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Civil and Structural Engineering

Highlights

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Wetted Perimeter Method

Doppler Shift Estimation

Water Requirement for Crops

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 7 VERSION 1.0

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Water Requirement for Crops in Barind Area- before and after Implementation of BIADP, Bangladesh

By M. Z. Alam, A. Chowdhury, A. A. Masum & M. Rahman
University of Engineering & Technology, Bangladesh

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Keywords: irrigation; consumptive use; irrigation requ- irements; BIADP.

GJRE-E Classification : FOR Code: 290899

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M. Z. Alam [α], A. Chowdhury [σ], A. A. Masum [ρ] & M. Rahman [ω]

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Keywords: irrigation; consumptive use; irrigation requirements; BIADP.

I. Introduction

Among the various phenomenon climate change is manifested by temperature rise along with the changes in precipitation, evaporation and relative humidity etc. threatening impacts in natural, social and economic systems. With the climate change, these factors will affect agriculture most [1,2]. Bangladesh is an agriculture dependent country. Most of the people (more than 80%) are involved in agriculture profession. Hence agriculture and its related things such as water resource management, irrigation, drainage etc. are most important in Bangladesh [2]. Improper knowledge and lack of modern technologies, farmers improperly lift water without considerate ground sources. As a result water table declines in many areas of Bangladesh. Hence groundwater (GW) level declined substantially during the last decade causing threat to the sustainability of water use for irrigation in NW region of Bangladesh [2,3]. The northwest region is almost entirely dependent on groundwater for irrigation purpose. The region is highly developed agriculturally with the largest irrigated area of all regions supplied mainly by shallow tube wells. The number of Deep Tube wells (DTW) has been significantly increased during the recent past years. About 2100 Deep Tube Wells, 45,000 Shallow Tube Wells (STW) and other mode of irrigation wells are being used in the study area for irrigation [4,5]. It covers about 88% of the total cultivable area in the study area. The remaining irrigable area has been intended to cover by installation of additional DTWs under a specific project [5]. The Barind Integrated Area Development Project (BIADP) under the Barind Multi-purpose Development Authority (BMDA) was sta- rted on late eighties century in the districts of Chapai Nawabgang, Naogan and Rajshahi with 25 upazilla for the improvement of agriculture in Bairnd area- northwest region of Bangladesh which covers an area of 7500 km^2 [7]. But in time considering for the better prospect of the project an expanded project area of 38 upazilla of an area of 9288 km^2 has been undertaken recently [8]. For the future development of Barind area BIADP fixed objectives like poverty mitigation, human resource improvement, food safety etc. [6,8]. Availability of water is the key factor for growing any kind of agriculture crop [9]. The water requirements will vary with the crops as well as with the place [10]. In other words, different crops will have different water requirements, and same crop may have different crop requirements at different places of the same country; depending upon the climate, type of soil, method of cultivation, and useful rainfall, etc [11]. Ground water condition of an area is mainly depending on geology, hydrologic parameter, soil properties, recharge and discharge and hydraulic characteristics of aquifer [12]. An important component of water balance equation is ground water recharge. Estimation of recharge volume is very important in forecasting groundwater condition in present stage and its effect on future stage [4,12].

II. Data Collection

The monthly rainfall data in Rajshahi district within the Barind area was collected from Bangladesh Meteorological department, Dhaka. The maximum and minimum temperature (°C) data for Rajshahi station was collected from Bangladesh Meteorological department,

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collected from Bangladesh Meteorological department, Dhaka. The crop coefficient of various crops was collected from Rice, and Wheat Research Institute in Rajshahi.

Blaney-Criddle Method was used for the determination of consumptive use and crop water requirement. As the consumptive use is depending on the temperature and monthly sunshine hours the trend of maximum, minimum temperature and monthly sunshine hours was analysed during pre- (1964-1985) and post- (1986-2008) implementation stages of BIADP (Fig. 1 to 11). To get real view of crop water requirement rainfall data was also analysed. To determine the difference of Cu, C.I.R the graphical representation was done for the periods of 1964-1985 and 1986-2008 for IRRI rice and wheat. Thus the each gradient represents the value of Cu, C.I.R for pre and post project respectively. The negative gradient of maximum and minimum temperature and positive gradient of rainfall indicates the positive input in Cu and C.I.R for crops. To determine the individual years Cu and C.I.R for the period of 1975-1984 and 1999-2008 at minimum and maximum temperature the values of Cu and C.I.R for individual years was plotted against years for each crop (Fig. 12 to 27). Statistical data of Cu and C.I.R was given for crops during 1964-1985 and 1986-2008 by taking the average value of temperature, sunshine hours, rainfall of February, March, April, May and June for IRRI rice; November, December, January and February for Wheat and Potato.

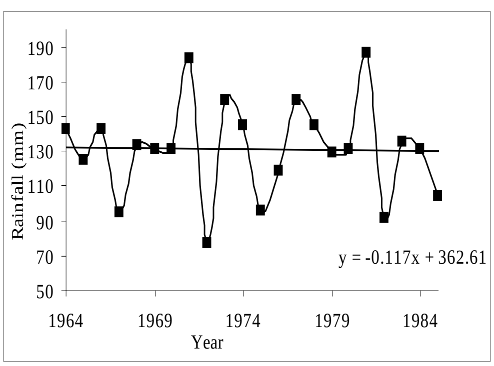

Figure 1 : Pre-project rainfall

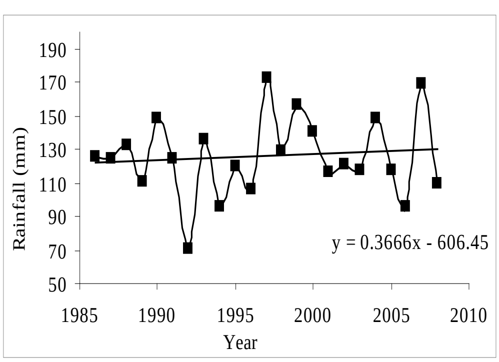

Figure 2 : Post-project rainfall

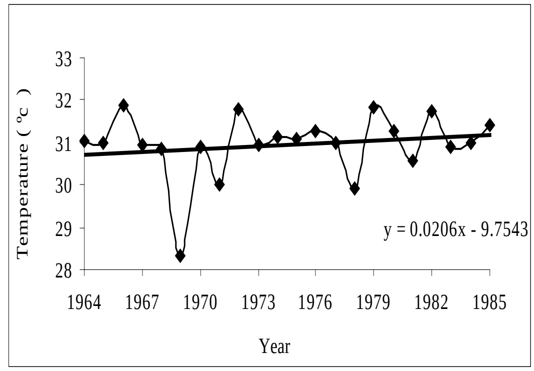

Figure 3 : Pre-project maximum temperature

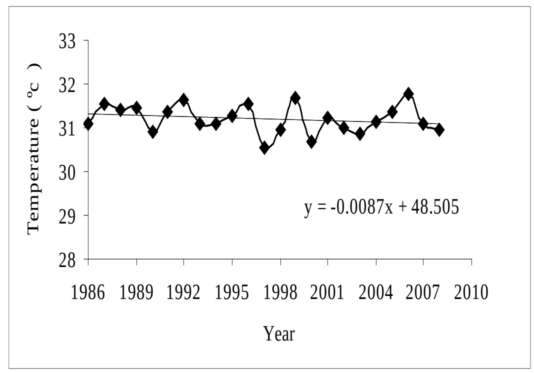

Figure 4 : Post-project maximum temperature

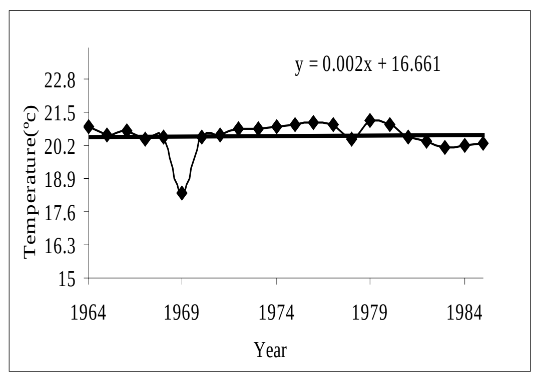

Figure 5 : Pre-project minimum temperature

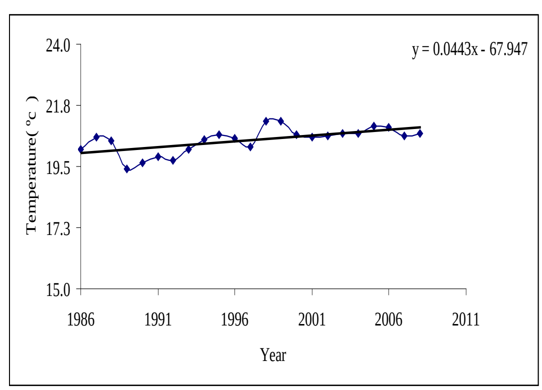

Figure 6 : Post-project minimum temperature

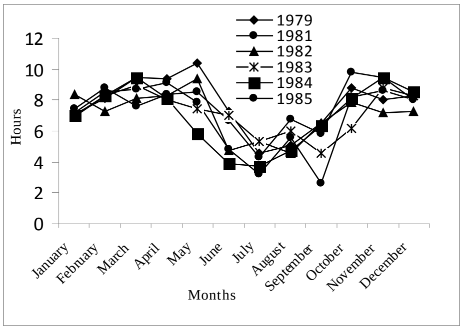

Figure 7 : Variation of monthly sunshine hours from 1979 to 1985

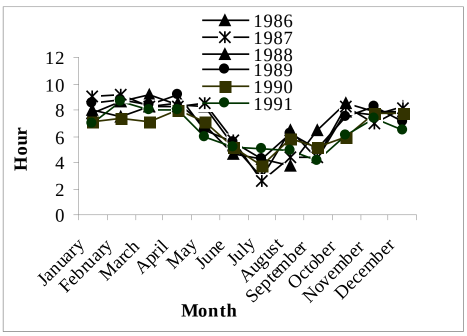

Figure 8 : Variation of monthly sunshine hours from 1986 to 1991

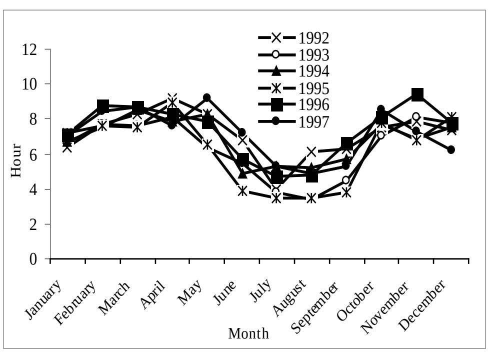

Figure 9 : Variation of monthly sunshine hours from 1992 to 1997

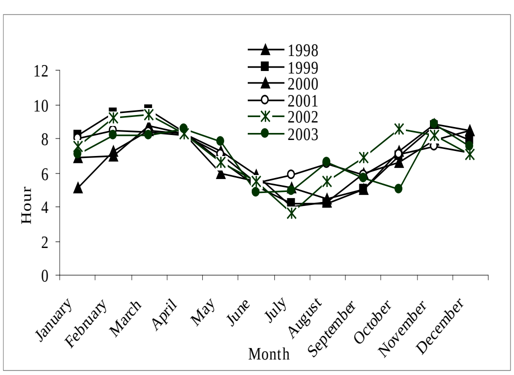

Figure 10 : Variation of monthly sunshine hours from 1998 to 2003

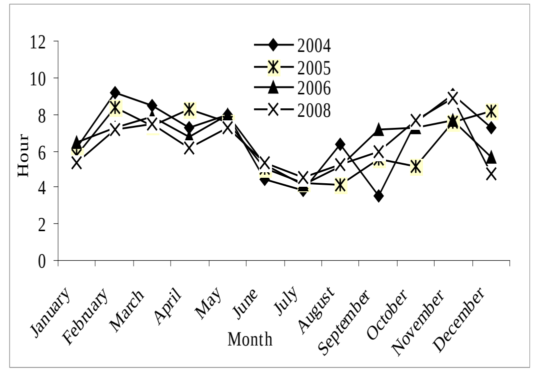

Figure 11 : Variation of monthly sunshine hours from 2004 to 2008

III. Graphical Representation and Discussion of Cu & C.I.R per Year (1975-1984,1999-2008)

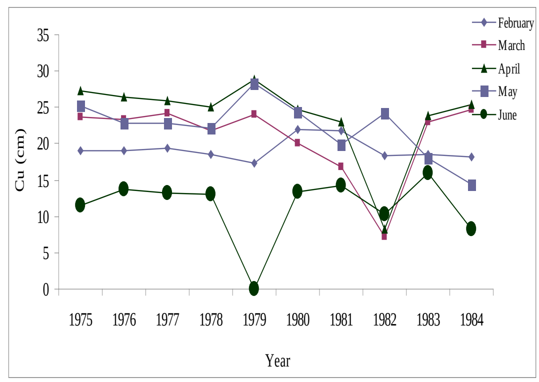

Figure 12 : Yearly variations of Cu for rice for maximum temperature (1975-1984)

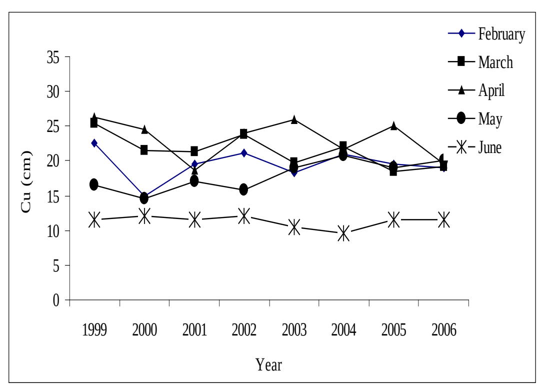

Figure 13 : Yearly variation of Cu for rice for maximum temperature (1999-2008)

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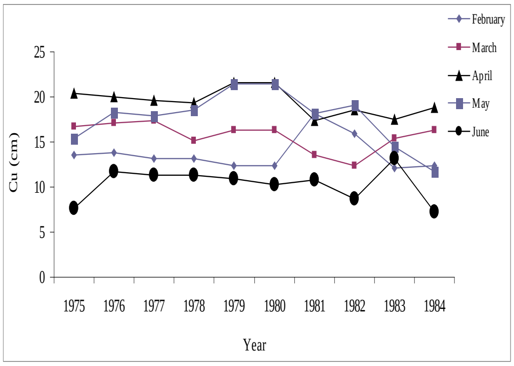

Figure 14 : Yearly Variation of Cu for Rice for minimum temperature (1975-1984)

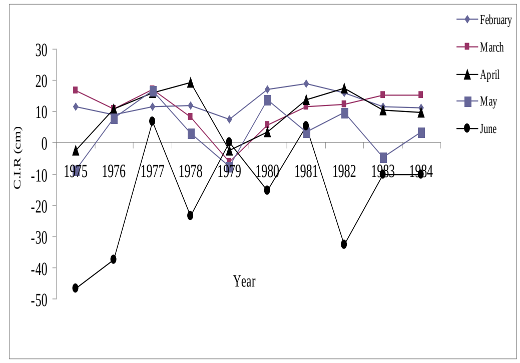

Figure 18 : Yearly Variation of C.I.R for rice for minimum temperature (1975-1984)

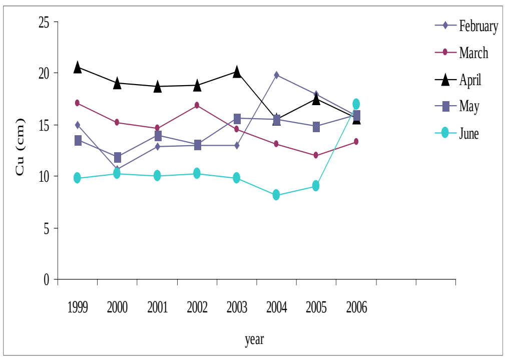

Figure 15 : Yearly variation of Cu for rice for minimum temperature (1999-2008)

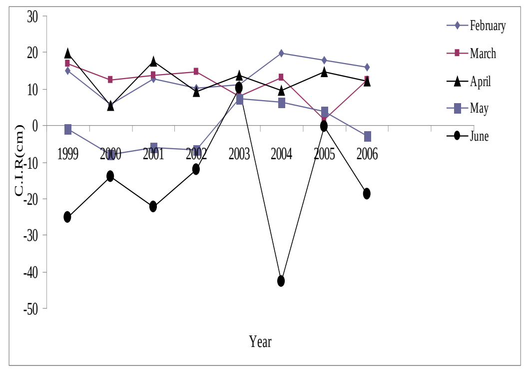

Figure 19 : Yearly variation of C.I.R for rice for minimum temperature (1999-2008)

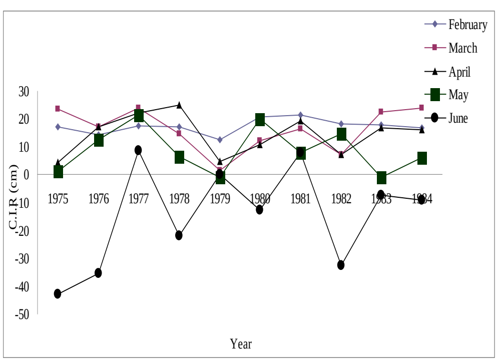

Figure 16 : Yearly variation of C.I.R for rice for maximum temperature (1975-1984)

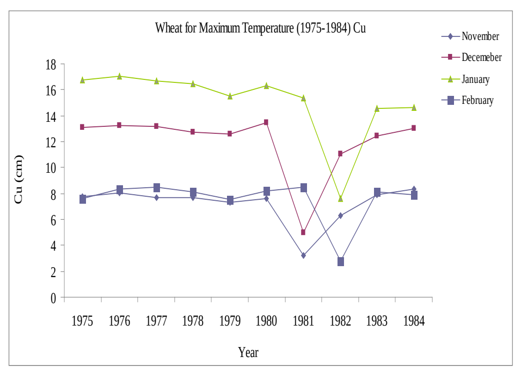

Figure 20 : Yearly variation of Cu for wheat for maximum temperature (1975-1984)

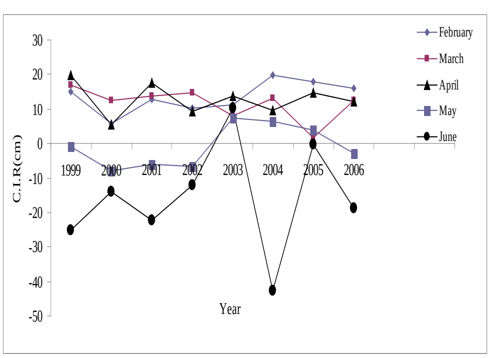

Figure 17 : Yearly Variation of C.I.R for rice for maximum temperature (1999-2008)

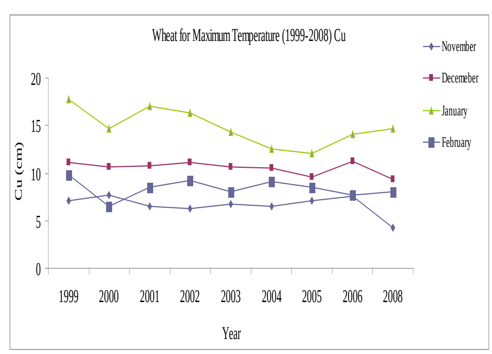

Figure 21 : Yearly variation of Cu for wheat for maximum temperature (1999-2008)

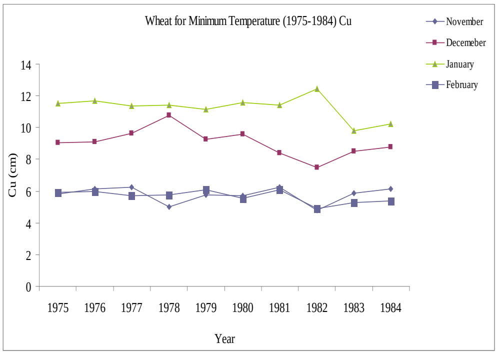

Figure 22 : Yearly variation of Cu for wheat for minimum temperature (1975-1984)

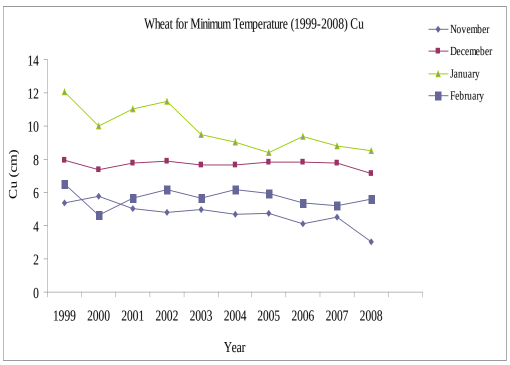

Figure 23 : Yearly variation of Cu for wheat for minimum temperature (1999-2008)

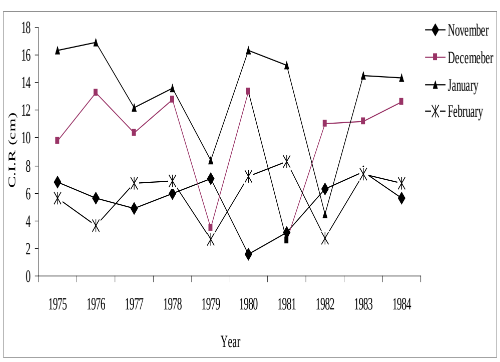

Figure 24 : Yearly variation of C.I.R for wheat for maximum temperature (1975-1984)

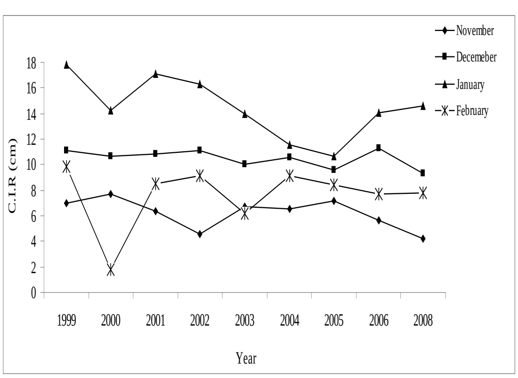

Figure 25 : Yearly Variation of C.I.R for wheat for maximum temperature (1999-2008)

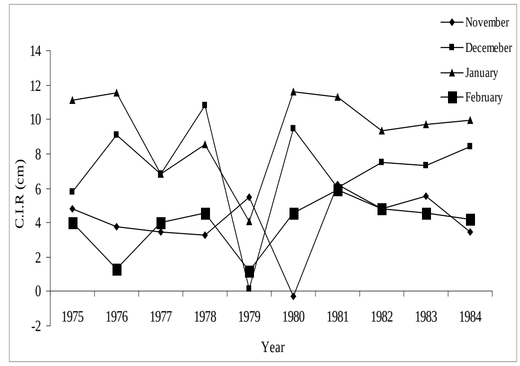

Figure 26 : Yearly variation of C.I.R for wheat for minimum temperature (1975-1984)

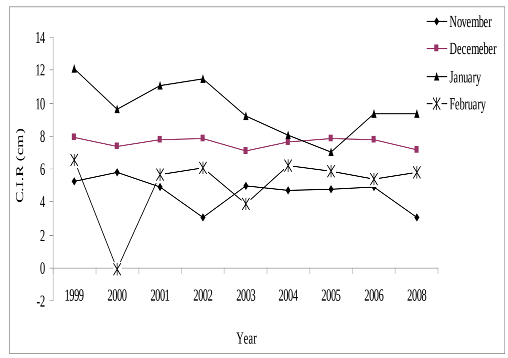

Figure 27 : Yearly Variation of C.I.R for wheat for minimum temperature (1999-2008)

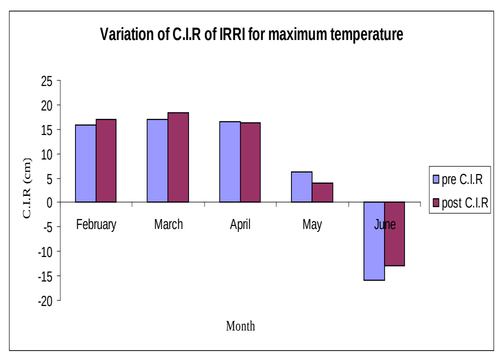

Figure 28 : Variation of C.I.R of rice for maximum temperature

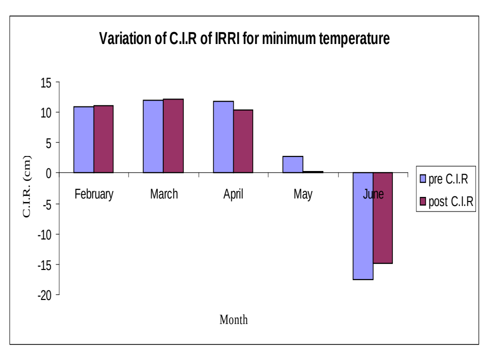

Figure 29 : Variation of C.I.R of rice for minimum temperature

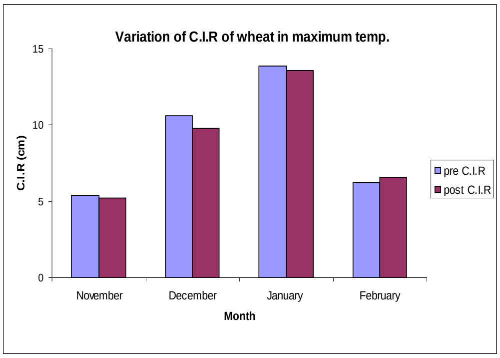

Figure 30 : Variation of C.I.R of wheat for maximum temperature

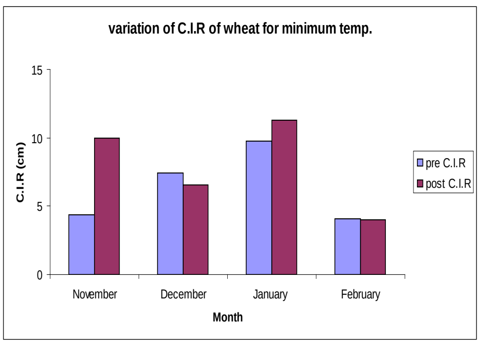

Figure 31 : Variation of C.I.R of wheat for minimum temperature

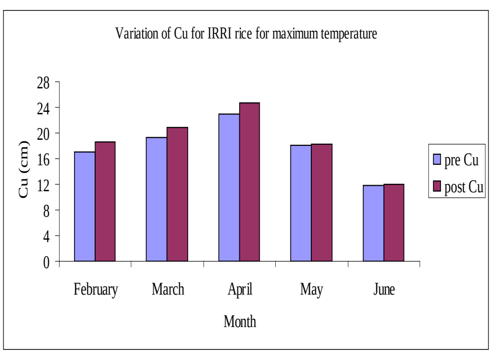

Figure 32 : Variation of Cu of rice for maximum temperature

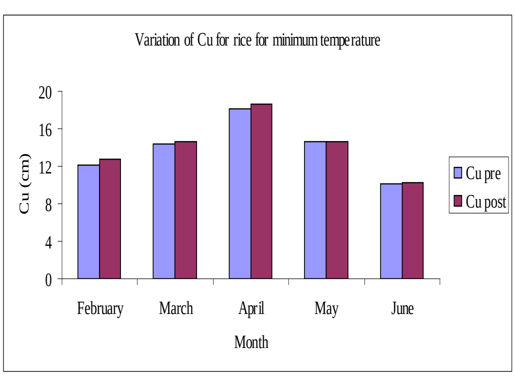

Figure 33 : Variation of Cu of rice for minimum temperature

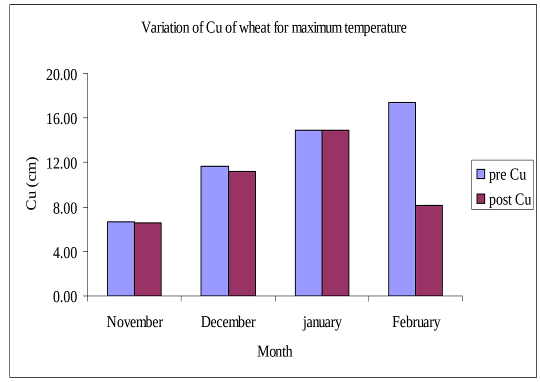

Figure 34 : Variation of Cu of wheat for maximum temperature

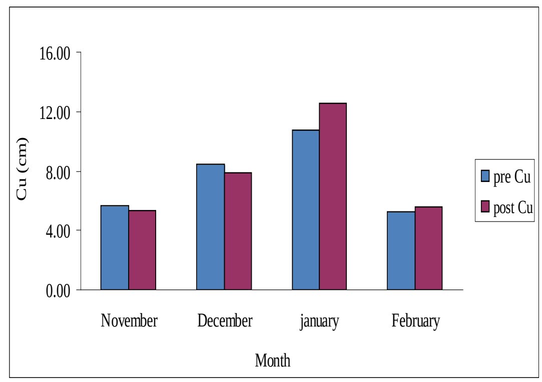

Figure 35 : Variation of C.I.R of wheat for minimum temperature

IV. Result and Discussion

Meteorological data analysis represents that before implementation of the project the rainfall was in decreasing trend and after implementation of the project it is increasing. Before implementation of the project maximum and minimum temperature was increasing this became in decreasing trend, after implementation of BIADP (Fig. 1 to 6).

Figure 7 represents that before 1985 the monthly sunshine hours was more than 10 hours in few months. On the contrary after 1985 the sunshine hour is less than 10 hours (Fig. 8 to 11).

The average value of Consumptive Irrigation Requirement (CIR) for IRRI rice during pre-project for maximum temperature for the month of February, March, April, May and June were 15.83 cm, 17cm, 16.52 cm, 6.22 cm and -15.81 cm respectively. The negative value indicates the excess of rainfall than Cu. On the contrary after implementation of the project for the same crops these values were 17.07 cm, 18.3 cm, 16.337 cm, 3.97 cm, and -13.02 cm respectively (Fig. 28).

The average value of CIR for IRRI rice for Barind area during pre-project at minimum temperature for the month of February, March, April, May, and June were 10.93 cm, 12.01 cm, 11.77 cm, 2.73 cm, -17.46c m, respectively and after implementation of the project for the same crops these values were 11.14 cm, 12.09 cm, 10.33 cm, 0.23 cm, -14.88 cm respectively (Fig. 29).

For Wheat, the average value of CIR before implementation of project at maximum temperature in the month of November, December, January, and February for Barind area were 5.40cm, 10.60cm, 13.85cm, 6.25cm respectively where after implementation of the project these values were 5.21cm, 9.89cm, 13.60cm, 6.56cm respectively (Fig. 30).

For Wheat, before implementation of project the average value of CIR value at minimum temperature for the month of November, December, January and February were 4.40cm, 7.44cm, 9.73cm, 4.10cm respectively where after implementation of the project at minimum temperature these values were 3.97cm, 6.53cm, 11.28cm, 3.97cm respectively (Fig. 31).

V. Conclusion

From the analysis of the meteorological data after implementation of BIADP the rainfall trend is increasing, maximum temperature and minimum temperature is decreasing and also a positive effect has been found for monthly sunshine hours.

The Consumptive use for rice and wheat was more before implementation of the project due to increased maximum, minimum temperature and sunshine hours which decreased after implementation of the project. The Consumptive Irrigation Requirement was decreasing at present due to increasing rainfall.

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Estimated Ecological Flow of the Preto River by the Wetted Perimeter Method

By Rodrigo Sanguedo Baptista
& Prof. Mônica De Aquino Galeano Massera Da Hora
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Keywords: ecological flow, wetted perimeter method, preto river.

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ESTIMATEDECOLOGICALFLOWOFTHEPRETORIVERBYTHEWETTEDPERIMETERMETHOD

Strictly as per the compliance and regulations of :

Estimated Ecological Flow of the Preto River by the Wetted Perimeter Method

Rodrigo Sanguedo Baptista [α] & Prof. Mônica De Aquino Galeano Massera Da Hora [σ]

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Keywords: ecological flow, wetted perimeter method, preto river.

I. Introduction

The rational use and preservation of water resources are vital elements of public policy. In Brazil, Law 9,433/1997 established the National Water Resource Policy, which includes a series of measures regarding the use of water resources for various purposes and preservation of the quantity and quality of water. In rivers, a minimum flow, called the ecological flow, is necessary to maintain the aquatic fauna. Although there is no consensus on the method to calculate this metric, it can be estimated by hydraulic methods that relate characteristics of the current and channel, considering reference flow values and including holistic methods based on economic values and habitat classification techniques to identify physical and environmental traits of the water course in question [1]. This article presents the ecological flow, estimated by two equations, to be considered for the Preto River, located in the Piabanha River Basin.

II. Piabanha River Basin

The Piabanha River Basin is located in the state of Rio de Janeiro (Figure 1). It covers approximately 4,484 km^2 and contains about 700 thousand inhabitants, in ten municipalities, of which six lie totally within the basin. The Piabanha River extends 80 km and passes through the municipalities of Petrópolis, Areal and Três Rios. The Preto River, with extension of 54 km, is its main tributary [2].

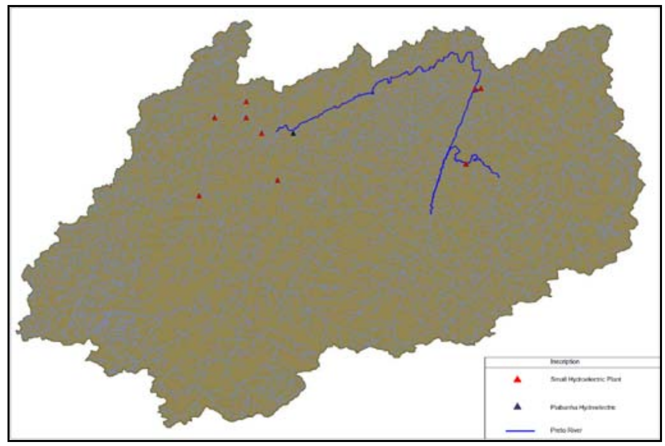

Figure 1 : Piabanha River Basin

III. Water Availability, Maximum Surface Water Withdrawal and Ecological Flow

The Preto River lies completely within the state of Rio de Janeiro, so according to Federal Law 9,433/1997, it is under state domain, with the Rio de Janeiro State Environmental Institute (INEA) having responsibility for its management. To grant water use rights, it is necessary to evaluate the water availability. This evaluation considers, among other factors, the maximum surface water withdrawal (MSW), which represents the maximum flow that can be taken from the river, or granted for use. The water availability is calculated by equation (1).

$$WA = MSW - \sum Q_{granted} - Q_{eco} \qquad (1)$$

Where WA is the water availability; MSW is the maximum surface water withdrawal; $\sum Q_{granted}$ is the sum of the flows granted for use upstream of the point studied and Q_{eco} is the ecological flow, defined as 50% of $Q_{7,10}$. $Q_{7,10}$ is defined as the smallest average flow occurring during a period of 7 consecutive days in a period of 10 years of recurrence.

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IV. Wetted Perimeter Method and Premises Adopted

The wetted perimeter method is based on the existence of a direct relation between the wetted perimeter and the availability of habitats for ichthyofauna [1]. This method assumes there is a relation between the wetted perimeter and the habitat availability [3].

To apply this method, we relied on data from the Fazenda Sobradinho stage gauge (code 58420000), located on the Preto River. These data are stored in the HidroWeb database [4]. Table 1 presents the descriptive information on this post.

Table 1: Descriptive information on the Fazenda Sobradinho stage gauge

Code	58420000
Name	FAZENDA SOBRADINHO
Sub-basin	PARAÍBA DO SUL RIVER (58)
River	PRETO RIVER
State	RIO DE JANEIRO
Municipality	TERESÓPOLIS
Latitude	-22:12:1
Longitude	-42:54:4
Altitude (m)	700
Drainage Area (km^2)	719

Source : ANA (2013)

The lowest flow value measured at the Fazenda Sobradinho stage gauge occurred on September 23, 1955. This flow and the associated hydraulic variables are reported in Table 2.

Table 2 : Discharge Measurement on September 23, 1955

Depth (cm)	Flow (m^3/s)	Wetted area (m^2)	Width (m)	Average current speed (m/s)
28	2.76	20.4	19	0.135

Source: ANA (2013)

However, the cross-section data available in the HidroWeb database do not include data for 1955, making it necessary to identify a cross section corresponding to the lowest flow in the historic series, which was September 9, 1997. It is important to stress that the use of the minimum flow values measured is based on the premise that the ecological flow must be present in all natural flows of the river, i.e., it is expected to be lower than or equal to the lowest flow measured/observed in the river. The information regarding this cross section, measured on September 9, 1997, is shown in Table 3.

Table 3 : Discharge Measurement on September 9, 1997

Depth (cm)	Flow (m^3/s)	Wetted area (m^2)	Width (m)	Average current speed (m/s)
53	6.12	18.8	23	0.326

Source : ANA (2013)

We superimposed the cross sections to note any relevant modification over the years for which data were available. This analysis is important, because if the cross section has undergone a considerable change, it means the cross section used as the baseline will not be an accurate representation to allow correlation with information for previous years. Figure 2 presents the overlapped cross sections avaialable in the database.

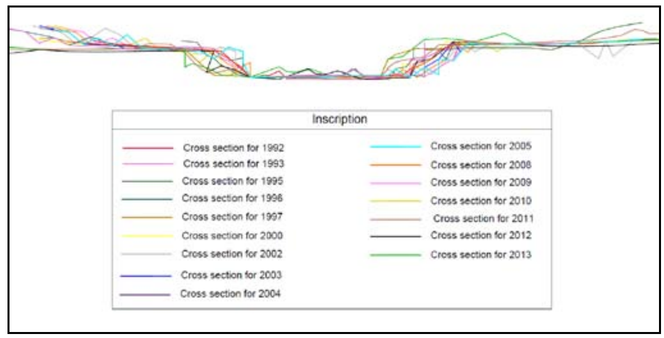

Figure 2 : Superimposed cross sections

Observation of Figure 2 shows the cross section did not undergo any relevant modifications over time. Figure 3 below depicts the cross section for 1997, plotted with Autocad 2013, for which distinct wetted areas, and hence wetted perimeter values, could be extracted based on the water depth.

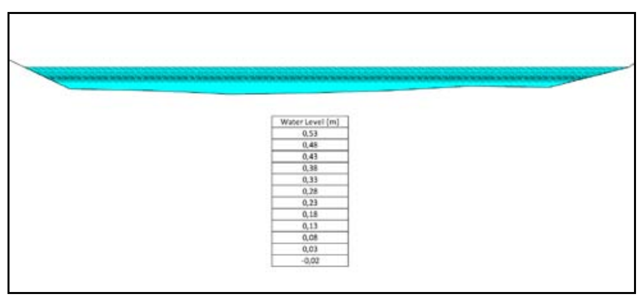

Figure 3 : Detail of the cross section for 1997

To calculate the ecological flow by the wetted perimeter method, we adopted the following premises [5]:

- Permanent and uniform flow, i.e., the flow is equal to the product of the wetted area and the average current speed. The average speed was defined as that corresponding to the lowest flow recorded in the historic series of net discharge measured at the Fazenda Sobradinho stage gauge.

- Definition of the critical point based on the maximum curvature [3].

Table 4 shows the flow results obtained by multiplying the wetted area by the current speed selected.

Table 4 : Flows obtained for each wetted area

Depth (cm)	Flow (m^3/s)	Wetted area (m^2)	Width (m)	Average speed (m/s)	Wetted perimeter (m)
53	2.38	17.65	22.71	0.135	23.00
48	2.23	16.52	22.41	0.135	22.68
43	2.08	15.41	22.11	0.135	22.36
38	1.93	14.31	21.80	0.135	22.04
33	1.79	13.23	21.50	0.135	21.72
28	1.64	12.16	21.20	0.135	21.40
23	1.50	11.11	20.90	0.135	21.09
18	1.36	10.07	20.60	0.135	20.77
13	1.22	9.05	20.30	0.135	20.45
8	1.09	8.04	19.99	0.135	20.13
3	0.95	7.05	19.69	0.135	19.81
-2	0.82	6.07	19.39	0.135	19.41

From the data in Table 4, we plotted a graph relating the flows and the corresponding wetted perimeters. According to [3], the ecological flow is the flow value corresponding to the highest slope present in this curve. To determine this point, [3] suggest using the maximum curvature method, for which purpose it is necessary to define the function that best fits the points on the graph. For this, as in [3] we used Manning's formula:

$$Q = \frac{1}{n} \cdot A \cdot R^{2/3} \cdot S^{1/2} \qquad (2)$$

Where Q is the flow; n is the Manning's roughness coefficient; A is the wetted area of the water course's cross section; R is the hydraulic radius and S is the water surface slope.

The geometry of river cross sections normally varies between roughly rectangular and triangular [6]. According to [3], from equation (1), for channels with rectangular and trapezoidal cross sections, the best approximation of the relation between the wetted perimeter and flow is given by a logarithmic function, represented by equation (3).

$$PM = a \cdot \ln(Q) + 1 \qquad (3)$$

According to [3], for channels with triangular cross sections, the best approximation of this relation is given by a power function represented by:

$$PM = Q^b \qquad (4)$$

From observation of Figure 2, it can be perceived that the cross section used to calculate the ecological flow is rectangular, so we used the logarithmic function to approximately fit the points on the graph. However, in Brazil the usual practice is to use a power function to relate the hydraulic characteristics of a cross section with flow, as recommended by [6]. Therefore, we employed both logarithmic and exponential equations to represent the relation between the flow versus wetted perimeter values, allowing comparison of the ecological flow results.

V. Results

We first plotted a graph of flow versus wetted perimeter by fitting a logarithmic trend line (Figure 4).

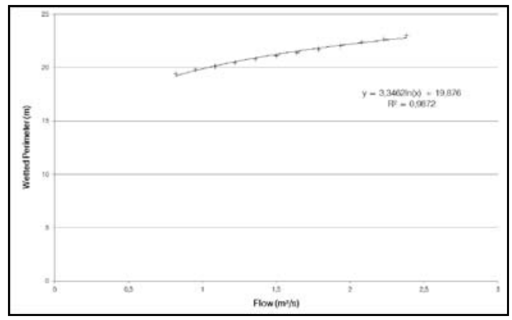

Figure 4 : Flows and wetted perimeters approximated by the logarithmic function

From equation (3) we used a scale factor to normalize the two axes of the graph, so that both ranged from zero to one, as shown in Figure 5.

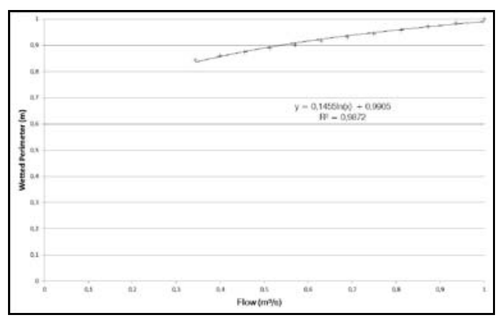

Figure 5 : Flows and wetted perimeters according to the scale factor

We fitted the same points by the power function, for subsequent comparison of the results produced by the two curve-fitting techniques. The resulting graph is shown in Figure 6.

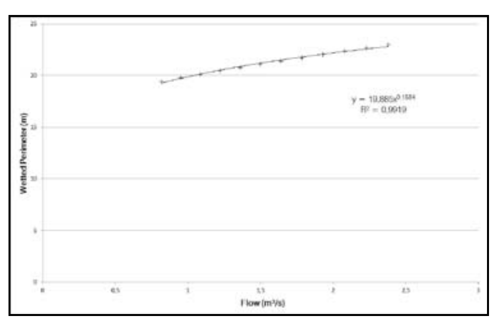

Figure 6 : Flows and wetted perimeters approximated by the power function

The curvature (k) is the rate at which a curve's slope changes. It is a function of the angle formed by the tangent line to the curve with the x-axis and the arc length [3], expressed by equation (5).

$$k = \frac{\frac{d^2y}{dx^2}}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}} \quad (5)$$

Where $\frac{d^2y}{dx^2}$ is the second derivative of the wetted perimeter in relation to flow; $\frac{dy}{dx}$ is the first derivative of the wetted perimeter, in m, in relation to flow, in m³/s.

To find the curvature of a logarithmic function, equation (6) is used, while to find the curvature of a power function, equation (7) is used.

$$|k| = \frac{\left|\frac{-a}{Q^2}\right|}{\left[1+\left(\frac{a}{Q}\right)^2\right]^{3/2}} \quad (6)$$

$$|k| = \frac{\left|b \cdot Q^{b-2}\right|}{\left[1+\left(b \cdot Q^{b-1}\right)^2\right]^{3/2}} \quad (7)$$

Where |k| is the absolute value of the curvature; Q is the flow; b is the exponent of equation (4) and a is the number that multiplies ln(Q) in equation (3).

By applying these two equations, we identified the points of greatest curvature, resulting in a flow equal to 0.206 m³/s for the logarithmic approximation and of 0.034 m³/s for the exponential approximation.

To help compare the order of magnitude of the ecological flow values resulting from application of the hydraulic method, we calculated the ecological flow adopted as a criterion by the INEA, namely 50%$Q_{7,10}$ (using the free software avaialable at [4]). Table 5 presents the results obtained.

Table 5 : Ecological flow results

$Q_{7,10}$ (m³/s)	50%$Q_{7,10}$ (m³/s)	Function	
		Logarithmic	Power
3.75	1.88	0.206	0.034

VI. Conclusion

Based on the ecological flow results calculated by the wetted perimeter method, it can be seen that these are lower than the ecological flow value adopted by INEA (50%$Q_{7,10}$). Therefore, the results can be classified as satisfactory. One of the difficulties encountered during this study was the shortage of data on cross sections, since the results would have more closely reflected the real situation of the cross section for September 23, 1955 had been available, when the lowest flow was recorded in the historic series.

In closing, as mentioned earlier, there is still no consensus on the best method to calculate a river's ecological flow, so further research is necessary, given the importance of this subject for environmental studies and water resource management policies.

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Engineering Applications of the Newly Available Roughness-Length Measurements by AOML at 213 ASOS Stations

By S. A. Hsu
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Abstract- Most recently, the Hurricane Research Division of the U. S. Atlantic Oceanographic and Meteorological Laboratory (AOML) has made extensive surveys of the roughness length (Zo) in each of the 213 Automated Surface Observation Stations (ASOS) located in tropical-cyclone prone regions. The original 8 values of Zo for each of the 45 degree segments within the 360 degree compass in each ASOS station are averaged geometrically to obtain one typical value for each of these 213 ASOS stations. Six ASOS stations are verified independently by the gust factor method during 5 hurricanes. Since the difference is within the 10 % composite accuracy for field measurements in wind speed, the computed geometric mean Zo values for each of the 213 ASOS stations are recommended for practical use. Applications of the proposed geometric mean Zo value to estimate the 3-second gust, peak gust, and peak factor during Hurricane Katrina are also provided for engineers as an example.

Keywords: roughness length; hurricanes; asos stations, turbulence intensity; power-law exponent; gust factor; peak factor.

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ENGINEERINGAPPLICATIONSOFTHENEWLYAVAILABLEROUGHNESSLENGTHMEASUREMENTSBYAOMLAT213ASOSSTATIONS

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Keywords: roughness length; hurricanes; asos stations, turbulence intensity; power-law exponent; gust factor; peak factor.

I. Introduction

Most recently, in its "Tropical Cyclone Wind Exposure Documentation Project", the Hurricane Research Division (HRD) at the Atlantic Oceanographic and Meteorological Laboratory (AOML), U. S. National Oceanic and Atmospheric Administration (NOAA), has made an extensive survey and monitoring of the roughness length (Zo) at 213 Automated Surface Observation Stations (ASOS). Most ASOS are located at hurricane-prone airports (see www.aoml.noaa.gov/hrd/asos/index.html). Because Zo is a parameter needed for wind and turbulence estimates for civil, structural and environmental engineers (see, e.g., Hsu, 2013), the purpose of this study is to utilize these newly available Zo measurements by AOML for engineering applications.

II. Geometric Mean zo for each ASOS Environment

According to AOML the 360 degree compass for the wind direction measurement is divided into 8 segments so that there is one Zo value for each 45 degrees at each ASOS. These 8 Zo values may be needed for aviation safety reasons. However, since the wind direction in a tropical cyclone is rotational in nature and since the strongest wind may come from any direction, it is not necessary for practical operation to have 8 Zo for each ASOS. Instead, a typical Zo value or the geometric mean for each ASOS is needed for most engineering applications. Therefore, the original list which consists of 8 Zo values for each ASOS is geometric averaged. Our results are provided in the Appendix with one geometric mean Zo for each of the 213 ASOS.

III. Validating the Relation between zo, Gust Factor and Turbulence Intensity

According to Panofsky and Dutton (1984, pp.130-131), it is common in engineering practice to describe the variation of the wind speed with height, i.e. the wind profile with a power law such that

$$U_2 / U_1 = (Z_2/Z_1) \wedge p \qquad (1)$$

According to Hsu (2008),

$$P = 0.2996\ Zo \wedge 0.168 \qquad (2)$$

Where U_2 and U_1 are the wind speed at height Z_2 and Z_1, respectively, p is the power-law exponent, and Zo is the roughness length.

Now, for each ASOS Station the appropriate value of p based on Eq. (2) is also provided in the Appendix.

According to Hsu (2013), for 5 second gust over the 2 minute duration, which is available routinely from the wind speed measurements by ASOS, we have

$$G = 1 + 2.04\ P \qquad (3)$$

$$= 1 + 2.04\ TI \qquad (4)$$

Where G is the gust factor (the ratio of 5-s gust to 2-min sustained wind speed) and TI represents the longitudinal turbulence intensity.

A forementioned equations are validated as follows :

a) Composite Field Accuracy for Wind Speed Measurements

In order to validate Equations (1) thru (4), one must first determine the composite field accuracy for the

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wind speed measurements. According to U. S. National Data Buoy Office (see http://www.ndbc.noaa.gov/rsa.shtml), The composite accuracy of field measurements for the wind speed and wind gust is +/- 10 %. In other words, if the difference between measurements and estimates related to wind and gust characteristics is within 10 %, one may accept those estimates as reasonable. Note that this 10 % margin of error can also be related to the different anemometers used in the field. An example is shown in Table 1.

Table 1 : Comparison of generated longitudinal turbulence intensity (TI) from different anemometers during Hurricane Bonnie in 1998

(1). UVW anemometer	(2). Propeller-Vane anemometer	Difference between (1) and (2)	Mean TI between (1) and (2)
0.175	0.195	10 %	0.185

(Data source: Schroeder, 1999)

b) Validation during Hurricane Bonnie in 1998

On the basis of Tables 2 and 3 and Fig.1, we can say that the geometric mean Zo for KILM as listed in the Appendix is valid for engineering applications. Furthermore, it is shown that p = TI.

Table 2 : Comparisons of wind speed measurements by ASOS and Texas Tech University at Wilmington Airport (KILM), North Carolina, USA, during Hurricane Bonnie in 1998

	ASOS Station	Texas Tech Station
0.2-Second Gust (m/s)	NA	38.2
3-Second Gust (m/s)	NA	33.6
5-Second Gust (m/s)	32.9	33.5
1-minute Sustained (m/s)	NA	25.0
2-minute Sustained (m/s)	25.2	24.4

(Data Source : Schroeder, 1999).

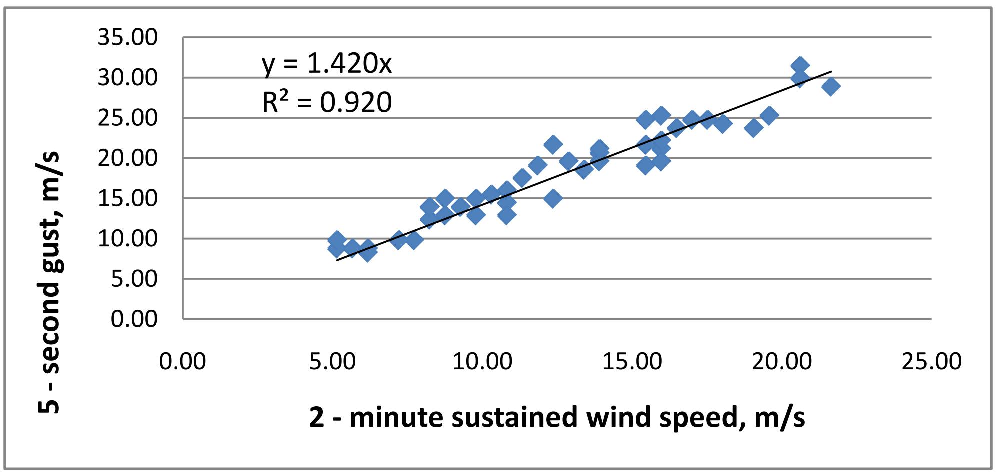

Figure 1 : Wind speed and gust measurements at ASOS Station at Wilmington Airport, N.C., USA, during Hurricane Bonnie in 1998

Table 3 : A comparison of measurements against 3 estimates of p using Eq. (3) and the geometric mean of Zo from Appendix at Wilmington Airport during Hurricane Bonnie in 1998

Source	(1). P based on either measured or estimated	(2). P from Appendix for KILM	Difference between (1) and (2)
UVW, Table 1	0.175	0.185	0.054
Prpeller-vane, Table 1	0.195	0.185	0.051
ASOS, Table 2	0.150	0.185	0.189
TTU, Table 2	0.183	0.185	0.011
Fig. 1	0.206	0.185	0.102
Mean	0.182	0.185	0.016

c) Validation during Hurricane Katrina in 2005

According to Henning (see http://ams.confex.com/ams /pdfpapers/108816.pdf), when Katrina was coming ashore near Pass Christian, MS, the aircraft measure- ments of maximum wind speed was 68.4 m/s at 350 m and at the near-surface (77m) it dropped down to 47 m/s. Therefore, according to Eq. (1), we have

$$(68.4/47) = (350/77)\ \hat{}\ p$$

$$\text{So that } p = \text{Ln}(68.4/47)/\text{Ln}(350/77) = 0.248 \qquad (5)$$

Since this value is identical to that at KASD for Slidell Airport, LA (which is not very far from Pass Christian), as provided in the Appendix, we can say that the geometric mean Zo for KASD is verified for practical use. Note that, during Katrina, nearly all surface wind measurements were not available because of massive power failure. Therefore, these aircraft measurements by U.S. Air Force Hurricane-Hunters are greatly appreciated.

d) Validation during Hurricane Rita in 2005

In 2005 Hurricane Rita passed near Lake Charles, Louisiana, USA. On the basis of Fig. 2 and Eq.

(3), P = 0.172. According to the Appendix for KLCH, p = 0.182. Since the difference between these two p values is 5.5 %, we can say that the mean geometric Zo value and the computed p value are validated.

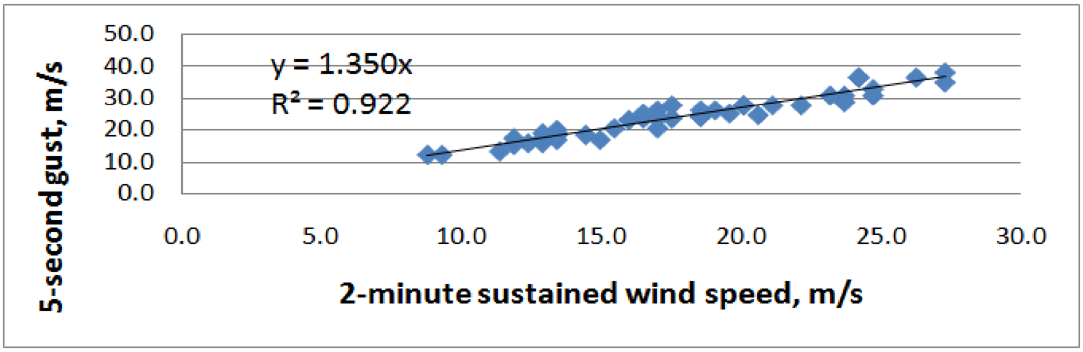

Figure 2 : Relation between sustained wind speed and gust on 23 Septmber 2005 at Lake Charles, Louisiana, USA during Hurricane Rita

e) Validation during Hurricane Ike in 2008

In 2008 Hurricane Ike passed over Houston, Texas, near an instrumented tower operated by Texas A & M University. According to Schade (2012), the mean Zo = 1m and p = 0.29. Substituting these values into Eq. (1), we have p = 0.2996. Since the difference between 0.29 and 0.2996 is approximately 3 %, we can say that Eq. (1) is further verified.

Now, according to Fig.3 and Eq. (3), p = 0.180. Since this value is nearly equal to that of 0.177for KHOU as shown in the Appendix, we can say that the geometric mean Zo for KHOU is validated.

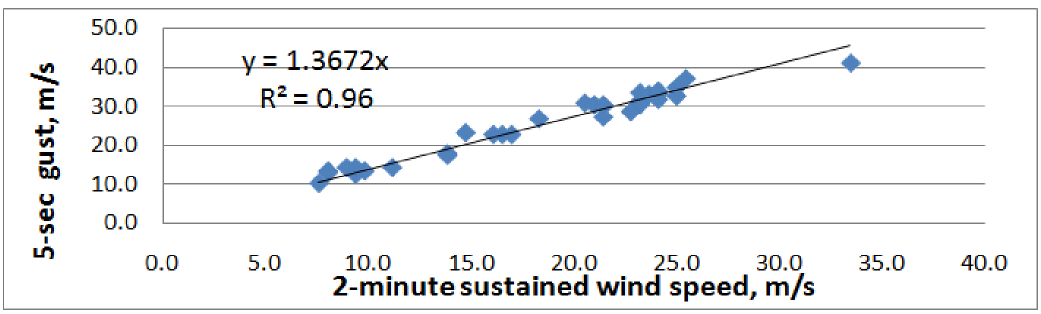

Figure 3 : Relationship between sustained wind speed and gust on 12-13 September 2008 in Houston Hobby Airport during Hurricane Ike

f) Validation during Hurricane Isaac in 2012

In 2012 Hurricane Isaac passed near New Orleans International Airport (KMSY), Louisiana,USA. This gave us the opportunity to validate the geometric mean Zo for p = 0.225 as shown in the Appendix. On the basis of Fig. 4 and Eq. (3), p = 0.239. Since the difference between p = 0.225 and p = 0.239 is approximately 5.9 %, we can say that the geometric mean Zo value as computed in the Appendix is acceptable for engineering applications. Another validation during Isaac is done in Fig. 5. Based on Fig. 5 and Eq. (3), p = 0.239. Since the difference between this value and that shown in the Appendix for KBVE, where p = 0.219, is 8.4 %, we can say that the geometric mean Zo provided in the Appendix for KBVE is validated.

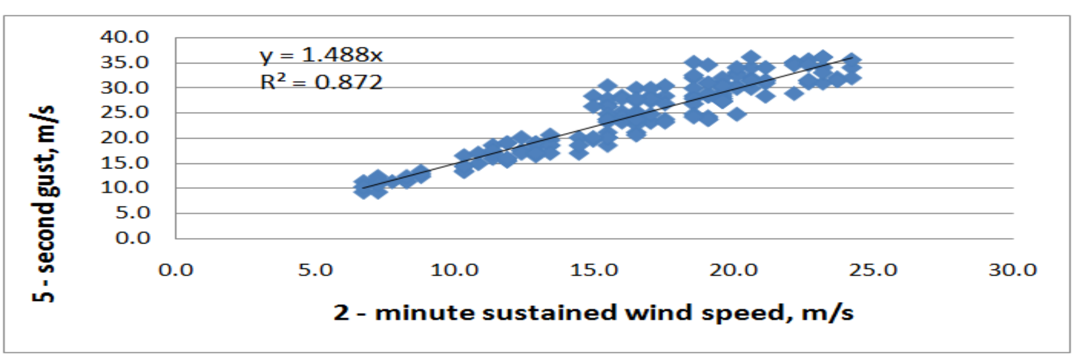

Figure 4 : Relation between sustained wind speed and gust from 27 to 30 August 2012 at New Orleans International Airport (KMSY) , Louisiana, USA during Hurricane Isaac

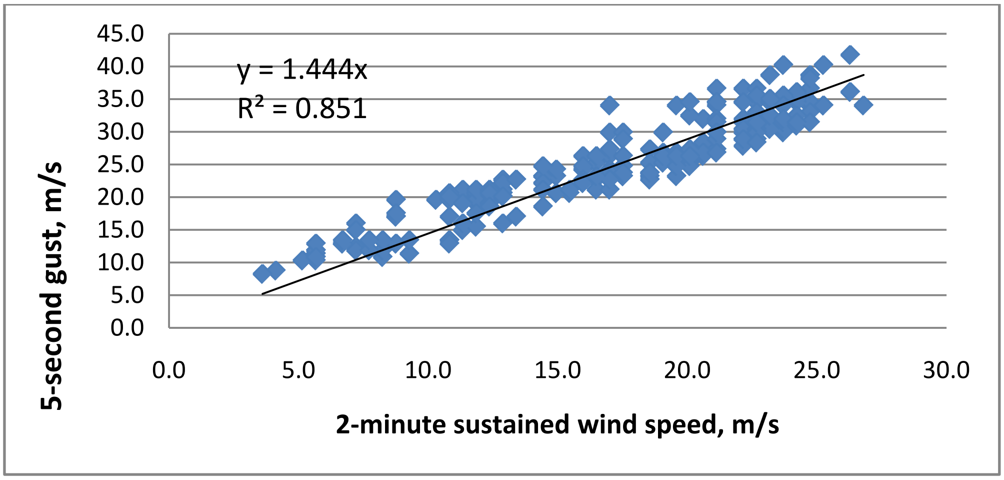

Figure 5 : Relation between sustained wind speed and gust from August 27 to 30, 2012 at Boothville (KBVE),Louisiana, USA during Hurricane Issac

IV. Applications: A Case Study During Hurricane Katrina in 2005

Since the information on both 3-second and peak gusts are needed for wind load analyses (see, e.g., Irwin, 2006) and since some data during Katrina are available, we can use Katrina as a case study. This is done as follows :

a) Application to estimate 3-second gust

In 2005 Hurricane Katrina devastated northern Gulf of Mexico including New Orleans, Louisiana and Waveland and Bay St. Louis, Mississippi, USA. Numerous infrastructures including the Louisiana Superdome were destroyed or damaged.

According to the Hurricane Katrina Post-Tropical Cyclone Report (http://www.srh.noaa.gov/lix/?n=psh_katrina) by the National Weather Service (NWS) in New Orleans,LA, there was an ASOS station located at 50 feet (or 15.2 m) over Lake Pontchartrain. That station recorded max 2-min sustained wind speed of 68 knots (35.1 m/s) and 5-second gust of 86 knots (44.3 m/s). Therefore, according to Eq. (3), p = 0.130. According to Hsu (2013) and Fig. 6, the gradient height over the Lake was 309 m so that the wind speed at 309 m is estimated to be

$$U_{309m} = U_{15.2m}(309/15.2)\text{^}\ 0.13 = 35.1*1.48 = 51.9\ m/s \quad (6)$$

Now, according to the Appendix, p = 0.225 for New Orleans International Airport (KMSY). Substituting this p value into the equation provided in Fig. 6, the gradient height over KMSY is estimated to be 467m. Therefore, based on Eq. (6), the 2-minute sustained wind speed over KMSY at the elevation of 467m was 51.9 m/s during Katrina. Although much of the data were not available due power failure during Katrina, there were two peak wind speed measurements located at 120 and 30 feet (36.6 and 9.1m), respectively.Thus, we can compare our estimates against the measurements. This is done as follows:

$$U_{36.6m} = U_{467m}\,(36.6/467)\text{^}0.225 = 51.9*0.564 = 29.3\ m/s,$$

therefore the 3-second gust based on Eq. (3) is

$$U_{36.6m,3\text{-}s} = 29.3*(1+2.04*0.225) = 42.7 m/s \quad (7)$$

Similarly,

$U_{9.1m} = U_{467m}(9.1/467)\text{^}0.225 = 51.9 * 0.412 = 21.4$ m/s, and

$$U_{9.1m,3\text{-}s} = 21.4*(1+2.04*0.225) = 31.2\ m/s \quad (8)$$

These results can be used to compare the two gust measurements made around the New Orleans International Airport during Katrina as provided in the website as quoted above. This is done in Table 4.Since the difference between estimated and measured is 5.5 % or less, the methods provided in this study should be useful in engineering applications.

Table 4 : Comparison of estimated and measured 3-second gust around New Orleans International Airport during Katrina

Height, m	Estimated, m/s	Measured, m/s	Difference In per cent
36.6	42.7 from Eq.(7)	43.8 From NWS	2.5 %
9.1	31.2 From Eq.(8)	33.0 From NWS	5.5 %

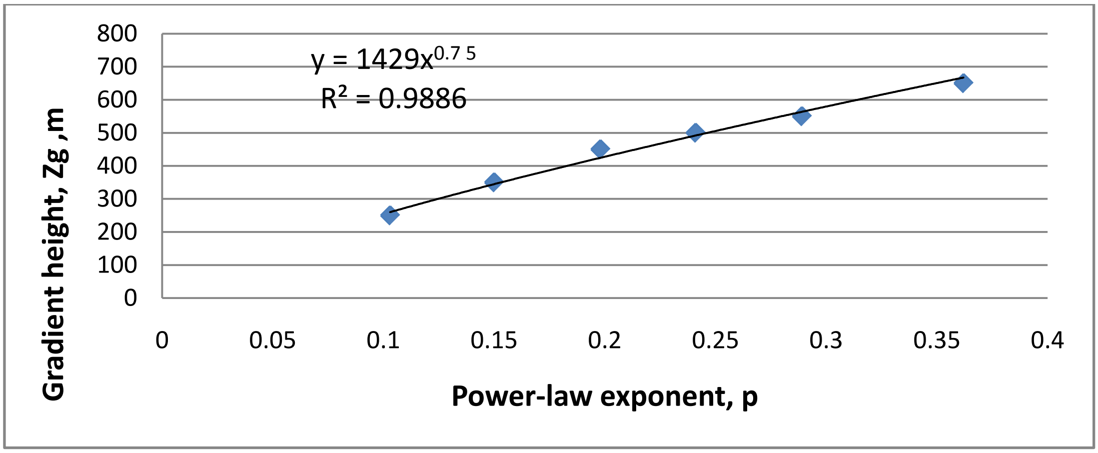

Figure 6 : Relationship between the gradient height and power-law exponent (Data source: Choi, 2009)

b) Application to estimate peak gust

As stated in 3.3 above, massive power outage made most ASOS stations out of order during Hurricane Katrina in 2005. Even though, some measurements of peak gust from non-ASOS stations were available for this study. They were:

1. Eastern New Orleans – NASA Michoud Facility, wind equipment at 40 feet (12.2 m), at Gage 2, the peak wind was 107 knots (55.2 m/s) measured at 1415UTC on 29 August 2005; and
2. Eastern New Orleans – Air Product Facility, wind equipment at 30 feet (9.1 m), the peak wind was 104 knots (53.6m/s) measured at 1400UTC on 29 August 2005.

A question was raised by some civil and structural engineers during their hurricane-damage assessment whether these peak gust measurements were for 3-second or less.In order to answer this question, we need to know the one-minute sustained wind speed measured in the general area and near the same time. Fortunately, there were two experimental wind towers set up specifically to study the hurricane impacts in the general area. One was operated by Florida International University (FIU) at Belle Chase to the south of Eastern New Orleans. The FIU10 m tower recorded the one-minute sustained wind speed of 68 knots (35.1 m/s) at 1427UTC and the 3-second gust of 89 knots (45.9 m/s) at 1132UTC on the same day.The other was operated by the Texas Tech University (TTU) at Slidell to the north of Eastern New Orleans. The TTU 10-m tower measured 61 knots (31.4 m/s) for the sustained wind speed and 87knots (44.8 m/s) for the 3-second gust. Since the peak gusts in the Eastern New Orleans area exceeded 104 knots (53.6 m/s), which was much stronger than the 3-s gust as measured both by FIU and TTU, the measured period must be less than 3-s.

Now, according to Hsu (2008), the maximum instantaneous gust (U_{max}) can be approximated by

$$U_{max} = U_{1\text{-}min} (1 + 3 p) \qquad (9)$$

According to Choi (2009) and Hsu (2013), the terrain category for Eastern New Orleans area may be represented as Category III (for the suburban) so that p = 0.198. By substituting this p value and the averaged $U_{1\text{-}min,}$ which is (35.1 +31.4)/2 = 33.3 m/s into Eq. (9), we have

$$U_{max} = 33.3*(1+3*0.198) = 53.0 \text{ m/s} = 103 \text{ knot} \qquad (10)$$

This estimated value is in good agreement with those measured value which ranged from 53.6 to 55.2 m/s or from 104 to 107 knots. Therefore, the answer to the questions raised by the civil and structural engineers is that those "peak gust" measurements in the Eastern New Orleans area as provided in its Hurricane Katrina – Post Tropical Cyclone Report by the National Weather Service in New Orleans were in fact not the 3-second gust but the maximum instantaneous gust, which represents the 3 standard deviation or within the top 1 % probability.

c) Application to estimate peak factor

Depending on anemometer system and averaging period, each dataset for the wind speed measurement consists of the duration of sampling such as 1 minute (e.g. see Table 2), 2 minutes (such as from ASOS station),10 minutes, or even one hour. Within this sampling duration, there is a maximum or peak gust, which represents the shortest period of measurement such as 0.2 second as shown in Table 2. Therefore, the generic formula similar to Eq. (9) is

$$U_{peak} = U_{duration} (1 + A p) \qquad (11)$$

$$\text{Or, } A = (U_{peak} / U_{duration} - 1) / p \qquad (12)$$

Where "A" is the peak factor.

An example is provided as follows:

According to Table 2, the maximum 1- min wind speed was 25.0 m/s and the max 0.2-second 38.2 m/s.

According to Table 1, p= 0.185, substituting these values into Eq. (12), we get A = 2.85. Since the difference between 2.85 and 3 (see Eq. 3) is 5 %, we can say that the 0.2-second gust measurement is near the top one per cent during a one minute period. Statistically, one can also get this "A" value from the ratio of 0.2 second and one minute such that 0.2/60 = 0.0033 or within the top 1 % probability. Furthermore, from statistics (see, e.g., Spiegel, 1961, p.343), (1-0.2/60)/2 = 0.4983 so that "A" = 2.93 for areas under standard normal curve from zero to z, where z is our peak factor. Note that this value of 2.93 is even closer to 3 as shown in Eq. (9).

V. Conclusions

On the basis of aforementioned analyses and discussions, several conclusions may be drawn:

1. Because of the instrument response and system design the composite accuracy of the anemometer for field application is illustrated to be approximately within 10 %.
2. The roughness length (Zo) measurements around the 360 compass in each of the 213 ASOS stations located in tropical-cyclone prone regions have been averaged geometrically.
3. Six geometric mean Zo values have been verified during 5 hurricanes including Bonnie, Katrina, Rita, Ike, and Isaac. And
4. Applications of these geometric mean Zo values to estimate the 3-second gust, peak gust, and peak factor are provided as an example for engineers during Hurricane Katrina in 2005.

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Appendix : A list of geometric mean for Zo and power-law exponent for p.

Station ID	Station Location	City	State	Geometric mean, Zo	p, based on Hsu (2008)
K40J	Perry-Foley Airport	Perry-Foley	FL	0.113	0.208
KAAF	Apalachicola Airport	Apalachicola	FL	0.191	0.227
KABY	Albany SW GA Regional Airport	Albany	GA	0.099	0.203
KAEX	Alexandria Intl Airport	Alexandria	LA	0.127	0.212
KAGS	Augusta Bush Field	Augusta	GA	0.165	0.221
KAHN	Athens Ben Epps Airport	Athens	GA	0.102	0.204
KAKH	Gastonia Municipal Airport	Gastonia	NC	0.339	0.25
KAKQ	Wakefield Municipal Airport	Wakefield	VA	0.479	0.265
KALB	Albany County Airport	Albany	NY	0.079	0.196
KALI	Alice International Airport	Alice	TX	0.03	0.166
KAMG	Alma Bacon County Airport	Alma	GA	0.213	0.231
KANB	Anniston Metro Airport	Anniston	AL	0.223	0.233
KAND	Anderson County Airport	Anderson	SC	0.089	0.2
KAOO	Altoona Blair County Airport	Altoona	PA	0.083	0.197
KAQW	North Adams Harriman	North Adams	MA	0.152	0.218
KARA	New Iberia Acadiana Regional	New Iberia	LA	0.154	0.219
KASD	Slidell Airport	Slidell	LA	0.322	0.248
KATL	Atlanta Hartsfield Intl Airport	Atlanta	GA	0.311	0.246
KAUS	Austin-Bergstrom Intl Airport	Austin-Bergstrom	TX	0.032	0.168
KAVL	Ashville Regional Airport	Ashville	NC	0.15	0.218
KAVP	Wilkes- Barre Scranton Intl Airport	Wilkes-Barre	PA	0.119	0.21
KBAZ	New Braunfels Municipal Airport	New Braunfels	TX	0.03	0.166
KBED	Bedford Hanscom Field	Bedford	MA	0.141	0.215
KBFD	Bradford Regional Airport	Bradford	PA	0.092	0.201
KBFM	Mobile Downtown Airport	Mobile	AL	0.15	0.218
KBGM	Binghamton Regional Airport	Binghamton	NY	0.068	0.19
KBHM	Birmingham International Airport	Birmingham	AL	0.216	0.232
KBKV	Brooksville Hernando Co. Airport	Brooksville	FL	0.149	0.218
KBLF	Bluefield Mercer Co. Airport	Bluefield	WV	0.258	0.239
KBMQ	Burnet Municipal Airport	Burnet	TX	0.329	0.249
KBOS	Boston Logan Intl Airport	Boston	MA	0.065	0.189
KBPT	Port Arthur Jefferson County	Beaumont	TX	0.035	0.17
KBRO	Brownsville S Padre Isle Intl Airport	Brownsville	TX	0.057	0.185
KBTR	Baton Rouge Ryan Airport	Baton Rouge	LA	0.186	0.226
KBUY	Burlington Alamance Rngl Airport	Burlington	NC	0.182	0.225
KBVE	Venice Phi Heliport	Venice	LA	0.153	0.219
KBVY	Beverly Municipal Airport	Beverly	MA	0.047	0.179
KBWI	Baltimore-Washington Int'l Airport	Baltimore	MD	0.089	0.2
KCAE	Columbia Metropolitan Airport	Columbia	SC	0.065	0.189
KCEU	Clemson-Oconee Co. Airport	Clemson	SC	0.083	0.197
KCEW	Crestview Bob Sikes Airport	Crestview	FL	0.216	0.232
KCHO	Charlottesville Albemarle Airport	Charlottesville	VA	0.126	0.212
KCHS	Charleston Intl Airport	Charleston	SC	0.048	0.18
KCLT	Charlotte Douglas Intl Airport	Charlotte	NC	0.056	0.185
KCOF	Cocoa Beach Patrick AF Base	Cocoa	FL	0.058	0.185
KCOT	Cotulla La Salle Co. Airport	Cotulla	TX	0.054	0.184
KCQX	Chatham Municipal Airport	Chatham	MA	0.145	0.217
KCRE	N. Myrtle Bch. Grand Strand Airport	N Myrtle Beach	SC	0.078	0.195
KCRG	Jacksonville Craig Municipal Airport	Jacksonville	FL	0.091	0.2
KCRP	Corpus Christi Intl Airport	Corpus Christi	TX	0.03	0.166
KCTY	Cross City Airport	Cross City	FL	0.082	0.197
KCUB	Columbia Owens Field Airport	Columbia	SC	0.25	0.237
KCXO	Conroe Montgomery County Airport	Conroe	AL	0.078	0.195
KCXY	Harrisburg Capital City Airport	Harrisburg	PA	0.065	0.189
KDAB	Daytona Bch Intl Airport	Daytona Beach	FL	0.092	0.201

KDAN	Danville Regional Airport	Danville	VA	0.052	0.182
KDCA	Washington Reagan National Airport	Washington	D.C.	0.043	0.177
KDCU	Decatur Pryor Field	Decatur	AL	0.043	0.176
KDDH	Bennington Morse State Airport	Bennington	VT	0.074	0.193
KDHN	Dothan Regional Airport	Dothan	AL	0.052	0.182
KDNL	Augusta Daniel Field Airport	Augusta	GA	0.092	0.201
KDRT	Del Rio International Airport	Del Rio	TX	0.034	0.17
KDTN	Shreveport Downtown Airport	Shreveport	LA	0.348	0.251
KDTS	Destin Ft. Walton Bch Airport	Destin	FL	0.301	0.245
KDWH	Houston Hooks Memorial Airport	Houston	TX	0.073	0.193
KDYL	Doylestown Airport	Doylestown	PA	0.144	0.216
KECG	Elizabeth City Coast Guard Airport	Elizabeth City	NC	0.062	0.188
KEET	Alabaster Shelby County Airport	Alabaster	AL	0.266	0.24
KELM	Elmira Corning Regional Airport	Elmira	NY	0.049	0.181
KEQY	Monroe Airport	Monroe	NC	0.079	0.195
KESF	Alexandria Esler Regional	Alexandria	LA	0.053	0.183
KEWB	New Bedford Municipal Airport	New Bedford	MA	0.093	0.201
KEWN	New Bern Craven Regional Airport	New Bern	NC	0.046	0.178
KFFC	Peachtree City Flacon Field	Atlanta	GA	0.069	0.191
KFIG	Clearfield Lawrence Airport	Clearfield	PA	0.041	0.175
KFIT	Fitchburg Municipal Airport	Fitchburg	MA	0.093	0.201
KFLL	Ft Lauderdale/Hollywood Intl Airport	Ft. Lauderdale	FL	0.087	0.199
KFLO	Florence Regional Airport	Florence	SC	0.034	0.17
KFMY	Ft Myers Page Field	Ft. Myers	FL	0.102	0.204
KFPR	Ft. Pierce/St. Lucie Co. Intl	Ft. Pierce	FL	0.157	0.219
KFTY	Atlanta Fulton Co Airport	Atlanta	GA	0.084	0.198
KFWN	Sussex Airport	Sussex	NJ	0.201	0.229
KFXE	Ft. Lauderdale Executive Airport	Ft. Lauderdale	FL	0.091	0.2
KGED	Georgetown Sussex Co Airport	Georgetown	DE	0.077	0.195
KGFL	Glens Falls Airport	Glens Falls	NY	0.074	0.193
KGIF	Winter Haven's Gilbert Airport	Winter Haven	FL	0.059	0.186
KGLS	Galveston Scholes Airport	Galveston	TX	0.038	0.173
KGMU	Greenville Downtown Airport	Greenville	SC	0.057	0.185
KGNV	Gainesville Regional Airport	Gainesville	FL	0.049	0.181
KGPT	Gulfport - Biloxi Regional Airport	Gulfport	MS	0.135	0.214
KGRD	Greenwood County Airport	Greenwood	SC	0.078	0.195
KGSO	Greensboro Piedmont Triad Intl	Greensboro	NC	0.069	0.191
KGSP	Greer Greenville - Spartanburg Airport	Greer	SC	0.052	0.182
PGUM	Guam Intl Airport	Agana	GU	0.082	0.197
KGVL	Gainesville Lee Glimer Mem Airport	Gainesville	GA	0.076	0.195
KGZH	Evergreen Middleton Field	Evergreen	AL	0.21	0.23
KHDO	Hondo Municipal Airport	Hondo	TX	0.034	0.17
KHGR	Hagerstown Washington Co. Regional	Hagerstown	MD	0.066	0.19
KHKY	Hickory Regional Airport	Hickory	NC	0.048	0.18
PHNL	Honolulu International Airport	Honolulu	HI	0.034	0.17
KHOU	Houston William P Hobby Airport	Houston	TX	0.043	0.177
KHRL	Harlingen Rio Grande Valley Airport	Harlingen	TX	0.03	0.166
KHSE	Hatteras Billy Mitchell Field	Cape Hatteras	NC	0.232	0.234
KHSV	Huntsville International/ Jones Field	Huntsville	AL	0.03	0.166
KHYA	Hyannis Barnstable Municipal Airport	Hyannis	MA	0.045	0.178
KIAD	Washington DC Dulles Intl Airport	Washington	DC	0.068	0.191
KIAH	Houston Bush Intercontinental Airport	Houston	TX	0.057	0.185
KIGX	Chapel Hill Williams Airport	Chapel Hill	NC	0.125	0.211
KIJD	Willimantic Windham Airport	Willimantic	CT	0.054	0.184
KILM	Wilmington Intl Airport	Wilmington	NC	0.056	0.185
KIPT	Williamsport Lycoming County Regional Airport	Williamsport	PA	0.063	0.188
KISP	Islip Long Island Macarthur Airport	Islip	NY	0.045	0.178
PITO	Hilo Intl Airport	Hilo	HI	0.038	0.173

KJAX	Jacksonville International Airport	Jacksonville	FL	0.034	0.17
KJFK	New York J F Kennedy Intl Airport	New York	NY	0.034	0.17
TJSJ	Luis Munoz Marin Intl Airport	San Juan	PR	0.073	0.193
KJST	Johnstown Cambria Airport	Johnstown	PA	0.038	0.173
PKOA	Kailua Kona Ke-Ahole Airport	Kailua	HI	0.03	0.166
KLBT	Lumberton Municipal Airport	Lumberton	NC	0.035	0.17
KLBX	Angleton / Lake Jackson Brazoria Airport	Angleton	TX	0.064	0.189
KLCH	Lake Charles Regional Airport	Lake Charles	LA	0.052	0.182
KLEE	Leesburg Municipal Airport	Leesburg	FL	0.052	0.182
KLFK	Lufkin Angelina City Airport	Lufkin	TX	0.066	0.19
KLFT	Lafayette Regional Airport	Lafayette	LA	0.04	0.174
PLIH	Lihue Airport	Lihue	HI	0.038	0.173
KLNS	Elizabethtown	Lititz	PA	0.034	0.17
KLVJ	Houston Clover Field	Houston	TX	0.091	0.2
KLWN	Lawrence Municipal Airport	Lawrence	MA	0.052	0.182
KLYH	Lynchburg Airport	Lynchburg	VA	0.076	0.194
KMAI	Marianna Municipal Airport	Marianna	FL	0.163	0.221
KMCB	McComb Pike County Airport	McComb	MS	0.054	0.184
KMCN	Macon Middle Regional Airport	Macon	GA	0.036	0.172
KMCO	Orlando Intl Airport	Orlando	FL	0.031	0.167
KMDT	Middletown Harrisburg Intl Airport	Harrisburg	PA	0.046	0.178
KMFE	McAllen Miller Intl Airport	McAllen	TX	0.039	0.173
KMGM	Montgomery Donnelly Airport	Montgomery	AL	0.096	0.202
KMIA	Miami International Airport	Miami	FL	0.032	0.168
PMKK	Molokai Kaunakakai Molokai Airport	Kaunakakai	HI	0.047	0.179
KMLB	Melbourne International Airport	Melbourne	FL	0.043	0.177
KMOB	Mobile Regional Airport	Mobile	AL	0.195	0.228
KMPO	Mount Pocono Pocono Mountains	Mount Pocono	PA	0.061	0.187
KMRH	Beaufort M Smith Field Airport	Beaufort	NC	0.036	0.172
KMSL	Muscle Shoals Regional Airport	Muscle Shoals	AL	0.035	0.17
KMSY	New Orleans International Airport	New Orleans	LA	0.18	0.225
KMVY	Martha's Vineyard Airport	Vineyard Haven	MA	0.043	0.177
KNEW	New Orleans Lakefront Airport	New Orleans	LA	0.055	0.184
KNGP	Corpus Christi Naval Air Station	Corpus Christi	TX	0.091	0.2
KNGW	Cabaniss Navy Auxiliary Landing Field	Cabaniss	TX	0.03	0.166
KNQI	Kingsville	Kingsville	TX	0.065	0.189
KOFP	Richmond Ashland Hanover Co.	Richmond	VA	0.069	0.191
KOGB	Orangeburg Airport	Orangeburg	SC	0.221	0.232
POGG	Kahului Airport	Kahului	HI	0.032	0.168
KOPF	Miami Opa Locka Airport	Miami	FL	0.03	0.166
KORE	Orange Municipal Airport	Orange	MA	0.034	0.17
KORF	Norfolk International Airport	Norfolk	VA	0.041	0.175
KORL	Orlando Executive Airport	Orlando	FL	0.034	0.17
KOWD	Norwood Memorial Airport	Norwood	MA	0.06	0.187
KOXB	Ocean City Municipal Airport	Ocean City	MD	0.042	0.176
KP92	Salt Point	Salt Point	LA	0.113	0.208
KPDK	Atlanta DeKalb - Peachtree Airport	Atlanta	GA	0.041	0.175
KPEO	Penn Yan Airport	Penn Yan	NY	0.052	0.183
KPFN	Panama City-Bay County Airport	Panama City	FL	0.164	0.221
KPGD	Punta Gorda Charlotte County Airport	Punta Gorda	FL	0.032	0.168
KPHF	Newport News International Airport	Newport News	VA	0.045	0.178
KPIE	St. Petersburg/Clearwater Airport	St. Petersburg	FL	0.036	0.172
KPIL	Port Isabel Cameron County Airport	Port Isabel	TX	0.042	0.176
KPNS	Pensacola Regional Airport	Pensacola	FL	0.039	0.174
KPOU	Poughkeepsie Dutchess Co Airport	Poughkeepsie	NY	0.05	0.181
KPQL	Pascagoula Lott Intl Airport	Pascagoula	MS	0.12	0.21
KPSF	Pittsfield Municipal Airport	Pittsfield	NY	0.068	0.19
KPTW	Pottstown Limerick Airport	Pottstown	PA	0.051	0.182

KPVD	Providence Green State Airport	Providence	RI	0.03	0.166
KPYM	Plymouth Municipal Airport	Plymouth	MA	0.087	0.199
KRDU	Raleigh Durham International	Raleigh	NC	0.049	0.18
KRIC	Richmond Intl Airport	Richmond	VA	0.041	0.175
KRKP	Rockport Aransas Municipal Airport	Rockport	TX	0.046	0.178
KRMG	Rome RB Russell Airport	Rome	GA	0.034	0.17
KROA	Roanoke Regional Airport	Roanoke	VA	0.036	0.172
KRSW	Ft. Myers SW Regional Airport	Ft. Myers	FL	0.076	0.194
KRWI	Rocky Mount Wilson Airport	Rocky Mount	NC	0.039	0.174
KSAT	San Antonio International Airport	San Antonio	TX	0.034	0.17
KSAV	Savannah Intl Airport	Savannah	GA	0.049	0.18
KSBY	Salisbury Wicomico Rgnl Airport	Salisbury	MD	0.052	0.182
KSEG	Selinsgrove Penn Valley Airport	Selinsgrove	PA	0.036	0.172
KSFB	Orlando Sanford Airport	Orlando	FL	0.073	0.193
KSHV	Shreveport Regional Airport	Shreveport	LA	0.035	0.17
KSMQ	Somerville Somerset Airport	Somerville	NJ	0.138	0.215
KSPG	St. Petersburg Albert-Whitted Airport	St. Petersburg	FL	0.043	0.176
KSRQ	Sarasota-Bradenton Airport	Sarasota	FL	0.054	0.184
KSSF	San Antonio Stinson Municipal Airport	San Antonio	TX	0.032	0.168
KSSI	Brunswick Malcolm McKinnon Airport	Brunswick	GA	0.032	0.168
TSTT	Charlotte Amalie Cyril E. King Intl Airport	Charlotte Amalie	St. Tomas USVI	0.034	0.17
TSTX	Christiansted Airport	Christiansted	St. Croix USVI	0.032	0.168
KSYR	Syracuse Hancock Intl Airport	Syracuse	NY	0.03	0.166
KTAN	Taunton Municipal Airport	Taunton	MA	0.08	0.196
KTCL	Tuscaloosa Regional Airport	Tuscaloosa	AL	0.165	0.221
KTHV	York Municipal Airport	York	PA	0.045	0.178
KTLH	Tallahassee Rngl Airport	Tallahassee	FL	0.159	0.22
KTOI	Troy Municipal Airport	Troy	AL	0.058	0.186
KTPA	Tampa International Airport	Tampa	FL	0.039	0.173
KUCA	Utica Oneida County Airport	Utica	NY	0.034	0.17
KUTS	Huntsville Municipal Airport	Huntsville	AL	0.141	0.216
KUUU	Newport State Airport	Newport	RI	0.046	0.179
KUZA	Rock Hill York County Airport	Rock Hill	SC	0.048	0.18
KVAY	Mount Holly South Jersey Regional	Mount Holly	NJ	0.078	0.195
KVCT	Victoria Regional Airport	Victoria	TX	0.03	0.166
KVLD	Valdosta Regional Airport	Valdosta	GA	0.052	0.182
KVRB	Vero Beach Municipal Airport	Vero Beach	FL	0.032	0.168
KWAL	Wallops Island Wallops Flight	Wallops Island	VA	0.045	0.178
KWST	Westerly State Airport	Westerly	RI	0.054	0.183

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Doppler Shift Estimation of Signals Modulated by Pseudorandom Sequences

By Oleg Sytnik
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Non-correlated and correlated types of noise lead to the errors in a thin structure of code sequences. In this paper a quasi-optimal receiver with non-coherent discriminators is proposed. The receiver has the two parallel channels which are synchronized by phase with a sounding signal. The receiver synthesis procedure, its operating conditions and its characteristics are fully considered. The synthesis is based on the modified non-linear filtering methods. This theory has been used to build the signal processing algorithm. The synthesis procedure consists of two steps. At the first step we assume that signal frequency has no shift and the base structure of the signal processing algorithm has been obtained. At the second step we assume that the structure of the algorithm remains unchanged, and using the theory of signal filtering the filter in the control loop for shifted frequencies is designed.

In is shown that the sequences of combined estimates of the frequencies shifts and the signal delay can be used as a model of a dynamic Kalman filter. Fig.: 3. Ref.: 18 pos.

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I. Introduction

Natural and anthropogenic disasters which are of regular occurrence in different areas of the Earth, take a heavy toll of tens of thousands of human lives. It is exactly for this reason that extensive studies are being pursued to design and develop the highly efficient devices for detecting and rescuing the people in the hardest-hit areas.

There are large number of devices based on different physical concepts. However, the class of radars, especially the hand-held devices, used in rescue operations hold a particular place, because they allow detecting the alive human beings in ruined buildings, under snow avalanches, during sand slides, etc. The operating range of these radars is within 10 to 20 m. at a range resolution of 0.5 to 3 m.[1 - 10].

Detecting an alive human being among optically opaque wreckages like brick and concrete walls or snow layer is made possible after analysis of the Doppler modulation of sounding signals reflected from a human body. This modulation brought about by the moving parts of a human body (the motion of limbs, the shifting of a human thorax in breathing and during heartbeat) [10 - 17].

There are two main trends towards creating the radars with rescue operation functions. One is based on the video pulse location [1 - 9] and the other is meant to use quasi-continuous pseudo-random signals [10 - 17]. Using the pseudo-random signals the measurement of a distance to a target is accomplished through phase-code-manipulated sounding signals.

Since the main components of the Doppler spectra of data signal lie in the range of □ 0.1 to 1.5 Hz [13 - 15], their measurement against the background of the correlated interferences provided by sounding signal reflection from obstacles, flicker noise, interferences caused by the operation of mechanisms and different-purpose radio-electronics devices is in fact a great challenge. Receiving these signals becomes problematic because the disturbance of the fine (thin) code-sequence structure. Because the thin structure of the code sequence gets disturbed, the coherent reception of such signal becomes somewhat problematic.

In the present paper we have made an attempt to synthesize the structure of the complex phase-code-manipulated signal receiver with non-coherent discriminators to be used in radars for rescue operations. The synthesis is based on the modified non-linear filtering methods. This theory has been used to build the signal processing algorithm. The procedure of synthesis consists of two steps. At the first step we assume that signal frequency has no shift and the base structure of the signal processing algorithm has been obtained. At the second step we assume that the structure of the algorithm remains unchanged and using the theory of signal filtering the filter in the control loop for shifted frequencies is designed.

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II. Problem Formulation

Let the realization of an additive mixture of reflected signals and noise arrive at the receiver input

$$\xi(t) = s(t) + n(t), \qquad (1)$$

Where $s(t) = Ag(t-\tau)\cos(\omega t + \varphi)$ is the signal reflected from a target; A is the signal amplitude; $g(t-\tau) = \pm 1$ is the signal modulation function according to the phase-code-law; τ is the reflected signal delay; ω is the radian frequency of a sounding signal; φ is the signal random initial phase, which has a uniform distribution on the interval $[0, 2\pi]$; $n(t)$ is the Gaussian noise with zero expectation equal to $E\{n(t)\}=0$, ($E\{\cdot\}$ is the symbol of expectation procedure) and the correlation function: $E\{n(t_1)\cdot n(t_2)\} = 0{,}5 N_0 \delta(t_2 - t_1)$; N_0 is the noise spectral density; $\delta(\cdot)$ is the delta-function.

The problem is to build an optimal structure of the signal receiving processor to calculate the estimates of parameters ω and τ using the observation data (1) and the known signal modulation law $g(t)$.

III. Optimal Non-Linear Filtering

First, let us assume radian frequency ω, signal phase φ and delay τ to be time constants. Then, according to [18], the differential equation of optimal nonlinear filtering will have the following form:

$$\dot{W}(t,\vec{\lambda}) = \left[F(t,\vec{\lambda}) - E\left\{F(t,\vec{\lambda})\right\}\right] W(t,\vec{\lambda}), \qquad (2)$$

where $W(t,\vec{\lambda})$ is the aposteriori probability density function of the vector of parameters $\vec{\lambda} = \{\omega, \tau, \varphi\}$.

The aposteriori probability density function for a considered type of signals and under the assumption of Gaussian noise can be given as

$$W(t,\vec{\lambda}) = C\exp\left\{-\frac{A^2 t}{N_0}\int_0^t g^2(t_1-\tau)\cos^2(\omega t+\varphi)\,dt_1 + \right.$$
$$\left. + \frac{A^2 t}{N_0}\int_0^t g(t_1-\tau)\cos(\omega t+\varphi)\,dt_1\right., \qquad (3)$$

where C is the constant.

Upon averaging of the left- and right hand parts of equation (2) over φ in view of (3) we can write

$$F(t,\vec{\lambda})W(t,\vec{\lambda}) = \frac{2AC}{N_0}\frac{\partial f(t,\vec{\lambda})}{\partial t}\exp\left\{-\frac{A^2 t}{2N_0} + \frac{2A}{N_0} f(t,\vec{\lambda})\right\}, \qquad (4)$$

where

$$f(t,\vec{\lambda}) = \cos(\varphi)\int_0^t \xi(t_1) g(t_1-\tau)\cos(\omega t_1)\,dt_1 - \sin(\varphi)\int_0^t \xi(t_1) g(t_1-\tau)\sin(\omega t_1)\,dt_1$$

Since the phase has a uniform distribution in the interval $[0, 2\pi]$, its probability density function can be given as $W(\varphi) = 1/2\pi$.

Then

$$\frac{1}{2\pi}\int_0^{2\pi} F(t,\vec{\lambda})W(t,\vec{\lambda})\,d\varphi == \frac{C}{2\pi}\exp\left\{-\frac{A^2 t}{2N_0}\right\}\frac{\partial}{\partial t}\left[\int_0^{2\pi}\exp\left\{\frac{2A}{N_0}f(t,\vec{\lambda})\right\}d\varphi\right] = C\exp\left\{-\frac{A^2 t}{2N_0}\right\}\frac{\partial}{\partial t}\left[I_0\left\{\frac{2A}{N_0}Z\right\}\right], \qquad (5)$$

where $I_0\{\cdot\}$ is the Bessel function;

$$Z^2 = \left[\int_0^t \xi(t_1) g(t_1-\tau)\cos(\omega t_1)\,dt_1\right] + \left[\int_0^t \xi(t_1) g(t_1-\tau)\sin(\omega t_1)\,dt_1\right]$$

.

As $W(t,\omega,\tau) = C\exp\left\{-\frac{A^2 t}{2N_0}\right\} I_0\left\{\frac{2A}{N_0}Z\right\}$, and the ratio is

$$\frac{\frac{\partial}{\partial t}\left[I_0\left\{\frac{2A}{N_0}Z\right\}\right]}{I_0\left\{\frac{2A}{N_0}Z\right\}} = \frac{\partial}{\partial t}\ln\left\{I_0\left\{\frac{2A}{N_0}Z\right\}\right\}$$

,Then in the Gaussian approximation we obtain the equation for the estimates of frequency and the delay of the complicated phase-code-manipulated signal:

$$\hat{\omega} = K_{\omega\omega}\frac{\partial}{\partial\omega}\frac{\partial}{\partial t}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega},\hat{\tau})\right]\right\} + K_{\omega\tau}\frac{\partial}{\partial\tau}\frac{\partial}{\partial t}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega},\hat{\tau})\right]\right\}, \qquad (6)$$

$$\hat{\tau} = K_{\tau\tau}\frac{\partial}{\partial\tau}\frac{\partial}{\partial t}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega},\hat{\tau})\right]\right\} + K_{\omega\tau}\frac{\partial}{\partial\omega}\frac{\partial}{\partial t}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega},\hat{\tau})\right]\right\}, \quad (7)$$

where the central correlated moments, $K_{\omega\omega}, K_{\omega\tau}, K_{\tau\tau}$ form the matrix:

$$\vec{K} = \begin{Vmatrix} K_{\omega\omega} & K_{\omega\tau} \\ K_{\tau\omega} & K_{\tau\tau} \end{Vmatrix}. \quad (8)$$

Herewith

$$\frac{d\vec{K}}{dt} = -\vec{K}^T\vec{D}\vec{K}, \quad (9)$$

Where $\vec{D} = \begin{Vmatrix} F_{2\omega\omega} & F_{2\omega\tau} \\ F_{2\tau\omega} & F_{2\tau\tau} \end{Vmatrix}$; $F_2 = \dfrac{\partial^2 F_1(t,\omega,\tau)}{\partial\omega\,\partial\tau}$; $F_1(t,\omega,\tau) = \dfrac{\partial}{\partial t}\ln\left\{I_0\left[\dfrac{2A}{N_0}Z(t,\omega,\tau)\right]\right\}$

The equations for central correlated moments in scalar mode are:

$$\begin{cases} \dfrac{dK_{\omega\omega}}{dt} = -\left(K_{\omega\omega}^2 F_{\omega\omega} + 2K_{\omega\omega}K_{\omega\tau}F_{\omega\tau} + K_{\omega\tau}^2 F_{\tau\tau}\right) \\ \dfrac{dK_{\omega\tau}}{dt} = -\left(K_{\omega\omega}K_{\omega\tau}F_{\omega\omega} + K_{\omega\tau}^2 F_{\omega\tau} + K_{\omega\omega}K_{\tau\tau}F_{\omega\tau} + K_{\omega\tau}K_{\tau\tau}F_{\tau\tau}\right) \\ \dfrac{dK_{\tau\tau}}{dt} = -\left(K_{\omega\tau}^2 F_{\omega\omega} + 2K_{\omega\tau}K_{\tau\tau}F_{\omega\tau} + K_{\tau\tau}^2 F_{\tau\tau}\right) \end{cases}, \quad (10)$$

where

$$F_{\tau\tau} = \frac{\partial^2 F_1}{\partial\tau^2} = \frac{\partial}{\partial t}\left[\frac{\partial B(Z)}{\partial Z}\left(\frac{\partial Z}{\partial\tau}\right)^2 + B(Z)\frac{\partial^2 Z}{\partial\tau^2}\right];$$

$$F_{\omega\omega} = \frac{\partial^2 F_1}{\partial\omega^2} = \frac{\partial}{\partial t}\left[\frac{\partial B(Z)}{\partial Z}\left(\frac{\partial Z}{\partial\omega}\right)^2 + B(Z)\frac{\partial^2 Z}{\partial\omega^2}\right];$$

$$F_{\omega\tau} = \frac{\partial^2 F_1}{\partial\omega\,\partial\tau} = \frac{\partial}{\partial t}\left[\frac{\partial B(Z)}{\partial Z}\left(\frac{\partial Z}{\partial\omega}\frac{\partial Z}{\partial\tau}\right) + B(Z)\frac{\partial^2 Z}{\partial\omega\,\partial\tau}\right]$$

$$B(Z) = \frac{\partial}{\partial Z}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\omega,\tau)\right]\right\}.$$

IV. Synthesis of Quasi-Optimal Receiver Structure

The solution to a set of equation (10) yield the zero values of coefficients $K_{\omega\omega}, K_{\omega\tau}, K_{\tau\tau}$ for the stationary case. It indicates that this procedure of calculating $K_{\omega\omega}, K_{\omega\tau}, K_{\tau\tau}$ in a stationary mode is unacceptable. It can be easily shown that, with the spectral density N_0 of Gaussian noise and the signal amplitude A, the frequency estimate dispersion is on the order of $12N_0/(A^2t^3)$.

The time-dependence of $K_{\omega\omega}$ is important in exploring the nonlinear dynamics of the signal frequency tracking system. Simplifying the optimal signal frequency tracking system is feasible if one changes it over to the quasi-optimal mode when the variable coefficients are replaced by constant ones. All this can be done under an obvious assumption that the frequency shifts are too small to get an alive man detected among optically opaque wreckages. As mentioned above, the main components of informative-signal spectrum are within the limits of 0.1 to 1.5 Hz.

The constant amplification coefficients can be derived by averaging the equations over F and K on condition that $t/\tau_i >> 1$, where τ_i is the time during which the parameter with index i remains practically constant, but t is the current estimation time. In this case, there is no needs to take into account the cross-connections $K_{\omega\tau}, K_{\tau\omega}$ between the frequency tracking and signal delay tracking networks. They can be taken into account as constant additive factors for amplification coefficients in the appropriate networks. In practice, these coefficients can be obtained by studying the dynamics of information process in training.

Based upon the assumptions that were earlier made, we can turn from partial differential equations to approximate equations, in which the partial derivatives are replaced by finite differences.

$$\hat{\omega} = \frac{K_{\omega\omega}}{2a}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega}+a,\hat{\tau})\right] - \ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega}-a,\hat{\tau})\right]\right\}, \quad (11)$$

$$\hat{\tau} = \frac{K_{\tau\tau}}{2b}\left\{\ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega},\hat{\tau}+b)\right] - \ln I_0\left[\frac{2A}{N_0}Z(t,\hat{\omega},\hat{\tau}-b)\right]\right\}, \quad (12)$$

where $a = \Delta\omega$ is the frequency increment; $b = \Delta\tau$ is the delay increment.

The structure of the device, which implements the frequency (11) and signal delay (12) estimation algorithm is shown in Fig. 1.

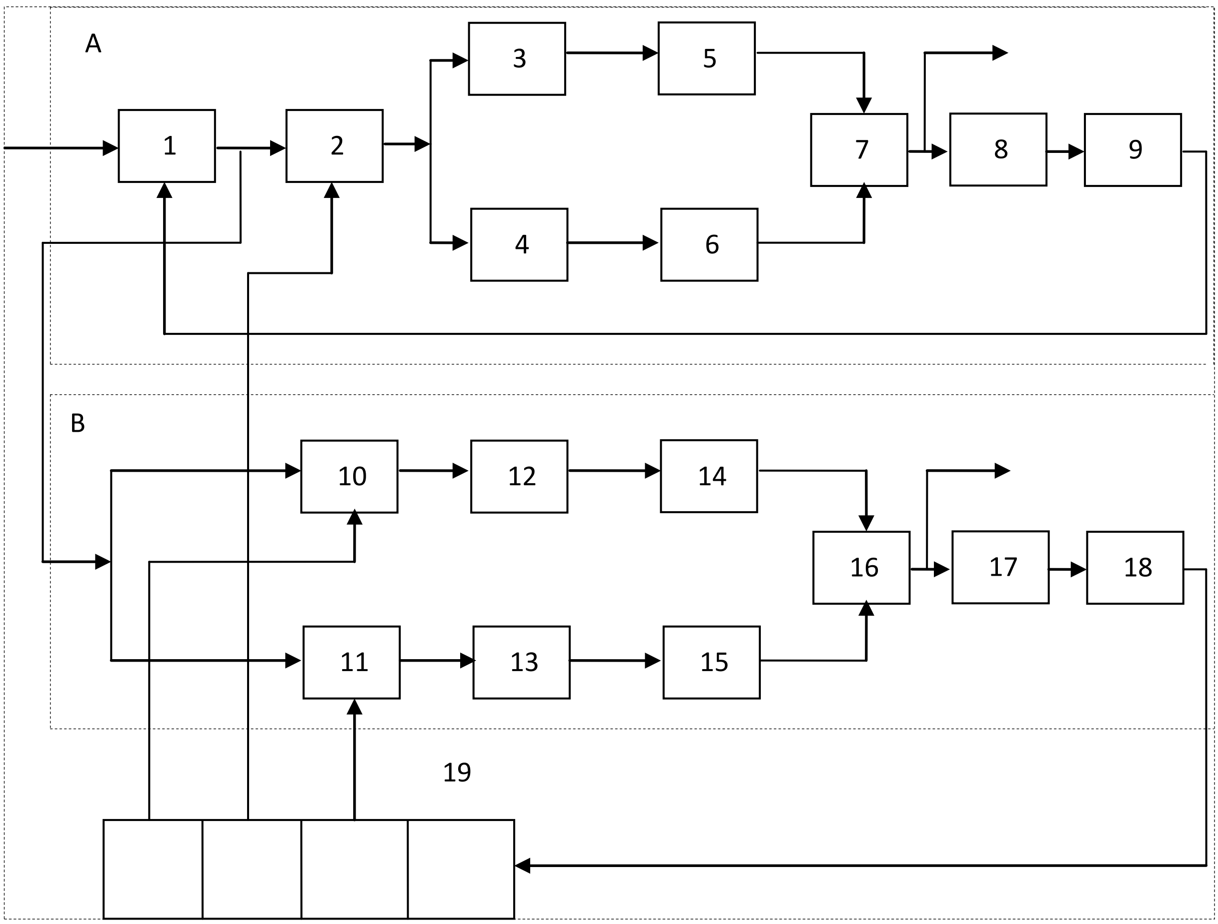

Figure 1 : The structure of the device for adaptive estimation of frequency and delay

Herein the following designations are used:
1,2,10,11 — multipliers;
3,4,12,13 — bandpass filters;
5,6,14,15 — discriminators;
7,16 — adders;
8,17 — amplifiers;
9 — controlled oscillator;
18 — controlled clock oscillator;
19 — pseudo-random sequence generator operated by the Mersenne law.

The device incorporates two parallel-connected channels A and B (they are outlined with dashed line in Fig.1) for signal processing as well as the generator 19 of pseudo-random sequences operated by the Mersenne law. Current estimates of the signal carrier frequency and its frequency shift with respect to a sounding signal are calculated in channel A, but in channel B the sequence estimates of signal delay are formed. In contrast to the optimal coherent receiver, the estimates of the signal frequency are calculated by the automatic frequency control networks, but the estimates of the signal delay are calculated by non-coherent discriminator. This design of an adaptive system provides its steady-state operation during large-scale phase and frequency fluctuations. As the sounding signals are being reflected from a human body, the reflected signal frequency fluctuates within a narrow range relative to the constant value of ω_0 because of the slow motion of a human thorax. In other words, we have

$$\dot{\omega}(t) = -a(\omega - \omega_0) + an_\omega(t). \quad (13)$$

It follows from (13) that it is convenient to use the Kalman filter in order to estimate the signal frequency for the stationary mode along with an information model. Then

$$\dot{\hat{\omega}}(t) = -a\hat{\omega} + K_\omega(\omega - \hat{\omega}). \quad (14)$$

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The difference $(\omega - \hat{\omega})$ is the output signal of the linearized frequency discriminator the algorithm of which is obtained by means of nonlinear synthesis.

Fig. 2 presents the performance characteristics of the proposed receiver as compared to an optimal coherent receiver (a family of curves for adequate-detection probability / as a function of the signal-to-noise ratio "q" at a fixed false-alarm level P_F). As is seen from Fig. 2, the signal energy losses resulting from the use of the constant amplification factors in the feedback loop of the frequency estimation channel do not exceed 1.5 to 3 dB. This is well suited for nonlinear data processing with apriori uncertainty in frequency fluctuation probability distribution.

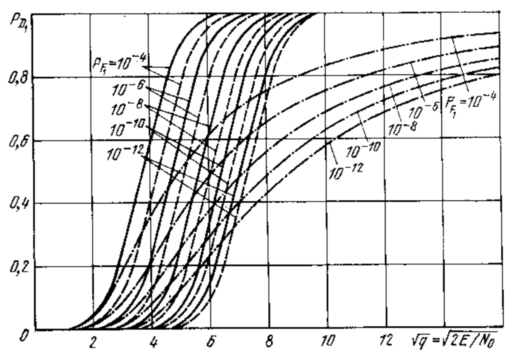

Figure 2 : The performance of the quasi-optimal receiver.

As evident from the above Figure, the solid lines indicate the operational characteristics of the optimal receiver with no apriori uncertainty of interference distributions. The dashed lines indicate the operational characteristics with apriori uncertainty of the initial phase, and the dash-and-dot lines point to the operational characteristics of the quasi-optimal receiver.

The general view of the radar in which an algorithm for nonlinear quasi-optimal frequency and delay estimation is shown in Fig. 3.

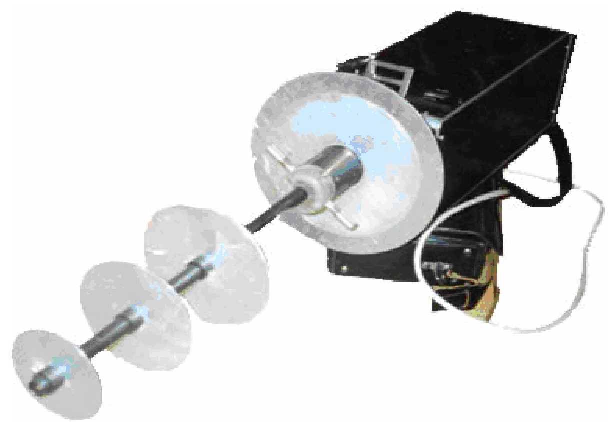

Figure 3 : The general view of the radar for rescuers

The basic performance characteristics of the radar are listed in Table 1.

Table 1

№	Qualitative characteristics.	Value.	Notes.
1	Range	1 to 2.5 GHz	
2	Average power	>100 to 150.0 mW	It is regulated depending on local noise.
3	Receiver sensitivity	-170 dBW	At maximum possible at the receiver band 10Hz.
4	Type of radiation	Continuous	
5	Modulation	Phase manipulation by a code.	
6	Width of main antenna lobe in azimuthal and elevation angle planes	15^0 to 25^0	$> 15^0$
7	Range resolution	1 to 2 m.	
8	Range (to the first obstacle)	5 to 15 m.	
9	Range of responsibility area after the first barrier	1.5 to 7m.	
10	Doppler filter band	0.1 to 5 Hz.	Depending on nose
11	Side-lobe level of ambiguity function,	-80 dB.	
12	Volume	8 to 10 dm^3	
13	Weight with power supply unit	2 to 3 kg.	

V. Conclusions

To summarize the foregoing, we can state that in a $\pm\pi$ stick-slip modulation of the sounding signal phase the Doppler shifts, which result from the chaotic and regular motions of an target, as well as the signal delays are estimated through the adaptive pseudo-coherent correlation processing procedure. The structure of the quasi-optimal receiver incorporates two-channel adaptive filters operating in parallel with a phase-synchronized input signal.

Using the proposed approach to synthesizing the receiver structure is governed by the lack of apriori information on the variations in the probability density of initial data generating processes. This gave rise to somewhat complicated calculations and at the same time ensured that the signal processing device could be invariant to a particular type of target motion. In particular, this sort of a receiver responds effectively both to the linear displacements of a target and to its circulations relative to a certain center of masses or to the rotary motion. Based upon the sequence of combined estimates of Doppler shifts and delays one can make an estimate of the target's motion law. This estimate may well be used as a model in the dynamic Kalman filtering procedure for improving an estimation accuracy.

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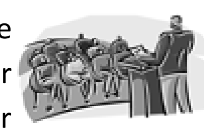

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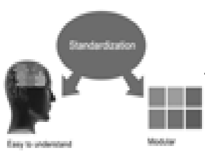

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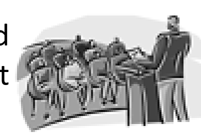

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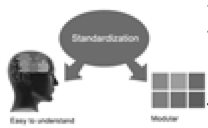

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16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and 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.

Administration Rules Listed Before
Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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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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