مدیریت فناوری‌های دیجیتال در صنعت ساخت

(بر اساس سندی از انجمن مدیریت ساخت آمریکا (CMAA))

ارائه‌دهندگان:

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نریمان درافشان

هانیه طباطبایی

زمستان ۱۴۰۳

قسمت ۱/۲

فصل اول: فناوری‌های دیجیتال در صنعت ساخت

قسمت دوم: داده

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داده

۱. داده
۲. مدیریت داده
۳. تولید داده
۴. پردازش داده
۵. ذخیرهٔ داده
۶. اشتراک‌گذاری و امنیت داده
۷. مرور نقش مدیر ساخت در فرایند مدیریت داده

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۵. ذخیرهٔ داده

Data Storage

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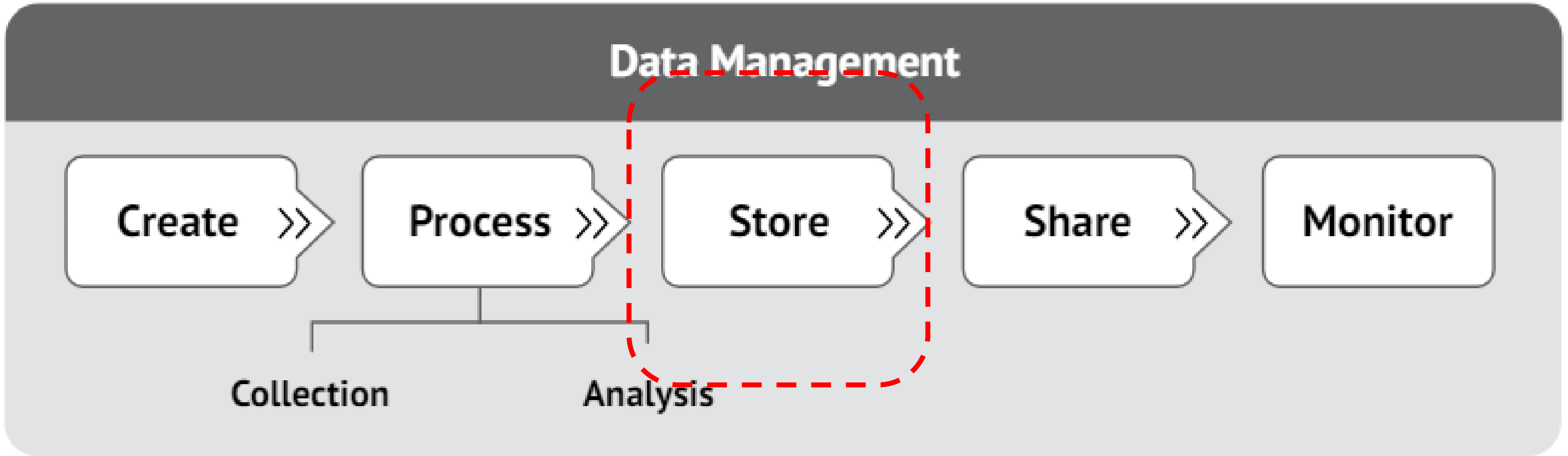
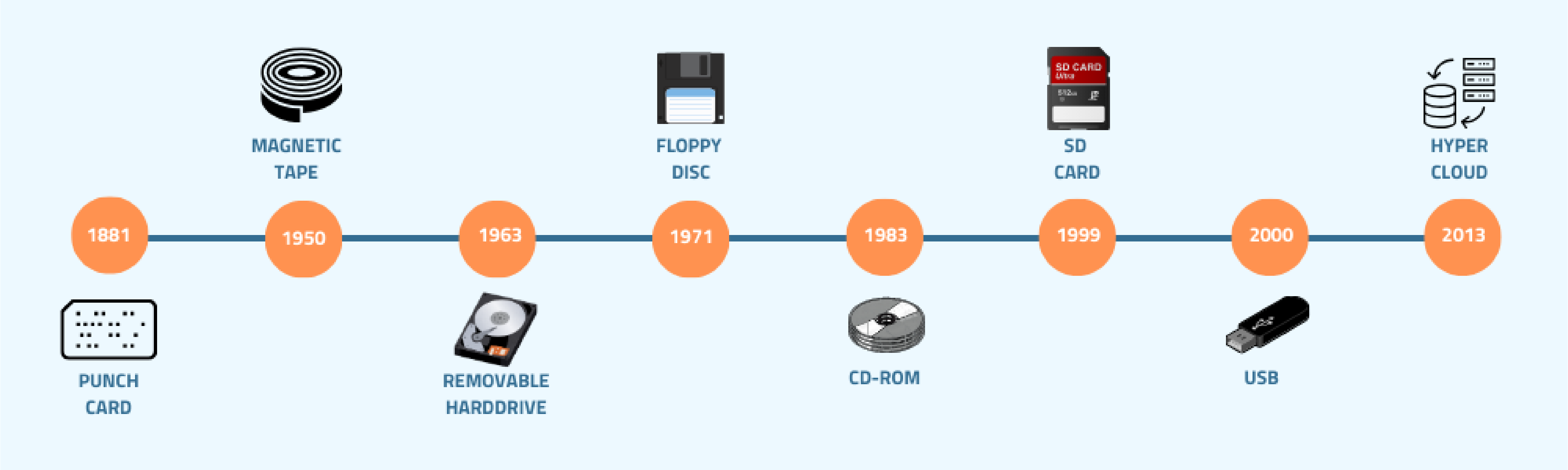
Data Management Flow: Storage



Some Storage Technologies



Data storage

- Data storage refers to **recording information** for later use.
- Data storage frequently **overlaps** with other data management activities.
  - For example, BI tools may access stored data and record their analysis simultaneously.

- Data storage is also **important** at the **end** of a project or program when the team should archive data to **preserve** it for future reference.

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Referring to Data

- The owner, CM, or other stakeholders may need to reference the data for
    1. O&M,
    2. Claims, or
    3. Improve future delivery

From what you've learned in other courses, what we need to ensure that we'll be able to refer to the data at a later date?

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Data storage

- It is **common** to store data and host software on **remote servers** that users can **access entirely** through the **internet**
- What are the advantage and disadvantage of each storage server?

Dedicated Servers

Bare Metal

Virtual Machine

Data Center

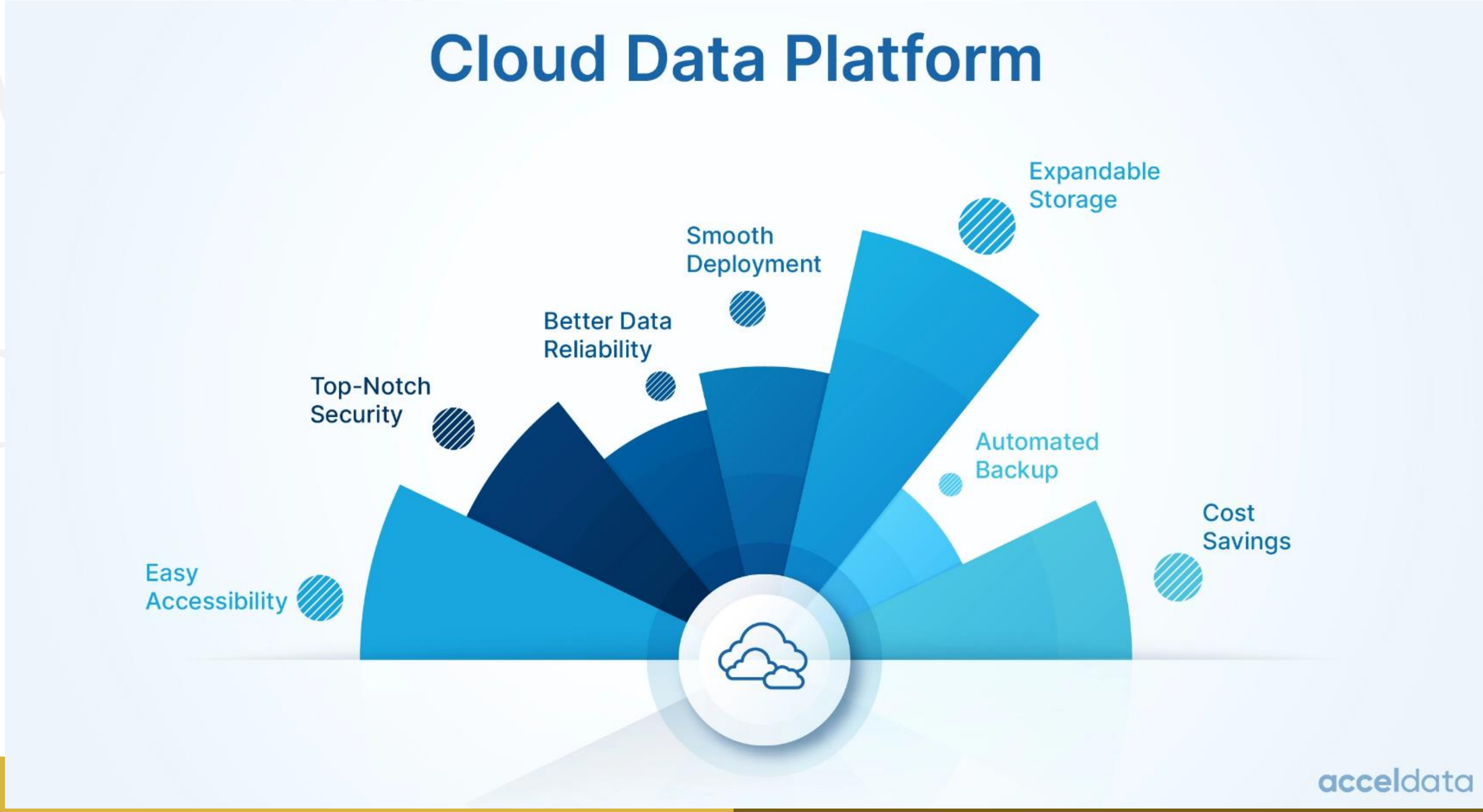
Virtual Private Server

Dedicated Server

Cloud

Cloud

- **Cloud-based data** storage is relatively quick, cheap, and easy to deploy.
- Software and vendors who provide data **storage tools** in the cloud are known as data as a service (DaaS) software/vendors.



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Local Data Storage

- However, some owners may prefer or require local data storage on the team's computers or onsite, **collocated servers**.

- This option may be **appropriate** for
  1. Owners with strict security or regulatory requirements ("cybersecurity");
  2. Owners that already have existing data storage infrastructure.

- DaaS options may also be too expensive for small projects.

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CM and Data Storage

- The CM must realize that there are now **many options** to store data reliably, so the CM must **consult** with and **advise** the owner to find the **best solution.**

- **DaaS/cloud storage** is more efficient but may **not be appropriate** for **certain owners**.

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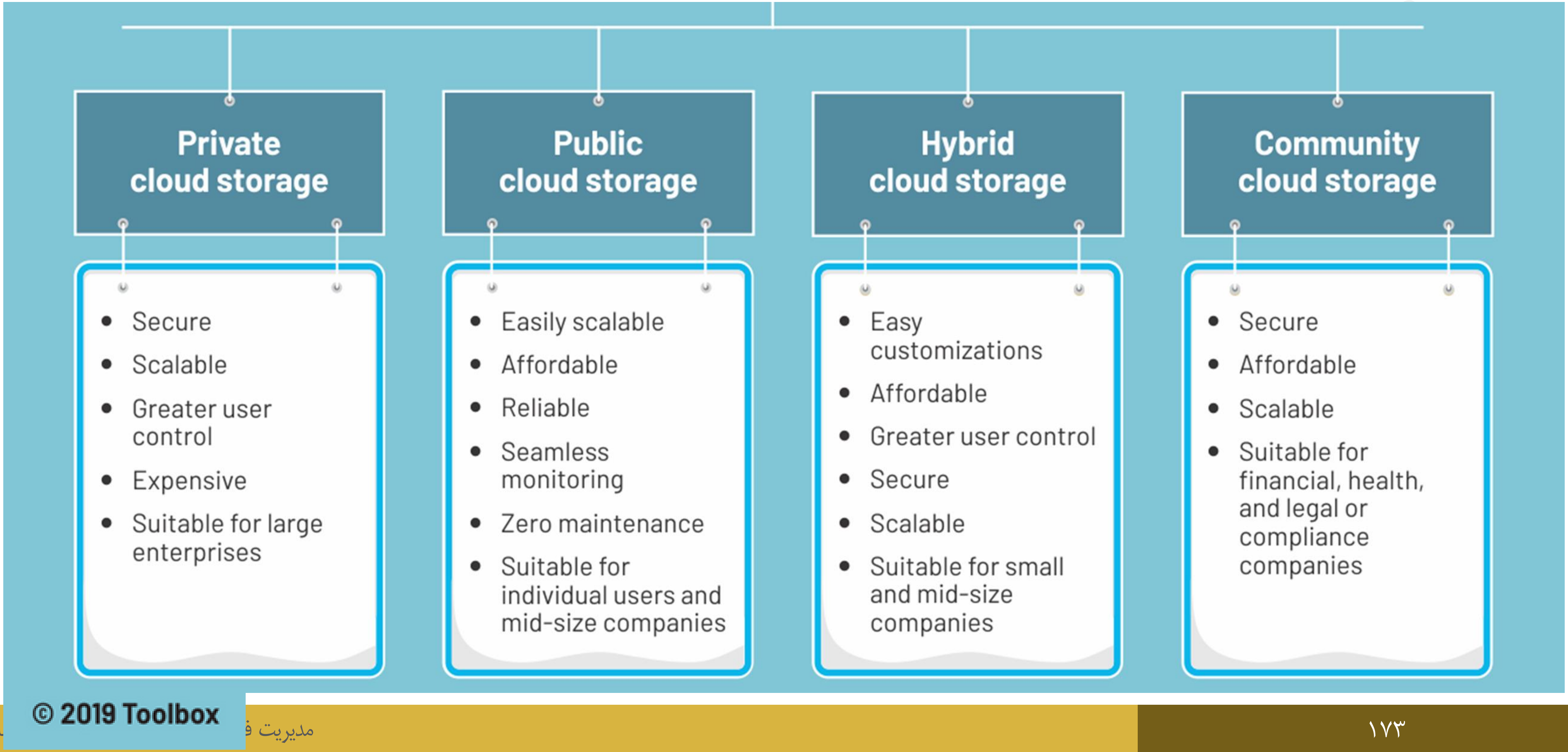
Types of Cloud Storage



Some Technical Considerations

- Server Type
- Accessibility
- Pricing
- High Availability
- Storage Topology
- Storage Device Technology
- RAID

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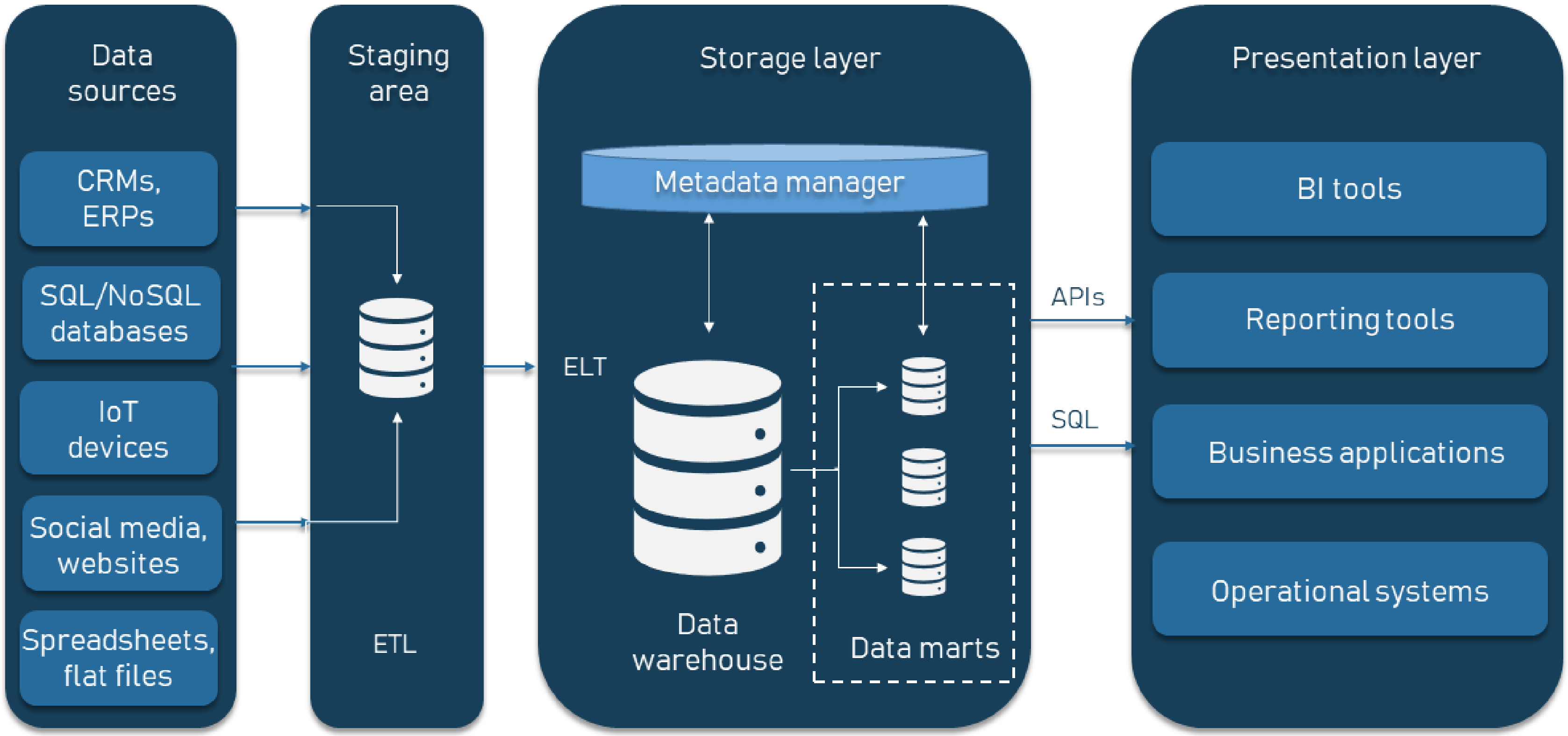
RAID (Redundant Array of Independent Disks)

Data Warehouse

- A data warehouse is a system that aggregates data from multiple sources into a single, central and consistent data store.
- Design Approach: Top-Down / Bottom-Up
- Data Mart Subsection



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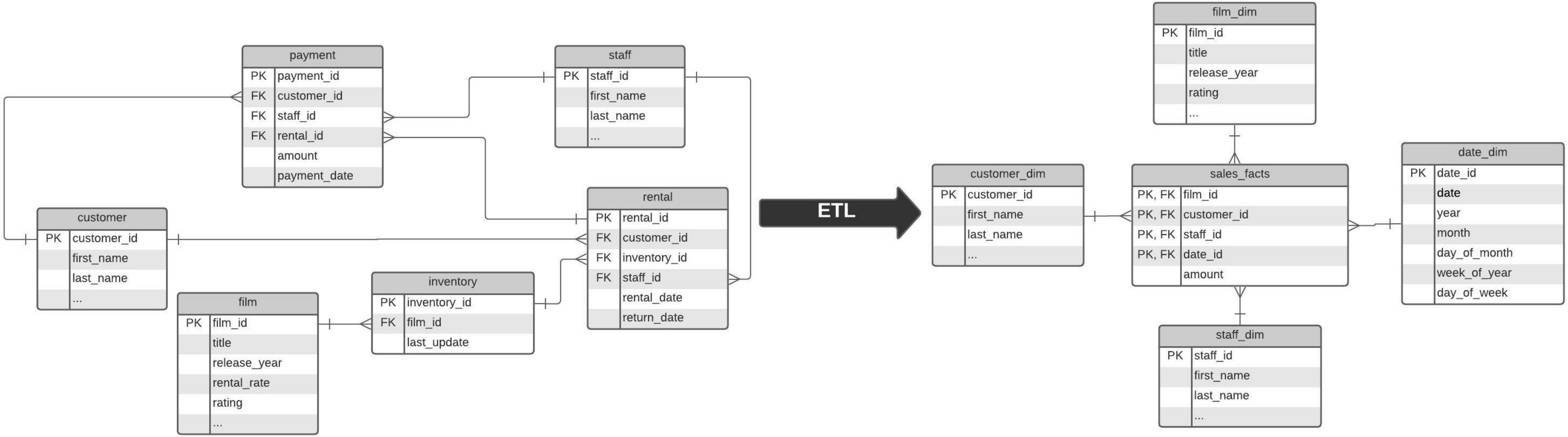
Online Analytical Processing Database (OLAP)

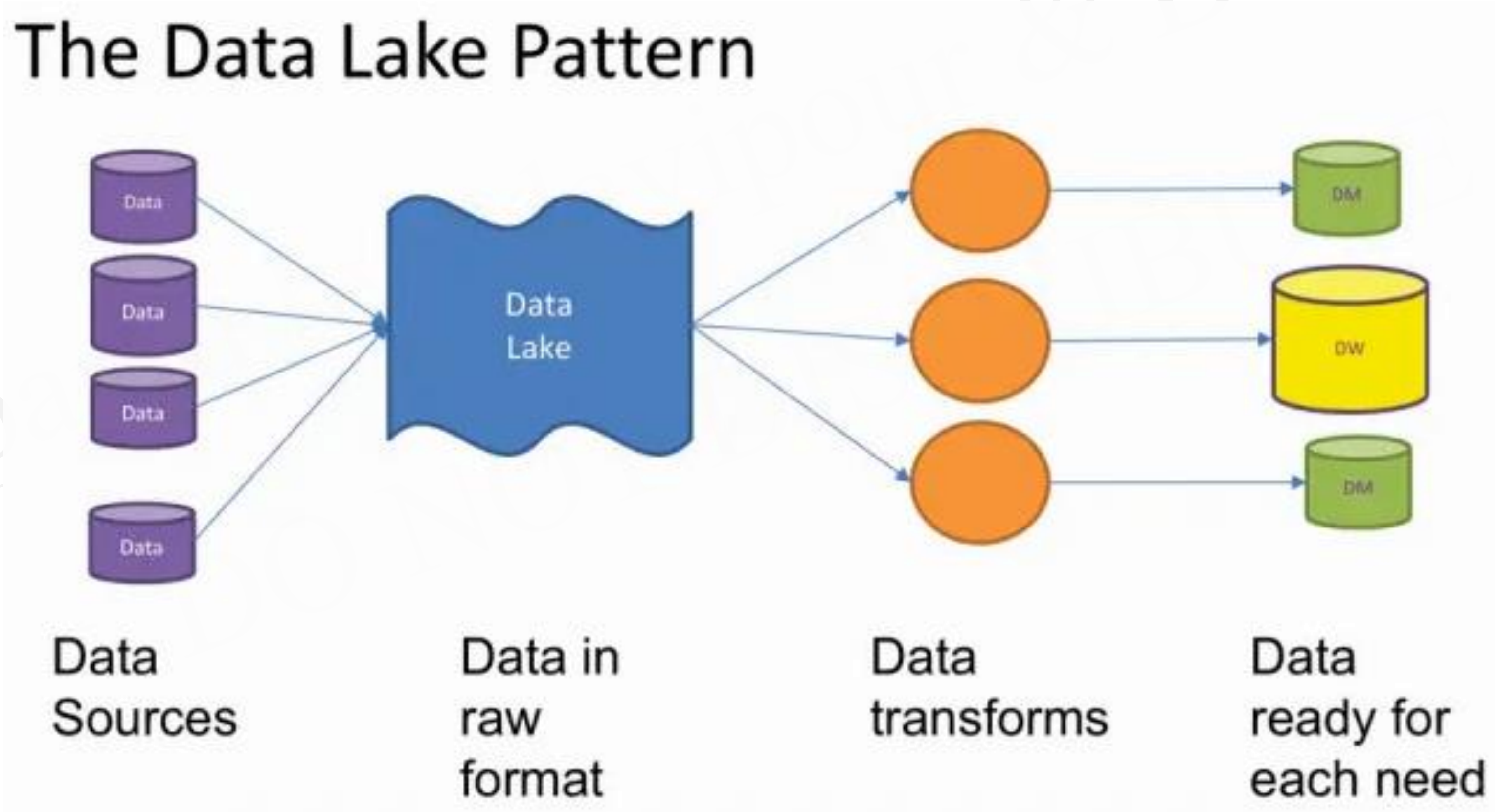
- Different Database Design Schema
- Used for Analysis

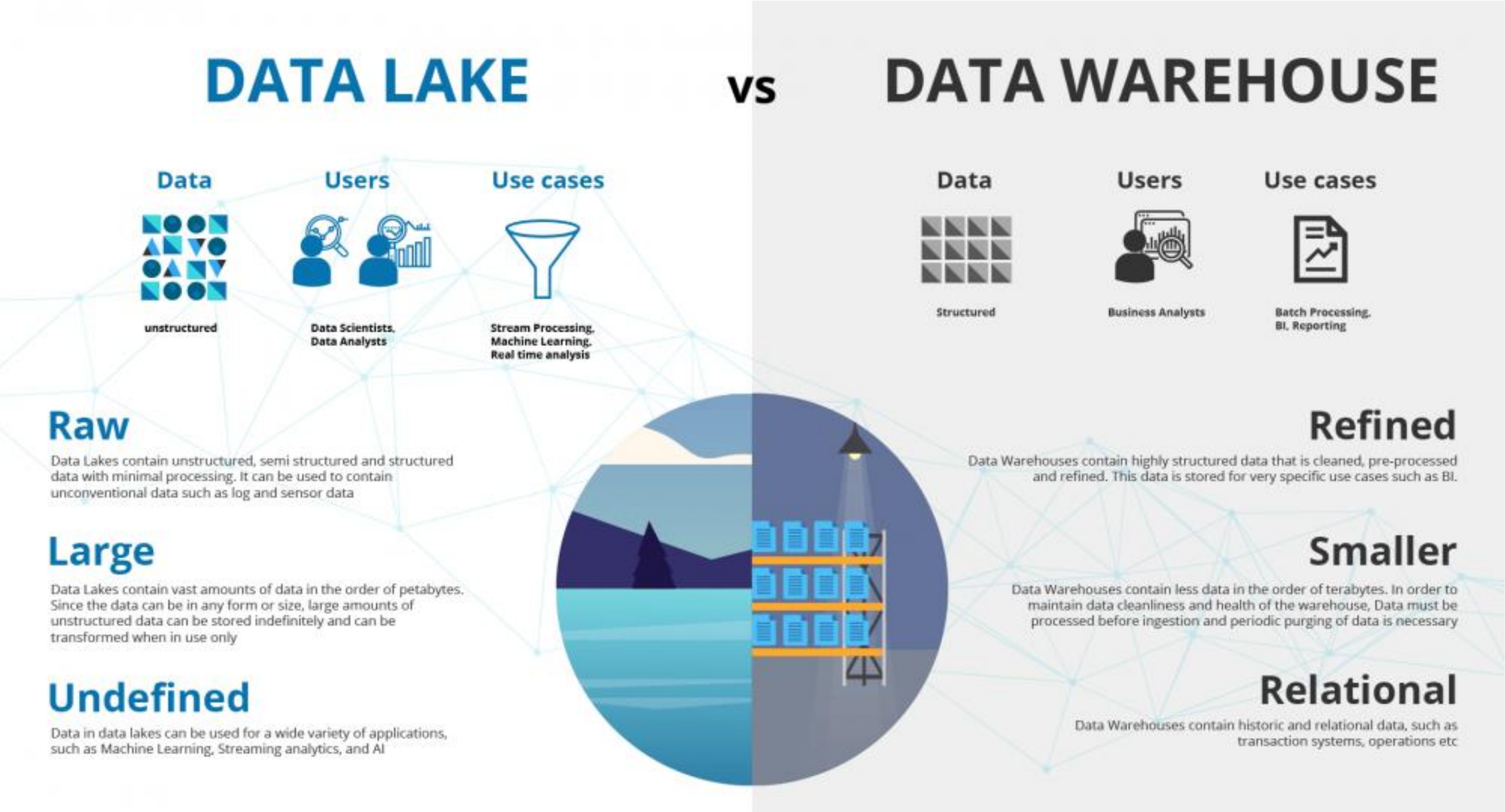


OLTP Schema **OLAP Schema**

Data Lake

- A data lake is a low-cost storage environment, which typically houses petabytes of raw data in both structured and unstructured formats.




DATA LAKE
vs
DATA WAREHOUSE
Data
Users
Use cases
unstructured
Data Scientists, Data Analysts
Stream Processing, Machine Learning, Real time analysis
Raw
Data Lakes contain unstructured, semi structured and structured data with minimal processing. It can be used to contain unconventional data such as log and sensor data
Large
Data Lakes contain vast amounts of data in the order of petabytes. Since the data can be in any form or size, large amounts of unstructured data can be stored indefinitely and can be transformed when in use only
Undefined
Data in data lakes can be used for a wide variety of applications, such as Machine Learning, Streaming analytics, and AI
Data
Users
Use cases
Structured
Business Analysts
Batch Processing, BI, Reporting
Refined
Data Warehouses contain highly structured data that is cleaned, pre-processed and refined. This data is stored for very specific use cases such as BI.
Smaller
Data Warehouses contain less data in the order of terabytes. In order to maintain data cleanliness and health of the warehouse, Data must be processed before ingestion and periodic purging of data is necessary
Relational
Data Warehouses contain historic and relational data, such as transaction systems, operations etc

۶. اشتراک‌گذاری و پایش داده

Data Sharing and Monitoring

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Data sharing and monitoring

- <u>Data sharing</u> is **distributing data** to users **without harming** the **data's integrity**.

- <u>Data monitoring</u> is **checking data** to
  1. Ensure project/program quality and
  2. Evaluating variances.

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Data sharing and monitoring

- **Useful information** helps no one if the **team does not**
  1. **Share** it with appropriate stakeholders or
  2. **Monitor** it for variances,

  so data sharing and monitoring are necessary for the team

  to **turn useful information** into knowledge about the project or program.

- The CM should recognize that the **team often performs** these **data management practices** **simultaneously**.

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Management information systems

- The CM should consider a **computerized** **management information system** (MIS, also known as a PMIS) to

  share and monitor data.

- The MIS provides a **“dashboard”** for the team to

  1. Monitor performance,
  2. Identify problems, and
  3. Evaluate variances.

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Management information systems

- The MIS should allow users to quickly
  1. See a summary of the project’s/program’s overall status,
  2. Access documents or data, and
  3. Share information with other users.

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How it differs from Decision Support System (DSS)?

Management information systems

- At a **minimum**, the MIS should address the team's
    1. Data sources,
    2. Schedule,
    3. Cost elements, and
    4. Output measures.

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Management information systems

- An **effective digital MIS** is

    1. Simple to use,
    2. Easy to understand, and
    3. Efficiently handles many common tasks.

- **Many exist** in the marketplace, or the owner (or CM's firm, if separate from the owner) may have **their own proprietary system**.

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Management information systems

- The CM should **understand**
    1. Where data in the digital MIS comes from and
    2. Basic concepts for deploying the system,

    but may **delegate** the **setup and administration** to other team members.

- If the CM **delegates** setting up and running the MIS,

  the CM should still
    1. **Monitor** the team's work and
    2. **Respond** to the owner's questions about the MIS.

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Management information systems

- The CM should
    1. **Understand** the **owner's needs** and
    2. **Help evaluate** the advantages and disadvantages of different systems

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Assessing a potential PMIS (1/2)

- When assessing a **potential MIS** for a project/program, the CM's considerations must include the following:
  - What is the project's/program's scope of work?
  - Does the team need the MIS during all phases, or is deployment needed after design, etc.?
  - **What services** does the CM perform that the MIS can accomplish?

    For example, document control, financial management, scheduling, risk management, etc.

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Assessing a potential PMIS (2/2)

- When assessing a **potential MIS** for a project/program, the CM's considerations must include the following:
  - Does the **owner have** a **budget** (with contingency) for an MIS that is appropriate for the project's/program's budget, duration, etc.?
  - Does someone on the **owner's/client's side want a viable MIS**?
  - Does the CM team have "**champions**" who are experts in **MIS deployments** and **administration**?

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SaaS MIS

- Organizations that are **unwilling** to accept the additional time and effort to build their **own proprietary** **MIS**

  may purchase a **subscription** **to an MIS**

  that runs on remote, cloud-based servers that users access through the internet.

- This type of **application** is called **software as a service (SaaS)**.

- **SaaS MIS software** is
  - Common in the marketplace,
  - Easily customizable, and
  - Many SaaS vendors perform regular updates on these systems for their subscribers.

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Cloud-based MIS

- A CM may
  - **Invest** in a subscription to a **cloud-based MIS** and
  - **Provide accounts** to stakeholders, compensable as part of the service the CM offers to the owner.
- Purchasing a **subscription** also allows the CM to effectively **extract** historical data from **completed** projects and programs, which **better informs** future estimates, schedules, and plans.

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Cloud-based MIS

- However, a **cloud-based MIS** may be expensive and

  only cost-effective on larger projects/programs or for serial builders.

- Sometimes the owner, the CM's firm, or another stakeholder may **host** the digital MIS and all integrated systems

  on their **local servers** that are physically **co-located** with the owner or the team.

On-premise Installation

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Hosting MIS on-premise

- This option may be **appropriate** for owners who
    1. Have very strict security requirements or
    2. Are unwilling to pay for a subscription.

- However, this option usually
    - Requires **more staff time** to maintain, and
    - Be **more difficult to extract** data at the end of the project/program to use for future comparisons.

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Other systems

- As noted above, the team may use other systems like

  AI/BI tools, commissioning platforms, geographic information systems, and scheduling software

  that allow the team to share and monitor data through **electronic dashboards.**
- These **systems' capabilities** may vary depending on the **owner's requirements**, but many exist in the marketplace and offer SaaS subscriptions.
- The owner or CM (if separate from the owner) may also have their **own proprietary systems.**

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Systems integration

- Many technologies can make **delivery** **more successful**,

  but **technology** that the team does **not properly manage**

  1. Creates inefficiencies,
  2. Drains resources, and
  3. Increases costs.

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Systems integration

- As a system becomes **more complex**,

  the risk grows that it will **isolate or duplicate** data in silos.

- This complexity creates **inefficiencies** that may include
  - Manual data re-entry,
  - Duplication of business functions, and
  - Reliance on paper to duplicate and exchange data.

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Systems integration

- Systems integration
  1. **Supports data sharing** and
  2. **Creates** a common data environment (CDE), i.e., A “single source of truth” to monitor data.

- **Software** from different manufacturers
  1. Exchange information and
  2. Work together

     for project/program success.

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Systems integration

- This **interoperability**
  - Speeds up delivery,
  - Reduces infrastructure vulnerability,
  - Decreases supply chain costs, and
  - Improves value for the owner.

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How can we cope with different software islands?

Systems integration

- Most construction software (e.g., AI/BI tools, an MIS, etc.) now includes a **built-in functionality** to integrate with other systems.
- **Connections** between software applications use a set of definitions and protocols called an application programming interface (API)

  which allows **systems to communicate** with each other.
- A team might use multiple APIs to

  connect the MIS with other systems and transfer data.

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Systems integration

- These **different systems** may function on
  - Devices on the jobsite,
  - Remote servers,
  - Computers or
  - Servers co-located with the team, or
  - Some combination.
- **Integrated systems** may also
  - Create data,
  - Producing a feedback loop that may require additional processing,
  - Etc.

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Systems integration

- The CM's responsibility is to **advise** the owner on the **most appropriate systems** integration options.
- The CM must **recognize** that full integration and interoperability may not always be in the **owner's best interest**.
- Organizations that do **not integrate systems** are **less efficient**, but owners and teams may choose
  - Not to integrate systems or
  - Only partially integrate systems due to the costs, security risks, or control issues associated with integration.

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Connected mobile devices

- High-speed data connections like Wi-Fi and 5G allow teams to
  - Share large amounts of data over wireless networks,
  - Reducing the weight, size, and
  - Computing power needed in handheld or wearable devices, and
  - Help the team monitor and perform the work.

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Connected mobile devices

- **Team members on the jobsite** with access to this sharing technology can open data-intensive models, documents, or other records on tablets, phones, or specialized equipment to perform and monitor work in real-time.
- These devices may also create data that the team can collect, analyze, store, share, and monitor.

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Connected mobile devices

- For example, augmented reality (AR) is an interactive tool that **overlays digital information** onto **real-world objects**, and

  virtual reality (VR) is a related tool that immerses a user in a digital environment.

- **Humans** can use multiple devices, mediums, and methods to view AR/VR data,

  including tablets and headsets

  connected to the **team's CDE.**

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Connected mobile devices

- On a **jobsite**, the team may **share data with users** based on their physical location or proximity to an object.
- A CM using AR might **point a camera** at a wall and instantly see an overlay on a screen that shows utilities or **equipment positioned behind the wall**.
- A CM using VR might be able to **operate a piece** of inspection equipment wirelessly

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Connected mobile devices

- Digital twins connected to mobile devices can help the team **quickly respond** to changes during construction.
  - For example, the architect of record could update the virtual model and then share the model's update with the general contractor on the jobsite.
- The contractor could
  - See the **update** on their connected tablet in real-time and
  - Re-sequence related schedule activities

  while the CM monitors the entire process.

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Connected mobile devices

- Connected mobile devices can increase **efficiency and safety**, but they are **only as dependable** as the data they receive.

- Missing or inaccurate data could create a safety hazard, delay, quality issue, etc.

- The team must have **clean**, **reliable data** and **follow** appropriate document distribution and control protocols.

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Connected mobile devices

- The CM must
  - **Advise** the owner on **how best to use** connected mobile devices and
  - **Ensure** that the **contract documents** clearly explain the <u>team's data responsibilities.</u>

- **All stakeholders** must
  - **Understand** their responsibilities and
  - **Ensure** they are **using the latest versions** of designs, documents, and other relevant data.

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Cybersecurity

- **Cybersecurity** is a practice to **allow** stakeholders to access appropriate information
  from digital systems and devices
  while also **protecting that data** from unauthorized persons and entities.

- **Data integrity** requires effective cybersecurity.

- **Stakeholders** must be able to access data
  that they reasonably know is accurate, complete, and safe from harmful actors.

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Cybersecurity

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- The CM must focus on **cybersecurity**
  whenever working with sensitive data,
  such as financial or operational information.

- The CM **balances** security and the ability to share information among stakeholders.

- Protecting information is critical to the team's success,
  but **avoiding new digital tools** because of potential cyber threats could also **limit successful outcomes**.

The CM manages the team to meet the owner’s cybersecurity requirements but does not need to be a cybersecurity expert.

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Cybersecurity Best Practices (1/3)

- The CM ensures that the team follows **cybersecurity best practices**, including:
  - **Following** an owner's (or their own organization's) cybersecurity plan;
  - **Deploying** the latest software updates to all systems, computers, and other digital assets (note, certain software subscriptions provide this service automatically);

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Cybersecurity Best Practices (2/3)

- The CM ensures that the team follows cybersecurity best practices, including:
  - **Establishing** appropriate controlled access procedures, such as different levels of access to MIS information on a "need-to-know" basis, requiring two-factor authentication for users to log in (a password plus one other item, e.g., a security key or verification code sent to a user's phone),
    - Limiting system logins to only specific locations like the jobsite or owner's offices,
    - Restricting system logins to regular work hours, etc.;

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Cybersecurity Best Practices (3/3)

- The CM ensures that the team follows cybersecurity best practices, including:
  - Encrypting all data as a default security setting;
  - Limiting who can copy data from the MIS and the team’s other digital systems;
  - Regularly backing up stored data; and
  - Requiring cybersecurity training and refresher training for all staff.

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Cybersecurity

- The CM must also understand any other **owner-specific requirements**.
- For example, a public owner may require compliance with **one of the following common cybersecurity standards:**
  - Cybersecurity Maturity Model Certification (CMMC)
  - Federal Information Security Modernization Act (FISMA)
  - Federal Risk and Authorization Management Program (FedRAMP®)

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گواهی افتا

- مخفف **امنیت و فضای تولید و تبادل اطلاعات**
- به مجموعه‌ای از اقدامات، استانداردها و گواهی‌نامه‌ها اشاره دارد که با هدف حفاظت از اطلاعات و داده‌های حساس در برابر تهدیدات سایبری و نفوذهای غیر مجاز طراحی شده‌اند.
- امروزه بسیاری از ارگان‌ها، سازمان‌ها و شرکت‌های دولتی در فرآیند برون‌سپاری پروژه‌ها و وظایف خود، از پیمانکاران و شرکت‌های فعال در حوزه‌های مختلف، گواهی افتای مربوطه را درخواست می‌کنند.
- این گواهی، که تحت نظارت مرکز مدیریت راهبردی افتای ریاست جمهوری صادر می‌شود، به عنوان یک استاندارد امنیتی معتبر شناخته شده و نشان‌دهنده توانایی شرکت پیمانکار، در اجرا و تأمین امنیت اطلاعات و شبکه‌ها مطابق با الزامات امنیتی کشور است.

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Cybersecurity Maturity Model Certification (CMMC)

- CMMC is a set of cyber protection standards issued by the U.S. Department of Defense (DoD) for organizations that do business with the DoD.
- The framework establishes processes for the flow of data (including to any consultants and trade partners), sets security implementation requirements for DoD contractors, and requires regular cybersecurity assessments.

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Federal Information Security Modernization Act (FISMA)

- FISMA is a law from 2014 that establishes the authority of the U.S. Department of Homeland Security and the Office of Management and Budget to provide technical assistance and oversee information security policies within certain U.S. federal agencies.
- FISMA replaced an earlier law from 2002 that was also known as FISMA called the Federal Information Security Management Act.
- The 2002 version of FISMA set standards for information security in the U.S. Federal Government.

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Federal Risk and Authorization Management Program (FedRAMP®)

- FedRAMP is a digital standard for agencies in the U.S. Federal Government.
- FedRAMP allows federal agencies to adopt cloud technology while also protecting digital information.

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Q.

What are roles and responsibilities of CM during Data Management Flow stages?

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مدیریت فناوری‌های دیجیتال در صنعت ساخت

(بر اساس سندی از انجمن مدیریت ساخت آمریکا (CMAA))

ارائه‌دهندگان:

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نریمان درافشان

هانیه طباطبایی

زمستان ۱۴۰۳

قسمت ۱٫۳

فصل اول: فناوری‌های دیجیتال در صنعت ساخت

قسمت سوم: بررسی تفصیلی چند فناوری کاربردی در صنعت ساخت

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چند فناوری دیجیتال کاربردی در صنعت ساخت

۱. اینترنت اشیا (IoT) و کاربردهای آن در صنعت ساخت

۲. مدلسازی اطلاعات ساختمان (BIM)

۳. بلاک‌چین و کاربردهای امکان‌پذیر آن در صنعت ساخت

۴. اتوماسیون فرایند رباتی (RPA)

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۱. اینترنت اشیا و کاربردهای آن در صنعت ساخت

Internet of Things and Construction Industry

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ATMEGA32


LEONARDO
ARDUINO

The Internet of Things (IoT)

- Internet of Things refers to
    - a network of physical devices, vehicles, appliances, and other physical objects
    - that are embedded with sensors, software, and network connectivity,
    - allowing them to collect and share data.

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IoT devices

- IoT devices—also known as “smart objects”—can range from
  - simple “smart home” devices like smart thermostats,
  - wearables like smartwatches and RFID-enabled clothing,
  - complex industrial machinery and transportation systems.

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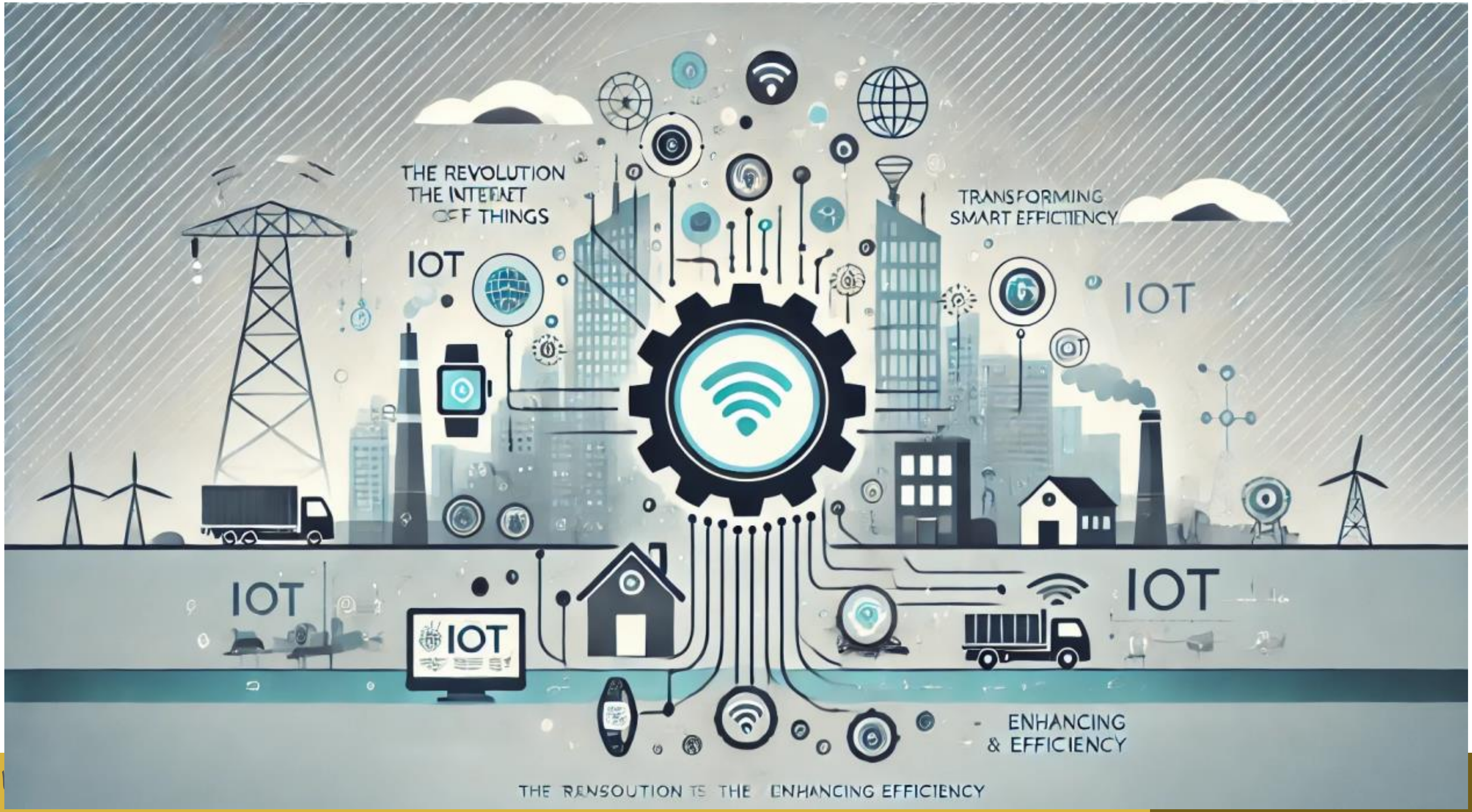
Envisioning Smart Cities

- Technologists are even envisioning entire “smart cities” predicated on IoT technologies.



Communicating with other devices (1/2)

- IoT enables these smart devices to
  - communicate with each other and with other internet-enabled devices, (like smartphones and gateways,)
  - creating a vast network of interconnected devices that can exchange data and perform various tasks autonomously

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Communicating with other devices (2/2)

- Data exchange and autonomous task performing can include:
  - managing traffic patterns with smart cars and other smart automotive devices
  - controlling machines and processes in factories
  - tracking inventory and shipments in warehouses
  - monitoring environmental conditions in sites

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Potential Applications of IoT

- The potential applications of IoT are vast and varied, and

  its impact is already being felt across a wide range of industries, including manufacturing, transportation, healthcare, and agriculture.

- As the number of internet-connected devices continues to grow, IoT is likely to play an increasingly important role in shaping our world.

  Transforming the way that we live, work, and interact with each other.

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IoT in enterprises

- In an enterprise context, IoT devices are used to monitor a wide range of parameters such as temperature, humidity, air quality, energy consumption, and machine performance.
- This data can be analyzed in real time to identify patterns, trends, and anomalies that can help businesses optimize their operations and improve their bottom line.

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Q.

Why is IoT important (also) in Construction?

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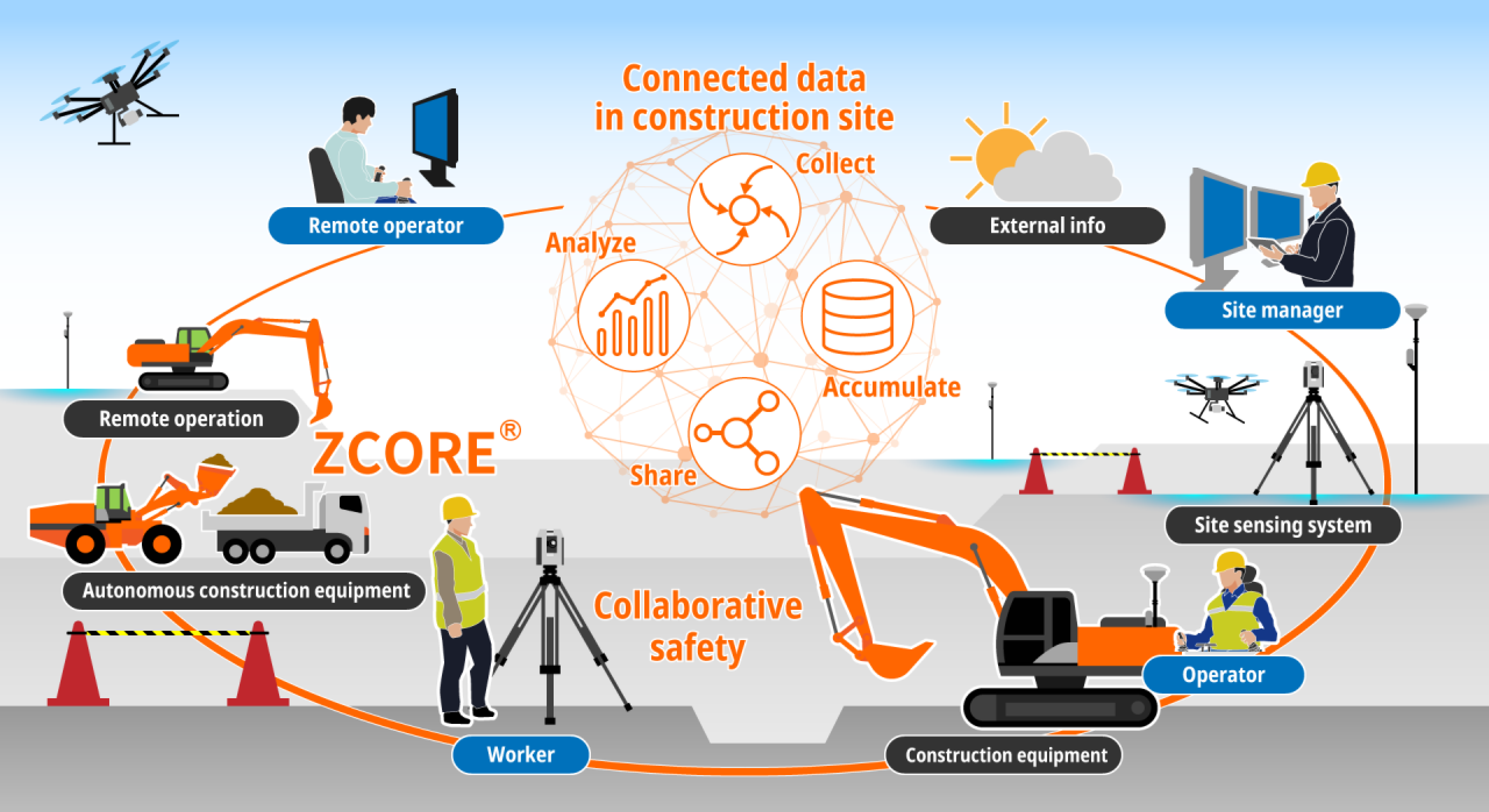

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Some Core Benefits of IoT in Construction

1. **Improving Jobsite Productivity (1/3)**

- informing workers on how to best use their time and effort to maximize results.
- The data acquired through IoT allows managers to cut back on menial tasks or idleness, freeing up more time for more effective work such as process improvements or quality assurance.
- IoT data helps improve scheduling so that work activities can be planned and executed in a logical order, minimizing time spent between construction phases.

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Some Core Benefits of IoT in Construction

1. **Improving Jobsite Productivity (2/3)**

By using IoT devices to automate and optimize processes, businesses can improve efficiency and productivity.

For example, IoT sensors can be used to monitor equipment performance and detect or even resolve potential issues before they cause downtime, reducing maintenance costs and improving uptime, also optimizing maintenance schedules.

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Some Core Benefits of IoT in Construction

1. Improving Jobsite Productivity (3/3)

One of the major factors in project efficiency is how well managers can allocate and manage their resources.

Labor and equipment are two primary resources that pose the biggest opportunities for managers to maximize project profitability.

1. identify high-performing workers and their areas of maximum productivity, leading to more efficient use of their time
2. make better-informed rental decisions, including renting the right equipment as needed to prevent costly downtime.

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Some Core Benefits of IoT in Construction

2. Safety

Committing to maintaining work site safety is a crucial responsibility for contractors and site managers.

- According to OSHA, the top four safety hazards that contribute to construction job site fatalities are:
  - Falls from heights
  - Being struck by objects
  - Getting caught in or between objects
  - Electrocutions

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Construction Safety

Did you know?

One of every five workplace fatalities is a construction worker.

Did you know?

One in four "struck by vehicle" deaths involve construction workers, more than any other occupation

Did you know?

Falls from elevation account for one third of all deaths in construction

OSHA® Occupational Safety and Health Administration

Some Core Benefits of IoT in Construction

3. **Cost-savings (1/2)**

Construction managers can leverage IoT technology and data to reduce construction waste or manage it in a more sustainable manner.

- In addition to reducing physical waste, IoT can help identify wasted fuel, water and energy consumption, which improves sustainability as well as financial control.
- IoT devices can help in streamline work activities, improve their quality and prevent costly rework.

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Some Core Benefits of IoT in Construction

3. Cost-savings (2/2)

By reducing manual processes and automating repetitive tasks, IoT can help businesses reduce costs and improve profitability.

For example, IoT devices can be used to monitor energy usage and optimize consumption, reducing energy costs and improving sustainability.

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Some Core Benefits of IoT in Construction

4. **Improved Reporting (1/2)**

With the advent of IoT in construction, reporting is now a much easier and more streamlined process.

Crucial information is stored in a central hub that managers use to monitor the overall health and productivity of projects.

Managers can now pull data and automatically generate comprehensive or specific reports regarding any aspect of the project.

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Some Core Benefits of IoT in Construction

4. Improved Reporting (2/2)

IoT in construction has streamlined reporting while also making communication much easier and more efficient.

Key parties now have access to the same crucial information at the same time, keeping everyone on the same page and alert to the same status reports regarding project progress.

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Some Core Benefits of IoT in Construction

5. **Data-driven decision-making**

Resulted by improved reporting

IoT devices generate vast amounts of data that can be used to make better-informed business decisions and new business models.

By analyzing this data, businesses can

- gain insights into operational performance, market trends, and workers behavior,
- allowing them to make more informed decisions about strategy, product development, and resource allocation.

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The technologies that make IoT possible

- Sensors and Actuators
- Connectivity Technologies
- (Cloud) Computing
- (Big) Data Analytics
- Security and Privacy Technologies

Risks and challenges in IoT

Security and Privacy risks

Interoperability Issues

Data Overload

Cost and Complexity

Regulatory and legal challenges

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How should businesses approach IoT?

1. **Plan your IoT strategy**

Before deploying any IoT devices, businesses should have a clear understanding of their objectives, use cases and desired outcomes.

This can help them choose the right devices, IoT platforms and technologies, and ensure that their IoT strategy is aligned with their business goals.

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How should businesses approach IoT?

2. **Choose Secure IoT products**

Security is a critical consideration for IoT solutions, as they can be vulnerable to cyberattacks.

Businesses should choose devices that are designed with security in mind and implement appropriate security systems, such as encryption, authentication, and access controls.

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How should businesses approach IoT?

3. **Monitor and maintain devices**

IoT devices need to be monitored and maintained regularly to ensure that they are performing optimally and are not vulnerable to security threats.

This can involve monitoring device health and performance, updating firmware and software and conducting regular security audits and predictive maintenance.

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How should businesses approach IoT?

4. **Manage data effectively**

IoT devices generate vast amounts of real-world data, which can be challenging to manage and analyze.

Businesses should have a **clear data management strategy** in place, including data storage, analysis, and visualization.

To ensure that they can extract meaningful insights from the data that is generated by their IoT devices.

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How should businesses approach IoT?

5. **Build an ecosystem**

IoT devices are often part of a larger ecosystem that includes other devices, platforms, and technologies.

Businesses should have a clear understanding of this ecosystem and ensure that their IoT devices can integrate effectively with other systems and technologies..

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۲. مدلسازی اطلاعات ساختمان

Building Information Modeling (BIM)

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ربط این بحث به دوره‌های دیگر موسسه چیست؟

استراتژی پیاده سازی BIM (بیم) در طول چرخه حیات پروژه

نقشه راهی به نام BIM (بیم) در مدیریت و کنترل پروژه

آموزش نرم‌افزارهای Navisworks + Synchro با رویکرد مدیریت پروژه

Introduction

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Building information modeling

- Building information modeling (BIM) is a **method** to **create** a **digital representation** of a <u>facility's physical</u> and <u>functional characteristics</u> that a team can **virtually**

  1. Analyze,
  2. Document, and
  3. Assess, then
  4. Revise iteratively

  throughout the design and construction process.

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Building information modeling

- BIM is an **important concept** for project/program controls.

- Throughout a **structure's lifetime**,

  the model serves as a shared knowledge resource that forms a reliable basis for **decisions**,

    from inception through design to construction, use/occupancy, operations, renovation, and eventual demolition.

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Many owners require BIM to manage delivery, so the CM should generally understand the concepts in this section and advise the owner, when applicable.

Remember, the CM does not necessarily need to be a technology expert, but a CM should understand a technology well enough to manage it.

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Building information modeling

- BIM is **more common** in <u>vertical construction</u> (buildings, etc.) **than** in <u>horizontal construction</u> (transportation, utilities, etc.), but **there are exceptions** and **owners** in both forms of construction who have **specific BIM requirements**.

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Building information modeling

- BIM **provides** data and context, allowing a team to
  - Produce drawings faster and help collaboration,
  - Increase efficiency,
  - Reduce risk, and
  - Improve safety.

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Building information modeling

- A BIM model should use a **CDE** to help the team
  - Define,
  - Store,
  - Analyze, and
  - Communicate the construction process in a virtual environment, including

    the sequence of work, means and methods, logistics, and documentation of as-built conditions.

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Building information modeling

- BIM allows for qualitative and quantitative **engineering analyses**

  to reveal the properties and state of the project/program.

- Projects and programs that use BIM

  benefit from improved coordination during the design,

  resulting in higher-quality designs that

  reduce rework, delays, and changes during construction.

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Building information modeling

- BIM should
  1. Increase the builder’s confidence in the design and
  2. Reduce trade coordination delays during construction.
     - For example, a BIM design can allow the team to use more pre-fabricated materials and assemblies, which reduces jobsite labor and costs.

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Building information modeling

- BIM should also
  - **Increase** the **owner's visibility** of the design and
  - **Access** to as-built information, streamlining the turnover, startup, and facility management processes.
- BIM **virtual models** can help the owner
  - **"Watch"** the construction process and
  - **Better understand** the completed design.

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Building information modeling

- The team also
  - **Develops** the BIM model(s) based on the owner's O&M requirements and
  - **Trains** the owner's staff.
- At the end of the project or program, the owner's O&M staff should know **how to use** the model(s).

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History of BIM

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History

- For many years, the industry often used the term **"BIM"** to refer to all technological innovations,

  with the **expectation** that BIM would improve

  - Collaboration,
  - Cost-effectiveness,
  - Productivity, and
  - Information accessibility

  because there would be **one data source**.

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CAD

- BIM's process of converting paper models to **computer-aided design (CAD)** models transformed the construction industry,

  but BIM also presented **challenges** with adoption, integration, cost, and risk of ownership

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CAD to BIM

- BIM **gradually evolved** from single CAD models to complex models that combine multiple disciplines.
- At first**, CAD technology** made the design process **more efficient**, but parts of the industry resisted adoption.
- Then, the industry began using federated models that **combined** the architectural model, structural model, and mechanical, electrical, and plumbing (MEP) model.
- The industry also adopted operations models to help the **owner's O&M staff.**

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Different models

- **Coordinating** the **different models** throughout a **structure's entire lifecycle** presented some challenges that are **still present in the industry**.
- **Designers** of different disciplines must collaborate to **perform** clash detection (checks for interferences by searching for intersecting volumes, "Key Concepts" later in this section)
  - However, the industry has **struggled to create interoperability** between different BIM software (e.g., standardized file types, data protocols, etc.), which can complicate clash detection and increase cost and risk.

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BIM teams

- Today, BIM teams must carefully <u>coordinate</u> and <u>maintain</u> **centralized BIM models** to minimize risk.
- <u>Contract documents</u> must clearly specify
    - **Acceptable BIM software** and
    - **Which team member(s)** may update the models (see “BIM integrator” below).
- The team can also enhance this **coordination** with a **CDE**.

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BIM teams

- When teams **use BIM well**,

  the CM can now use BIM to access virtual models during design to review the designers' progress,

  during construction on the jobsite to monitor the installation of a structure's systems, and

  during closeout to hand over the as-built record models to the owner for O&M.

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Key Concepts

A concise summary of some **important BIM topics** that may apply throughout **all phases.**

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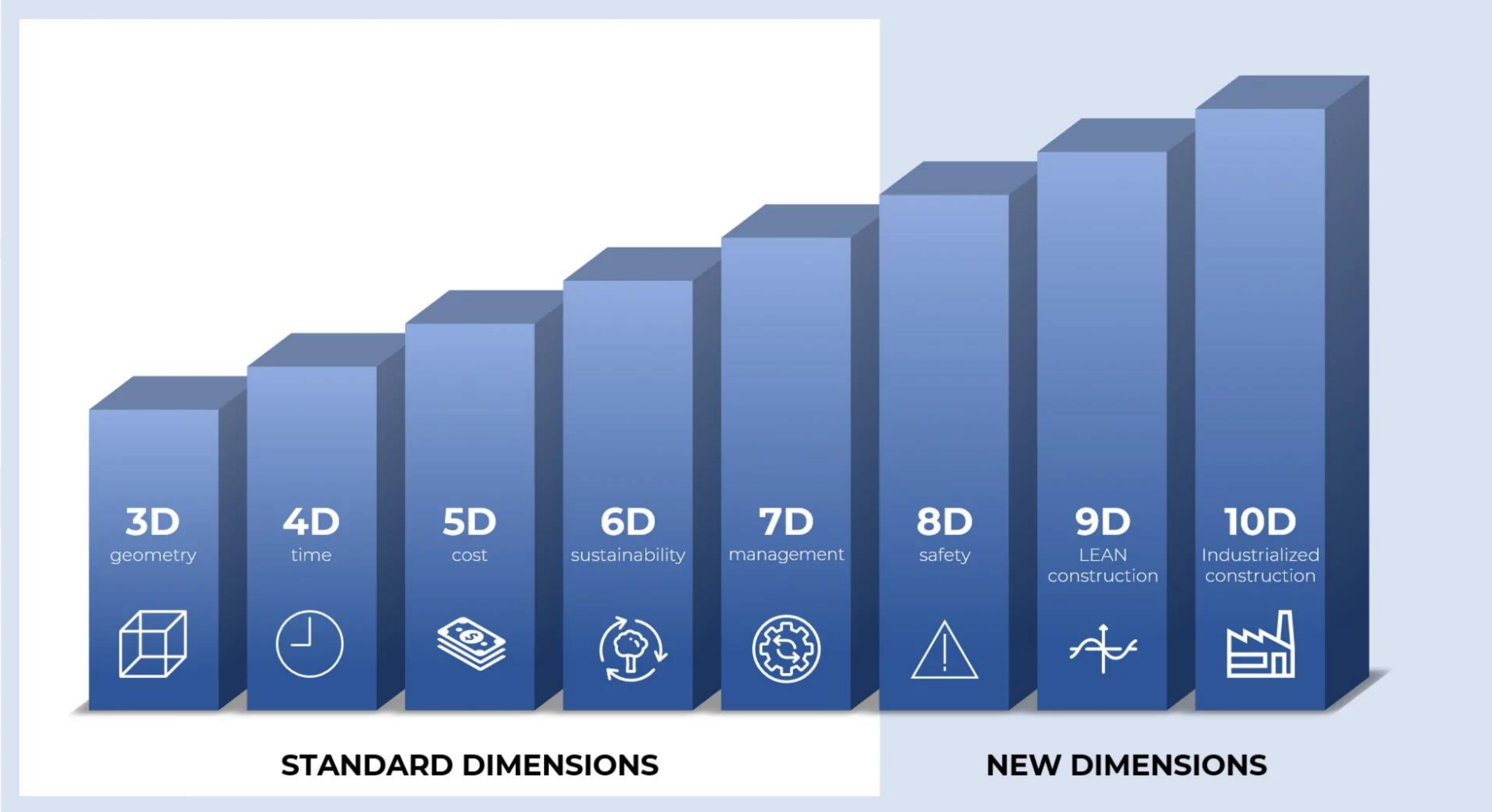
BIM dimensions

- A BIM model includes **multiple dimensions**, such as:
  - 3D (Spatial)
  - 4D (Time/duration)
  - 5D (Cost)
  - 6D (Sustainability)
  - 7D (Facility management)
  - 8D (Safety)
  - 9D (Lean construction)



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3D (Spatial)

- This model provides a **digital representation** of the physical and functional characteristics of a facility in a **better design environment**

  than 2D CAD.
- **3D modeling applications** can
  - Capture design intent parametrically,
  - Facilitating model creation and editing,
  - Reducing the chance of coordination errors.
- BIM 3D environments can
  - Export traditional 2D documents,
  - Making the BIM 3D environment a source of official 2D drawing documentation.

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4D (Time/duration)

- A **4D scheduling application** dynamically links the **critical path method (CPM) schedule** activities to 3D BIM objects.
- This link allows for a **graphically rich and animated** representation of the **planned construction sequence** over time.
- **4D schedules** are a tool for
  phasing, coordinating, and communicating planned work to various audiences,
  including owners and those solely responsible for executing the work.
- These schedules also support **simulated what-if scenarios.**

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5D (Cost)

- <u>Every BIM element</u> is attributed to what it will represent in **terms of resources and respective costs.**
- 5D allows **parametric and dynamic** quantity takeoffs for
  - **bills of materials**, resulting in a <u>more accurate</u> estimate.
- 5D also allows the **estimators** to spend
  - ✓ <u>Less time</u> on the quantity take-off and
  - ✓ <u>More time</u> performing the cost estimate analysis.

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6D (Sustainability)

- A 6D application applies sustainability and energy efficiency elements to the model,

  which **estimates**

  - structure’s energy costs,
  - environmental impact,
  - pollution risks, etc.

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7D (Facility management)

- The model applies facility management elements, which allows a **more accurate estimate** of the owner’s O&M costs over the facility’s entire lifecycle.

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8D (Safety)

- An 8D application provides **safety information**.
- This dimension's **safety model**
  - Includes operators' risks and
  - Helps to prevent critical hazardous scenarios

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9D (Lean construction)

- This dimension applies lean construction elements to the model, which may **benefit resource management**, such as using **automated machinery** on the jobsite, **pre-fabrication** of building materials, etc.
- 9D may also benefit **asset management** during the structure's operational life.

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BIM execution plan

- A **BIM execution plan** (BEP, sometimes abbreviated as BxP) is a written document
  - that provides a **framework** for the team to
    - determine the **most effective BIM** application throughout a facility's lifecycle.
- The BEP may be
  - Part of the PMP/pgmp, CMP, or
  - A separate document on larger or more complex projects/programs.

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BIM execution plan

- The BEP
  - Confirms the goals for BIM's use and
  - Documents important protocols,

    such as
    - How the team manages BIM data,
    - Model level of development within phases, and model transitions,

      including from the **design consultant** to the CM,

      the general contractor, and the owner.

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BIM execution plan

- The BEP continues to evolve throughout the project/program. A BEP includes:

» BIM requirements;

» BIM roles and responsibilities;

» BIM platform/software specifications;

» BIM templates;

» File naming, content, and sharing policies;

» Data storage, access, updating, ownership, and protocols;

» Quality control and quality assurance;

» Level of development in each phase; and

» Intended use of the model(s) in each phase.

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BIM execution plan

- A BEP **helps** the CM lead the team and promotes effective BIM use, including
  - Collaborative design development,
  - Quality management,
  - Clash detection,
  - Cost and schedule management,
  - Change management, and
  - Design reviews.

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BIM integrator

- **Delivery methods** that involve separate design and **construction stakeholders** require a team member to serve as the BIM integrator.
- The BIM integrator can be
  - a single person, or
    - the role can transfer from one person to another at certain milestones.
- The BIM integrator could be
  - the CM, an architect/engineer, a builder, or an independent party.

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BIM integrator (1/2)

- The BIM **integrator's responsibilities** include the following:
  - <u>Preparing and maintaining</u> the BEP, with support from the BIM leads from each stakeholder;
  - <u>Maintaining</u> a central model and incorporating the latest available information from participants;
  - <u>Bringing</u> new team members (consultants, vendors, etc.) up to speed on the BIM requirements and current model;

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BIM integrator (2/2)

- The BIM **integrator's responsibilities** include the following:
  - Verifying in all phases that the model meets the owner's BIM requirements and specifications;
  - Assuring interoperability between models when multiple models are necessary; and
  - Ensuring a smooth model transition from design to construction and from the construction phase to the owner.

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BIM integrator

- **Even if** the CM is not the BIM integrator,

  the CM should **work closely** with the BIM integrator to

  develop the BEP and understand how BIM supports the owner’s requirements.

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Clash detection

- Clash detection is a method to check for **interferences** by searching for intersecting volumes.
- This application provides the **opportunity** to not only clash a single model but **combine and clash** multiple models from different sources in a CDE.

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Element data

- Element data is **information** about building components that will **assist** with O&M.
- **This information** may come from **other sources outside** the model,
  - such as other databases.
- The team may **input or link** this data to objects in the model.
- Examples include
  - power requirements,
  - model numbers,
  - serial numbers,
  - spare parts lists,
  - warranties,
  - permits,
  - sign-offs etc.

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Layer

- A layer is a **definition** in the BIM model
  that **controls** the properties of objects placed inside it.

- In a construction project or program,
  layers typically represent different design disciplines (e.g., structural, MEP, etc.) or areas/zones on the jobsite.

- During design, the **team develops layers**
  that should **remain in the model** throughout construction and
  in the **as-built model** that the team transitions to the owner.

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Level of development

- A BIM model's level of development (LOD) refers to the effort the **team spends** developing a model's detail,

  which may determine the **model's reliability**.

- As a model's LOD increases,

  the ease and efficiency with which the structure can be **built also increases**.

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Level of development

- The CM must understand the following LOD levels:

» **LOD 100:** A conceptual model that derives information from other model elements;

» **LOD 200:** Schematic layout with approximate size, shape, and location;

» **LOD 300:** Modeled as design-specified size, shape, spacing, and location of equipment;

» **LOD 350:** Modeled as actual size, shape, and spacing with location and connections of equipment; and

» **LOD 400:** Supplementary components added to the model required for fabrication and jobsite installation.

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Property set

- A property set is a **group** of equipment, fixtures, materials, or other components that the **team links** together in the model.

- Property sets should **identify all relevant information** for the O&M personnel, such as element data, system types, etc.

- The team can either
  1. Manually input this data or
  2. Link it from other sources, such as a manufacturer's website.

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Tagging

- Tagging links data from the owner’s or team’s system(s) to **building elements** in the model.

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Virtual design and construction

- BIM is the **most common way** to perform virtual design and construction (VDC).

- The industry often uses the terms "BIM" and "VDC" **interchangeably** because BIM can **perform VDC**, but they are not identical.

- BIM uses data to build virtual models of a structure, whereas VDC is a methodology to use data to **plan the physical** construction process.

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Virtual design and construction

- In other words, BIM <u>can be a VDC tool</u>.
  - VDC refers to <u>using technology</u>

    to plan construction and BIM is the **most common method** to perform VDC.

- The **construction team** may use BIM data

  to **perform** <u>VDC tasks</u>

  such as estimating, risk analysis, and schedule planning for the construction phase.

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Record Models

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Record model

- The CM (and the BIM integrator, if separate from the CM) **ensure** that all BIM models
  1. Reflect as-built conditions and
  2. Transfer the models to the owner after construction is complete.
- The handover of the **record/as-built model(s)** should benefit the owner's facility management processes.
- The record model(s) provide the owner with **digital twins connected to** physical elements, components, and processes in the actual facility/ facilities.

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Record model

- As early as possible, the CM must **help** the owner's O&M team define
  - What they will need from the model(s) and
  - How to format the model(s) for the owner's future use.
- The CM also ensures that the **owner and facility operators** receive training on how to use the model(s).
- **Training ideally begins** during construction,

  but **some training may occur** after the owner assumes responsibility for the facility.
- The **owner's COS** should clearly document this requirement.

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