Defence Science Journal, Vol 47, No 3, July 1997, pp. 359-363

SHORT COMMUNICATION

Anukalpana 2.0 : A Performance Evaluation Software Package for *Akash* Surface-to-Air Missile System

G.S. Raju and Prahlada

Defence Research & Development Laboratory, Hyderabad-500 058.

ABSTRACT

An air defence system is a complex dynamic system comprising sensors, control centres, launchers and missiles. Practical evaluation of such a complex system is almost impossible and very expensive. Further, during development of the system, there is a necessity to evaluate certain design characteristics before it is implemented. Consequently, need arises for a comprehensive simulation package which will simulate various subsystems of the air defence weapon system, so that performance of the system can be evaluated. With the above objectives in mind, a software package, called *Anukalpana* 2.0, has been developed. The first version of the package was developed at the Indian Institute of Science, Bangalore. This program has been subsequently updated.

The main objectives of this package are: (i) evaluation of the performance of *Akash* air defence system and other similar air defence systems against any specified aerial threat, (ii) investigation of effectiveness of the deployment tactics and operational logic employed at the firing batteries and refining them, (iii) provision of aid for refining standard operating procedures (SOPs) for the multitarget defence, and (iv) exploring the possibility of using it as a user training tool at the level of Air Defence Commanders. The design specification and the simulation/modelling philosophy adopted for the development of this package are discussed at length. Since *Akash* air defence system has many probabilistic events, Monte Carlo method of simulation is used for both threat and defence. Implementation details of the package are discussed in brief. These include: data flow diagrams and interface details. Analysis of results for certain input cases is also covered.

1. *AKASH* AIR DEFENCE SYSTEM

Akash weapon system is an air defence system intended for the defence of high value vulnerable points or areas against low level, high speed and high density air raids. *Akash* weapon system consists of one group control centre (GCC) and several fire control batteries. Each fire control battery consists of a battery level radar (BLR), battery control centre (BCC) and four *Akash* self-propelled launchers (ASPLs). Each launcher carries three *Akash* medium range surface-to-air missiles (SAM).

Received 03 January 1997

1.1 Modes of Operation of *Akash* Weapon System

There are two modes of operation of the Akash system: group mode and autonomous mode. In group mode, all fire control batteries are connected to a GCC through real-time communication channels, and GCC controls the functioning of each fire control battery. In the autonomous mode, each fire control centre works in a stand-alone mode. All the defence functions would then be carried out by the battery itself.

2. SIMULATION/MODELLING PHILOSOPHY

Anukalpana 2.0 is a simulation package[1] designed and developed to evaluate the performance of *Akash* missile system, against a given aerial threat. The basic model of the system is based on *Anukalpana* 0 developed by the Indian Institute of Science, Bangalore[2]. Discrete simulation approach was adopted to enhance the efficiency in terms of execution time. The original model, written using GASP-IV[3], was using a continuous simulation approach. This model had several disadvantages in terms of long execution time and non-portability to different hardware platforms. Since *Akash* air defence has many probabilistic events, Monte Carlo method of simulation is used for the analysis of performance of both threat and defence.

Simulation of *Akash* fire control batteries includes simulation of functions and characteristics of BLR, BCC, ASPL, *Akash* missile and GCC in case of Defence and Aircraft and attack formation and different weapons (such as bombs, air-to-surface missile (ASM), anti-radiation missile (ARM), jammers etc., targeted against vulnerable points (VP), vulnerable areas(VA) and radars) in case of threat.

2.1 Defence

2.1.1 *Functions & Characteristics of BLR*

Akash BLR is a multifunction ground-based radar. The main functions are to detect and track multiple tracks for assignment and engagement against ground clutter, weather clutter and electronic counter-measures (ECM). The radar can also guide multiple missiles towards the targets simultaneously for:

- Identifying hostile/friendly targets,
- Tracking the fired missile, and
- Transmitting command guidance to missiles.

2.1.2 *Functions & Characteristics of BCC*

The BCC, interfaced with the BLR, performs the following command control functions:

- Initialising launchers and missiles,
- Controlling four launchers,
- Determining the firing zone for each launcher and time to launch and mode of engagement,
- Launching missiles against the target (in single shot and salvo firing mode),
- Generating guidance commands and transmitting these to missiles via BLR,
- Assessing kill of the target, and
- Communicating with GCC.

2.1.3 *Characteristics of* Akash *Launcher*

Each *Akash* launcher carries three *Akash* missiles. Each launcher is assigned to a particular hostile target for firing of missiles. The control functions include:

- Slewing launchers to assigned targets,
- Carrying out automatic checkout of missiles, and
- Launching missiles one after the other automatically, depending on the firing mode.

2.1.4 *Characteristics of* Akash *Missile*

Akash is a medium range surface-to-air missile. It has three phases in trajectory: unguided boost phase, command guidance, which starts immediately after the boost phase, and terminal guidance.

2.1.5 *Functions & Characteristics of GCC*

These include :

- Multiradar data fusion and generation of GCC track data,
- Threat evaluation, identification, and prioritisation, and
- Assignment of threatening targets to fire control batteries for engagement.

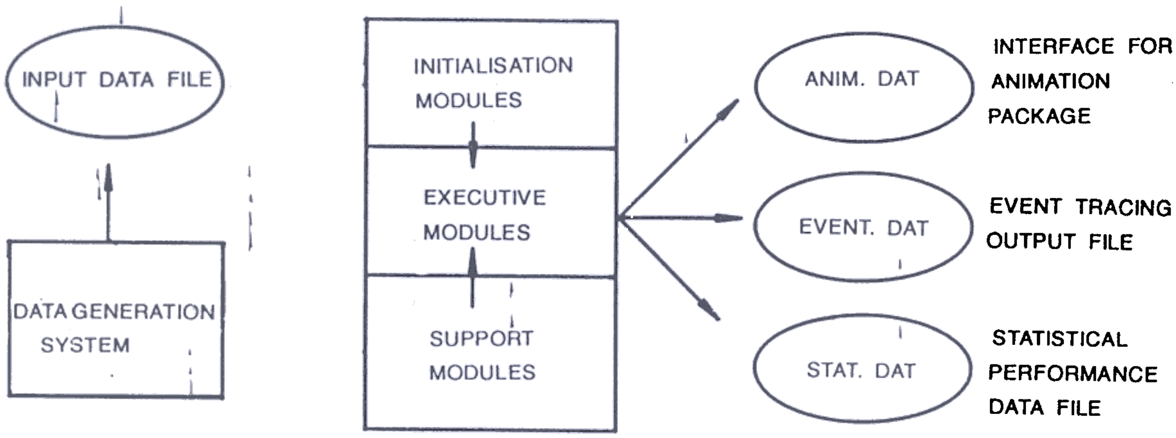

Figure 1. Software architecture for *Anukalpana*

2.2 Threat

2.2.1 Flight Path Simulation

The flight path of each aircraft will be given to the simulation as input. The flight path consists of:

- Number of manoeuvring points in the flight path of the aircraft,
- Start time of the aircraft,
- Coordinates of aircraft at each manoeuvring point, and
- Velocity of aircraft for each leg of the flight path.

Weapons' Release

The type of weapons carried by an aircraft, its quantity and the target are given to the model as input data.

3. IMPLEMENTATION

The package is divided into three major modules:

- Initialisation module,
- Executive module, and
- Support module.

The software architecture and data flow diagrams are shown in Figs 1 and 2, respectively.

3.1 Initialisation Module

This module reads the defence and threat parameters from the file and initialises all simulation data structures.

3.2 Executive Module

Simulation is carried out by scheduling events into an event file. The module continues popping the next event and executing a corresponding routine till the event file is empty. After collection of performance statistics, the simulation is repeated:

Major event routines are

DTBCC	Detection by BCC
TRABLR	Tracking by BLR
SAMRDY	SAM ready
SAMRLS	SAM release
SAMINTC	SAM intercept
LANRDY	Launcher ready
WPNRLS	Weapon release
WPNINTR	Weapon intercept.

4. RESULTS

A scenario consisting of five batteries defending specified vital points/areas against an aerial threat of 27 aircraft (16 bombers, 5 jammers, 4 ARM carriers, 2 decoys), as shown in Fig. 3, was simulated. Statistical results are presented in Table 1. The kill of aircraft by SAM, kill of target

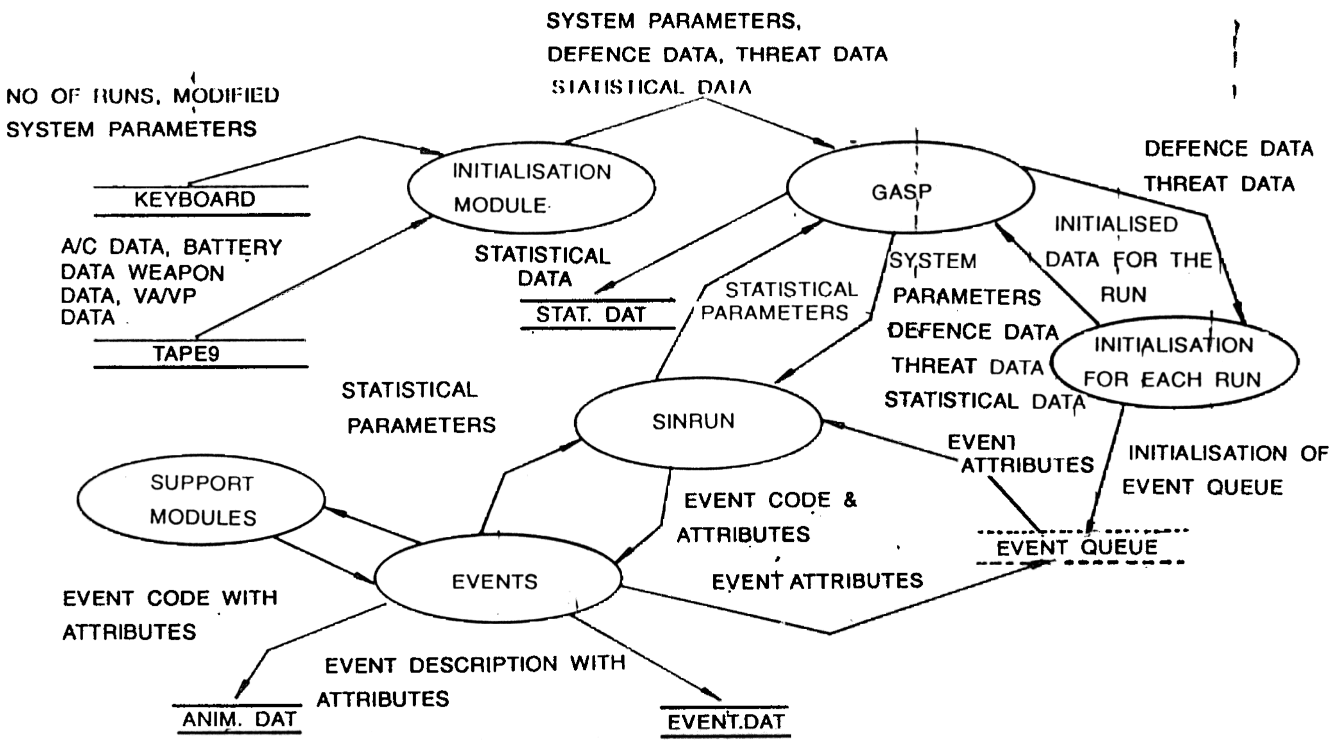

Figure 2. Data flow diagram for *Anukalpana* 2.0

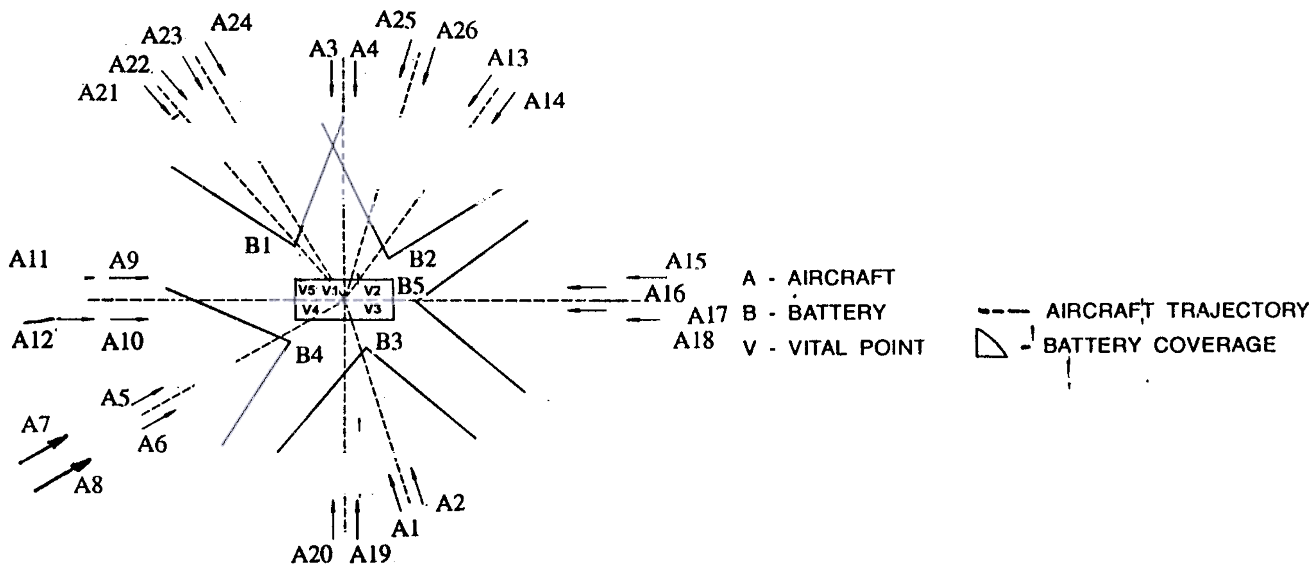

Figure 3. Scenario

(ex. VA,VP) by weapons carried by aircraft, target (aircraft) detection by BLR, etc. are all probabilistic events. These events are therefore simulated using random numbers. The time of detection of targets, number of aircraft killed, number of VA/VPs killed, etc. are going to vary from one run to another. So, the simulation was run several times for statistical analysis.

5. UTILITY OF THE SYSTEM

The package, being modular and flexible, can have many versions, each providing for a certain

Table 1. Statistical results

	Mean	Standard deviation	Minimum	Maximum
Batteries killed	2.56	0.65	1.00	4.00
VPs killed	0.12	0.33	0.00	1.00
Aircraft killed	16.72	1.14	14.00	18.00
SAMs used	33.96	0.20	33.00	34.00
Weapons used	8.72	1.02	8.00	11.00

type of deployment and tactics. This package is useful for obtaining simulation results for different deployment patterns to select the best deployment pattern, which in turn aids the commander of the system in the field. The deployment pattern and engagement tactics are influenced by the attack formations, their parameters, type of weapons carried by the attacking aircraft and flying patterns. The options can be studied off-line and the tactics worked out.

Comparison of the effectiveness of different SAM systems can be made using this package. Already effectiveness and comparison of one of the air defence systems existing with our Armed Forces and *Akash* weapon system have been simulated and the results sent to the users.

REFERENCES

Anil, J.K. & Anuradha, V. *Anukalpana* 2.0, DRDL, Hyderabad, 1992. DRDL-7100-1111-512.

2. Sarma, I.G.; Dwarakanth, C.K. & Usha Ramanathan. *Anukalpana* 0, IISC, Bangalore, 1986. JATP-85-012.

3. Pritsker, A.A.B. *The GASP-IV Simulation Language.* John Wiley & Sons, UK, 1974.

Contributors

Shri GS Raju obtained his MSc (Statistics) from Osmania University, Hyderabad, in 1984. He joined DRDL, Hyderabad, in 1986. Presently, he is working as a member of the Software Development Team at Computer Centre, DRDL.

Shri Prahlada obtained his BE (Mechanical Engineering.) from Bangalore University, (Aeronautical Engg.) and ME from Indian Institute of Science, Bangalore. He has worked in various research establishments like Vikram Sarabhai Space Centre (VSSC), Trivandrum, Defence Research & Development Laboratory (DRDL), Hyderabad and Aeronautical Development Establishment (ADE), Bangalore. The areas of his interest include flight controls, guidance, propulsion and system engineering. Currently, he is working at DRDL, Hyderabad as Project Director for the indigenous surface-to-air missile system, *Akash*.