies, while aviation deals with the skill development required for the flight, operation and manufacturing of the aircraft. A growth in Avionics owes to the development in the engineering fields of electrical, wireless communication, control and computer engineering. Modern Avionics technologies have contributed greatly to the development of Aviation technologies for aircraft and satellite systems. Research topics on Avionics include ground/aerial/space navigation, aircraft and satellite communications, embedded systems, mechatronics, and radio- or image-based detection and tracking. We are also active in Aviation research, especially in relation to air traffic management, that is one of the nation's strongest interests in recent years due to increasing air traffic flows in Asian aviation market. Detailed research topics include aircraft collision avoidance, scheduling/routing of aircraft en route or during LTO (Landing and Take-Off), aircraft tracking systems, safe landing and navigation system using global navigation satellite systems (GNSS) and reduction of air-pollution due to the aircraft aviation.

4) Airborne Vehicles and Systems

The department is traditionally very strong in the core technologies for designing and developing various aircraft, helicopters and guided weapons. Continuing research efforts are made to further enhance the current technologies to develop as multidisciplinary analysis and design tools. High-performance, parallel computing facilities and advanced numerical algorithms in Computational Fluid Dynamics (CFD) greatly improve a computational efficiency in large-scale problems. Our high-fidelity, in-house developed aerodynamic solvers can resolve wide range of flow regimes from low-speed, transonic, supersonic to hypersonic cases. A computational aeroacoustics is integrated into the aerodynamic analysis and design to analyze noise characteristics of aerospace vehicles, enabling the environmentally-friendly design aspects. In the field of structures and materials, composite materials are under development that contains high specific stiffness, specific strength and excellent fatigue characteristics. In addition, various smart structures capable of structural health monitoring, electromagnetic wave absorption and vibration control are being intensively studied. Research group on aeroelasticity carry out structural stability analysis of various aerospace vehicles. Flight dynamics and control research has developed theories, algorithms, softwares, and hardwares for guiding and controlling aircraft, guided weapons and other flight vehicles, taking into account real-world issues in sensors and actuators.

5) Aerospace Power and Green Energy

Aerospace power and green energy research comprises combustion phenomena, rocket propulsion, spacecraft thrusters, high-efficiency aircraft engine, and wind turbine blade research as next-generation energy resource. For combustion research, mitigation of NOX for air pollution issue, diesel fuel combustion analysis by numerical approaches as well as experiment, rapid compression machine for combustion study, and micro-scale heat transfer are being investigated. In rocket propulsion, thrusters, at 100N and 250N output level, are designed using hydrogen peroxide fuel oxidizer which is highly environment friendly. The aircraft engine research is focused on increasing fuel efficiency of conventional engines and computational approaches for aero-acoustic analysis for performance improvement. Various S/W analysis tools have been developed for the applications at hand. Furthermore, as one of the next-generation energy resources, research on wind turbine blade with an effort to increase efficiency is conducted, which will provide core technologies for large lightweight blade structures.

6) System of Systems

An aerospace system is composed of many subsystems and components related to various academic disciplines. Effective integration of the subsystems in an organized way is one of core capabilities to successfully develop a large and complex system like the aerospace system. Value of the system which is commensurate to the vast amount of time and cost is hardly obtainable if we do not collectively consider the whole procedures throughout the lifecycle of the system. Our approach aims to provide solutions to problems in many different disciplines by taking system-oriented approaches. Furthermore, we pursue to create an overall design framework from the perspective of system of systems in order to effectively integrate systems from different disciplines and achieve overall sustainability of the systems as a whole entity. We also focus on high-level issues such as demand modeling, conceptual design, project management, reliability analysis, and financial analysis, which make huge impact on the value of the system.