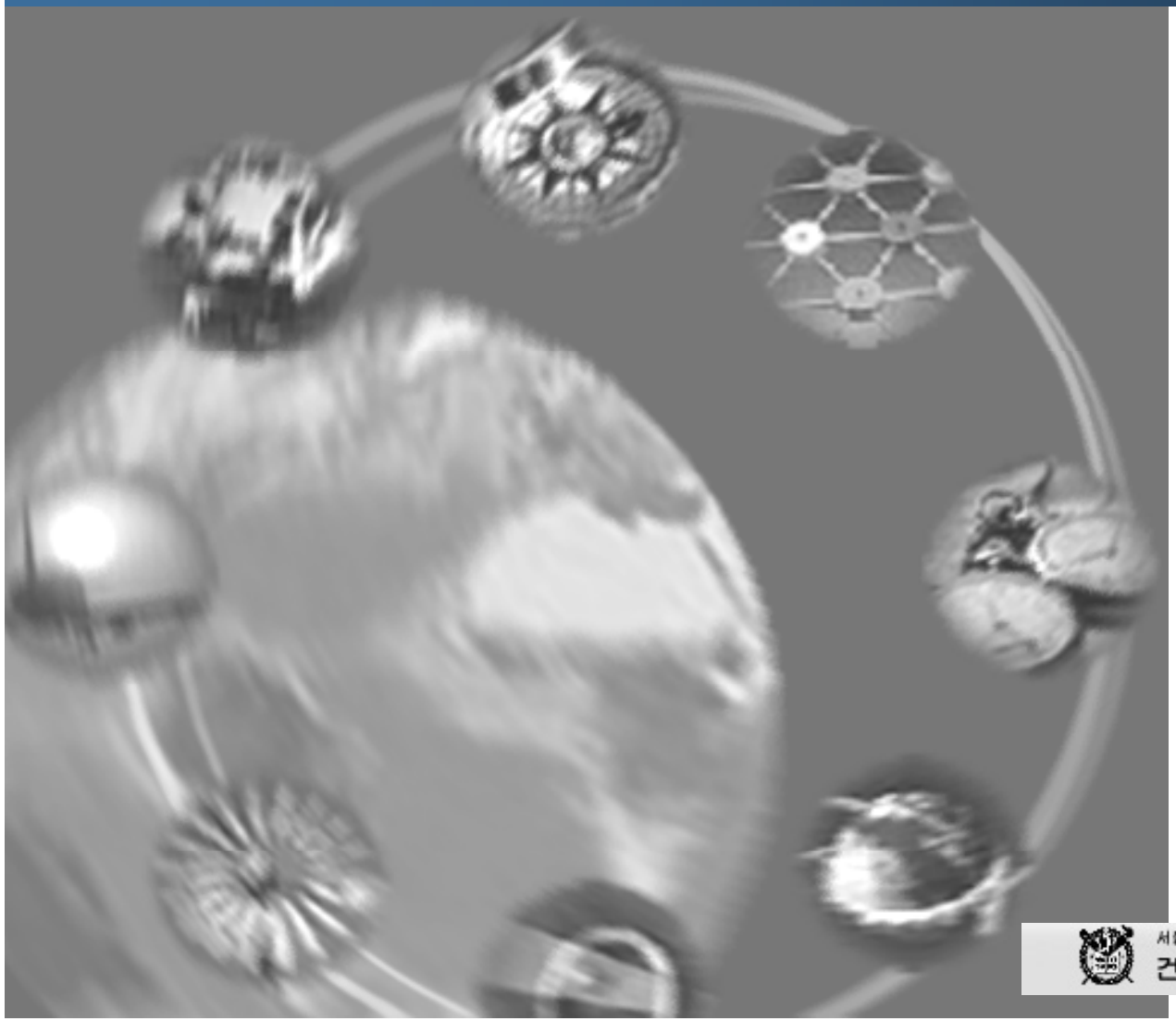
Visualization

4013.407 Construction Technology



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과학기술부 국가지정연구실 National Research Lab.

Changes of visual representation

Visualization

이미지를 다양하게 조립하다.

Visual Communication

정보의 대량 전달과 빠른 전달 속도

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Information representation

Text based Information

- Document
- Work sheet etc.

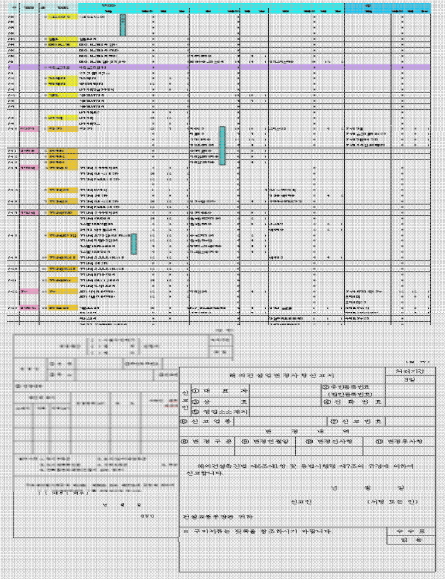
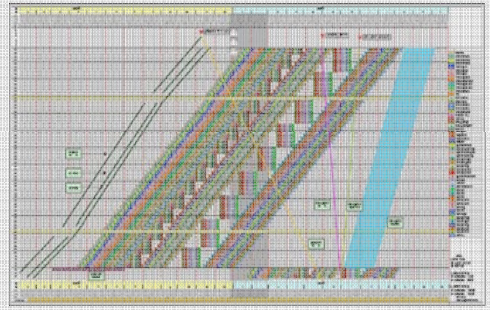


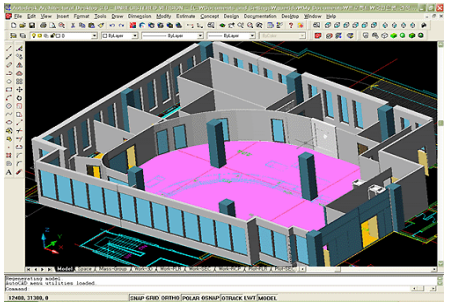
Diagram based Information

- CPM network Diagram
- Barchart etc.



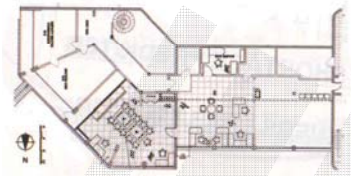
Graphic based Information

- 2D Drawing
- 3D Modeling
- 4D Modeling etc.

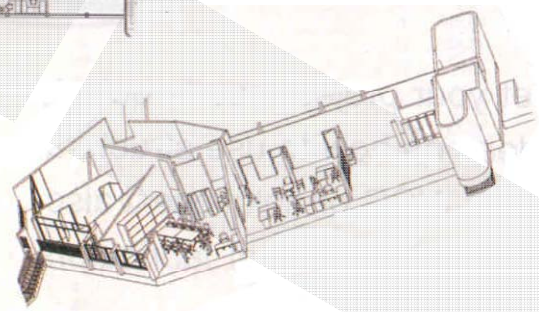


Development of Visual representation

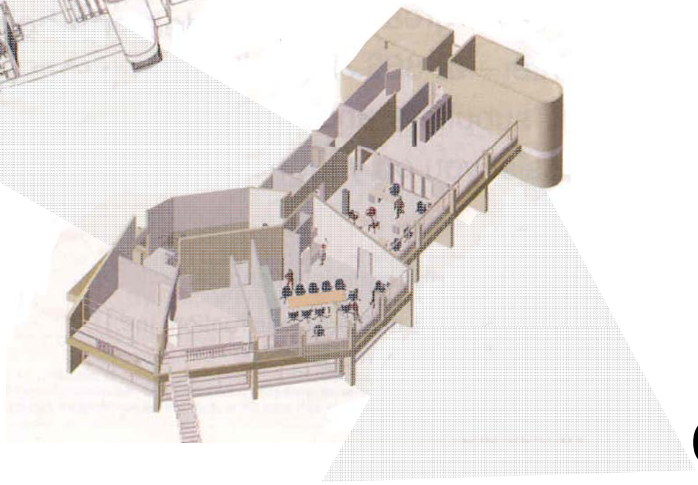
2D



3D



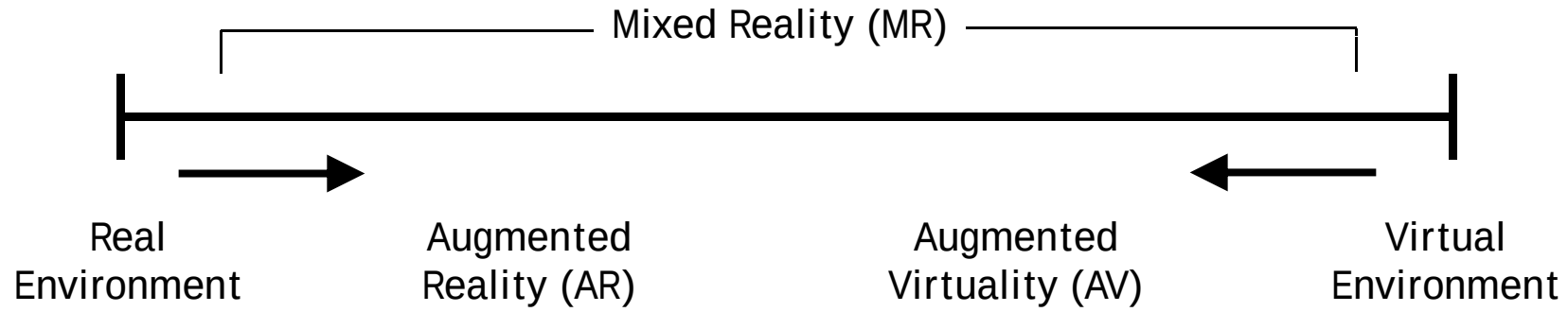
Rendering



Computer generated environment

Computer generated environment

- Virtual Reality
- Augmented Viruality
- Augmented Reality



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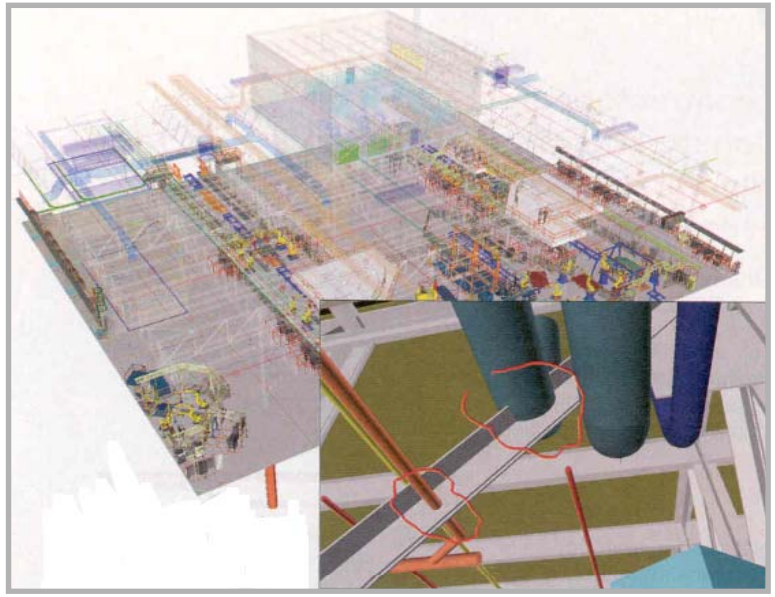
Virtual reality

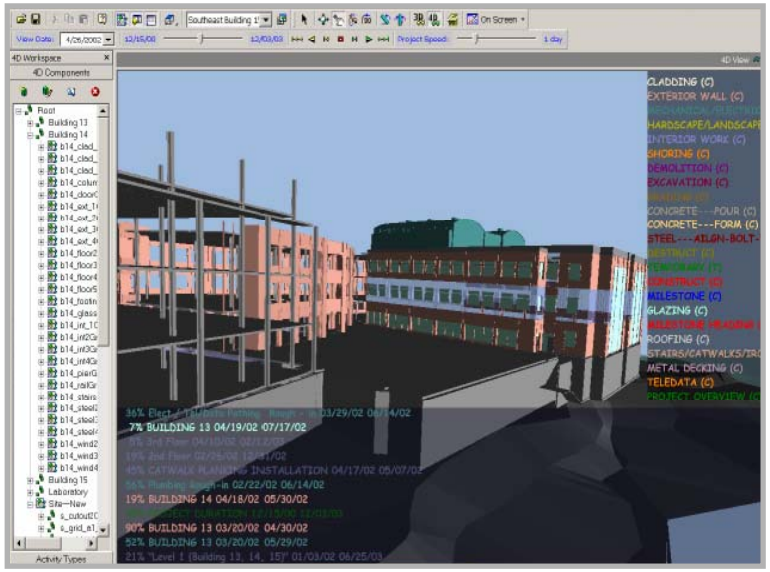
- "A computer generated, interactive, three-dimensional environment in which a person is immersed" (Aukstakalnis and Blatner 1992)
  - Computer generated three dimensional scene to provide an adequate level of realism
  - Real-time response from the system
  - Immersed in the virtual environment

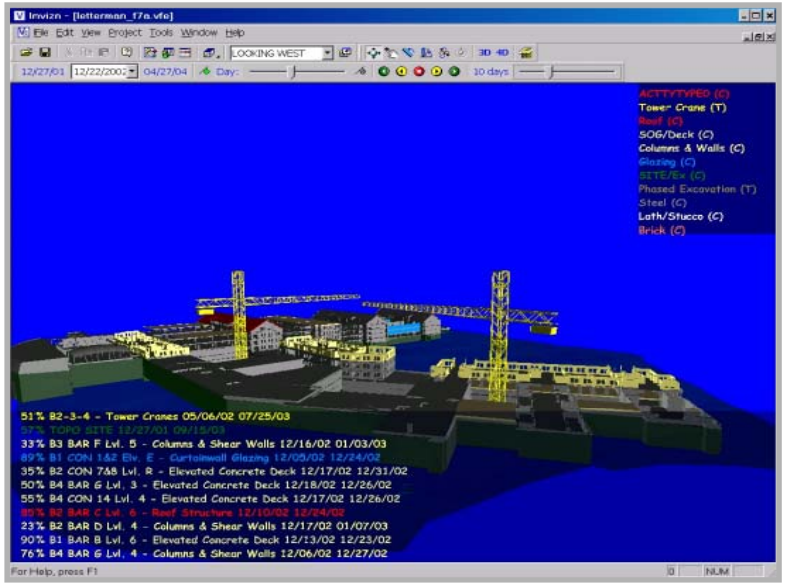
Virtual reality in design phase



Virtual reality in construction phase

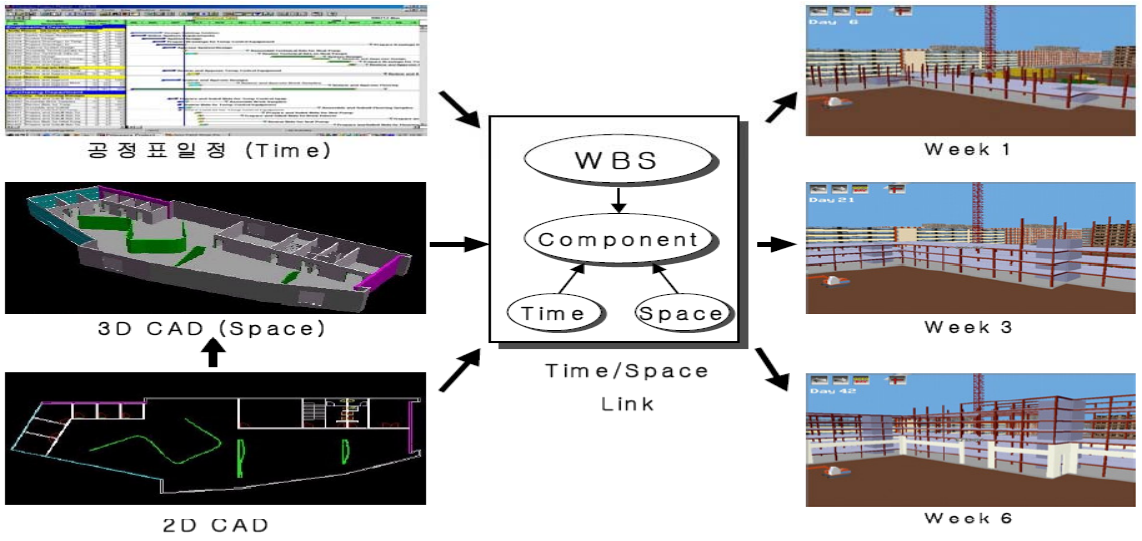
4D CAD





What is a 4D Modeling?

- 4D CAD SYSTEM
  - 2차원 공정표와 3차원 도면이 연계
  - 공사경과기간에 따른 시설물의 완성상태를 VR기술 등으로 구현
  - 공정표의 시간(Time)과 3D 도면(Space)이 통합구현되는 체계



What is a 4D Modeling?

4D History

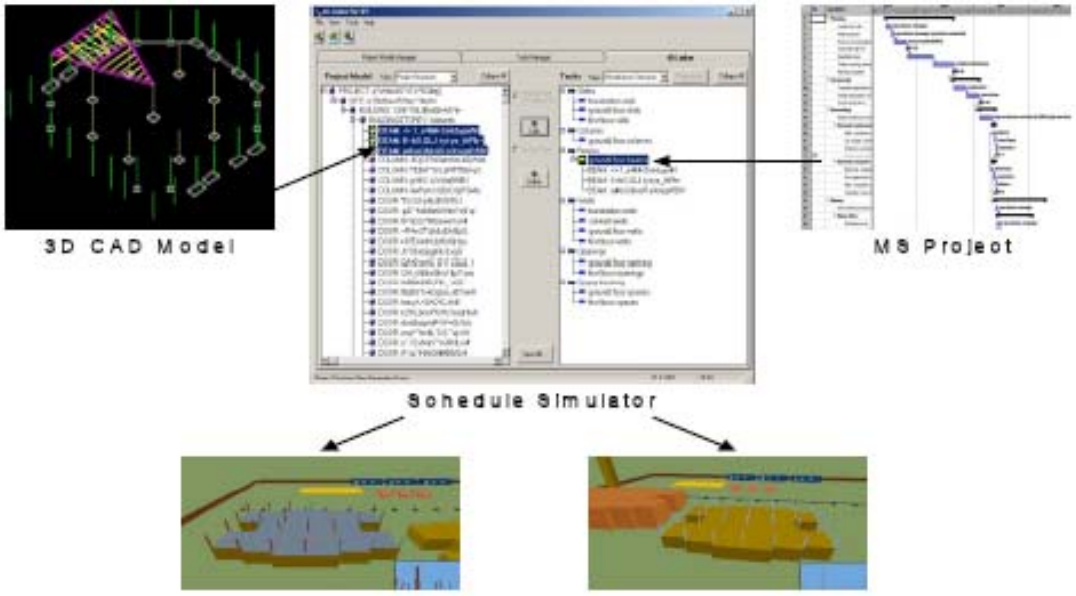
- First developed in the EPC industry for industrial project
- Bechtel 4D modeling software for Hitachi in 1987
- Commercial 4D products since 1992
- About seven 4D modeling tools on the market now
- Mostly deterministic, graphical 4D models

Constructing & Maintaining a 4D Model

- 4D CAD consist of
  - 3D CAD Tools
    - AutoCAD or MicroStation
  - Scheduling Tools
    - MS Project, Primavera etc.
  - Tools to link schedule to 3D model
    - Bently's Schedule Simulator, Integraph's Schedule Review etc.
  - Tools for Virtual Reality Modeling : Cosmo, Superscape, Cortona etc.

Constructing & Maintaining a 4D Model

- Schedule Simulator
  - 공정표상의 액티비티와 3D 도면 객체 연결
  - 4D 화면 생성



Constructing & Maintaining a 4D Model

- Key Issues

  In applying 4D models:

  - Identify the burning issues
    - Purpose and level of detail of model
  - Bring the team together in a timely manner
    - Organizational changes needed
    - Management guidelines needed
  - Every project has and needs lot's of project specific detail
    - Functionality to exchange and manipulate data needed

Constructing & Maintaining a 4D Model

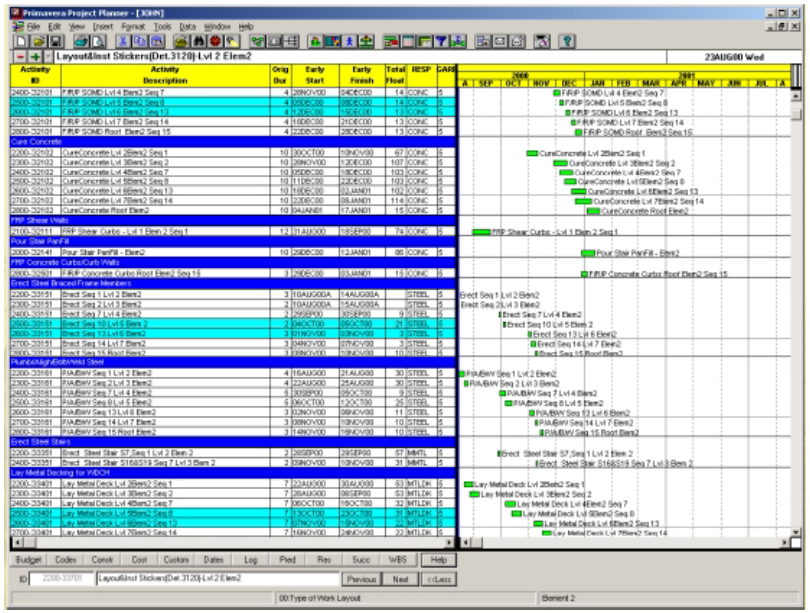
- Essential Features of 3D and 4D tools
  - Object-based
  - Import/export CAD objects from multiple platform
  - Import schedule data from multiple project management tools
  - Extensible and flexible data visualization
  - Easy data maintenance and manipulation
  - Easy-to-use interface for model producers and consumers

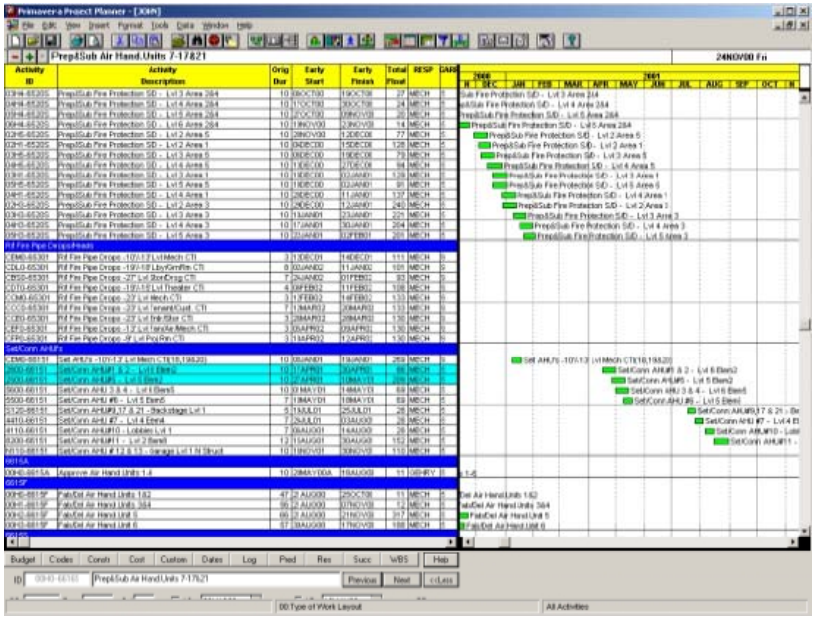
Reasons for 4D

"If you cannot build it virtually, you will not be able to build it in reality."

Martin Fischer

Reasons for 4D





Can you build the project according to this schedule?

Reasons for 4D

- Limitation of CPM schedule
  - Doesn't provide any information pertaining to the spatial context and complexities of the project components
    - Hard to identify mistakes (e.g., checking the schedule for its completeness and correctness of logic)
  - Abstract representation of the project schedule → need to interpret the activities to comprehend the sequence
    - Cause inconsistent interpretations of the schedule by different project members

Reasons for 4D

- Why 4D?
  - Communicate designs and schedules better
  - Make schedules more predictable
  - Integrate design and construction information
  - Evaluate constructibility and schedules
  - Resource planning
  - Coordinate trades and site logistics

Reasons for 4D

- 4D Solutions

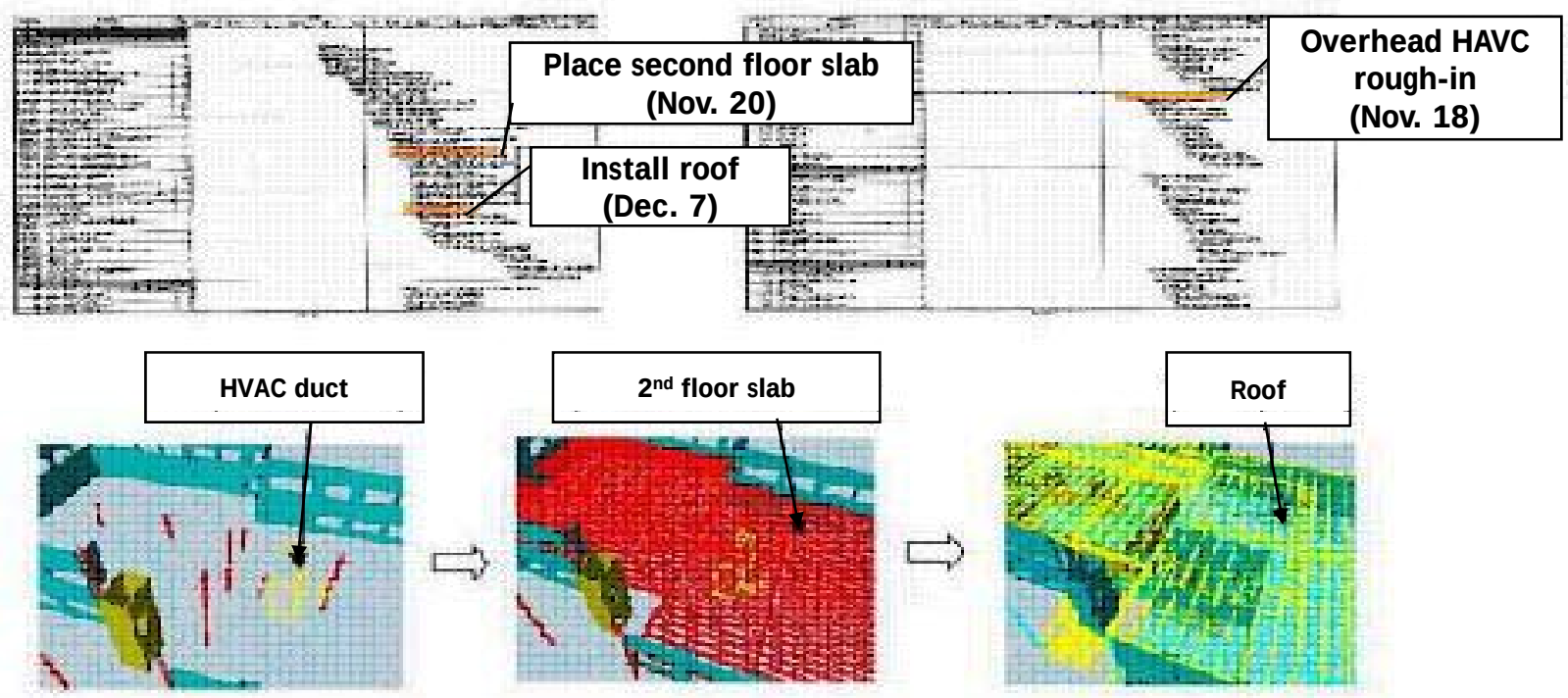
  4D models become the visual dashboard that:

  - Transform complex project data into relevant management information
  - Link schedule, cost, and resource data to a 3D project model
  - Interactively show the impact of design or schedule changes

Advantages of 4D as a Visualization Tool

- Visualizing and Interpreting construction sequence
  - Prevent miscommunication caused by inconsistencies in the interpretation of a schedule
  - Improve collaboration by better perception of the schedule
- Conveying spatial constraints of a project
  - Identify space-related conflicts
  - Show *what* is being built *when* and *where*
  - Detect a time-space conflict or anticipate an accessibility problem

Advantages of 4D as a Visualization Tool

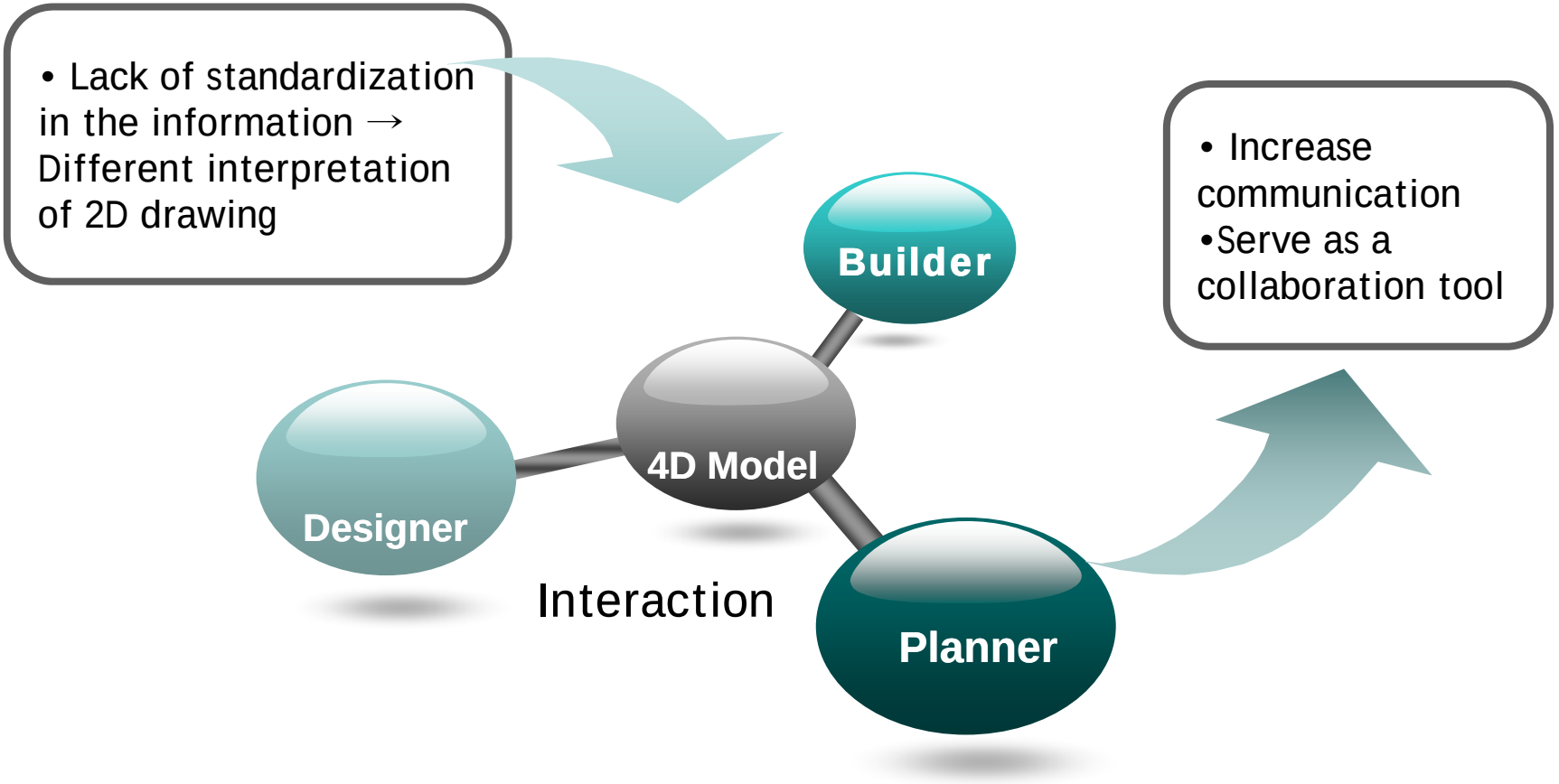


Problems related to the schedule

• HVAC system was scheduled to be installed before the second floor slab were completed. There would not have been support from which to hang the HVAC ducts
• The HVAC and electrical subcontractors are working on the second floor while roof is still being installed. But roof installation is not completed, there is no protection from the weather even though the execution dates are in the winter season.

Advantages of 4D as a Integration Tool

- Formalizing Design and Construction Information



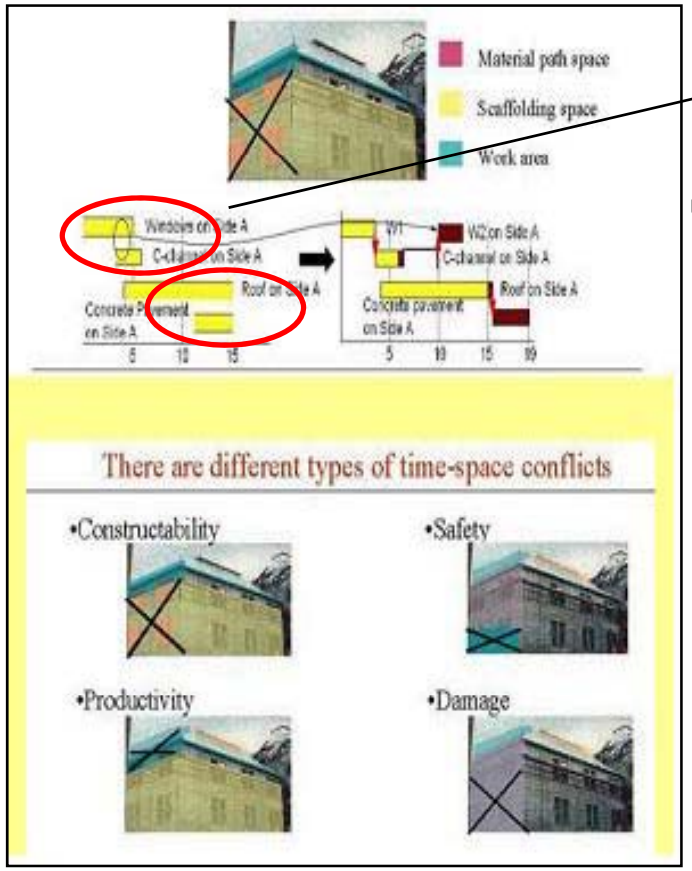
Advantages of 4D as Analysis Tool

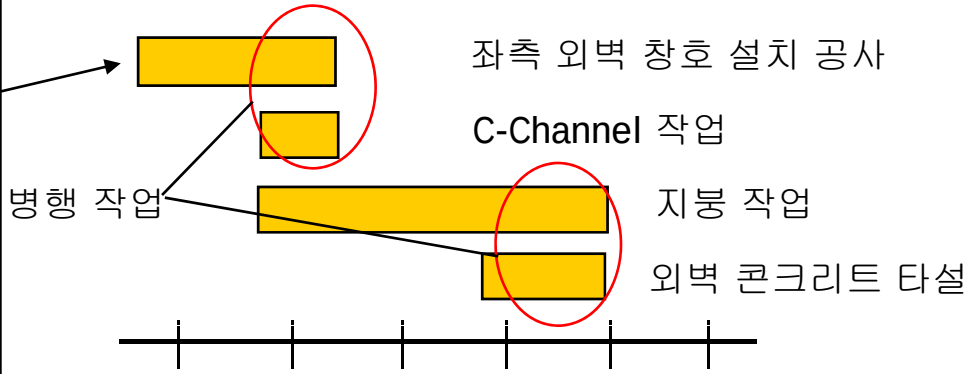
- Anticipating Safety Hazard Situations
  - By viewing 4D model

    1. Detect areas where accident may occur and execute prevention measures (such as placing warning signs, restricting access, or providing safety guards, etc.)
    2. Perceive how separate crews may affect one another and therefore inadvertently create hazardous situation

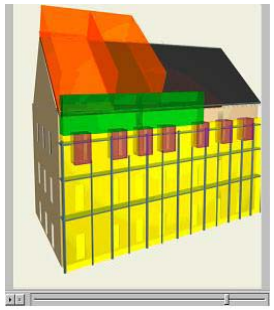
Advantages of 4D as Analysis Tool

- Analyze productivity and efficiency





As-planned schedule

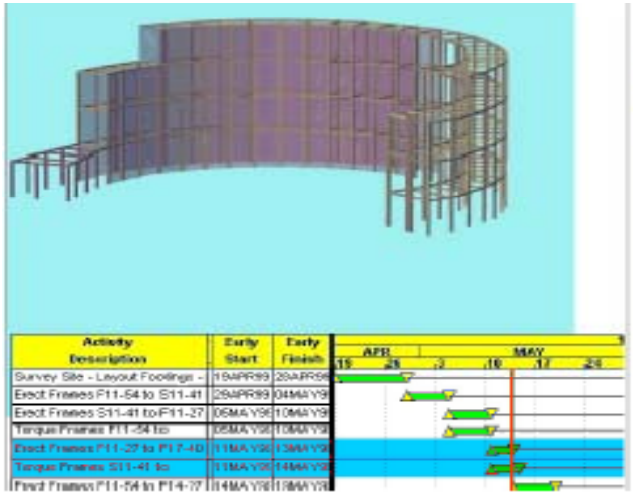


4D Simulation

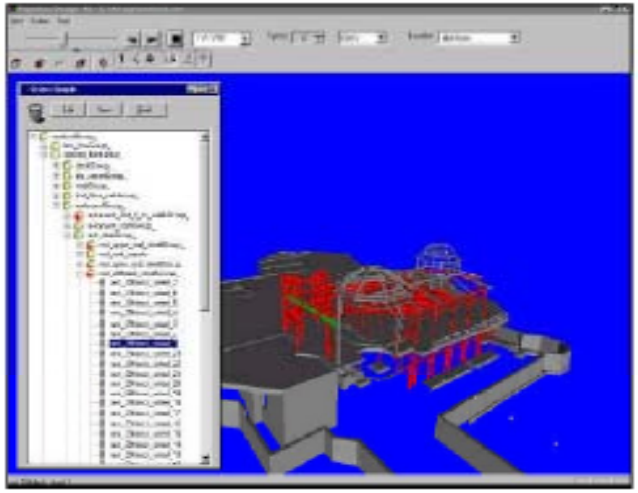
- 작업 여건상 창호 공사화 C-Channel 작업 불가
- 지붕 작업과 콘크리트 타설 병행시 지붕재의 낙하 및 타설면 손상 가능

Function Analysis of current 4D system

- 일정과 도면의 연계
  - 스탠포드대학 CIFE (Center for Integrated Facility Engineering)
  - 설계 정보 수정시 4D 재구현 어려움
    - 수정이 필요한 경우 일정정보와 3D모델정보 별도 수정필요



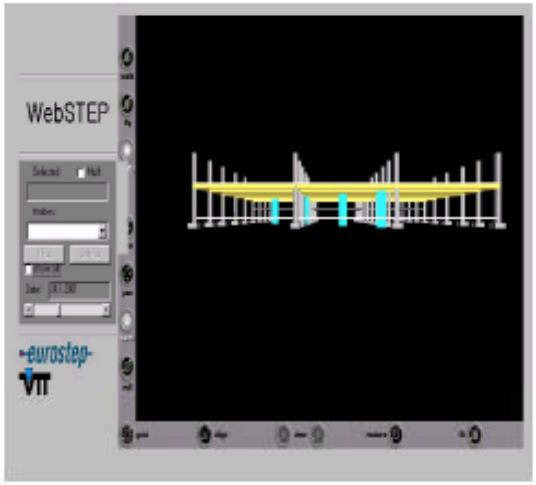
3D 모델 + P3



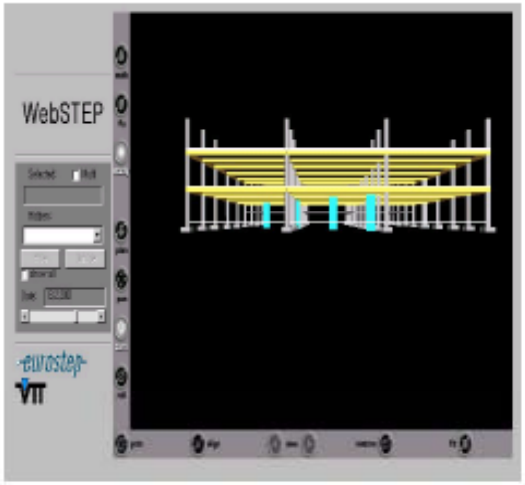
객체모델 연동

Function Analysis of current 4D system

- 객체모델의 연계
  - VTT (Research Center of Finland)
  - 객체 모델기반으로 구성된 파일 이용
  - CAD 정보파일 공유 및 호환



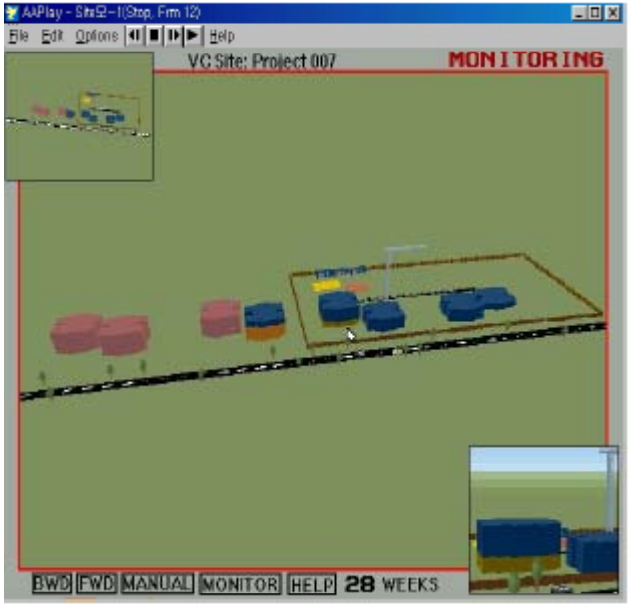
VTT (2001-03-02)



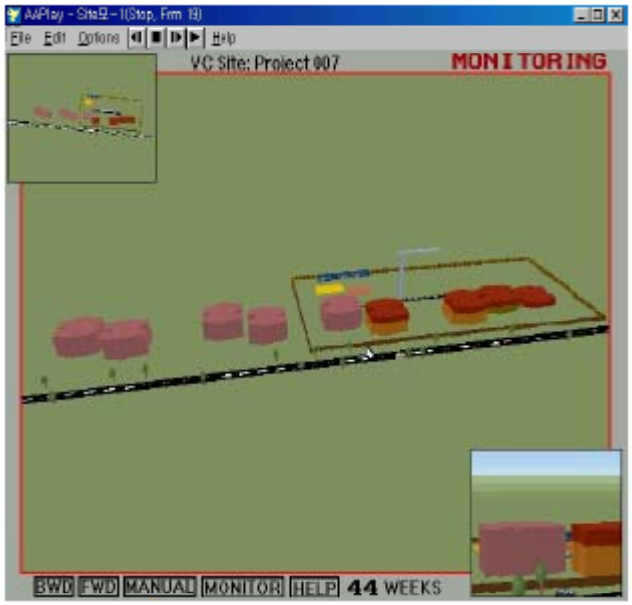
VTT (2001-03-15)

Function Analysis of current 4D system

- 진도관리기능의 연계
  - 스코틀랜드 Strathclyde 대학 VCSRG (Virtual Construction Simulation Research Group)
  - 계획대비 일정의 진도관리상태를 4D와 연동하여 시각적으로 표현(색상 차이)



진도초과 (28주)



진도지연 (44주)

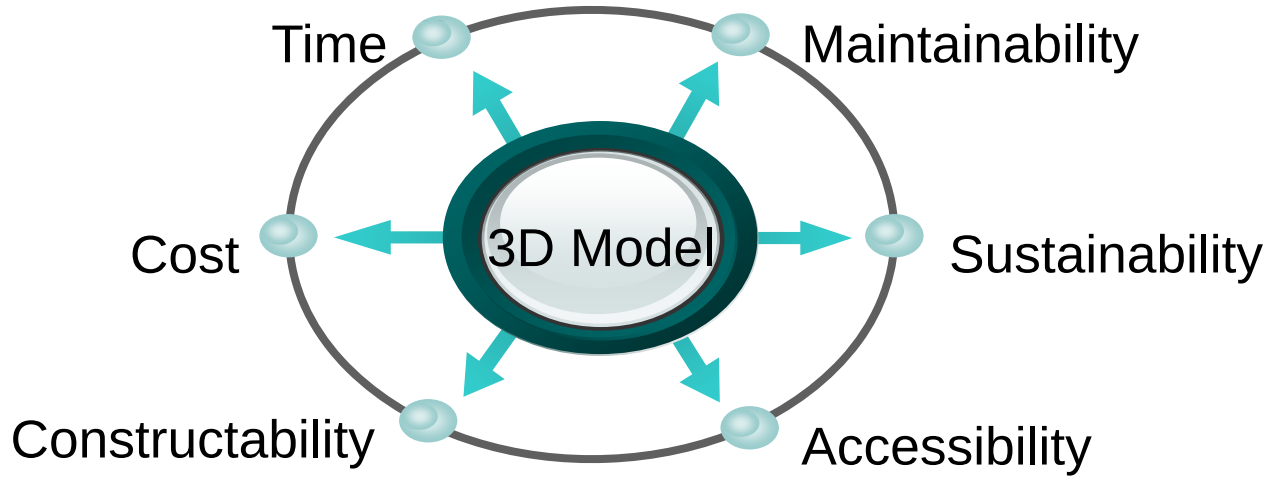
Function Analysis of current 4D system

- 자원, 비용관리의 연계
  - VirtualSTEP's 4D Navigator
    - 공정기능과 비용관리 및 유지관리기능 접목
  - CSA (Construction Systems Associates)
    - 액티비티별 물량과 비용 동시에 연계

- 일정의 진행기간을 일, 주, 달 단위로 조정
- 현재 진도율 47%

Beyond 4D

- nD CAD



  - This nD construction world encompasses infrastructure, methodologies and technologies that allows users to create, share, contemplate and apply knowledge from multiple perspectives of user requirements allowing construction professionals to perform true what-if analyses at a very early stage of a project.

Table of Contents

What is Augmented Reality?

- **Mixed Reality**
  - Real world objects + Virtual world objects in single display
  - Enhance the real world by superposing information onto it
  - Augmented Reality and Augmented Virtuality
    - AR : An environment wherein digital content (information, graphic) is inserted into the user's view of a real world scene
    - AV : enhance a virtual world with real world entities

Augmented Reality -Example

Augmented Reality -Example

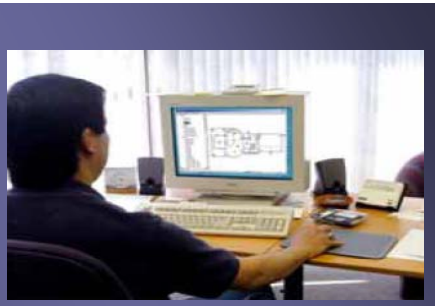
Virtual Studio

Augmented Reality Technology

Computer-generated Information

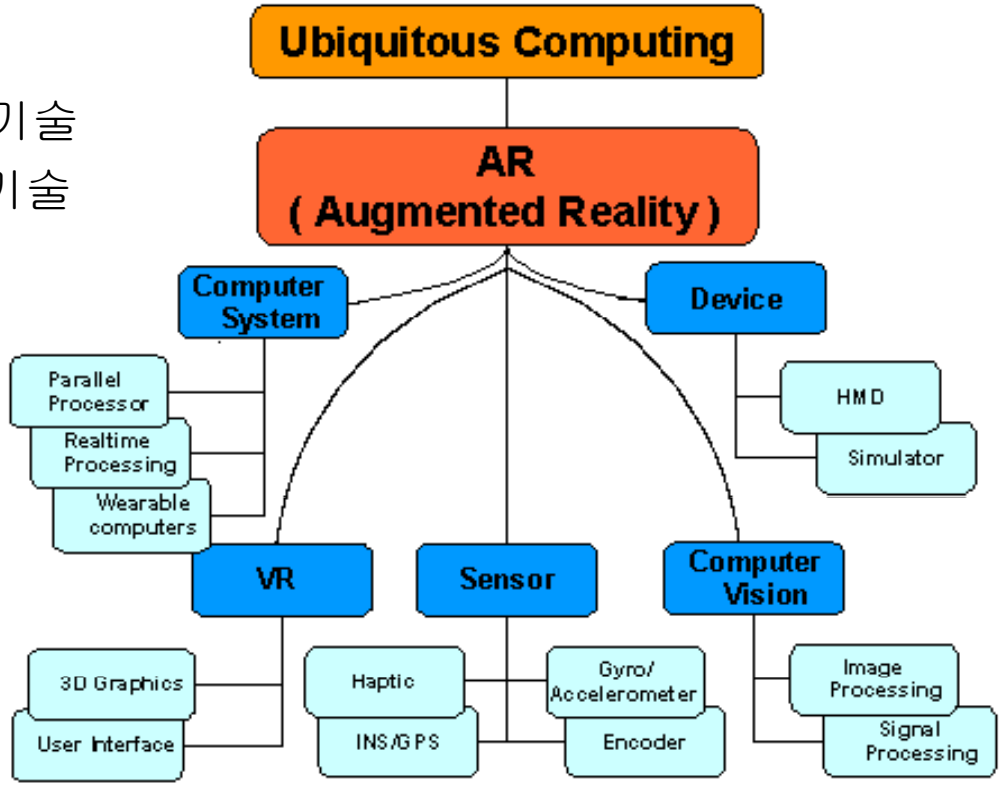
- Text
- Indicator
- 2D Image & Inserted video
- 3D wire frame
- 3D Data
- 3D Grouped Uni-Object
- 3D Ungrouped Objects

+ Real World



Augmented Reality Technology

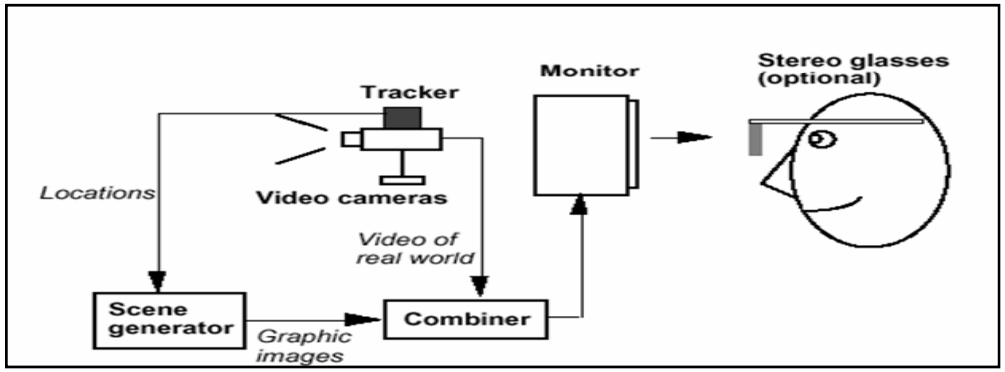
- AR 핵심 기술
  - 실시간 영상 처리
  - 3D Graphics
  - 실시간 모션 추적 기술
  - 실시간 S/W 개발 기술
  - Simulation 기술
  - System 통합 기술



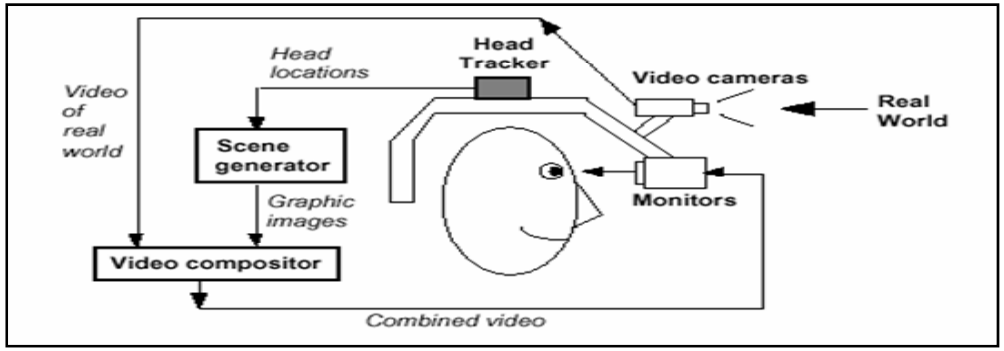
Augmented Reality Technology

Type of visual display

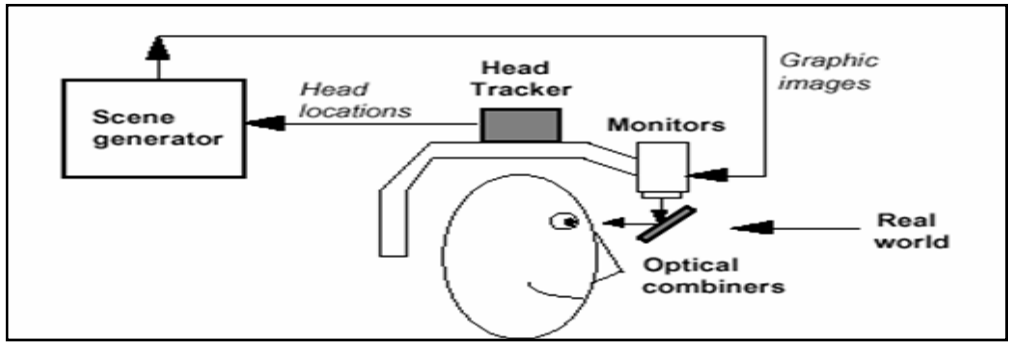
Monitor-based Display



Video-based see-through Display

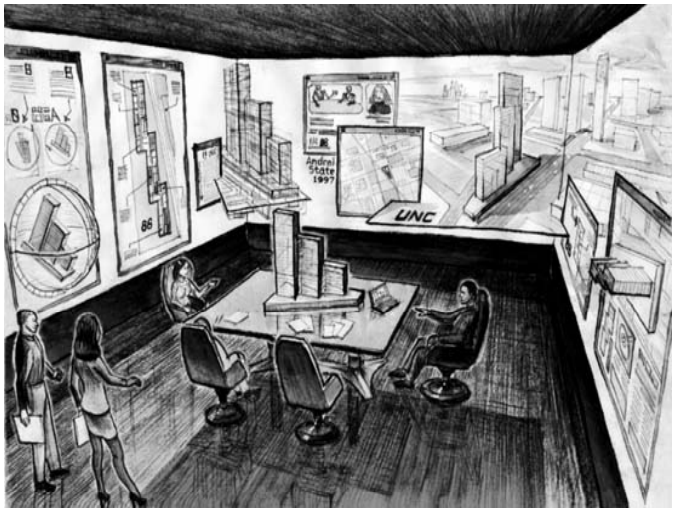


Optical-based see-through Display



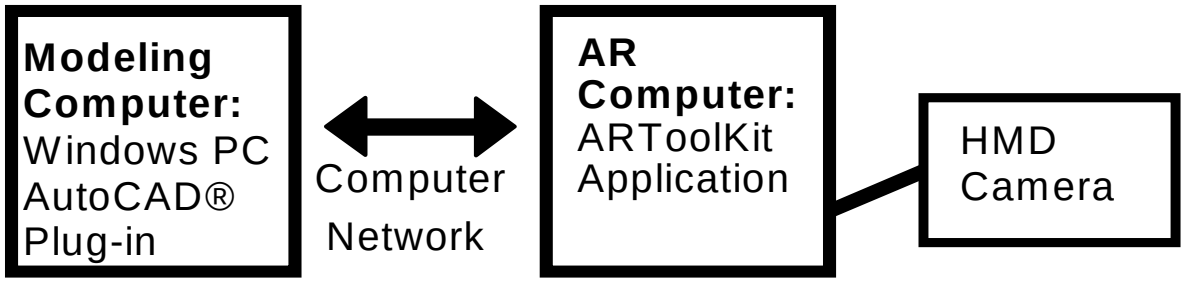
Application in construction (1)

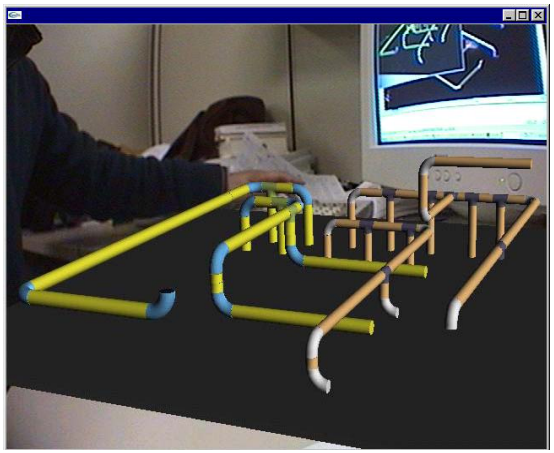
- Design and Marketing
  - Creating a design and evaluating it for function and esthetics, and showing a customer what a new structure will look like in its final setting. AR provide the unique opportunity to integrate the design into the real world

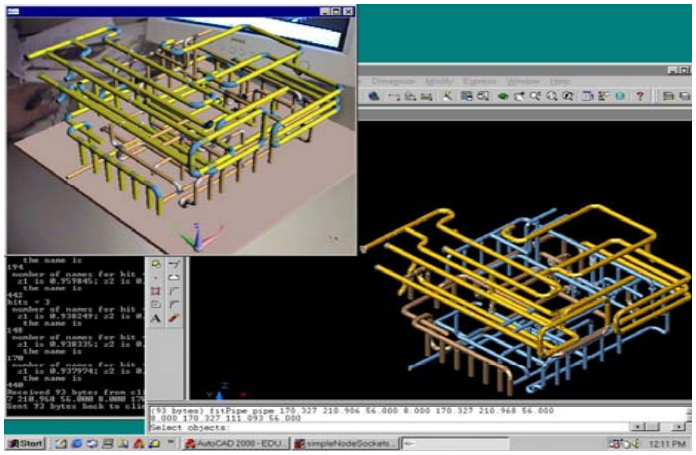


Application in construction (2)

- Design phase
  - Mixed reality AR-CAD in collaboration design in the perspective of spatial cognition.





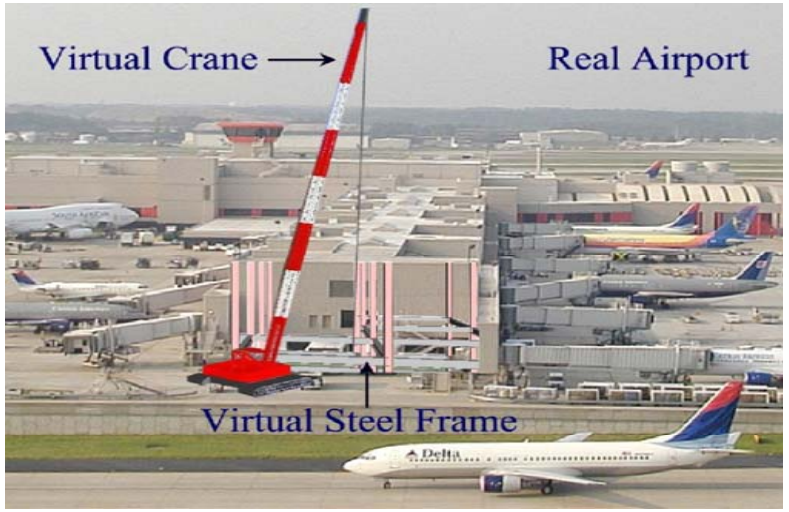


Application in construction (3)

- Planning phase

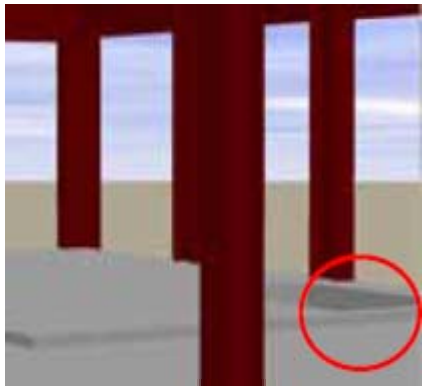
  project investigates methods to accurately superimpose (augment) graphical images of construction operations over real-world jobsites

  The ability to visualize simulated construction operations in 3D augmented reality can be of significant help in alleviating model engineering problems that affect traditional visualization in virtual reality.



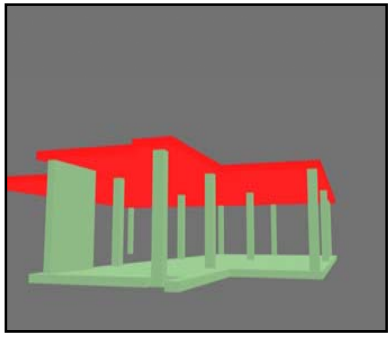
Application in construction (4)

- During Construction
  - Visualization whether an actual structure is built in accordance with the design
  - Quick update of work plans after a design change
  - Visualization of consequences of potential design changes before they are agreed upon.

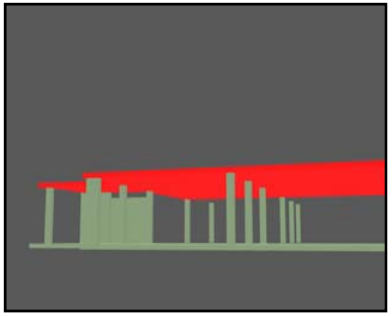


Application in construction (5)

- During Construction
  - Progress Monitoring



As-planned Schedule

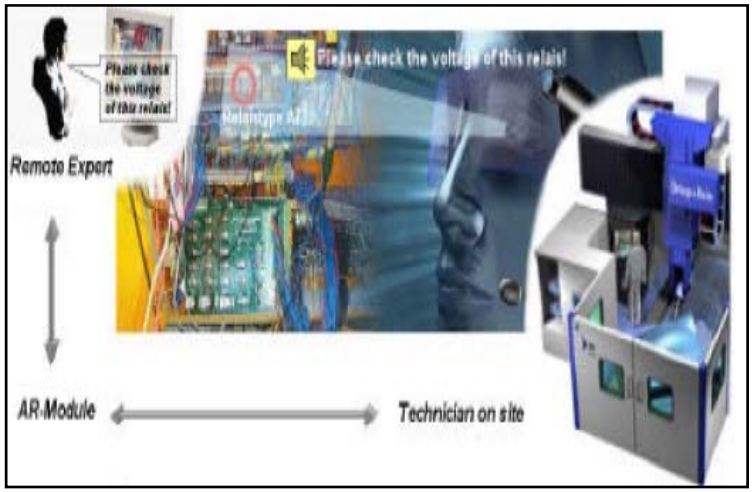


As-built Schedule

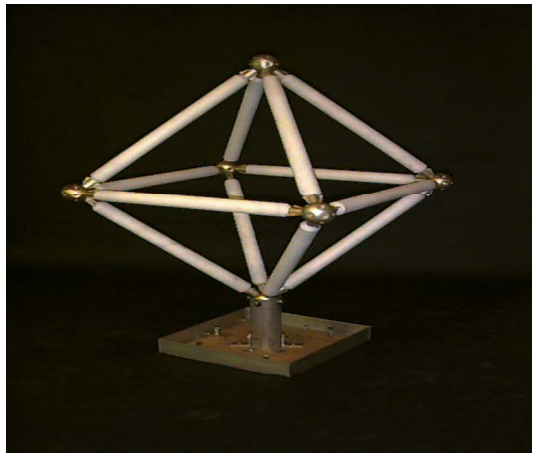
Application in construction (6)

- Maintenance and Renovation
  - Visualization of hidden information (wires, pipes, beams in a wall)
  - Visualization of non-graphical information (heat and pressure of pipes, maintenance schedules and records, manuals)
  - Visualization of potential redesigns (interior, exterior) to evaluate their compatibility with existing structures, and placement of new structure

PLAY



Application in construction (7)



Computer-generated Information

- 3D computer model of the spaceframe
- An ordered list of assembly steps
- A digitized set of audio files containing instructions for each step

1. Directs the worker to a pile of parts and tells her which part to pick up
2. Confirms that she has the correct piece (by scanning a barcode)
3. A 3D virtual image of the component indicates where to install the component
4. Verifies that the component is installed by asking her to scan the component with the tracked barcode scanner

Application in construction (8)

AR Viewing of Underground Utilities

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