The Application of Cost Management and Life-Cycle Cost Theory to Homeland Security National Priorities

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As the nation's homeland security environment develops and evolves, federal, state, tribal, and local partners must continually implement and adapt homeland security programs that address both national and local homeland security priorities, while simultaneously managing the costs and resources necessary to maintain an adequate level of preparedness. Without a flexible, logical, and transparent method of managing homeland security costs and programs, homeland security leaders are faced with a daunting task. This article proposes life-cycle cost (LCC) theory as a method to identify and quantify the costs of achieving and sustaining preparedness capabilities across the nation.

The purpose of this article is threefold. First, it documents a methodology that uses LCC theory to quantify the costs of achieving and sustaining target capabilities to support the National Preparedness System. Second, as an example case, the article applies the methodology to the *Explosive Device Response Operations (EDRO)* target capability, which is the capability to coordinate, direct, and conduct improvised explosive device (IED) response after initial alert and notification. We chose to exemplify the application of LCC methodology using the *EDRO* capability because this particular capability includes a complex structure with many cost components. As such the example provides a robust overview of the methodology. Third, it articulates a number of next steps needed to develop and apply LCC methods to national preparedness.

INTRODUCTION

In March 2005, the Department of Homeland Security (DHS) issued the Interim National Preparedness Goal. In September 2007, DHS published the *National Preparedness Guidelines*, which finalized the development of the national goal. The goal describes the following national preparedness system vision: A nation prepared with coordinated capabilities to prevent, protect against, respond to, and recover from all hazards in a way that balances risk with resources and need.[1]

To support the preparedness system vision, DHS created a conceptual framework to build, sustain, and improve national preparedness for a broad range of natural, man-made, and technological threats and hazards within the following four mission areas: prevent, protect, respond, and recover.[2] A collection of aggregate capabilities outlines the homeland security tasks associated with each mission area. Each capability integrates multiple disciplines, processes, and procedures through a method detailing the conditions under which tasks take place and describing desired outcomes. The collection of these capabilities comprises the Target Capabilities List (TCL).

The TCL is a generic model of operationally ready capabilities that define preparedness for all types of hazards. Target Capabilities List 2.0 describes the amount of capability a jurisdiction must achieve in (1) planning factors, which provide estimates of the amount of a capability necessary to address a specific scenario and (2) national target levels, which provide estimates of the amount of a capability needed across the nation to achieve national preparedness.[3] The next iteration of the TCL, 3.0, will describe the level of capabilities a jurisdiction must achieve in terms of performance class, performance objective, and capability element frameworks.[4]

As DHS policy has matured over the last several years, the importance of quantifying levels and costs of capabilities has gained importance. Government Accountability Office (GAO) reports have emphasized the need to determine capability costs, determine what governments can afford, establish capability baselines, develop coordinated funding plans and expenditures, and develop life-cycle cost practices.[5] For the federal government, this will require that homeland security program analysts quantify, in some way, the costs associated with achieving and sustaining the target levels of capability that make the nation fully prepared. For state, tribal, and local governments, this will require that homeland security program managers determine the levels of capability a jurisdiction needs and associated costs so that they can take full advantage of grant programs and effectively manage homeland security programs within their jurisdictions.

Furthermore, as mandates like the Homeland Security Act of 2002 (which requires states to report an estimate of homeland-security related expenditures for each prior and current fiscal year) and the 2006 Post-Katrina Emergency Management Reform Act (which requires states to report homeland security preparedness levels in annual State Preparedness Reports) take hold, the calculation of capability cost will need to be more than an opinion. Potentially, there may be many ways to calculate the cost of preparedness. We propose a thorough and robust method of calculation that determines the components of people, planning, organization, equipment, training, and exercise that make up a capability; identifies, models, and annualizes component costs; and calculates costs for accomplishing and sustaining national target-levels of capability.

COST MANAGEMENT

Developing and maintaining viable homeland security programs within states and jurisdictions requires federal, state, tribal, and local officials to understand the costs involved in acquiring and sustaining programs associated with national priorities. With fifty-six states and territories and approximately sixty urban areas executing homeland security programs under differing strategies with a multitude of goals and objectives, the cost-management process is extremely complex.[6] However, modern cost-management methods used by industry and federal agencies such as the Department of Defense[7] can provide insight and permit the Department of Homeland Security to mature cost-management practices while avoiding "unprofitable" pitfalls.[8]

Cost management helps managers plan and control expenditures by providing managers and designers with better information on when and where costs occur and what costs add to the value of a product.[9] Further, the development of cost-analysis techniques can provide insight on the return-on-investment of federal grant programs, such as the Homeland Security Grant Program (HSGP). Applying modern cost-management methods to homeland security cost management requires homeland security project managers to focus on four major concepts:

1. Expand existing views of capability cost beyond the purchase of new equipment to achieving and sustaining an entire target capability through long-term programs in states and urban areas.
2. Develop capability cost estimates by detailing capability components and their cost variables and developing a model for each target capability element.
3. Determine the most expensive components (cost drivers) of a capability to balance limited resources and needs.
4. Calculate the target capability-element level that must be achieved to comply with capability planning factors and national target levels so that costs are quantified and risk-benefit analysis is possible.

LCC AS A METHOD FOR COST MANAGEMENT

Life-cycle cost (LCC) is a methodology that can assist cost management efforts by calculating the 'total' cost of owning an asset.[10] Total cost includes the cost to not only acquire the asset, but also to use, maintain, rehabilitate, and replace it. While the uncertainty and dynamic nature of many sectors in our society introduce challenges to identifying and maintaining accurate long-term cost projections,[11] LCC methodology continues to become an increasingly popular method of cost management and financial planning as society more frequently demands greater accountability and cost effectiveness, noticeable return-on-investment, and defendable justifications for asset acquisition. For example, the public works,[12] public and private contracting,[13] and construction[14] industries have begun relying on LCC methodology to inform marketing, acquisition, procurement, and project justification activities.

LCC methodology has proven to be useful in a wide range of environments, including manufacturing and the management of government acquisition programs. For example, by identifying and modeling the many costs incurred in the manufacturing industry (e.g., equipment maintenance, production quality and rework, and de-manufacturing and recycling costs), LCC theory allows engineers to optimize the production process, reduce costs, and increase product quality.[15] Likewise, LCC models that capture operating and support costs, in addition to acquisition costs, allow the Department of Defense to make sound and informed investments.[16]

The success that LCC methodology has brought to these environments also may be recognized in the homeland security sector. Specifically, of the many cost-management methods that may be used to calculate homeland security costs,[17] LCC is promising in its ability to model the costs that states, tribal entities, and urban areas incur to achieve a particular level of capability and then sustain it. The ability of LCC methods to expand project management beyond a focus on initial acquisition costs to operations and support cost considerations can lead to more successful homeland security programs.

Specifically, the goal of using LCC methods is to help states, tribal entities, and urban areas forecast target capability costs and make decisions on when investments are needed and at what amount. When the resource needs of a jurisdiction align well to the Target Capabilities List planning factors and target levels, the standardization offered by LCC cost models can facilitate planning and serve as example investment strategies. Standardization is certainly useful in aggregating cost at the state and federal level to calculate preparedness cost estimates. When the resource needs of a jurisdiction do not align well to the TCL, the models may be adapted to specific jurisdictional needs and continue to provide insight into local costs.

At local, state, and federal levels LCC methods make it possible to forecast annual support and replacement costs for homeland security programs, distribute investments to cover these costs over their lifetime, and establish viable long-term procurement strategies that acquire only the equipment and personnel supportable within a defined budget. LCC estimates also determine which operational components cost the most and help influence strategies to manage these cost drivers.

LCC METHODOLOGY

LCC methodology provides states, tribal entities, urban areas, and local jurisdictions with estimates of the acquisition cost as well as the steady-state costs of maintaining a specific target capability or national priority over time. We implement the methodology using a flexible and transparent spreadsheet model consisting of the operational units (elements) of a capability and the costs associated with their individual parts, or components (e.g., people, equipment, and training). The model is flexible because cost variables and capability components are easily modified based on stakeholder feedback and data. The model is transparent because it is implemented in a way that permits stakeholders to understand its presentation in a spreadsheet. Figure 1 includes the key terminology of the methodology and an explanation of how different terms relate.

Figure 1: Key terminology of the LCC method

Capability	A specific aptitude to protect against, prevent, respond to or recover from an incident or hazard. A capability is comprised of elements.
Elements	Groupings of people, planning, equipment, training, and exercise resources into units that are employed in an operational fashion. An element is comprised of components.
Components	Individual people, planning, organization and leadership activities, equipment, training, and exercises. Each component is associated with a cost variable.
Cost Variables	Categories that capture the specific dollar amounts to procure and sustain individual components.
Cost model	A spreadsheet that calculates the total cost to acquire and sustain a capability. A cost model contains all of the cost variable, component, and element data for a given capability.

Our implementation of the methodology follows the six steps listed here and explained in the following paragraphs.

1. Determine the capability elements
2. Identify and characterize capability components
3. Develop LCC variables for each component

4. Develop a cost model
5. Annualize the cost model and identify cost drivers
6. Link the model to national targets and assigned levels

Step 1: Determine the Capability Elements

The first step requires the identification of capability elements. We use element to mean a grouping of people, planning, organization and leadership, equipment, training, and exercise resources into a unit that is employed in an operational fashion.

Every national priority and target capability integrates multiple elements, which collectively represent the resources required to perform critical tasks associated with the capability.[18] For example, an element in the *Explosive Device Response Operations (EDRO)* capability would be a bomb team (Type I, II, or III). The DHS Target Capabilities List is a good reference for learning what elements are in a capability. The TCL lists the capability elements for each of the thirty-seven target capabilities.

Step 2: Identify and Categorize Capability Components

Once capability elements are identified, we further categorize the components of each element. Components include the people, planning, organization and leadership activities, equipment, training, and exercises that make up a capability element. To identify capability components, we use the TCL, advice from advisory groups and subject matter experts, and existing standards (e.g., resource typing). While consideration of component standards and requirements in national doctrine such as the TCL is of obvious import, we recognize that certain on-site circumstances (e.g. competing priorities, limited funding, or lack of political support) may alter component configurations from those expected. As such, consultation with advisory groups and subject matter experts allows us to validate the components included in our LCC models. Federal, state, tribal, and local users of LCC methodology have similar flexibility to create models that include only the components necessary for their jurisdiction's specific needs or requirements.

Step 3: Develop LCC Cost Variables

To accommodate the life-cycle of target capabilities, we use five LCC cost variables to capture and categorize the individual acquisition and sustainment costs of capability components. These cost variables and some example costs are shown in Figure 2. To determine individual component costs, we use the Responder Knowledge Base, which is a database that provides emergency responders, purchasers, and planners with a trusted, integrated, online source of information on products, standards, certifications, grants, and other equipment-related information.[19] We also reference information gathered from vendor data, published salaries and backfill costs, advisory groups, training program guides, and subject matter experts. Depending on the user, these costs may represent exact figures, such as when a program manager is using LCC methodology to demonstrate current and future budget expenditures, or industry averages, such as when a new program manager is attempting to identify the long-term costs of potential investments.

Figure 2: The five LCC cost variables

Acquisition Cost	Sustainment Costs			
Initial Cost	**Energy Cost**	**Operating Cost**	**Repair Cost**	**Upgrade Cost**
Purchase Price *Salary* *Backfill Cost* *Attendance Fee*	*Cost of Resources Needed/Used to Operate Particular Types of Equipment*	*Storage Costs* *Administration Costs* *Logistics Support Costs*	*Routine/Periodic Maintenance and Calibration Costs*	*Equipment/Software Upgrade Costs* *Update Costs*

It is important to note that not all components have costs associated with all five LCC cost variables. For example, a piece of equipment that cannot be upgraded does not have an upgrade cost. Further, for assets that are shared between jurisdictions, users may include only the costs that they actually contribute to the resource.

Step 4: Develop a Cost Model

All LCC cost variables must be analyzed collectively to see how they contribute to the total cost of the capability element. A cost model, in the form of a spreadsheet, is an effective way to display the cost composition of a capability element. Thus, we create a spreadsheet that calculates the cost of individual capability elements and aggregates these costs to provide the total cost associated with an entire capability. Figure 3 provides an example of a LCC model for a Type I bomb team.

Figure 3: Sample Cost Model

Type I Bomb Team								
Item Description	Quantity	Comp Cost	1 Initial	2 Energy	3 Operating	4 Repair	5 Upgrade	Shelf Life
Equipment Components								
EOD Response Vehicle	1	$225,000.00	$225,000.00	$4,320.00	$1,200.00	$1,800.00	$0.00	15
Binoculars	1	$2,500.00	$2,500.00	$60.00	$0.00	$0.00	$0.00	15
Optics, Thermal Imaging and/or Light Amplification (not required)	1	$8,890.00	$8,890.00	$162.00	$0.00	$0.00	$0.00	10
Robot, Large	1	$173,000.00	$173,000.00	$100.00	$0.00	$1,300.00	$4,000.00	15
Robot, Small	0	$93,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	15
Chemical Agent Monitor	1	$8,670.00	$8,670.00	$71.00	$0.00	$100.00	$0.00	5
Personal Radiation Detector (Pager)	1	$465.00	$465.00	$10.00	$0.00	$50.00	$0.00	10
Ballistic Helmets	2	$396.00	$792.00	$0.00	$0.00	$0.00	$0.00	15
Body Armor (TEV)	2	$885.00	$1,770.00	$0.00	$0.00	$0.00	$0.00	5
Clothing, Operational, and Specialized/Protective Gear IED/EOD (charcoal ur	2	$720.00	$1,440.00	$0.00	$0.00	$0.00	$0.00	3
CBRNE Containment Vessel	1	$279,000.00	$279,000.00	$0.00	$0.00	$240.00	$0.00	15
Disruptor, Pan (with expendable rounds)	1	$4,690.00	$4,690.00	$200.00	$0.00	$0.00	$0.00	15
Equipment, Hand Protection, IED/EOD	1	$300.00	$300.00	$0.00	$0.00	$0.00	$0.00	5
Equipment, Head and Face Protection, IED/EOD	1	$5,000.00	$5,000.00	$0.00	$0.00	$0.00	$0.00	5
EOD Bomb Suit	1	$15,000.00	$15,000.00	$0.00	$0.00	$0.00	$0.00	5
EOD Comm System	1	$2,600.00	$2,600.00	$0.00	$0.00	$0.00	$0.00	5
EOD Tech Tool Kit	1	$1,340.00	$1,340.00	$0.00	$0.00	$0.00	$0.00	15
Kit, Fiber Optic (not required)	1	$8,130.00	$8,130.00	$0.00	$0.00	$500.00	$0.00	10
Team Supplies (per year)	1	$0.00	$0.00	$0.00	$5,000.00	$0.00	$0.00	1
Suit, "Search", Improvised Explosive Device/Explosive Ordnance Disposal (IE	1	$6,550.00	$6,550.00	$0.00	$0.00	$0.00	$0.00	5
X-Ray Unit, Portable or Transportable	1	$29,500.00	$29,500.00	$0.00	$0.00	$250.00	$0.00	10
Hardware, Computer, Integrated	1	$14,100.00	$14,100.00	$0.00	$0.00	$0.00	$0.00	3
EOD Body Cooling System	2	$955.00	$1,910.00	$0.00	$0.00	$0.00	$0.00	5
SCBA 30, 45, 60 Min. & Rebreathers	2	$4,800.00	$9,600.00	$0.00	$0.00	$100.00	$0.00	5
Undergarment, Non-Flame-Resistant (cotton)	2	$35.00	$70.00	$0.00	$0.00	$0.00	$0.00	3
Personnel Components								
Bomb Technician	2	$87,500.00	$175,000.00	N/A	N/A	N/A	N/A	N/A
Training Components								
Basic Hazardous Devices School (6-week)	2	$4,000.00	$8,000.00	$19,800.00	N/A	N/A	N/A	N/A
Recertification (1-week)	2	$1,650.00	$0.00	$3,300.00	N/A	N/A	N/A	N/A
LE Response to WMD - Operations level (24 hrs)	2	$990.00	$0.00	$1,980.00	N/A	N/A	N/A	N/A
WMD HazMat Techician Training (24 hrs)	2	$990.00	$0.00	$1,980.00	N/A	N/A	N/A	N/A
Post Blast Investigation Training (6-week)	2	$9,900.00	$0.00	$19,800.00	N/A	N/A	N/A	N/A
Robot Operator's Course	2	$1,650.00	$0.00	$3,300.00	N/A	N/A	N/A	N/A

Equipment costs

Comp Cost	Cost to purchase a single unit
1 Initial	Initial costs: purchase price of all units
2 Energy	Energy costs: gas, oil, electricity
3 Operating	Operating costs: storage, administration, logistics support
4 Repair	Maintenance and repair costs: routine / periodic maintenance, calibration
5 Upgrade	Technological Costs: upgrades, updates
Service Life	Years of use before replacement

Personnel costs

LC Cost1	Annual Salary

Training costs

LCCos1	Cost to Attend
LCCos2	Backfill Cost

Step 5: Annualize the Cost Model and Identify Cost Drivers

We annualize the cost calculated in Step 4 to provide states, tribal entities, and urban areas with cost estimates that can support the development of long-term program and project plans. Not all costs, however, are incurred on an annual basis. For example, the initial cost of a piece of equipment or the cost to attend a training session tend to be one-time investments, only to be incurred again when equipment needs to be replaced or there is personnel turnover. Energy, operating, and repair costs, however, are traditionally presented in an annual format.

Thus, to allow an annualized assessment of capability costs, our methodology requires the creation of an additional cost variable to represent the annual depreciation, or replacement cost (R-Cost), of a component. The replacement-cost variable can be thought of as a replacement-cost reserve that builds to permit the purchase of new equipment as old equipment wears out. Our replacement cost assumes a zero percent discount rate. The need for a discount rate depends on the use of the analysis. In matters where cost comparisons are made on a year-by-year basis, a discount rate is of limited use.

For equipment components, we obtain this replacement cost by dividing the initial equipment cost by the equipment's expected life span (service life). In the case of personnel components, the replacement cost reserve may fund the hiring or training of new personnel once existing personnel move on. To calculate the replacement cost of training, we divide initial training cost by anticipated duration of employment. To complete this calculation, we make the assumption that people do not stay at their jobs indefinitely. Our past LCC analyses assume a nine-year service period for personnel. To follow that methodology as closely as possible, we make the same assumption in this article.

Annualized cost models offer an understanding of how multiple components of a capability might fit into a budget and which components are most costly. The cost information from this type of analysis can support the following activities:

1. Sequence and/or limit the purchase of the most costly equipment to ensure that funds are available to maintain and upgrade existing equipment.
2. Stagger large purchases by making equally spaced investments determined by the equipment service life, establish equipment rotations, and avoid periods when all equipment becomes unserviceable at the same time.
3. Determine what capability level is affordable and what additional capability should be acquired through mutual aid.

Step 6: Link the Model to National Targets

Finally, our methodology links element costs to national target and assigned capability levels (provided by the Target Capabilities List or subject matter experts) to quantify the cost of maintaining a jurisdictional preparedness level for an entire target capability. National target levels are derived from the National Planning Scenarios and were developed through stakeholder working groups. The national target level is the amount of capability required throughout the country to accomplish mission area tasks during a major event. It is anticipated that most jurisdictions will not locally sustain national target levels of capability for a major event, but contribute some capability elements to the national target levels and achieve the remainder of the capability through mutual aid agreements.[20]

ANALYSIS OF THE *EXPLOSIVE DEVICE RESPONSE OPERATIONS (EDRO)* TARGET CAPABILITY TO DEMONSTRATE LCC METHODS

To demonstrate the application of the LCC methodology to a capability, this section discusses our LCC analysis of the *Explosive Device Response Operations (EDRO)* target capability.[21] According to the Target Capabilities List, *EDRO* is the capability to coordinate, direct, and conduct an improvised explosive device (IED) response after initial alert and notification. The critical tasks associated with the *EDRO* capability, such as intelligence fusion and analysis, the implementation of render-safe procedures, and the conduct of searches for additional explosive devices, are accomplished by a bomb squad that is able to dispatch bomb teams to the incident site.[22] A bomb squad is a bomb response organization, consisting of at least one bomb team, accredited by the Federal Bureau of Investigations Hazardous Devices School, and compliant with the standards set by National Bomb Squad Commanders Advisory Board (NBSCAB).

Dispatch of one or more bomb teams may be due to a wide range of incidents and emergencies, and may involve chemical, biological, radiological, nuclear, and explosive (CBRNE) materials. A bomb team is a sub-unit within a bomb squad consisting of at least two certified bomb technicians and a complete set of standardized equipment that varies depending on the type of bomb team. The 'type' or capacity of a bomb team for a specific incident is dependent on the response requirements of the incident and the training and experience required of personnel. The FEMA *Typed Resources Definitions* outline the characteristics of three bomb team types. This section highlights key points in applying our LCC methodology to the *EDRO* target capability.

EDRO Step 1: Determine *Explosive Device Response Operations* Elements

The *Explosive Device Response Operations* capability is team-based, which means that the tasks performed within the capability are conducted by members of an easily identified team. All *EDRO* capability costs are incurred to support National Bomb Squad Commanders Advisory Board accredited bomb squads, which are composed of one or more bomb teams that vary in type and qualification. As a result, we identified the *EDRO* capability elements as Type I, Type II, and Type III National Bomb Squad Commanders Advisory Board-accredited bomb teams. Figure 4 displays some of the qualifications of the three bomb team types.

Figure 4: Qualifications of National Bomb Squad Commanders Advisory Board accredited bomb teams

Type I Bomb Team	Type II Bomb Team	Type III Bomb Team
Handles multiple simultaneous incidents	Handles multiple incidents	Handles single incidents
Possesses large robotic vehicle	Possesses small robotic vehicle	Does not possess a robotic vehicle
Able to work in a CBRNE environment	Trained and equipped to work in a CBRNE environment	Trained, but not equipped to work in a CBRNE environment

EDRO Step 2: Identify and Categorize *Explosive Device Response Operations* Components

Bomb team composition is modeled based on the FEMA *Typed Resource Definitions*. While these resource definitions were helpful in providing general information on the composition of teams, we required more detailed information on each equipment, personnel, and training component of the teams. Therefore, we worked with the National Bomb Squad Commanders Advisory Board Equipment Subcommittee to obtain greater specificity in bomb squad and ultimately bomb team composition. Additionally, we identified each equipment component location in the FEMA National Preparedness Directorate, Department of Homeland Security, Responder Knowledge Base, Authorized Equipment List (AEL), which is a generic list of equipment items that may be purchased using federal grant funds.[23]

Our research resulted in the identification of twenty-four equipment, one personnel, and six training components for a bomb team. We also recognized that equipment configuration may vary depending on the bomb team type. For instance, a Type I bomb team possesses a large robot, a Type II bomb team possesses a small robot, and a Type III bomb team does not possess a robot. As such, we created a separate cost model for each bomb team type, which is discussed in the *Explosive Devise Response Operations* Step 4 below. Figure 5 details the equipment, personnel, and training components for a Type I bomb team.

Figure 5: Type I bomb team components

Equipment Components	
EOD Response Vehicle	EOD Bomb Suit
Optics, Thermal imaging and/or Light Amplification	EOC Communications System
Robot, Large	EOD Tech Tool Kit
Robot, Small	Kit, Fiber optic
Chemical Agent Monitor	Team supplies, per year
Personal Radiation Detector	Suit, "search", IED/EOD
Ballistic Helmets	X-ray Unit, portable or transportable
Body Armor (TEV)	Hardware, computer integrated
Clothing, Operational, and Specialized/Protective Gear IED	EOD Body Cooling System
CBRNE Containment Vessel	SCBA 30, 45, 60 min. & rebreathers
Disruptor, Pan (with expendable rounds)	Undergarment, non-flame-resistant (cotton)
Equipment, Hand protection, IED/EOD	Equipment, Head and Face Protection, IED/EOD
Personnel Component	
Bomb Technician	
Training Components	
Basic Hazardous Devices School (6-week)	WMD HazMat Technician Training (24 hours)
Recertification (1-week)	Post Blast Investigation Training (6-week)
LE Response to WMD – Operations level (24 hours)	Robot Operator's Course

EDRO Step 3: Develop LCC Cost Variables

We identified the following cost variables for each bomb team component (see Figure 6).

Figure 6: LCC cost variables by bomb team component

Equipment
- Acquisition Costs
  - *Initial*
- Sustaining Costs
  - *Energy*
  - *Operating*
  - *Repair*
  - *Upgrade*

Personnel
- Acquisition Costs
  - *Salary*

Training
- Acquisition Costs
  - *Backfill Costs*
  - *Costs to Attend Training*

EDRO Step 4: Develop a Cost Model

We utilized the *Explosive Device Response Operations* components and the LCC cost variables identified in the previous steps to form the framework of the cost models for the three bomb team types. Figure 7 provides an example of the information included in the cost models.

Figure 7: Sample LCC model information: Type I bomb team

Equipment		**Acquisition Costs**	**Sustainment Costs**			
Item Description	*Quantity*	*Initial*	*Energy*	*Operating*	*Repair*	*Upgrade*
EOD Response Vehicle	1	$225,000	$4,320	$1,200	$1,800	$0
Binoculars	1	$2,500	$60	$0	$0	$0
Optics, Thermal imaging	1	$8,890	$162	$0,	$$0	$0
Robot, Large	1	$173,000	$100	$0	$1,300	$4,000
Personnel		**Acquisition Costs**	**Sustainment Costs**			
Item Description	*Quantity*	*Salary*				
Bomb Technician	2	$175, 000	N/A	N/A	N/A	N/A
Training		**Acquisition Costs**		**Sustainment Costs**		
Item Description	*Quantity*	*Cost attend*	*Backfill*			
Basic Hazardous Devices School	2	$8,000	$19,800	N/A	N/A	N/A
Recertification	2	$0	$3,300	N/A	N/A	N/A
LE Response to WMD – Ops Level 1	2	$0	$1,980	N/A	N/A	N/A

Costs rounded to the nearest tens digit.

EDRO Step 5: Annualize the Cost Model

We annualized the bomb team costs to provide jurisdictions with an understanding of annual costs to sustain a bomb team. Figure 8 provides an example of the information included in the annualized cost models.

Figure 8: Sample annualized LCC model information: Type I bomb team, equipment

Item Description	Initial	R-Cost	Energy	Operating	Repair	Upgrade	Annual	Service Life
EOD Response Vehicle	$225,000	$15,000	$4,320	$1,200	$1,800	$0	$22,300	15
Binoculars	$2,500	$170	$60	$0	$0	$0	$230	15
Optics, Thermal Imaging	$8,890	$890	$160	$0,	$$0	$0	$1,050	10
Robot, Large	$173,000	$11,530	$100	$0	$1,300	$4,000	$16,930	15
Robot, Small	$0	$0	$0	$0	$0	$0	$0	15
Chemical Agent Monitor	$8,670	$1,730	$70	$0	$100	$0	$1,900	5
Personal Radiation Detector	$465	$50	$10	$0	$50	$0	$110	15
Ballistic Helmets	$792	$50	$0	$0	$0	$0	$50	10
Body Armor (TEV)	$1,770	$350	$0	$0	$0	$0	$350	5
Operational/Protective Gear	$1,440	$480	$0	$0	$0	$0	$480	3
CBRNE Containment Vessel	$279,000	$18,600	$0	$0	$240	$0	$18,840	15
Disruptor, Pan	$4,690	$310	$200	$0	$0	$0	$510	15
Hand Protection	$300	$60	$0	$0	$0	$0	$60	5
Head and Face Protection	$5,000	$1,000	$0	$0	$0	$0	$1,000	5
EOD Bomb Suit	$15,000	$3,000	$0	$0	$0	$0	$3,000	5
EOC Communications System	$2,600	$520	$0	$0	$0	$0	$520	5
EOD Tech Tool Kit	$1,340	$90	$0	$0	$0	$0	$90	15
Kit, Fiber Optic	$8,130	$810	$0	$0	$500	$0	$1,350	10
Team Supplies, per Year	$0	$0	$0	$5,000	$0	$0	$5,000	1
Suit, "Search," IED/EOD	$6,550	$1,310	$0	$0	$0	$0	$1,310	5
X-Ray Unit	$29,500	$2,950	$0	$0	$250	$0	$3,200	10
Hardware, Computer Integrated	$14,100	$4,700	$0	$0	$0	$0	$4,700	3
EOD Body Cooling System	$1,910	$380	$0	$0	$0	$0	$380	5
SCBA 30, 45, 60 m. Rebreathers	$9,600	$1,920	$0	$0	$100	$0	$2,020	5
Undergarment (Cotton)	$70	$20	$0	$0	$0	$0	$20	3

In the case of equipment, the component annual cost represents the sum of the annualized replacement cost, and all other costs incurred annually (energy, operating, repair, and upgrade costs). The annual equipment cost for the Type I bomb team shown in Figure 5 is $85,400. Equipment cost drivers are those components that annually cost the most. In the Type I bomb team the obvious components are the response vehicle, containment vessel, and bomb robot ($22,300, $18,840, and $16,930 respectively). Less obvious components are the team supplies and integrated computer with lower initial costs, but more frequent replacement costs ($5,000 and $4,700 respectively).

Personnel costs are annual costs that vary widely throughout the country. However, a reasonable cost estimate based on a median patrol officer salary ($50,000) and a business cost ratio of 1.75 (to account for overhead) resulted in an annual cost of $87,500 per person. The $50,000 median patrol officer salary is based on an average of median salaries reported by several web-based salary resources,[24] and we assume the 1.75 business cost ratio is a reasonable estimate for the security industry.

We based our annual training calculation on the assumption that a bomb team member receives all necessary training and stays on the bomb squad for nine years. Training costs include the cost of attending the Basic Hazardous Devices School and backfill costs for the Basic Hazardous Devices School and all other training courses, which are provided at no cost. Assuming the $41.25 average backfill cost for a law enforcement official reported in the DHS 2003 and 2004 State Homeland Security Assessment and Strategy Program and the average bomb technician remaining in the position for nine years, we estimated the annualized cost of training to be $3,600 per person.

Multiplying the personnel ($87,500) and training ($3,600) costs by two, to account for the two bomb technicians on a Type I bomb team, and adding all component annual costs ($85,400) reveals that the total annual cost to maintain the Type I bomb team is $267,600.

EDRO Step 6: Link the Model to National Targets

The final step of our LCC methodology is to calculate the target capability element level that must be achieved nationally to comply with capability planning factors and national target levels. According to the Target Capabilities List, national target levels call for 458 accredited bomb squads in the U.S.

Interestingly, the FEMA *Typed Resources Definitions* that we used when developing our models specifies equipment, personnel, and training components for a bomb *team*, not a bomb *squad*. Thus, we had a disconnect between the resource typing standard we used as the foundation for our cost models and the national target level as described by the Target Capabilities List. Therefore, we needed to create a bomb-teams-to-squad relationship for the *EDRO* capability.

To develop this relationship, we used population tiers to describe the number and type of bomb teams needed by a bomb squad for a certain jurisdictional population size. We developed this relationship first by using a capabilities-based threat assessment method described by Thomas Goss[25] and then validating that relationship through analysis of interview data on twenty-three bomb squads of various-sized jurisdictions. Figure 9 shows our results in the number and type of bomb teams possessed by bomb squads in jurisdictions of various sizes.

Figure 9: Number and type of bomb teams required of jurisdictions of various sizes

Jurisdiction size	Type I	Type II	Type III
Total population under 117,000	0	0	1
Total population from 117,000 to 300,000	1	0	0
Total population from 300,000 to 1,000,000	2	1	0
Total population greater than 1,000,000	3	0	2

Based on these criteria, a jurisdiction with a total population of 500,000 would, on average, achieve and sustain an *EDRO* capability consisting of two Type I bomb teams, at a cost of $267,600 per team per year and one Type II bomb team, at a cost of $249,900 for a total cost of $785,100 per year.

CONCLUSION

In applying LCC methods to the *Explosive Device Response Operations* capability, we built models that used a lot of detailed information to capture capability components, their costs, and target levels. This level of detail is precisely what is needed by local, tribal, state, and federal officials to accurately determine how resources contribute toward achieving and sustaining local and national preparedness.

In managing the cost of homeland security grant programs, we believe it is important to know whether funding is used by a state or local jurisdiction to hire people or to purchase planning, organization and leadership, equipment, training, or exercise resources. But, we assume it is equally important to know how target levels of capability are achieved and how much it will cost to sustain target levels of capability in the future. Life -cycle cost methods and capability modeling can be used to provide this necessary information.

To further the development and application of the LCC methodology, we recommend the following:

1. Focusing on capabilities aligned to the national priorities in the National Preparedness Guidelines.
2. Conducting a national-level LCC analysis for each national priority capability.
3. Creating and sharing prototype tools with jurisdictions to facilitate use of this methodology.
4. Creating a central Web-enabled database to share cost models among jurisdictions.
5. Incorporating LCC tools into future grant management systems for use by state and local jurisdictions.

Cost analysis will be vital to achieving and sustaining target levels of capability, particularly in helping make difficult resource allocation decisions across coordinated capability needs. As risk-assessment efforts identify those risks posing the greatest danger to homeland security, it will be necessary to ensure we can achieve, sustain, and afford the capabilities that target the right risks.

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[1] U.S. Department of Homeland Security, *National Preparedness Guidelines* (Washington, DC: DHS, September 2007).

[2] U.S. Department of Homeland Security, *National Response Framework* (Washington, DC: DHS, January 2008).

[3] U.S. Department of Homeland Security, *Target Capabilities List, A Companion to the National Preparedness Guidelines*, Version 2.0 (Washington, DC: DHS, September 2007).

[4] *DHS/FEMA Target Capabilities List Implementation Project Fact Sheet.* For more information about the TCL Implementation Project, contact TCL@DHS.gov.

[5] Government Accountability Office (GAO), *DHS' Efforts to Enhance First Responders' All-Hazards Capabilities Continue to Evolve,* GAO-05-652 (Washington, DC: GAO, July 2005); GAO, *Billions Invested in Major Programs Lack Appropriate Oversight,* GAO-09-29 (Washington, DC: GAO, November 2008).

[6] U.S. Department of Homeland Security, *State and Urban Area Homeland Security Strategy: Guidance on Aligning Strategies with the National Preparedness Goal* (Washington, DC: DHS, July 2005).

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[8] Office of the Secretary of Defense Cost Analysis Improvement Group, *Operating and Support Cost-Estimating Guide* (Washington, DC: Government Printing Office, May 1, 1992).

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[15] Jan Emblemsvag, *Life-cycle Costing: Using Activity-based Costing and Monte Carlo Methods to Manage Future Costs and Risks* (Hoboken, New Jersey: Wiley & Sons, Inc., 2003), 24-25.

[16] Office of the Secretary of Defense Cost Analysis Improvement Group, *Operating and Support Cost-Estimating Guide* (Washington, DC: Department of Defense, May 1, 1992), 2-5 to 2-9.

[17] Modern cost management methods include activity-based costing, which focuses on the activities that transform raw materials into finished products (Babad and Balachandran, "Cost Driver Optimization in Activity-based Costing"); strategic cost management, which focuses on the value that product features present to customers through value chain and value activity (J.M. Freeman, "Estimating Quality Costs," *The Journal of the Operational Research Society* 46, no. 6, June 1995, 675- 686); life cycle cost management, which focuses on the acquisition and long term sustainment requirements of a product (Hutton and Wilkie, "Life-cycle Cost: A New Form of Consumer Information"), and environmental management which goes beyond LCC by accounting for the environmental issues and impacts resulting from business activities (Michael Berry and Dennis Rondinelli, "Proactive Corporate Environmental Management: A New Industrial Revolution" *The Academy of Management Executive* 12, no. 2, May 1998: 38-50).

[18] DHS, *Target Capabilities List,* Version 2.0.

[19] The Responder Knowledge database: www.rkb.us/.

[20] DHS, *Target Capabilities List*, Version 2.0.

[21]The full report of this analysis is available upon request.

[22] DHS, *Target Capabilities List*, Version 2.0.

[23] https://www.rkb.us/mel.cfm?subtypeid=549.

[24] Some web-based salary resources are:
http://www.payscale.com/research/US/Industry=Law_Enforcement/Salary,
http://swz.salary.com/salarywizard/layouthtmls/swzl_compresult_national_LG12000003.html, and
http://www.policejobsinfo.com/salaries/

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