CLOCKWORK SOLUTIONS

CASE STUDY

ARROW Anti-Tactical Ballistic Missile Defense System

Introduction

The Arrow Anti-Tactical Ballistic Missile (ATBM) is under joint development by the United States and Israel. Its purpose is to provide a security umbrella over Israel and, in the future, other small countries under missile threat from their neighbors. In order to succeed, the Arrow must consistently intercept incoming missiles at altitudes where warheads will detonate too high to fall on defended territory. Its mission is so critical that the United States and Israel have already spent $1.1 billion on its development.

As designed, Arrow's altitude capability extends to 30 miles above the Earth's surface (approximately 16,000 feet or 5,000 meters) and its speed can reach nine times the speed of sound. It can detect and track incoming ballistic missiles from as far away as 500 kilometers and it can launch and intercept such missiles 50-90 kilometers away. An Arrow missile need not hit its target directly; detonation within 50 meters can incapacitate an incoming warhead.

The Arrow system comprises multifunction phased radar, guidance, communications, launch stations, and missiles. All of these subsystems are integrated to enable the Arrow's formidable capabilities. But at the same time, this complex, real-time integration presents an intricate system reliability problem.

What Makes Deployment and Support of Arrow So Complex?

Arrow's design, development, and maintenance are exceedingly complex due to many factors. There are many threat scenarios with which Arrow must contend. From where are attacking missiles likely to come? How are they going to be fired? All at once? A few at a time? In some sort of sequence? What types of missile are likely to be launched? What types of warheads will they be carrying?

Arrow is so critical to modern anti-missile defense strategy that it must perform at an extremely high level all the time. Hence, reliability is of critical importance. The ability to correctly monitor system performance and the capability to suggest improvements at any point in time are extremely important.

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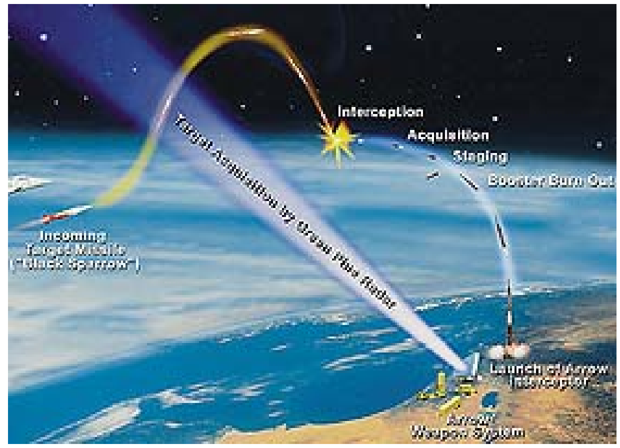
Performance

Maintaining requisite system performance relies on two major systems engineering issues. First, Arrow must have optimal reliability engineered into its *design*. For example, there must be the correct level of component and subsystem redundancy. Too little redundancy renders Arrow unable to fulfill its mission. Over-redundancy adds to weight decreasing effectiveness, and adds to expenses increasing the life-cycle cost of the system.

Second, *logistics processes* must enable scheduled inspections and maintenance without weakening performance at any point in time. Since aging in Arrow renders it sub-optimally effective, the scheduling of preventive maintenance must consider the effects of aging on Arrows' subsystems and components in the context of the overall performance of the national missile defense system. In addition, preventive maintenance scheduling must manage outages so that the temporary loss of some units due to inspection, parts replacement, etc. will not adversely affect overall capability of missile defense. Furthermore, spare parts must be available in the proper quantities at the proper times so as to minimize scheduled downtime and to stay within budget constraints.



Graphic illustrates how the Arrow 2 intercepted a Black Sparrow target missile fired from a Boeing F-15 fighter. (Source: IAI)

The SPAR Project

Clockwork and its proprietary SPAR™ technology were chosen for the analysis of Arrow's performance. Only SPAR is capable of handling the complexities of the Arrow system.

Our SPAR™ model captured the intricate relationships and interactions among all critical components and subsystems, and quantified the trade-offs between performance metrics and costs over the entire life-cycle of the system. This project was one of the largest and most complex SPAR™ models ever built encompassing thousands of elements, the logistics support infrastructure, inspections, spare parts, and detailed time-dependent, mission scenarios – all in one, comprehensive, integrated model.

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