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HELPING BUSINESS THRIVE ON TECHNOLOGY CHANGE

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The Total Economic Impact™ Of Deploying Sun's Secure Global Desktop

Project directors: Jon Erickson and Shaheen Zojwalla

FORRESTER®

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Headquarters

Forrester Research, Inc., 400 Technology Square, Cambridge, MA 02139 USA
Tel: +1 617/613-6000 • Fax: +1 617/613-5000 • www.forrester.com

TABLE OF CONTENTS

Executive Summary	4
Purpose	4
Methodology.....	4
Approach.....	4
Key Findings	5
Disclosures.....	6
Sun Secure Global Desktop: Overview	6
Analysis.....	6
Interview Highlights.....	6
TEI Framework	8
Benefits	8
Costs	10
Risk.....	12
Flexibility.....	14
TEI Framework: Summary.....	14
Study Conclusions.....	16
Appendix A: Total Economic Impact Overview	17
Benefits	17
Costs	17
Risk.....	17
Flexibility.....	17
Appendix B: Glossary.....	18
Source: Forrester Research, Inc.Appendix C: Adjusting For Investment Risk (Example)	18

Appendix C: Adjusting For Investment Risk (Example) 19

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Executive Summary

In May 2006, Sun Microsystems commissioned Forrester Consulting to examine the total economic impact and potential return on investment (ROI) that enterprises may realize by deploying Sun's Secure Global Desktop (SGD). This report highlights the benefits of deploying SGD as demonstrated from the interviews and analysis of an organization implementing the solution. The report examines the estimated return on investment (ROI) for the organization and represents the findings derived from the interviews and analysis process, as well as the independent research of Forrester Research.

In conducting in-depth interviews with an existing customer, Forrester found that the company achieved significant savings in administration costs, as well as reduced software and software maintenance costs.

Purpose

The purpose of this study is to provide readers with a framework to evaluate the potential financial impact of Secure Global Desktop on their organizations. Forrester's aim is to clearly show all of the calculations and assumptions used in the analysis. Readers should use this study to better understand and communicate a business case for investing in Sun's Secure Global Desktop product.

Methodology

Sun selected Forrester for this project because of Forrester's Total Economic Impact™ (TEI) methodology. TEI not only measures costs and cost reduction (areas that are typically accounted for within IT) but also weighs the enabling value of a technology in increasing the effectiveness of overall business processes.

For this study, Forrester employed four fundamental elements of TEI in modeling Secure Global Desktop:

1. Costs and cost reduction.
2. Benefits to the entire organization.
3. Flexibility.
4. Risk.

Given the increasing sophistication that enterprises have regarding cost analyses related to IT investments, Forrester's TEI methodology serves an extremely useful purpose by providing a complete picture of the total economic impact of purchase decisions. Please see Appendix A for additional information on the TEI methodology.

Approach

Forrester used a four-step approach for this study.

1. Forrester gathered data from existing Forrester research relative to Sun Secure Global Desktop.

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

2. Forrester interviewed Sun Secure Global Desktop marketing and sales personnel to fully understand the potential (or intended) value proposition of Sun Secure Global Desktop solutions.
3. Forrester conducted a series of in-depth interviews with an organization currently using Sun Secure Global Desktop solutions.
4. Forrester constructed a financial model representative of the interviews. This model can be found in the TEI Framework section below.

Key Findings

Forrester's study yielded several key findings:

- **ROI.** Based on the interviews with an existing customer, Forrester constructed a TEI framework for the organization, as well as the associated ROI analysis illustrating the financial impact areas. As seen in Table 1, the ROI for the sample company is 86% with a breakeven point (payback period) of 0.8 years after deployment.
- **Benefits.** The benefits included significant savings in administration costs, as well as reduced software and software maintenance costs.
- **Costs.** The costs included in the model were the initial SGD license fee, the cost of ongoing maintenance and support, as well additional hardware costs required for SGD implementation.

Table 1 illustrates the risk-adjusted cash flow for the sample organization, based on data and characteristics obtained during the interview process. Forrester risk-adjusts these values to take into account the potential uncertainty that exists in estimating the costs and benefits of a technology investment. The risk-adjusted value is meant to provide a conservative estimation, incorporating any potential risk factors that may later affect the original cost and benefit estimates. For a more in-depth explanation of risk and risk adjustments used in this study, please see the Risk section.

Table 1: Sample Company ROI, Risk-Adjusted

Summary financial results	Original estimate	Risk-adjusted
ROI	125%	86%
Payback period (years)	0.8	1.0
Total costs (PV)	(\$274,925)	(\$274,925)
Total benefits (PV)	\$617,536	\$510,746
Total (NPV)	\$342,611	\$235,821

Source: Forrester Research, Inc.

In presenting this sample organization, we hope to show the logic and calculations for an organization considering migration to an SGD environment. The assumptions in the calculations that follow are based on the interviews with an organization that has undergone this migration. However, it is important to remember that organizations, needs, and environments vary, and the most relevant numbers are those that take your own situation into account.

Disclosures

The reader should be aware of the following:

- The study is commissioned by Sun and delivered by the Forrester Consulting group.
- Sun reviewed and provided feedback to Forrester, but Forrester maintained editorial control over the study and its findings and did not accept changes to the study that contradict Forrester's findings or obscure the meaning of the study.
- The customer names for the interviews were provided by Sun.
- Forrester makes no assumptions as to the potential return on investment that other organizations will receive. Forrester strongly advises that the reader use his or her own estimates within the framework provided in the report to determine the appropriateness of an investment in Sun Secure Global Desktop.
- This study is not meant to be used as a competitive product analysis.

Sun Secure Global Desktop: Overview

Sun Secure Global Desktop Software provides secure access to server-based applications running on Microsoft Windows, Solaris, Linux, HP-UX, AIX, mainframe, and midrange systems from a wide variety of client platforms and devices. The software Web-enables legacy applications quickly without costly rewrites and delivers those applications side-by-side with modern server-based applications. This allows for consolidation of critical applications and data onto highly reliable, centrally maintained servers and off individual desktop and laptop computers, improving manageability while increasing flexibility.

Analysis

As stated in the Executive Summary, Forrester took a multistep approach to evaluate the impact that implementing Secure Global Desktop can have on an organization:

- Interviews with Sun marketing and sales personnel.
- In-depth interviews of an organization currently using Secure Global Desktop.
- Construction of a financial framework for the implementation of Secure Global Desktop.

Interview Highlights

As previously mentioned, Forrester's TEI conclusions are derived in large part from information received in a series of interviews with executives and personnel at a customer organization that has deployed SGD.

The customer interviewed is a technology services company; the organization delivers information technology and business process outsourcing services to clients in a variety of industries. Forrester observed several important characteristics in the organization interviewed, including:

- The client had a heterogeneous environment, using a large variety of operating systems.

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

- The sample company was extremely security conscious and needed to manage administrative access of its internal applications across geographic locations.
- The interviewed organization anticipated a reduction in administrative and support costs, a key driver in deploying SGD.

From these value statements, Forrester was able to extrapolate and generate a potential ROI for an organization that is considering using SGD in its existing environment.

The interview revealed the following benefits obtained by the client from deploying SGD in its environment:

- Reduced software licensing costs.
- Reduced administrative costs.
- Reduced software maintenance costs.

TEI Framework

Introduction

From the information provided in the in-depth interviews, Forrester has constructed a TEI framework for those organizations considering implementation of Secure Global Desktop. The objective of the framework is to identify the cost, benefit, flexibility, and risk factors that affect the investment decision.

Framework Assumptions

Table 2 lists the discount rate used in the PV and NPV calculations and time horizon used for the financial modeling.

Table 2: General Assumptions

Ref.	General assumptions	Value
	Discount rate	10%
	Length of analysis	Three years

Source: Forrester Research, Inc.

Organizations typically use discount rates between 8% and 16% based on their current environment. Readers are urged to consult with their finance departments to determine the most appropriate discount rate to use within their own organizations.

In addition to the financial assumptions used to construct the cash flow analysis, Table 3 provides salary assumptions used within this analysis.

Table 3: Salary Assumptions

Ref.	Metric	Calculation	Value
A1	Hours per week		40
A2	Weeks per year		52
A3	Hours per year (M-F, 9-5)		2,080
A4	Hours per year (24x7)		8,736
A5	Hourly salary		\$48

Source: Forrester Research, Inc.

Benefits

The first component of this analysis looks at the potential benefits associated with an organization investing in SGD. As a result of the interview process, the representative organization indicated that it received benefits from reduced overall support cost, as well as reduced software licensing and maintenance costs.

Support Cost Savings

One of the primary drivers mentioned by the interviewed organization from implementing the SGD solution was to improve and protect access of existing applications. Prior to implementing SGD, the

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

organization noted that it was difficult to monitor and control usage of the existing applications by users. Monitoring was performed locally with a portion of support time required for effective enforcement and control of the existing environment. By implementing SGD, applications could now be controlled centrally, allowing support greater control while at the same time reducing the amount of time required to enforce a secure application environment. The organization noted that with SGD, it now knows which employees had access to and were accessing the different Web servers running on behalf of their clients. For the purpose of this analysis, we assume that the organization over time could reduce its support requirements with SGD. We assume that prior to SGD a total of eight FTEs were responsible for managing the application environment. Assuming an annual salary per FTE and an estimated 20% reduction in the support requirements, we can calculate the full annual savings per year of \$192,000. For the purpose of this analysis, Forrester also assumes that 75% of the benefit is received in Year 1 of the analysis, 100% in Year 2, and 100% in Year 3 to take into account the ramp-up time for the SGD solution.

Table 4: Support Savings

Ref.	Metric	Calculation	Year 1
A1	Total number of support staff		8
A2	Annual salary		\$120,000
A3	Estimated savings		20%
A4	Administration cost savings	$A1 * A2 * A3$	\$192,000

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Reduced Software License Savings

In the case of software, the organization indicated that it could reduce the number of software administration licenses within its environment through a shift to SGD. Allowing administrators within the organization access to these applications through a client/server environment, rather than having them reside on the individual users' desktops, reduced the number of software licenses within the organization. For the purpose of this analysis, we assume the annual per-license cost to the organization is \$300. Assuming that in the first year the organization is able to reduce the number of licenses by 500, the total savings to the organization equates to \$150,000.

Table 5: Software Utilization Savings

Ref.	Metric	Calculation	Year 1
B1	Annual software cost		\$300
B2	Number of licenses reduced		500
B3	Software licensing savings	$B1 * B2$	\$150,000

Source: Forrester Research, Inc.

Reduced Software Maintenance Savings

Associated with the savings in licensing costs, there is also a savings realized by the organization in the annual software maintenance fees. Assuming that the average maintenance on the software

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

used in the organization was 20%, with a license cost of \$150,000, we have an annual savings of \$30,000 in maintenance costs.

Table 6: Software Utilization Savings

Ref.	Metric	Calculation	Year 1
C1	Total software cost (Avoided)		\$150,000
C2	Percent maintenance		20%
C3	Software maintenance cost savings	C1*C2	\$30,000

Source: Forrester Research, Inc.

Total Benefits

The total benefits derived from deploying SGD at the interviewed customer are summarized in the table below.

Table 7: Total Benefits

Cash-flow analysis (original estimates)						
Benefits	Initial	Year 1	Year 2	Year 3	Total	Present value
Administration cost savings		144,000	192,000	192,000	528,000	433,839
Reduced software spend		150,000			150,000	136,364
Reduced software maintenance spend			30,000	30,000	60,000	47,333
Total		\$294,000	\$222,000	\$222,000	\$738,000	\$617,536

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Costs

Costs around SGD for the interviewed organization include cost of SGD licenses, annual support, and additional hardware. The actual cost of the solution will vary depending on the size of the application environment and the number of end users accessing applications through SGD.

SGD License Cost

SGD costs incurred by the organization include the license costs of the SGD product itself. For the purpose of this analysis, we assume that the organization purchases a total of 1000 licenses at a total discounted cost of \$162.18 per license. It should be noted that this cost reflects an overall volume discount as compared to typical list price of \$349 for the SGD product. Table 8 illustrates the cost to the organization.

Table 8: SGD Costs

Ref.	Metric	Calculation	Initial
A1	Cost of license for connecting to Windows, Unix, AS/400, and mainframe servers		\$162.18
A2	Number of license keys required		1,000
A3	SGD license cost	A1*A2	\$162,180

Source: Forrester Research, Inc.

SGD Maintenance Cost

The organization also incurred annual costs associated with maintenance and support of the Sun SGD environment. The annual license cost was 18% of the initial license fee. Table 9 provides an illustration of the calculation used.

Table 9: Software Support Costs

Ref.	Metric	Calculation	Initial
B1	Initial license cost		\$162.18
B2	Maintenance rate		18%
B3	Number of licenses		1,000
B4	Software support cost	B1*B2*B3	\$29,190

Source: Forrester Research, Inc.

Additional Hardware Cost

In addition to the cost of SGD licenses and ongoing support, the organization noted the need to purchase additional hardware to implement the SGD platform. These costs include the cost of additional Sun Fire servers and the cost of additional server support, as well as the cost of connectivity hardware for the SGD platform.

Table 10: Additional Hardware Costs

Ref.	Metric	Calculation	Initial
C1	Server costs		\$32,328
C2	Three-year server support		\$3,110
C3	Connectivity hardware		\$4,716

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

Ct	Additional hardware costs	C1+C2+C3	\$40,154
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Total Costs

The total costs for deploying SGD at the sample organization are listed below.

Table 11: Total Costs

Cash flow analysis (original estimates)						
Costs	Initial	Year 1	Year 2	Year 3	Total	Present value
SGD license cost	(162,180)				(162,180)	(162,180)
Annual support		(29,190)	(29,190)	(29,190)	(87,570)	(72,591)
Additional hardware costs	(40,154)				(40,154)	(40,154)
Total	(\$202,334)	(\$29,190)	(\$29,190)	(\$29,190)	(\$289,904)	(\$274,925)

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Risk

Risk-adjusted and non-risk-adjusted ROI are both discussed in this study. The assessment of risks provides a range of possible outcomes based on the risks associated with IT projects in general and specific risks relative to desktop and infrastructure projects. In our research, we discovered that implementing the Sun Ray solution depends in large part on end user acceptance.

Risk factors are used in TEI to widen the possible outcomes of the costs and benefits (and resulting savings) associated with a project. Since the future cannot be accurately predicted, there is risk inherent in any project. TEI captures risk in the form of risks-to-benefits and risks-to-costs.

The following general risks (which apply to most IT projects) were considered in this report:

- Lack of corporate discipline in creating processes and procedures to best take advantage of the benefits.
- Lack of appropriate training for IT and end user personnel who will be responsible for achieving and optimizing the benefits from Sun Ray thin clients.
- Failure to reduce administrative and capital cost savings.
- Internal inertia, conflicting priorities, and turnover reducing the organization's ability to achieve the benefits.

The following risks associated with thin-client implementation were considered in this report::

- Costs can be greater than anticipated. Experience indicates that project size will be a significant risk factor for cost.

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

- Benefits may not be realized, as estimates will not be tracked and not translate directly to quantifiable savings within the organization.

If a risk-adjusted ROI still demonstrates a compelling business case, it raises confidence that the investment is likely to succeed since the risks that threaten the project have been taken into consideration and quantified. The risk-adjusted numbers should be taken as realistic expectations, since they represent the expected value considering risk. Assuming normal success at mitigating all risk, the risk-adjusted numbers should more closely reflect the expected outcome of the investment. For the sample organization, Forrester applied low to moderate risk factors to each cost and benefit. For more information on the risk calculation, please see Appendix C.

Steps For Measuring Investment Risk

In order to calculate the final risk-adjusted estimates, Forrester applies a multistep process examining the impact of bias and variance on cost and benefit estimates.

Step 1: Calculate original cost and benefit estimates. This is the initial calculation of the cost and benefit estimates without accounting for the impact of investment risk.

Step 2: Calculate the impact of bias for cost and benefit estimates. To account for the impact of bias (most organizations overestimate benefits and underestimate costs), this step recalculates the original cost and benefit estimates by using the average of the original estimate (calculated in Step 1) and a low and a high estimate.

Step 3: Calculate variance for cost and benefit estimates. This step measures the impact of variance on cost and benefit estimates. Variance is a measure of the possible range of outcomes for cost and benefit estimates. Higher variance implies a wider range of possible outcomes, increasing the uncertainty in cost and benefit estimates.

The three steps are used to identify and incorporate the full impact of risk as part of a technology decision. The tables below illustrate the impact of implementation and impact risk on cost and benefit estimates.

Table 12: Total Costs, Risk-Adjusted

Cash-flow analysis (risk-adjusted estimates)						
Costs	Initial	Year 1	Year 2	Year 3	Total	Present value
SGD license cost	(162,180)				(162,180)	(162,180)
Annual support		(29,190)	(29,190)	(29,190)	(87,570)	(72,591)
Additional hardware costs	(40,154)				(40,154)	(40,154)
Total	(\$202,334)	(\$29,190)	(\$29,190)	(\$29,190)	(\$289,904)	(\$274,925)

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Table 13: Total Benefits, Risk-Adjusted

Cash flow analysis (risk-adjusted estimates)						
Benefits	Initial	Year 1	Year 2	Year 3	Total	Present value
Administration cost savings		121,440	161,920	161,920	445,280	365,871
Reduced software spend		118,300			118,300	107,545
Reduced software maintenance spend			23,660	23,660	47,320	37,330
Total		\$239,740	\$185,580	\$185,580	\$610,900	\$510,746

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Flexibility

Flexibility, as defined by TEI, represents the value of the options created by the technology platform. When one considers an investment, one can look at both the immediate benefits and the possibility of adapting that investment to meet unanticipated or potential needs. For example, if one buys a house, one will receive the benefit of living in it. If the house that was purchased can also be expanded to meet a changing family need, that extra option is of value to the original purchaser and makes the house more valuable than just the direct benefits imply. TEI attempts to put a value on these options, since they represent an additional asset that the organization has obtained as a result of implementing the basic technology platform.

With any option, just as with the example of the option to expand a house, taking advantage of these options will require a second investment. We can estimate this cost and use it to value the options created, as with the value of the new house, or the additional business produced by the option.

Likewise, if the second investment is not made, due to business conditions not being in favor of the option's exercise, the option of flexibility will expire, worthless. For the purpose of analysis here, two budget cycles, or two years, is often used as a good first step in looking at this expiration date for the option. The fact that this secondary project may or may not be funded in two budget cycles is reflected in the value of the option benefit.

Last, to value the option, we must consider the base value of money — which is reflected in the risk-free rate of return on capital — and the volatility or uncertainty about future conditions and needs. If an organization has clarity about the future and there is little or no volatility, then a financial analysis of future spending becomes a net present value calculation. If there is uncertainty, then purchasing or obtaining options to hedge future business risks creates added value.

TEI Framework: Summary

Considering the financial framework constructed above, the results of the costs, benefits, flexibility, and risk sections using the representative numbers can be used to determine a return on investment, net present value, and payback period.

Table 14 below shows the risk-adjusted values, applying the risk adjustment method indicated in the Risk section.

Table 14: TEI Summary Results

Summary financial results	Risk-adjusted estimates
ROI	86%
Payback period (years)	1.0
Total costs (PV)	(\$274,925)
Total benefits (PV)	\$510,746
Total (NPV)	\$235,821
Internal rate of return (IRR)	74%

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It is important to note that values used throughout the TEI Framework are based on in-depth interviews with a sample organization. Forrester makes no assumptions as to the potential return that other organizations will receive within their own environment. Forrester strongly advises that readers use their own estimates within the framework provided in this study to determine the expected financial impact of implementing Secure Global Desktop.

Study Conclusions

Forrester's in-depth interviews with Sun Secure Global Desktop's customers yielded the following important observation:

- Based on information collected in interviews with current Secure Global Desktop customers, Forrester found that organizations can realize benefits in the form of improved system administrator productivity, as well as reduced software licensing and maintenance costs.

The financial analysis provided in this study illustrates the potential way an organization can evaluate the value proposition of Sun Secure Global Desktop. Based on information collected in the in-depth customer interview, Forrester calculated a three-year risk-adjusted ROI of 86% for the sample organization with a payback period of within 0.8 years. All final estimates are risk-adjusted to incorporate potential uncertainty in the calculation of costs and benefits.

Based on these findings, companies looking to implement Secure Global Desktop can see both cost savings and productivity benefits. Using the TEI framework, many companies may find the potential for a compelling business case to make such an investment.

Appendix A: Total Economic Impact Overview

Total Economic Impact is a methodology developed by Forrester Research that enhances a company's technology decision-making processes and assists vendors in communicating the value proposition of their products and services to clients. The TEI methodology helps companies demonstrate, justify, and realize the tangible value of IT initiatives to both senior management and other key business stakeholders.

The TEI methodology consists of four components to evaluate investment value: benefits, costs, risks, and flexibility. For the purpose of this analysis, the impact of flexibility was not quantified.

Benefits

Benefits represent the value delivered to the user organization — IT and/or business units — by the proposed product or project. Often product or project justification exercises focus just on IT cost and cost reduction, leaving little room to analyze the effect of the technology on the entire organization. The TEI methodology and the resulting financial model place equal weight on the measure of benefits and the measure of costs, allowing for a full examination of the effect of the technology on the entire organization. Calculation of benefit estimates involves a clear dialogue with the user organization to understand the specific value that is created. In addition, Forrester also requires that there be a clear line of accountability established between the measurement and justification of benefit estimates after the project has been completed. This ensures that benefit estimates tie back directly to the bottom line.

Costs

Costs represent the investment necessary to capture the value, or benefits, of the proposed project. IT or the business units may incur costs in the forms of fully burdened labor, subcontractors, or materials. Costs consider all the investments and expenses necessary to deliver the proposed value. In addition, the cost category within TEI captures any incremental costs over the existing environment for ongoing costs associated with the solution. All costs must be tied to the benefits that are created.

Risk

Risk measures the uncertainty of benefit and cost estimates contained within the investment. Uncertainty is measured in two ways: 1) the likelihood that the cost and benefit estimates will meet the original projections, and 2) the likelihood that the estimates will be measured and tracked over time. TEI applies a probability density function known as "triangular distribution" to the values entered. At a minimum, three values are calculated to estimate the underlying range around each cost and benefit.

Flexibility

Within the TEI methodology, direct benefits represent one part of the investment value. While direct benefits can typically be the primary way to justify a project, Forrester believes that organizations should be able to measure the strategic value of an investment. Flexibility represents the value that can be obtained for some future additional investment building on top of the initial investment already made. For instance, an investment in an enterprisewide upgrade of an office productivity suite can potentially increase standardization (to increase efficiency) and reduce licensing costs. However, an embedded collaboration feature may translate to greater worker productivity if activated. The collaboration can only be used with additional investment in training at some future point in time. However, having the ability to capture that benefit has a present value that can be estimated. The flexibility component of TEI captures that value.

Appendix B: Glossary

Discount rate: The interest rate used in cash-flow analysis to take into account the time value of money. Although the Federal Reserve Bank sets a discount rate, companies often set a discount rate based on their business and investment environment. Forrester assumes a yearly discount rate of 10% for this analysis. Organizations typically use discount rates between 8% and 16% based on their current environments. Readers are urged to consult their own organizations to determine the most appropriate discount rate to use in their own environments.

Net present value (NPV): The present or current value of (discounted) future net cash flows given an interest rate (the discount rate). A positive project NPV normally indicates that the investment should be made, unless other projects have higher NPVs.

Present value (PV): The present or current value of (discounted) cost and benefit estimates given an interest rate (the discount rate). The PV of costs and benefits feed into the total net present value of cash flows.

Payback period: The breakeven point for an investment. The point in time at which net benefits (benefits minus costs) equal initial investment or cost.

Return on investment (ROI): A measure of a project's expected return in percentage terms. ROI is calculated by dividing net benefits (benefits minus costs) by costs.

A Note On Cash Flow Tables

The following is a note on the cash flow tables used in this study (see the Example Table, below). The initial investment column contains costs incurred at "time 0" or at the beginning of Year 1. Those costs are not discounted. All other cash flows in Years 1 through 3 are discounted using the discount rate shown in Table 2 at the end of the year. Present value (PV) calculations are calculated for each total cost and benefit estimate. Net present value (NPV) calculations are not calculated until the summary tables and are the sum of the initial investment and the discounted cash flows in each year.

Example Table

Ref.	Category	Calculation	Initial cost	Year 1	Year 2	Year 3	Total

Source: Forrester Research, Inc.

Appendix C: Adjusting For Investment Risk (Example)

This example provides a high-level illustration of the measurement of investment risk to a single benefit estimate. The table below provides a high-level overview of the following steps.

Benefit	Step 1			Step 2		Step 3	
	Original estimate	High	Low	Bias adjustment		Risk adjusted	
				%	Value	%	Value
Benefit 1	\$2,000	\$2,400	400	80%	\$1600	87%	\$1395

Step 1: Calculate original cost and benefit estimates

Suppose that an organization is trying to estimate the different types of benefits that might arise from a given technology investment. One potential expected benefit is savings per employee from the use of the technology. A sample benefit calculation is as follows:

Ref.	Metric	Calculation	Estimate
A1	Number of employees		200
A2	Savings per employee		\$10
A3	Total yearly estimated savings	A1 * A2	\$2,000

The \$2,000 represents the organization's original estimate of the yearly impact of the technology investment.

Step 2: Calculate the impact of bias for cost and benefit estimates

In Step 2, we account for the impact of bias in our original cost and benefit estimates. To measure the impact of bias, we need to calculate the range of possible outcomes of our original estimate by estimating possible high/low variables around our original estimates.

Ref.	Metric	Calculation	Estimate	Low	High
A1	Number of employees per year		200		
A2	Savings per employee		\$10		
A3	Total yearly estimated savings	A1*A2	\$2,000	\$400	\$2,400
B1	Bias adjusted estimate	$(\$2,000 + \$400 + \$2,400) / 3$	\$1,600		

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

In the case of our example, we have calculated our original estimate (\$2,000), our low estimate (\$400), and our high estimate (\$2,400). The unbiased estimate is calculated as the mean of the high and low estimates: $[(\$2,000 + \$1,200 + \$2,400)/3 = \$1,600]$. The revised estimate is now \$1,600. Reference A4 in the above table presents the revised estimate.

Step 3: Calculate the impact of variance on cost and benefit estimates

Once we have determined the impact of bias in our original estimates, the next step is to calculate the impact of variance. Variance measures the possible spread within our estimates. In the case of our example, the variance is based upon the low estimate (\$400), the high estimate (\$2,400), and the revised estimate (\$1,600). A wider spread would create higher uncertainty and, as a result, greater risk.

To calculate the impact of variance, we need to use the following calculations:

$$\frac{[(Lx)^2 + (x2)^2 + (Hx)^2] - (Lx)*(x2) - (Lx)*(Hx) - (x2)*(x2)*(Hx)}{18} = Var(x2)$$

Where		
Lx	Low estimate	\$400
X2	Revised (biased adjusted) estimate	\$1,600
Hx	High estimate	\$2,400

$$\frac{[(400)^2 + (1600)^2 + (2400)^2] - (400)*(1600) - (400)*(2400) - (1600)*(2400)}{18} = 168889$$

The standard deviation represents the square root of the variance:

$$\hat{\sigma}(x2) = \sqrt{Var(x2)}$$

$$\hat{\sigma}(x2) = \sqrt{168889} = 411$$

The Total Economic Impact Of Deploying Sun's Secure Global Desktop

The final calculation in our analysis is to create a measure for the impact of risk on the cost or benefit estimate. To do this, we use the following equation:

Risk impact: [(standard deviation of estimate)/ (unbiased estimate)] * 1/2

$$\text{Risk impact} = 1 - \left[\frac{[\partial(x2)]}{x2} \right] * \frac{1}{2}$$

$$\text{Risk impact} = 1 - \left[\frac{411}{1600} \right] * \frac{1}{2} = 1 - 12.8\% = 87.2\%$$

The logic behind the equation for risk impact is as follows:

- We first divide the standard deviation into the unbiased estimate to get an estimate of the magnitude of the mean of the distribution to the possible spread of the distribution. This ratio allows us to compare the impact of risk multiple cost and benefit estimates by reducing it to a percentage.
- We next multiply the original ratio by 1/2 to measure only the likelihood of the potential downside of the estimate. Multiplying by 1/2 allows us to look at the part of the distribution where the likelihood that the costs will be higher than estimated (the right side of the distribution) or benefits that are lower than originally estimated (the left side of a normal distribution).

The table below illustrates the progression of the original benefit estimate to the risk-adjusted benefit estimate, accounting for the impact of variance.

Impact of bias and risk	
Original estimate	\$2,000
Revised estimate	\$1,600
Risk-adjusted estimate	\$1,395