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PLANNING & STRATEGY

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Data center management software and services: Effective selection and deployment

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Data center infrastructure management (DCIM) software is widely considered essential for running modern, flexible and efficient data centers, yet is also notoriously difficult to select and deploy. This report, the first in a two-part series, provides information spanning DCIM, new cloud services and artificial intelligence-driven approaches, as well as practical advice for success.

30-45 minutes to read

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This Uptime Institute Intelligence report covers:

ABOUT UPTIME INSTITUTE INTELLIGENCE

Uptime Institute Intelligence is an independent unit of Uptime Institute dedicated to identifying, analyzing and explaining the trends, technologies, operational practices and changing business models of the mission-critical infrastructure industry. For more about Uptime Institute Intelligence, visit https://uptimeinstitute.com/ui-intelligence.

KEY FINDINGS

• Data center infrastructure management (DCIM) is as much a management approach that needs to be institutionalized as it is a technology. One DCIM tool or many — integration will be critical, as will business and operational processes, which must be "built into" the software.

• Deploy features over time, beginning with proof-of-concept trials.

• For colocation providers, DCIM deployment goes beyond operational efficiency: it is critical to exploiting the potential of customer portals. In the short- to medium-term, colos should consider DCIM-based customer portals a competitive enhancement, not a new revenue stream.

• New big data-driven cloud services known as DMaaS (data center management as a service) deliver customized analysis via a wide area network and are paid for on a recurring, as-you-go basis. We believe DCIM software deployed on-site (on-premises) will coexist with DMaaS. Operators should carefully analyze how the two approaches compare and interoperate.

• Deploying a DCIM system is a long-term commitment. Give careful consideration to the type of DCIM product (or products) selected, including the numerous feature and functionality options, as well as ongoing product support from the DCIM vendor. See our companion report for specifics.

This report, the first in a two-part series, may help organizations choose and deploy DCIM successfully from the outset. Its primary goal is to arm organizations with information about DCIM software and related cloud and AI (artificial intelligence) services that will meet the needs of their particular data center(s). Our companion report, **Data center management software: Critical procurement considerations**, details specific questions to ask DCIM vendors so important procurement considerations are not overlooked.

Introduction

DCIM is an important class of software that, despite many false starts, is now regarded as essential for running modern, flexible and efficient data centers. DCIM is finally becoming a mainstream technology. In Uptime Institute's 2019 global industry survey, 42% of data center designers, consultants and suppliers said most of their customers are now deploying DCIM.

Whether deployed as a cloud service (DMaaS) or a full suite of software spanning multiple, large data centers, DCIM holds the same promise: managers and customers achieve greater control of their infrastructure, greater visibility, more efficiency, improved responsiveness and, in theory, better availability.

DCIM has also proved notoriously difficult to select and deploy and is, at scale, expensive. Many managers have abandoned projects, and others have made damaging mistakes in selection and deployment. This has made operators cautious and has slowed adoption. DCIM

was, for a long time, surrounded with an aura of skepticism, despite its steadily improving functionality, usability and stability.

Even so, there are signs that even those who were initially unhappy are still willing to re-invest. The modern data center can no more function without centralized information management and some automation than can an aircraft, a large corporation, or a power station. It has become not a matter of "if," but of how, and how much.

As shown in Figure 1, most DCIM users we surveyed had successful implementations (74%), but thorough preparation is key, including accurately scoping requirements (66%) and ensuring adequate staffing (61%). Additionally, most said that the software met their expectations, including vendor expectations (65%).

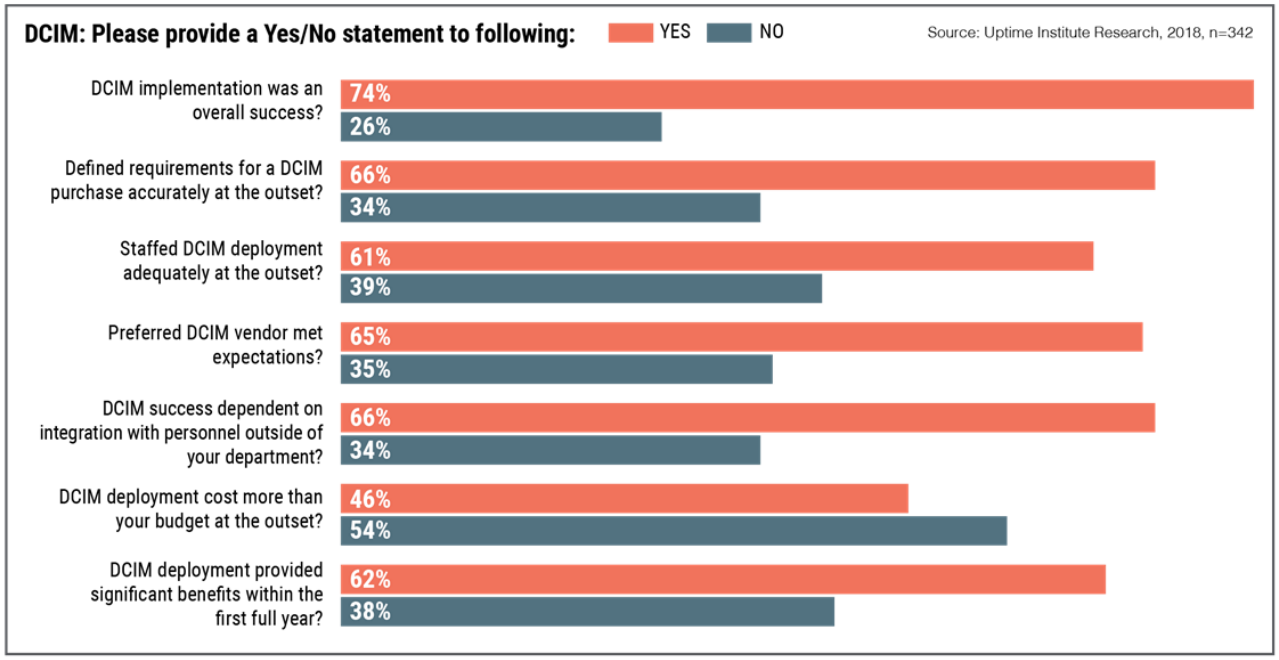

Figure 1. **For many, DCIM delivers on most but not all expectations**

Of the 26% of survey respondents who had an unsuccessful deployment, one-third said they had no current plans to pursue the software. The remaining two-thirds are working on secondary DCIM implementation options.

Budget overruns are common. A small majority of respondents said their DCIM deployment cost more than their budget at the outset. Implementing DCIM is usually a major undertaking. Deployment costs for commercial, out-of-the-box DCIM is typically similar to, if not greater, than the initial purchase price of the software (for more on actual prices, contact Uptime Institute Intelligence). Large DCIM implementations typically require configuration, integration and (if

control features are deployed) calibration, which can add significantly to the cost. Because of the work involved in getting DCIM software up and running, it can be difficult to switch from one vendor's DCIM system to another. Choose well at the outset.

Many operators are now investing in their second or even third DCIM system. Given that migrations are never easy and are often expensive, anyone buying today will expect their chosen configuration to last as long as the data center, and ideally beyond (DCIM systems can be used as the basis for successful migration, both into new enterprise data centers and into colocation facilities). Moreover, many DCIM systems will be used for managing multiple data centers: a system change on this scale is demanding.

The DCIM supplier market has consolidated and matured in recent years. Today there are still many players, but the market is dominated by only a handful, each with strong positioning, viability, strategy, architecture and innovation. They have largely re-architected their products to be cloud-friendly, more scalable, or both. The choice for most buyers, then, is likely to be one of five vendors — and this supplier will likely be a platform partner for a decade or more. Further functions and integrations are also likely be needed; these should be important considerations in the buying decision.

DCIM in context

What is DCIM?

DCIM technology has many functions and components, and it attempts to address numerous technical and business issues. This has made it difficult to define. People use the term "DCIM" to mean many different things. Our definition of DCIM, which has been adopted by some of the largest vendors, is:

A data center infrastructure management system collects and manages information about a data center's assets, resource use and operational status. This information is then distributed, integrated, analyzed and applied in ways that help managers meet business and service-oriented goals and optimize their data center's performance.

This definition is wide, encompassing a variety of products. Typically, DCIM systems support automation, but may not incorporate it; they link to building management systems (BMS) but may not replicate all the functions; and they will often cover some power management functions but may not monitor and manage power directly.

While DCIM software as a service (SaaS) has long been deployed, particularly for small data centers and proof-of-concept trials, the recent introduction of DMaaS brings new big-data and artificial

intelligence (AI) capabilities to DCIM. This is discussed in **New cloud services: DMaaS and AI.**

DCIM components and functions

DCIM systems can collect data, report on trends, analyze information, and assist with planning and forecasting. They can also alert managers when problems arise or trigger human (or automated) corrective actions. Figure 2 illustrates the two foundational components of a DCIM system: unified monitoring; and asset, change and configuration management. Often referred to as simply "monitoring" and "asset management," these are the core components of DCIM and, when combined, comprise a DCIM suite. In addition, DCIM can also include dynamic cooling optimization, IT power management and control, and/or data center operations management (DCOM). Many (but not all) DCIM systems also include the ability to integrate with non-DCIM data, to varying degrees.

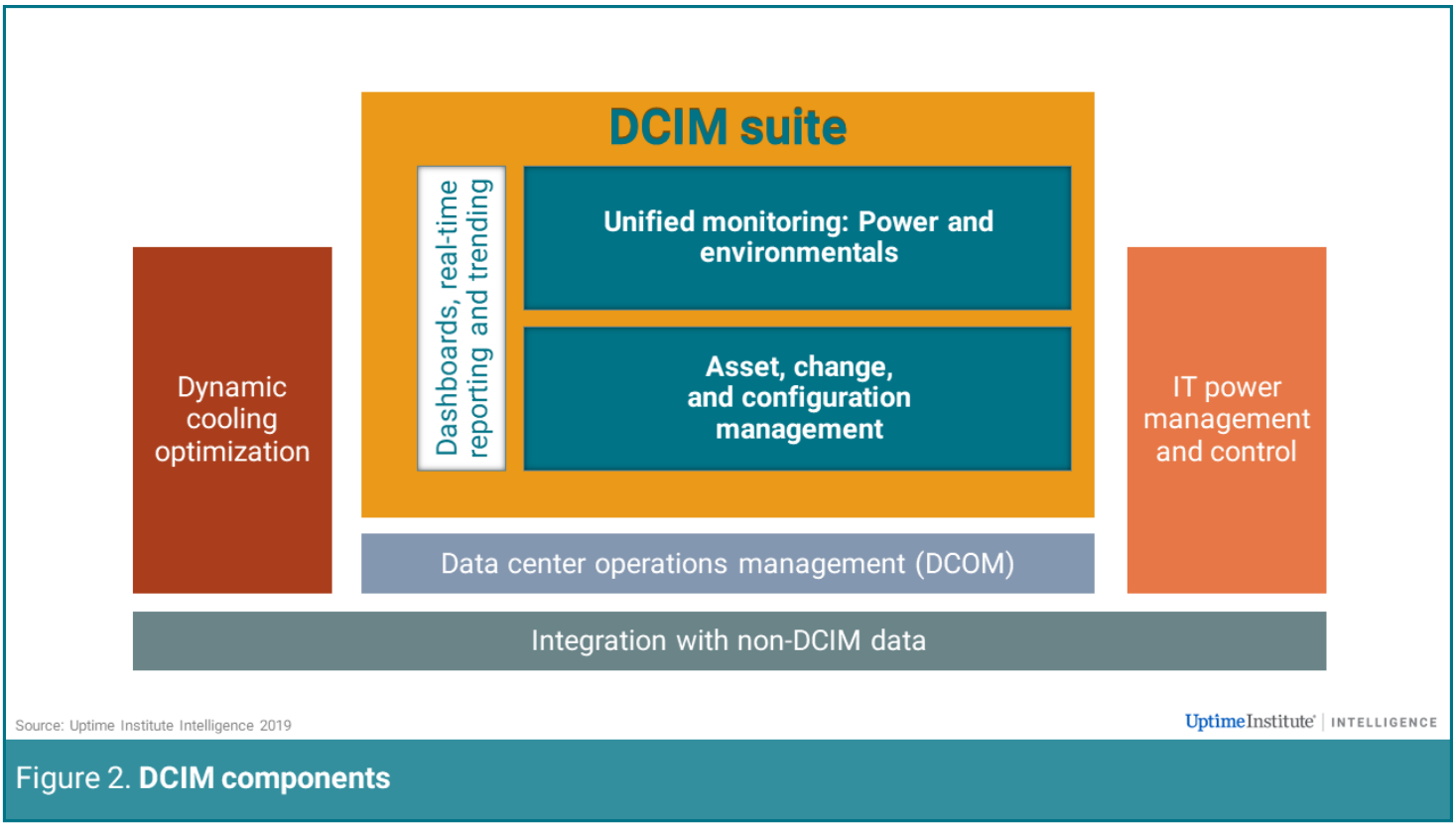

Figure 2. **DCIM components**

Which components do operators typically deploy first? For enterprises, it is either monitoring or asset management, usually one after the other (the order will depend on requirements or goals) although sometimes both at the same time. Colos typically deploy monitoring, first at an operational level (to monitor their data center facility operations), then at a customer level with an end-user portal. (See **Colocation and DCIM**.)

Uptime Institute recommends that all organizations deploy additional features and integrations with non-DCIM data over time, beginning with proof-of-concept trials. It is not uncommon for suppliers to charge for proof-of-concept deployments, which we view as a valuable investment.

Core DCIM Components

Monitoring and asset management can be purchased as separate, stand-alone products or they can be individual modules of a DCIM suite. Whether sold as a stand-alone product or a bundled suite, monitoring and asset management include dashboards, real-time reporting and trending reports. In other words, dashboards and reports are typically not sold separately.

Other DCIM Components

Integration

DCIM already integrates with a range of facility systems, including sensors, smart power distribution units (PDUs) and other metering, and BMSs, among others. In recent years, DCIM has become more tightly integrated with non-facility systems (non-DCIM data), such as:

- IT management systems for workloads, configurations and commissioning.
- Management reporting systems and external-facing systems and data sources, including financial reporting and customer relationship management (CRM).
- Public and private cloud instance monitoring and hybrid cloud management.

Data integration (DCIM with non-DCIM data) is an important function, but it may not be a core component of a DCIM product. Leading DCIM systems provide application programming interfaces (APIs), either bundled into the product or as add-ons. In Uptime Institute's studies, a better return on investment (ROI) on a full DCIM suite may be achieved when managers closely integrate DCIM with other systems and pre-plan the introduction of some end-to-end and possibly automated business processes. This approach requires strong integration of technology and management processes. (See **DCIM as a hub: Integrations**.)

Data center cooling optimization

Data center cooling optimization is sold as separate software or a separate software component. Leading control systems are based on AI/machine-learning "engines" (algorithms) that determine and continually "learn" relationships between variables, such as rack temperature, cooling unit settings, cooling capacity, cooling redundancy, power use and risk of failure.

The leading data center cooling optimization supplier Vigilent (whose software is white-labeled and resold by others) and others are using AI to predict what would happen if an operator took a certain action — for example, shutting off a cooling unit or increasing the set-point temperature. (See **New cloud services: DMaaS and AI**.) AI is also being

leveraged to help improve cooling operations by addressing challenges around maintenance, reliability and unknown risks; capacity management; and energy use, by providing alarming and recommended actions. Newer features include identifying and forecasting areas of unknown risk by predicting rooms or data centers that have a higher likelihood of extreme temperature events. This can include units that are consuming power but not providing full cooling capacity because of an inefficient fan or faulty compressor, for instance.

Some data center cooling optimization can also quantify the cost savings if cooling improvements were made. Some products, which are of particular interest to colos, can forecast the actual cooling capacity required to meet business objectives, such as installing additional customers in a colocation facility, without overprovisioning. They track the real-time operating conditions of cooling equipment and how it varies with different IT load, IT utilization, outside weather conditions and other factors. The measurements (and forecasts) are based on operating performance, as opposed to manufacturers' ratings.

IT power management and control

IT power management and control enables fine-grained monitoring and policy-driven automation of IT equipment power states. These products are typically sold as separate software direct to customers or as software-development toolkits that DCIM vendors or organizations can use to create IT power management modules. Intel, for example, has a product that acts as an interface (and API) for its IT power management capabilities. This product can be integrated into other management platforms or accessed as an online console. It includes features to collect and analyze data — for example, to identify hot and cold areas, detect underutilized servers and visualize power consumption. Users can create power-consumption policies and automate server power states based on those policies.

Data center operations management

DCOM software digitizes conventional day-to-day processes and standard operating procedures, including production scheduling and control, inventory management, quality control and inspection, materials handling, and equipment maintenance policies. Some of these are critical and may have to be performed under the pressure of imminent and sometimes catastrophic failure (such as restarting a cooling unit before overheating occurs). Others are less immediate but equally important, ranging from ensuring safety and environmental compliance to cleaning fuel for the generators. DCOM can also manage other complex processes, such as onboarding clients in colocation and hosting. These are the operational areas that are not well covered by most DCIM systems.

DCOM automates and digitizes the kinds of functions and data often found in computerized maintenance management systems. These include asset management, as well as maintenance scheduling and tracking; management of and access to documentation (contract,

history); staff qualifications; alerting and escalation procedures; description of interdependencies with other equipment; change management workflow; and root-cause analysis for incidents. These step-by-step methods of procedure and standard operating procedures can be pre-scripted and supported by documents (audit trail), pictures and video.

DCOM may in some cases provide some more immediate returns than DCIM and may also be helpful in leveraging an investment in underlying DCIM. However, the software can present some particular challenges: not only is every data center different, but every data center is managed differently and has different — and sometimes frequently changing — processes. For this reason, DCOM needs to be very flexible, allowing operators to easily develop their own (software) scripts and processes. This is easy enough for simple, stand-alone tools but can be complicated when security, multiple classes of operator, and different asset databases become involved.

Key DCIM functionality

The following table summarizes some of the key functions that individual DCIM components can deliver.

Key functions of DCIM components

DCIM component	Key functionality
Unified monitoring: power and environmentals	• Standardizes data formats for power/energy measurement and estimation, including for facility and IT equipment and for data center environmental monitoring (e.g., temperature, humidity, air pressure). • Provides alarming (for power, temperature, maintenance issues, etc.). • Standardizes different polling rates (typically higher rates are used in "premium" facilities). • Provides IT utilization tracking for power estimates or finding underutilized assets (not included in all DCIM systems).
Asset, change and configuration management	• Tracks information about assets: location; operating thresholds; connections; physical attributes (including weight); dependencies and interrelationship with other assets; maintenance history (can optionally be sourced from an IT service management (ITSM) system via application programming interface (API). • Enables (tactical, short-term) capacity planning, forecasting, "what if" scenarios.

Table continues next page

Key functions of DCIM components (continued)

DCIM component	Key functionality
Reporting and analytics	• Analysis and dashboards are typically bundled into a DCIM monitoring and/or DCIM asset management product. • Reports/dashboards are templated for different staff roles and can be customized by users.
Integration with non-DCIM data	• Can include business process management capabilities or can feed into a third-party business process management tool. • ITSM and virtual machine management are the most common integrations for DCIM asset management. • Most DCIM systems include API libraries (sometimes at an additional cost). • Some DCIM systems integrate into event-processing/middleware platforms to enable data exchanges. • Integration should be bi-directional to avoid data-integrity issues across different software systems.
Dynamic cooling optimization	• Polls data once a minute (or more) from carefully placed temperature sensors (wired or wireless). • Controls cooling units, including variable frequency drives, by turning units on and off; adjusting variable frequency drive speeds up or down; and adjusting units' temperature setpoints.
IT power management and control	• Enables responsive, fine-grained monitoring and control of power consumption and thermal profiles by IT equipment, including servers, racks and groups of servers. • Controls processor power consumption by altering voltages and frequency, based on policies.
Data center operations management	• Digitizes conventional day-to-day processes and standard operating procedures, including production scheduling and control, inventory management, quality control and inspection, materials handling, and equipment maintenance policies. • The software should be customizable, enabling operators to easily develop their own (software) scripts and processes.

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Why DCIM?

Data centers are becoming ever more complex, especially when viewed as part of a network of capacity, working with others to support critical business services. It is essential to have accurate and meaningful information about a data center's assets, resource use and operational status, from the lowest level of the facility infrastructure to the middle of the IT stack. This information enables operators to plan, forecast and manage; to make decisions based on real-time data; and to use automated systems with confidence. The list below shows how, among other things, DCIM helps data center operators and managers.

How DCIM helps data center operators and managers

Reduces the risk of data center downtime
Reduces waste and unnecessary overprovisioning of power, cooling, space and IT resources
Provides insight into the overall performance and requirements of the data center
Helps plan for investments and new data center capacity
Optimizes energy consumption
Increases efficiency by automating time-consuming or manual tasks
Can share status updates with customers, management and partners
Facilitates adaptation to technical and business change

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The strongest driver for a DCIM deployment is an availability or capacity crisis. The most common driver is a need to understand and forecast capacity requirements. Often there is a need by management to understand their data center capacity requirements to determine or prioritize potential investment in alternatives, such as colocation, public cloud and managed hosting services.

While DCIM can significantly improve efficiency — in energy consumption and space utilization — this is typically a secondary consideration to these other drivers. Data center consolidation and migration, as well as new data centers builds, also often trigger a DCIM purchase.

Within a DCIM suite (comprising the core components of monitoring and asset management), there are various functions that provide different benefits. The following table details some of those functions, grouped into four high-level benefits: reducing risk; increasing agility; improving capacity management and forecasting; and meeting compliance and corporate social responsibility requirements and/or goals. Note that some functions listed also require integration with non-DCIM data (as indicated).

Benefits of DCIM functions

DCIM functions for reduced risk

- Constant operational status.
- Fault detection closer to the IT load (rack, server and/or motherboard-level DCIM monitoring can, for example, detect anomalies before the problem is reported via a cooling unit alarm).
- Determine/visualize power paths, network connections and asset dependencies.
- Map IT workloads to physical data center assets, such as servers, power equipment, etc. (by integrating DCIM with IT service management data).
- Root-cause analysis of issues and anomalies.
- Alarm rationalization.
- Failover simulation.
- Real-time visibility of redundancy.
- Automated, traceable work orders.

DCIM functions for increased agility

- Asset management: perform on-demand asset audits within seconds/minutes.
- Analyze integrated monitoring and asset management data: understand the performance of a data center beyond just power usage effectiveness (with business and other key performance indicators [KPIs]).
- Map workloads to assets (requires integrated IT data):
  - Achieve end-to-end visibility to better match IT demand with data center resource supply.
  - Calculate the true cost of IT service and support server refresh decisions.
  - Automate workload placement or moves.
  - Carry out optimal workload placement, according to specific requirements.

DCIM functions for capacity planning and forecasting

- Visualize capacity: eliminate stranded capacity, release unused capacity and/or avoid overprovisioning space, power, cooling and cabling.
- "What if" scenario planning (e.g., What if this asset or workload is moved, added or changed?).
- Map workloads to assets (by integrating DCIM with IT and virtual machine management data): ensure data center resource utilization and availability.
- Identify underutilized servers, including "zombies": investigate for asset consolidation and decommissioning.

Table continues next page

Benefits of DCIM functions (continued)

DCIM functions for compliance and corporate social responsibility

- Asset audits: compliance can be monitored for security and other regulatory standards (ongoing and on-demand).
- Asset integrity monitoring: prevent unauthorized physical devices being added to restricted areas.
- Environmental KPIs: consolidate environmental data for each phase of the data center lifecycle. Assess the environmental footprint of IT hosted in the data center with specific KPIs, such as:
  - Infrastructure efficiency, including power usage effectiveness, carbon usage effectiveness and water usage effectiveness.
  - Lifecycle analysis KPIs, such as greenhouse gas emissions, water consumption, energy consumption and resource depletion.
- These KPIs can be dedicated to each level of service within specific functional units, such as:
  - Data center infrastructure.
  - IT equipment.
  - Digital services.

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DCIM key performance indicators

Role-based DCIM dashboards are important to ensure DCIM is broadly useful across an organization. Choose DCIM that enables customizable dashboards to be readily created (without the need for software coding skills), or that provides customizable templates for different roles. Customization includes the ability to create bespoke key performance indicators (KPIs). Below are examples of KPIs based on business benefits for different types of role-based DCIM dashboards.

DCIM dashboard for the C-suite

AGILITY

Ability to understand and compare the performance of different data centers by

- Location
- Utilization
- X (specific business parameter)

REDUCED RISK

Data center "health" scores calculated by risk factors and actual unforeseen incidents

COMPLIANCE AND CORPORATE SOCIAL RESPONSIBILITY

Audits and compliance checks

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DCIM dashboard for IT decision-makers

CAPACITY PLANNING AND FORECASTING; AGILITY

- End-to-end costing, such as
  - Server cost per hour: minimum, maximum, average
  - Cost per virtual machine
  - Number of virtual machines per IT device
- IT asset utilization
- IT asset efficiency

REDUCED RISK

- Vulnerability level for IT failures for
  - Individual IT assets
  - Groups of IT assets
- Time to recovery
- Number of incidents, including by severity

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DCIM dashboard for data center operations

CAPACITY PLANNING AND FORECASTING

- Utilization of power, space, cooling and connectivity
- For power; space; cooling and/or connectivity ports per device/rack/row/room/data center/data center portfolio/region
  - Capacity: actual utilization; reserve capacity; "time to zero" (i.e., the point at which capacity is full)
  - Stranded capacity
  - Maximum, minimum, average, trending over time
- For IT and data center assets (per device type, model or other grouping)
  - Actual power utilization/reserve
  - Inventory deployed versus reserve
  - Weight
  - Warranty and/or service status
- Asset interdependencies

REDUCED RISK

Status/health of

- Equipment
- Zones within a data center
- Data center portfolio

COMPLIANCE AND CORPORATE SOCIAL RESPONSIBILITY

- Power usage effectiveness/global power usage effectiveness/percentage of power usage effectiveness target
- Regulatory compliance status for IT and data center assets for individual devices by
  - Device types
  - Asset models
  - Other

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DCIM dashboard for business users and units	
CAPACITY PLANNING AND FORECASTING	**REDUCED RISK**
Cost and efficiency of IT service IT capacity utilization Available data center capacity	Vulnerability level for IT failures (redundancy levels)

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Challenges

There are many challenges of deploying DCIM. Figure 3 shows those most commonly reported.

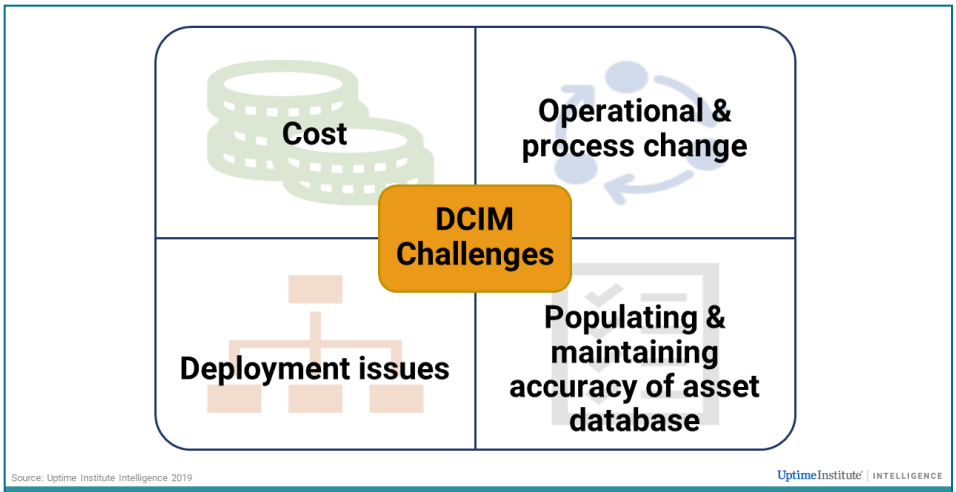

Figure 3. **DCIM challenges**

Cost is typically an issue; not just the cost of the software but also the cost to deploy it. As we often hear, and as our survey data shows (refer to Figure 1), it is common to spend more on services for integrations than expected (common add-on charges include integrations, report creation, customization, etc.).

The largest challenge is typically the changes to operational and business processes and workflows that are required to maximize the benefits from DCIM data. DCIM is an enabling technology — DCIM can automate some actions, but mostly DCIM data and analysis are used to support decisions. This means that DCIM is as much a management approach as it is a technology.

Successful deployments require project leadership as well as operational processes, for example, to ensure data is continually being entered into the software in a timely manner. Some DCIM platforms have built-in (optional) operational process templates, particularly around workflows, that can help. DCOM software can assist, as can consulting services available from DCIM suppliers and others, to create the processes and procedures needed to support actions that can arise from DCIM data and analysis.

In addition, organizations often experience issues with the following when deploying DCIM:

- Integrating DCIM with building management systems, computer room air conditioning units, and other equipment (some DCIM suppliers offer asset-component libraries for protocol mapping).
- Scaling across multiple facilities and consolidating data from multiple instances into a centralized repository for portfolio analysis.
- Choosing a format for normalized data.
- Ensuring system accuracy, including making certain that data is entered into the system.
- Dealing with a lack of vendor support.
- Finding that localized language versions of the software are unavailable or inadequate.

Perhaps the most common issue for DCIM asset management is populating the asset database and maintaining its accuracy. In the absence of active radio-frequency identification tracking of IT assets, the accuracy of DCIM asset databases is typically dependent on staff to enter information into the software in a continuous and real-time manner. This can be particularly problematic if third-party asset installation/decommissioning services are employed. Even a small inaccuracy in a DCIM asset database can render related analysis useless.

There can also be unintended consequences for colos deploying DCIM. For example, DCIM metering may cause customers to reduce their power/space use or overprovisioning on their power requirements. After a colo provider introduces a DCIM customer portal, it is not uncommon for colo customers to buy additional power in smaller increments.

Another challenge, closely related to cost, is that, owing to the many variables and intangibles involved, it is impossible to quantify the true value of DCIM. This is true for other business management systems, such as enterprise resource planning.

Some of the most significant benefits from DCIM can be the most difficult to measure. One of the largest benefits is avoiding a potential outage when, for example, a DCIM system alerts an operator to a critical fault — say, a failing uninterruptible power supply. But it can be very difficult to quantify the cost savings of avoiding downtime. Similarly, DCIM can enable more efficient use of resources, such as power, cooling and space, which can delay the need for additional capacity. Organizations can add capacity in a number of ways, including building a new data center and outsourcing some capacity to third-party service providers, which can complicate the savings picture. Yet power savings, while relatively small in comparison, can

be readily calculated. The table below exemplifies the paradox of quantifying DCIM benefits.

DCIM Benefits	Financial impact	Challenge to quantify
Utility bill savings	Small/medium	Easy
Deferred data center capex	Large	Hard
Reduced chance of outage	Very large	Very hard

Source: Uptime Institute Intelligence 2019

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There are other challenges when calculating a DCIM ROI. Different business units and different roles will be most concerned with the benefits (and costs) that are directly relevant to them. For example, the finance department might value the internal controls that DCIM can enable (such as regulatory compliance), while the IT department will be focused on efficient server refreshes. The total cost of ownership of a DCIM system and the return it delivers will vary among teams. Taking a multi-disciplinary approach to calculating ROI for DCIM is key.

For many organizations, the less easily measured but strategic business benefits of DCIM are reason enough to deploy the software, and a cost-benefits analysis is not required.

We have conducted in-depth studies into DCIM's value and ROI and found that not all use cases for DCIM — taken in isolation — will deliver an ROI in the short term (one to three years). But when multiple use cases or benefits are exploited, most DCIM users can reasonably expect an ROI within three years of deployment. Expectations for ROI outcomes for DCIM can vary significantly for enterprises versus colos, as shown in Figure 4.

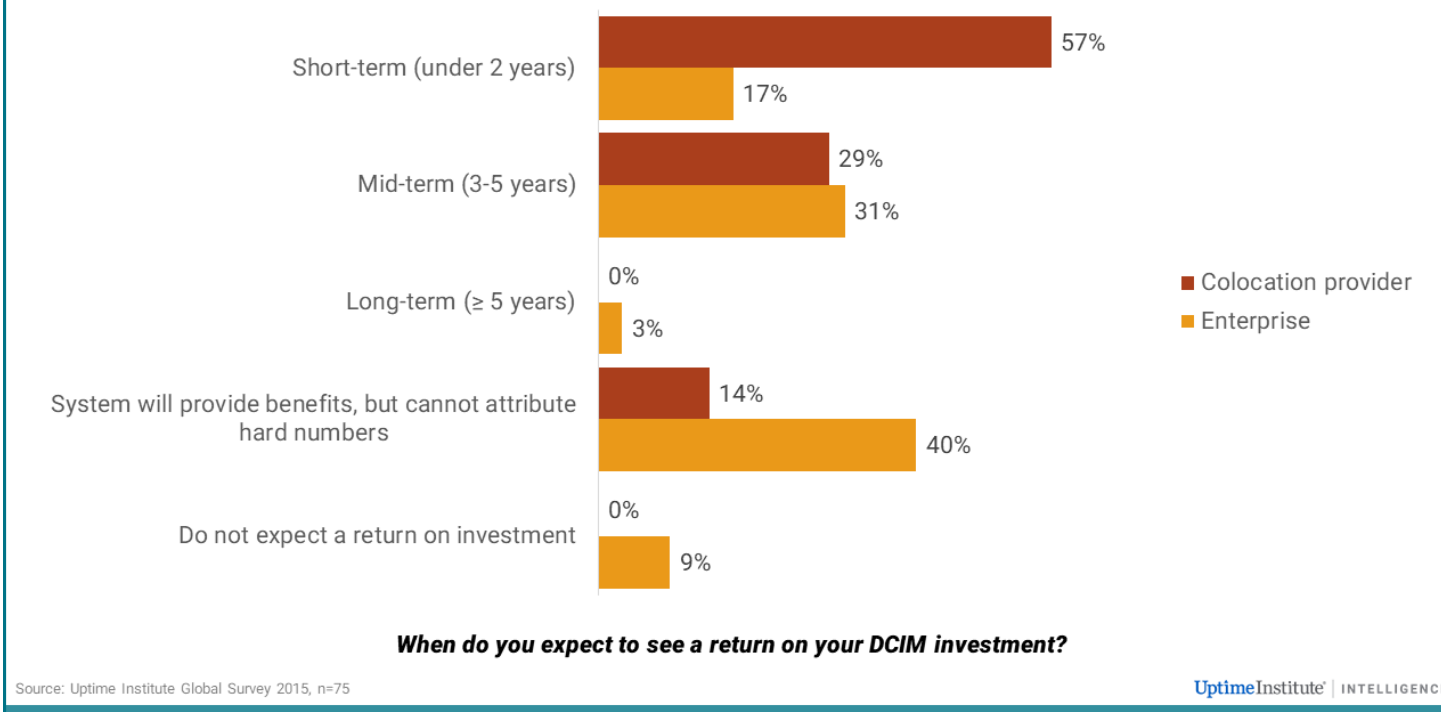

Figure 4. **DCIM return on investment may be easier to achieve for colos than enterprises**

One explanation for the disparity between colos and enterprises, as discussed in **Colocation and DCIM**, is a difference in the types of DCIM features adopted and, in turn, deployment complexity and cost.

DCIM maturity model

Uptime Intelligence has long argued that, although it may take many years, the long-term trend is toward a high level of automation in data centers, covering many functions that managers and operators would not currently trust to machines or outside programmers. Recent advances in AI have made this seem more likely. Our data center management maturity model (below) shows this long-term evolution. Today, most DCIM deployments fall into Level 2 or Level 3 of our maturity model. The advent of AI-driven, cloud-based DMaaS will, we believe, drive greater efficiencies and, when deployed in combination with on-premises DCIM, enable more data centers to reach Level 4 (and, over time, Level 5).

Data center management maturity model

LEVEL	DESCRIPTION	OPERATING EFFICIENCY	SOFTWARE
Level 5: Self-optimizing, autonomic	AI-driven integrated management software adjusts data center behavior and makes best use of resources according to goals, rules and service requirements throughout its lifecycle.	HIGH	AI-driven, integrated DCIM with automation
Level 4: Optimizing	Physical and virtual IT and data center subsystems integrated; models used for prediction, service management and multiple views, optimizing in near real time. AI is applied to DCIM-based data lakes for advanced analytics.	MEDIUM	AI-driven, integrated DCIM
Level 3: Proactive	Physical data center equipment characteristics, location and operational status is tracked. Energy and environmental data is used to reduce risks and waste.	MEDIUM	Integrated DCIM
Level 2: Reactive	Software installed to monitor environmentals and equipment power use. Able to adjust basic controls (e.g., cooling) to demand.	LOW	DCIM monitoring
Level 1: Basic	No integration of infrastructure data. Basic monitoring supplied with equipment. Relies on BMS data. Simple alarming, error messaging.	LOW	Ad hoc

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Although procurement decisions today may be only minimally affected by current automation needs, a later move toward greater automation should be considered, especially in terms of vendor choice/lock-in and integration. Integration capabilities, as well as the use and integration of DMaaS and the application of AI, are important factors in both the overall strategic decision to deploy DCIM and the choice of a particular supplier/platform.

DCIM as a hub: Integrations

There is a growing recognition that achieving a good ROI from automation and management software will be easier if important management and reporting systems are linked together, leveraging both visibility and existing processes and functions. DCIM is increasingly playing an enabling role as part of a software-defined operational and services strategy for enterprises and colos. By integrating DCIM, organizations are able to tightly couple demand for the virtualized and logical resources at the top layer of a digital stack (IT and networking) with the supply of underlying physical data center resources (power, cooling and space). Doing so enables cost efficiencies and reduces the risk of service interruptions due to underprovisioning.

By integrating data from DCIM with a range of other management systems, organizations are able to make more informed decisions around best-execution venues (internally and for colo customers), taking into account the cost and availability of IT, connectivity and data center resources. Ultimately, by integrating DCIM with systems up the IT stack, organizations can more effectively plan for data center capacity investments. Using DCIM to optimize utilization of existing facilities could also mean enterprises and colos may need fewer or smaller facilities in the future.

While integration is typically a “phase two” strategy (i.e., following the full deployment of a DCIM suite), integration goals should be factored in when choosing a DCIM system.

Process and data integrations are important functions and will likely become more so as the world becomes more automated. They are, however, approached by vendors in different ways. Options include ad hoc one-to-one integrations (which can be services-heavy and require constant management); the use of a middleware platform, in a data hub-and-configuration architecture (effective, and introduces a management and process layer, but can be more expensive initially); or the use of a toolset and integration library from a DCIM or IT service management (ITSM) provider (very useful, but depends on the ability of the supplier to manage large numbers of integrations). In practice, it may be necessary to use a mix of these approaches.

In more complex and integrated data centers — those aspiring toward higher levels of automation — DCIM software will play an important integrating role, linking facility management tools and systems to IT and business management systems (see Figure 5). DCIM systems can pull (and push) different types of data from (and to) a number of these other systems.

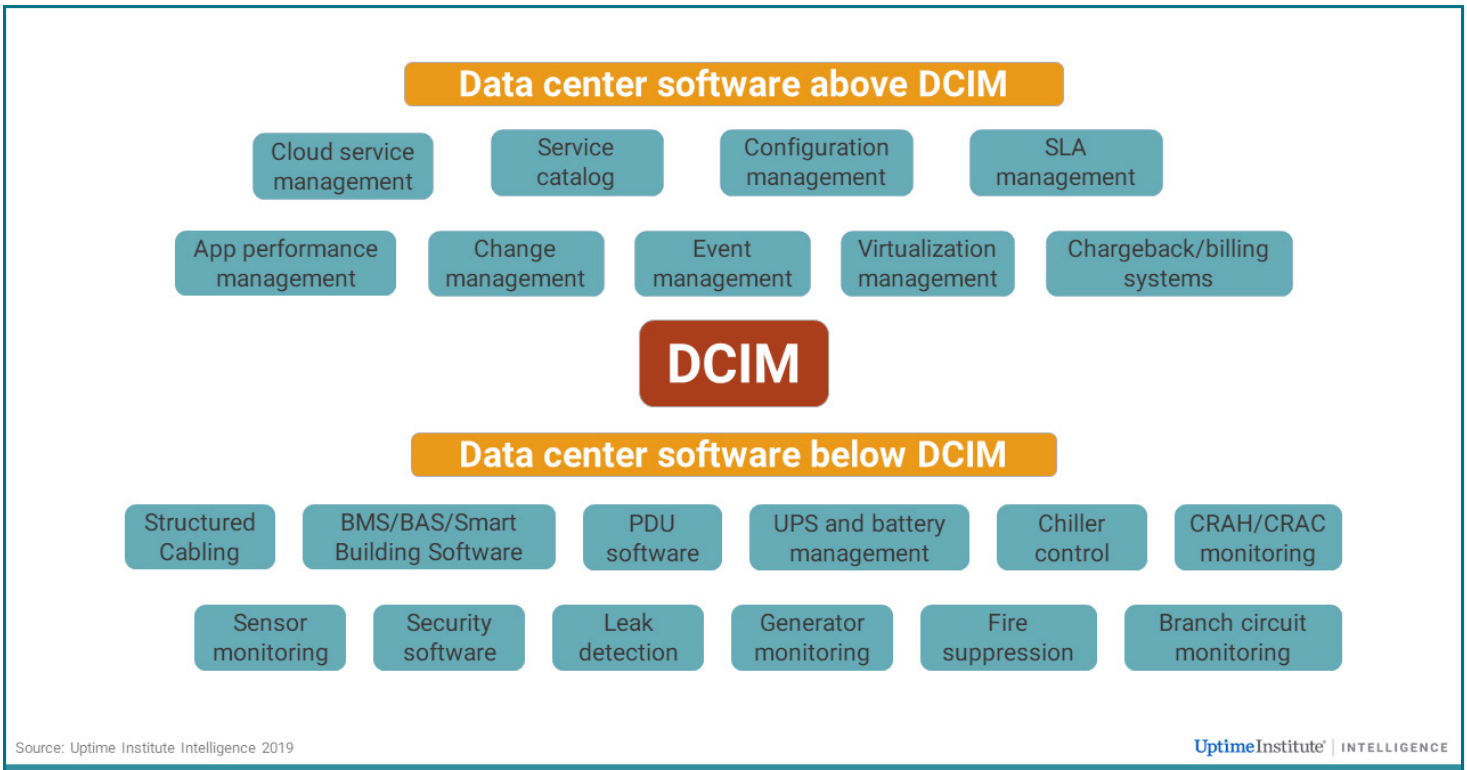

Figure 5. **Where DCIM sits in the data center**

Integration capabilities may, or may not, be a core component of a DCIM product. More advanced integrations, such as linking diverse databases and process together, will likely require external tools and services. Leading DCIM systems may provide APIs, but they can be costly extras. And interfaces alone may not be enough to create end-to-end automated processes — we advise a detailed assessment.

There are many possible integrations with DCIM. Figure 6 is a simplified view of some of the data sources from systems spanning the IT stack that organizations with DCIM can (or aspire to) integrate with.

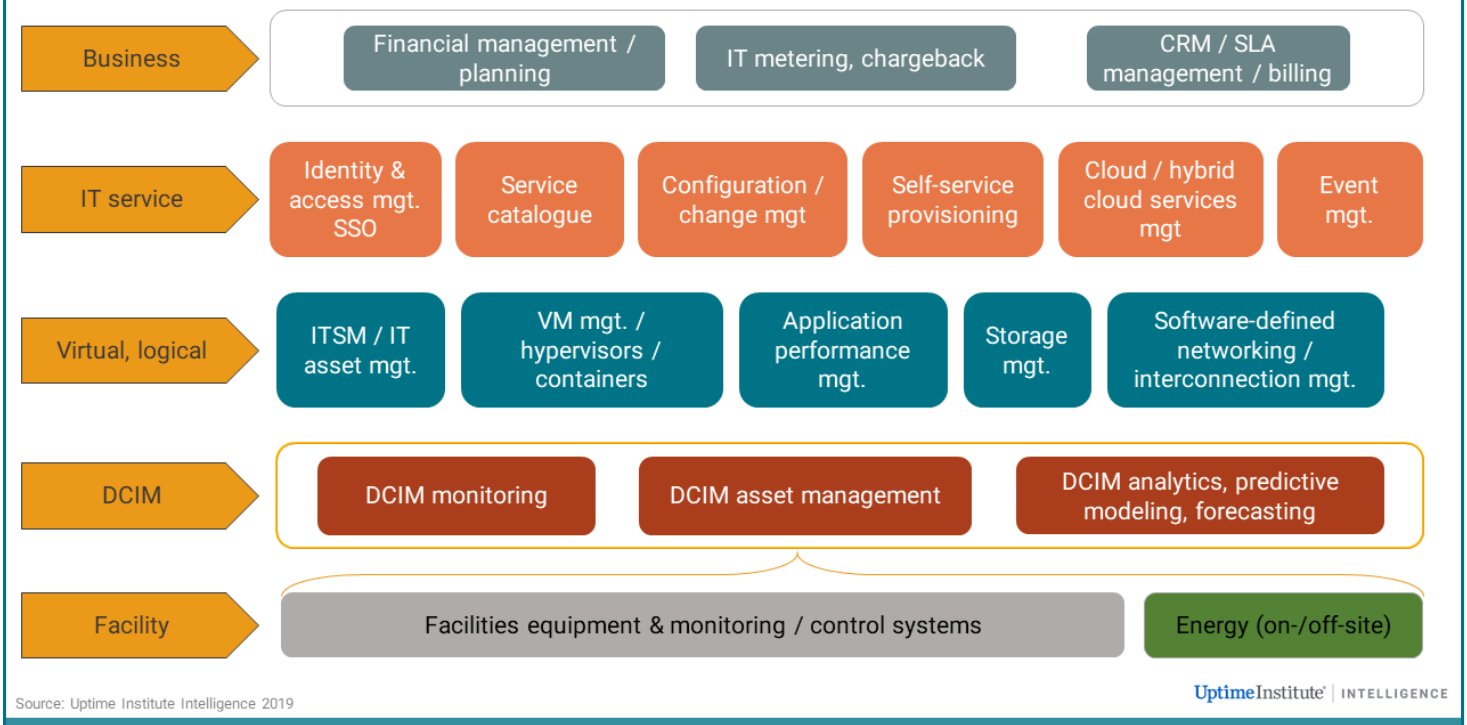

Figure 6. **Simplified view of some data sources for DCIM integration**

The following are examples of processes that will likely require multisystem integration:

Monitoring capacity across clouds and on-premises data centers (enterprise and colocation)

• Possible software integrations: Cloud service APIs for cloud monitoring, virtual machine (VM) management, DCIM suite, ITSM.

Adjusting or moving workloads according to availability or energy costs/reliability, or to reduce risk during maintenance

• Possible software integrations: DCIM suite, VM management, cloud service APIs for cloud monitoring and hybrid cloud management, ITSM/IT asset management, maintenance management, service catalogue.

Colocation portal providing key data to customers

• Possible software integrations: service level agreement (SLA) management, CRM, DCIM, ITSM/IT asset management, interconnection management.

Data center service-based costing (real-time, chargeback)

• Possible software integrations: CRM, service management, financial management, DCIM power monitoring, VM/IT resource use. Also useful for carbon/energy tracking/reporting.

Cloud-based resiliency/disaster recovery

• Possible software integrations: DCIM, IT monitoring, workload management, capacity management, storage management, VM management, cloud service APIs for cloud monitoring and hybrid cloud management, disaster recovery/backup.

Unified incident/problem management

• Possible software integrations: DCIM, ITSM, maintenance management, workorder system.

Identifying and eliminating underused/comatose servers

• Possible software integrations: DCIM monitoring, ITSM utilization, IT asset/capacity management, VM management.

End-to-end financial planning

• Possible software integrations: Financial planning, DCIM capacity planning.

Automated services (provisioning, colocation customer onboarding, audits, etc.)

• Possible software integrations: DCIM monitoring, CRM, financial management/planning, IT asset management.

DCIM: Facilities and IT cooperation

A DCIM system, however well deployed, will not solve all management problems within a data center. Effective collaboration between a data center's facilities and IT managers is critical. Collaboration will become ever more important as IT and electrical/mechanical systems become more tightly linked and as DCIM systems advance beyond data center facility infrastructure to both physical and virtual IT assets.

Before buying DCIM software, managers should establish a working relationship between the data center's facilities and IT departments (or for colos, with their largest customers responsible for IT management). Historically, these two teams operate independently in many areas. They may have different priorities, technical skills, vocabulary, budgets, metrics and targets. Even if the two groups work together, it is common for neither group to fully understand all

the ways their actions impact the other. In its more advanced forms, DCIM can be regarded as (potentially) a cross-over middleware product through which IT and facilities departments may share critical information and merge some key processes.

Close IT-facilities collaboration will have many benefits, including:

- Better understanding of how fluctuations in IT load affect power and cooling requirements.
- Better sharing of details for capacity planning and optimizing resource use.
- Shared understanding of the true cost of resources (space, power, cooling, etc.).
- Fixing "split incentives" — for example, a situation in which IT decision-makers have no reason to prioritize efficiency because all energy-related costs are borne by the facilities group.

(Dealing with split incentives is more complex in colocation facilities. Billing processes may need to be redesigned so that the facility provider can show and possibly bill for the return from any investments, rather than merely passing on energy savings to its IT clients.)

In enterprise data centers, there is also the issue of which department's budget should pay for DCIM: IT or facilities? In most IT organizations, systems management spending is significant and high. Meanwhile, software budgets for (facilities-side) data center management are often limited. Component-level DCIM systems, such as energy sensors and monitoring software, may be comfortably financed out of the facilities operational budgets, but when data centers seek to scale monitoring systems across multiple racks, multiple rows, or multiple data centers, the cost begins to escalate and can soon reach hundreds of thousands of dollars.

While most DCIM is primarily targeted at facilities, in some cases, it can be unclear whether an organization's IT or facilities department should take the lead in deciding whether to pursue DCIM. (A DCIM vendor's sales team may well end up having to convince two departments at once.) And after purchasing, it may be unclear which team should lead implementation and be responsible for maintenance. Software development and ongoing maintenance is usually a significant cost that requires specialist skills from the IT side. Clearly, work is required by both teams.

Colocation and edge

Colocation and DCIM

Colocation companies — which account for about 20% of constructed capacity (source: 451 Research), a significant portion of the overall data center market — have specific requirements that DCIM can help meet. In particular, a growing number of colos are offering DCIM monitoring data to their customers. This introduces filtering, controls, security and data management requirements, as well as the complication of new functions enterprises don't require. Some colos charge customers a fee for DCIM asset management and for more advanced services, such as analytics and forecasting.

Most colos today are deploying basic DCIM monitoring to provide customers, via secure online portals, visibility about their individual power usage; environmental information, such as temperature and humidity; and equipment connections. Greater visibility will help tenants make more informed decisions regarding their capacity utilization and future requirements. Increasingly, customers are expecting a DCIM-driven customer portal as part of their standard colo service, with basic features available at no or low cost.

Some colos offer their customers (or plan to offer) more advanced features (see list below), typically for an additional fee. However, many smaller customers will be slow or hesitant to adopt features beyond basic monitoring. Large customers may have standardized, or are planning to standardize, on their homegrown DCIM or on commercial products they have already deployed elsewhere — basic monitoring data from a colo portal will be another feed into these existing systems. For these reasons, colos should consider DCIM-based customer portals a customer enhancement (and, increasingly, a competitive necessity), not a new revenue stream, at least in the short- to medium-term future.

Some DCIM suppliers sell "colo" versions of their software suites. These are identical to original "enterprise" versions — that is, they include DCIM monitoring and asset management — but with add-on tools, such as multi-tenancy/partitioned dashboards. Colocation DCIM can include APIs to integrate DCIM data into billing, workflow and customer-management systems, for showback and consumption-based billing, and to show SLA compliance. There are DCIM portals for colos to manage their clients, and there are portals for the clients themselves.

Colos require DCIM systems to have a "back-end" administrative side, which the operator can use for customer management, as well as a customer-facing side. If this customer view is primarily information-only, it will often be delivered via a portal that for security reasons may require a secondary, secure copy created from data feeds from the main DCIM system. A DCIM system for a colo, then, can be more complex.

The availability of DCIM tools for colos does not necessarily mean that full DCIM suites cannot already provide the functions needed for colocation — it is just that suppliers have carried out the extra work to optimize and customize their tools. Some colos use enterprise versions of DCIM to manage their internal operations and use rule-based logic in the software to share certain data with customers via dashboards.

Large colos, including Equinix, NTT and others, use DCIM to incorporate and analyze a wide range of data, from the availability and performance of cross-connects to dynamic, end-to-end costing for data center capacity and various services. In time, we expect the largest colos will build, buy and/or partner to create a wide-reaching platform that connects physical data center resources (via DCIM) with all areas of their businesses, including financial and capacity planning; interconnection management; and services and customer management.

These integrations could, for example, show if there is a conflict in resource allocation, which can help avoid reselling and can speed up the onboarding of new customers. When DCIM data is shared with sales teams, they can reserve customer space (and power and cooling resources) at the point of sale via mobile device access. In addition, colos can calculate cost/revenue per customer (offered by certain DCIM suites only).

However, colos often have very specific business processes for allocating capacity and implementing moves and changes, and this has proved challenging to colos trying to implement DCIM. Most colos keep information about their internal capacity and operations confidential, to protect their profit margins, and to maintain their ability to effectively negotiate customer pricing. Also, if a colo facility has inefficient cooling, for example, and the DCIM systems show it, customers could notice and ask for upgrades.

Over time, we believe colos will expand their DCIM-based offerings to customers, via a customer portal (with sign-on control and zoned management) to help build stronger customer relationships. The following table shows likely customer-facing features and integrations.

Customer-facing DCIM features and integrations

Basic

- Environmental and power monitoring and trending.
- Alerts and alarms in real-time, including via email, text and/or phone notifications.

Advanced

- IT asset change and configuration management.
- IT asset lifecycle management, including maintenance records.
- Cable, connectivity and port management.
- Predictive "what if" scenario planning.
- Capacity forecasting (space, power, cooling).
- Integration with IT service management systems (e.g., Remedy, ServiceNow).
- Integration with virtual machine/container management software.
- Integration with cloud (including public, private and hybrid cloud) management platforms.
- Service level agreement reporting and management, including power consumption (kWh) suitable for billing.
- Integration with other, proprietary management systems.
- Real-time diagnostics for IT (when customer data is available/shared with the provider).
- Analytics to support best-execution venue decisions, including artificial intelligence-driven recommendations and models.

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Edge, micro data centers and DCIM

Data center workloads are spreading out beyond large data centers, with many large enterprises (telecommunication providers, retailers and healthcare providers in particular) expecting to deploy micro data centers at the edge, near where the data is generated or consumed. Many micro data centers will operate as remote "lights-out" facilities and will need to be managed by lightweight DCIM tools that enable the following, among other things:

- Good remote (wide area network) support.
- Redundancy in case of remote failure.
- Adequate security.
- Out-of-band management (remote functionality for when IT hardware fails).
- Basic features, such as real-time monitoring of power and environmental conditions (e.g., humidity, temperature, air pressure).

Increasingly, many of these capabilities will be prepackaged into prefabricated micro data centers. Centralized management of many DCIM installations will also be required. This may be possible via a role-based dashboard in which data from multiple installations is analyzed and reported on. If a centralized dashboard feature is not available, organizations will typically designate a single DCIM installation into which data from multiple DCIM instances can be fed, analyzed and reported on (as a centralized, single "source of truth").

New cloud services: DMaaS and AI

In late 2016, some DCIM suppliers began offering data center management as a service: big-data driven cloud services that deliver customized analysis via a wide area network and are paid for on a recurring, as-you-go basis.

DMaaS is in the process of revolutionizing and disrupting the DCIM market, and all operators should carefully analyze how the two approaches — on-site DCIM and cloud-based DMaaS — compare and interoperate. DMaaS can be much cheaper to deploy, but many functions will be delivered as individual services; it will not be a full, configurable on-site (on-premises) DCIM suite. Yet DMaaS is better positioned to deliver data-driven AI than organizations using on-premises DCIM alone can achieve.

DMaaS aggregates and analyzes large sets of anonymized monitored data about equipment and operational environments from different facilities (customers). The data is analyzed using different big-data techniques, including machine learning. Results for individual

DMaas adoption drivers and impediments

Drivers

Risk mitigation - DMaaS promises to monitor data centers, with statistical analysis guiding decisions. This could lead to faster mean time to recovery and more effective capacity provisioning.

Streamline operational processes - Tying analysis to traditional on-premises services, such as equipment repair and maintenance, could auto-trigger functions (e.g., service work orders) and automate recommended actions based on environmental and external data.

Better management of digital assets - Integrating DMaaS with other systems could facilitate business decision-making. For example, combining DMaaS with information from a transactive (demand-response) energy service and an on-demand public cloud service could enable a private data center to dynamically manage its on-premises capacity and its public cloud usage.

Impediments

Data security concerns - Some operators will resist sending data (even encrypted) about their critical infrastructure outside their private firewall. Regulations may be a barrier to DMaaS adoption for some.

Increased risk - Outsourcing the maintenance process and other procedural controls of critical equipment could create an additional layer of risk, either real or perceived.

Network limits - Latency issues and other problems could limit real-time intelligence and automation features.

customers may be tailored to their specific data center and delivered via dashboard (available online and/or in a mobile application), as well as in email, text and phone notifications.

Some of the limitations or impediments to DMaaS will require that many mission-critical data centers need to also deploy DCIM software on-premises, even those that have also adopted DMaaS. For example, closed-loop and other automation systems enabled by DCIM data will require fast (local) networking processing, which cannot be assured with DMaaS.

Resiliency issues may also be a concern. Once a customer's data goes off-site to a third-party data center, the data is vulnerable to any potential problems associated with that data center, beyond just problems in the local network. Some operators will want complete control over the entire monitoring system and will choose to deploy DCIM on-premises only (and not also adopt DMaaS).

There may also be lock-in concerns around ownership of data with DMaaS and other data center AI services. We are unaware of any commercial product or service that does not enable customers to keep their own data should they wish. As such, all providers advertise that their customers own their own data. In reality, customers are co-owners of their data. The supplier typically also keeps a copy of the data, even long after the customer stops using the service (when the paid service stops, the data becomes an anonymous part of a supplier's data lake).

Whether lack of certainty or clarity over data ownership and locality is a risk to data centers is vigorously debated. Some say that if hackers accessed the data, it would be of little use as the data is anonymized and, for example, does not include specific location details. Others say hackers could apply techniques, including AI, to piece together sensitive information. Potential risks associated with data center AI offerings can be grouped as commercial; legal and SLA; technical; interoperability; and "unknown unknowns." (For detailed information on the use of AI on data centers, see our report **Very smart data centers: How artificial intelligence will power operational decisions**.)

All that notwithstanding, it is already clear that many operators, both enterprise and colos, are very interested in and are experimenting with or adopting DMaaS.

DMaaS and AI

DMaaS can include prebuilt machine learning models, which means no historical data or existing DCIM system is required. As new data is fed into a prebuilt model (via the service), the analysis accuracy improves. One AI cloud service, for example, can simulate data center environments, which marketers like to call a "digital twin," by applying a prebuilt model. It can do a basic simulation using as few as two types of data: blueprints of the data center building and of the mechanical systems.

Using a prebuilt model (and visualization tools), the service simulates the current operations of a data center (i.e., its digital twin today) and a simulation of a more efficient data center (i.e., its theoretical digital twin if certain actions were taken). The delta between the two helps identify areas for efficiency improvements or lower risk.

Another area of data center AI is cloud services or SaaS that make use of AI algorithms embedded into data center equipment, such as cooling units. These services are in development and are not yet widely available.

DCIM + DMaaS?

By no means will DMaaS make on-premises DCIM irrelevant. DCIM will still likely be required for very low-latency local monitoring (on-premises), such as for certain critical equipment and automation systems, and for security, data governance and other requirements. In these cases, we believe DMaaS will increasingly coexist with on-premises DCIM.

One significant driver for DMaaS is that it promises to alleviate the challenges often associated with implementing a broad DCIM suite on-premises. DMaaS also offers a quick, low- or no-capex way for customers to gain access to basic features.

While immediate widespread uptake of DMaaS is not assured, we believe the statistical capabilities of DMaaS will drive demand — diverting investment by data center operators in on-premises DCIM platforms to cloud services for many smaller or non-mission-critical data centers. For mission-critical facilities, we believe both DCIM and DMaaS may be widely used as complementary approaches.

What is the best practice? It is still early days. In facilities where DCIM is deployed, DCIM can be a rich source of data for any machine learning approach. An advantage is the historic data stored within DCIM, which can be used to speed up the training and accuracy of machine learning models. The same accuracy can be achieved over a long timeframe, without pre-existing models.

For any data center seeking closed-loop automation or mission-critical alarming, we advise on-premises DCIM installation to avoid potential latency or service interruptions that can arise when relying solely on a wide area network/the internet.

Summary and recommendations

• DCIM is a management approach that needs to be institutionalized. One DCIM tool or many — choose a master system of record for integration and reporting. Integration will be critical, as will business and operational processes, which must be "built into" the software.

• For colos, DCIM should be considered a competitive enhancement to customer service, not a new revenue stream, in the short- to medium-term future.

• Deploy features over time. Enterprises typically deploy either DCIM monitoring or asset management first, followed by the other — the order should be driven by the organization's immediate goals/pain points. Colos deploy DCIM power and/or environmental monitoring/reporting, first at an operational level (internally and at key sites), then at a customer level (end-user portal). At some point, DCIM asset management and other features will be a competitive advantage — colos should choose a product for the long term.

• Proof-of-concept trials are essential. Expect to spend on services. Successful DCIM deployments require dedicated project leadership/ownership on an ongoing basis and significant in-house resources. For enterprises, buy-in from the IT team will be critical.

• DMaaS should be assessed alongside DCIM software, as some DMaaS capabilities may be complementary and/or available for a lower cost — such as DMaaS's artificial intelligence-driven recommendations and equipment predictive maintenance. Many mission-critical data centers are likely to deploy DCIM software on-premises to enable real-time alarming and to support closed-loop and other automation systems, while also utilizing DMaaS for big data-driven insights.

For organizations that require specific guidance in assessing and selecting DCIM software, our companion report, **Data center management software: Critical procurement considerations**, includes dozens of questions to ask DCIM vendors, grouped into core areas of functionality.

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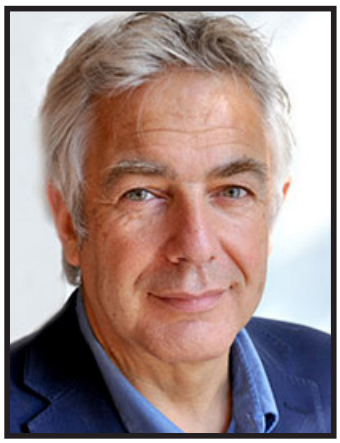

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