SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

AIR5788 REV. A

Issued 2005-05
Stabilized 2012-08

Superseding AIR5788

Common Launch Acceptability Region (CLAR) Truth Data Generator Interface Control Document (ICD) for the CLAR Approach (CLARA)

RATIONALE

The Technical Committee which originally created this document is no longer active.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE AS-1B Aircraft Store Integration Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

INTRODUCTION

Aircraft and weapon systems use many different Launch Acceptability Region (LAR) algorithms. Because each aircraft/weapon integration project developed its LAR solution separately, they created a plethora of expensive, difficult-to-maintain-and-reproduce, and time-consuming solutions.

The U.S Air Force Executive Weapon System Review (EWSR) formed a Task Group (TG) to study the feasibility of developing a Common LAR (CLAR) that the Air Force could use to reduce development and maintenance costs. The EWSR TG surveyed Air Force weapon and aircraft contractors to determine if a CLAR approach is possible and if so what approach would best fit the Air Force requirements. The EWSR TG completed the survey and presented its results to the EWSR on 4 August 1998. As a follow-up, the EWSR task group requested the assistance of the SAE to determine if a CLAR approach is feasible. The objective was to reduce cost and time associated with each new weapon integration by defining a common coefficient-based LAR algorithm.

The SAE created AS-1B5 CLAR Approach (CLARA) Task Group to develop the CLAR approach useable across a wide variety of weapon systems. This approach consists of four functions (Data Space Generator, Truth Data Generator, Coefficient Generator, and Reconstructor) that standardize the solution to the LAR problem.

1. SCOPE:

1.1 Purpose:

This document specifies the CLARA interfaces of the CLAR Truth Data Generator as shown in Figure 1. The solid bold arrows are defined in Table 1 and Table 2. The dashed arrows from the CLAR Coefficient Generator and Truth Database to the CLAR Data Space Generator indicate a feedback loop and are defined in the CLAR Data Space Generator ICD (Reference 1). The dashed arrow from the Truth Database to the CLAR Coefficient Generator is defined in the CLAR Coefficient Generator ICD (Reference 2).

1.1 (Continued):

The objective for the CLAR Truth Data Generator is to produce impact data sets to be used in the CLAR Coefficient Generator first to score and form LAR boundaries, and then to generate coefficients. A model of the weapon system that predicts weapon delivery performance to a predefined accuracy is to be used for this purpose. The model can be the Six-Degree-Of-Freedom (6DOF) equations of motion or another mathematical representation that meets the objective for the weapon system LAR.

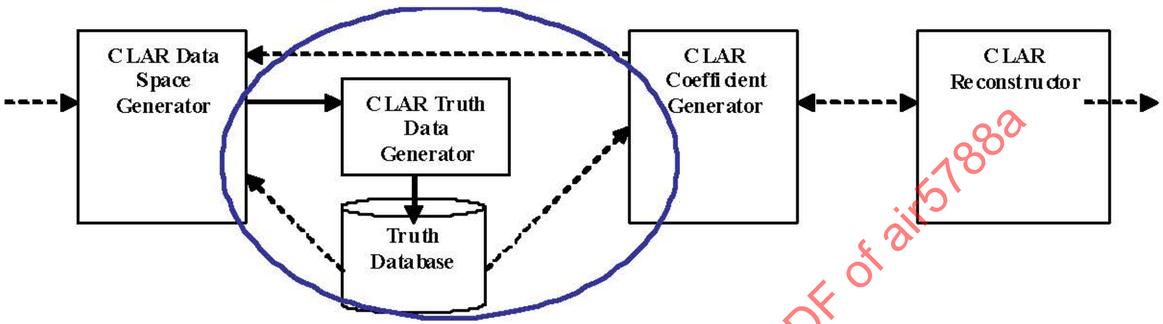

FIGURE 1 - CLAR Data Flow Diagram

1.2 Applicable Documents:

1. SAE ACE paper 2001-01-2953 titled "Common Launch Acceptability Region Task Group".
2. SAE AS-1B5 CLARA Glossary document.
3. SAE AS-1B5 CLARA Requirements document.
4. SAE AS-1B5 CLARA Rationale document.
5. NOAA-S/T 76-1562 US Standard Atmosphere, 1976.

2. REFERENCES:

Reference 1. CLAR Data Space Generator ICD, To Be Written and Released.

Reference 2. CLAR Coefficient Generator ICD, To Be Written and Released.

Reference 3. Society of Automotive Engineering Technical Standards Board Standard, TSB 003 as issued 1965-06 and revised 1999-05.

Reference 4. NOAA-S/T 76-1562 US Standard Atmosphere, 1976.

3. CLAR TRUTH DATA GENERATOR INTERFACES:

3.1 Overview:

The weapon system model used by the CLAR Truth Data Generator is referred to as a Weapon Truth Model with its inputs and outputs shown in Figure 2. The definitions of the CLAR Truth Data Generator interfaces are based on this representation.

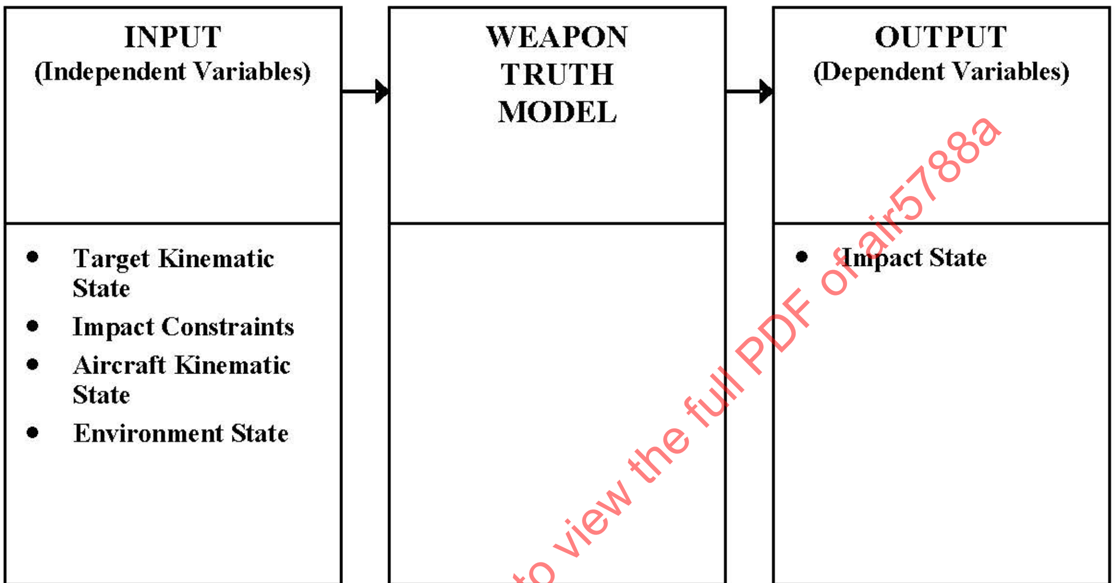

FIGURE 2 - Weapon Truth Model Block Diagram

3.2 Functions Interfacing With the CLAR Truth Data Generator:

3.2.1 CLAR Data Space Generator: The Data Space Generator defines the appropriate number and location of input conditions necessary to properly characterize the dynamics of a set of impact states. The input conditions to properly characterize the data space may be non-uniformly distributed. The Data Space Generator also defines the number of impact state sets used for training and validation of the CLAR Coefficients.

3.2.2 CLAR Truth Database: The CLAR Truth Database encompasses the impact state sets that are created by the CLAR Truth Data Generator and used by the CLAR Coefficient Generator to create and verify the coefficients of the CLAR algorithm.

3.3 Coordinate Systems:

3.3.1 Launch Coordinate Frame: The launch coordinate frame for launch states and aim-point locations is defined as an aircraft-centered, local level, right-handed coordinate system with X-axis positive forward along the horizontal component of the velocity vector, and Z-axis positive down. The origin (0,0,0) is the initial position of the weapon at launch.

3.3.2 Impact State Coordinates: The coordinate system for impact states is defined as the launch coordinate frame with the origin translated to the intended aim-point. Impact azimuth is positive from the X-axis toward the Y-axis and is the angle between the X-axis and the weapon velocity component in the X-Y plane at impact. Impact Angle is measured from the horizontal plane toward the Z-axis in the plane that includes the weapon velocity vector at impact.

3.3.3 Wind Coordinates: Wind shall be defined as a velocity vector in the launch coordinate frame, i.e. tail wind is defined as positive. (Wind Vx)

3.3.4 Weapon Coordinates: The weapon's coordinate system is depicted in Figure 3.

The weapon's body axis system consists of an orthogonal triad of axis, X_w, Y_w, and Z_w with origin (0,0,0) at the fixed location determined to be the optimum for that weapon. The X_w axis is positive in the forward direction of the weapon. The Y_w axis is positive to the right of the forward direction of the weapon. The Z_w axis is positive down through the lower side of the weapon.

The weapon's attitude relative to the inertial velocity vector is defined by the inertial Angle of Attack (iAOA) in the weapon (X, Z) plane and the inertial Angle of Sideslip (iAOSS). The order of rotation is: iAOA and then iAOSS.

Weapon impact is shown in Figure 3 as a point on the ground plane and some miss distance from the intended center of the target area. Weapon impact Angles, Velocity, Angles of Attack and Sideslip are defined pictorially in this figure. These conditions with miss distance define the terminal impact results that are to be stored in data files for utilization by the CLARA process to construct the LAR for the weapon.

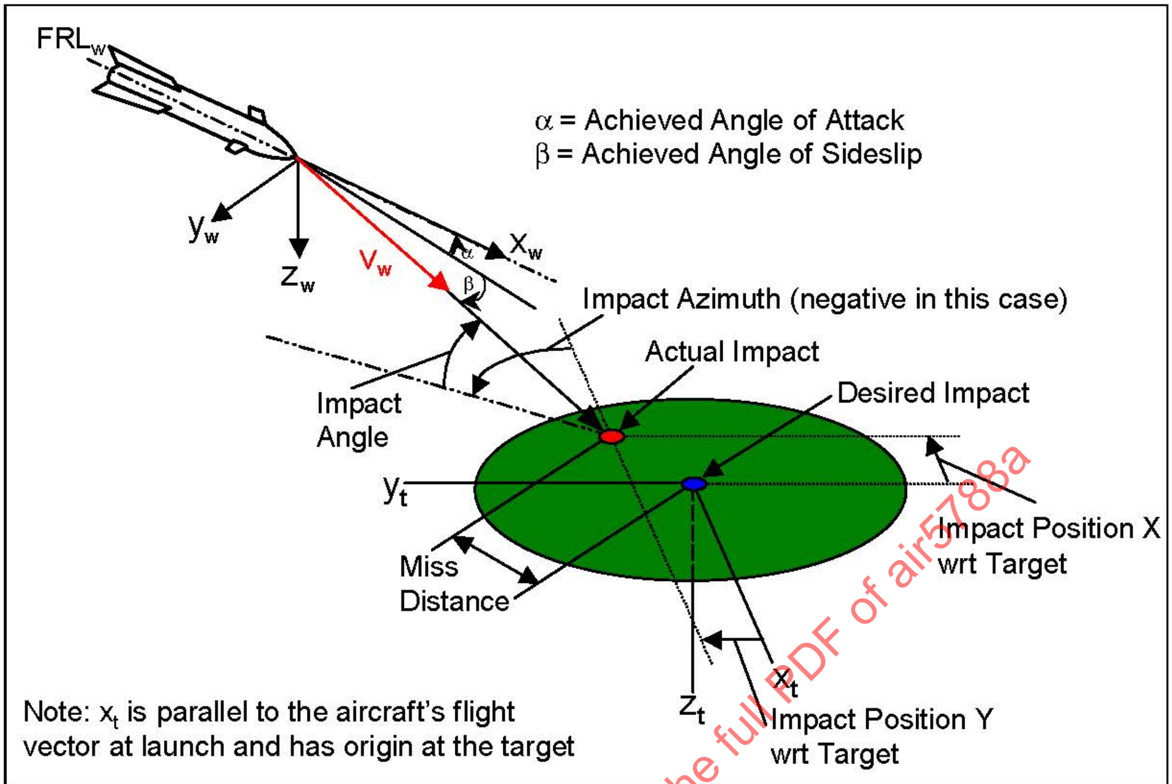

FIGURE 3 - Weapon Impact relative to Target

3.4 Units:

All units shall be metric conforming to Reference 3.

3.5 Atmospheric Model:

A Standard Atmospheric Model defined in Reference 4 shall be used. The Standard Day is default, however it is recognized that multiple conditions may be used to model conditions at a particular location, region, or season.

3.6 Wind Model:

A single wind model shall be used. The model shall be defined as a given wind speed at the weapon release that is linearly decayed to 0 at -1219.2 m Height Above Ellipsoid (HAE) with a constant direction throughout the profile.

3.7 Input Data:

Table 1 defines the input data required by the Weapon Truth Model to generate the impact states. Additional input data elements required to model the weapon LAR performance may be used as necessary. If additional input data elements are required they shall be appended to the list of input data in Table 1.

3.8 Output Data:

Table 2 provides a list of output data elements from the CLAR Truth Data Generator, which are generated by the weapon truth model. Additional outputs required to model the weapon LAR performance may be used as necessary.

3.9 Input File:

As a minimum, the input file shall consist of a header to include: the data security classification, the weapon name, the weapon-contractor proprietary identifier, and definitions of any hot or cold day conditions used. Additional comments are optional. The Input data consists of the input state followed by the target grid-point or target state as defined in Table 3. For each set of input state data there is a set of target state data that corresponds to each target grid-point or desired impact point. This target state data is varied over all target input values (grid points) for the given input state. The set of output data that results spans the output grid and this output data is used to determine a LAR for this given input state. There is a scoring process applied (see CLAR Coefficient Generator ICD, Reference 2) to the output data to arrive at the LAR. The complete input data file shall contain input variable values for all input states and target state values for each desired target grid point. The input file shall be label-based. The order of the input data elements in the input file shall follow the order of the input data elements as listed in Table 1. Input data elements from Table 1 that are not applicable for all conditions may be omitted from the input file. The input file shall be a tab-delimited ASCII text file.

3.10 Output File:

Table 3 defines the format of the output file. An output file has an output data set corresponding to a single input state but spanning all target grid points as defined in 3.9. The output data for each grid point is called an impact state. The total output is the collection of all output file data from all input states of a particular Data Space. The number of output files in the total output corresponds to the number of input states. The output file consists of input state data followed by target grid point data. The target grid data consists of target state data and the output data. The target state is the x-y grid corresponding to the desired impact coordinates. The output data corresponds to the achieved impact state. If there are “P” target grid points, then there are “P” target state and impact states. Also, if there are “N” input states, then there are a total of NxP impact states spanning the “N” output files that correspond to the results of all input data. The

3.10 (Continued):

output data shall be provided in a sequential order defined by Table 3. Data must be available for delivery in tab-delimited ASCII. If data is delivered in any file format other than ASCII, it shall be delivered with a file specification. The output will consist of a grid of impact states starting at the minimum Down-Range and Cross-Range. Down-Range value varies as an “inner loop” while cross-range varies as the outer loop. Note that the miss distances are either raw miss distance from a single run or a statistical measure, e.g. mean, standard deviation or Circular Error Probable (CEP) if a collection of runs is performed to yield the single statistical measure.

TABLE 1 - Input Data

Element	Units	Range	Precision	Notes
Impact Constraints				
Impact Angle	Radians	0 to $\pi/2$	0.001	
Impact Azimuth	Radians	$-\pi$ to π	0.001	
Impact Speed	m/sec	Note 1	0.1	
Target Kinematic State				
X-axis Distance from Aircraft to Target	m	Note 1	0.1	Down-Range
Y-Axis Distance from Aircraft to Target	m	Note 1	0.1	Cross-Range
Z-Axis Distance from Aircraft to Target	m	Note 1	0.1	
X-Axis Speed at Launch	m/sec	Note 1	0.1	
Y-Axis Speed at Launch	m/sec	Note 1	0.1	
Aircraft Kinematic State				
Vx	m/sec	Note 2	0.1	Inertial
Vz	m/sec	Note 2	0.1	Inertial
Altitude	m	Note 2	0.1	HAE
Environmental State				
Wind Vx	m/sec	Note 3		
Wind Vy	m/sec	Note 3		
Atmospheric Model Day	n/a	Note 5	1	
Weapon Specific Input Data				
Weapon Specific Input #1				Note 4
…				
Weapon Specific Input #J				Note 4

Notes:
1) Max value is weapon-specific.
2) Range of values is weapon/aircraft-specific
3) Wind speed range is determined by system requirements.
4) Weapon-unique data may be added as necessary.
5) Standard Day, Hot Day, Cold Day. Coefficients may be generated based on any or all of these days at program discretion.

TABLE 2 - Output Data

Elements	Units	Range	Precision	Notes
X-axis Distance from Aim-Point to Impact Point	m	Note 1	0.1	Down-Range Deviation
Y-axis Distance from Aim-Point to Impact Point	m	Note 1	0.1	Cross-Range Deviation
Z-axis Distance from Aim-Point to Impact Point	m	Note 1	0.1	Altitude Deviation
Impact Speed	m/sec	Note 1	0.1	
Impact Angle	Radians	0 to $\pi/2$	0.001	
Impact Azimuth	Radians	$-\pi$ to π	0.001	
Achieved iAOA (inertial AOA)	Radians	$-\pi/2$ to $\pi/2$	0.001	Positive where Body C/L is above velocity vector
Achieved iAOSS (inertial AOSS)	Radians	$-\pi/2$ to $\pi/2$	0.001	Positive where nose is left of velocity vector
Total Time of Flight	Sec	Note 1	0.1	
Weapon Specific Output Data				Note 2

Notes:

1) Range of values is weapon-specific.
2) Weapon-unique data maybe added as necessary.