EVALUATING CT CAPACITY USING SPACE PRODUCTIVITY™

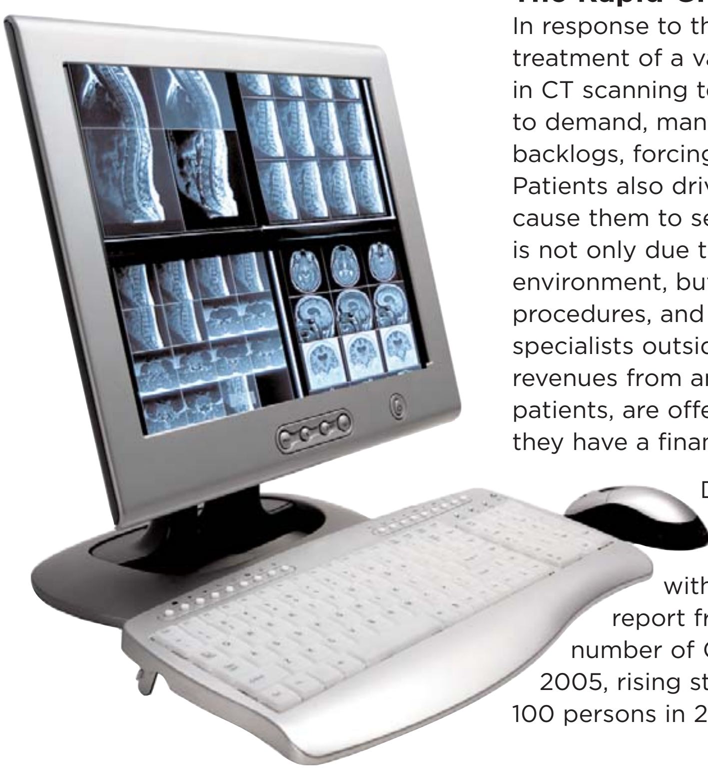
Authors: Robert Denny and Karl Korinek

There are numerous avenues to explore when attempting to increase computed tomography (CT) throughput. Historically, hospital executives have focused on the traditional approaches of increasing the number of CT scanners and/or redesigning workflow to increase throughput on existing scanners. One little-explored approach is the interaction of physical space and technologist staffing levels as a method to increase throughput. Specifically, there are circumstances where providing extra space for a given CT scanner and adding technologists can dramatically improve the throughput of the existing equipment. This benefit can potentially be achieved in addition to improvements seen through workflow redesign and does not carry the high a price of new equipment.

These options are difficult to evaluate without the ability to see how the different operating components relate to one another in an integrated conceptual and analytical framework. Optimizing the performance and utilization of a CT scanner requires a deeper look at an imaging department's use of space. The concept of Space Productivity is introduced to address these important and complex challenges.

An assessment of Space Productivity integrates several key performance indicators across five fundamental components of operations: workflow, people, equipment/supplies, information technology (IT) and space. These analyses incorporate benchmarks that allow hospitals to measure and monitor the complex and multi-faceted interactions that affect the productive utilization of hospital space dedicated to key diagnostic and treatment services such as CT imaging.

The Rapid Growth of CT Demand, Utilization and Capacity



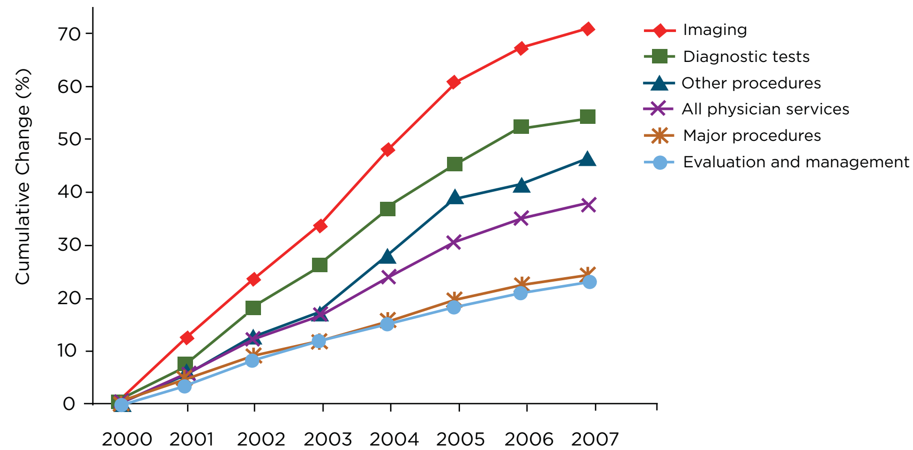
In response to the rapid adoption of CT as a powerful tool in the diagnosis and treatment of a variety of diseases, hospitals have made substantial investments in CT scanning technologies. However, despite diligent efforts to match capacity to demand, many find their machines to be plagued by long appointment backlogs, forcing many physicians to look elsewhere when writing referrals. Patients also drive this shift, as their impatience to get the scan completed may cause them to seek an alternate location. Physicians are reporting that this shift is not only due to shorter appointment wait times outside of the hospital environment, but also improved patient satisfaction, streamlined scheduling procedures, and shortened turnaround times for scanning results.[1] In addition, specialists outside of the field of Radiology, in an effort to supplement their revenues from ancillary services and provide convenient imaging services to their patients, are offering self-referral services in their offices or facilities in which they have a financial stake.[2,3,4]

Despite these inauspicious trends for hospitals, the overall use of advanced imaging technologies like CT scanners has grown significantly over the past decade, both in absolute terms and with respect to other physician-ordered services (Figure 1a).[5] A report from January 2007 estimated that the annual growth rate in the number of CT scans performed in the U.S. was 13 percent from 2000 to 2005, rising steadily from 12 CT scans per 100 persons in 2000 to 22 scans per 100 persons in 2005 (Figure 1b).[6]

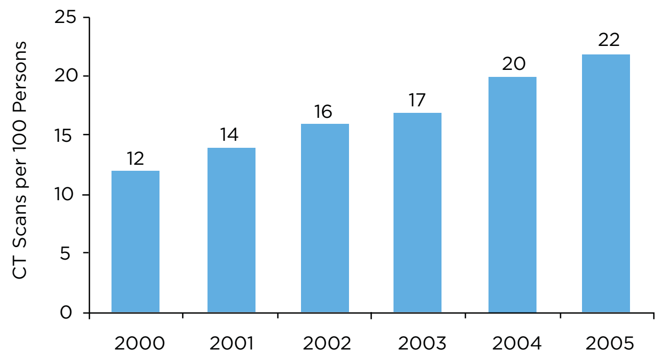
To what extent these trends will continue in the future is up for debate, especially considering significant recent efforts by both private health plans and Medicare to constrain spending by targeting advanced imaging. Nevertheless, the well-established value of CT imaging will continue to increase demand within facilities that can safely and efficiently provide such services.[7,8] More than ever, proving value will be critical. With advanced imaging equipment such as CT scanners expected to play an ever-growing role in generating hospital income — utilized not only for a wider range of diagnostic procedures, but also an increasing number of interventional radiology and cardiology procedures — protecting this revenue source is clearly a pressing concern for hospitals.[9,10,11] Insuring sufficient future capacity is a must, but determining the best option on how to get there requires more study and scrutiny than have typically occurred to date.

Figure 1:
Trends in CT Imaging Services Utilization

(a) Rates of Use of Imaging Services Versus Other Physician-Ordered Services Per Medicare Beneficiary



(b) CT Scans Per 100 Population, All Payers



Sources: (a) Iglehart, John K. "Health Insurers and Medical-Imaging Policy — A Work in Progress." NEJM, March 2009.
(b) McKinsey and Co. "Accounting for the Cost of Health Care in the United States." January 2007.

Evaluating CT Capacity in Today's Economic Climate

One option often considered to increase CT capacity is the purchase of additional scanners. Although modern scanning equipment alone costs upwards of $3.5 million (including a fully-integrated Radiology Information System (RIS)/Picture Archiving and Communications System (PACS) and the space and infrastructure required to house such equipment also comes with a substantial price tag, the dramatic dollars at stake in terms of foregone revenue often justifies the high cost. However, when coupling the magnitude of such an expense with the current economic climate, which, according to the American Heart Association (AHA) has already begun to impact hospitals (see Table 1 and Figure 2a), executives need to be more prudent than ever as they evaluate increasing CT capacity.

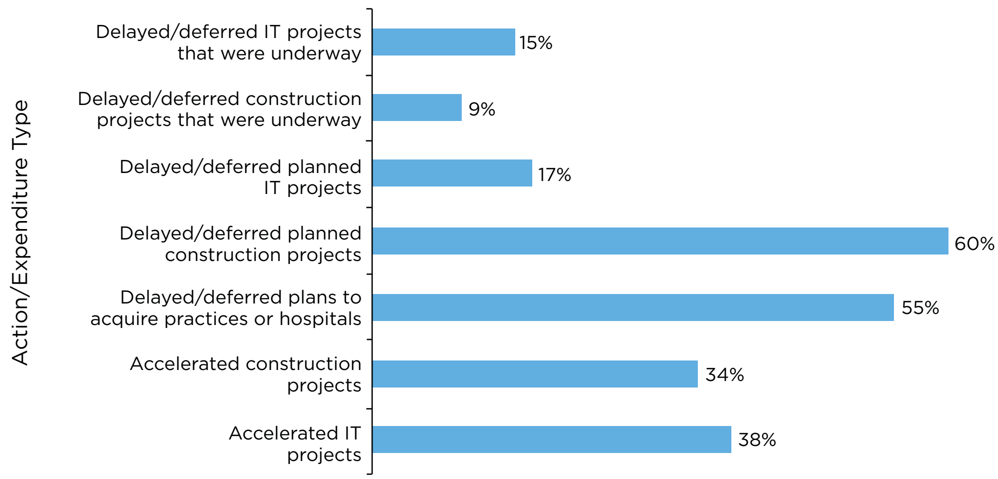
Table 1:
Initial Impact of Economic Crisis on Hospitals, November 2008

FACTOR	IMPACT
Capital Crunch	• Increased costs of borrowing • Decreased access to financing for facility and technology needs • Investment gains turning to losses
Patient Mix and Volume	• Lower admissions and elective procedures • Rising unemployment leading to increased uncompensated care
MD Assistance	• More physicians are seeking financial support from hospitals
Supplier Expense	• Healthcare manufacturers and suppliers are asking for price increases to offset their losses
Medicare/ Medicaid	• Stresses on state and federal budgets raise worries about cuts • Programs support half of patient care provided but are already severely underfunded

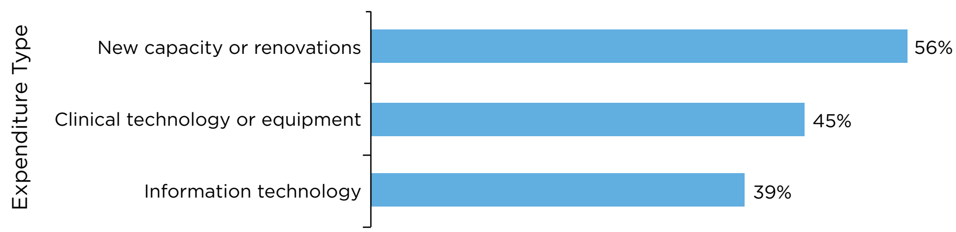
Source: "The Economic Crisis: Impact on Hospitals." AHA Rapid Response Survey. November 2008.

Figure 2:
Hospital Capital Expenditure Postponement or Reconsideration

(a) Percent of Hospital Executives Who Have Made (or Plan to Make) Changes in Capital Investment (n = 53, Nov. 2008)



(b) Percent of Hospital CEOs Reconsidering or Postponing Capital Expenditures (n = 736, Nov. 2008)

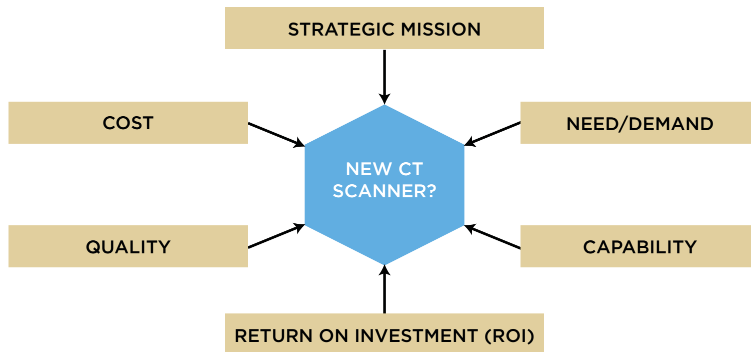


Sources: (a) "Treatment Plan; Hospitals Respond to Economic Crisis." CSC Hospital Survey. November 2008.
(b) "The Economic Crisis: Impact on Hospitals." AHA Rapid Response Survey. November 2008.

When assessing whether a significant capital expenditure like the purchase of a new CT scanner is necessary, there are several criteria that should be considered to ensure that capital resources are being allocated appropriately. Examples of capital investment criteria may include alignment with the strategic mission, initial acquisition and setup cost, quality of the equipment as it relates to improving patient care and safety, need for the equipment based on demand in the marketplace, capability to acquire the machine and then utilize it at or near capacity, and overall expected return on investment (see Figure 3). If these criteria are met, then an organization's leadership can be confident that the strategic, financial and capital planning objectives are aligned.

As a result of the current economic climate, executives are reassessing their needs for capital expenditure/investment and reconsidering whether capital requests do indeed meet such criteria. A survey conducted by CSC in November 2008 showed that 60 percent of hospital executives (Figure 2a, n=53) are delaying or deferring planned construction projects, and 34 percent are doing the same for projects that were already underway. Another survey conducted in the same month by the AHA showed that almost half of hospital CEOs (Figure 2b, n=736) have decided to reconsider or postpone what they deem a non-critical capital expenditure for the purchase of clinical technology and equipment such as CT scanners. So although the acquisition of a CT scanner has typically been considered a sound investment and an efficient use of resources, the capital costs associated with such a purchase are forcing executives to look more closely at other innovative solutions to streamline processes, increase demand, utilization and capacity, and ultimately improve return on their assets.

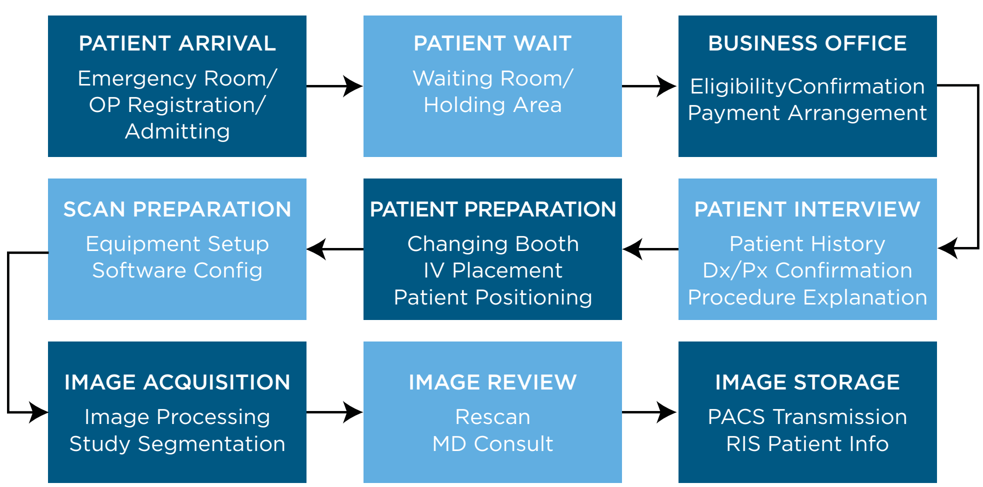
Figure 3: Criteria for Capital Expenditure Decisions



Operations Management Applied to CT Throughput and Capacity

Instead of expanding capacity through the purchase of additional equipment or an extension of operating hours, what if your current CT scanners could be used more efficiently to increase throughput and capacity? This is not a new question of course, and many organizations have long been studying ways to do just that. The focus has been predominately targeted towards workflow redesign — finding better ways to use the equipment and people to increase throughput. Because there are several independent and dependent steps along the CT workflow path, there are ample opportunities for productivity improvement (see Figure 4). While this is clearly a valuable avenue to pursue, recent studies have shown that there are other opportunities for both improved throughput and margin by increasing your number of technologists.[12] But what if you can't increase hours of operation and don't have the space to increase staff? Ensuring adequate space can have positive effects on staff productivity and patient satisfaction — indeed staffing, equipment and space are deeply interrelated and changes in one affect the others — yet space is also the second most expensive asset for most hospitals, so addressing space concerns requires further examination. We will return to that question shortly.

Figure 4: Overview of Typical CT Scanner Workflow



The field of operations management has a rich tradition of studying the economies of human labor in relation to the throughput of production machinery. And while this may seem like a blunt comparison to the cutting edge technology that modern CT scanners represent, we would do well to glean the bits of wisdom available. One such potential gem lies in the application of the production principle of diminishing returns. It is clear to most managers that if they keep adding staff to a process, eventually people are stumbling over one another and work productivity decreases, regardless of demand. However, what is less often considered is how additional technologists may lead to increased output per technologist due to increased economies of scale. In an assembly line environment, it is easier to see how these principles can be applied to determine the appropriate inputs required to optimize the system's outputs.

Applying these concepts to CT throughput, assume that there is one technologist operating a CT machine who can run eight scans over the course of an eight-hour day (see Table 2). If hiring a second technologist results in a marginal increase of 10 daily scans to deliver a combined machine output of 18 scans per day (nine per technologist) then the addition of the second person more than doubles CT throughput. This gain in throughput, productivity and revenue justifies the incremental staff expense for the additional technologist. If hiring a third technologist more than triples CT throughput, then the addition of the third technologist would be a prudent business decision based on marginal throughput or productivity alone, assuming a positive contribution margin per exam (contribution margin = net collections – direct variable cost). This reasoning continues as long as the marginal throughput continues to increase as new technologists are hired.

Table 2: Sample CT Throughput Analysis

		THROUGHPUT			VARIABLE CONTRIBUTION MARGIN (CM)					NET INCOME	
	Number of CT Techs	Total CT Exams	Marginal Increase in CT Exams	Average CT Exams Per Tech	Net Collections/ CT Exam[1]	Total Daily Net Collections	Total Tech Labor Exp @ $500/Day	Other Variable Exp @ $150/Exam	Total Daily CM[1]	Daily Fixed/ Overhead Cost	Daily Net Income
	1	8	8	8	$500	$4,000	($500)	($1,200)	($2,300)	$2,000	$300
	2	18	10	9	$500	$9,000	($1,000)	($2,700)	$5,300	$2,000	$3,300
MAX INCOME	3	30	12	10	$500	$15,000	($1,500)	($4,500)	$9,000	$2,000	$7,000
	4	32	2	8	$500	$16,000	($2,000)	($4,800)	$9,200	$3,000	$6,200

[1] Contribution Margin equals Net Revenue/Collection minus Direct/Variable Expense

However, what if marginal throughput decreases? In the example above, one can see that the maximum income can be reached with three technologists. There could be many potential reasons for why a fourth technologist results in reduced overall margin. For example, due to capacity constraints, the throughput could not be increased significantly with a fourth technologist, yet additional space for the technologist's workstation might be required which would result in incremental fixed costs.

It would only be in the best interests of management to hire a fourth technologist if: (a) the volume is available in the market, (b) the scanner is operating below capacity, and (c) the incremental space is available to accommodate the additional work area required. Furthermore, if the purpose of hiring a new technologist is to reduce the appointment backlog, improve physician or patient satisfaction, or otherwise protect scanning volume from competition, then these strategic factors must also be incorporated.

A recent study has shown that the concepts explained above apply directly to a CT scanning "assembly line."[13] Similar to the example above, this study found that moving from one to two technologists more than doubled the number of patients processed, and moving to three technologists more than tripled the throughput. The authors observed that a CT technologist must complete an average of 34 unique tasks over the course of 27 minutes to process a patient through a CT scanner and a majority of these tasks must be performed in series. Adding personnel allows for many of these steps to be performed in parallel, especially when technologists are trained in areas that have traditionally been considered tasks of radiology nurses, such as IV catheterization.

So how do managers assess how many technologists are optimal for their CT scanner or whether the current allotted space enables staff to work productively? As highlighted in the examples above, these questions are difficult to answer without the ability to see how the different operating components relate to one another in an integrated conceptual and analytical framework. The solution: An assessment of an organization's use of physical space, or Space Productivity.

Introducing CSC's Space Productivity

Space Productivity is a framework that looks at how an organization utilizes space by benchmarking performance using a selection of carefully chosen operational and financial metrics. It looks at more than just traditional benchmarks (see Table 3 for a selected list of traditional parameters and facility characteristics). It is all too common to see benchmarks such as the "number of technologists in an imaging department of a 300-bed urban teaching hospital." While this may provide some useful insight into how peer organizations are operating, it tells you precious little about whether their operation would work for you, or even whether their operational benchmarks make economic sense for your organization. For example, the costs of utilizing more space for a landlocked urban hospital will far exceed those for a suburban hospital which is currently in the design phase. It might, therefore, be more cost-effective to consider other options instead of increasing CT scanner space, even if it would increase profits. In order to determine which option is best requires an examination of the criteria specified. A Space Productivity assessment can provide this required additional level of detail to support effective estimates of your combined requirements.

Table 3:
Traditional Facility Benchmarking Characteristics

PARAMETER	SELECTED CHARACTERISTICS
Facility Type	Academic Med Center, Teaching Hospital, Community, Diagnostic Imaging Center
Facility Size	Small (<200 Staffed/Operating Beds), Very Large (>600 beds)
Geographic Region	Northeast, New York Metropolitan Area, State of California
Community Type	Urban, Suburban, Rural
Service Mix	General Tertiary, Specialty, Centers of Excellence
Case Mix	Low (CMI <1), High (CMI ≥1.12)
Payer Mix	Medicare, Medicaid, HMO, Commercial, Self-Pay

A common refrain when installing new CT scanners is, "How much space is this machine going to take?", with the implied meaning that less would be better. This is understandable given the large price tag for space within a hospital and the dozens of competing uses for that space. A brief look at the technical literature provided by the major manufacturers reveals this bias as well: a prominent specification is the minimum amount of space required to operate the equipment.[14]

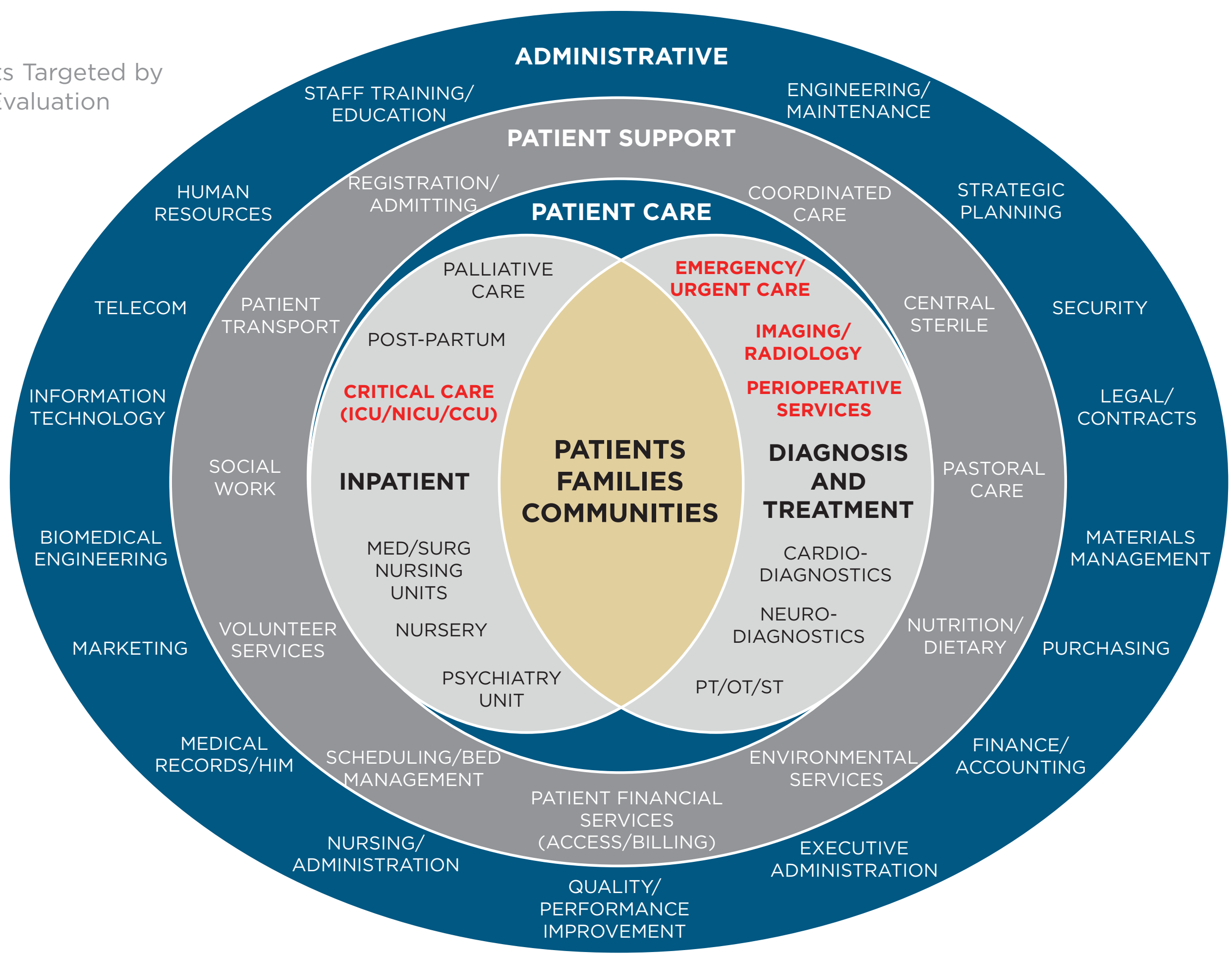
But given the potential revenues and high profit margins associated with CT scanning, the more relevant question would be, "What is the RIGHT amount of space for this equipment to maximize throughput, income, quality, patient safety, comfort and convenience to name a few?". An evaluation of Space Productivity helps to answer this question effectively through an integrated examination of several key performance indicators associated with patient throughput, staffing, financial performance and the breakdown of departmental gross square feet.

An in-depth analysis of Space Productivity allows hospitals to measure and monitor the productive utilization of hospital space with respect to Space Productivity benchmarks to gain a better perspective of potential opportunities within the organization which may not be revealed with a narrow look at basic throughput and staffing indicators. By identifying the best levers to drive improvements, not only can executives focus resources and effort appropriately to improve quality and performance, but they can also design and plan for new capital projects with a better understanding of potential risks, challenges and opportunities. For example, as surgery and interventional radiology continue to converge, inefficiencies will often emerge if careful consideration is not given to the requirements for designing and staffing an integrated productive space. An understanding has to be reached between surgery, interventional radiology and cardiology — plus several other patient care and support departments — of the cooperation and compromises required for success.

The previous example illustrates another key element to Space Productivity: The optimized utilization of hospital space requires the efficient functioning of all departments of the hospital that impact that service. To provide another example, a CT scanner may be perceived as operating at capacity as a result of limitations in technologist productivity. However, Radiology managers have reported situations where the source of the problem was actually a result of substantial scheduling conflicts with the Emergency Department.[15]

Figure 5 identifies the major departments of a typical hospital which may be contributing to throughput issues. Those departments highlighted in red are the departments which often benefit most from a high-level Space Productivity evaluation. All of these areas incorporate a complex interaction between various departments of the hospital, in a time-sensitive environment, and staffed by people with a diverse and specialized skill mix.

Figure 5:
Hospital Departments Targeted by Space Productivity Evaluation

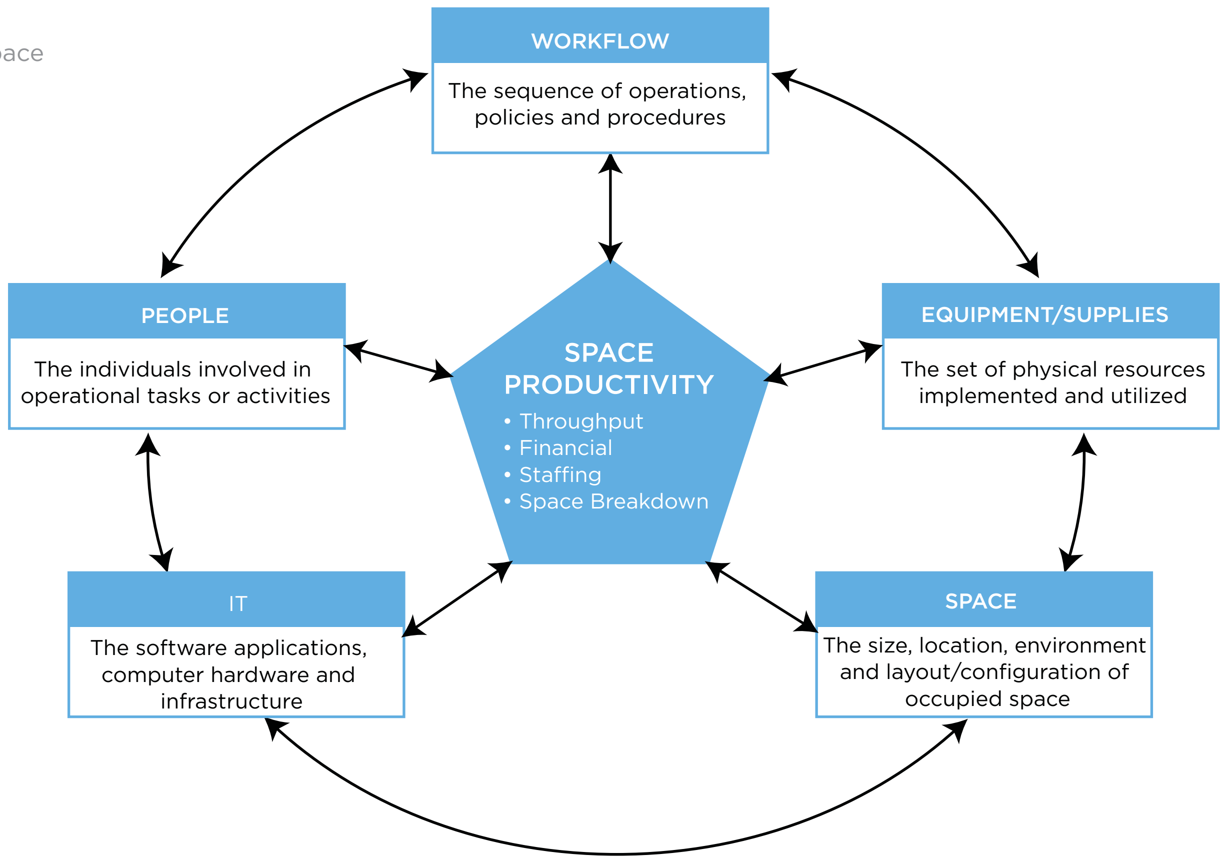


Space Productivity and Five Fundamental Components of Operations

The key performance indicators of Space Productivity measure the complex and multi-faceted interaction between five fundamental components of operations: workflow, people, equipment/supplies, IT and space (see Figure 6):

- Workflow — The sequence of operations, policies and procedures performed by the people within the system
- People — The individuals involved in any operational task or activity that directly or indirectly affects performance
- Equipment/Supplies — The set of physical resources implemented and utilized to allow people to perform their required operational tasks
- IT — The software applications, computer hardware and infrastructure that affect or monitor the performance of people and equipment
- Space — The configuration, size, location and environment of the physical space occupied by the people, IT or equipment to allow for completion of the necessary operations

Figure 6:
Five Components of Space Productivity



To show how key indicators can be used to benchmark the performance of these interdependent components of operations, a more thorough examination of Space Productivity follows. The next section will hone in on how the concepts and tools of Space Productivity can be employed to benchmark an imaging department's CT-dedicated space in an attempt to identify potential opportunities to improve performance.

A Focus on CT Space Productivity

In order to maximize throughput, CT imaging has moved towards a technologist-driven model. Table 4 illustrates a typical cost breakdown for operating five CT scanners, recorded during a study on CT costs in a full-service tertiary care academic medical center providing inpatient, outpatient and emergency services.[16] Are these scanners being used productively? Is the space taken up by these scanners being used productively? Are they at capacity? Are they generating enough income to justify the space and staff they utilize?

Table 4:
Technical Labor and Non-Labor Costs Incurred at CT Examinations

TYPE	ANNUAL COST ($)	% OF TOTAL DIRECT COST
Labor		
Technologist	1,090,599	23.4%
Management	177, 961	3.8%
Nurses	38,016	0.8%
Secretary	72,659	1.6%
Receptionist and/or Scheduler	59,737	1.3%
Radiographic Librarians	119,911	2.6%
Transcriptionists	70,899	1.5%
Inpatient Transporters	67,020	1.4%
Miscellaneous	47,851	1.0%
Subtotal Labor	1,744,653	37.5%
Non-Labor		
Equipment	1,006,510	21.6%
Equipment Servicing	531,265	11.4%
Film	416,723	8.9%
Contrast Media	283,230	6.1%
Medical-Surgical Stock	285,031	6.1%
Hospital Payments	253,897	5.5%
Miscellaneous	135,626	2.9%
Subtotal Non-Labor	2,912,282	62.5%
Total Direct Cost	4,656,935	100.0%
Est. Indirect Cost (as % of Direct)**	3,958,395	85.0%
Total Direct + Indirect Cost	8,615,330	185.0%

Source: Saini, Sanjay, et. al. "Technical Costs of CT Examinations." Radiology, 2001.

In order to address this question, information on labor costs alone is insufficient. What is the throughput of these machines? How much space do they require? How much revenue do they generate? Answers are required to confidently assess whether these machines are truly productive from the perspective of not only the equipment, but the department and the hospital as a whole. Table 5 lists some of the key throughput, financial, staffing and space breakdown metrics that should be examined when conducting an assessment of Space Productivity. Let's take a look at some of the key Space Productivity measures for CT scanners to get an idea of how a sample analysis may look.

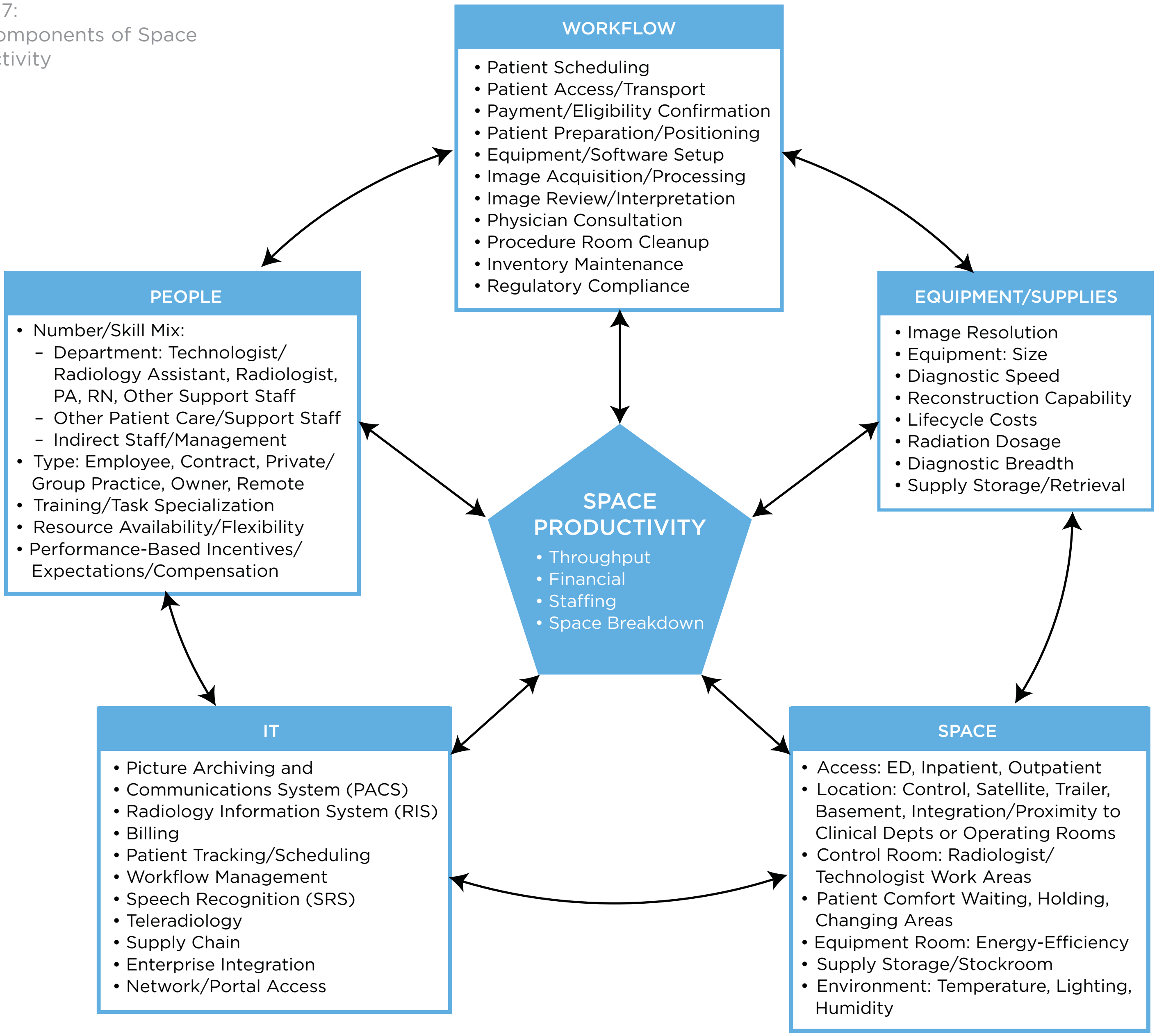
Table 5:
Measures of CT Space Productivity

CATEGORY	MEASURE	
Throughput	• Procedures Per Day (IP/OP/SDS) • Results Turnaround Time (TAT) • Procedure TAT	• Exams Per Room Per Day • Appointment Backlog • OP/SDS Operating Hours
Financial	• Daily Revenue Per Scanner • % Non-Labor Exp. of Operating Revenue • Payer Mix: % Patients with Medicine	• Contribution Margin Per Exam • Income per RVU • Labor Expense Per Exam
Staffing	• Technologists Per Scanner • Total Radiology Tech Worked Hours	• Exams Per Technologist • Nurse to Technologist Ratio
Space Breakdown	• Dept Gross Sq. Footage/Radiology Tech • Main Dept Gross Sq. Footage/Satellite Dept Gross Sq. Footage	• Dept Gross Sq. Footage/ Machine

The five components of Space Productivity provide an excellent framework to illustrate the components of CT Space Productivity (see Figure 7). The key measures help an organization assess which solutions for increasing productivity should be considered or implemented. Three previously identified critical tactics to increase inpatient and outpatient CT productivity are as follows:

- Addition of technologists or other personnel
- Redefining workflow of technologists and other key personnel
- Enhancement and integration of existing information systems (RIS and PACS) and other databases associated with CT workflow

Figure 7:
Five Components of Space Productivity



So how does one determine which solution, or combination of solutions, is best to improve operating performance? The answer is provided by the final key element to Space Productivity: Benchmarking an organization's performance against industry best practices.

Benchmarking Space Productivity to Operating Performance

In order for hospital executives and managers to incorporate the concepts of Space Productivity in their organization, they must understand how their organization compares to industry benchmarks and best practices. An integrated look at the various interconnected key performance indicators of Space Productivity allows one to determine sources of inefficiencies and opportunities for improvement.

The first step in an assessment of Space Productivity is to define an organization's compare group based on several key statistics such as number of machines by modality and physical configuration. For CT, measures should be compared based on departments with the same number of machines instead of comparing the operational performance of the CT departments of hospitals with a similar number of beds.

Standard benchmarking practices of examining a single type of benchmark may not provide enough (or the right) information. The holistic approach of Space Productivity analyses can significantly enhance decision making. Analyzing hospital performance data with the purpose of methodically examining Space Productivity allows managers to consider people, space, volume and money simultaneously, rather than in separate analyses. CT departments everywhere must evolve from rudimentary management/benchmarking style to this more advanced, integrated Space Productivity approach.

Table 6 below is a simple illustration of this concept. If an organization were to just look at Radiology Technologist Worked Hours, both scenarios indicate that the organization needs to do a focused examination of these worked hours. However, using this benchmark alone does not provide much insight. As is shown in Table 6, the organization facing Scenario 1 is missing opportunities, while the organization of Scenario 2 finds itself in a desirable position.

Table 6:
Space Productivity Assessment of CT Department

	SCENARIO 1 Performance Compared to CT Departments with Similar Number of Machines and Physical Configuration	SCENARIO 2 Performance Compared to CT Departments with Similar Number of Machines and Physical Configuration
Radiology Technologist Worked Hours	🔴 HIGH	🔴 HIGH
CT Department Gross Square Footage	🔴 LOW	🟡 ON TARGET
Gross Revenue of Department	🔴 LOW	🟢 HIGH
Procedure Volume	🔴 LOW	🟢 HIGH
Expense Per Procedure	🔴 HIGH	🟡 ON TARGET

Next Steps with Space Productivity

It is clear that the demand for CT technology is outpacing available capacity. However, with limited capital, care must be taken in how that additional capacity is created. It is no longer a matter of "either ... or," smart organizations are looking for ways to accomplish both. In a similar manner, the older methods of assessing operational performance based on one or two benchmarks will no longer meet the financial rigors of today. To remain quality-driven and fiscally responsible and build long-term value by continuing to exceed customer expectations, healthcare executives must adopt more sophisticated operational analytic methodologies. The unique approach of Space Productivity relates space, throughput, worked hours, revenue and expense, and allows healthcare leaders to gain an understanding of how well space is being used in comparison to similar healthcare facilities.

For more information on CSC's Space Productivity framework, contact Dawn Gay at 312.939.2000 | dgay4@csc.com.

References

1 Tynan, Ann, Robert A. Berenson and Jon B. Christiansen. "Health Plans Target Advanced Imaging Services: Cost, Quality and Safety Concerns Prompt Renewed Oversight." *Issue Brief: Findings from the Center for Studying Health System Change.* February 2008.

2 Iglehart, John K. "The New Era of Medical Imaging — Progress and Pitfalls." *NEJM*, June 2006.

3 Mitchell, J.M. "The Prevalence of Physician Self-referral Arrangements after Stark II: Evidence from Advanced Diagnostic Imaging." *Health Affairs*. Web Exclusive. Published online April 17, 2007.

4 Gazelle, G.S., et. al. "Utilization of Diagnostic Medical Imaging: Comparison of Radiologist Referral versus Same-Specialty Referral." *Radiology*. October 2007.

5 Iglehart, John K. "Health Insurers and Medical-Imaging Policy — A Work in Progress" *NEJM*, March 2009.

6 McKinsey and Co. "Accounting for the Cost of Health Care in the United States." January 2007.

7 Iglehart, John K. "Health Insurers and Medical-Imaging Policy — A Work in Progress." *NEJM*, March 2009.

8 "Report to the Congress: Medicare Payment Policy." Washington, DC, Medicare Payment Advisory Commission. 2007.

9 Berenson, Alex and Reed Abelson. "Weighing the Costs of a CT Scan's Look Inside the Heart." *NY Times*, June 29, 2008.

10 Budoff, MJ, et. al. "Diagnostic performance of 64-multidetector row coronary CTA ... results from the prospective multicenter ACCURACY trial." *J Am Coll Cardiol*, Nov 2008.

11 Anderson, Stephan W. "Upper Extremity CT Angiography in Penetrating Trauma: Use of 64-Section Multidetector CT." *Radiology*, December 2008.

12 Giles W. L. Boland. "Enhancing CT Productivity: Strategies for Increasing Capacity." *American Journal of Roentgenology*, July 2008.

13 Giles W. L. Boland. "Enhancing CT Productivity: Strategies for Increasing Capacity." *American Journal of Roentgenology*, July 2008.

14 Toshiba Aquilion. http://medical.toshiba.com/Products/CT/DynamicVolume/. Accessed 12/04/08, Philips Brilliance iCT, http://www.healthcare.philips.com/main/products/ct/products/ct_brilliance_ict/index.wpd. Accessed 12/04/08. Siemens SOMATOM. http://www.medical.siemens.com/siemens/en_US/gg_ct_FBAs/files/brochures/ct_somatom_emotion.pdf. Accessed 12/04/08.

15 Interview with Susan McConnell, Director of Radiology, Mercy Health System, Philadelphia, PA, 1/14/09.

16 Saini, Sanjay, et. al. "Technical Costs of CT Examinations." *Radiology*, 2001.

CSC
266 Second Avenue
Waltham, Massachusetts 02451
United States
+1.800.272.0018

Worldwide CSC Headquarters
The Americas
3170 Fairview Park Drive
Falls Church, Virginia 22042
United States
+1.703.876.1000

Europe, Middle East, Africa
Royal Pavilion
Wellesley Road
Aldershot, Hampshire GU11 1PZ
United Kingdom
+44(0)1252.534000

Australia
26 Talavera Road
Macquarie Park, NSW 2113
Australia
+61(0)29034.3000

Asia
139 Cecil Street
#08-00 Cecil House
Singapore 069539
Republic of Singapore
+65.6221.9095

About CSC

The mission of CSC is to be a global leader in providing technology enabled business solutions and services.

With the broadest range of capabilities, CSC offers clients the solutions they need to manage complexity, focus on core businesses, collaborate with partners and clients, and improve operations.

CSC makes a special point of understanding its clients and provides experts with real-world experience to work with them. CSC is vendor-independent, delivering solutions that best meet each client's unique requirements.

For 50 years, clients in industries and governments worldwide have trusted CSC with their business process and information systems outsourcing, systems integration and consulting needs.

The company trades on the New York Stock Exchange under the symbol "CSC."

BE09_0167