Determining the Design Margins of Nose of an AUV by using Monte Carlo Simulation

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Abstract - *Determining the design margins of Nose of an AUV by using Monte Carlo simulation Method. The objective of this research is to develop a scrupulous foundation for determining design margins in the by choosing one of the component part of a complex multidisciplinary system such as AUV. As an example, application, the investigated method is applied to the conceptual-level for the nose of an AUV. The method begins with an analysis of the CAD design of the Nose. Identifying a set of tradable system-level parameters and estimating the parameters. The variables of the design are identified, classified, and assigned appropriate probability density functions are defined by the Monte Carlo Simulation Method. The probability density and cumulative density function graphs i.e., pdf's and cdf's drawn by from simulated values of the tradable parameter are used to determine the margin levels. The method is repeated until the design engineers are satisfied with the balance of system-level parameter values. For the above example of nose of an AUV, margins for different weights of nose involved in the design are considered to be a set of tradable system-level parameters. The above approach gives the differences between the estimated and simulated design margins in the design of nose of an AUV.*

Key Words: Autonomous Underwater Vehicle (AUV), Margins, Parameter Estimates, Tradable Parameter, Monte Carlo Simulation, Probability Density Function, etc.

1. INTRODUCTION

An AUV is an unmanned un-tethered international underwater vehicle with an on-board battery bank and relies on onboard circuits with pre-programmed artificial intelligence and commands to execute a mission. These vehicles are the new target of competitions to foster research on mobile robots in a natural environment with numerous industrial applications. These are primarily used for covert operations such as surveillance of designated areas in underwater. In general, an algorithm for AUV localization GPS-denied undersea environment. Furthermore, adaptive plume detection and tracking system are developed which results in tracking algorithms [1]. It is essential to have a clearer and common description of design margins which can reduce the undesired iteration in development processes arising from misconceptions and aggregation effects in the development of complex systems [2] for many complex systems a taxonomy for uncertainty in aerospace systems design is introduced which provides a mechanism for consistent modeling of uncertainty from any conceivable source to efficiently obtain robust design solutions [3]. Randomly by in the present study includes in determining the design margins for nose of an AUV using Monte Carlo simulation method. Weight is considered as a tradable parameter and the values for different weights of the parts in Nose are estimated numerically based on the formulas derived from the CAD analysis of Nose in AUV. Variables in different sections of its structure in Nose are identified. As we know Uncertainty leads to systems that are over confined margins which lead to overdesigned systems that are not optimized for the requirements they are designed to satisfy. In concern of tradable parameters and establishing them as a function of risk tolerance and on further measuring them relative to mean expected system performance, and on comparing via worst-case expected values in a multidisciplinary system to have a method to determine the margins accordingly in conceptual design . AUV is an example of a complex multidisciplinary system that requires developers to deal with the issues of design uncertainty. Though these systems are difficult to model and understand as it includes different discipline areas in it these are designed to have reliable predictability and to reduce uncertainty. First, a method to determine the margins is introduced next, and the investigated method is summarized. An application of the method follows, finally the paper ends with concluding remarks in Margin management in design of nose of an AUV.

The present method is done by using the managed system-level margins. Margins are variations in design parameters measures relative to the estimated values. Although the definition often differs from resource to resource many marines are expressed as percentages using the Worst-case estimate (WCE) and the current estimated values (CEV).

$$\%\text{margin current} = \frac{\text{WCE} - \text{CEV}}{\text{CEV}} \times 100 \qquad (1)$$

Where WCE is the Worst case estimate and CEV is the current estimated value [4]. As part of a research feasibility study for a family of solar UAVs, and a trade study for commercial aircraft looking at the tradeoffs between noise and fuel burn for aircraft which are also complex systems[5]. An analysis about the redesign or to plan a new design should include the experiences of many multidisciplinary research groups who have been directly involved in important areas such as hydrodynamics (hull's geometry), materials and manufacture and, operation; fields that can be taken in to account to redesign or design AUV´s [6].

2. METHODOLOGY

The methodology can be explained by the below flowchart includes a sequence of five steps in determining the design margins of Nose of an AUV.

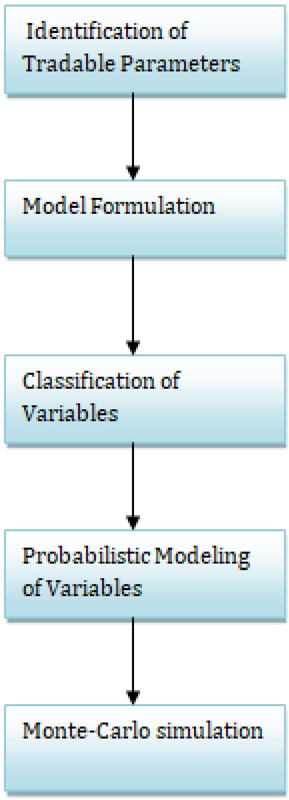

Fig -1: Flowchart of Methodology.

3. APPLICATION OF METHOD

According to the investigated methodology the steps are applied to Nose of an AUV, and the design margins are to confine by the decision-maker. Every effort in this design was made to make the analysis as realistic as possible. The tradable parameter is analyzed and margins are determined accordingly followed by analysis and comparison.

3.1. Identification of Tradable Parameters

The first step is the identification of tradable parameters. The design and development of nose in AUV are motivated by the overarching requirement of maintaining within specified margin ranges. It is essential to identify the tradable parameters which are more important in satisfying the requirements which are to be placed in the complex multi-disciplinary. Engineering parameters will necessarily result from this analysis.

3.2. Model Formulation

Once tradable parameters have been identified, an analytic model must be generated to calculate each of these parameters. Determining how accurate models need to be effectively determining the margin levels in design is a critical issue and is discussed in the paper.

3.3. Classification of Variables

Once models have been created for all desired tradable parameters, the variables used are classified. Classifying the variables into their uncertainty types is useful in understanding their respective impact on the overall design.

3.4. Probabilistic Modeling of Variables

The next step in the investigated method is probabilistic modeling of each variable previously described. Characterization of variables can be done by a probability density function. The probability density distribution applied to each variable may be determined from existing data, analogy, analysis, expert opinion, or a combination of these.

3.5. Monte-Carlo Simulation

Once all the variables involved in the design have been given a probability density function, a Monte-Carlo simulation is performed. A Monte-Carlo simulation involves hundreds to thousands of simulations, each using different variables generated by their relevant probability distributions. For each simulation, the tradable parameters are recorded. Hence, the Monte-Carlo simulation generates probability density distributions of each tradable parameter. The more simulations performed, the smoother the resulting tradable parameter distributions. Statistical techniques can be used to estimate the required number of Monte Carlo samples.

4. ANALYSIS

With distributions of each tradable parameter provided by the Monte-Carlo simulation, an analysis of the complex multidisciplinary system is performed. Each tradable parameter distribution yields a mean and three percentiles. A percentile is defined as the value that is greater than a specified percent of all the values in a set. A percentile of 50 is simply the statistical median of a sample. Percentiles provide a confidence indication in the value of a tradable parameter. The 95, 99, and 99.9 percentiles of a tradable parameter provide decision-maker with a low-, medium-, and high-confidence estimate in the probability that a tradable parameter will not be exceeded. The difference between these 95, 99, and 99.9 percentiles and the deterministic result provide the decision-maker with a margin value to be maintained at the current stage of the design. The percent margin is this margin divided by the deterministic result (and multiplied by 100).

$$\%\text{margin proposed} = \frac{EV - SV}{EV} \times 100 \quad 2$$

Where EV is the estimated value from the design and SV is the simulated value.

The outer diameter of the AUV is initially setup and the inner diameter is calculated based on the thickness of the shell which varies from floodable to free floodable sections.

$$Rib = Ro - T \text{ And } \quad Ri = Ro - T$$

As the Nose is a free floodable section thickness (T) is considered and it has three subsections in it accordingly the formula was generated.

$$Vnc1 = (\pi \times ro \times (0.5 \times (Ro^2) + 0.5 \times (rc^2) + 0.1666 \times (ro^2)) \quad 3$$

$$Vnc2 = (\pi \times ri \times (0.5 \times (Ri^2) + 0.5 \times (rc^2) + 0.1666 \times (ri^2)) \quad 4$$

$$Vn1 = Vnc1 - Vnc2 \quad 5$$

$$Wn1 = \rho \times Vn1 \quad 6$$

$$Wn2 = \rho \times (\pi \times (Ro^{\wedge}2 - Ri^{\wedge}2) \times ln) \quad 7$$

$$Wn3 = \rho \times (\pi \times rc^{\wedge}2 \times Tffs) \quad 8$$

$$Wn = Wn1 + Wn2 + Wn3 \quad 9$$

$$Wns = 0.15 \times Wn \quad 10$$

$$WN = Wn1 + Wn2 + Wn3 + Wns + Wc \quad 11$$

5. RESULTS

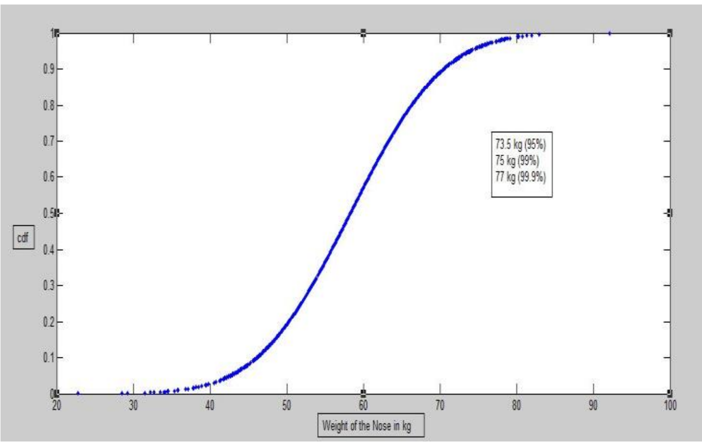

Chart -1: Cdf of Nose.

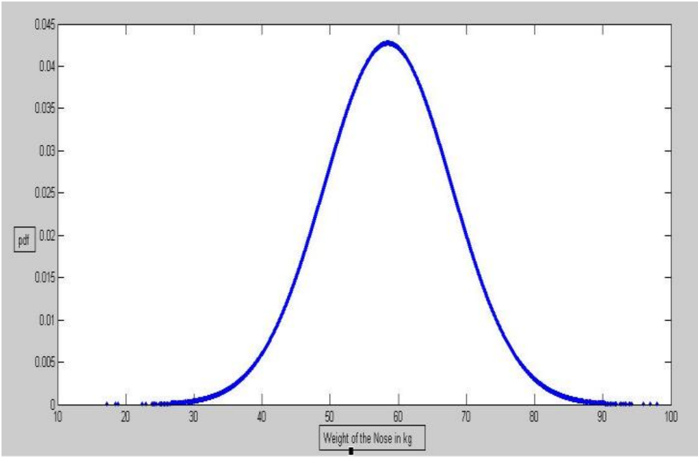

Chart -2: Pdf of Nose.

6. CONCLUSIONS

Determining the design margins of Nose of an AUV by using Monte Carlo Simulation has been proposed. The aim of the research is to determine design margins of Nose an AUV by using Monte Carlo Simulation method. The margins are the function of weight and are determined in accordance to estimated weight through design and determined weights obtained from the simulation method i.e., Monte Carlo Simulation margin values are determined at percentile values of 95, 99, 99.9 by Pdf and Cdf graphs such that the obtained margins can be used to have persistent design of Nose of an AUV.

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