

Einführung in die Erweiterte Realität

- 5. Mixed Reality, Information Presentation -

Gudrun Klinker

Nov 18, 2003

Agenda

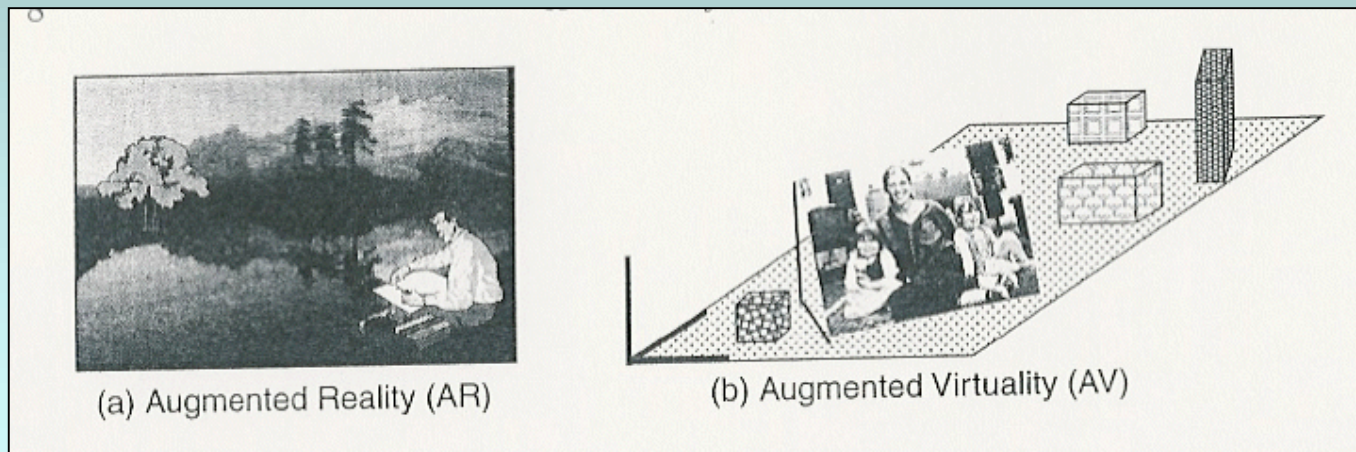
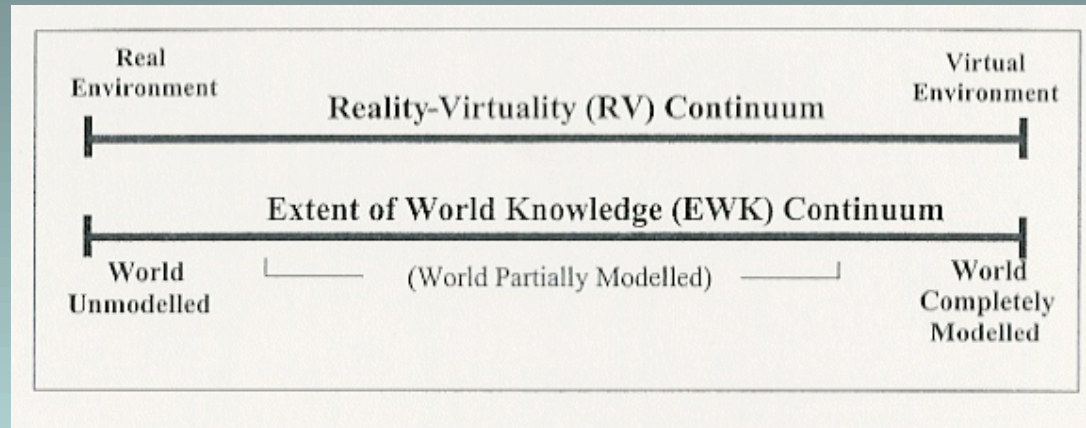
1. A Taxonomy of Real and Virtual World Display Integration (Paul Milgram & Herman Colquhoun Jr, ISMR'99)
2. Augmented maintenance of powerplants: A prototyping case study of a mobile AR system (Klinker et al, ISAR'01)

A Taxonomy of Real and Virtual World Display Integration (Milgram & Colquhoun)

What is Augmented Reality ???

- Augmentations shown in HMDs (“classical AR”).
- Augmentations shown on other displays (“any case in which an otherwise real environment is augmented by means of virtual objects”).
- Any mixture of real and virtual environments.

Reality-Virtuality Continuum



Augmented Reality

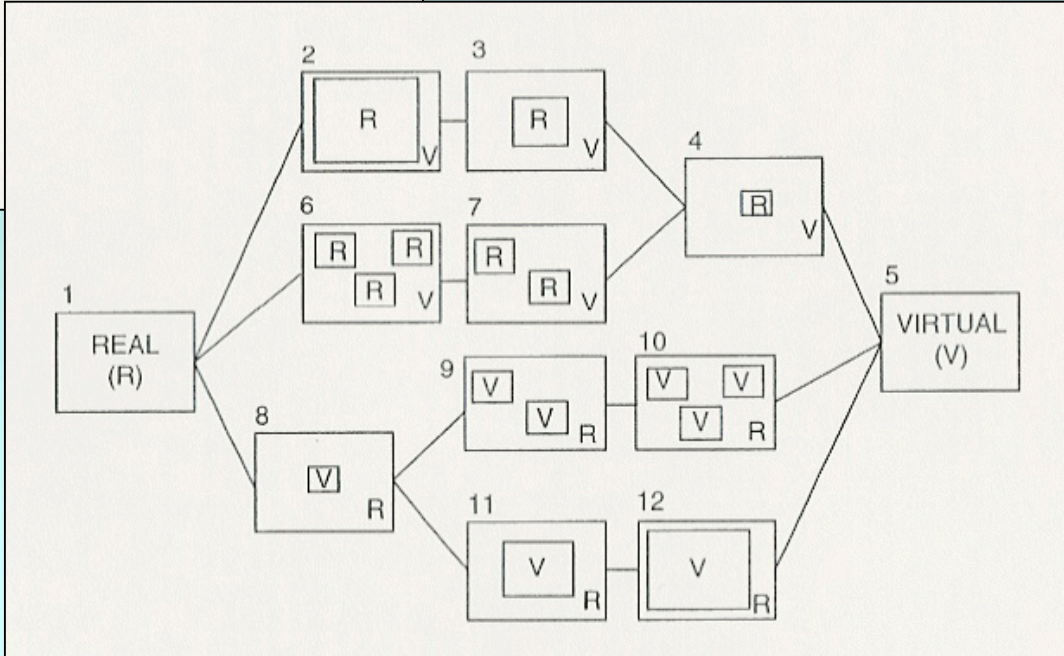
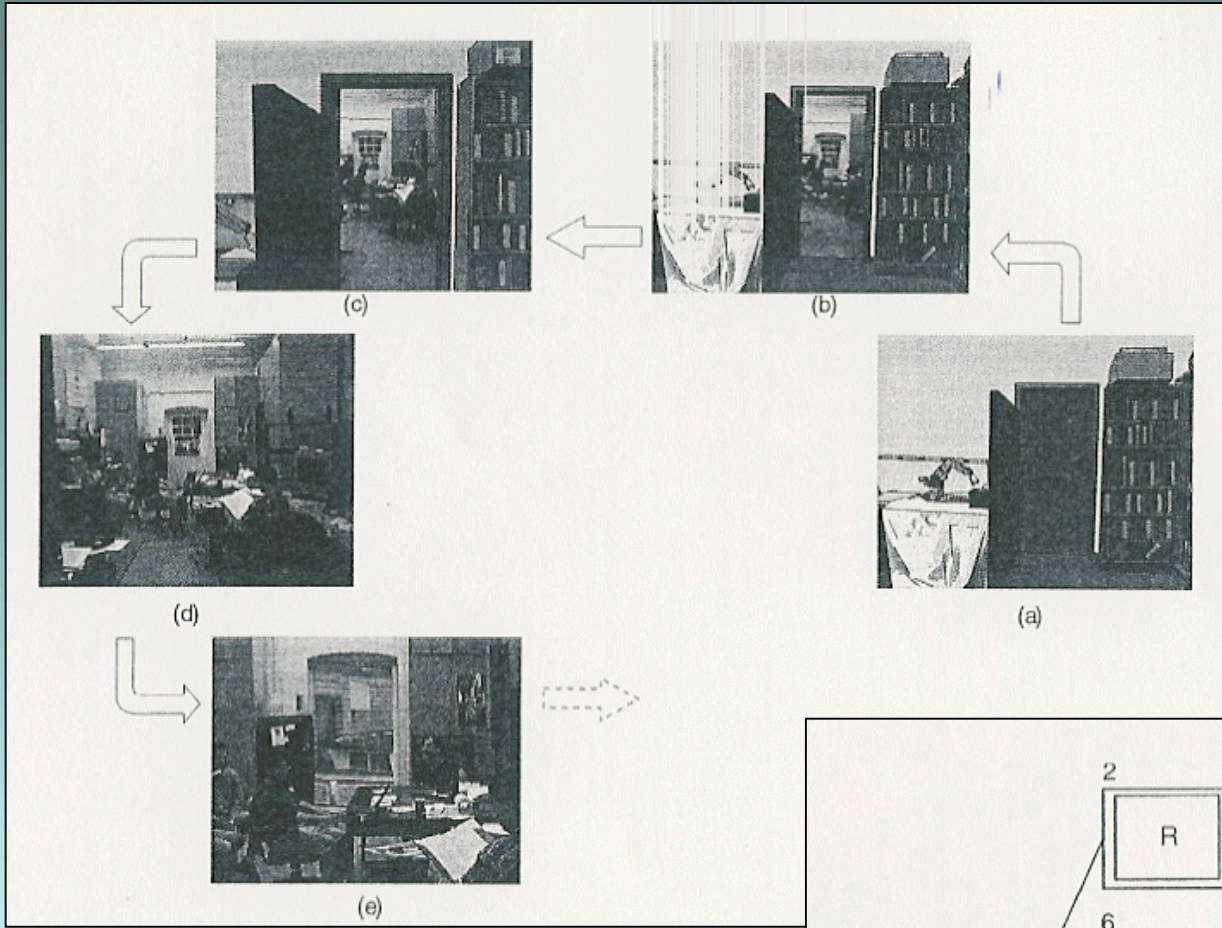
Occluded Reality

Diminished Reality

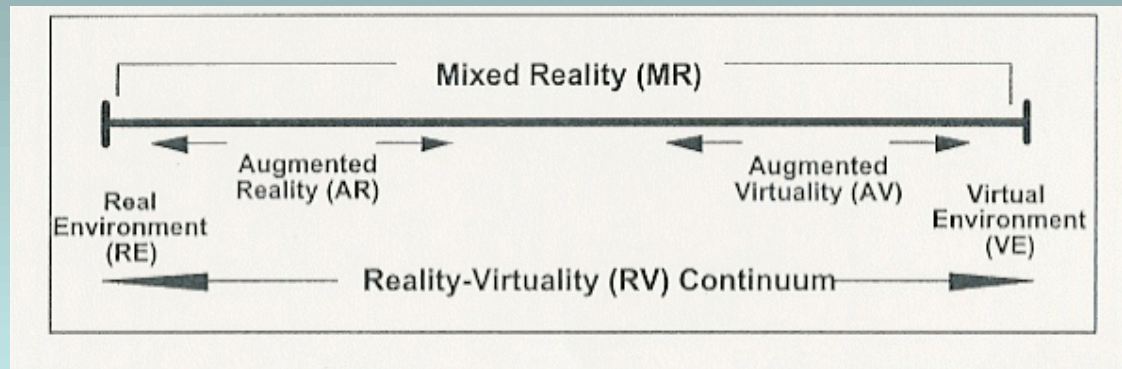
Reality Models

Virtual Studios

Virtual Models

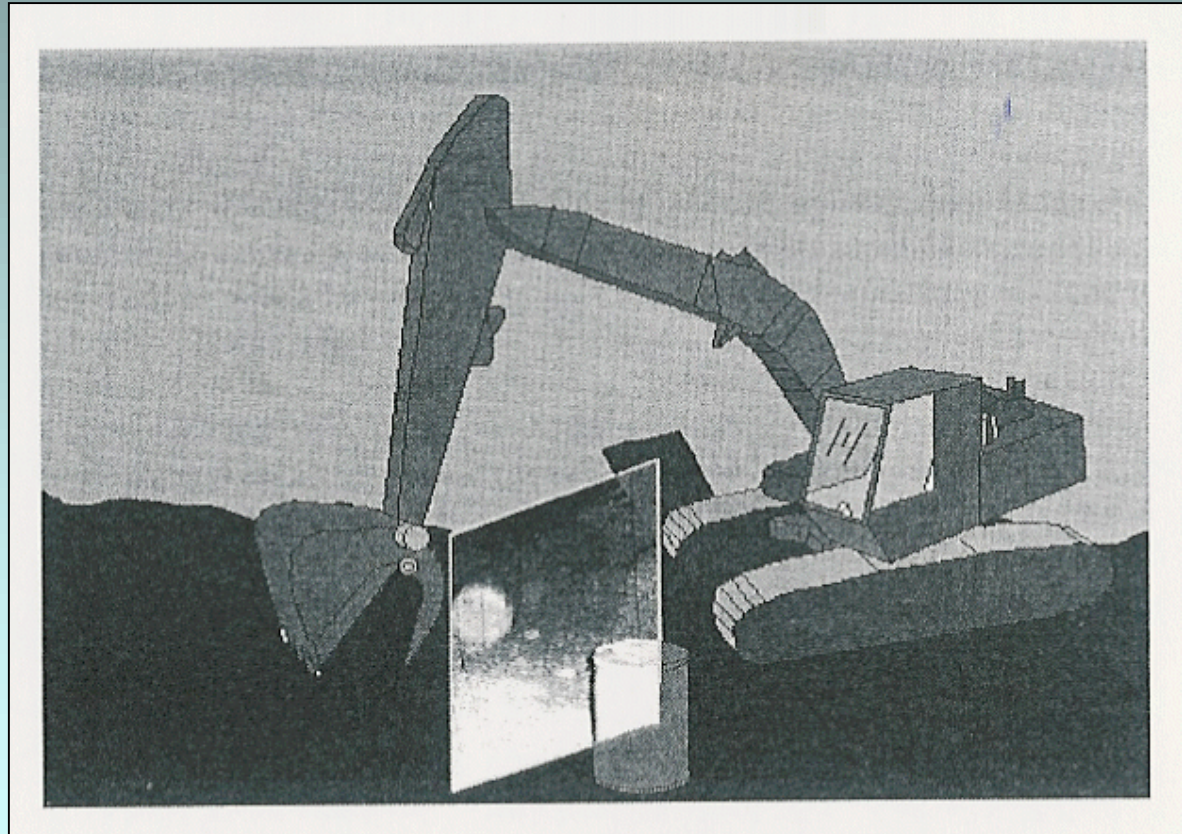


Mixed Reality

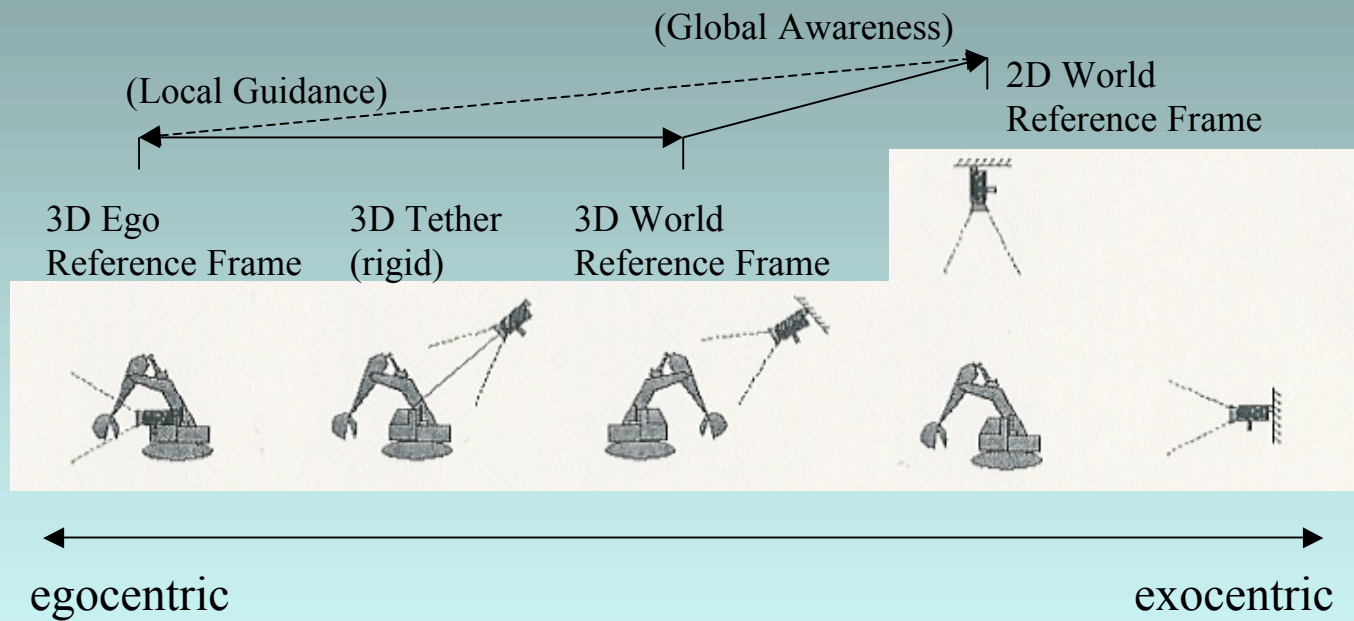


Remote Mixed Reality Excavation: - Long-distance Tele-Operation -

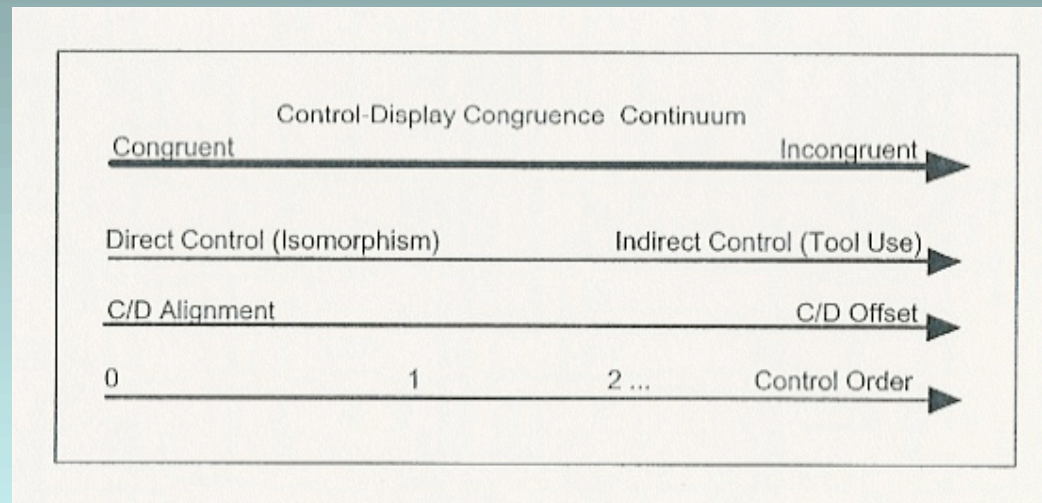
- Real site:
 - Video more detailed than model
 - Large time lag
- Control site:
 - Simulated operations
- Issues
 - Display centricity
 - Control-display mapping



Display Centricity



Control-Display Mapping

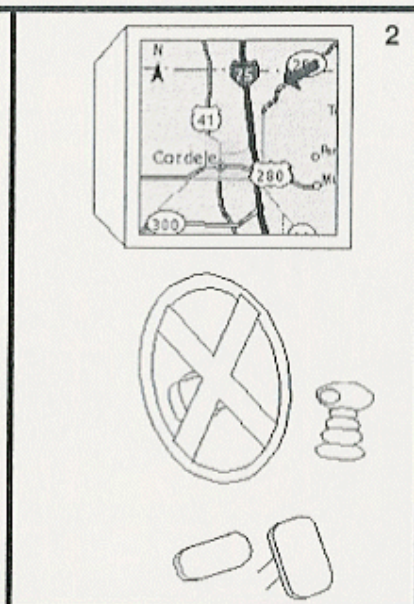
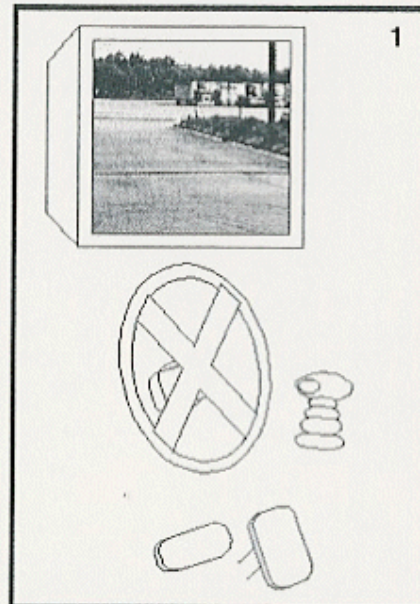


Displays

Egocentric

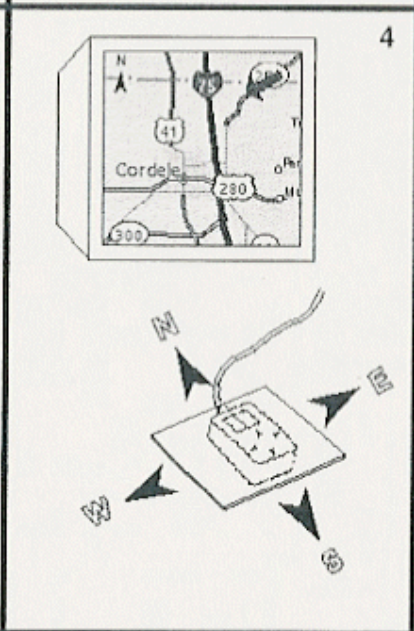
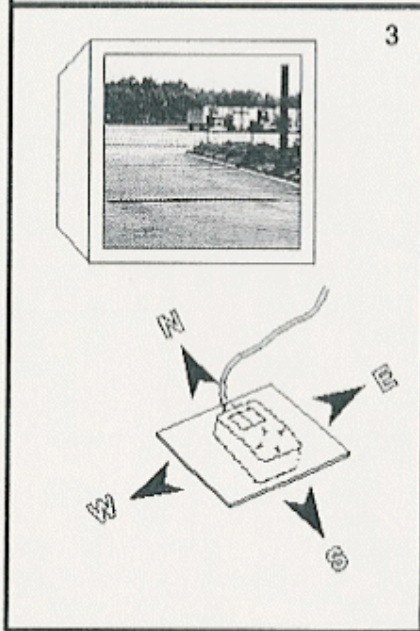
Exocentric

Ego-referenced

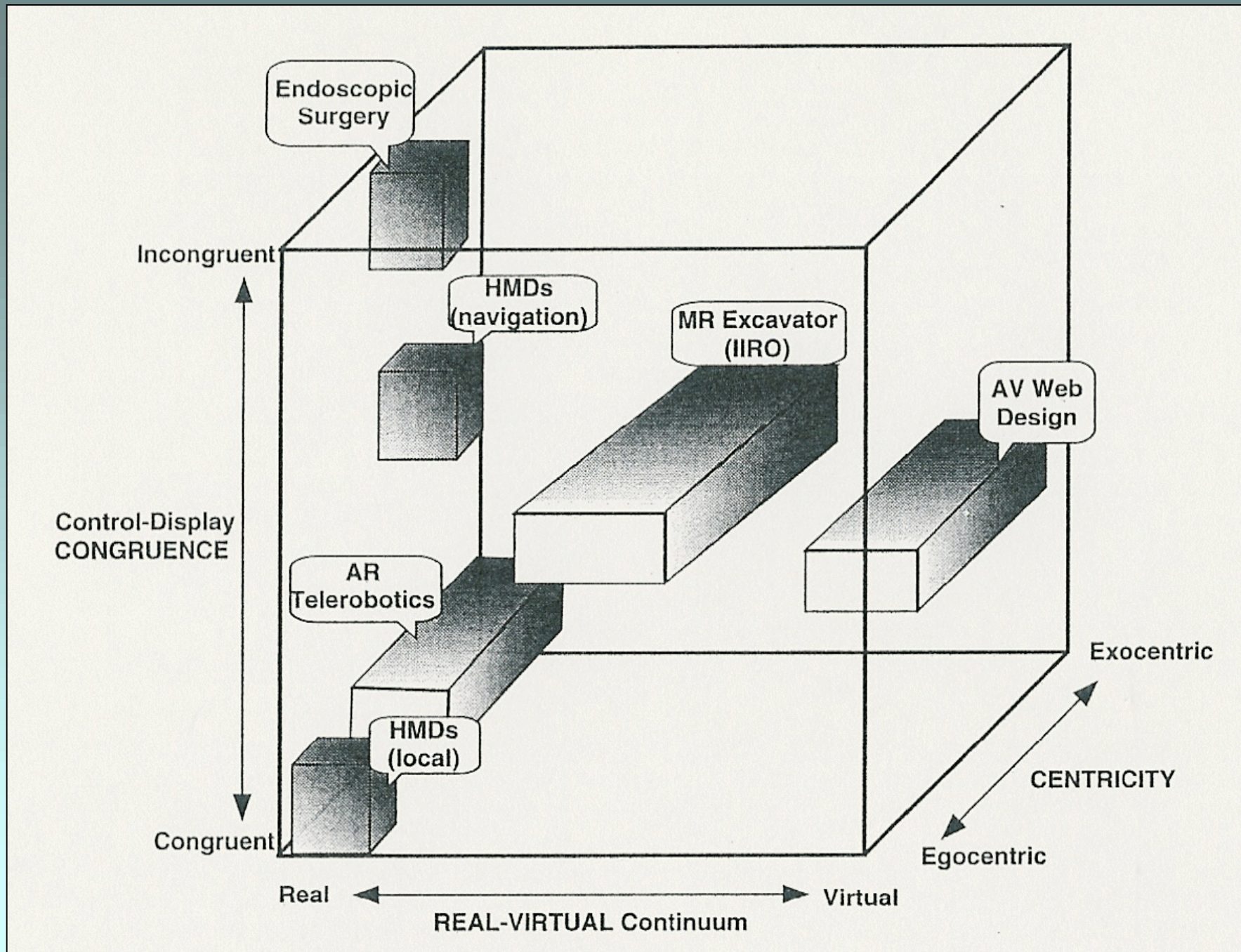


Controls

World-referenced



AR Taxonomy



STARS

*Augmented maintenance of
powerplants:
A prototyping case study of
a mobile AR system*

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Outline

- Goals & approach
- Motivation
- Problem domain
 - Current situation
 - Visionary situation
- STARS architecture
- Results
- Lessons learned

Goals & Approach

Long term goal:

- Provide an AR framework enabling information system developers to reuse and adapt AR components to their application domain.

Approach

- Conduct a series of case studies, prototyping with real clients visionary AR applications.
- Improve framework with lessons learned.

This presentation

- STARS case study in nuclear power plant maintenance (“Praktikum” at CMU and TU Munich).

Motivation

- Industrial settings of mobile AR systems introduce new issues in information systems:
 - Information storage and modeling
 - Transmission of information to the user
 - Visualization of massive information
- Current research focus in AR typically on:
 - Robust tracking
 - 3D graphics with HMD
- Related work:
 - Feiner et al.
 - Curtis et al.
 - ARVIKA

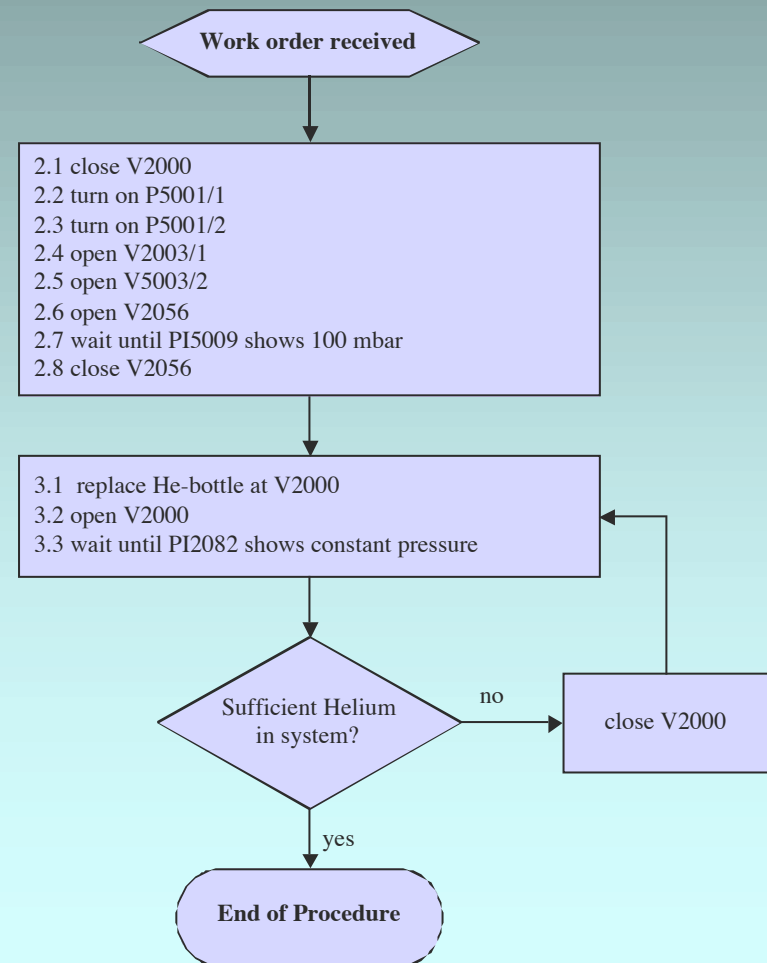
Problem domain: Nuclear powerplants

Conflicting criteria:

- Regulation compliance, safety
- Cost
- Parallel work

Highly encoded preventive maintenance procedure

Current system is paper-based



Current situation



He-System bis zu den geschlossenen Ventilen evakuieren,
dazu

Ventil, H	V2000	ZU	<u>vor F-Bau I</u>	
Vakuumpumpe	P5001/1	EIN	G-Haus	_____
Vakuumpumpe	P5001/2	EIN	G-Haus	_____
Ventil, H	V5003/1	AUF	G-Haus	_____
Ventil, H	V5003/2	AUF	G-Haus	_____
Ventil, H	V2056	AUF	G-Haus	_____

Warten (evakuieren) bis
Druckanzeige an

Meßstelle (Evakuier-Sammelleitung)	PI5009	$1 \cdot 10^{-1}$ bar abs	G-Haus	_____
dann				
Ventil, H	V2056	ZU	G-Haus	_____

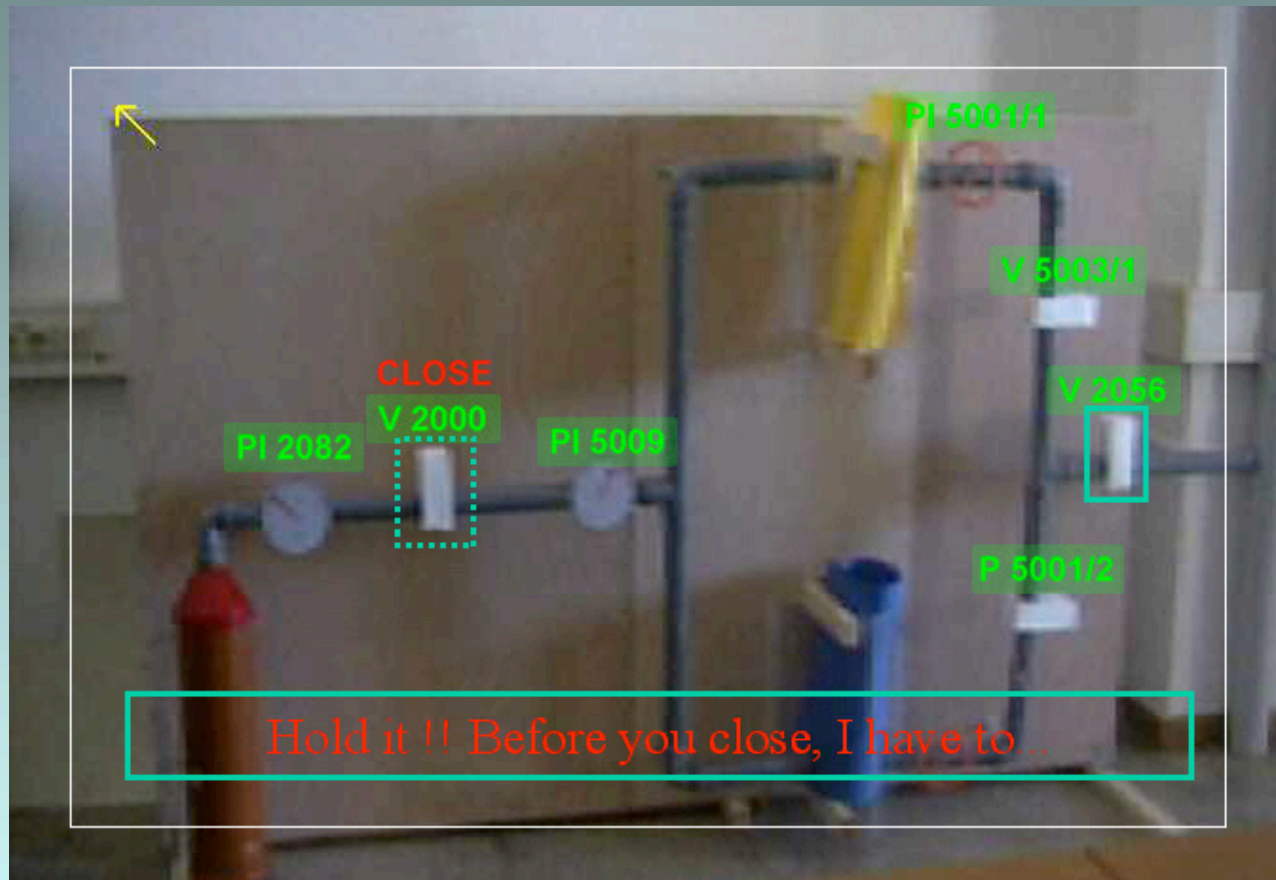
Visionary situation: IETMs

- Interactive Electronic Technical Manuals
- Hierarchical, executable procedures, analog to a computer program.
- Steps are organized in conditional statements and in loops.
- Already used in aircraft maintenance.

The screenshot displays an XML editor interface with a tree view on the left and a detailed view of the selected XML element on the right. The tree view shows a hierarchy starting with 'techinfo', followed by 'system', 'task', and 'step-seq'. The detailed view shows the following structure:

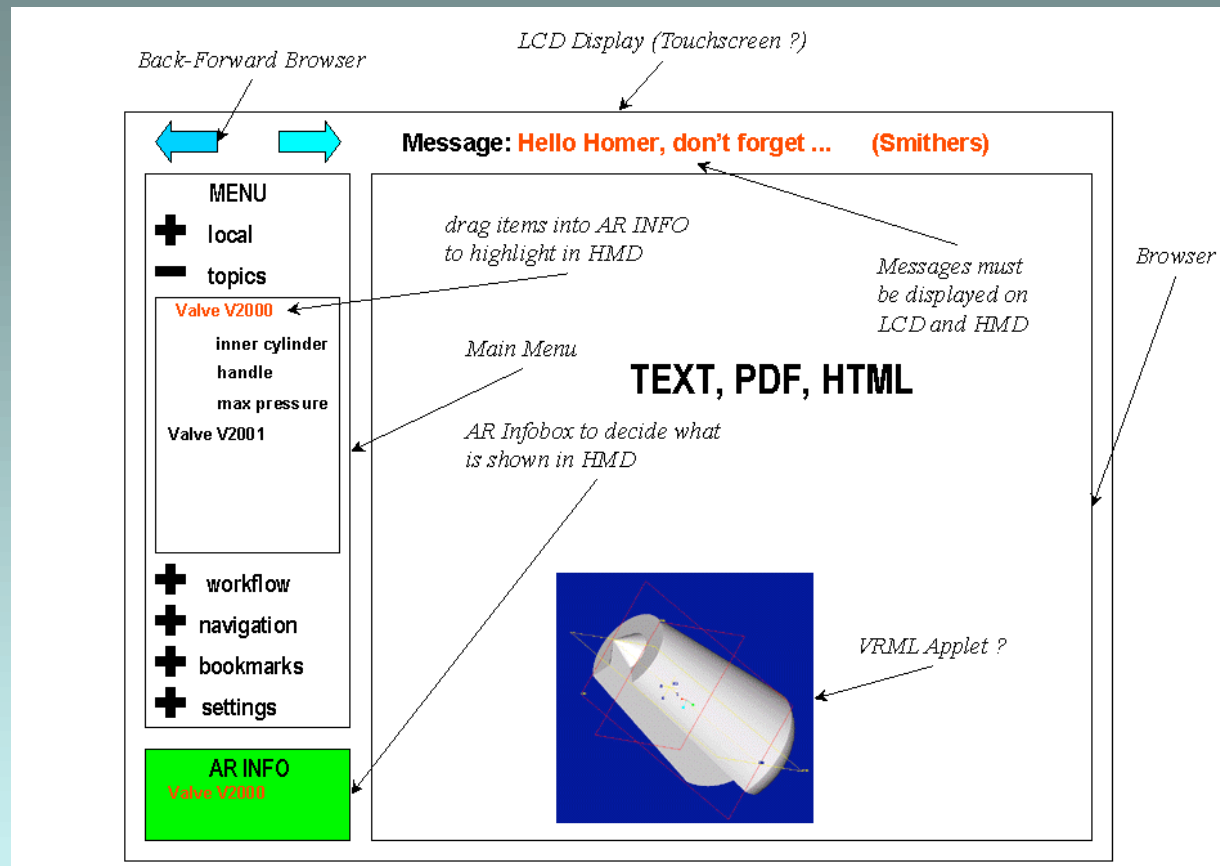
id	id1
name	Helium Flushing System
starttopic	id100
system	
id	id10
name	Helium Flushing System
task	
id	id100
name	Bimonthly Check of Helium Flushing System
step-seq (4)	
id	id2
step	step (0)
id	id3
step	step (3)
id	id4
loop-step	
id	id41
expression	
id	id410
expression	id=rid411
id	id412
expression	id=rid413
step-seq	id=rid420
id	id5
step	step (1)
partinfo	
name	helium
id	id61
partbase	partnum=He id=id65 name=helium bottle:
location	id=id61001 location-x=42 location-y=5

Visionary situation: HMD



- The technician wears an HMD
- Augmentations indicate device IDs
- Individual devices involved in the procedure are emphasized.

Visionary situation: LCD

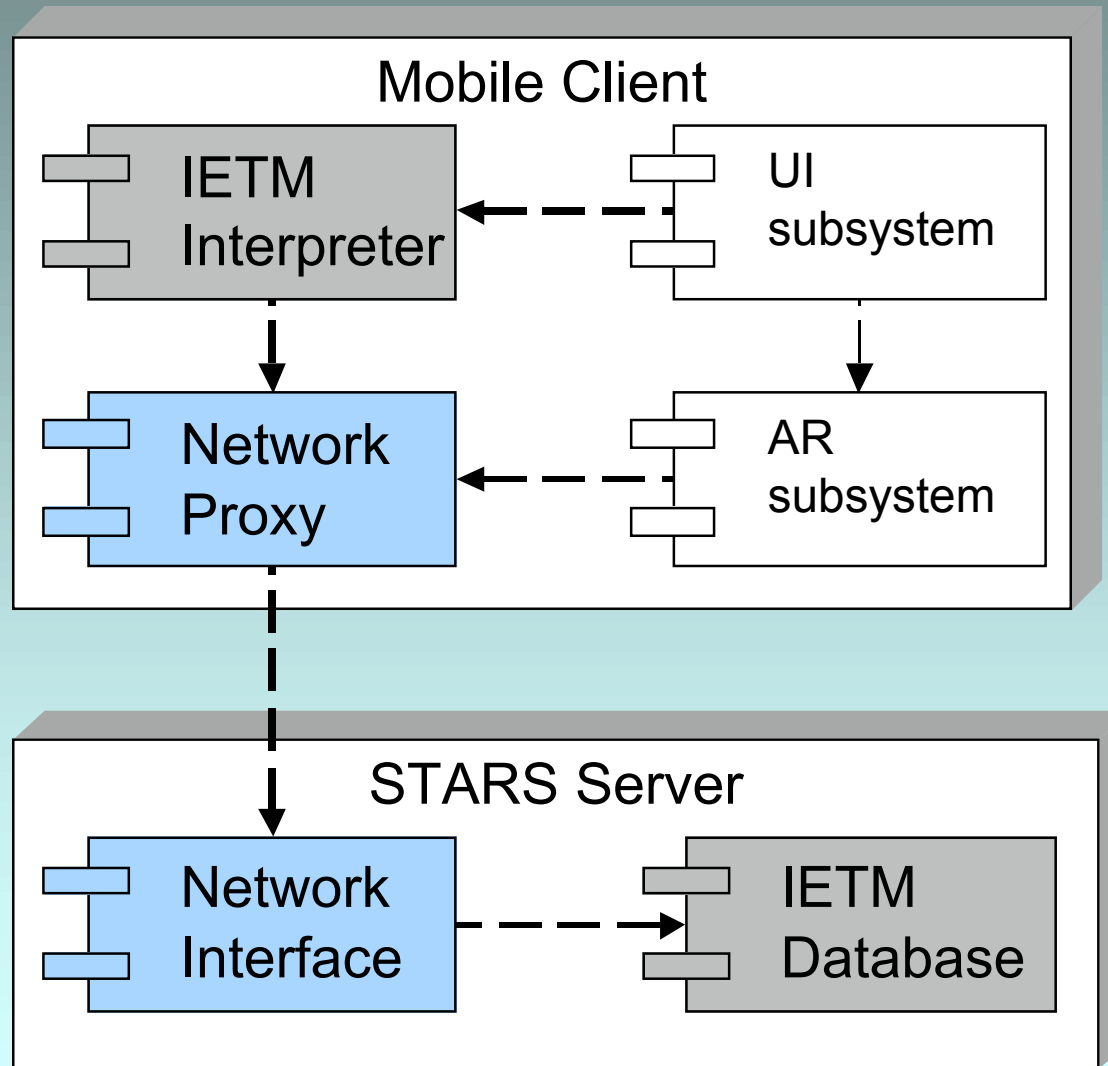


- High density information is displayed on an LCD plate
- The HMD display can be flipped up to enable the technician to examine the LCD plate.
- The LCD plate is stowed away when not needed.

Constraints & Challenges

- Wireless network
 - Mobile client should be able to function, even in the absence of a network connection
- Multimodal user interface
 - User must be able to select a user interface mode most appropriate to its work and environment
 - Speech, AR, LCD-plate, mouse, [smartcard, iButton]
- Legacy information
 - Current maintenance manuals are on paper
 - Need to be converted into IETMs
 - Need to be related with geometrical world model

STARS Architecture



STARS Subsystems

IETM

- Interpreter is separated from the database and runs on client
- Enables execution of procedure in the absence of connection

Network

- Transparent retrieval of IETMs and supporting material (video, audio, etc.)
- Prefetch and caching based on:
 - Location
 - Work order
 - statistical analysis of history

User Interface/AR

- Tsai tracking
- High-level commands between UI and AR

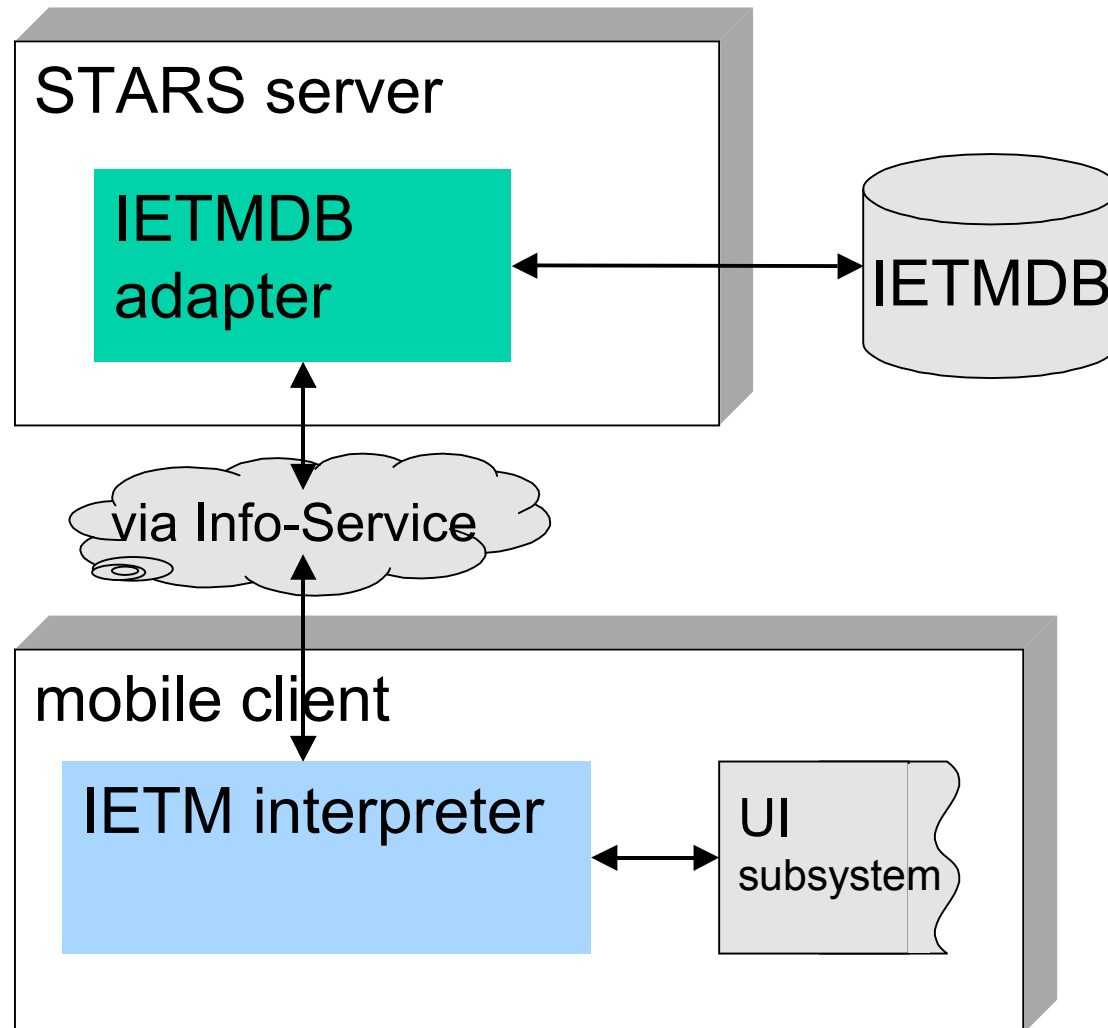
STARS Subsystems : IETMs (Interactive Electronic Technical Manuals)

- Specification by DoD (SGML or XML)
 - MIL-M-87268: behave and look
 - MIL-M-87269: database spec & DTD
- in STARS: XML formatted IETMS (DTD derived from 87269)

The screenshot displays an XML editor interface with a tree view on the left and a detailed view of the selected XML element on the right. The tree view shows a hierarchy starting with 'XML', followed by 'DOCTYPE techinfo', 'techinfo', 'system', 'task', 'step-seq', and 'loop-step'. The detailed view shows the following structure:

id	id1	
name	Helium Flushing System	
starttopic	id100	
system		
id	id10	
name	Helium Flushing System	
task		
id	id100	
name	Bimonthly Check of Helium Flushing System	
step-seq (4)		
id	step	loop-step
1	id2	step (0)
2	id3	step (3)
3	id4	
loop-step		
id	id41	
expression		
id	id410	
expression	idrid411	
id	id412	
expression	idrid413	
step-seq	idrid420	
4	id5	step (1)
partinfo		
name	helium	
id	id61	
partbase	partnum=He id=id65 name=helium bottle:	
location	id=id61001 location-x=42 location-y=5	

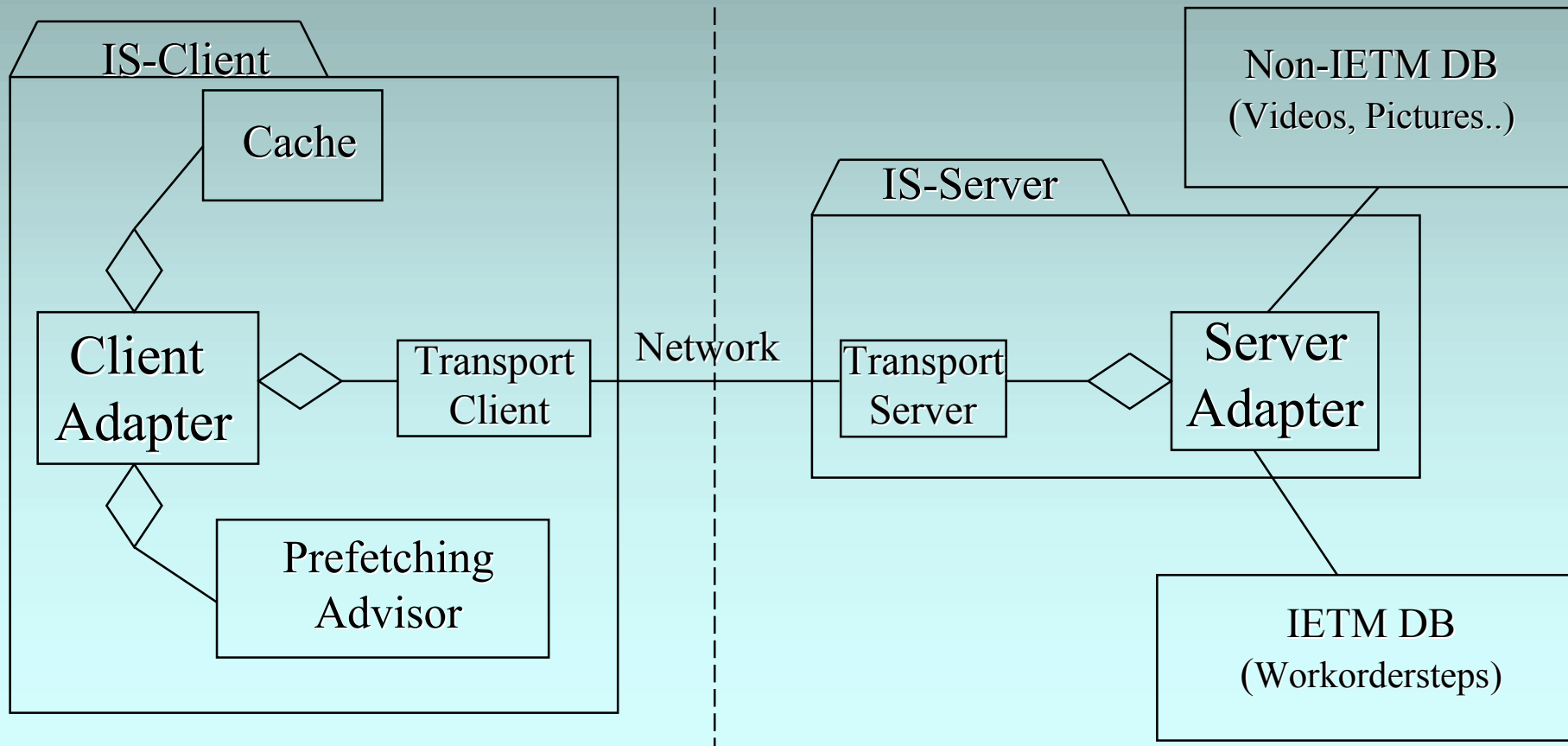
STARS Subsystems: IETM Overview



- Interpreter is separated from the database and runs on client
- Enables execution of procedure in the absence of connection

STARS Subsystems: Network

- Transparent retrieval of IETMs and supporting material (video, audio, etc.) across unreliable network connections
- Prefetching and caching



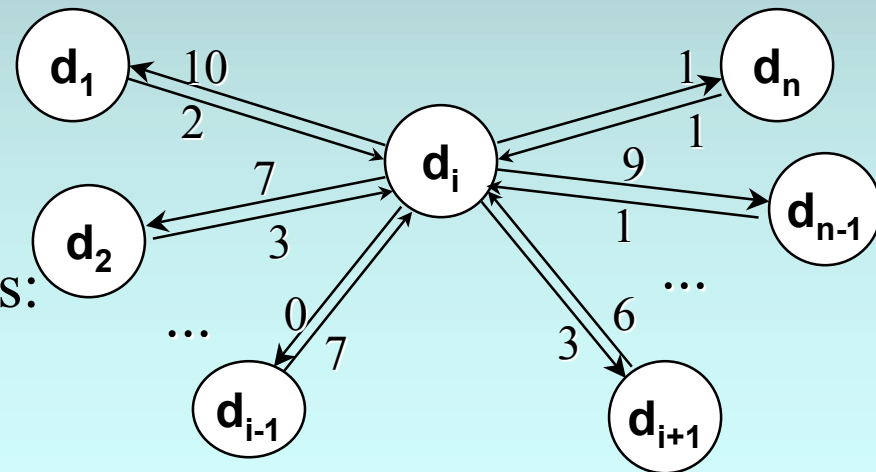
STARS Subsystems: Network

Prefetching and caching based on

- location
- work order
- statistical analysis of history

Request statistic:

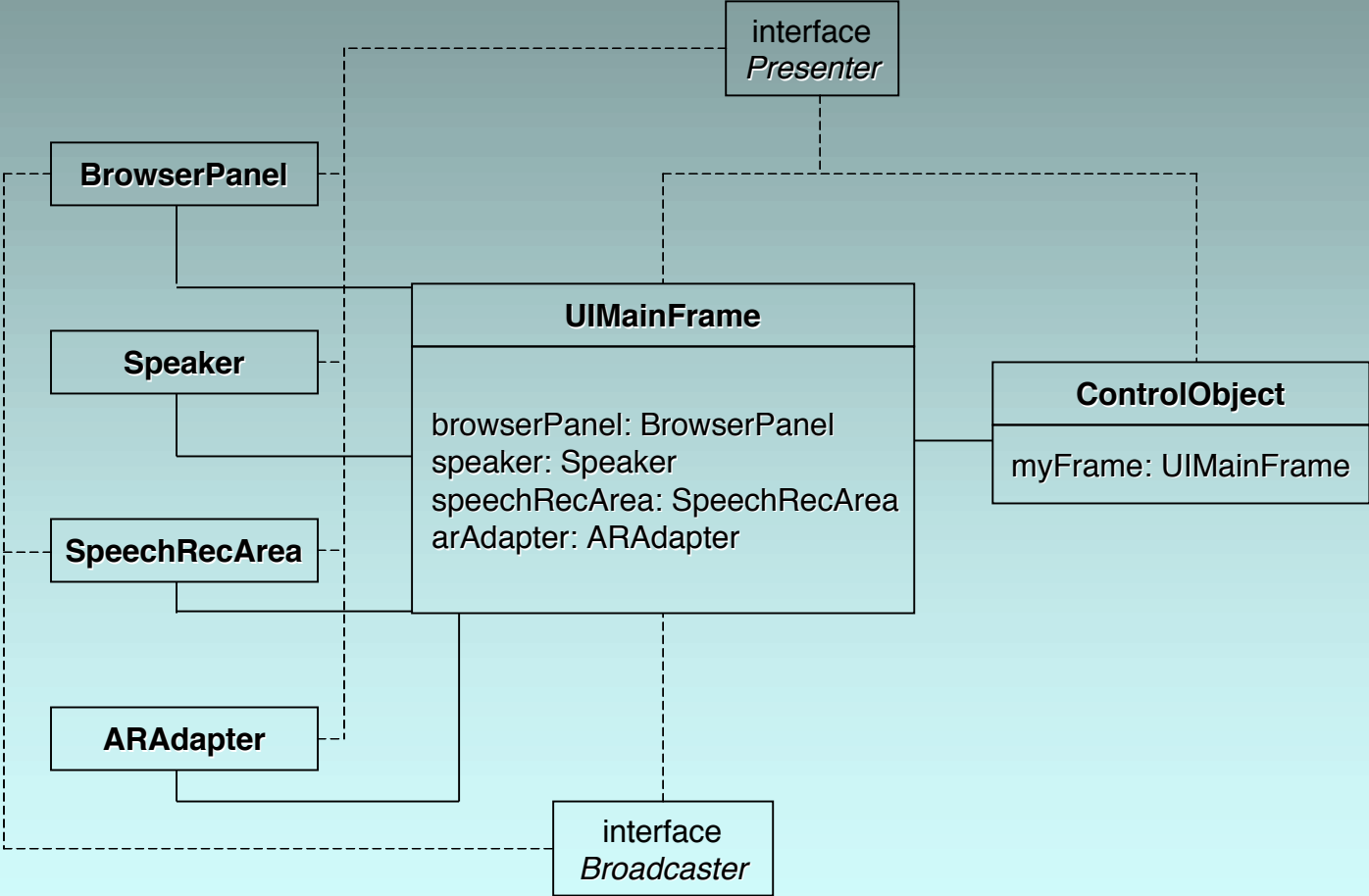
- History $[d_{t1}, d_{t2}, \dots]$
- Update rules for weights:
 $w(d_{ti-1}, d_{ti}) += 2$
 $w(d_{ti-2}, d_{ti}) += 1$



STARS Subsystems: User Interface

- Permanent maintenance support by showing single work steps and involved items
- Support through technical multimedia documents: Texts, AR, 2D graphs, movies, images, pdf-documents
- Input modes:
Speech, recognition, keyboard input, access card, iButton
- Output modes:
HMD, LCD plate, speech synthesis

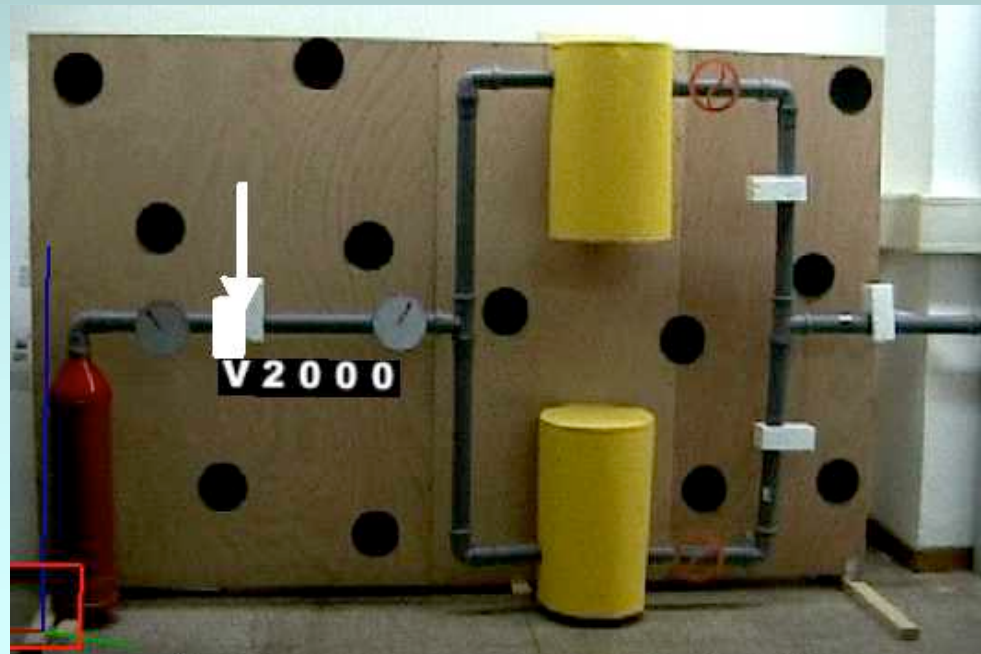
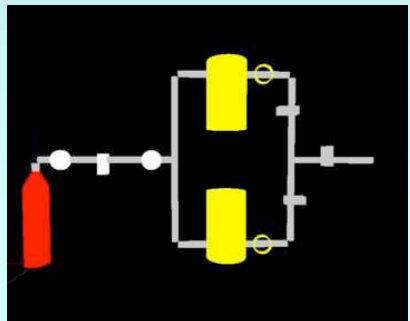
STARS Subsystems: User Interface



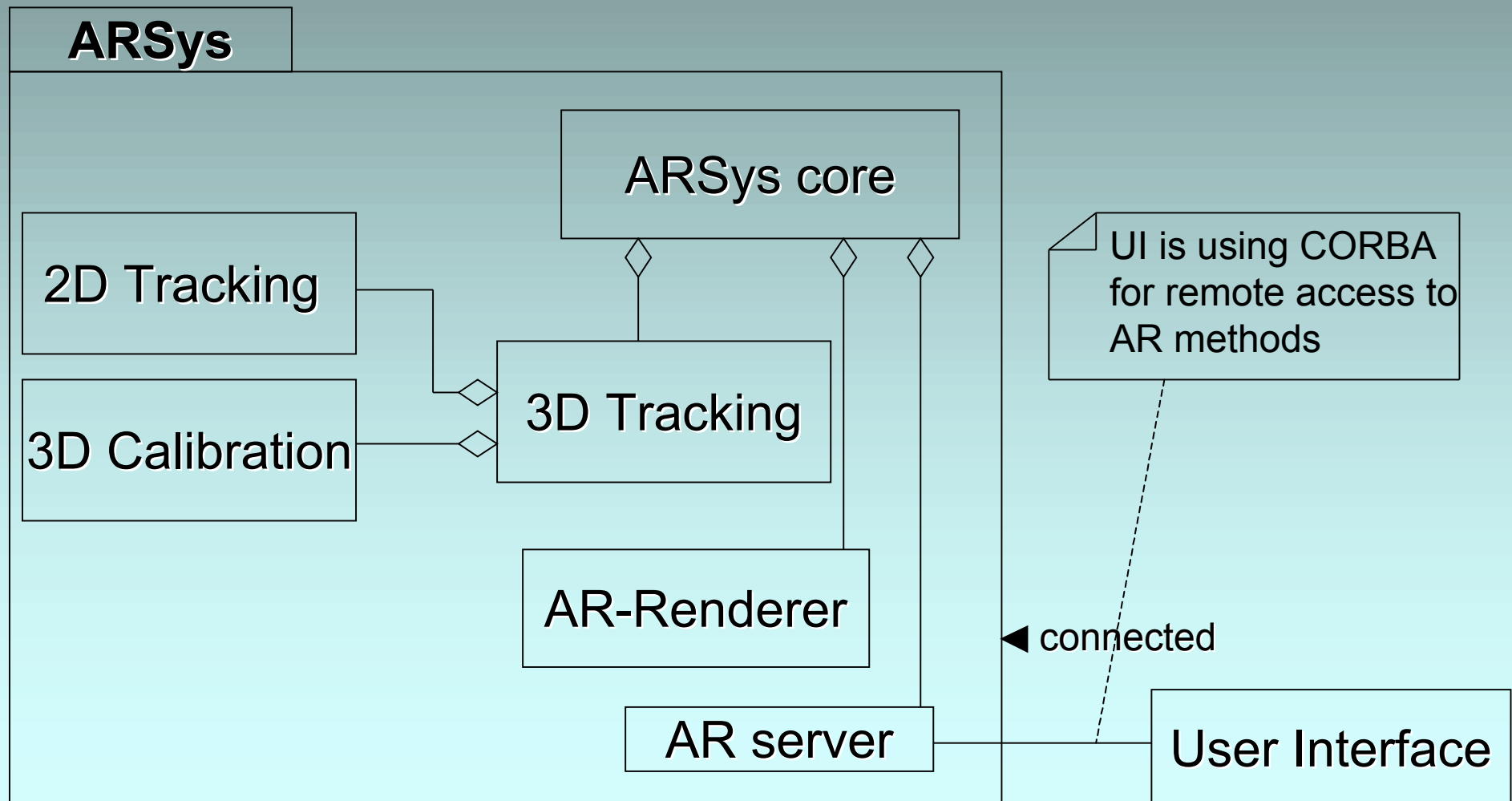
STARS Subsystems: Augmented Reality

Ingredients:

- Physical mockup
- Virtual model (OpenGL, VRML)
- 2D tracking (normalized cross-correlation)
- 3D calibration (Tsai)
- 3D rendering (OpenGL)
- Connection to user interface component (CORBA)



STARS Subsystems: Augmented Reality



STARS Subsystems: Augmented Reality

Augmented rendering

- Connection to the user interface component:
 - Highlight object (obj, form)
 - Label object (obj, text)
 - Display information (text, screenpos): id
 - Clear information (id)
 - Set compass (object, form)
 - Is visible (obj): bool
- Geometric primitives
 - Objects with unique ids, geometric & photometric descriptions, local transformations
 - Optional labeling string + transformation
 - Transformation for arrow placement
 - Drawing style: normal (full, wireframe), highlighted, not drawn

Results

Prototype implementation focusing on

- Network
- User Interface/AR mode
- Rudimentary implementation of IETM subsystem

Two hour demo with customer (Siemens Nuclear Power):

- Helium Flushing procedure
- Simulated variety of situations and UI modes

Lessons learned

- Linking geometrical information models
 - Geometrical model is usually not present in explicit form in the legacy information
 - Manually linking geometrical models and legacy information is costly, if feasible
 - Need for AR authoring system for creating such links.
- Generic AR components
 - Current standards (VRML) defined for visualization
 - AR requires more dynamic languages, enabling the interactive manipulation of geometrical models
 - Need for domain independent interface between AR and UI

Lessons learned (2)

- Multi-model user interface
 - AR is only one of several user interface modes
 - An AR view needs to interact with other user interface components and views.
 - Need for a component oriented view of AR systems.
- Mobile and unreliable networks
 - AR systems are often mobile
 - Rely on wireless networks for data exchange, unreliable and low bandwidth
 - Geometrical models and related information models are usually large
 - Need for a network component for shielding the system from crashes and low bandwidth

Acknowledgments

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