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Aeronautics & Astronautics

Highlights

- Model-Based Analysis
- Study of Possible Explosion
- Critical Validation Algorithm
- Optimization of Monopropellant

Discovering Thoughts, Inventing Future

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Model-Based Analysis of Safety Critical Validation Algorithm

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Abstract- Safe operation of a critical embedded system requires reliable information about the state of the system and signal condition of the system. Validity of sensors which measure the process variables are of great importance. Signal validation comprises of detection, isolation and characterization of faulty signals. Signals that are validated are critical for their increased availability in the system. Model-Based Engineering (MBE) approach provides means of modeling, analyzing, and validating the signals for critical embedded system design, and development. The abstract nature of the models provides mechanisms to analyze verify and validate the system functionality, at a much early stage in their development process.

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Abstract- Safe operation of a critical embedded system requires reliable information about the state of the system and signal condition of the system. Validity of sensors which measure the process variables are of great importance. Signal validation comprises of detection, isolation and characterization of faulty signals. Signals that are validated are critical for their increased availability in the system. Model-Based Engineering (MBE) approach provides means of modeling, analyzing, and validating the signals for critical embedded system design, and development. The abstract nature of the models provides mechanisms to analyze verify and validate the system functionality, at a much early stage in their development process.

In this paper we present MBE approach to analyze the input signal processing algorithm with the case study of analog signal for Stall Warning System (SWS) of an aircraft using NI LabVIEW. The approach helps in analysing the functionality and completeness of the algorithm, mathematically and by simulation. The validation of analog signals with different frequencies and amplitude establishes data prudency and maintains the integrity of avionics systems. The result of this approach highlights the advantage of using MBE which enables in analysing the data algorithm for its correctness and guarantees the properties of the model early in the development life-cycle. MBE approach also helps in re-assuring the integrity of the system, before it is developed. This also terminates the contiguous data set and annunciates the sensor fault conditions.

Keywords: analog input processing, stall warning system (SWS), model-based engineering (MBE), safety- critical system, NI LABVIEW.

I. Introduction

Validity of the data input-output of Safety-Critical Systems such as avionics systems, medical instruments, and nuclear systems is critical and needs to be analyzed for its functionality, performance, and safety. Complex avionics systems encompassing multiple critical sensor data associated with the plurality of sensors that needs to be validated for the correct data and also detect fault condition of the sensor. Productivity challenges are on the rise with the increase in the complexity of the software involved in Safety-Critical Systems. Such systems are considered to be least intolerant with safety of the overall functionality of the system, as well as dependency and reliability of the system. Model-Based Engineering (MBE) approaches provide the means of creating and analyzing the models of the Safety-Critical System. These approaches accomplish the task of providing prediction and analyses capabilities of various operational qualitative attributes like performance, productivity, reliability and security. In the development life-cycle, with the application of Model-Based Engineering (MBE) approaches, the system-level problems, are detected at an early stage during their development process which are usually discovered during the system integration and acceptance test, using the conventional approaches. This avoids in rework during the later stages of their development and also minimizes the maintenance cost. The paradigm of developing the application software for Safety-Critical Systems are shifting with the introduction of Model-Based Engineering approaches. The graphical representation of the Safety-Critical System control algorithm application software, using MBE, serves the primary purpose of representation of the application software as a re-usable executable model. This can be re-used at any stage during their development process in the entire life-cycle. This executable model analyzes the predicted system properties and validates them against the system implementation, considering the evaluation of various quality assurances attributes in the course of analyses.

Models representing a Safety-Critical System integument of data-flow, topology and the behavioral aspects of the application software, are created using a suitable modeling language. This modeling language is regarded as formal representation of the application software being developed with precise perception of the actual implementation of the control logic. This ultimately forms the basis for conformance testing against the system requirements.

Modeling language used in creating the models serves as a multi-purpose graphical representation encompassing all the aspects of the Safety-Critical System application software as an abstract. Laboratory Virtual Instrument Engineering Workbench (LabVIEW), a system design and development environment from National Instruments, in conjunction with the Visual Programming Language (VPL) [1] provides the means of creating the Safety-Critical System models. LabVIEW basically makes use of VPL, wherein the application software is created by manipulating the software components graphically as symbols along with the

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textual notations. LabVIEW makes use of "G" language – a graphical language used for systems design and simulation.

Using LabVIEW the Safety-Critical System application software model is created precisely in coherence with the system requirements, describing all the aspects of the system. This MBE approach with LabVIEW renders the model to define the domain oriented abstractions that define the system components, states, transitions between the states. The validation of such clutter less models to cover different levels of formalities like model checking [3], prototyping and simulation [2]. By combining the effectiveness of the domain specific abstract models and its implementations with prototyping and simulation the application software model is validated for its functionality.

The paper is organized as follows: section II, provides an insight into the related works carried out with MBE. With section III, we introduce to the characteristic features of analog input signal data in Stall Warning System (SWS) and the need for validation. Afterwards, section IV focuses on the analog input processing algorithm and the implementation of the algorithm for different analog signals of SWS, using LabVIEW. Section V sketch the results and summarize the overall validation process. Section VI concludes the work discussed in the context and comment on future work to be done with this reference.

II. Literature Survey

The need to validate the health of the input data signals which are interfaced with certain critical decision making systems is very much essential, in aerospace applications and avionics systems. This helps in the differentiation of the signals as faulty and healthy. The process of differentiating the signals as two different categories, are handled by efficient algorithms developed and implemented. Manju Nanda et al. [4] had proposed a contemporary validation algorithm in validating the signals and thus helping the underlying systems in making appropriate critical decisions. Also the need to verify the correctness of the abstracts of the models of a system under test, corresponding to Model-Checking and Model-Based Testing was proposed by Stefan Gulan et.al.[7]. The early introduction of these approaches for safety mechanisms relevant to the safety of the software was evaluated with an industrial case study sufficiently to address the relevant failures in the systems and its software components.

The exponential growth in the discovery of the system-level faults at the development stage in SDLC process has adverse turn-around effects, such as increase in the cost of development and the rigorous changes that may be subjected to the system and its underlying software components. This can be overcome with the use of Model-Based Analysis and Validation approaches as suggested by Peter H Feiler [8]. With MBE a single source approach is provided to the developer to analyze the system for its operational attributes as well as the system qualitative attributes. This is more reliable through model annotations. Also Bringmann et.al. [9] has proposed with the help of an industrial case study that the quality assurance with the model-based developments with the introduction of graphically testable models representing the software components of the system under test enables the user to understand the architecture of the algorithm of the software. It was also suggested that it helps in expressing complex, fully automated closed-loop test scenarios in real-time. Using MBE approaches for modeling the software component of a system, it is like performing the actual implementation of the algorithm or the software component and defining their relationship between each other. This was proposed by Andree Blotz et.al [10]. The models are created using different languages and are regarded as the formal representation of their functionalities. With all these findings the complex processing algorithm of SWS/AIC i.e. the Analog Input Processing algorithm is modeled using NI LabVIEW. Its operations, capabilities in validating the input data from various aircraft interfaced sensors are discussed in this paper.

III. Analog Input Signal Data of SWS

The digital computer based Stall Warning System (SWS)/ Aircraft Interface Computer (AIC) [5], a state-of-art designed around a customized APM2000 module by SAGEM. The module consists of two processing units Motorola MC68060 along with the co-processor units MC68360, designed as per DO-178B standards [6]. The system consists of input interfaces to different signals of types ARINC429, Discrete and Analogous and processes them accordingly. The SWS systems also provide a stall warning by activating the shaker actuator of the aircraft and indicating them suitably through LED, on the Caution Warning Panel (CWP).

The analog signals read by APM2000 kernel when invoked by the application software and the inputs that are acquired are converted into digital signals for processing by the processor units using a 12-bit Analog-Digital Converter (ADC). The acquired values are made available to the Analog Input Processing algorithm application software in a specified memory location for further processing by the kernel. Any fault or error during the acquisition is examined and returned after the validation by the Analog Input Processing algorithm application software.

a) *Angle of Attack (AOA) Sensors Interface*

The Angle-Of-Attack (AOA) is the physical angle measured between the chord of the aircraft wing and the relative wind direction. There are basically two AOA vane sensors that act as potentiometers. Both the left and right potentiometer sensors are excited by 11.3V DC power supply. As an analog input for the system, the physical range is from -10° to +40°. The DC analog signal ranges from 0V corresponding to -10°, while 11.3V corresponds to +40°. The value of the sensor reading is stored in the memory and used to estimate the AOA value during validation.

b) Fuel Remianing Input Interface

The SWS/AIC have the interface to the fuel system to get the fuel remaining in the fuel tank of the aircraft. This input from the interface is obtained as an analog input from the fuel tank capacitor probes provided for both the left and right channels in the aircraft. The physical analog range of the fuel remaining varies from 0V DC corresponding to 0kg, to 5V DC corresponding to 1000kg. But there is a constraint of minimum fuel remaining to be 12.5kg. The fuel value corresponding to the amount of fuel present during the take-off is stored in the memory location. This value is used for the weight estimation during the validation.

c) Torque Pressure Transducer Sensor Input Interface

The torque pressure transmitter is connected to the torque meter in the cockpit. The SWS/AIC system shall have an interface with the torque pressure transducer and reads the engine torque as an analog input. The transducers are present on both left and right channels of the aircraft. The engine torque input ranges from 0 to 5V DC, corresponding to 0 to 44.34psig equal to 3.684V. Here the torque value being greater than or equal to 16.85psig (38% or 1.3999V) indicates that the aircraft is ready for take-off.

For the landing condition the torque value shall be less than or equal to 20% (8.868psig or 0.736V) on both the left and right engines. Even if there happens to be a value of 50% torque on one engine (22.17psig or 1.824V) if the other engine is in-operative with a torque value less than 10% (4.434psig or 0.368V).

d) Pitch Trim Position Sensor Input Interface

The SWS/AIC have the interface with the pitch trim potentiometer to get the position of the pitch trim tab as an analog signal from the potentiometer. The pitch trim position sensors are physically combined as a single channel from both the right and left channels. The pitch trim sensor is excited with a voltage value of 11.3V. The analog input signal acquired from the pitch trim position sensor varies from -15o to +8o. This input is used to limit the electrical travel of the actuator. An input voltage value of 11.08V is read when the excitation voltage of 11.3V is provided across the potentiometer with a bias of 5.54V. The error tolerance is defined to be +/- 0.065V.

e) Hydraulic Pressure Sensor Input Interface

The SWS AIC have been interfaced with the hydraulic pressure sensors to get the value of the hydraulic pressure as analog input. The input range varies from 0-4000psi, corresponding to 0.25V to 5.25V DC.

IV. Implementation of Analog Input Processing Algorithm

The continuously time varying signals from a plurality of aircraft interfaces like AOA sensors, Fuel Tank sensors, Pitch Trim sensors, Hydraulic Pressure sensors are obtained and are independent of each other. These signals obtained from various sensors, which are either simplex (from a single source) or duplex (from dual sources) needs to be validated and compared to measure the quality of the signal/data received and indicate it via a validity flag.

The rate of change of the signal from the physical system is matched to a sampling rate of 25millisecond. This is the same time duration for which the algorithm is designed to read the signal/data recorded by the sensor. During the continuous acquisition of signal/data from the sensor, for a persistence time of 250millisecond, implying that 3 samples are considered in an averaging window, the rate at which the acquired signal/data changes is constantly monitored. This rate of change is compared with a pre-defined threshold value. The recently acquired signals are compared with the previous samples of signal/data and monitored for their values, which may be well within the specified tolerance value. Based on the comparator output the signal/data is termed as healthy or unhealthy, by monitoring it over the period of persistence time. The process of analyzing the analog input signals is as shown below in Figure 1. The basis for this algorithm is that, any signal acquired from any of the aircraft sensors is to be declared as valid or invalid, based on the fixed sample approach. The acquired signal is declared valid or invalid, over a persistence time of 250ms, based on the comparison with their difference between the current valued signal/data that has been acquired with the previously acquired signal (if nothing then to be considered as zero), termed as Difference |B| and the difference between the last previous valued signal/data to that of the previously acquired signal/data as Difference |A|. The magnitudes of both the differences are then compared with the priori specified tolerance band (default +/- 2% of the nominal value – full range value). This range check is carried out for all the acquired input signals/data and the engineering value conversion is done for the analog inputs.

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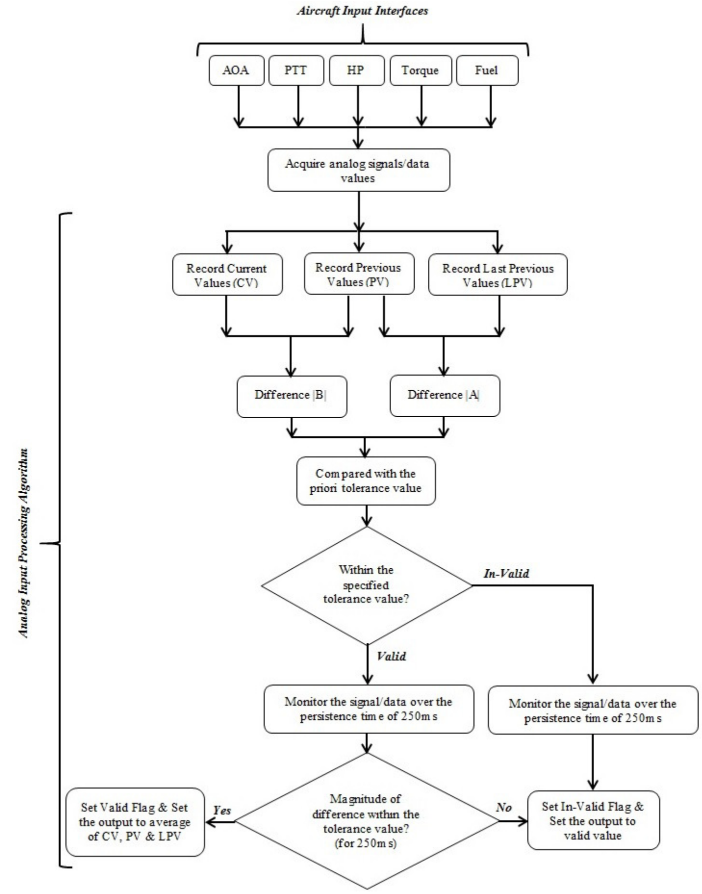

Figure 1: Control Flow of the Analog Input Processing Algorithm

In case the acquired analog input signal is out of bounds of the specified tolerance band, then the output value is clamped to the minimum value if the acquired signal value is less than the minimum value. It is clamped to maximum, if the acquired signal value is more than maximum range specified. This is done along with the storage of the association of the suitable flag status, set either as Valid or Invalid. The purpose of the acquired signal is only for the validity or the invalidity check. For all the analog inputs that are acquired from the sensors, if the signal/data is invalid then the invalid flag is set to TRUE and the output data is latched to a particular valid data that was acquired currently, previously or past the previous acquisition. In case of valid signal/data, the valid flag is set TRUE and the average value of the current, previous and the value past the previously acquired signal/data is latched as the output data. This analog input processing algorithm was developed using Model-Based Engineering (MBE) approach, using LabVIEW from National Instruments. This approach helps in defining the processing control algorithm software components as models that can be re-used and provides more efficiency and robustness as compared with other conventional approaches.

A. *Translation of the Analog Input Processing Algorithm to Model*

1) *Functional Translation*

The LabVIEW tool suite is used in modeling the analog input processing algorithm application software. The models that are designed in the LabVIEW development environment will be termed as Virtual Instruments (VI), as the models virtual represents the physical implementations of the system being designed and developed. This tool suite provides the option of categorically and hierarchically modeling features, with the option of defining the subsystem modules/components as Subsystem Virtual Instruments (Sub VI) and can be re-used as library components. This feature is used in the implementation of the Analog Validation Loop and the Data Sorting Loop. The hierarchical categorization of the loops in the model block diagram shown in Figure 2 is as follows;

i. Data Sorting Loop – This loop sorts the acquired analog signal/data in the form of an array and the array is sorted into three different categories as Current Valued, Previous Valued and Last Previous Valued Array. The initial element values in the Previous and the Last Previous Valued Arrays will be considered as zero and later is shifted with the acquisition of the new signal/data values from the aircraft interface sensors.

ii. Analog Validation Loop – This loop categorizes the analog signal/data value as a valid or an invalid signal/data by taking the difference of their magnitudes and comparing it with the priori specified tolerance value. If invalidity persists, the Invalidity Counter is incremented till the persistence time (i.e. for 250ms) as 10 counts, with each sampled signal/data value for 25ms. Upon reaching the counter value of 10 with invalidity, the Invalid flag is set TRUE and the output value is latched to the valid data value among Current Valued, Previous Valued and Last Previous Valued Array.

iii. Validity/Invalidity Declaration Loop – This loop monitors the validity/invalidity based on their magnitude differences between the Current Valued, Previous Valued and Last Previous Valued Array and comparing the difference value with the tolerance value for the full scale range. The valid/invalid flag is set TRUE conditionally based on the compared output value.

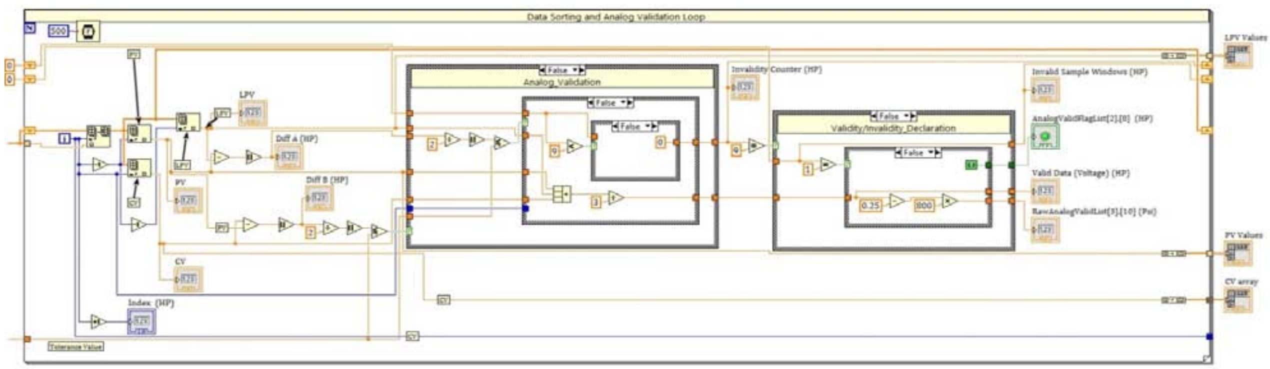

Figure 2: Analog Input Processing and Data Sorting Model (Block Diagram)

The Current Valued, Previous Valued and Last Previous Valued Array are displayed on the Front Panel in LabVIEW, as shown in Figure 3. The LabVIEW tool suite has an inherent feature of providing two sets of windows for the VI. The Front Panel layout representing the UI or the outer layer of the system that is visible with suitable controls and indicators, while the Block Diagram layout which represents the actual layout wherein the system implementation is designed and developed using various available library components as Sub VI. Each Sub VI being categorized based on their applications, functionality and characteristics (Hardware or a Software component), stored as library components that can be re-used.

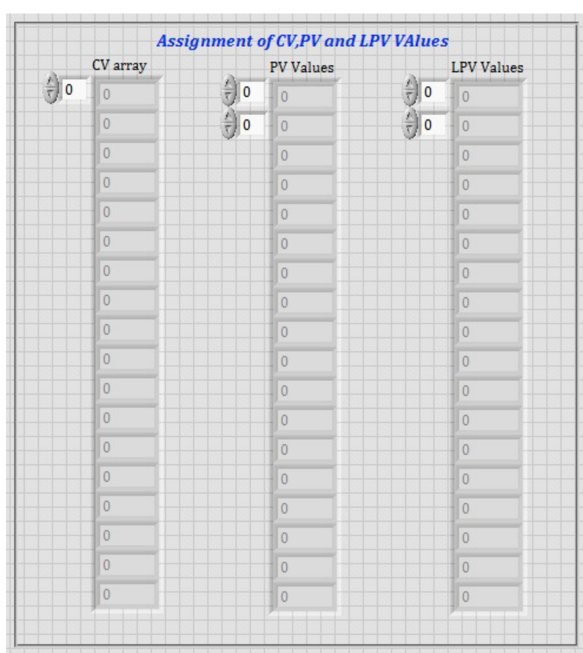

Figure 3: Acquired Analog Data Sorting as Current Valued Array, Previous Valued Array & Last Previous Valued Array (Front Panel)

2) Performance Translation

a) Hydraulic Pressure Sensor Input Interface

The actual system implementation for Hydraulic Pressure Sensor Input Interface is designed as shown in Figure 4. In case of the Hydraulic Pressure Sensor input being invalid the output data is computed based on the lower and upper limits as explained in III.E, and latched to the previous/current/last previous valid data. The valid flag is set to FALSE and there is no computation warning being generated for the Hydraulic Pressure by the SWS/AIC. The block diagram implemented is as per the specifications for its analog input signal/data scaled to its equivalent digital voltage valued array. The range is also validated for Hydraulic Pressure Sensor Input as shown in Figure 4.

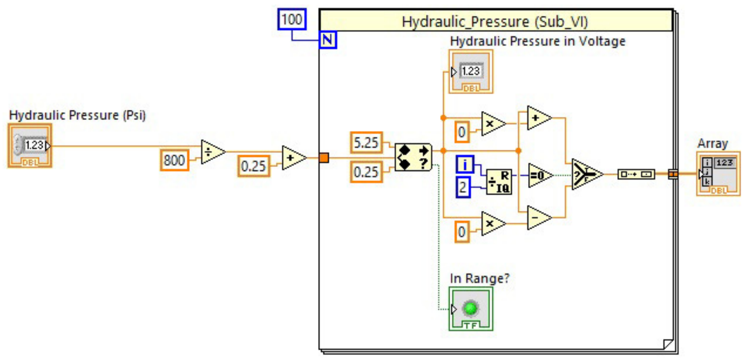

Figure 4: Hydraulic Pressure Sensor Input Interface Block Diagram as Sub VI (Virtual Instrument)

The array is fed as input into the error injection loop, as shown in Figure 5. This loop is present in all the analog input interface modules. This loop allows the user to define the error value i.e. the user has the liberty to set any error value. The tolerance is to be adjusted to the full scale range of the analog input interface and the array is resized to the actual input array size in this loop. Here in this loop, the privilege of inserting the error value into a particular index of the array is also provided. The error injection is controlled using the LabVIEW control switch termed as Error ON/OFF. This helps in inserting the error value in the index of the array during the simulation, dynamically. This is simulated and as well being considered for computation of the warning suitably from the index/time of its insertion into the array. An error valued data is inserted for a time factor of 25ms, every time in the array. This array of input with or without the error is fed into the Analog Validation and Data Sorting loop for the data to be sorted and validated as per the specified limits.

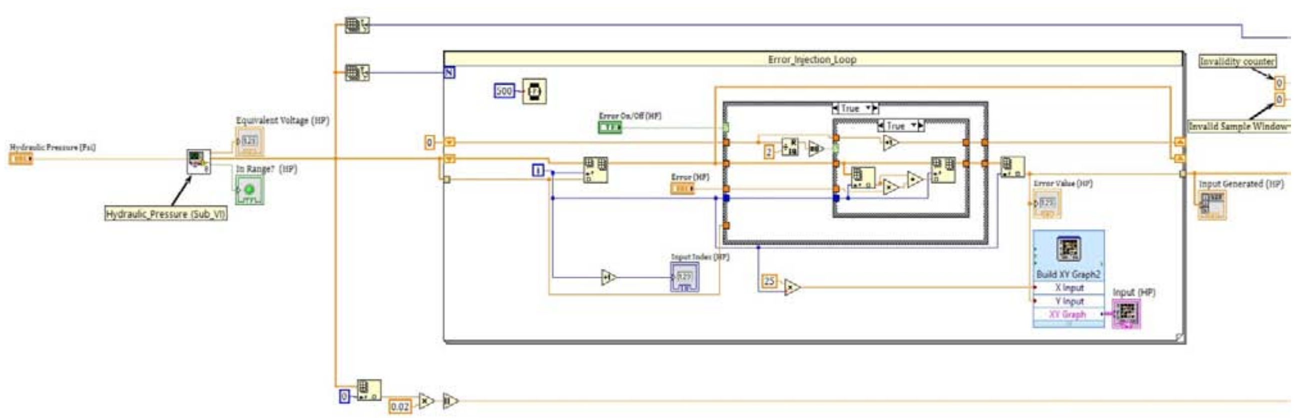

Figure 5: Hydraulic Pressure Sensor Input Interface Error Injection Block Diagram

b) Fuel Remaining Input Interface

The Fuel Remaining Input Interface system implementation is done as shown in Figure 6. There are two fuel tanks present in an aircraft. One in the right wing, which corresponds to the right channel while the other in the left wing corresponding to the left channel. During the Analog Validation, in case the right fuel tank input on the right channel is invalid then the output data is computed and latched to the previous/current/last previous valid data. This means that the Analog Input Processing algorithm shall use the average value of the last correct/valid weight estimate and the aircraft with no fuel remaining.

The same case applies with the left fuel tank input on the left channel being invalid, the output data is computed and latched to the previous/current/last previous valid data. And the SWS/AIC Analog Input Processing algorithm uses the average value of the last correct/valid weight estimate and the aircraft with no fuel remaining from the left channel. In both these cases, the valid flag is set to FALSE. If the data from either or both the channels are valid then the average value of all the three data sets, i.e. previous valued, current valued and the last previous valued data from the array is computed and the output data is set to the average value. The valid flag is set to TRUE. The process of error injection is repeated for this Sub VI also and the array data corresponding to Fuel Remaining is also sorted and validated using the Analog Input Processing and Data Sorting Sub VI loop, as shown in Figure 5.

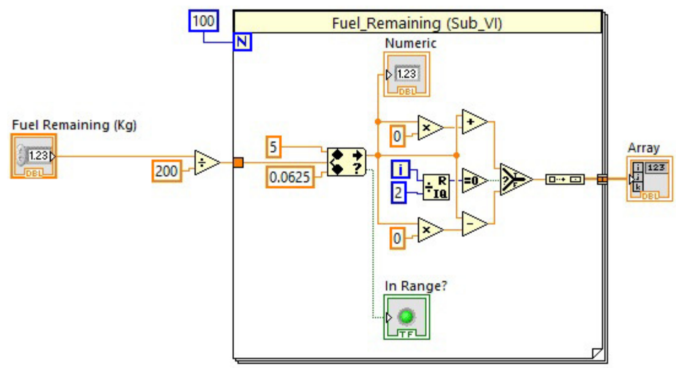

Figure 6: Fuel Remaining Input Interface Block Diagram as Sub VI

c) Angle-Of-Attack Sensors Interface

The model implementation with the given specifications in III.A, for Angle-Of-Attack Sensor Interface is as shown below in Figure 7. There are two channels, (Left & Right Wings) with AOA sensors. The range of the value sensed by the AOA sensor is being validated and the array of inputs is built. The input array is fed into the Analog Input Processing and Data Sorting algorithm Sub VI loop for validation and data sorting, respectively.

In case, the left AOA sensor sensed data is invalid then the AOA value shall be computed for the output data and latched to the previous/current/last previous valid data. Similarly in case of the right AOA sensor sensing an invalid data set, then the AOA value shall be computed for the output data and latched to the previous/current/last previous valid data. In both the cases the valid flag is set to FALSE. For the AOA sensors, as is special case, the mounting error for the left channel AOA with respect to the right channel AOA sensor with a zero bias value of 2.3634V is used in the application software, shown in Figure 7, during the data set being valid. Also the dead band of 0.724V and 0.364V shall be used for left AOA and right AOA engineering value conversions. Different fixed error value considerations are being made to distinguish and compute left channel AOA with the right channel AOA, as 1.389o and 0o respectively. A suitable method such as Ratiometric method is used to compute the AOA values for better accuracy.

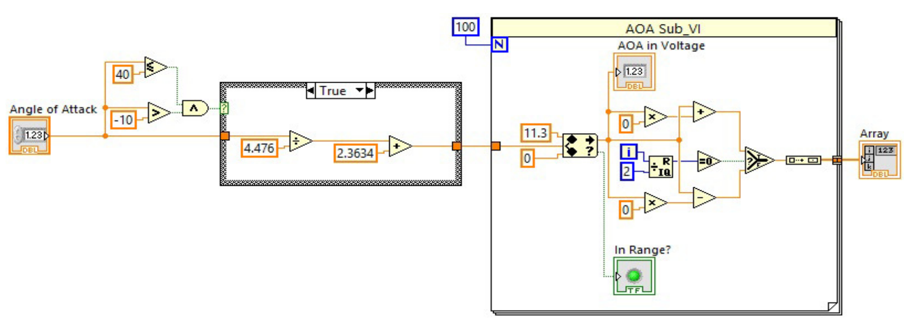

Figure 7: Angle-Of-Attack Sensors Input Interface Block Diagram as Sub VI

d) Pitch Trim Position Sensor Input Interface

The implementation of the Pitch Trim Position Sensor Input Interface model with reference to the given specifications in III.D, is as shown in Figure 8. The range of the value sensed by the Pitch Trim Position sensor is being validated and the array of inputs is built. Both the left and the right channel sensors are combined as an individual channel component for computation of analog data, fed to the Analog Input Processing and Data Sorting Sub VI loop.

In case the pitch trim position input is invalid then the data set is computed for the output data and latched to the previous/current/last previous valid data. The valid flag is set to FALSE and a suitable warning shall be generated for the same. In this case of pitch trim sensor invalid data, the pilot switched over to the manual mode from the automated mode. In case if the data is valid, then the valid flag is set to TRUE and the output data is computed based on the average of current, previous and last previous valued data from the array, and latched to it.

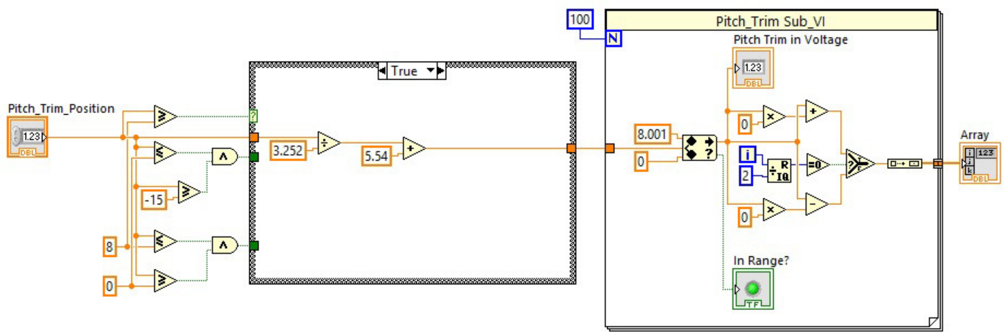

Figure 8: Pitch Trim Position Sensor Input Interface Block Diagram as Sub VI

e) Torque Pressure Transducer Sensor Input Interface

The implementation of the Torque Pressure Transducer Sensor Input Interface model with reference to the given specifications in III.D, is as shown in Figure 9. The range of the value sensed by the Torque Pressure Transducer sensor is being validated and the array of inputs is built. Both the left and the right channel sensors are combined as an individual channel component for computation of analog data, fed to the Analog Input Processing and Data Sorting Sub VI loop.

In case of left engine torque as sensed by the Torque Pressure Transducer sensor, is invalid, and then the output data is computed by the Analog Input Processing algorithm and is latched to the previous/current/last previous valid data. Similarly, in case of right engine torque sensed by the right channel as invalid, the output data is computed and is latched to the previous/current/last previous valid data. In both the cases the valid flag is set to FALSE, and the right/left engine torque is not considered for the takeoff warning computations by SWS/AIC. In case if the data is valid, then the valid flag is set to TRUE and the output data is computed based on the average of current, previous and last previous valued data from the array, and latched to it.

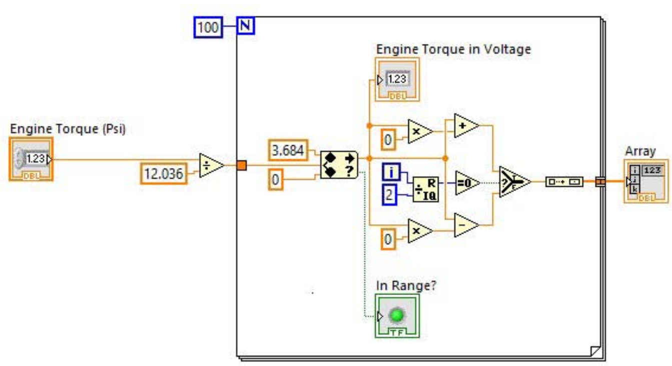

Figure 9: Torque Pressure Transducer Sensor Input Interface Block Diagram as Sub VI

V. Simulation and Analytical Results

The actual implementation of the Analog Input Processing application software is modeled using NI LabVIEW. The input data, is as per the values as given below in Table 1. The static Hardware-Software Integration (HSI) segregated test data is fed into the models respectively and is being kept in loop to create a semi dynamic nature of inputs to the system.

Table 1: Analog Inputs Data/ Test Conditions

Sl No	Signal Name	Physical Range	Scale Factor	Bias	Accuracy	Resolution	Refresh Rate
1.	RawAOALA	-10 to +40°	4.8216 deg/V	2.074V	±0.0152 V	0.0224 deg	once/ 25 ms cycle
2.	RawAOALB*	-10 to +40	4.8216 deg/V	2.074V	±0.0152 V	0.0224 deg	once/ 25 ms cycle
3.	RawAOARA	_10 to +40	4.8721 deg/V	2.0525V	±0.0152 V	0.0224 deg	once/ 25 ms cycle
4.	RawAOA RB*	-10 to +40	4.8721 deg/V	2.0525V	±0.0152 V	0.0224 deg	once/ 25 ms cycle
5.	Fuel Remaining left (LftFuelTank)	0-1000 kg for	200kg/V	-	±0.0152 V	1.016 kg	once/ 25 ms cycle
6.	Fuel Remaining right(RgtFuelTank)	0-1000 kg for	200kg/V	-	±0.0152 V	1.016 kg	once / 25 ms cycle
7.	Left Engine Torque (EngTorqueL)	0 – 44.34psig	12.035 psig/V	-	±0.0152 V	0.061 psig	once / 25ms cycle
8.	Right Engine Torque (EngTorqueR)	0 – 44.34psig	12.035 psig/V	-	±0.0152 V	0.061 psig	once / 25 ms cycle
9.	Pitch trim position (PtchTrimPos)	-15 to +8 deg.	5.3097^{0} V	5.54V	±0.0152 V	0.0269 deg	once / 25 ms cycle
10.	Hydraulic pressure (HydPress)	0- 4000 PSI	800 PSI / V	0.25 V	±0.0152 V	4.05 psi	once / 25 ms cycle

The inputs are being input to the Analog Input Processing application software algorithm with the help of their respective sensor interface Sub VIs. The input data is up to a maximum of 100 index values and the constant valid data is being fed into the sub-systems. A suitable error vale (in terms of %), computed on the full scale input range is inserted at suitable index in the input array. Their equivalent DC voltage values are recorded as array values/elements and this is done dynamically, i.e. during the simulation. The system is being simulated for a particular Hydraulic Pressure value as shown in Figure 10 or Fuel Remaining as shown in Figure 11or AOA as shown in Figure 12 or Pitch Trim position as shown in Figure 13 or Engine Torque as shown in Figure 14. The Error On/Off control, regulates the control of insertion of error value to the specified hydraulic pressure/pitch trim position/fuel remaining/AOA/engine torque pressure value.

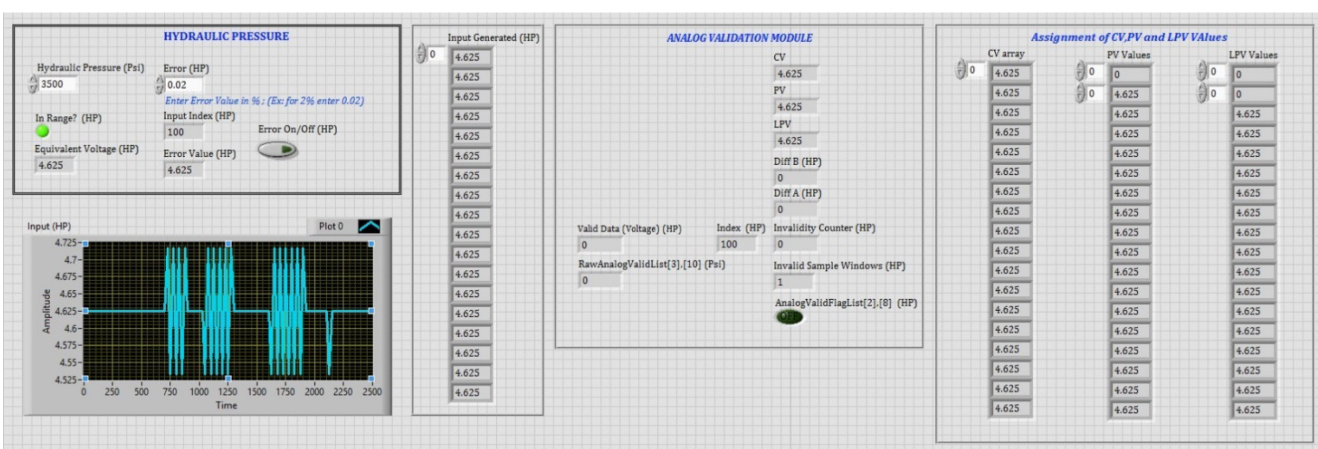

Figure 10: Hydraulic Pressure Sensor Input Interface Analysis with +/-2% tolerance band

Here in order to justify the analog input processing algorithm functionality for hydraulic pressure sensor inputs, the hydraulic pressure of 3500psi is considered (within the specified range as given in Table 1). An error value of +/-2% of 3500psi (~= 4.625V DC) is considered, at suitable time intervals (as shown in the simulation window of Input(HP)). An input array values with 100 elements is recorded as the input array, which is fed into the Analog Input Processing application software algorithm and Data Sorting algorithm loops to validate the data and sort the data as Current Valued, Previous Valued and Last Previous Valued array, as shown in Figure 10.

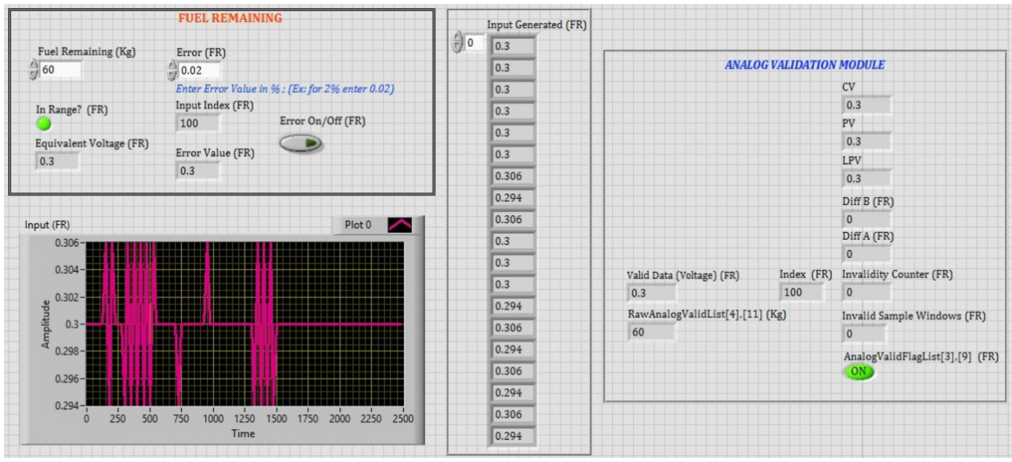

Figure 11: Fuel Remaining Input Interface Analysis with +/-2% tolerance band

The Analog Input Processing application software algorithm validates al the 100 elements in the input array and sorts them accordingly as Current Valued, Previous Valued and Last Previous Valued array. The magnitude of the differences, |Diff A| and |Diff B| are computed and the invalidity counter counts the number of invalid samples in the array correlating the magnitude of their differences correspondingly. This in-turn sets the AnalogValidFlagList to either TRUE or FALSE. Here the RawAnalogValidList data corresponds to the engineering converted value. The valid flag is set to FALSE as there is invalidity in the sensed data set with the Invalid Sample Window count set to 1.

Similarly for Fuel Remaining the data input of 60kg of fuel is considered. An error value of +/-2% of 60 kg (~= 0.3V DC) is inserted suitably in the input array of 100 elements at certain time intervals, for 25ms as each sample. The process is repeated as specified in the above section for Hydraulic Pressure Sensor Input Interface. Here it can be observed that the AnalogValidFlagList is set to TRUE as there is a valid data and the Invalid Sample Window count is 0.

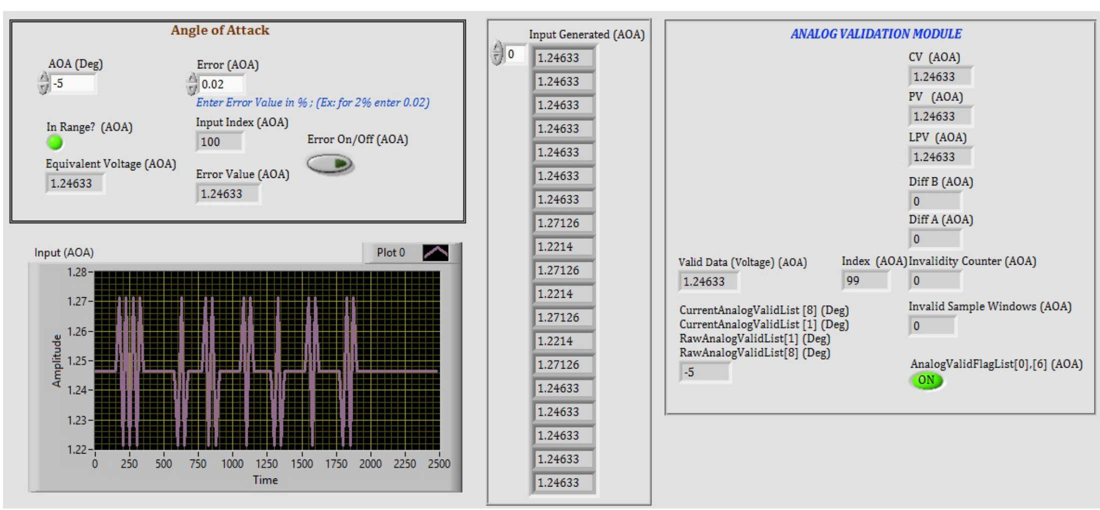

Figure 12: Angle-Of-Attack Sensors Interface Analysis with +/-2% tolerance band

For Angle-Of-Attack, the input value considered is -5deg, which is within the specified limits for the AOA analog input data. An error value of +/-2% of -5deg (1.24633V DC) is inserted into the input array for Analog Input Processing and Data Sorting VI to validate and sort the data. Here the AnalogValidFlagList is set TRUE, as there exists a magnitude of difference values that is well within the specified tolerance bands. The Invalid Sample Window count is 0.

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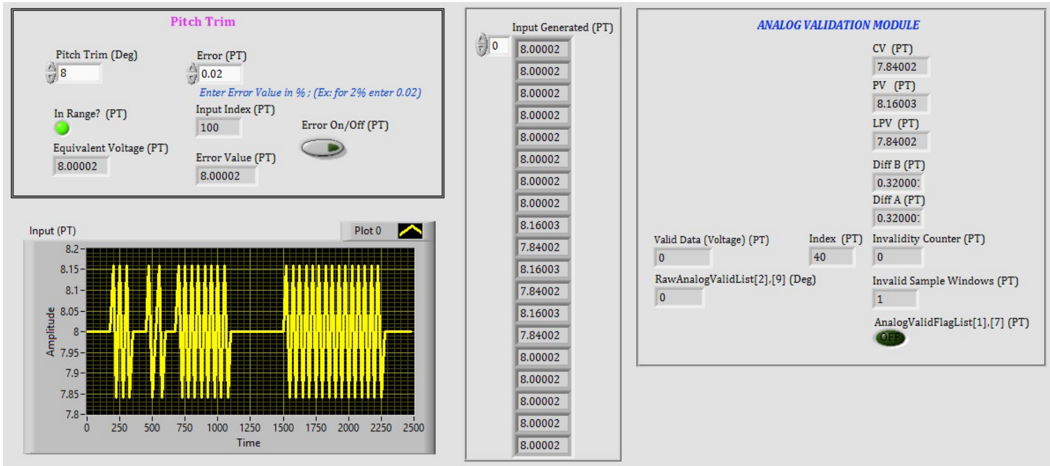

Figure 13: Pitch Trim Position Sensor Input Interface Analysis with +/-2% tolerance band

A maximum input value of 8deg is considered as input for the Pitch Trim Position sensor input interface. An error value of +/-2% of the maximum full range scale (~= 8.00002V DC) is considered and inserted into the array of 100 input elements, for further processing and sorting. During the simulation, as can be seen in Figure 13, at the index value of 40, there exists an invalidity of the samples. This is being analyzed and the AnalogValidFlagList is set to FALSE. The Invalid Sample Window count is set to 1, as there exists an invalidity, which can be inferred from the magnitude of the difference values (i.e. 0.320002) in this case at that time period is way above the priori specified tolerance value. The RawAnalogValidList corresponding to the output data is set to 0 and will be replaced with the valid Current/Previous./Last Previous value from the sorted input array upon the completion of the validation process by the Analog Input Processing application software algorithm

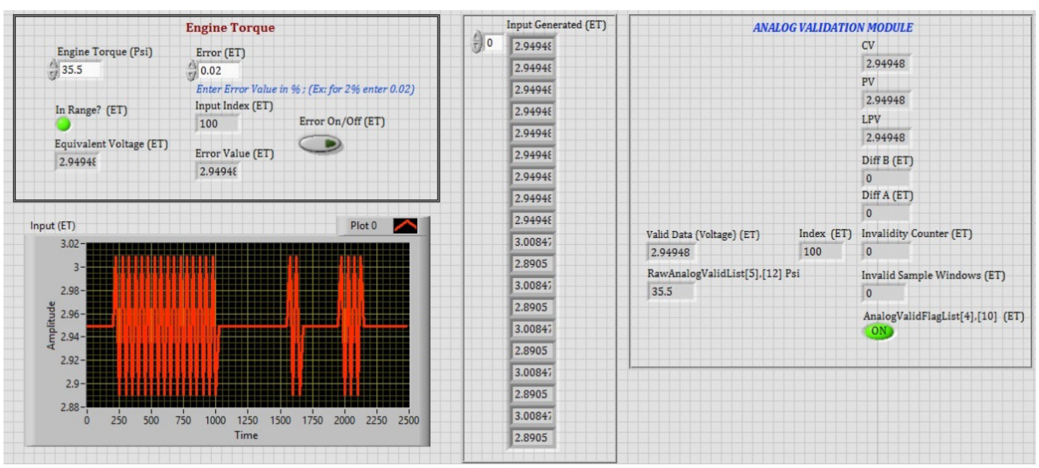

Figure 14: Torque Pressure Transducer Sensor Input Interface Analysis with +/-2% tolerance band

Similarly for the Torque Pressure Transducer Sensor input interface, an input value corresponding to 35.5psig of engine torque is considered. An error value of +/-2% of 35.5psig (~=2.94948V DC) is inserted at suitable time intervals into the input array computation. At the end of the computation by the processing algorithm for the application software, it can be seen that the valid data corresponds to as value of 2.94948V DC with the RawAnalogValidList (output data) to 35.5psig. The AnalogValidFlagList is set to TRUE as there is no invalidity processed by the processing algorithm. Also the Invalid Sample Windows count is 0.

VI. Conclusion & Future Scope

This algorithm considers the stabilization factor for the analog signals and provides suitable warnings in case of invalidity. The ambiguous nature of the analog signals with their characteristic features like amplitude, frequency, and phase may lead to uncertainty over the data being valid or invalid. This may lead to the generation of spurious and unwanted warnings during flight or on-ground testing. With MBE the signals and their validation algorithm such as Analog Input Processing application software algorithm is modeled mathematically that proves the correctness and effectiveness of the algorithm and the need for such an approach. The objective of achieving a high reliable processing algorithm, with more complexity was successfully met.

In this paper we have proposed and implemented a novel MBE approach with the help of NI LabVIEW tool suite, with the Analog Input Processing software algorithm as a case study. The results obtained from the analyses of these models were reliable, versatile and also suitably substantiated in the removal of vexation. Validation of the implementation against the system specified requirements and the analysis of the output data against the test cases obtained during the conventional test approaches were compared and no deviations were observed. This also helped in addressing the unrealistic and unreliable situations early during the development phase, thereby reducing the overall work around cost in fixing the bug/error.

VII. Acknowledgements

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Real time Characteristics of Tandem Wing UAV

By B Rajesh Kumar, C Reginald, R Sivasankaran, S Vignesh, B Ragavan, Vasudevan G & Dharmahinder Singh Chand

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Abstract- The paper deals with the study of aerodynamics of small Unmanned Aerial Vehicle for the purpose of reconnaissance which usually carries payloads like Camera. The two wing setup is termed as Tandem Aircraft. Researchers authenticated that tandem wing setup provides better aerodynamic efficiencies at low Reynolds Number compared to conventional. The airfoil used in experimental study is NACA 651-212. The scaled model was tested in the wind tunnel to study the flight behavior and the results have been compared with the value obtained from the computational analysis using Ansys fluent. The prototype interior structure was fabricated with light weight and higher strength glass fiber and multigrain wood. The skin was made of polyester fabric. Field test with various conditions were done. The results were efficient enough that the study further investigated to use of light energy as a power source of the aircraft, which in turn can provide increased mission hours.

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GJRE-D Classification: FOR Code: 090199

REALTIMECHARACTERISTICSOFTANDEMWINGUAV

Real time Characteristics of Tandem Wing UAV

B Rajesh Kumar [α], C Reginald [σ], R Sivasankaran [ρ], S Vignesh [Ѡ], B Ragavan [¥], Vasudevan G[§] & Dharmahinder Singh Chand [χ]

Abstract- The paper deals with the study of aerodynamics of small Unmanned Aerial Vehicle for the purpose of reconnaissance which usually carries payloads like Camera. The two wing setup is termed as Tandem Aircraft. Researchers authenticated that tandem wing setup provides better aerodynamic efficiencies at low Reynolds Number compared to conventional. The airfoil used in experimental study is NACA 65_1-212. The scaled model was tested in the wind tunnel to study the flight behavior and the results have been compared with the value obtained from the computational analysis using Ansys fluent. The prototype interior structure was fabricated with light weight and higher strength glass fiber and multigrain wood. The skin was made of polyester fabric. Field test with various conditions were done. The results were efficient enough that the study further investigated to use of light energy as a power source of the aircraft, which in turn can provide increased mission hours.

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I. Introduction

Unmanned Aerial Vehicle has become an active research area due to the vehicles drastically making a difference in versatile field, such as remote sensing, reconnaissance, surveillance, disaster relief, mineral exploration, military forces, search and rescue. The advent of small UAVs (MAV) has made the task much simpler than large UAVs. Moreover the small UAVs are portable in a bag pack i.e., they follow the break apart system which is useful in the time of emergency situations. The early biplane configuration is well known, which has a pair of wings one over the other making low aspect ratio high agility aircrafts possible but had a drawback of interference effect, to be specific. By replenishing and modifying this order version for better aerodynamic performance, a tandem wing arrangement is adopted in which the wings are placed one behind the other. This arrangement is chosen because of its increased number of lifting surfaces.

Along with the developments of smaller UAVs, termed mini UAVs, has come issues involving the endurance of the aircraft. Endurance in mini UAVs is problematic because of the limited size of the fuel systems that can be incorporated into the aircraft. Energy harvesting is an attractive technology for mini UAVs because it offers the potential to increase their endurance without adding significant mass or the need to increase the size of the fuel system. This paper will focus on the aerodynamic analysis and construction of sUAV using ambient sunlight. The concept of analyzing two wing configurations termed as Tandem Aircraft will provide better aerodynamic characteristics at low Reynolds Number than conventional aircraft. The merits of such arrangements are payload can be increased because of two low aspect ratio wings, lift produced is more than the conventional aircraft, and cruising velocity is high. The maximum flight duration of unmanned aerial vehicles varies widely. "In 2007, Scientists André Noth, Roland Siegwart, and Walter Engel" [1] proposed from their research that solar electric UAVs hold the potential for unlimited flight. Further, they expiated on how these Solar Powered Micro Vehicle uses the energy obtained from the sun through the solar cells installed on the surface areas of the aircraft model that is going to be designed. Solar Powered MAV is an emerging field of flight research aimed towards attaining limitless endurance to explore vast areas in a single flight whereas solar powered flights will develop from MAV's into huge stable flights travelling in the future and helps make flight travelling eco-friendly and economical which is an innovative initiative said by "C.K.Patel, H.Arya and K.Sudhakar" [2] on the International Seminar and Annual General Meeting of the Aeronautical Society of India presentation where they presented their work on design, build and fly a Solar Powered Aircraft held at 2002.

An airplane in motion through the atmosphere is responding to the "four forces of flight" -- lift, drag, thrust and weight. Just how it responds to these four forces, determines how fast it flies, how high it can go, how far it can fly, and so forth. These are some of the elements of the study of airplane performance by [3] "John Anderson" on his 7th Edition of Introduction to flight book. He further said that, an aircraft should be stable in order to come back to its equilibrium position after when it is deviated from its flight path. Highly stable aircraft requires powerful control to take the aircraft from one equilibrium to other. This paper will focus on quantifying the energy available from ambient sunlight and the UAVs performance and stability study. On considering

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the above said merits, the project takes the path towards the design and analysis of tandem wing configuration sUAV.

II. Preliminary Design

From the Literature survey, it is identified that the small unmanned aerial vehicle used for the purpose of surveillance is mostly reliable and simple. Initially, the dimensions and parameters of sUAV were identified for the design. The wing span is around 2m which is the special feature of sUAV for the tandem wing arrangement and moreover the length of the sUAV is about 1.8 m. The tandem wings are also suggested to be placed at a distance where the interaction is to be low. Therefore different horizontal arm distances are considered viz., 3 times the chord (3c), 5 times the chord (5c). Similarly the width of the fuselage is calculated to be around 0.15m, based on accommodating the components like electric motor, GPS, etc. By taking this into account, the vertical arm distances are categorized into 0c, 0.5c, 1c. Among these distances, one of the combinations is chosen using analysis. The wing loading for this tandem arrangement is calculated by doing simple weight estimation and the resultant value comes out to be 4.55kg/m^2. The aspect ratio is considered to be in the range of 4 to 6 for a small aerial vehicle and hence AR is assumed to be 4. From the AR, the chord of the airfoil is determined to be 250 mm. Now the dimensions are found accordingly and the 2D design is triggered with brief estimation from [4] "Daniel P. Raymer" book on Aircraft Design: A Conceptual Approach shown in Fig1.

Fig. 1: Tandem Wing sUAV Design

a) *Wing Planform Analysis*

The aerofoil selected for the wing is the low drag laminar series NACA 65_1212 with reference from the NASA Contractor Report 165803 by [5] "Carmichael, B. H" on Low Reynolds number airfoil survey on November 1981. This series is chosen due to the following reasons:

1. High maximum lift coefficient
2. Very low drag over a range of operating conditions
3. Increased laminar zone for the flight Reynolds number.

The significance of having two main wings is to be deeply studied for its aerodynamic efficiency because of its difference from the pure aerodynamic design. To start with, the airfoil sketch is made for the analysis work exclusively designed at the aerodynamic efficiency results. Several combinations are chosen for the design such as 3c-0c, 3c-0.5c, 3c-1c, 5c-0c, 5c-0.5c, 5c-1c, where c represents the chord of the airfoil as mentioned in Fig2. From the analytical results, the tandem wings are decided to be located at 5c-0c & 0.5c distance.

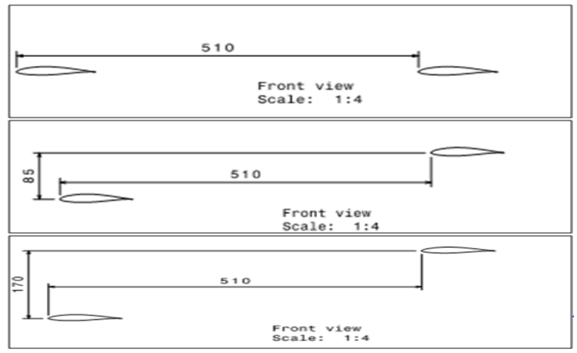


Fig. 2: (i) 3c-0c (ii) 3c-0.5c (iii) 3c-1c

This project deals with the tandem configuration of a fixed wing aircraft where there are two wings. One is placed at lower, front side and the other is placed at higher, rear side. The Wing structure consists of front and rear spars of dimension 10 x 8 mm and 11 ribs which are placed at equal spacing between each other. The front spar is placed at 15% of the chord distance and the rear spar is placed at 65% of the chord distance. The spars and ribs are then covered with a fabric cloth which then doped with nitro cellulose solution to increase the stiffness of the screen as indicated in Fig3.

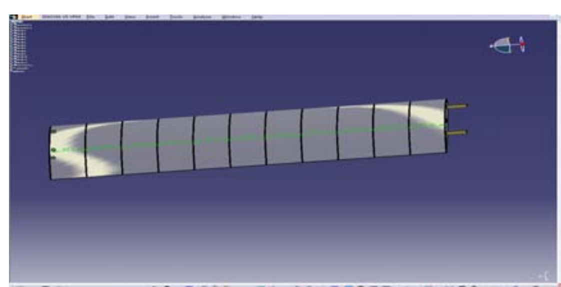


Fig. 3: Wing Design

b) *Fuselage Analysis*

The fuselage design is initially considered to have different shapes but the finalized design is one having a simple shape with low drag making it easy for fabrication for further wind tunnel testing. Therefore the fuselage design starts with a simple square shape with a nose ensuring the streamlined flow over the entire body. This can even be suitable for the motor fixation. The dimensions of the fuselage are set according to the maximum vertical distance between the wings (0.5c). The total length of the aircraft is found out based on the distance between the wings and the accommodation of the components inside the fuselage. The fuselage also serves to position control and stabilization surfaces in specific relationships to lifting surfaces, required for aircraft stability and maneuverability. One of the famous Semi-Monocoque fuselage constructions was considered and designed for this aircraft as shown in Fig 4.

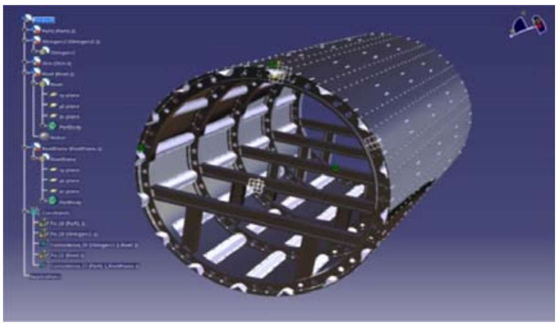


Fig. 4: Semi-Monocoque Fuselage Design

c) Wing-Fuselage Attachment Design

The major challenge is to attach the wing model to the above mentioned fuselage design. The attachment should be made such that wing and fuselage should hold together firmly and should not vibrate or deviate from its position while acting upon the loads and stresses. Hence while designing the wing, about 5 cm clearance has been given to both the front and rear spars which will be used as a portion to attach the entire wing into the fuselage. The spar box designed where wing's spars will be directly inserted into the hole and then joined with special adhesives such that spar box and spar should not rotate or move independently. The integrating part of the wing and fuselage was shown in Fig5.

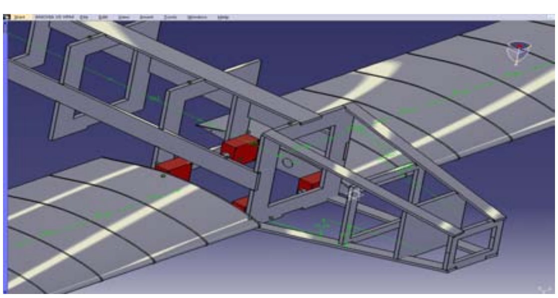


Fig. 5: Integrating fuselage with the wing

d) Weight Estimation

A sUAV can be sized using some existing motor, battery and solar panel and other electronics. The existing motor, battery and solar panel are fixed in size and thrust. They can be scaled to any thrust so the thrust-to-weight ratio can be held to some desired value even as the SUAV weight is varied. This approach allows the designer to size the SUAV to meet both performance and range goals, by solving for takeoff gross weight while holding the thrust-to-weight ratio required meeting the performance objectives. In the weight estimation, the different components like solar panel, avionics, batteries, servos are considered in terms of surface area of the wing after performing comprehensive studies and estimations from 85th volume of [6] "SHAMPO: Solar HALE Aircraft for Multi Payload Operation" presented by G.Romeo, G.Frulla, E.Cestino and F. Borello to the Aerotecnica Missili & Spazio (Journal of the Italian Association for the Aeronautics and Astronautics) on Sep 2005. Simultaneously, motor and structural weights are considered in terms of percentage of total weight of the SUAV.

$$W_0 = W_{solar\ panel} + W_{structural} + W_{avionics} + W_{servo} + W_{battery} + W_{motor} + W_{propeller}$$

The total weight of the aircraft is found to be 4.55 kg including the structural and solar panel weight of 2.55 kg. While calculating, the wing loading is assumed to be 4.55kg/m^2, since it ranges from 4 to 6 kg/m^2 for slow fliers. From the known values, the wing area, wing span and aircraft length are estimated as 1m^2, 2m and 1.8m. Choosing the thrust to weight ratio as 0.3 and considering the cruising altitude as 1.3km which is limited with the avionics, the required thrust is calculated to be 1.365 kg and the cruising thrust to be 1.1675 kg. The thrust required is estimated using the propulsion thrust bed test. The thrust bed is designed in order to have an experimental study over the thrust produced, using plywood board and rail movement mechanism as indicated in Fig6.

e) Airfield Requirements

If the required runway length is too short, the aircraft cannot take-off with full fuel or full payload and the aircraft economics are compromised. The landing velocity depends upon the deceleration and landing distance. Landing distance has been estimated as per CAR regulations and chosen as 360 meter runway. The deceleration is usually taken as 0.18g and 0.2g if reverse thrust is applied. Then, the landing velocity and the stall velocity are estimated as 37.5851m/s and 32.6827m/s respectively.

f) Aircraft Performance

Aircraft performance includes many aspects of the airplane operation. Here we deal with a few of the most important performance measures including airfield performance, climb and cruise.

The ability of the aircraft to fly up and over obstacles depends critically on its climbing characteristics are compared and plotted various altitude as shown in Fig7.

Time required reaching the cruising altitude by the airplane is determined by using the $1/(R/C)_{max}$ vs Altitude plot. The Area under this plot gives the time to climb to cruising altitude as mentioned in Fig8. These characteristics were carefully extracted from [7] "Preliminary reliability design of a solar powered high-altitude very long endurance unmanned air vehicle by Frulla". From Graph, Time to climb the cruising Altitude of 1.3 Km is 7.84min.

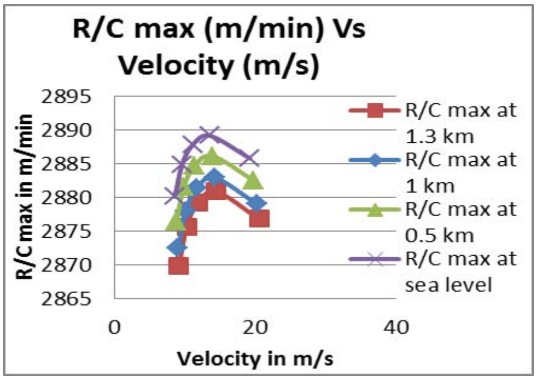


Fig. 7: Rate of Climb at various altitudes

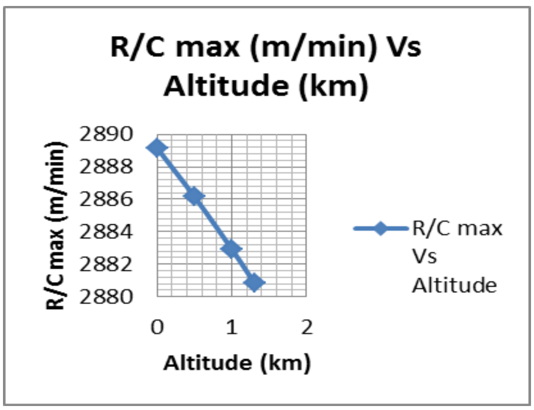


Fig. 8: Max Rate of Climb at various Altitude

g) Endurance

Endurance (E) is the time duration for which the Airplane can fly with maximum fuel and with maximum payload. Range (R) is the maximum Horizontal Distance Covered by an Airplane. Once endurance is known, Range (R) can be estimated by multiplying it with cruising velocity. Without the solar panel, the endurance is estimated to be 17 min. From the above values it's evident that the obtained value is higher than the assumed value. In order to increase the endurance, the solar panel is mounted on the surface of the wing with the reference to the [8] "Solar powered High Efficient Dual Buck Converter for Battery Charging" journal by EstherGlory.S, Dhivya.P.S, Sivaprakasam.T.

III. Discussion of Test Results

The aerodynamic and performance characteristics of sUAV had done by two analyses: CFD analysis and Wind Tunnel analysis with scaled model.

a) CFD Analysis

Computational fluid dynamics (CFD) is a tool that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. The geometry of the airfoil is initially sketched in CATIA V5R20 by importing the NACA 65_1212 airfoil coordinates and suitable size of rectangular domain is drawn. The domain with the airfoil is then meshed with a fine dimensional grid. The meshed airfoil is read in ANSYS FLUENT and the grids were checked. The main scope of the analysis is to find the airfoil combination having:

1. Greater Aerodynamic efficiency
2. Less interaction
3. Acceptable aerodynamic center shift

Using Ansys Fluent, the above different combinations are analyzed for aerodynamically efficiency combinations. The algorithm and theoretical study for the research were carefully studied from research journal named [9] "An introduction to theoretical and computational aerodynamics" by Moran Jack and Dover. P. The domain is drawn accordingly by giving opening boundary condition. The velocity is calculated to be 12m/s. For different angles of attack the domain is kept constant and the direction of the flow is changed with respect to the chord line. From the analyses, the forces and moments over each airfoil are calculated. The contours and the flow patterns across each airfoil are depicted below for all the combinations. Initially the 6 combinations of airfoil locations are considered and the analysis is made determining the total lift and drag. From this substantial analysis, the combination was confined which is having good aerodynamic efficiency, smaller shifts in aerodynamic center and further taken to the design for 3D layout as shown in Fig9.

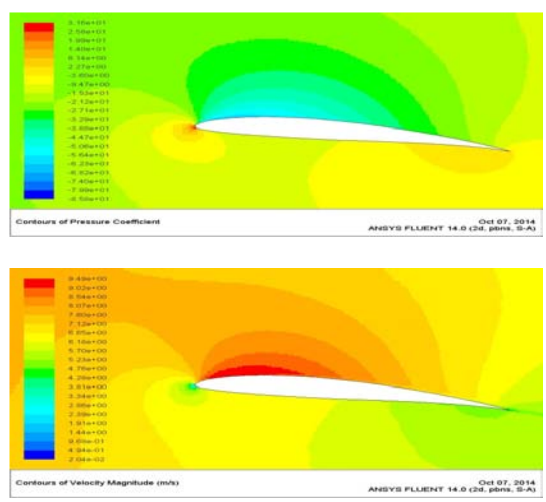


Fig. 9: Contours of pressure coefficient and Velocity magnitude

b) Aerodynamic Efficiency

The lift and drag values across the front airfoil (A1) and the aft airfoil (A2) are tabulated along with the total lift and drag using wind tunnel balance. For different angles of attack the forces are resolved to get the corresponding lift and drag which were measured with the help of Wind Tunnel. The results are tabulated for the chosen combinations respectively for those of velocity 12m/s and area $1m^2$. The tabulated forces and the determined dimensionless coefficients are now plotted against the angle of attack to determine the combination having appropriate C_L (Fig10) and C_D (Fig11). With reference to the book, [10] "Fundamentals of Aerodynamics" by Anderson J.D. The plots are drawn between C_L and C_D which results in aerodynamic efficiency of the airfoils, which is primarily the lift-to-drag ratio as compared and mentioned in Fig12. From these plots, it can be observed that the stalling angle of attack is beyond 15 degrees and the 5c-0.5c combination having efficient lift with acceptable drag are chosen.

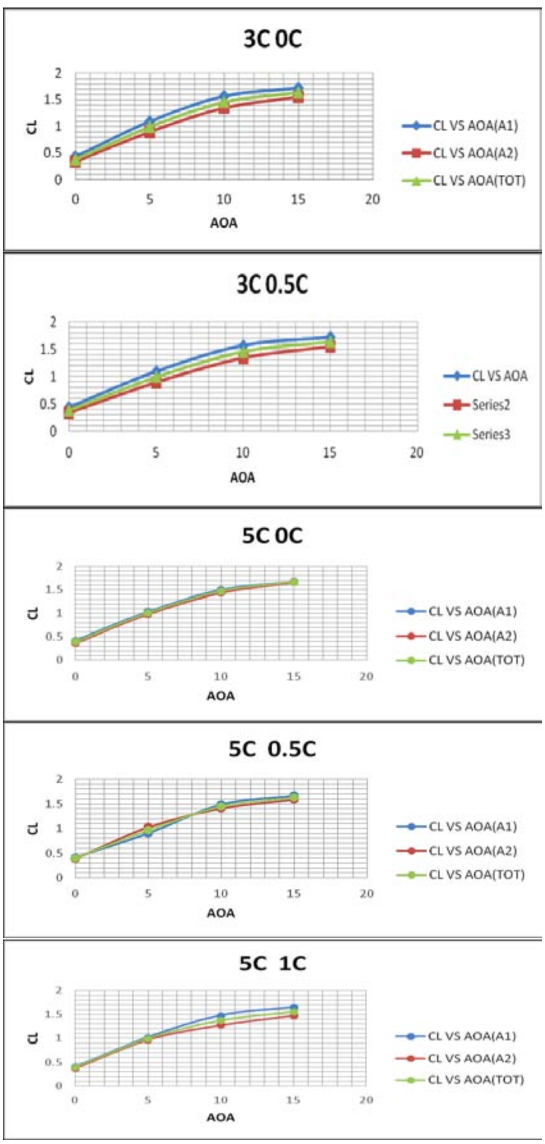


Fig. 10: AOA vs C_L for 3c and 5c combinations

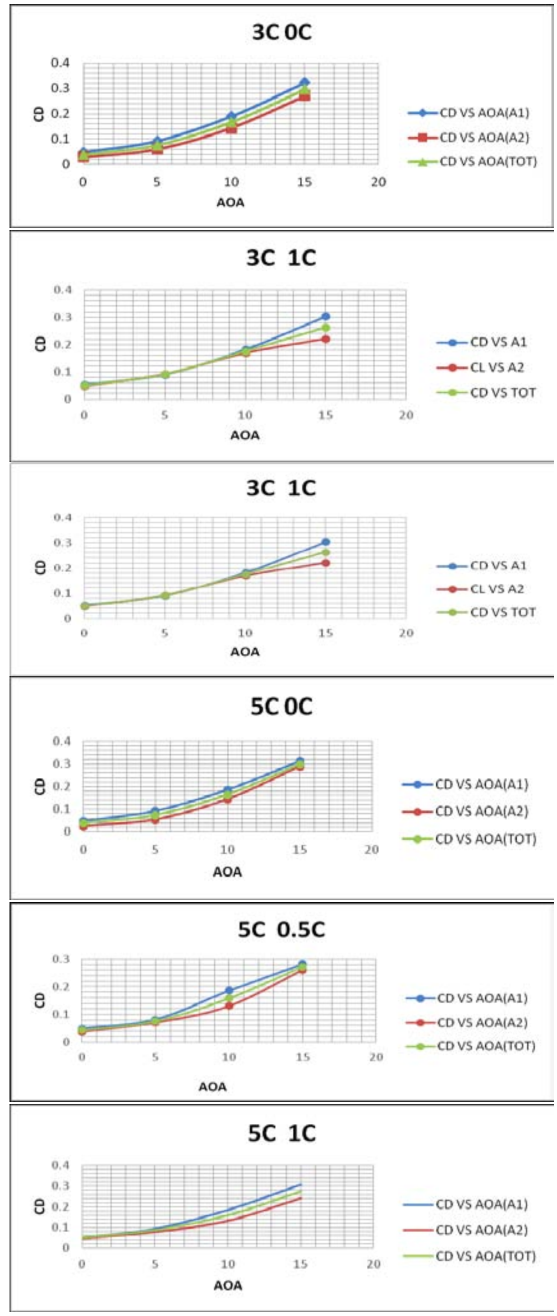
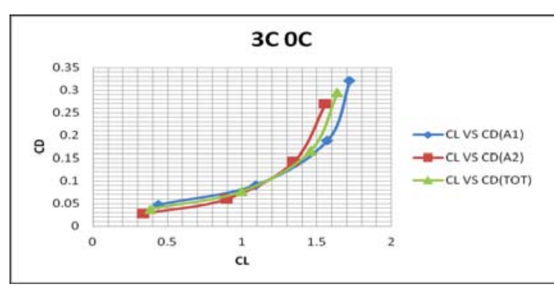


Fig.11: AOA vs C_D for 3c and 5c combinations



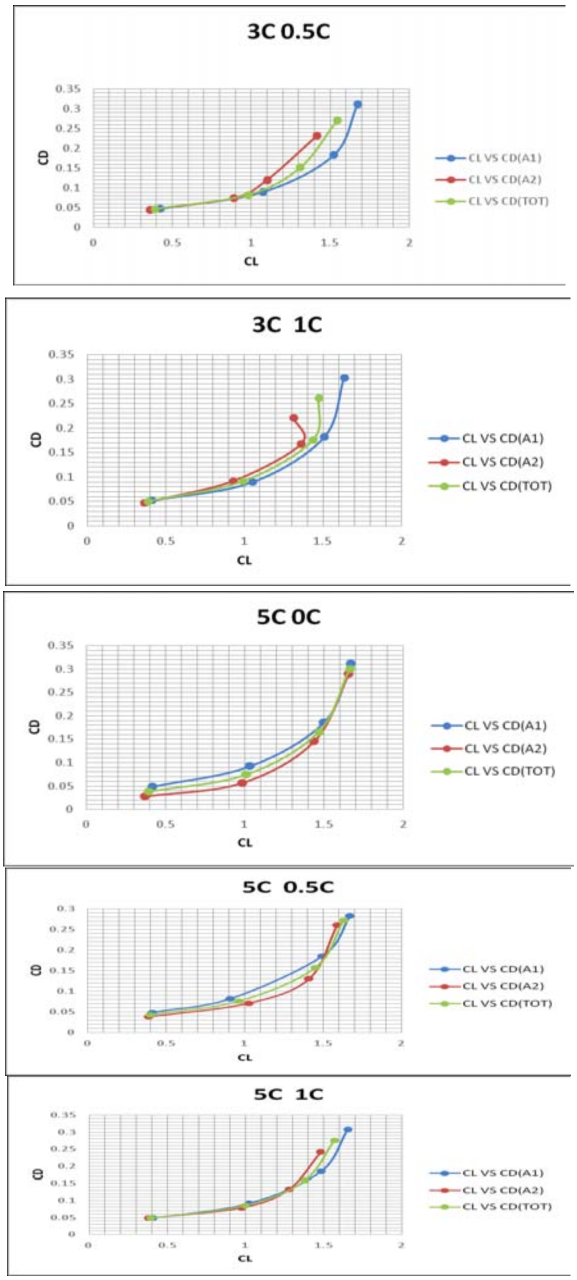


Fig. 12: C_L vs C_D for 3c and 5c combinations

c) Shift in Aerodynamic Centre

The determination of aerodynamic centre plays a key factor in the stability of the aircraft. Thus before taking the maximum C_L and minimum C_D values into account for design from the previous analysis, it is important to carry out the analysis for minimum shift in aerodynamic centre. By choosing the configuration with minimum shift in aerodynamic centre, CG is fixed and the design process is then carried out. The mesh files used for analysis of different wing arrangements is again used for the determination of aerodynamic centre. The graphs are plotted between the pitching moment coefficients and the distance at which they are calculated from the leading edge as shown in Fig13.

From the graphs, the shift in aerodynamic centre is calculated from which the one with least is chosen.

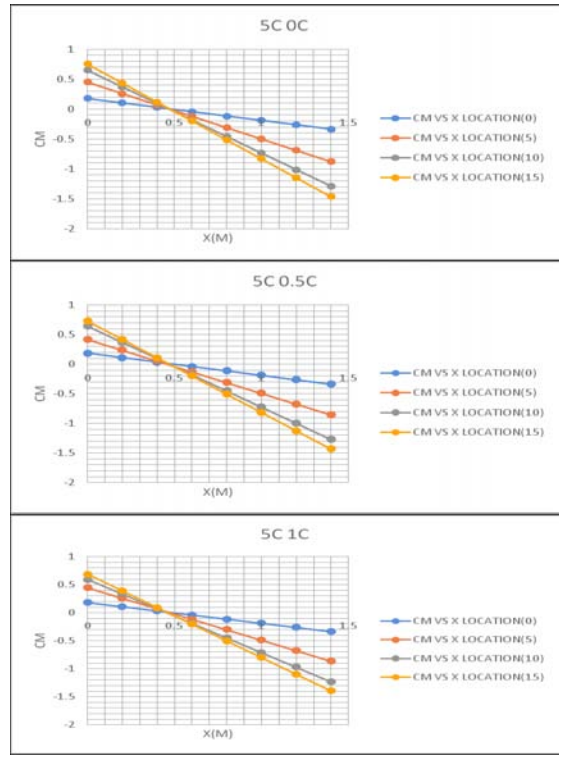


Fig. 13: C_M vs X distance for 5c combination

The shift in moment is less for the 3c combination but comparing this with the interaction analysis using the velocity and streamline patterns, 3c combination has more interactions while comparing with 5c. Therefore, the 5c-0.5c combination is selected because of its acceptable shift in ac and less interactions depicted by the following contours at different angles of attack as shown in Fig14.

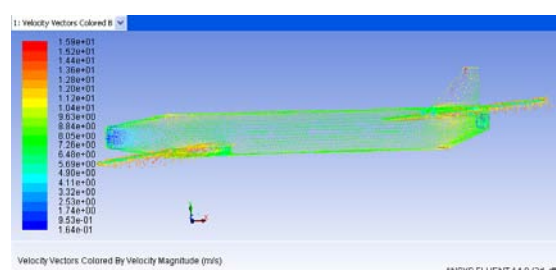


Fig. 14: Velocity Contours for 5c-0.5c

d) Structural Stability Analysis of the Wing Members

The structural stability analysis of the wing have been tested with computerized software such as Static structural analysis on ANSYS , Harmonic analysis on Nx - Nastran and also experimental load test on the wing structure. The wing analysis was carried out with the study of T.H.G Megson[11] work on the book "Introduction to Aircraft structural analysis".

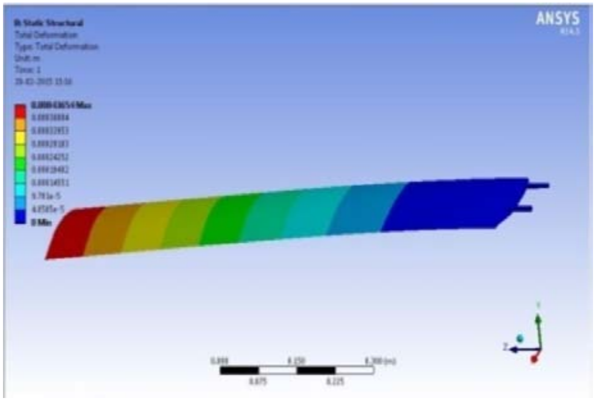


Fig. 15: Structural analysis of wing

The comparison between the spars have been made based on many factors such as cost effectiveness, market availability and required deflection and concluded that spar with dimension 10 x 8 x 1000 mm have been finalized.

e) Wind Tunnel Testing

The lift and drag values have been obtained using 5c-0.5c scaled model which is fabricated in the material of wood. This model was tested by using the balance setup with the help of wind tunnel, the values were obtained by the software termed as SCAD 508 and the device named as PYRODYNAMICS where the values displayed in the monitor connected to the device as shown in Fig15.

Fig. 16: Wind Tunnel Balance and Scaled Model

The angle of attack of the model was changed by using pitch-yaw controller setup which is available in our laboratory. The values taken for the following angle of attack: 0^0, 5^0, 10^0 and 15^0. The values were tabulated and the graphs were plotted and compared with 2D analysis results as mentioned in Fig16.

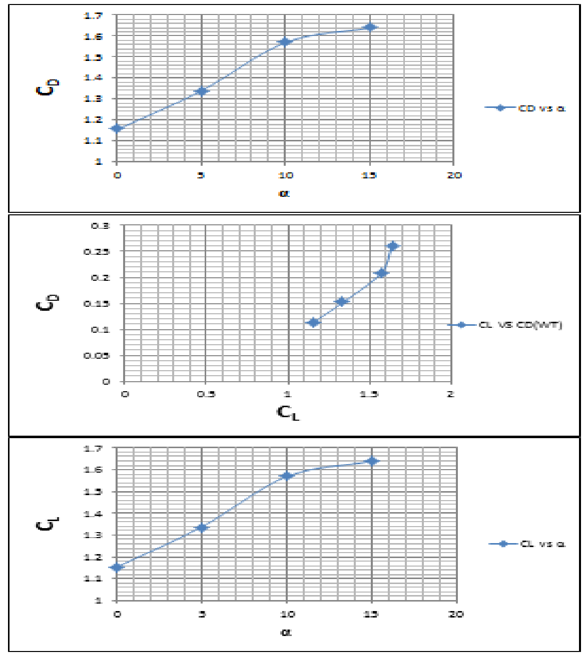


Fig. 17: Plot between C_L, C_D and α

f) Models Testing

After the scrupulous testing and estimations with reference to [12] "Estimating R/C Model Aerodynamics and Performance" by Nicolai, Leland M, A remote controlled hobbyist aircraft was chosen as the test bed for this study because the aircraft is inexpensive and easy to assemble, spare parts are readily available, and the aircraft is on the same length and weight scale as some existing military UAVs. The test bed has been divided into two categories. First the test fly was made possible using the chloroplast sheet of 5mm thickness. The aircraft is constructed with an electric propulsion system composed of an electric motor and an 11.1 V, 2100 mAh Lithium Polymer battery. It has a wing span of 1m, a length of 0.94m, area of $0.125m^2$, chord of 0.125m, aspect ratio of 8, thrust of 2kg and a flying weight of 1390g constituting the weight of fuselage, motor, front wing, rear wing, battery, ESC and other avionics as shown in Fig17.-

Fig. 18: Model made of Chloroplast

Tandem aircraft was tried to fly on 10^{th} August, 2014 in the open ground at early morning 7am in Chennai. This flight was flown over 60sec in the air and unfortunately crashed. With regard to the aircraft journal, [13] "Micro-air-vehicles: Can they be controlled better" by Gad-el-Hak, M., the second test flight was made by constructing the aircraft using plywood and it was carried out for test fly on 7^{th} march, 2015 in the open ground in Vellore and it also fails due to overweight of the aircraft. It has insufficient runway and thrust for lifting the aircraft as shown in Fig18.

Fig. 20: Flight test of Tandem wing aircraft

Finally, the prototype was made using glass fiber for wings and plywood for fuselage. Several modifications were performed on the original aircraft in order to include the photovoltaic energy device for generating alternative energy source as shown in Fig19.

Fig. 21: Prototype made of Composite material and multigrain

IV. Conclusion

An experimental study has been carried out to analysis the aerodynamic and performance characteristics of small unmanned aerial vehicle. The thrust required and available are determined by analyzing the characteristics of the given motor and also the power required has been determined for the unmanned aerial vehicle. The endurance of the aircraft is determined and increased by placing alternative solar energy power source. The structure of the aircraft was designed and analyzed through the software and compared with the results obtained from the wind tunnel. Based on the flight tests that have been performed, it can be concluded that the sUAV is effective in aerodynamic design and the solar energy device has the capability of charging energy storage devices with high endurance meticulously studied from, [14] "Solar-Powered Unmanned aerial vehicles" journal published on 31^{st} International Energy Conversion Engineering Conference by K.C. Reinhardt. Thus the endurance and range of the unmanned aerial vehicle has been increased due to tandem wing configuration.

V. Acknowledgment

We express our heartfelt thanks to the management for providing us with the necessary laboratory facilities and intellectual resources which were indispensable aids throughout the course of the project. We also express our gratitude towards *Dr. P. Kasinatha Pandian*, Principal for the freedom he gave us to complete the project. We extend our list of acknowledgement to *Dr. Dharmahinder Singh Chand*, Professor and Head of the Department and project supervisor for providing guidance and clarification whenever needed throughout the project. We also thank our entire faculty members to make realize our mistakes, mis-conception and to lead us in a correct way during our course of project.

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Appendix

AR = Aspect Ratio of the wing
α,AOA = Angle of Attack
b, c = Span and Chord length of the wing
C_a = Local axial coefficient
C_D = Total drag coefficient
C_L = Total lift coefficient
C_M = Total moment coefficient
C_P = Coefficient of pressure
e = Oswald efficiency factor
Re = Reynolds Number
P = Pressure
ρ_∞ = Free stream density (1.19kg//m^3)
V_∞ = Free stream velocity of air
LOC = Line of control
$W_{structural}$ = Structural weight of an aircraft
$W_{avionics}$ = weight of the avionics used
W_o = Total weight of an aircraft
T/W = Thrust to Weight ratio
Li-Po = Lithium Polymer
ESC = Electronic Speed Controller
M = Mach number
R/C = Rate of Climb
n = Load factor
C_T, C_R = Tip Chord, Root Chord

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A Study of Possible Explosion Effects in the New 1-WTC Tower

By G. Szuladzinski

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I. Introduction

A historic example, which was a motivation for this work, was the collapse of the World Trade Center, which took place on the 11th of September 2000. Each of the two main towers was struck by an aircraft flying at large speed with the purpose of inflicting maximum damage.

Plenty of engineering work was done to explain the mechanism of WTC collapse,. The best known and the most extensive engineering investigation is presented in NIST reports, of which [1] could be the most relevant example. According to the reports, the reason for the collapses of the structures weakened by the aircraft impacts was the thermal effect caused by prolonged fires. Unfortunately, the simulations did not clearly demonstrate the mechanism of failure. In this sense, the effort was a failure of engineering science. More details can be found in Szuladziński [2].

Although those simulations took into account the impact of the fuel mass, they ignored the explosions of fuel, which were clearly visible and audible in the wide media coverage of the event. This problem was addressed by Szuladziński [2], who demonstrated how significant the damage can be even if only a fraction of available fuel detonates.

While the investigation of past collapses is valuable, sensitivity of new structures is of interest too. The "replacement" building for WTC towers is 1-WTC, a new tower somewhat resembling a tapered and twisted pyramid. This article is devoted to estimating an effect the fuel explosion might have on a possible collapse of 1-WTC building.

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A fairly extensive description of building geometry is provided by Szuladziński [3]. It is sufficient, for our purpose, to use only the top one-third height of the building proper, while retaining the spire. The mentioned segment is treated as built-in at the base. This is justified because the effect of a blast has a somewhat localized response. Besides, it is vertical effects are of main interest which makes a limited distance from the new base quite acceptable.

The explosive properties of the air-fuel mix and some of its effects in this type of event were presented in detail by Szuladziński [2]. To have a good picture of the structural effects some basic design features and static relationships must be considered first.

II. Floor Plate Design Loads

This follows the values used in the design of the old WTC towers. The mass per unit surface m is the total of the dead load (DL) and the design live load (LL) expressed in mass units. For a typical floor, one can expect DL = 300 kg/m^2 (61.44 psf) and LL = 205 kg/m^2 (42 psf) with a total of m = 505 kg/m^2 or the equivalent surface pressure of p_0 = 4,954 N/m^2. (The most likely LL for the building was used in place of the design load for a single floor, the latter being LL = 244 kg/m^2)

III. Material Properties

a) Steel

The peripheral column material is A514 steel. This is a quenched and tempered alloy steel, designated by its maker, Arcelor Mittal as T-1. Its nominal (minimum guaranteed) properties are

F_y = 690 MPa = 100 ksi (yield)
F_u = 759 MPa =110 ksi (ultimate)
ε_u = 0.081 (ultimate strain)

The above values hold for a thickness below 63.5 mm. The strength is somewhat smaller for thicker material.

The above data is used for design. When estimating the effect of accidental events, which are usually of dynamic nature, we are entitled to use two factors, which enhance strength. The first allows us to take advantage of the difference between the nominal and the expected average properties. [4] The second is the dynamic enhancement of strength, which can be calculated in several ways. We have multiplied the quoted values only by 1.1 to account for the two factors.

(Dynamic strengthening is usually small for strong steel.) The same multiplier was used for the second steel involved, A588, employed for beams, which had the following nominal properties.

F_y = 529 MPa = 100 ksi (yield)
F_u = 634 MPa =110 ksi (ultimate)
ε_u = 0.103 (ultimate strain)

Finally, the reinforcing steel of the wall was characterized by

F_y = 451 MPa (yield)
F_u = 580 MPa (ultimate)
ε_u = 0.14 (ultimate strain)

b) Floor concrete slab

The slab is built using light-weight concrete poured over corrugated, galvanized steel sheet with a conventional reinforcement. This is in turn supported by metal beams, perpendicular to the corrugations. The directions of both change, as we go around the circumference of the building.

The lightweight (1602 kg/m^3) concrete has F'_c = 20.7 MPa and F_t = 2.7 MPa (tensile strength in flexure). The modulus is E_c = 12,500 MPa.

Supporting beams spacing imposed the strength requirement. For the 6m span of the beams, treating the slab as one-way type and assuming an intermediate condition at the supports the maximum bending moment induced by p_0 becomes 17,836 N-m/m. This, along with the factor of safety of 1.8 dictates the strength of the equivalent slab material. No dynamic enhancement of strength was used.

c) Reinforced concrete wall

The wall is cast with F_c = MPa concrete, whose estimated tensile strength is

$F_t = 0.6\ \sqrt{F_c} = 4.45$ MPa

and the Young's modulus, according to [4] is

$E_c = 3320\sqrt{F_c}\ +6900 = 31{,}522$ MPa

The main design load for the core walls of the building is compression caused by gravity. Under a strong lateral pressure pulse, however, bending predominates. A simplified computational method will be employed, which states that a wall element fails if the net tension exceeds F_t' calculated using the limit bending capacity M_0:

$$F_t' = \frac{5M_0}{BH^2} \quad (1)$$

The coefficient of 5 is mid-way between an elastic case of 6 and a perfectly plastic one of 4. We assume that the wall is reinforced with a square pattern of rebars giving an effective 1% of steel section in both horizontal and vertical directions. For a H = 160 mm thick wall, which is postulated here and a unit width B = 1 mm, a commonly used bending strength formula gives the yield moment as 56,015 N*mm/mm. When this is inserted into Eq. (1), the apparent strength on the tensile side becomes F_t' = 10.94 MPa. (This is a conservative approach, as it does not allow for a compressive failure and therefore it makes the wall appear stronger in the simulation to follow.)

IV. Estimate of slab Damage Caused by Explosion

We assume the detonating charge to have 200kg of aviation fuel mixed equally (by volume) with air. This gives a volume of 0.5m^3 and is equal to mass density of about of 400 kg/m^3 This corresponds to a cube with the side length of 794 mm. The fuel is treated as energetically equivalent to TNT (per unit of mass) in accordance with [2].

A simplified section of the space between floors is shown in Fig.1. The fuel-air mix, depicted as a centrally placed block is allowed to detonate. The approximate assessment will be coarse, just to find the extent of the threat. The first action is to replace the block of fuel by a concentrated mass at its geometrical center. This allows the use of such a popular code as CONWEP (a computerized version of [5]) to estimate the peak pressure and impulse reaching the floor slabs. The load imposed on the slab is found in a simplified way, as a pressure history based on the nominal distance of 2.21m. According to CONWEP, the charge of 200 kg placed at that distance should yield the following pressure p_0 and specific impulse i (reflected) values:

p'_o = 54.58 Mpa and i = 12.91 MPa-ms.

The fuel-air mix is likely to have the same or even larger impulse as the energetically equivalent solid explosive. However, pressure is significantly reduced in magnitude while lasting much longer [6]. Except for the immediate vicinity, impulse is the real measure of a structural damage to follow. For this reason, the Conwep value of the impulse is retained, while the pressure applied is samaller than mentioned above.

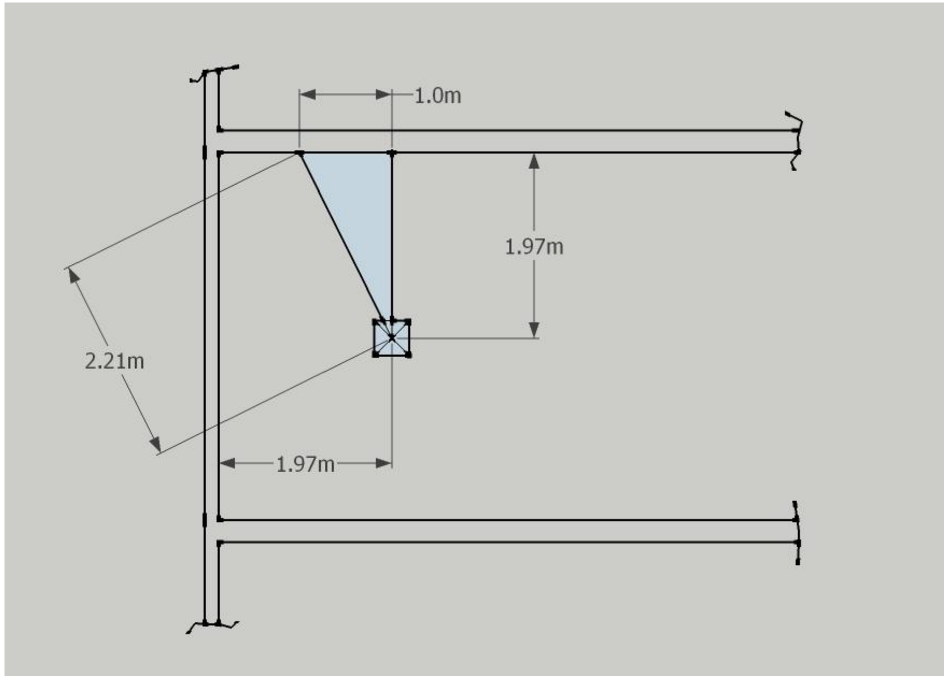

Fig.1: Section through a typical office floor, between two slabs and internal wall, with a block representing the fuel-air mix. The nominal distance from the center of the block to each of three surfaces is taken as 2.21m.

V. Dynamic Response of Floor and Wall Slabs

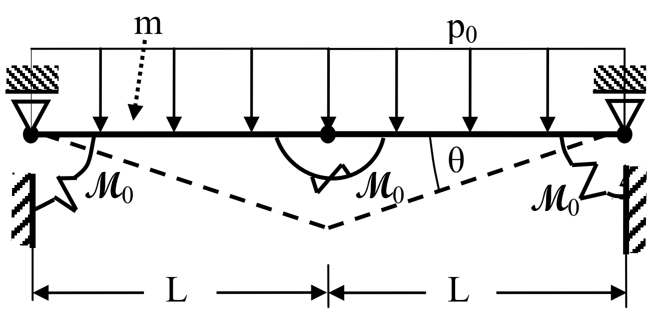

Fig.2: A beam with rigid supports subjected to a short impulse of pressure of magnitude p_o. (Szuladziński [7], Case 10.21)

A unit-width beam, acted upon by an impulse applied by distributed load p_0 is depicted in Fig.2. (The actual pressure distribution will not be uniform, but it is expected the nominal value used will provide the result with a minor error only. Also, if the beam is of width b, then p_0 in Fig.2 and the equation below must be replaced by $w_0 = bp_0$) Angular springs at ends and at the center have a rigid-plastic characteristic and their capacity is equal to that of the slab Mo. When the initial kinetic energy is equated to the energy absorption by the plastic springs, the maximum angle of permanent rotation is found as θ_m:

$$\theta_m = \frac{3L}{16}\frac{(p_0 t_0)^2}{m\mathcal{M}_0} \qquad (2)$$

where L is the half-span, $p_o t_o$ is an impulse of pressure p_o applied over short time to, (poto stands for the impulse magnitude regardless of its shape. If the beam is b wide and not of unit width, then p_0 should be replaced by w_0, where $w_0 = bp_0$.) Finally, m is the mass per unit length of the beam. (One should remember that this is a small-deflection formula.) We have, for a beam 1 mm wide and 250 mm deep (A = 250 mm2):

L = 6000/2 = 3000 mm

$p_o t_o$ = 12.91 MPa-ms.

Density ρ = 2020 kg/m^3 = 0.00202 g/mm^3 (incl. steel)

m = ρA = 0.00202 x 250 = 0.505 g/mm

$\mathcal{M}_o$ = 17,836 N-mm/mm

Substitution into (2) gives θ_m = 10.41 rad = 596°. This is an absurdly large response and the figure is merely due to the small-deflection limitation of (2). Indirectly, it tells us that the impulse will easily break the slab. Using the same procedure it is easy to check that the wall slab will also fail under dynamic loads Apart from the above there is a major threat in the pulverization mode caused by excessive pressure (spall). Even if we take pressure to be 4x smaller than calculated before (on account of the nature of our exploding material), which gives $p_0'/4$ = 13.6 MPa, which is more than the tensile strength of concrete, F_t = 4.45 MPa. (This is applicable to the wall. The situation is not any better for the floor, but somewhat different because of steel lining of the bottom.)

VI. Simulated Impact Zone Damage

The transient dynamic problem of the explosion effect was solved using LS-Dyna code [8]. The solid elements (concrete) were modeled with Type 2, fully integrated elements. Metal plates are represented by Type 2, Belytschko - Tsay shells. The slab reinforcement and truss diagonals are modeled using Type 1 beam, Hughes-Liu with section integration.

Figure 3 shows one-half of the building model. It is zoomed on the blast-affected zone, which is modeled in a greater detail than the rest of the structure. The long reinforcing beams run radially as well as along floor edges. Magnitude and duration of the pressure pulse was applied as described before. No secondary enhancements such as reflections were included.

As Fig.4 shows, soon after the explosion parts of the floor, ceiling and the wall are blown away. The ceiling falls on the floor in the impact zone, which helps the periphery columns to lose their stability. As a result the floor above loses its support and begins to descend. So do all floors above in a pattern known as 'progressive collapse'. This leads to a collapse of the entire structure, as shown in Figs. 5,6 and 7.

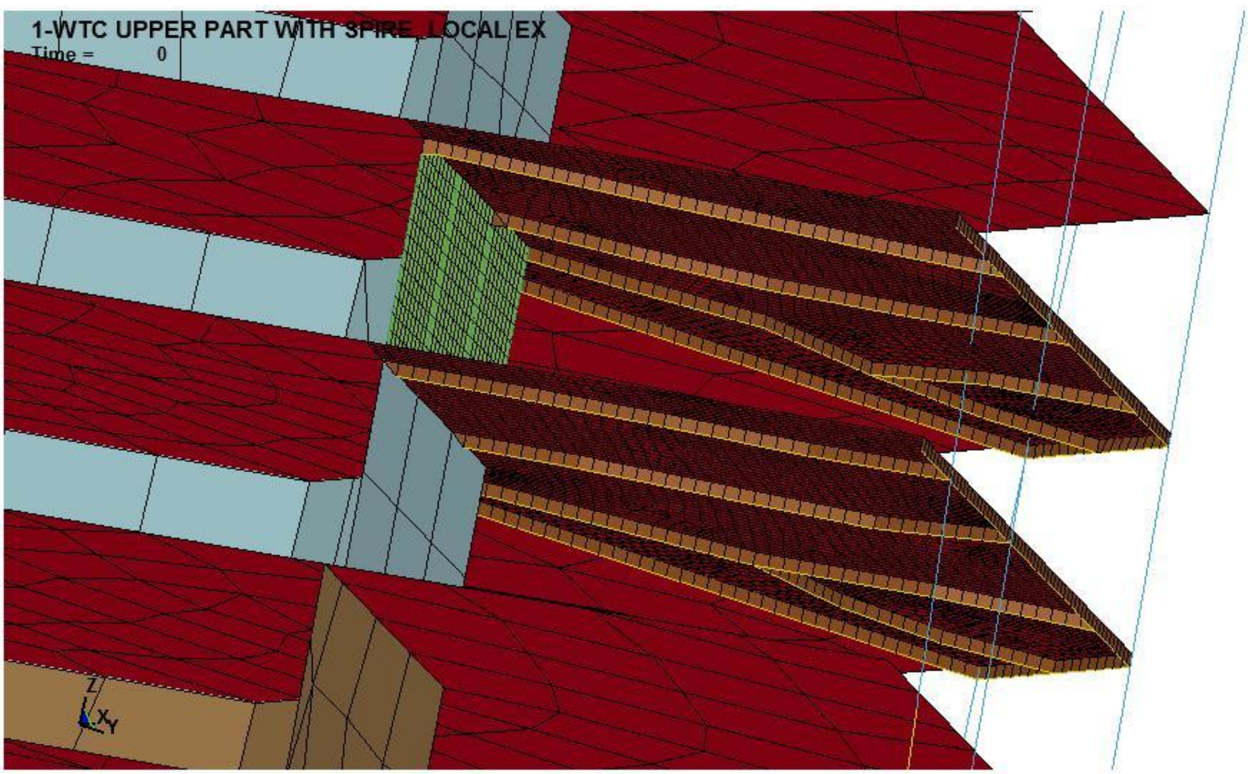

Fig. 3: Fragment of the tower showing the impact zone, where the floor and ceiling are modeled in detail. The view is from below, from the plane of symmetry

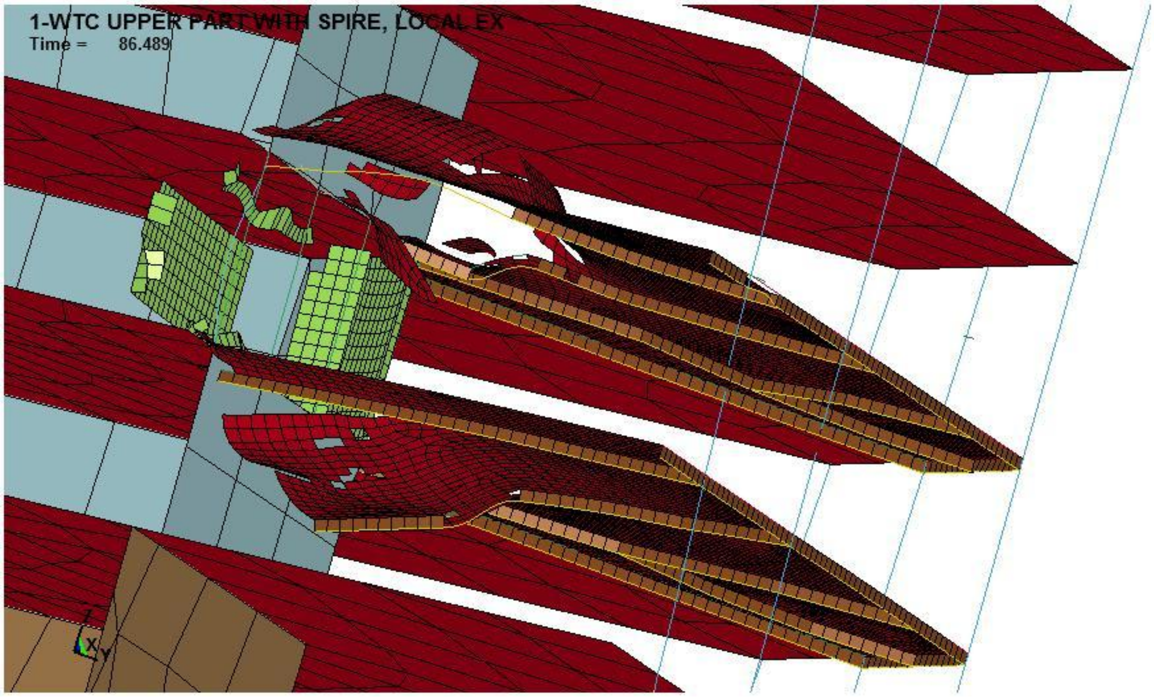

Fig.4: The status shortly after explosion. Both floor and ceiling are blown off the wall. Also, a part of the wall is separated from the rest.

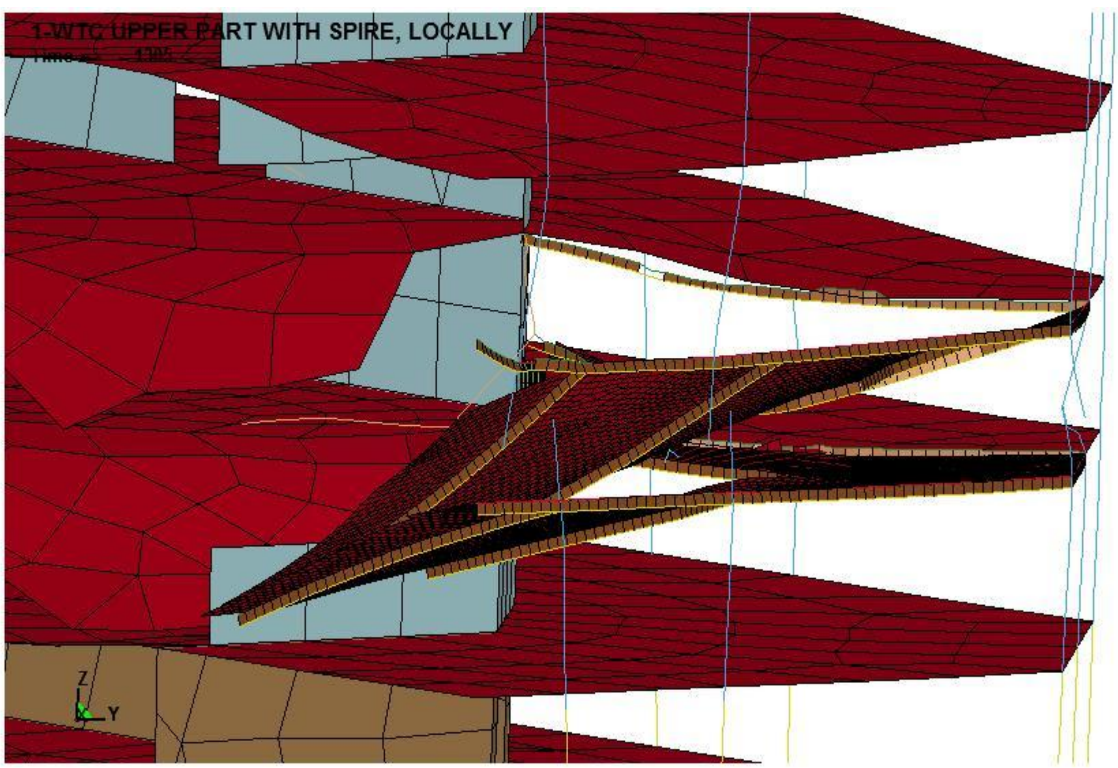

Fig. 5: The ceiling detaches and falls on the floor of the impact zone

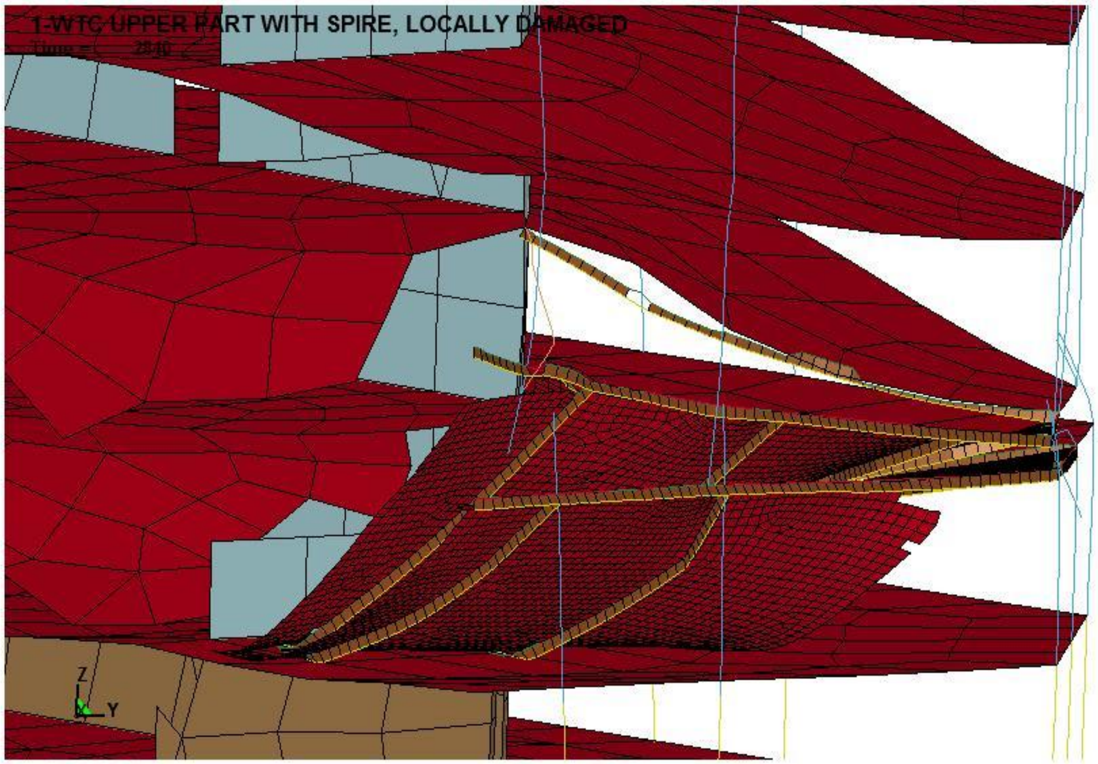

Fig.6: Both floor and ceiling impact the slab below.

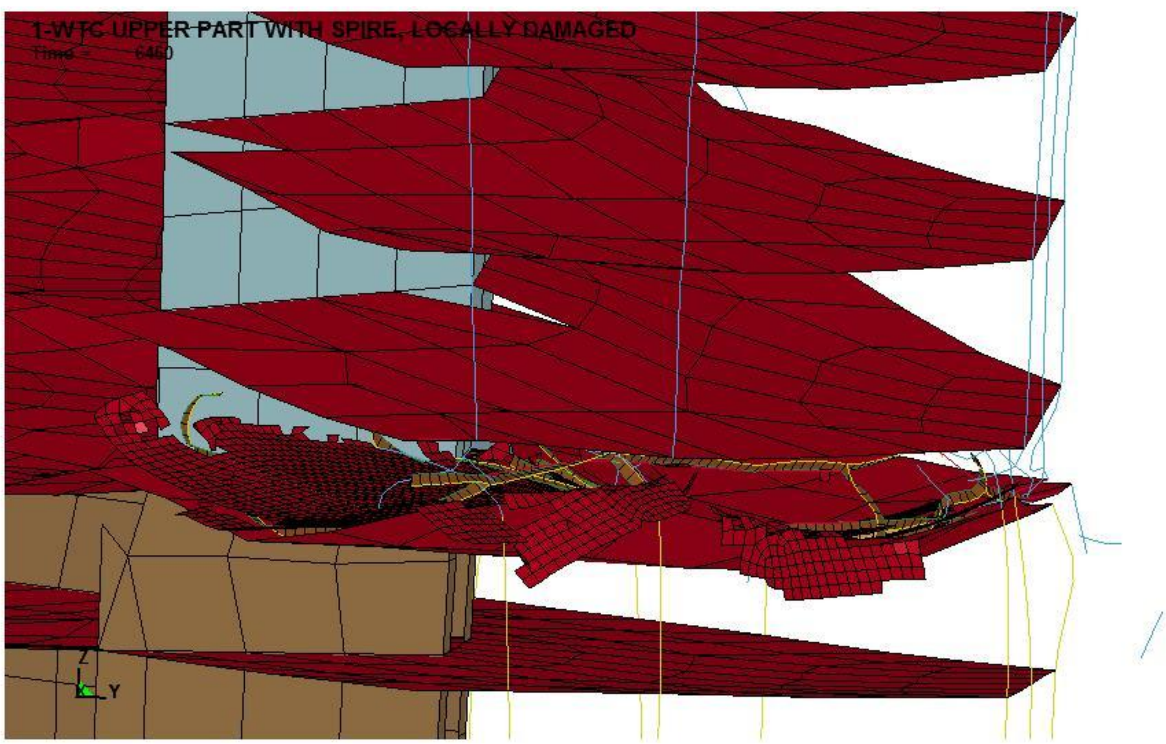

Fig. 7: The damage is deepening as the falling slabs pull down the floors above them.

Fig. 8 As a result of wall damage the upper part of the building tilts and begins to fall. This motion can't be stopped

VII. Summary and Conclusions

After estimating the energy content of the 200 kg portion of fuel assumed to be detonating the pressure impulse created by said detonation was evaluated. A conventional check on flexural failure of the concrete wall demonstrated that this mode of failure is easily attainable. It is obvious, however, that in addition to general collapse the slabs not far from explosion sources will be subject to spalling.

The explosion at the critical floor level caused the wall, a part of the floor area as well as the ceiling to be blown off. This was the source of collapse, first taking place locally and then spreading throughout the entire structure. This lead to the whole building collapse, of which only the initial moments are simulated. (One should note that the overall speed of the downward movement was increasing.)

In the event mentioned before, the old WTC collapse, the amount of fuel carried by the aircraft was close to 30,000 kg. This means that in a similar event we are assuming less than 1% of the fuel content to be detonating. The amount is not inconsistent with the explosion seen after the attack on the old WTC.

Why is 1-WTC not as tolerant to such an attack than its predecessor? (a) Larger floor area in the latter (compared with the floor area at the impact level here) which imposes more damage on the moving craft. (b) More distributed manner of supporting the weight, with center columns placed rather far apart and not by a monolithic wall. (c) Only a minor fraction of the perimeter columns in the old WTC were destroyed in the attack. In our structure there are much fewer such columns so the influence of their demise has a lager over-all effect.

Many thanks are owed to Mr M. Soll for his careful study of this text, which made it a more comprehensive document.

The reader can watch the animations of this work on: http://www.youtube.com/user/gs98765432

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Fellows

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Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards "FARSE" title to individuals. The 'FARSE' title is accorded to a selected professional after the approval of the Editor-in-Chief /Editorial Board Members/Dean.

- The "FARSE" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSE or William Walldroff, M.S., FARSE.

FARSE accrediting is an honor. It authenticates your research activities. After recognition as FARSE, you can add 'FARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

The following benefits can be availed by you only for next three years from the date of certification:

FARSE designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

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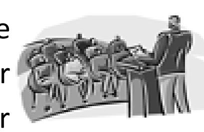

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The FARSE can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

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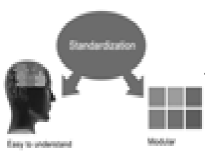

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MARSE accrediting is an honor. It authenticates your research activities. After becoming MARSE, you can add 'MARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

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The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

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The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
The author fees of such paper may be waived off up to 40%.

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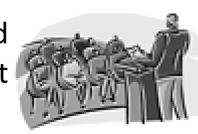

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The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

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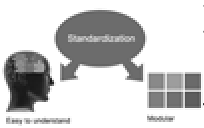

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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Complete support for both authors and co-author is provided.

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Based on potential and nature, the manuscript can be categorized under the following heads:

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Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

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Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

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Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

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- One should avoid outdated words.

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Acknowledgements: Please make these as concise as possible.

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Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

The Administration Rules

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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