"If the Department of Defense is to stay prepared for the security challenges of the 21st century, we must transform not just our defense strategies, not just our military capabilities, not just the way we deter and defend—but we must also transform the way we conduct our business."

Defense Secretary Donald Rumsfeld, 4 June 2003

**Real Options for Defense**

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Office of Force Transformation

Increased competition in a global arena has caused nations, organizations, and militaries to realize that the most competitive strategy for survival is a high option, high value approach. This is achieved through increased flexibility. How does defense value and how valuable is flexibility to the nation? In financial markets, the original forum for the application of option-based frameworks, value is placed on flexibility. An option is the right, but not the obligation, to take action in the future. Some options are associated with investment opportunities that are not financial in nature. These operational options are termed Real Options to emphasize that they value real activities or real commodities, as opposed to purely financial commodities such as common stock options.

To merely upgrade or modify legacy components based on current fiscal metrics cannot resolve or take into account the vast number of inputs that a new environment demands. The trend in warfare is no different than the trend in the commercial marketplace - mitigation of risk by hedging against uncertainty, brought about by rapid dynamic changes. While the losses, both in life and fiscally, are disproportionate to losses in any single business endeavor, the perceived calamity and the strategies to succeed in solving individual problems remain the same - the valuation of flexibility and the creation of options.

The inherent progression of complexity and the increasing competitiveness of the environment, produce discontinuity, turbulence and perceived chaos. Adaptive organizations and the need for strategic flexibility dominate rapidly changing landscapes. Existing organizations and strategic planning methods are too large, far too stable, and contain very limited dynamic hedging. Large, stable,
analytical tools developed in the 1960’s, were introduced to DoD by then Secretary of Defense Robert McNamara. The highly optimized product efficiency models were based on industrial age metrics and timelines (McNamara was an executive at Ford - then one of the most respected and profitable companies listed on the New York Stock Exchange). Two of McNamara's principle deputies during this era were Alain C. Enthoven and K. Wayne Smith, who described the concept in the following text:

"First, the word 'systems' indicates that every decision should be considered in as broad a context as necessary . . . . The word 'analysis' emphasizes the need to reduce a complex problem to its component parts for better understanding. Systems analysis takes a complex problem and sorts out the tangle of significant factors so that each can be studied by the method most appropriate to it."\(^1\)

McNamara's lasting systems legacy was the Planning-Programming-Budgeting System (PPBS) instituted by DoD Comptroller Charles J. Hitch. Developed to analyze defense requirements systematically and produce a long-term, program-oriented Defense budget. It was a laudable approach to solve industrial era system complexity, which sought to match a complex analytical tool to the growing complex programs needed for Defense in the early 1960's. It was the first DoD total system approach that satisfied the conditions of matching process with environment for the level of complexity at the time. According to Enthoven and Smith, PPBS intended:

"to put defense program issues into a broader context and to search for explicit measures of national need and adequacy"; "consideration of military needs and costs together"; "explicit consideration of alternatives at the top decision level"; "the active use of an analytical staff at the top policymaking levels"; "a plan combining both forces and costs which projected into the future the foreseeable implications of current decisions"; and "open and explicit analysis, that is, each analysis should be made available to all interested parties, so that they can examine the calculations, data, and assumptions and retrace the steps leading to the conclusions."\(^2\)

Unfortunately DoD is still using this method forty years after its introduction. The rudimentary understanding of the complexities of the Information Age is it’s chief failing today, because the parts are inseparable and the whole is no longer reducible. Another surviving management tool that McNamara used to develop and implement PPBS was the Five Year Defense Plan (FYDP) which was a series of tables projecting forces for eight years and costs and manpower for five years in mission-oriented, rather than individual service, programs. But the increasing pace of uncertainty in the Information Age will not wait eight, five or even three years for programs to match a rapidly unfolding and unpredictable future.

Traditional tools such as PPBS and the FYDP are not adequate enough for a planning environment influenced by dynamic external pressures. The future defense climate requires strategic flexibility, organizational adaptability, management of higher degrees of uncertainty and an evaluation tool for alternative paths, valuation metrics, and options. One such suggested approach is offered by Real Options, proposed by Myron Scholes, Fischer Black, and Robert Merlon who were awarded the 1997 Nobel prize in economics for their financial-options valuation model.\(^3\)

\(^2\) Ibid.
\(^3\) Black-Scholes Equation: \(Se^{\ast N(d_1)} - Xe^{-rt} N(d_2)\), where \(d_1 = \frac{(\ln(S/X) + (r - d + s^2/2)t)}{st}\) and \(d_2 = d_1 - st\), and where \(S\) = stock price, \(X\) = exercise price, \(d\) = dividends, \(r\) = risk-free rate, \(s\) = uncertainty, \(t\) = time to expiry, and \(N(d)\) = cumulative normal distribution function.
Real Options are based on the financial options theory of Black-Scholes as a financial valuation tool, which assigns an economic value to organizational flexibility in a world of uncertainty. It allows institutions to adapt decisions in response to unexpected market or environmental developments. As a strategic management tool, real options are designed to characterize and communicate the value of an investment project effectively. Traditional methods such as Net Present Value (NPV) or DoD's PPBS fail to capture the economic value of investments in an environment of widespread uncertainty and rapid change. Real options are a strategic investment valuation designed to enable corporate decision-makers to leverage uncertainty and limit economic risk.

Within the notion of Real Options, there exists a definitive connection to and a significant value for this method to assess and determine strategic decisions for defense. The concept of Real Options applied to defense, is that it may be suitable for shaping requirements based on the value of flexibility of a program that must ultimately operate in uncertain and dynamic environments. This approach may also mitigate and minimize risk by opening up opportunities not achievable by DoD's rigid programmatic process.

Strategically, the value of Real Options lies in that it offers decision makers alternative paths. What the alternatives are, what they should be based on, and how they relate to defense's unique demands is an immediate imperative. Additionally, the validity of option pricing theory’s assumptions on defense related programs and necessary capabilities for future conflict requires further analyzes for real investment compared to traditional methods such as PPBS.

Both the Black-Scholes model and Defense’s strategic imperatives rely on occupation of a niche & specification of property rights (path dependency and initial conditions). It requires parallel development of competing products and technologies (Beinhocker's - fitness landscapes), technological flexibility (investments in modular products and mission capabilities), and investments in organizational adaptability (alternative Command and Control structures). The tensions and economic trade-offs between standardization and flexibility are based on the amount of uncertainty and ambiguity resident in the landscape.

While PPBS may work for "Clear and Present" dangers it is unsuited for rapidly changing and emerging conditions. The valuation model provided by Real Options decreases the necessity for formal (requirements) and less restrictive assumptions (Program of record), with a consistent requirement for a rigorous assessment of the level of uncertainty present (as decreasing clarity for planning as well as future development of competitive environment becomes less quantifiable). The span of uncertainty exists between predictable futures, alternative futures, a range of futures, and true ambiguity. How dynamic and complex the environment is and how uncertain the future will be, drives the necessity for strategic flexibility and a demand for a broadened base of capabilities.

There is a consistent theme that runs between the evolving and co-evolving organisms that Stuart Kauffman describes in his fourth law of thermodynamics and the complex tools that financial markets use in order to resolve ambiguity and maintain fitness. Equitable solution for most complex adaptive

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environments requires the discovery, creation, and the matching of the equivalent complex tools to the problem—tools that ensure survival and ensure dominance to those that use them first. The requirements for future combat capabilities and the tools to purchase and operate them are no different.

**Combat Option levers:**

Keith Leslie and Max Michaels provide six levers (dimensions) or inputs for extending the mathematical model provided by Black-Scholes to the financial market. Previous financial tools for business, such as the NPV framework, lacked analytical flexibility since they were limited to two criteria; current pricing and present value. Both of these static measurements cannot take into account valuating the changing conditions of rapid time constants. How can these levers be applied to defense?

**Financial-option value levers**

<table>
<thead>
<tr>
<th>Time to expiry</th>
<th>Present value of fixed costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise price</td>
<td>Risk-free interest rate</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>Uncertainty of expected cash flows</td>
</tr>
<tr>
<td>Uncertainty of stock price movement</td>
<td>Present value of expected cash flows</td>
</tr>
<tr>
<td>Stock price</td>
<td>Value lost over duration of option</td>
</tr>
<tr>
<td>Dividends</td>
<td>(-) Increase lowers option value, (+) Increase raises option value</td>
</tr>
</tbody>
</table>

Extending this model further it is proposed that DoD could use similar inputs such as:

**Combat-option value levers**

- Time until a competitor adapts to our current capabilities
- Present value of current capability
- Risk free stable environment (utopian world)
- Value of current capability in an uncertain future
- Present value of projected capability
- Combat value lost over duration of current (or future) combat capabilities

Where for financial options; \( S = \text{stock price}, X = \text{exercise price}, d = \text{dividends}, r = \text{risk-free rate}, s = \text{uncertainty}, t = \text{time to expiry}, \) and \( N(d) = \text{cumulative normal distribution function}. \) For DoD it would become:

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S = \text{Combat capability at execution}
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\[ X = \text{Current combat capability of option} \]
\[ d = \text{portion of capability available now} \]
\[ r = \text{rate of increase in legacy capability} \]
\[ s = \text{uncertainty in combat capability} \]
\[ t = \text{time to potential enemy advantage over legacy force} \]
\[ N(d) = \text{normal distribution function} \]

How do we quantify these items and present them in mathematical form for it to be of value in a similar uncertain environment endemic to conflict? How do we quantify these items and present them in mathematical form? Are these the right valuations and do they compare to financial options?

**Link between DoD procurements and Black-Scholes Inputs**

<table>
<thead>
<tr>
<th>Investment Opportunity</th>
<th>Variable</th>
<th>Financial Call Option</th>
<th>DoD Call Option??</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present value of program's Free Cash Flow (program matched accurately to assessment of threat)</td>
<td>S</td>
<td>Stock price</td>
<td>Existing Expenditure on program or cash flow from cancelled program</td>
</tr>
<tr>
<td>Expenditure required to acquire program</td>
<td>X</td>
<td>Exercise price</td>
<td>Cost of new program</td>
</tr>
<tr>
<td>Length of time the decision may be deferred (emerging threat timeline)</td>
<td>t</td>
<td>Time to expiration</td>
<td>Time before capability is needed</td>
</tr>
<tr>
<td>Time value of money (vs. doing nothing)</td>
<td>( r_f )</td>
<td>Risk-free rate</td>
<td>Time value of ensuring success</td>
</tr>
<tr>
<td>Riskiness of project assets (How soon can the capability be brought to combat?)</td>
<td>( s^2 )</td>
<td>Variance of returns</td>
<td>Alternative technological path</td>
</tr>
</tbody>
</table>


The real work comes in assessing the values to create reliable (skewed) distribution data sets that are produced by experimentation. It would force the evaluation of product development not on conjecture and supposition, but on information relevant valuations of empirical evidence. The problem
that exists today is that there is little evidence of assessing the value of current capabilities. Evaluating tomorrow’s force will be immeasurably more difficult and significantly more important.

**Invest, Defer, and Divest options:**

Real Options in business is often divided into three categories in order to determine how much flexibility is worth and consequently needed: Invest/grow options, defer/learn options, and divest/shrink options. Using these categories as a template, it would seem that the ability to invest and grow is predicated on the capacity to scope or scale-up. For defense, this extends to having a variety of platforms and hence a family of chassis which are configurable for multiple missions. The necessity to scale-up is directly proportional to the Regional Combatant Commanders requirement for numbers, very high numbers of scale variant, recombinant assets. In creating the option to defer, the decision to act, or the time to deliberate must be supported with the desire to learn. To learn all that will be necessary in future conflict during a time of uncertainty.

Up until last year, the time between the end of the Cold War, and what may considered a new era of strife between globalized nation and terrorist networks, was an interwar period. While terrorism represents the current challenge for the engagement of combat forces, it does not tax the full potential of the defense department. This then is the time to diversify, to learn and understand the complex environment, and to value education. Educating the officer corps on network phenomenology, information dynamics, organizational behavior, emerging network societies, complex adaptive systems, cellular automata, and Real Options may be a start.

Finally the decision to divest from current systems or weapons platforms is often not as financially difficult as it may seem. Culturally, it is often incomprehensible. The demand for all elements in the combat quiver should be measured by the value of their flexibility to adapt to changing conditions and their ability to add to or be part of the network. The new standard for decommissioning, shutting down and divesting a legacy system, is that if it is not capable of gaining access to the net then it should be considered a threat to the total force, and if it is on the net it should be capable of routing with the information field that it encounters. New equity stakes are most certainly not replacement platforms but instead tools that permit the combat force to leverage knowledge gleaned from the multitude of sources, not only supplied by the network, but demanded by its users. Companies such as Askme, Mindtel, and Livewave provide new algorithms and tools that generate the control and access to the most powerful assets in an information age arsenal - information and knowledge.

**Strategic option in acquisition:**

For risk evaluation, Real Options blends strategic intuition with analytical rigor applied to decisions. Decisions that determine investments in new capabilities, legacy system extensions, and R&D investments:

- An industry operating in uncertainty and focusing on creating, identifying and exercising options (oil, gas, mineral reserves, high-numbers).
- Market-leading dynamic businesses needing to look at strategic opportunities that offer economies of scale and scope (information technology, NCW).

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• Where uncertain markets exist (futures, stock options, the littorals)
• Preserving the right to play (initial conditions)

Past business investment strategies used two tools for evaluating growth potential and positive cash flow on decisions: Net Present Value - NPV and Discounted Cash Flow - DCF: Both compare current investment outlays to the present value of an investment's future cash flow if there are no changes in the market. But neither method is capable of analyzing multi-variable inputs to dynamic outcomes. Both are static, single-dimensional tools designed for relatively stable landscapes - combat in the littorals is any thing but static or stable.

The shortcomings of PPBS, for new program development, are that it assumes a certain amount of stasis predicated on 15 to 20 year time constants. Therefore, PPBS is ill suited for and cannot properly acquire, set the requirements for, nor capture the full combat potential necessary in information age demands. Nor can it provide the flexibility to generate a capability-oriented approach in a rapidly shifting, dynamic landscape. The PPBS was not constructed to permit alternative paths or to generate decision criteria based on whether to abandon a program at different stages of development because of rapidly changing external landscapes. As a result, skipping a generation or phase spiral development is seemingly alien to most budget programmers today. Real Options creates time-to-market advantage and provides maneuver space to hedge risk by managing strategies based on a multitude of inputs.

By applying insights from the valuation of Real Options, a framework for the assessment of new program development at different stages can be established. Moreover, the options solution derives criteria to speed up or slow down the development process necessary for the introduction of the necessary capabilities. In business, the options process provides the basis for assessment and is the tool for choosing an optimal set of program initiatives from a variety of feasible alternatives in a complex adaptive market.

**Options for development of new products - "the next best thing":**

Success hangs in the balance for traditional businesses that focus on optimizing operations, hierarchies, planning, and central control oriented to find the "the next best thing." As a result, the institution becomes static and fragile, dependent not on innovation, but instead reliant on the good will of the market. Unfortunately, luck, free lunches, and good will is not a sound business model for survival in any competitive landscape. The alternative is a high option strategy, where organizations value adaptation, whose leaders are provided free rein because all aspects are measured, where formal planning gives way to "small jumps," and where strategic programming incorporates intuition and creativity.

Today’s world is characterized by major changes in market conditions, coupled with rapid advances in technology and high rates of economic change. Leaders of the military services now confront the dilemma of whether or not to invest in a particular stage of a new program, or given market and technology uncertainties surrounding the perceived need, delay such decisions. The changing economic conditions of technology-driven or high-tech markets, combined with increased domestic and global competition, changes customer needs. The result is rapid product obsolescence and the

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emergence of new competitors, which require a fast resource allocation process inherent in development of new programs (DNP).

The uncertainty resident in complex adaptive environments demands flexibility. As a consequence, the trade-off between accelerating time-to-operations, and making pre-launch improvements in product performance, is not only a concern, but of vital interest. On the one hand, accelerating operational debut may lead to substantial gains for initial conditions (equivalent to future market share). The advantage is that a rapid time-to-operations for DNP can be achieved by skipping phases. On the other hand, rapid deployment is only advisable when it does not threaten the lives of the operators who must eventually use it.

An Options approach, for DNP, requires a fast and flexible framework that incorporates market and technology uncertainties in all decisions. These characteristics are required for rapid time constants and dynamic landscapes. The related Real Option approach for flexible product design is that a thorough analysis of the value of modularity must be considered.9

The notion of modularity popularized in current procurement programs, and the economic relevance of the concept's application, is neither widely understood nor are the dimensions of its scaling laws. While the application of combat power must be a function of scale, the individual components should seek to be scale invariant.10 Scalar invariance provides the Regional Combatant Commander with the capability to recombine assets with as much fractal structure and diversity as possible. Merely stipulating that the concept of modularity already exists in construction techniques is neither relevant nor applicable to the utility of combat allocation (although it does provide economies of scale at the lowest end in an industrial setting). At issue is whether the assets available and the recombination of elements existing, provide sufficient flexibility in order to match scale with scale at requisite complexity and computation equivalence.11

Managing complexity and ensuring complex equivalence matters (matching product to the complexity of the environment) - failing to understand this relationship is what doomed the 5000 series of acquisition rules and consequently puts at risk current forces in the highly dynamic global landscape.12 Complexity is a function of scale - modularity resident in numbers and in recombination of components is the only manner in which to address and match future capabilities to external demands and threats of the information age.

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10 The fractal application of scale invariance is presented in the context of grouping elements together to form new aggregate forces. The aggregation of elements possess all of the mathematical characteristics, forms and relationships of the original problem. These scale invariance properties therefore permit new ways of relating abstract functions to subjective expectations. Such properties therefore provide potential applications in analysis, statistical inference, and adaptation to rapidly changing conditions where future forces have the capacity to recombine assets for the dynamic challenges ahead.
The effort to correlate Real Options to defense procurement and strategic decision-making, is not to take the Real Options template and stamp the model onto program, analysis, and evaluation (PA&E) acquisitions. Instead, the approach is to highlight the fact that in uncertain and complex environments, options are necessary because of multi-variable inputs, accelerated time-lines, and dynamic complex landscapes. Real Options evaluate flexibility and introduce a distinction between uncertainty and stochastic variability of operations. The more volatile the circumstance, the more value is resident in an options approach and the greater is the need for the valuation of flexibility.

Real Options Framework:

The option approach introduced here, builds upon the insight that research and development (R&D) inherently creates, rather than on fixed obligations of predictive requirements. Subsequently, leadership has to time option decisions for either operational launch of a new program after R&D has been completed or introduce it before completion. By treating the DNP as a spiral decision process rather than an end product, the Option approach gives explicit decision rules for the trade-off between validating the project (continuing) or operational pre-emption (immediate insertion, continual improvement and replacement).

The main contribution of the Options approach, is to derive economic criteria (valuation) for the go/no-go decision before and after R&D stages - including the decision to launch a new product - based upon the flexibility to opt-out at each decision point. When economic criteria for assessing a project’s flexibility, in terms of the value to opt out are lacking, the justifiable decisions needed for feasible program initiatives cannot be initiated (rigid stasis).

When uncertainty is high, there is a high probability that previously high valued programs turns out to be of low value and hence irrelevant to operational forces. This is often the case when programs take 15-20 years to become operationally viable. Real Options provide leadership with the flexibility to opt out at all stages, thereby mitigating risk and increasing potential. Therefore, the higher the uncertainty, the more beneficial option valuation becomes particularly at the early stages of projecting a requirement. However, with high uncertainty at the final stages (because of the duration for development), the option approach induces the military services to postpone or cancel operational introduction of a program. A program or capability ill suited for an environment in which it was never intended, is of little value to any Regional Combatant Commander.

The focus on uncertainty during the development of a new program, the decision to skip the validation stage entirely, or refrain from operational introduction, and an objective comparison of the institution’s capabilities should be analyzed in a deterministic setting. With option analysis, R&D and experimentation are not considered a necessary cost of business in terms of overhead expenses, but instead are treated as an investment that can be analyzed with the same consistent and explicit financial

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14 Early launch of an R&D program such as HSV-XI Joint Venture, was used by the U.S. Army, Marine Corp, and Navy for operational testing during its first year of "test & evaluation."
15 Derivations pre and post R&D options enable an objective comparison between all relevant programs. This way, a justified assessment for new product initiatives at all stages of the DNP is provided in an uncertain environment.
criteria used for other investments within the military institution. The static PPBS analytical approach, is suitable when there are clearly defined milestones, for known threats, and stable environments.

In an environment where uncertainty and dynamic change dominates, the complex problem depends on Real Option solutions. Options provided by R&D, experimentation, and empirical evidence with clear choices to stay in or opt-out. The following guidance for Acquisition Options is provided:

- Improved resource allocation on R&D, experimentation, and exploration.
- Investment that hedge against uncertainty
- An option framework to solve timing issues of sequential explorations
- Analyzing the value of organizational flexibility at R&D and launching stages, thereby creating explicit rules for the decision to conduct R&D or operational insertion.
- Introduce option portfolios that enable leadership to discriminate between different but equally feasible alternatives.

"A real option framework of decision-making is based on the opportunity to make a decision after events unfold. With the real option approach, modeling the cash flows from the completed project to estimating the value of the underlying asset, and then using that estimated asset value as an input to the option valuation. Real option pricing can be seen as a special (risk-neutral) version of decision analysis that recognizes market opportunities to trade and borrow. It is the version of decision analysis that has adopted the market perspective, allowing determination of expected values using risk-neutral probabilities and discounting at a risk-free rate. The major difference among these approaches is the perspective used to determine value, which may then lead to differences in accounting for risk. Certainly, there is no dominant choice among these methods for all cases. Under certain conditions, decision analysis plus some other treatments (such as risk-adjusted probabilities) may yield results that are consistent with the option approach (Smith and Nau (1995)). However, both decision analysis and capital asset pricing analysis are based on fixed investment scenarios, such that there is no clear way to reconcile, aggregate, or choose between scenarios. Furthermore, many of the changes taking place in manufacturing operations are most likely market driven (complex). Strategic investment decisions often require an allocation of resources that is irreversible (or costly to reverse), and therefore, flexibility to change the course, pace or use of the project in the future may be valuable to the firm if the future unfolds in an unexpected way. This makes the options approach the most natural choice for modeling manufacturing system changes in a dynamic environment." 16

Some hoping for quick transformational wins for their respective services seek to initiate a policy of "picking low hanging fruit." But hinging transformational imperatives on picking low hanging fruit is a misguided acquisition strategy. Drawn a step further, proponents of this method would choose to gather fallen fruit - or may prefer to sit under the tree awaiting the fruit to fall into their laps. The trouble with these approaches is that both low hanging and recently fallen fruit is at an advanced stage of ripening. While easy to pick and potentially satisfying, low hanging or fallen fruit ages quickly, spoils immediately after discovery, and often contains worms.

Each new synthesis shapes the nature of future observations - strategic objectives and architectural choices that are now established will consequently shape the future. If defense does not understand the laws of requisite variety, the necessity to broaden the base of capabilities, or the necessity to increase options available, then it is at risk of having to react to potential and real threats of the future. Path dependency matters not just in war but also in concept development. The trajectory currently pursued within defense may prove fatal. Choosing low-hanging fruit and the billions that will be spent wrongly is only secondary. Broadcast spending, such as this, is a process for seeding a lawn, and should

not be an acquisition strategy that must produce a 21st century military force. Defense has a limited set of options but an infinite set of Global influences. 17 Creating options hedges against this inequity.

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i = \langle \text{Global} \mid \text{Defense} \rangle, \text{ where } i = \text{interface between (Global) influences and (Defense) Options.}\]

NOTE: Transformation Trends is provided as a means to highlight new and emerging issues in defense and commercial realms to key decision-makers and in no way constitutes endorsement or official recognition of any idea, concept or program.