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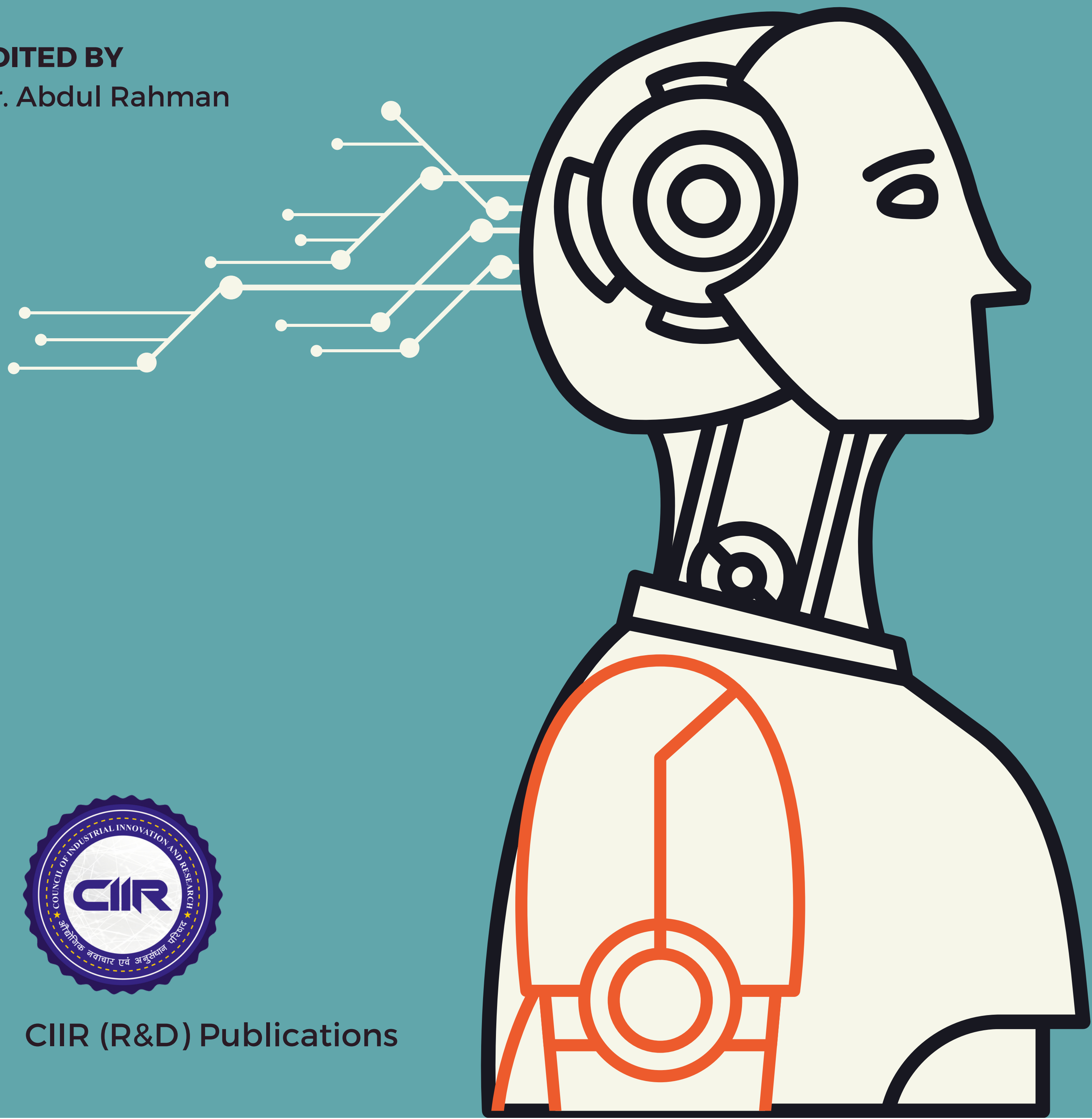
AUTOMATED SYSTEMS & APPLICATION

EDITED BY
Dr. Abdul Rahman



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Automated Systems and Application

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Contents

Preface

An automation system is a combination of sensors, controllers, and actuators that is created to carry out a task with little or no assistance from humans. This topic is covered by the interdisciplinary discipline of engineering known as "mechatronics," which blends mechanical, electrical, and electronic systems. The majority of automation systems are based on manual procedures like drilling, cutting, welding, and other similar activities. These systems control the motion of the tool that carries out the original purpose using robotic arms. Automation is used in other applications to monitor and manage process parameters, particularly in the field of process control. To do this, control valves are used to open or isolate process lines or to alter the operation of equipment like heaters, motors, pumps, and compressors. Even for a single specialized purpose, automation systems come in a variety of setups.

Reducing human intervention is the major goal of an automated system. A human operator is prone to mistakes and exhaustion, which can result in a number of issues. Profit, production rate, safety, and quality will all significantly improve with the adaptation of an automation system. The benefits and drawbacks of using automation systems are listed below. The benefits are:

More Consistent Production: When designed properly, robotic systems can speed up production by performing complex tasks quickly. A larger output volume and greater profit result from a faster production rate. The driver must provide enough effort, and the links and joints must move smoothly without making any needless transitions, in order to obtain faster operations. A computer's processing speed is also faster and more effective than a human. While computers do perform better when human error, breaks, and sick days are taken into consideration, humans can comprehend more complicated information than computers.

Increased Repeatability: A manufacturing line is effective because the operator is "programmed" to perform the same series of movements repeatedly. As most of the actions are guided by a predetermined, detailed set of instructions, this only requires minimum decision-making. These repetitive motions can be reduced to easy translations and rotations that a robot can be trained to perform. Repeatability is improved since the actuators have a nearly constant range of motion.

Precision and Accuracy: The actuators are made to carry out motions within a fixed range, as was already described. Unless there is a feedback signal or a change in the control variables, the properties of an actuator's movement will not change. The automation system can be adjusted to consistently produce the same result with little to no variation.

Product quality is improved because of automated processes' consistent production. Errors resulting from human error and arbitrary judgement are prevented. Automated systems employ logic to determine whether a given state corresponds to the desired outcome. Feedback systems that operate more effectively than humans can undertake ongoing verification.

A better working environment Personnel safety is put at risk by processes that use poisonous materials, tremendous forces, extreme temperatures, and high pressures. Robots can perform dangerous activities without causing harm or even death thanks to automation.

Lower Operating expenses: In addition to the increased profit brought about by greater quality and a constant increase in production rate, there are further financial advantages to be gained from less wasted raw materials and lower labour expenses. By using automatic feeding systems, raw materials are consistently used, resulting in less material waste. Programming makes it simple and easy to optimise the amount of feed. One robot can replace numerous employees in terms of labour savings. Long-term, these advantages will outweigh the large initial investment required to set up an automated system.

Disadvantages:

High Investment Cost: The main barrier discouraging process owners from using an automated system is the high investment cost. An automation system also includes other auxiliary systems including the power supply, compressed air system, hydraulic system, and lubrication system in addition to the sensors, controllers, and actuators. Depending on how advanced the desired automation is, robotic systems might cost hundreds of thousands or even millions of dollars.

Additional Upkeep Necessary Although automated systems may not experience fatigue the same way that human operators do, the constant running might cause components to inevitably wear out. Regular maintenance is performed to check for and/or avoid any problems that could lead to an unscheduled shutdown in order to maintain its peak performance and service life.

Less Versatility: The majority of automation systems are difficult to change. Additional characteristics like programmability and modularity drive up the price of the machinery. Furthermore, because robots can only function in accordance with predetermined instructions, any circumstance outside of their programming may result in unforeseen results or unexpected system failure. Human operators can assess these circumstances and take appropriate action.

This book provides practical applications of automated systems which consists of a device capable of receiving input (sensor, human-machine interface, etc.), a computing system (processor), and the manipulators that perform the actual work (actuator). The most important part of the three is the computing or control system.

Dr. Abdul Rahman
Editor

CHAPTER - 1

INTRODUCTION TO AUTOMATED CAR PARKING WITH EMPTY SLOT DETECTION

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The idea of an autonomous automobile parking system is demonstrated in this "Automatic guided Car Parking" project. Automated parking is the efficient operation, management, and monitoring of parking via the use of cutting-edge technology integrated into an urban mobility plan. It is challenging to locate an empty parking place in a big parking lot using the current manual approach. The suggested automatic parking system aids in locating open spaces even before parking. The monitor at the front of the parking gate will show the message "Space not available" if there are no free slots, which will prevent the gate from being opened by a servo motor. The use of various hardware and software can do this. The Arduino Mega Board is the project's main piece of hardware [1].

The Arduino Mega Board, a user-friendly device that can be readily linked up with almost any sensors or modules on the market today, serves as the project's main piece of hardware. While the software side of things is handled by the Arduino core, which MySQL is utilized to store and manage every entry in its databases, and PHP is used to obtain all of this information from the Arduino board. RFID tags, antennas, readers, barriers, IR sensors, servo motors, and the software stated above make up the system's primary parts. The software component is equally crucial for running the Arduino core and for displaying all parking information online so that users may determine the availability of parking spots even before they arrive.

The software's goal is to carry out different operational operations, keep records, and retrieve such records from the backend. In other words, the software serves as a tool for automation. An automated identifying technique called radio-frequency identification (RFID) allows for the remote retrieval of data from RFID tags or transponders. The RFID scenario in this project may be briefly summed up as follows: the gate will only open if there are available spaces in the parking area and the RFID identification is valid when the passenger car enters the parking lot. Consequently, the manual effort required to determine if the parking lot contains open spaces is reduced. The parking system's online interface may be used to check the availability of parking spaces.

Even before you arrive at the allotted area, you may check the availability of parking spaces using the parking system's web interface. There should be a solution to the parking lot space issue by keeping track of the overall number of spaces available as well as the total number of cars pulling into the parking lot. This will save time that would otherwise be wasted looking for a parking spot. As manual identification takes longer than tag identification, the issue of slow verification is also being resolved. As there is no need for manual registers and the data is retained in the form of files that may be used later, logs and records can also be kept for an extended length of time [2].

Automated parking is also made feasible by cutting-edge fields like customer service smartphone applications, mobile payments, and inside-the-car navigation devices. The capacity to access, gather, evaluate, share, and take action on data regarding parking use is the basis of the idea of smart parking managers and drivers may use this data, which is increasingly being delivered in real-time by smart devices, to maximize the use of space capacity. Therefore, the

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suggested approach may aid society's economic, social, and security-based considerations; similarly, it can be done to preserve time and fuel. It enables us to do an economic study and can assist in identifying a workable proposal to discover the best parking arrangement without suffering a financial loss. Future technological developments are also taken into consideration to create a system that is more effective, dependable, secure, and reasonably priced.

In a multilevel car park, it might be challenging, if not impossible, to locate a free spot right away, particularly on the weekends or on official holidays. On weekends and holidays, it can take about 66% of visitors more than 10 minutes to find parking. Stadiums, Peak hours are extremely congested, making it difficult for consumers to locate open spaces in places like shopping malls, hospitals, etc. There are not enough parking places, which causes traffic jams and aggravates drivers. Inappropriate parking is when a car is parked such that it takes up two parking spaces rather than just one. If a motorist doesn't respect the rights of other drivers, such inappropriate parking may happen to create a sophisticated automated parking system.

Features and Motivation to use Smart Parking:

One must be persuaded and content to utilize this most recent technology to reject and switch to the recommended parking management system. Otherwise, there would be little incentive to migrate from the old to the new system.

Below are some reasons to use smart parking:

Optimized parking: The owner of the vehicle will locate a parking space, saving time, energy, and effort. The parking lot is effectively filled, allowing businesses and corporations to make good use of the increased space.

Reduced pollution: A day's worth of gasoline is burned during a parking search. Therefore, this ideal parking solution will greatly cut travel time and fuel costs, lowering daily car emissions [3].

New Business Streams: The suggested technology opens up a wide range of new revenue opportunities. For example, a parking space owner may allow multilayer installation options depending on the space's location. To energies Rehashing customers and incentive schemes may both be implemented into current models.

Integrated Payments: Returning clients can substitute their phones for day-to-day hand cash payments with account invoicing and application payments. This could likewise permit valuable user feedback and customer loyalty programs.

Improved User Experience: This automated parking system integrates the complete customer experience into a single activity. The driver's payment, location inquiry, site identification, and time alerts all become a component of the process for entering the parking space [4].

Enhanced security: Data that is available in real-time to parking lot workers can help to stop parking offenses and any suspicious activity. Reduced distraction-related accidents can also be achieved by lowering spot street search traffic from searches of parking.

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CHAPTER - 2

RFID-BASED MANAGEMENT SYSTEM

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There are several different approaches to creating intelligent or autonomous parking systems. The literature used to launch this project, which is based on RFID, is based on a paper published in the Indian Journal of Science and Technology with the title "A Prototype for IOT-based smart Cities Car Parking Management System [1]. There are undoubtedly numerous contrasts between that article's methodology and the one used in this project when one studies it. For instance, the literature suggests substituting a Raspberry Pi and a DC motor for the Arduino and servo motors used in this project. Additionally, the paper makes no indication of the database or language that was employed [1].

The primary topic of the article and the project stay the same even though some of the software and hardware listed in this article are different from those used for this project. The necessity of such a project is covered in the article as to how the current parking system may be made more convenient. In the conventional approach, many personnel is needed to keep an eye on a parking lot to count the available spaces and compare them to the space available. The number of people hired would drastically decrease if the outdated method of parking was replaced by an automated indication. The piece also touches on the significant problem of parking cars.

The piece also touches on the significant problem of parking cars. Another issue that annoys and irritates the owners of damaged car parks is improper parking and damaging other automobiles when parking a car. The server receives communications from the parking system for each slot. This automatic technology assists the customer in correctly parking the vehicle and maintains all records in a database, making it easy to identify the vehicle's damage. A code that has been created on this Arduino board is what controls it. The software calculated the total number of slots present by deducting the number of switches pressed, where each switch represents a slot. The LCD screen is used to show how many vacant free spaces there are. The use of a servo motor is another concept mentioned in the essay. In essence, the servo motor is a motor that allows for variable and controllable angular velocity. The concept was motivated by an RFID-based attendance system that records staff and student information using an RFID tag and reader to keep track of attendance. The information that is tagged is compared while switching from the RFID to the reader.

The tagged data is compared to the microprocessor data information that is linked up with the reader when the RFID is switched to the reader to identify the user. An LCD is connected to the microcontroller to show the user's name. Aside from that the status button shows the user's overall attendance. A separate strategy is adopted for the RFID-based application as well, which improves current parking management. User IDs in the unit allow legitimate parking system authentication [2].

The smart library management system (LMS), a pilot project created for university and school libraries, is where the concept of employing RFID was also borrowed. To handle all the library features and client requirements, a Graphical User Interface (GUI) has been created. Different kinds of the goal of shelf antenna design and production are to provide users of libraries with 100% tag readability in a low-SAR situation. To ensure limited coverage around the shelf and

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prevent the unintentional identification of books kept on surrounding shelves, prototype smart cabinets were put together, constructed, and tested using several types of near-field shelf antennas. SAR simulations were run in the presence of human phantom models that were placed near to the cabinet near the cabinet, and the shelf antenna has been improved.

Low-occurrence RFID uses the radio wave theory and operates at a frequency of 200 Hz. The RFID tag has a coil that, when exposed to a magnetic field, transmits an identifying code to a machine for further processing. The RFID tag is used as identification for a specific customer. If the client's identification (represented by their serial tag number) matches the one currently recorded in the system, they will be given immediate access. In addition, this RFID-based protected access system has a good amount of other capabilities. For instance, a new client can register themselves within the system. A registered user may also delete their entry into the system. By depressing the tactile switch attached to the microcontroller, users can access these functionalities [3].

At the outset, the customer is asked to scan his or her identity (RFID Tag). The reader module detects the tag's serial code and sends it to AT89C51 for verification. If the microprocessor is the customer is given access to a parking place if the ID checks out. Contrary to what one might anticipate, a notification reading "Not Valid" appears on the LCD if the tag cannot be identified. Radio Frequency Identification is referred to as RFID. RFID is a member of the family of item identification technologies known as Automatic Identification and Data Capture (AIDC).

There are two primary components: the RFID Reade, signal transmission and reception, and the attached to the item through a transponder. A gadget called an RFID tag utilizes radio waves to identify and track items like people, animals, and products. Some tags can be read from a few meters away, out of the reader's line of sight. RFID tags can be active or passive and come in a variety of sizes and forms. The RFID reader and tags communicate wirelessly, therefore there is typically no need for an obvious path between them. Water and metal are conductive materials that an RFID scanner cannot read, although even these may be circumvented with the right modifications and location.

In addition to the previously mentioned passive type, multi-frequency, powered, and tag-talks-first, RFID tags come in a wide variety of forms. Additionally, there could be many kinds of RFID antennae. Moreover, not all RFID systems employ low-frequency electromagnetic waves. There are read-write tags as well as read-only tags available. Product data can be found on up to 2K tags, however, each tag only holds one product number Tags can be employed in safety devices, environmental monitoring systems, and methods for maintaining the integrity of the product in addition to serving as a product ID [4].

Types of Tag:

Most RFID tags include two components at a minimum. One is an integrated circuit that stores and processes data as well as modulates and demodulates RF signals. An antenna is the second component, used for both signal reception and transmission. Two types of RFID tags are often used found: one is a battery-powered active RFID tag that can send its signal on its own, while the other is a battery-less passive RFID tag that needs an external source to initiate signal transmission.

Passive Tag:

When compared to dynamic labels, passive tags are often smaller, lighter, and less costly. They may be attached to items in severe conditions, require no maintenance, and last for a very long period. Transponders are turned on just inside the range of a reader's response. The RFID reader uses a low-power radio wave field to reinvigorate the tag and transmit any chip information.

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Active Tag:

Active tags differ in that they include a built-in power source, whereas passive tags may act as a transmitter rather than a reflector of radio waves, giving them access to a larger range of choices including read/write and programmed capabilities.

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CHAPTER - 3

RFID FREQUENCIES AND MODULES

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Radio waves are used as information carriers between the readers and tags. The strategy for RFID according to the application, communication often uses frequency allocation. The wider range of usable frequencies is covered. Government bodies oversee the frequency distribution, which calls for oversight when different nations take into account RFID applications. Avoiding standardizing initiatives these problems. Since changing frequencies might make some applications more effective, prior knowing the requirements is essential when picking a certain type of RFID technology. Security access, the two most prevalent applications of low-frequency are quality chasing and animal identification systems. They frequently have small reading ranges and affordable system costs.

High-frequency systems are employed for tasks like automated toll collection and railroad car pursuit. They offer reading at a rapid pace and over a wide area. Typically, pricing is determined by greater pricing for higher performance as a result of improved performance. The power level of the interrogator and therefore the ability of the tag to respond at regular intervals can confirm the range of reading that can be obtained in an RFID system. Similar to the regulations on carrier frequencies, there are legal limitations on power levels. Environmental factors can affect communication in many ways, especially at higher frequencies [1].

RFID Module:

A highly integrated contactless communication module operating at 13.56 MHz is the MF RC522 for a variety of 13.56 MHz contactless communication protocols and techniques. An outstanding modulation and audio decoding abstract are used in this transmission module, and it is integrated with radio-frequency identification (RFID), tags attached to items are located and followed using electromagnetic fields. The data that has been electronically stored is contained in the tags [2].

Arduino Mega Board:

An open-source hardware and software prototyping platform is Arduino. Arduino boards can automate a variety of tasks with other electrical devices, like reading light inputs from a sensor, turning on LEDs, working with various motor types, and connecting to the internet via a network shield. The board's microcontroller complies with a set of instructions defined in a programming language, allowing it to do a variety of amazing tasks. It resembles the mind of any project. Numerous additional electrical devices, such as a computer, another Arduino, or different microcontrollers, may interface with an Arduino. It contains 16 analogue inputs, 4 UARTs a 16 MHz crystal oscillator, 54 digital input/output pins, including 14 PWM outputs, and a USB connector.

It comes with everything you need to support the microcontroller; all you have to do is connect it to a computer via a USB cable, or power it initially using a battery or an AC-to-DC converter. The majority of Arduino shields are compatible with the Mega. Arduino board features include being controlled by uploading instructions to the onboard microcontroller using the Arduino IDE also known as uploading software.

Arduino Ethernet Shield:

When used with an Arduino Mega Board, the Arduino Ethernet Shield R3 may connect an Arduino board to the internet. This shield is based on the Consists of educational W5100 Ethernet chip datasheet. A network stack (IP) with TCP and UDP support is offered by the Wisent W5100.

IR Sensor:

A sensor that detects infrared light (IR) emitted by objects in its field of vision is known as an infrared sensor. This project keeps track of if there are any cars in the parking spot and transmits information in response. The 10-bit converter in the Arduino ADC converts 1024 decimal numbers (0–1023) to a power supply range of (0–5)V. IR sensors detect vehicles in parking spaces, therefore 5V indicates that the spot is occupied, and 0V indicates that it is not occupied [3].

Servo Motor:

A DC motor, gearbox, potentiometer, and unit control circuit are all components of a servo motor. Gears connect the engine to the steering wheel. The revolving motor causes a change in the potentiometer's resistance. The control loop will therefore precisely adjust the movement and the motor's motion. Pulse width modulation, sometimes known as PWM, is a method of controlling servos from the control wire (PWM). There are three different types of pulse width: maximum, minimum, and repetition rate. Because servo motors are simpler to regulate and more precise than conventional DC motors, they are utilized instead of DC motors. They feature three wires, one for power, one for control, and one for ground.

LCD Screen:

Our cell phones and other Nanotechnology products employ LCD (liquid crystal display) technology. LCDs allow displays to be considerably smaller than the technology used for cathode ray tubes (CRT), which frequently have quite large sizes, just as light-emitting diode (LED) and gas plasma. LCDs use a lot less electricity than LED and gas displays because they operate on the principle of blocking light rather than sending it [4].

Software Required:

To create a logic that will allow the Arduino Mega board to comprehend its needs, a programming language and interface are required. To make Arduino compatible with both hardware and software, several libraries have been employed. The required programming languages and software are utilized to create a fully functional web page that can be viewed over the internet.

Arduino Core:

Any microcontroller that is used today needs a development environment so that it may be programmed before being used. Fortunately, Arduino Maker offers a free, open-source SDK that may be downloaded. The most recent version of this IDE is for Arduino 1.8.8. Different libraries are used to speed up project development. The text was shown using libraries like the Eda GFX library for LCDs and the Eda Font library. As the physical board was new to the market, custom libraries were built for numerous device interfaces.

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CHAPTER - 4

DEVELOPING A SMART PARKING MANAGEMENT SYSTEM

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Finding parking requires a large amount of time and effort, which results in high prices. This is especially true for those who always feel under time pressure. Smart cities use a variety of contemporary technology to efficiently manage and improve resources. Urban parking lots are a crucial asset that has to be maintained. To manage to park and help consumers save time, effort, and money, we created a smart parking management system (SPMS). It has become imperative to enhance parking availability searches and reduce traffic jams at parking entrances in the context of modern living. An improved alternative to looking for parking in a parking lot is to search for or reserve available parking online in advance [1].

A better alternative to looking for parking in a parking lot if there is a chance of not finding any is to search for or reserve available parking online early. A range of technologies is used by the suggested system to manage to park. Users may use it to make payments, make bookings, and seek parking, among other necessary services. It has been expanded to include more sophisticated features like monitoring the parking situation and getting warnings and data. India is becoming more motorized, meaning there are more private automobiles than there are public transportation options. The requirement for parking spaces to park cars grows together with the percentage of individuals who own cars. However, the present situation is that there are not there are enough parking spaces available, or individuals may be unaware of the permitted parking spaces in their area. This condition causes unnecessary overcrowding of automobiles on the road and makes it difficult for people to cross the street. To address these issues, we are putting forward a multilingual Android application that will enable users to search for parking spaces online.

Digitally means that this specific system will allocate the parking space based on the user's present position and the parking space that the user desires based on his or her convenience. The simplicity of discovering the precise slot. Digital payments or payments made at vending machines are both acceptable. The end user can register and log in with his or her account, which will aid the system in locating the user and showing the closest parking area and available parking spaces in that area. If not, it will point users to the next available spot that is closest, and so on [2].

The current parking system consists of both conventional and application-based approaches. The manual way of parking, which requires the user to go great distances and pay additional fees, is used in the conventional approach money. Applications that, for example, supply parking spaces for a certain location make up an application-based strategy. Parking Panda is an application that offers parking spaces for venues including stadiums and sporting events. The key to each nation's success is its transportation system. Many people today have the choice to travel by using their automobile. The demand for goods will undoubtedly rise as a result, but "parking" is one of the issues brought on by increased traffic parking all of these

Parking cars in big metro areas has become a laborious and challenging process, and it has become troublesome. The implementation of improved and more intelligent parking management techniques is the subject of much research and development worldwide. The present-day wireless sensors or smart parking systems Network Wireless sensor network

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module, an embedded web server, and a central web server are required for parking. Infrared (IR) sensor nodes are used by sensor networks to verify the status of the parking space and transmit.

Thus, the user may check for available car spots using the information shown on an LED panel. The users are not guided by these devices to the parking lot. if there are no open slots. This project is anticipated to deliver a productive and economical fix for the parking issues with vehicles. The user's mobile device has to have the application installed. In contrast to the current system, we propose using client-server architecture, where the client requests the reservation of slots, and the server replies with the slots that are open at that moment. With our technology, the user may choose the parking spot that best suits his or her needs. The benefit of this will significantly cut down on how long the car takes [3].

The benefit of this is that finding a parking space will take much less time for the car. Additionally, the user may make payments using advanced payment modules such as an e-wallet, debit card, or credit card. A penalty will be appended after the user-specified entrance and leave times, along with any late exits and excessive use of the slot. On cancellation of a parking space and an early departure, a reimbursement will be issued the manager must keep an eye on the region.

The increased number of automobiles on the highways and in parking lots is overwhelming several of the vehicle parking facilities. The wireless sensor networks module, now used in smart parking systems or wireless sensors network parking, Central Web-Server, embedded Web-Server. Infrared (IR) sensor nodes are used by sensor networks to check the parking spot condition and transmit this information to an embedded web server. Thus, the user may check for open car spots using the information shown on an LED panel. Additionally, image capture equipment is used to continually take images of the parking lot to guarantee that there are no open spaces, which results in significant power consumption and high maintenance costs. There are several methods available, such as smart parking services.

There are several products on the market, such as smart parking services, which employ wireless sensor networks to efficiently locate parking spaces. However, installing additional hardware in the automobile is necessary to operate this system, which is not practical. In a busy metropolis, parking spaces might be quite difficult to come by. When visitors visit a parking garage, they frequently discover that it is filled and that there is no room for them [4].

New technologies are currently revolutionizing the parking sector, enabling cities to drastically cut congestion levels. The fundamental intelligence of smart parking systems is provided by sensor networks that detect car occupancy. Thanks to Smart Parking technology, it is now possible to locate available parking spots in real-time and to assist vehicles in reaching their destination. The gathering of parking information has made use of several vehicle detectors. The inductive loop, acoustic sensor, infrared sensor, or ultrasonic sensor are the most common types of vehicle detectors.

It was suggested that data be gathered in a parking lot. However, inclement weather and nighttime operation might damage a video camera sensor. Additionally, it is costly and produces a lot of data, which might make it challenging to transfer to wireless internet. Due to their excellent accuracy, magneto-resistive-based detection systems in combination with wireless area networks are the most widely used method. However, this form of sensor has its problems, including the possibility of electromagnetic interference, which reduces accuracy, and the requirement for continual data collection, which wears down batteries. A parking sensor system has been suggested to boost car recognition precision and prolong battery life.

A parking system has been suggested to boost car recognition precision and prolong battery life. While power management strategies have been put in place to use a two-fold sensor technique, energy usage, and high occupancy monitoring accuracy are obtained. A series of dark and measurement-based Signal Strength Index approaches are used. The wireless sensors, which are either buried in the pavement or attached to the surface of every parking lot, are nonetheless obtrusive. Existing sensors can cost up car parks, such as ground-based parking sensors. Because so many sensor units are needed to cover the whole parking lot, smart parking technology employing wireless sensor nodes for outdoor parking is expensive. However, parking occupancy tracking devices have become more common.

This solution's complexity and high cost of implementation when a detecting device is deployed on each parking lot constitute a drawback. Furthermore, when a vehicle is detected using merely an RFID transmitter, electromagnetic interference can cause problems for the system's identification and reduce its accuracy. Additionally, this system is built to identify a car as it pulls into a parking space and requests payment, but information about empty parking spaces is not offered. It has been suggested to use two cameras one to record a vehicle's arrival and the other to film it exiting the parking space to monitor vehicle parking.

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CHAPTER - 5

SYSTEM ANALYSIS AND DESIGN

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The Node MCU has adopted the TCP/IP protocol, allowing any microcontroller to connect to a 2.4 GHz Band WI-FI network. Node MCU may host an application through the web protocol or connect to an already-established wireless connection. Each Node MCU module already has an AT command firmware pre-programmed, so you can connect it to your Raspberry Pi device and use it as a Wi-Fi shield. The reason we chose a microcontroller instead of Arduino Uno is that it is more cost-effective. In Arduino, we must buy an Ethernet shield to offer secure Ethernet communication, but node MCU includes all of these capabilities as well as a USB port [1]. All these functions are offered by node MCU, which also has an updated feature of Wi-Fi, where you may charge or connect your system via Wi-Fi. In Arduino, we must utilize the Ethernet shield, which gives us secure Ethernet communication. There are open-source prototype board designs for the Node MCU open-source firmware. Node and MCU are combined to form the moniker "Node MCU". In actuality, the firmware rather than the related development kits are what is meant by "Node MCU" in this context.

The designs for the prototype boards and firmware are also open sources. The Lau programming language is employed by the firmware. The firmware was created using the Digital signal processing Quasi SDK for the Wi-Fi module and is based just on a personal data project. It makes extensive use of open-source initiatives like Special deals and command-line. Users must choose the components necessary for their project and create firmware specific to their requirements due to resource limitations. Additionally, compatibility for the 64bit ESP32 has been included a circuit board is the usual prototyping tool.

A circuit board acting as a dual in-line package (DIP) that incorporates a USB controller with a smaller surface-mounted board holding the MCU and antenna is the prototype hardware that is frequently utilized. The DIP format's selection makes breadboard prototyping simple. The ESP-12 module of the ESP8266, which is a Wi-Fi SOC combined with a ten silica Tense LX106 core and is extensively utilized in IOT applications, served as the design's basic foundation [2]. If you're searching for a more portable module that includes Wi-Fi and you've already finished several Arduino projects and are familiar with Arduino, utilizing Node MCU rather than Arduino Uno is the natural next step. The Espresso ESP8266-12E Wi-Fi System-On-Chip serves as the foundation for Node MCU. It is open-source and based on firmware written in Lau. As Arduino cannot operate wirelessly, it is ideal for Internet of Things applications, particularly other Wireless connection projects. It must be connected to Bluetooth or an NRF module. This chip and the Arduino are both prototype boards containing microcontrollers that can be programmed using the Arduino IDE, thus they have a lot in common. Because the ESP8266 is more recent and less established than Arduino, it has more robust specs.

16×2 LCD Display:

An LCD is a type of electronic display module that creates a visual image using liquid crystal. A fairly basic module that is frequently used in DIY projects and circuits is the 162 LCD. The 162 represents a display with two lines of 16 characters each. That is LCD The display of each

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character uses a 5 by 7-pixel matrix. The amount of empty and spilled spots are shown on the 16*2 display. Additionally, it is updated on the LCD when a vehicle parks [3].

Liquid crystal display is referred to as LCD. It is a particular type of electronic display module used in a wide array of circuits and devices, including mobile phones, calculators, computers, TVs, and other electronics. These displays are mostly favored for seven segments and multi-segment light-emitting diodes. The primary advantages of adopting this module are its low cost, ease of programming, animations, and unlimited ability to show bespoke characters, unique animations, etc.

Aspects of an LCD 16x2

The following are the primary characteristics of this LCD.

1. This LCD's working voltage ranges from 4.7V to 5.3V.
2. There are two rows, each of which may output 16 characters.
3. With no lighting, the current use is 1 mA.
4. A 5-by-8-pixel box may be used to create any character.
5. Alphanumeric LCDs display letters and numbers.
6. Can displays operate in both 4-bit and 8-bit modes?
7. Blue & Green backlit versions of these are available.
8. Several custom-generated characters are displayed.

IR sensor:

An electrical device that monitors and detects infrared radiation in its environment is called an infrared (IR) sensor. William Herschel, an astronomer, made the unintentional discovery of infrared radiation in 1800. When calculating the temperature was highest just beyond the red light (red light was separated from other colored lights by a prism). Despite being on the same electromagnetic spectrum as visible light, IR has a longer wavelength than visible light, making it invisible to the human eye. Infrared radiation is produced by everything that emits heat (i.e., everything with a temperature higher than around five degrees Kelvin) [4].

System Architecture:

The pin diagram for our model is displayed in the diagram below. One node MCU, one dc motor, one 16*2 LCD, and three IR sensors make up this device. The brain of our system, the node MCU, controls all other components. It has a 16*2 LCD using node MCU using jumper wires to link the display and node MCU.

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CHAPTER - 6

SMART PARKING SYSTEM TEST PLAN

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Objectives of the Smart Parking System Test Plan:

Review of the system: The Windows Kinect System handles the Admin Login, Teacher Enrollment, Teacher Login, Admin Assign Subject to Teacher, and Teacher Logout. Manage the class, the subject, and the quiz.

Overview of the paper: This document includes a strategy and timeline for system testing as well as a mapping of the tests to specific system requirements.

Submitted Documents: SRS and test cases created for the system are the papers that are being referenced.

Environmental Test: For Software University Lab7 Resources is the name of the test site(s).

Software: The necessary software is Front end: Sublime Text 3 as the back end MSSQL

Hardware: A Core i5 processor running at 2.40 GHz with 4GB of RAM and a 500 GB hard drive are the minimum system requirements.

Other Resources: Not relevant

Issues with licensing: All of the software tools being utilized have development licenses, according to UNIVERSITY lab 7.

Installing, evaluating, and controlling: At UNIVERSITY Lab7, the Kinect for Windows v2 System will be created. Additionally, testing will be done on the grounds of the university lab. The software installation and testing will be handled by UNIVERSITY Lab. Once installed, UNIVERSITY Lab 7 will be in charge of maintaining and controlling the program.

Personnel: The exam will be conducted by Rai Sajid, Nadia Khan, and Kulsoom Bibi, who will thereafter report to Dr. Qurat-Ul-Ain Alam.

In many large cities throughout the world, parking is one of the most pressing difficulties for thousands of automobile owners. The reason is that if there isn't enough room, you can spend hours driving around the required region in search of a spot for your automobile. Thankfully, there are now applications for parking cars. For a wide audience in several places, many startups and large corporations provide smart parking solutions. To avoid any bugs and performance problems, smart parking software should be thoroughly tested by experts to continue to be effective. How therefore can the parking software be tested most thoroughly and efficiently [1]?

The most crucial thing to understand about park-and-ride services is that there are two categories of applications that let you find a spot for your car without paying for it and vice versa. First of all, several applications provide their customers with distinctive options to locate open spaces with a convenient payment method. These are therefore dynamic and sophisticated parking applications. Second, some apps just let you effortlessly pay for parking [2]. We will concentrate on presenting a testing procedure for this digitalization because the first type of app is more modern and demanding for consumers.

Case One:

This instance demonstrates that there are no open parking spaces, hence the system will permit a car to enter the parking zone. The 16*2 LCD will display the number of empty and filled spots, and the program will display it similarly.

Case Two:

In the scenario that follows, a slot number is displayed when the user is close to the parking detect sensor. When the user parks, it displays the parking start time and the parking slot number where the user should put his car.

Case Three:

The app view and the model view are shown in the example below when a slot is full and a new car approaches the vehicle detection sensor. The user then receives a notification describing in what manner the gate was opened by the DC motor and which space he can use to park his car. After successfully parking his car in the slot, the driver will receive a notice with the slot number and start time of his parking session [3].

Case Four:

The example below demonstrates details when a user removes their car from a parking space, a message including the start time and finish time of their parking is shown. The user would concurrently be permitted to pay a nominal fee that will be shown on the application. The count of the 16*2 display would be refreshed after he had successfully unmarked his car.

Case Five:

In this scenario, a notification indicating that there are no more available unoccupied spots in the parking zone would be shown. This message appears when all available parking spaces are taken and whenever a new car approaches the parking detect sensor to inquire about space. Additionally, since the DC motor does not operate the gates, it is more logical that there are no more parking spaces available and therefore no signs stating parking spaces are filled should be posted by maintenance personnel effectively saving human labor [4].

Most parking applications come with specific instructions designed to make utilizing a product simple and easy for the user. The following is a summary of the steps that users of these well-liked digital solutions typically take: Sign up for or log into your account during registration. Finding empty spaces the user starts looking for an empty location to park their vehicle employing a variety of criteria, such as time, cost, and other aspects, for comparison. After selecting a vacant spot, it's time to make a reservation Payment: paying for a parking space via the app or with cash at the designated location driving to the designated parking space: finding the location after arriving at the desired location, the user selects a spot that has been booked.

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CHAPTER - 7

INTRODUCTION TO DEFY COMBAT COPTER

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For more than a century, aviation has been a vital component of the military's kinetic capabilities, with combat aircraft being essential in several conflicts. The conceptual and functional shifts in a kinetic force are still present and connected to the current and developing security environment. Due to its dependence on technology, combat aircraft, a critical kinetic capability, requires ongoing re-equipment and improvement. For the best utilization of the capacity that is already available, the force structure and organization must also be adjusted. In the past 50 years, combat airpower has changed and improved in all important areas. The capability expansion strategy for combat airpower has to be reviewed in light of how conflict is evolving to remain relevant. Rebalancing the many components of airpower is challenging given limited budgetary resources [1].

This piece makes an effort to provide concrete answers. What changes have occurred in combat aviation during the past 50 years? Will combat aircraft continue to be a significant factor in the deployment of kinetic force? What part will it be played again? To be purchased and operated, combat aircraft require a significant expenditure of resources. In 1968, there were over 18,000 combat aircraft in use worldwide; fifty years later, the number is nearly the same. The inventory of combat aircraft reached its peak in 1958 when it was close to 38,000. Its subsequent steady fall was caused by changes inside the geopolitical environment, the nature of battle changing, the advancement of technology, and the emergence of substitutes.

In this book, the combat aircraft inventory data that is currently accessible is examined for patterns and likely causes of changes in the holding before projecting the course of manned combat aircraft in the future. Also explored is the function of combat aircraft and how it interacts with various aspects of Indian air power capacity and its potential future. The concept of combat aviation, the history of force application, and its technique are all discussed in the first section. The trajectory of combat aviation is outlined in the following section with specifics on the combat aircraft inventory from 1968 to 2018. Military forces are a powerful tool for expressing a nation's political intent. These troops always work in an unpredictable environment and are equipped to handle the complication of battle. The truth is that wars only create winners and losers.

At that point, the deployment of kinetic force serves as the main tactic. An examination of ongoing wars throughout the globe reveals that the operating environment and, as a result, how force is applied, is changing. The operating environment has been designed and upgraded in five crucial areas: battlespace transparency, communication, increased weapon effective range, precision aiming, and mobility speed. While these modifications have increased the size of the kinetic battlespace, the introduction of non-kinetic weapons has changed wars into a continuous multi-domain, multi-dimensional activity [2].

Consequently, it is challenging to pinpoint the opponent or his motives. Even more challenging is the challenge of accurately defining the start or conclusion of a conflict. Threats have

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changed as a result of improvements in telecommunications and technology. Threats that were formerly limited inside national borders have evolved into transnational and ideational problems that respect neither existing governance institutions nor state sovereignty. Hybrid conflict is a reality, and war's traditional binary results are fading.

To get the intended outcome, it is crucial to make financial investments and rebalance various aspects of air power. The operating environment is dynamically changing, and the previous it's time to revisit the concept of building independent, self-sufficient fighting units. Field commanders had a tremendous lot of liberty in how they fought their engagements because of independent troops. Each unit received a brief and focused mission. The ramifications of individual engagements were rarely known to field operators, even though these modest activities were a part of a bigger plan. A comprehensive review and reassessment must be done to meet or surpass the conflict due to changes in the operating environment. It is challenging to make sure that each minor goal for each unit is consistent with the changing broad picture [3]. Combat aircraft have been an integral feature of numerous battles since aviation became a part of military kinetic capabilities more than a century ago. Combat air power is prepared to deliver the punch that contemporary geopolitics may call for: quick, powerful, accurate, and collateral-free. The capability expansion strategy for combat airpower has to be reviewed in light of how conflict is evolving to remain relevant.

It is challenging to make sure that each minor goal for each unit is consistent with the changing broad picture. As a result, the war must now be planned largely at a higher level for the larger fighting zone to best utilize useable force to accomplish the objectives. This necessitates changing the way the fighting space is controlled. In the past two decades, there has been a significant change in the security landscape in India. Numerous hybrid war concepts are still in use, and peace is elusive. The Indian Air Force (IAF), as a kinetic instrument in this "no peace, no war" situation, has undergone several adjustments to stay relevant in the changing operating environment [4]. While the nature of combat has changed, our organizational structures and capabilities development models are 50 years behind the times. Given the current multinational character of risks, the surprise will be surprised if we do not make a deliberate effort to catch up in some areas. In any event, the Indian armed forces have been completely taken by surprise in every major fight to date, except for 1971. In 1971, a carefully prepared campaign did win us an astounding victory and 93,000 POWs (POW). India is a developing nation where resource sharing is fiercely competitive. The amount that can be set aside for defense and security is little. These resources are limited, thus it is important to use them to build defenses against calamities. The Indian armed forces, based on present institutions, are overly reliant on offensive capabilities as a form of conventional deterrence. Below these combat aircraft must adapt to difficult conditions.

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CHAPTER - 8

COMBAT AVIATION

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India now faces a greater number of difficulties, but a coordinated response to them has been elusive. Changed tactics are required due to the evolving nature of combat and the battle environment. It is now time to discuss how to deal with growing threats as each arm builds frameworks for collaboration in warfare. This discussion will establish an Indian response to the problem. Combat strategy inconsistencies have been heavily exploited, leading to recurrent failures at the tactical, operational, and strategic levels. The entire spectrum of warfighting has to be reevaluated at this point by the Indian Armed Forces. For instance, we might not be able to effectively use our offensive capacity without the necessary battle space clarity. The same is true for new aspects of communication, swift movement, and longer-range weaponry [1].

The operational grid also has to include new aspects of communication, fast movement, and longer-range weaponry. Only then may this occur at a reduced resource cost, a lesser offensive capacity with the necessary battle space transparency would be a better option. The military must also uphold the idea of delegating authority and guaranteeing accountability within its sectors. Therefore, a comprehensive strategy is required to lessen both our present and future problems. Considerations for evaluating possibilities should be made concerning four key areas: thoughts, tools, applications, and the TEAM idea can help with creating a clear plan and optimizing the advancement of India's military strength to be future-ready. The objective is to start by understanding and assessing the future course of our armed forces with this orientation in mind [2].

Will combat aircraft continue to be a significant factor in the deployment of kinetic force? What role will combat aircraft play going forward? How has it changed over the past 50 years? Technological Military aviation has advanced in terms of propulsion, control layouts, avionics for navigation, attack systems, and weapon, transforming aircraft into full-fledged fighting systems. Technology's influence on aircraft used for weapon delivery is the greatest. Weapon delivery standoff distances have surpassed 100 kilometres, although targeting precision of three to five meters is still maintained. Combat aircraft are some of the most sought-after pieces of military hardware because of their power to reshape the battlefield.

According to the United Nations' definition of a combat aircraft, a fixed-wing aircraft is used primarily as a weapon platform definition. Since their creation, the speed, manoeuvrability, weapon carrying capacity, onboard sensor, communication systems, data linkages, Radar Cross Section (RCS), weapon targeting, and navigation systems of combat aircraft have all seen significant improvements. Today, a variety of aircraft across the globe that range from low subsonic low massive amount aircraft to supersonic jets, from aircraft that essentially fly over the target while delivering air-to-surface weapons to a variety of fifth-generation aircraft that can launch weapons on a goal hundreds of kilometres away, meet this definition criterion. There is a significant technology divide in this area between different states.

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Genesis of Aviation and Combat Aviation:

Man has long desired the ability to fly ninth King of Britain, made a deadly effort to fly using feather-covered wings from the Temple of Apollo in London. Just goes to show how long it has taken for the human race to perfect flight. The human yearning for the heavens culminated in hot air balloons in the late 18th century when Father Bartolomeo de Gismo displayed a miniature model of a hot air balloon that ascended to 3.5 m on August 8, 1709. Many straightforward and intricate but unsuccessful attempts ensued. The very first men to complete a free flight in a hydrogen-filled balloon over a distance of 43 km were Jacques Alexandre, Cesar Charles, and M. Robert.

The first men to complete a 43-kilometre free flight in a hydrogen-filled balloon were Jacques Alexandre, Cesar Charles, and M. Robert. France's Tuileries to 10 Range, speed, endurance, control and safety characteristics were lacking in this design. A heavier-than-air vehicle's first controlled flight by the Wright Brothers was accomplished in December 1903, more than a century later. Following this demonstration of the feasibility of aircraft, much work was put into extending flight time and improving machine control. This skill swiftly entered the battlefield as technology advanced and the safety record improved. The aircraft improved the chances of victory by providing an unmatched top view of the enemy's positioning [3].

The aircraft expanded the line of sight while posing comparatively little threat and provided an unprecedented top view of the enemy's positioning. From the first moments of today, military aviation, where the planes were utilized as observation posts and for mapping out enemy troop movements, may determine how a country battles. Aircraft are being utilized as platforms for weapons and are outfitted with high-fidelity, long-range sensors for offensive, defensive, and surveillance missions. The use of aircraft as a quick transporter was increased by scaling up the fundamental design and adding strong engines to lift a greater mass. The advent of cargo planes altered mobility characteristics.

Between the start and conclusion positions, the terrain and barriers were irrelevant. With a swift military and armed forces movement across continents, hardware is becoming a fact of life. Large military contingents may be transferred from one location to another within a day. The logistical procedure for troop sustenance has been redesigned due to some transport aircraft capacity to paratroop personnel and equipment, operate from partially prepared surfaces, and need little maintenance. With the advent of helicopters, which permitted tactical movements in addition to observation and firepower flexibility, the battlefield saw yet another revolution. Helicopters were a crucial component of ground soldiers on the battlefield and could be used to transport troops aboard ships because of their capacity to take off and land vertically [4].

Helicopters were a crucial component of ground soldiers on the battlefield and could be used to transport troops aboard ships because of their capacity to take off and land vertically. The third dimension was introduced to surface forces at the capability for vertical envelopment and tactical level. Quick Inter-Valley Troop Transfer (IVTT) was made possible by Heli-lift, eliminating the requirement for instant water barrier crossing. With the use of helicopters, personnel and equipment could be quickly positioned behind enemy lines without having to navigate minefields or other intervening Ditch Cum Bund (DCB) barriers. In all terrains and areas, tactical troop deployment plans now inextricably include helicopters. Battles are being planned with information thanks to the introduction of unmanned aircraft (UAV) for monitoring with hyperspectral images and targeting with precise weaponry.

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CHAPTER - 9

THE HISTORY OF MILITARY AVIATION

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A noteworthy instance of resolving regional demands for the legality of state boundaries was the Arab-Israeli confrontation in 1973. The use of airpower during the Falklands War was the sea realm between the two contending factions when one side possessed a significant geographic advantage. The Gulf War I in 1991 redefined the role of air power as a main weapon of kinetic power to shape the operational environment for use by other components and as an example of a multinational force collaborating to overcome a well-equipped opponent [1]. A well-defined and powerful military state targeting a non-state actor by a state with the assistance of a multinational army occurred in Afghanistan, and in Syria, the lines between opposing parties are even hazier while other players are pursuing their goals in the same fighting arena. The globe has experienced other conflicts during the past 50 years as well. The most important conflict on the Indian subcontinent took place in 1971, and as a consequence of a resounding military victory, an independent nation was founded. India's east and west were the frontlines of the conflict. On these two fronts, political objectives and, as a result, military aims and methods were significantly different from one another.

Arab-Israel War:

The 1973 Arab-Israeli War was fought on a condensed, compact battlefield. Aggressive air power usage to combat the despite the presence of several radars and related Air defense Missile Systems, the main focus was on an opponent who was both in the air and on the ground. Combat aircraft from both sides were used largely to target enemy airfields, air defense installations, and surface forces during the brief but fierce 20-day conflict. Combat aircraft were sent to target bridges and bridgeheads and protect the surface forces from enemy air strikes. More than 1500 combat aircraft, principally MiG21, MiG17, Su7, Mirage III, F4, and A4 flown by Egyptian, Syrian, and Russian. Although total numbers are not publicly accessible for obvious reasons, it is usually thought that 500–600 combat aircraft were lost on either side lost in air combat and to air defense guns and missiles. Its significance is evidenced by the fact that a multi-layered anti-aircraft system with several sensors [2].

The armament systems and sensors were strong, but a crucial element for reliable and efficient communication was absent. The number of fatalities from fratricide was above 50. Israeli ground troops were occasionally assaulted by their air force, which also targeted aircraft from both sides. With a numerical inferiority ratio of 1:2 for combat aircraft, Israel was engaged in a classic two-front battle. By utilizing the concentration of power, a fundamental tenet of battle, the combined strength of the Egyptian and Syrian Air Forces, bolstered by other players like Iraq in the region, got off to a good start. It was carefully planned to launch a massive offensive attack package involving more than 300 aircraft at many target systems in the late afternoon of a significant religious holiday in Israel operational debut of the long-range space missile.

The long-range Kelt3 air-launched missile also made its operational debut. Due to its massive size, high Radar Cross Section, and slow speed because of its limited weight of attack and precision, most of the missiles were intercepted, and those that did reach the target had little effect. However, the initial offensive impetus was not maintained, perhaps as a result of the greater than-anticipated casualties and the aborted second wave of strikes against Israel. The tactical halt and change of emphasis away from the Israel Air Force target gave the Israel Defense Forces much-needed breathing room.

The Israeli Air Force was subsequently given more operational leeway as a result of this. The core tenet has always been that the air force is supported by surface troops, and this was a classic instance of that air power that gives the surface troops room to manoeuvre. The nature of air operations was slightly different over the Golan Heights. Israeli ground troops were the target of Syrian offensive missions intended to support Israeli land forces in combat. However, Israel's air defense effort was intense and successful. As a result, Syrian air strikes on the Israeli land troops were mostly avoided. In a classic instance of confusion brought on by improper communication amongst Syrian, Jordanian, and Iraqi soldiers engaged in combat against a common [3].

Identification problems from the Syrian side led to their aircraft targeting Jordanian soldiers, Iraqi aircraft striking Syrian land forces, and Syrian air forces shooting down Iraqi aircraft, all of whom were common enemies in Iraqi planes. The Syrian Air Defense Barrier was successful in the beginning, but an Israeli strike on its computerized control centre on October 9, 1973, and Syria's decision to remove SA6 batteries to defend Damascus following the raid, altered the situation. One key lesson learned was that combat aircraft, when used properly, can be a powerful defensive instrument against a ground attack or a supporting tool to expedite a surface advance. Each of the three parties to this battle began their campaigns with a predetermined strategy, but they rapidly discovered.

All three parties to this war began their campaigns with a predetermined strategy, but they immediately had to alter their plans to account for fresh information about the operational environment's realizations. According to the intensity of the conflict and the need, Israel quickly moved its use of combat aircraft from Sinai to the Golan Heights, demonstrating the adaptability and indivisible character of combat airpower.

Falklands War

In 1982, the Becca Valley in Lebanon witnessed another battle almost ten years after the Arab-Israeli conflict of 1973. Argentina and the UK engaged in conflict over the sovereignty of the Falklands Islands in the same year. While the Becca Valley confrontation raised attention to the use of non-kinetic cyber warfare and the openness of battlespace, the tale developing in the southern hemisphere was radically different. Argentina had a geographic advantage, while the UK was engaged in conflict 12,000 miles from the major bases, with ship-based capabilities. Using the Stanley was occupied by Argentina on April 2, 1982, until it was retaken by the 74-day conflict involving British forces. When fighting in the air, 20 Sea Harriers (eventually eight more aircraft) flew out of two aircraft means of transport [4].

Nearly 150 aircraft, including Mirage III, Daggers, and 20 Sea Harriers later joined by eight more aircraft operated from two aircraft carriers engaged in the air conflict operating from airfields in Argentina including the Super Standard and A4. A Super Standard of the Argentine Navy fired an except air-to-ship missile at the HMS Sheffield of the Royal Navy on May 4, 1982. Due to this, both British aircraft carriers were compelled to operate away from the Argentine mainland and east of the Falklands. The strategy was to reduce the likelihood of a hit by a Super Standard carrying an except missile On the other hand, because of the great distance between the Argentinean mainland and the Falkland Islands, Argentinean combat aircraft had a limited amount of operational time.

Similarly, the downing of an Argentinian Canberra the same day was a ruse to solely assign Canberra aircraft to nighttime strikes on ships with hardly little prospect of success limited receiver and fuel capacity for aerial refuelling, and a lack of reliable navigational tools compelled an aircraft from Argentina to use a restricted approach corridor swarm British ship. This contributed to the high number of interceptions made by the Sea Harrier attacks against Argentina until a substitute Pathfinders' method was used. Alternatively, the UK used Vulcan bombers to attack airfields in the Falkland Islands with high expectations and slim chances of achievement. Vulcans can transport 1000-pound bombs with electronic countermeasures AGM45 missiles.

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CHAPTER - 10

MILITARY AIRCRAFT INDUSTRY IMPLICATIONS

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A crucial element is airpower, which may be used to execute strikes on ground targets across the border or as a stand-alone instrument as part of a brief ground offensive to capture territory. Combat aviation is largely offensive and is frequently the front end of air power. Attacks against a variety of targets and systems can be made possible by this offensive capability. Combat aviation thus offers a way to accomplish goals. Combat platforms, weaponry on combat platforms, and combat aviators make up the main or core components of combat aviation. For mission success, this triad which represents the reverse end of combat aviation requires several additional support components. In other words, combat aviation is a component of a sophisticated operating system and not a standalone vector [1].

This chapter lists and defines numerous components to decipher the combat aviation system. Taking a global view, aiming at a specific location, and radially it has been decided to list the main aspects of combat aviation from the outside in. Basic operational planning for engaging a target is the first step in the procedure. The operational parameters that determine the function and mission needs of combat aircraft will be better understood with the help of this method. On the other hand, the corollaries to the aforementioned questions apply in the case of a defensive strategy. The circumstance can necessitate acting on your own and starting actions against a hostile power. The decision-makers and commanders require answers to inquiries concerning the enemy's intent, resources, capacity, force application plan, criticalities, vulnerabilities, and recoverability in both offensive and defensive alternatives. Due to improved situational awareness and the availability of a comprehensive picture to plan strategic, operational, and tactical actions, accurate information on the locations and capabilities of all actors in the combat zone enhances the likelihood of success. All combat and combat-support components of the enemy must first be identified, and then their locations must be localized.

Since then, techniques have included setting up advance posts and placing observers on high grounds or platforms to get around line-of-sight restrictions. Wars first appeared in human history. It was usual practice to conceal a man oeuvre behind suitable terrain features, in complete darkness, or behind a smokescreen to prevent the opposition from learning about it. When it came to delivering commands and reporting observations in the military, telegraphy and later the telephone was first used. Radars and wireless communications have increased the transparency of the fighting space. A well-known instance in the maritime realm is the Prince of Wales' employment of radars to track Bismarck during World War II. Every technological innovation results in a paradigm shift in conflict dynamics [2].

The pace and effect of operations were increased through the use of electromagnetic waves and network warfare. The distinctions between technical support teams, non-uniformed actors, and uniformed warriors for their roles in combat circumstances are becoming hazy. Wars have mostly changed during the past century from being an event to a process. This process is ongoing with varied intensity but lacks a distinct beginning or end point. Low-intensity conflicts with sporadic terrorist attacks, system outages and system interferences make up the lowest end of this phase. Up until a full-scale conventional battle starts, the intensity and tempo

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are increased by the direct engagement of combat units and the employment of kinetic weapons. Thankfully, except for one incident involving the USA, the intensity has not peaked with the use of nuclear weapons.

Operational Planning Process:

A clear goal continues to be the central concern for operational planning, even though combat is changing as we move from the industrial to the information age. Consequently, choosing a target system or systems is one of the initial tasks. By posing the fundamental query, "What, if denied, will cause the opponent to capitulate?" this choice is inextricably related to the overarching goal of the conflict. History is rife with instances where the loss of a particular geographic region, the breakdown of a command-and-control system, or the denial of a certain kinetic capacity resulted in disastrous outcomes. Targeting the aforementioned centre of gravity might not always be viable for practical reasons [3].

In these circumstances, systems that sustain the centre of mass are chosen as appropriate goals with the ultimate goal of reaching the evaluated centre of mass. The next logical step is target analysis. This involves evaluating the target system's criticality, vulnerability, and availability of alternatives. The attacker can so reduce the number of physical targets even further. The identified targets' functional, operational, and structural examination comes next. To locate, identify, and establish the position of the target systems, a variety of tools are used.

The target's vulnerability index is evaluated concerning all potential harm mechanisms. Air-launched weapons cause blast, fragmentation, fire, penetration, and shock, either alone or in combination. The vulnerability indices of the target are matched with these characteristics for every weapon in the inventory. This evaluation is carried out more effectively with the use of computerized tools like the Joint Munition Effectiveness Manual (JMEM) and Weapon Advisory for Staff Planning (WASP). To choose an effective mode of attack to engage the target, it is essential to evaluate the operating environment in the target region in terms of the topography, lighting conditions, weather, and air defence measures. As a consequence, the best weapon-platform-mode-of-attack combination is chosen for targeting.

The number of guns needed to cover a target with sufficient damage is determined based on the target's size and structural strength. The number of platforms necessary to launch these weapons is calculated in the next step depending on the platform's capability to carry weapons. An adequate number of aircraft are planned to account for failures due to platform or weapon malfunction and/or enemy action to ensure that the requisite number of aircraft deliver their munitions. The support package for the basic strike is prepared after the required number of platforms are equipped with the required weaponry. Anti-aircraft that accompany the strike package is included in this. The protection is provided by anti-aircraft outfitted with air-to-air armaments like missiles and guns [4].

Aerial refuels offer in-flight refuelling whenever necessary and possible to increase the range and endurance of all airborne vehicles. Moreover, the platform's strategy to weaken the functioning of the enemy's electronic sensors includes outfitted with electronic warfare suits. Almost always, the surface-based anti-aircraft components defending the intended target are also taken out. This targeting is either temporary using electronic methods and Suppression of Enemy Air Defense (SEAD) operations or permanent using Demolition of Enemy Air Defense (DEAD) missions. This raises the strike aircraft's survivability and, as a result, the mission assurance level. Bomb Damage Assessment (BDA) missions are also planned post-strike to determine the extent of damage, either by combat aircraft with reconnaissance equipment or by alternative methods using satellites or UAVs.

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CHAPTER - 11

ASSESSING THE POTENTIAL OF COMBAT AIRCRAFT

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The enemy's capacity to conduct combat aircraft will be eliminated if one of the domains is completely overpowered. Even if the two parties have reached an agreement, the likelihood of total success remains quite low significant differences in capacity. On the other hand, simultaneous attacks across all domains need a sizable force structure. Because of this, the ultimate answer is typically a choice of a mix of domains that are intended to accomplish the goal. Battle space transparency and appropriately competent force formations are prerequisites for high certainty of the effectiveness of offensive operations. If this strategy is carried out effectively, the enemy's capacity for offensive fighting may be diminished. The main goal of active defensive operations is to reduce losses if the opponent employs offensive combat aviation assets [1]. The foundation of this tactic is the construction of several protective shields.

Typically, combat aircraft in concert with different sensors and command structures fly the outermost ring tools to stop the approaching attack before the weapon releases. Defense planes always have more radar coverage thanks to their ground-based radars as well as aerial assets. However, the invader still has the initiative when it comes to the attack's planning, force composition, intended target, method, and timing. The defender must be prepared to repel the onslaught around-the-clock with sufficient strength looking up the aircraft, aircrew, operations, and maintenance team consumes a lot of resources. Surface-to-Air Guided Weapons make up the centre ring of the defensive strategy.

Surface-to-Air Guided Weapons make up the centre ring of the defensive strategy (SAGW). Typically, it is a cost-efficient choice, but it has restrictions in terms of the scope. The middle ring's perimeter has been widened by new systems like S400, which has a 400 km range. This frees up combat aircraft from specific anti-aircraft responsibilities. Close-In Weapon Systems (CIWS), which can be a combination of fast-response surface-to-air missiles and antiaircraft guns, are the innermost ring of defensive operations. Having a strong multi-layered defensive system raises the cost of operations for the attacker even if no defensive structure is invulnerable.

A quantitative and qualitative evaluation of all an organization's fighting components is required to determine its combat potential. This feature of combat aircraft is covered in this section. Comparing quantitatively is straightforward and can be done using "Bean Counting," but only if the platforms are equivalent in terms of quality with contributions and assertions from producers, operators, and technocrats, the relative importance of combat platforms is a constant topic of discussion among practitioners and theoreticians. The issue, however, can only be resolved if the platforms are pitted against one another. Only if the platforms operate in similar operating contexts would the outcomes of such a contest be valid it is not feasible. So, the argument continues. Some pertinent criteria are mentioned here for evaluating such a dispute to put into perspective a combat aircraft's capacity for battle [2].

Platform Performance:

Any conversation on combat aviation always starts and ends with combat aircraft. A combat aircraft must first be conceived before being translated into a physical design. Although each

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platform's combat effectiveness has been the focus, the aviation industry has also placed a high priority on the platform's safety. Combat effectiveness is only useful if the platform endures. The guiding idea is "Safety, Security, and Strike." Before evaluating a fighting platform, the fundamental fundamentals of safety and dependability must be shown beyond a reasonable doubt. When an aircraft was first being developed or put into service, these standards were frequently not reached. The platform must be secure to use, with suitable and dependable systems and enough redundancies [3].

The platform must have sufficient redundant systems that are competent and dependable for basic flight to be safe to operate. This addresses the design definition's "Safety" component. After that, comes the next test will determine whether the aircraft can function in the anticipated operating environment and whether it has systems that can detect and eliminate threats. This is the element of "Security." Last but not least, the "Strike" - the aircraft ought to be able to deliver the armaments on the selected target, whether it is airborne or on the surface, mobile or static, or covered in camouflage. While the potential to strike is quite evident, the distinction between security and safety elements is becoming less clear.

As a result, several automated technologies are also being created to improve operational safety and security. An extension of the Automatic Ground Collision is featured in the most recent series. A fully functional combat autopilot is made possible by the Avoidance System (Auto GCAS). A fighter aircraft's sensors and information about the terrain are used by Auto GCAS to determine the likelihood of a ground collision. The algorithm then determines the optimum approach to return the aircraft to a safe trajectory using the trajectory, speed, and absence of pilot input. It takes charge of the aircraft's flying controls automatically and steers it away from danger. A controlled flight into terrain (CFIT) due to insufficient fuel or goal fixation, gravity-induced loss of consciousness, or pilot confusion are all common causes of ground collision.

After early operations, experience has shown a variety of design, hardware, or software flaws that must be changed to increase the degree of dependability and safety to pass the initial evaluation step. The platform is then evaluated based on its capacity to launch and land with the intended armament and fuel load. The take-off roll provides information on the airframe and engine performance at low speeds. 10 Operations from short airfields benefit from low landing speeds and resulting low landing rolls. Platforms that have the potential for vertical takeoff and/or landing have lessened the reliance on the availability of large runways. Other important features have to do with how long it takes an aircraft to take off when the pilot boards it [4].

To determine the best combat aircraft configuration for a given mission, several techniques have been investigated, including take-off, ascent, cruise, targeting, and return phase. The fundamental definition of maximum weight, wing loading, and the thrust-to-weight ratio are calculated during the conceptual design process itself based on the mission profile and objectives. However, a combat aircraft's design and use for actual missions are severely constrained by the outcomes of such crude methodologies. The designing procedure doesn't start until a feasibility study has been completed. It integrates design ideas that explore numerous configurations and amalgamates them with already existing and emerging technology. A Project Definition that comprises a Group's Business, Design and Development, Approval of Type Record, and Transitions from Development is then presented.

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CHAPTER - 12

PLATFORM PERFORMANCE

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Any conversation on combat aviation always starts and ends with combat aircraft. A combat aircraft must first be conceived before being translated into a physical design. Despite although each platform's combat effectiveness has been the focus, the aviation industry has also placed a high priority on the platform's safety. Combat effectiveness is only useful if the platform endures. The guiding idea is "Safety, Security, and Strike." Before evaluating a fighting platform, the fundamental fundamentals of safety and dependability must be shown beyond a reasonable doubt. When an aircraft was first being developed or put into service, these standards were frequently not reached. The platform must be secure to use, with suitable and dependable systems and enough redundancies [1].

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Platform Signature:

Each fighter plane has a unique electromagnetic, optical, thermal, and radar signature. The shape, size, colour palette, and exhaust gas emission trail of the aircraft all contribute to its visual identity. This aspect is especially important in battle as the aircraft is first identified visually before being targeted. The visual signature is crucial for engagement by surface-based weapon systems that use electro-optical or visual sighting systems, as well as in aerial warfare. This category includes a variety of anti-aircraft weapons and man-portable missile systems. An aircraft's skin and engines provide the heat signature of a combat aircraft. Although the heat produced by the aircraft's engines is more pronounced at the back of the plane, the heat is produced.

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An aircraft's skin and engines provide the heat signature of a combat aircraft. Although the heat from the engines is more noticeable towards the back hemisphere of an aircraft, the heat produced by its skin as a result of operating at high speed may be seen very uniformly from all angles. The homing heads of missile systems are designed to take advantage of the fact that these two separate heat signatures occur at different frequencies. The likelihood of being struck by a heat-seeking weapon is decreased the lower the platform's infrared signature. A combat platform's Radar Cross-Section (RCS), as seen by a radar electromagnetic wave, serves as its radar signature. One of the main radar-related factors is the RCS.

Among the several radar characteristics that determine the range at which an aircraft may be detected, the RCS is a crucial one. The form and layout of some techniques to reduce the RCS include using radar-absorbing material and radar-absorbing paint. An aircraft's electromagnetic signature is produced as a result of electromagnetic waves that are produced within the aircraft as a result of the functioning of various onboard systems. Radars, radios, and radio altimeters are the most noticeable of these EM transmitters. If analyzed properly, they can reveal both the existence and the kind of aircraft. Additionally, a combat aircraft's aural signature may be mapped, but with longer-range armaments for both offence and defence [3].

However, a combat aircraft's auditory signature is still used in regions that are not monitored by sensing devices like radars to identify the presence of a battle plane. This technique is frequently utilized in hilly terrain when warplanes flying in the valleys or the shadows of hills try to avoid being detected by radars. This feature has to do with the kinetic weaponry that combat aircraft may transport and fire. The primary criteria for evaluating and contrasting fighting systems in this regard relate to the quantity and kind of efficiency with which portable weapons can be discharged at their intended targets. Both air-to-air and air-to-surface weapons are included in this. A combat aircraft's combat effectiveness is greatly influenced by the range at which it can fire its armament at a target. Although different platforms might fire identical or similar weapons, the platform needs to offer a proper interface and make targeting simple with an internal system like a radar or other sensor.

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The person who uses the machine, not the equipment itself, determines the output. The degree of a pilot's comfort in the cockpit has a significant bearing on the result of combat aviation employed on a platform. The pilot's ability to see beyond the cockpit is greatly influenced by the size and form of the space, particularly how the cockpit's canopy affects the location of the test eye. The role of the control column, the throttle and stick controls, the flow of information on cockpit displays, and the availability of data on helmet-mounted sights can all have a significant impact on the outcome of a battle where the difference between success and failure can be measured in milliseconds.

Rarely do the combat planes work together as a single unit. To improve situational awareness, a combat aviator communicates with other fighting platforms and support systems. The techniques for voice and data are the two forms of communication. However, numerous inputs may be reliably transmitted to a fighting platform via data lines, but verbal inputs heavily rely on operators and their shared understanding. This might relate to the whereabouts of allies and enemies in the area or the whereabouts and movements of possible targets. The output of different onboard sensors can also be sent through data connections to other fighter planes or ground stations. Data linkages, a platform environmental interface, operate as a force multiplier due to accuracy, quantity, and speed of information transfer.

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CHAPTER - 13

TECHNOLOGICAL INNOVATIONS IN COMBAT AVIATION

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Material and Structure:

Weight, strength, and ease of maintenance were the three basic important factors for the selection of material for the manufacture of aircraft at the beginning of military aviation. Easy access to materials and other elements that influenced the development of aircraft designs and material selection were pricing, machining, and binding. Along with the development of materials and designs for combat aircraft, manufacturing techniques also advanced. The base aircraft design was a biplane, and the wooden frame's structure was reinforced with wire reinforcing and covered in fabric skin before enough knowledge of aerodynamics was available. Wire bracing, such as that used in the Fokker Dr1 triplane in 1918, was removed by cantilevered wings with larger airfoils and stronger box spars. Costs were also raised by the development of anybody fuselages with reduced weight and improved drag performance [1].

Costs were also raised by the advent of anybody fuselages with reduced weight and improved drag performance. Semi-monologue was a test subject for the German Albatross construction. Massive amounts of wood skin panels adhered to interior bulkheads and longitudinal lingering by the middle of the 20th century, metal had taken the role of wood, and stressed skin had taken the place of quasi. Early aircraft manufacturing relied heavily on metals; subsequently, new materials like titanium and composite materials were added to non-bearing components. Modern technology has greatly increased the use of sophisticated materials in combat aircraft, an area that is extremely sensitive to weight. In both civil and military applications, composites, titanium, and other sophisticated materials are becoming more significant.

The body, wings, and tail of the F-22, a 5th aircraft in use by the USAF, are made of composite materials. Composite materials and titanium alloy make the most of it. As they moved closer to creating an all-composite aircraft, manufacturers gradually relaxed the constraints on the initial material use. There haven't been any significant structural alterations since then, except the introduction of new materials in the shape of different composites and alloys.

A lot of new technologies, materials, and production techniques have led to tremendous advancements in aircraft performance. New technologies are developing concurrently. The complexity of aircraft construction and the requirement for accuracy. The number of combat aircraft needed to complete a mission decreases as platform capability per platform improves, increasing the combat potential of each combat aircraft. This is accompanied by rising development and production expenses as a result of the sophisticated technical and material requirements for operational relevance. Overall, when it comes to combat aircraft, governments are leaning toward high quality and a small number [2].

In the first twenty-four months of the previous century, the development of aircraft capabilities and their integration as essential military tools were the main priorities. True to Douhet's9 main principles ideas said that a battle in the air was a logical evolution and urged for dominance in the air with a bigger profusion of aviation assets. The most important capability throughout the first 50 years of combat aircraft in the military was speed. Due to the cannon's aft positioning guns pointed backwards and inadequate electronic surveillance, it was necessary to move

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quickly to fire an intruder. Although the structural layout of combat aircraft was altered to enable faster speeds, the aircraft engines were what made this capability possible. There was a significant transition from pistons to jets.

There was a significant shift in military aviation from piston to jet engines. Additionally, engine technology has constantly improved to produce better SFC, or specific fuel consumption improves battle range. The MiG-21's brutal engine power and svelte design gave it an unmatched advantage in combat effectiveness in the 1960s. The MiG-21's design caused a stir and quickly propelled it to the top spot among combat aircraft, where its fleet quickly grew. Understanding relaxed stability and being able to manage it was a turning point in structural design for combat aircraft, and by utilizing this newfound knowledge, the famous red line of aerodynamic stability was broken to obtain better agility. This compelled the change of the primary characteristic of combat aircraft from speed to agility.

In this field, the F-16 from Lockheed Martin stole the show and dominated the combat aircraft market. After then, sensor technology saw fast growth and was used in warfare aircraft. The onboard sensors of the F-15, F-18, and Su30 enabled each platform to be a full-fledged combat system with a range of capabilities and the capacity to rule huge stretches of airspace. Up to the arrival of the next disruptor, sensor fusion was the dominant trend in combat aircraft. This modification was compelled by the extended ranges and high-fidelity electronic sensors that were developed. A high level of tactical transparency was made possible by sensors that were placed on the ground or their miniature variants that were mounted on aerial platforms, including combat aircraft [3].

Now the competition was to out-detect an opponent rather than out-run or out-manoeuvre them in the air. Aircraft were valued by armament systems beyond visual range (BVR). The most important characteristic is low observability. Its creation and introduction had begun in the final fourth of the previous century. Aircraft speed and agility were severely sacrificed in the initial design for minimal observability. The operating environment of today and 2050 is anticipated to continue to demand low observability (LO), particularly low radar cross section (RCS). By then, it's anticipated that the operational environment would change once more.

The designed and operationalized aircraft combine modern technology with all the technical features of the preceding generation of combat aircraft. Technology advancement and its integration are not properly earmarked for combat aircraft. It often happens in minor steps, making it challenging to historically identify every generation of any combat aircraft. It typically takes drawings to develop a combat aircraft; replacing all of them to create a new platform is time-consuming and ineffective, especially if certain components reflect the best-case scenario. Practitioners sometimes use terminology like "3.5 Generation" to describe the platform, which combines certain characteristics of fourth-generation aircraft with all the abilities of the third generation to reconcile this paradox [4]. Sometimes, a sacrifice is made to improve another trait.

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