Digital Systems

Automated Compliance Checking for Layouts:

Knowledge-based evaluation of layouts 2009–2011
Validation of Use of Virtual Prototypes for Control Room Verification and Validation 2012–2014

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Objectives

- Develop a spatial evaluation method that can be used to define sets of tests to support knowledge-based evaluation of a 3D layout
  - Use-cases include
    - Review of control centre ergonomics
    - Operations and outage planning
    - Decommissioning

Knowledge-based Spatial Layout Evaluation

- Method based on encoded knowledge
  - Properties of things/people in a virtual layout (ontologies)
  - Design rules (required/desirable) to check against
    - Design patterns to aim for and anti-patterns to avoid
- Represent guidelines and/or requirements as rule-based tests (e.g. based on NUREG-0700)
  - Tests can be executed by an analysis tool
  - Tests are reusable/repeatable
- An evaluation or review comprises of a set of reusable tests

Objective: Accuracy

- Rules combined with scene analysis techniques
  - More consistent and accurate results
  - Faster repetition of tests while maintaining accuracy

POINT	DESCRIPTION	YES	NO	NA	REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
1.4.8	Can the operator get in and out of the chair at the workplace freely? *Minimum requirements for operator maneuvering space are approximately 760 mm laterally ("sideways") and 915 mm from the edge of the desk to any opposing surface ("backwards").* *Ref. Figure 4.3, inspired by NUREG0700*					NUREG 0700, rev 2, 12.1.1.3.5 DC: NORSOK S 002, REV 4, Annex C. *The chair should be able to be rotated to allow easy access - at least 180 degrees.*	

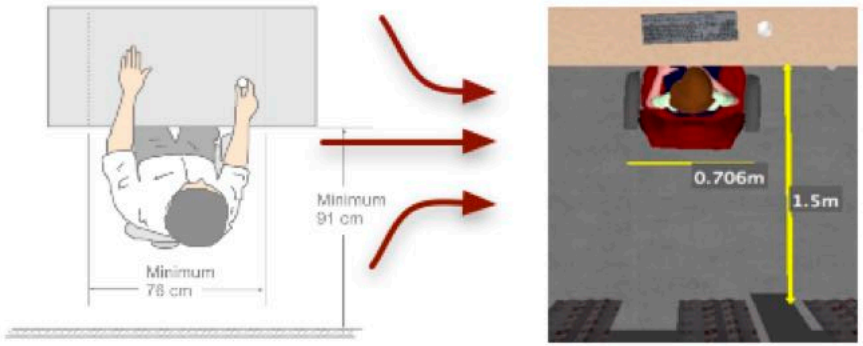


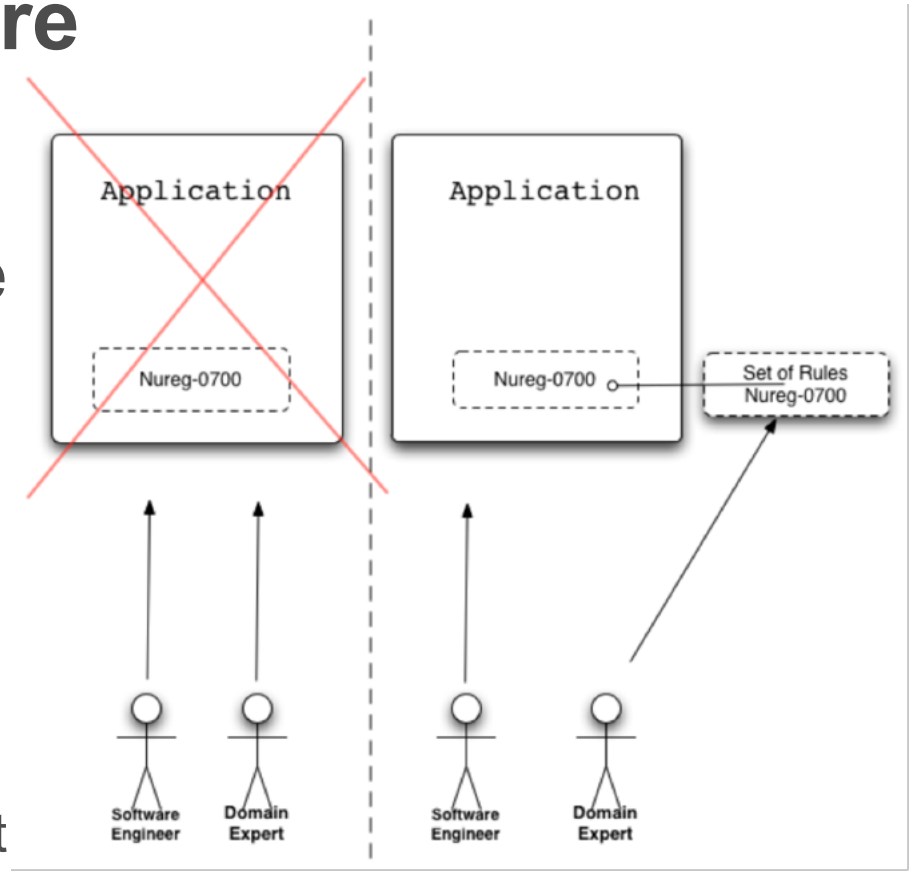
Figure 4.3: Spacing of equipment to accommodate seated users (In cm as suggested in original figure)

Objective: Open Architecture

- Can incorporate knowledge from multiple sources, e.g.
  - Ergonomic guidelines
  - Fire and emergency procedures
  - Input from operator experience interviews
  - Knowledge from earlier design phases & iterations
- Broader scope of information can help designers make good decisions early

Objective: Open Architecture

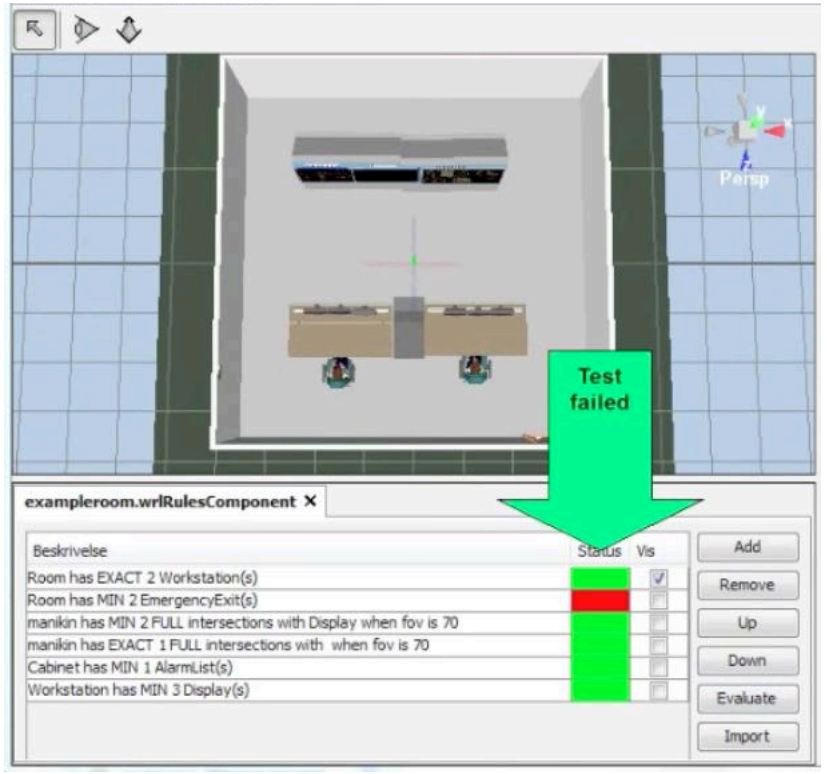
- Specify semantics and rules using open standards if possible
- Underlying knowledge handled separately from application
- Reuse tests without changing application code
  - Define once and reuse across projects
  - Domain experts can adapt tests to different guidelines



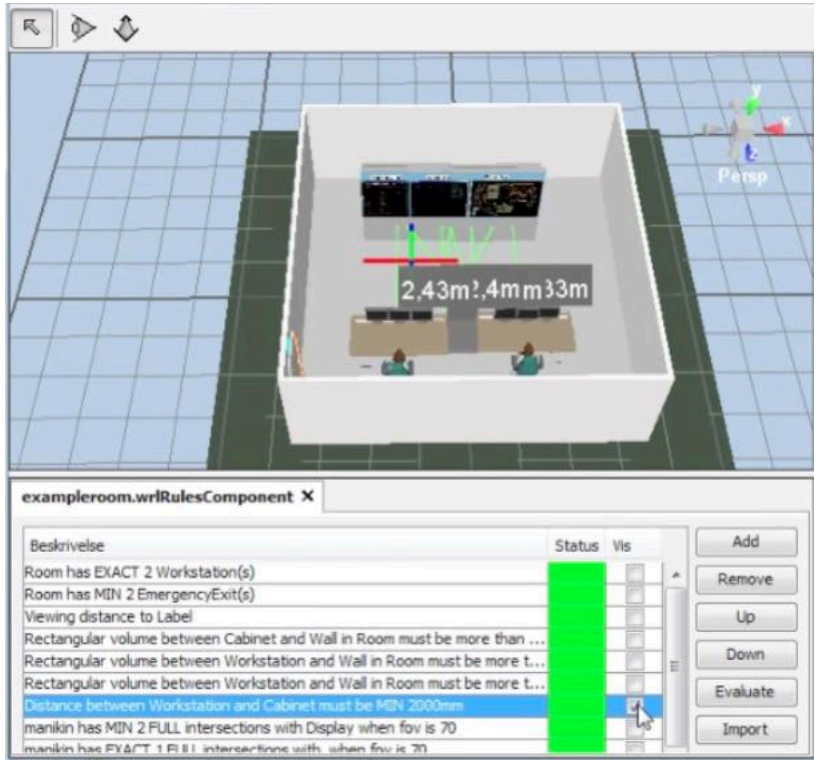
Approach

- Focused initially on W3C Semantic Web
  - Open standards for semantic data and knowledge representation
  - Well-established technologies
- Using RDF and OWL
  - Applications of XML
  - Human and machine readable
  - Inference and knowledge reasoning supported by open rule-engines

Testbed and Proof of Concept 2009-2011



Requirements handling using knowledge-based techniques



Geometry analysis to enable spatially-oriented tests

Ref: Gustavsen & Louka

Examples of guidelines from NUREG-0700 Rev. 2

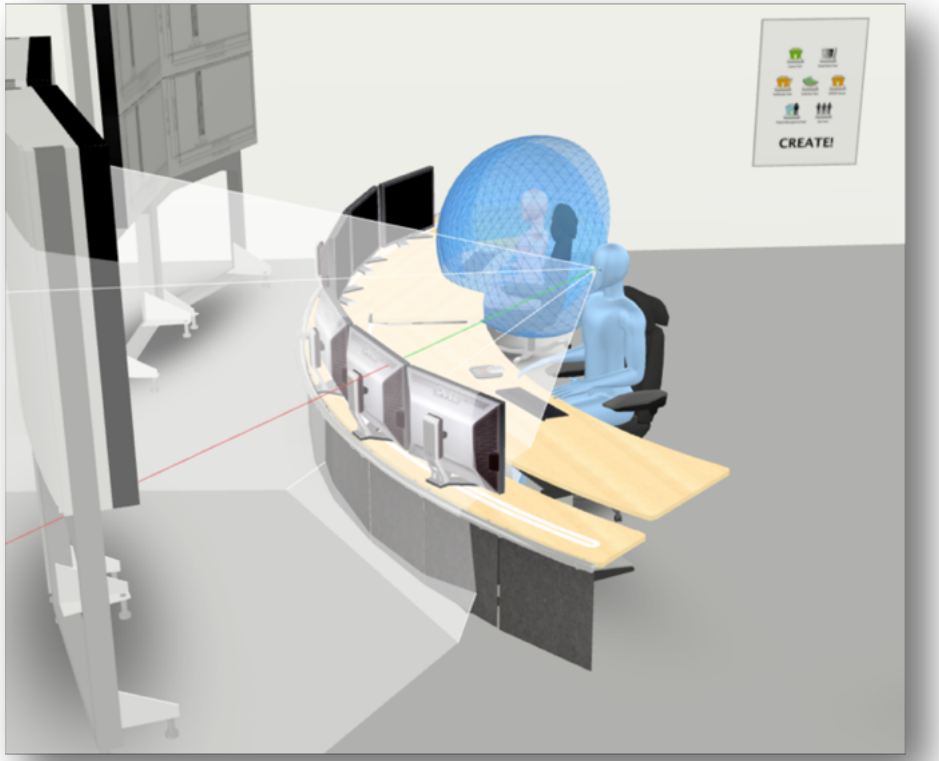
Semi-Automated Control Room Layout Verification

Control Room V&V

- Does the design contain everything it needs to?
  - Human-system Interface inventory and categorisation
    - Overview of all needed HSI items and their categories
  - Task support
    - Overview of HSI items needed to support specific tasks
- Will it meet user & organizational requirements as an interactive system?
  - Compliance with HFE guidelines
  - Supports task scenarios
  - Checklist of specific requirements
- Collecting evidence that a design is fit for purpose

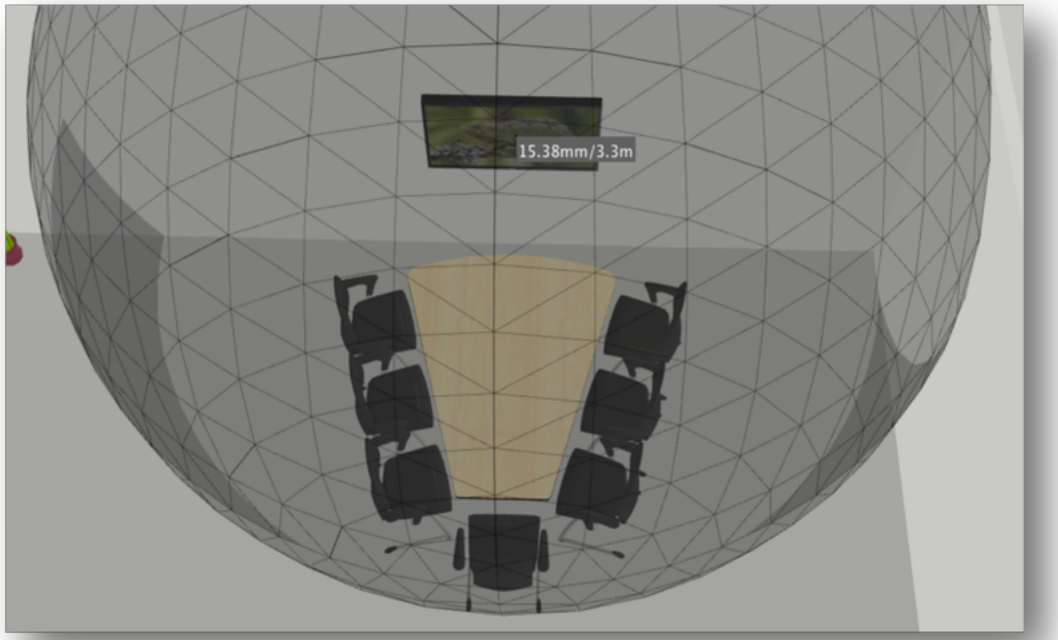
Evaluating Ergonomics

5th & 95th Percentile manikins of target population. Line of sight, view cone, reach, simulated view



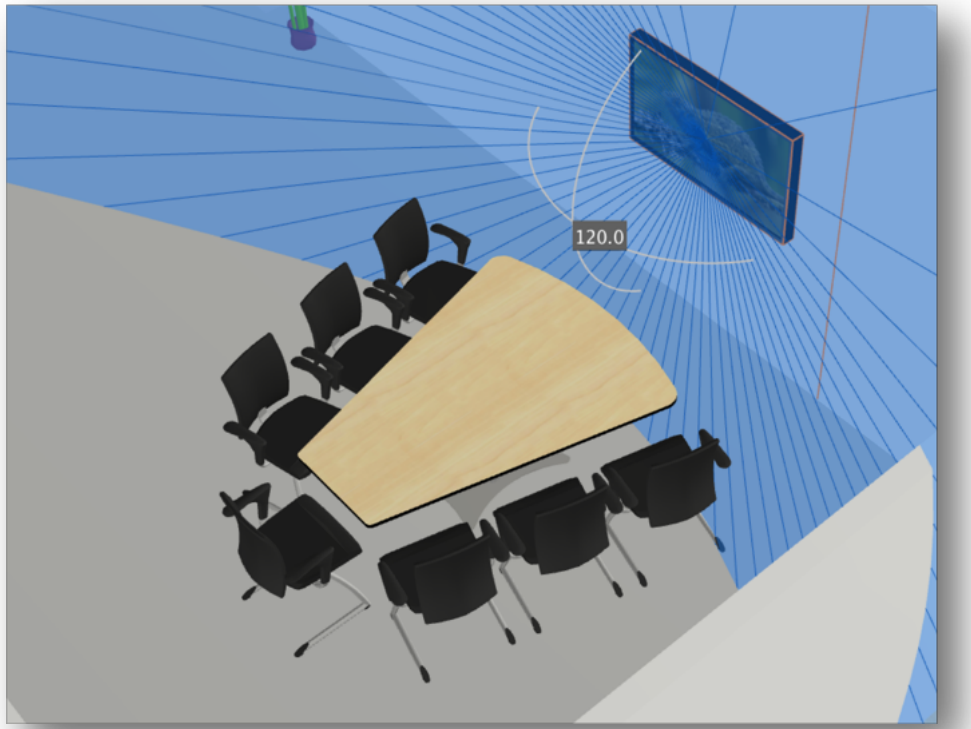
Distance, Perpendicular Distance, Angles, Volumes, Dimensions

Evaluating Ergonomics

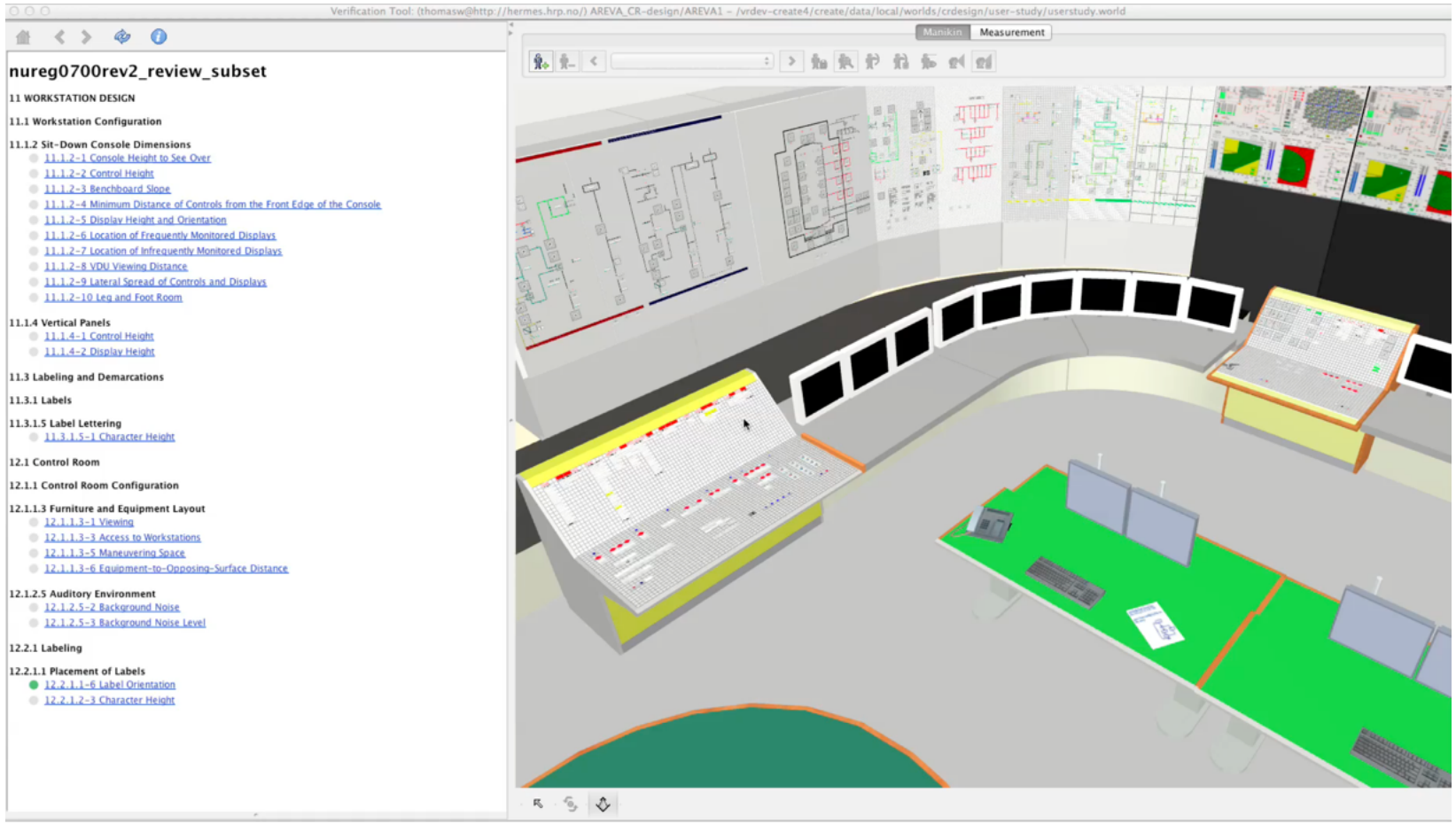


Minimum legible text size

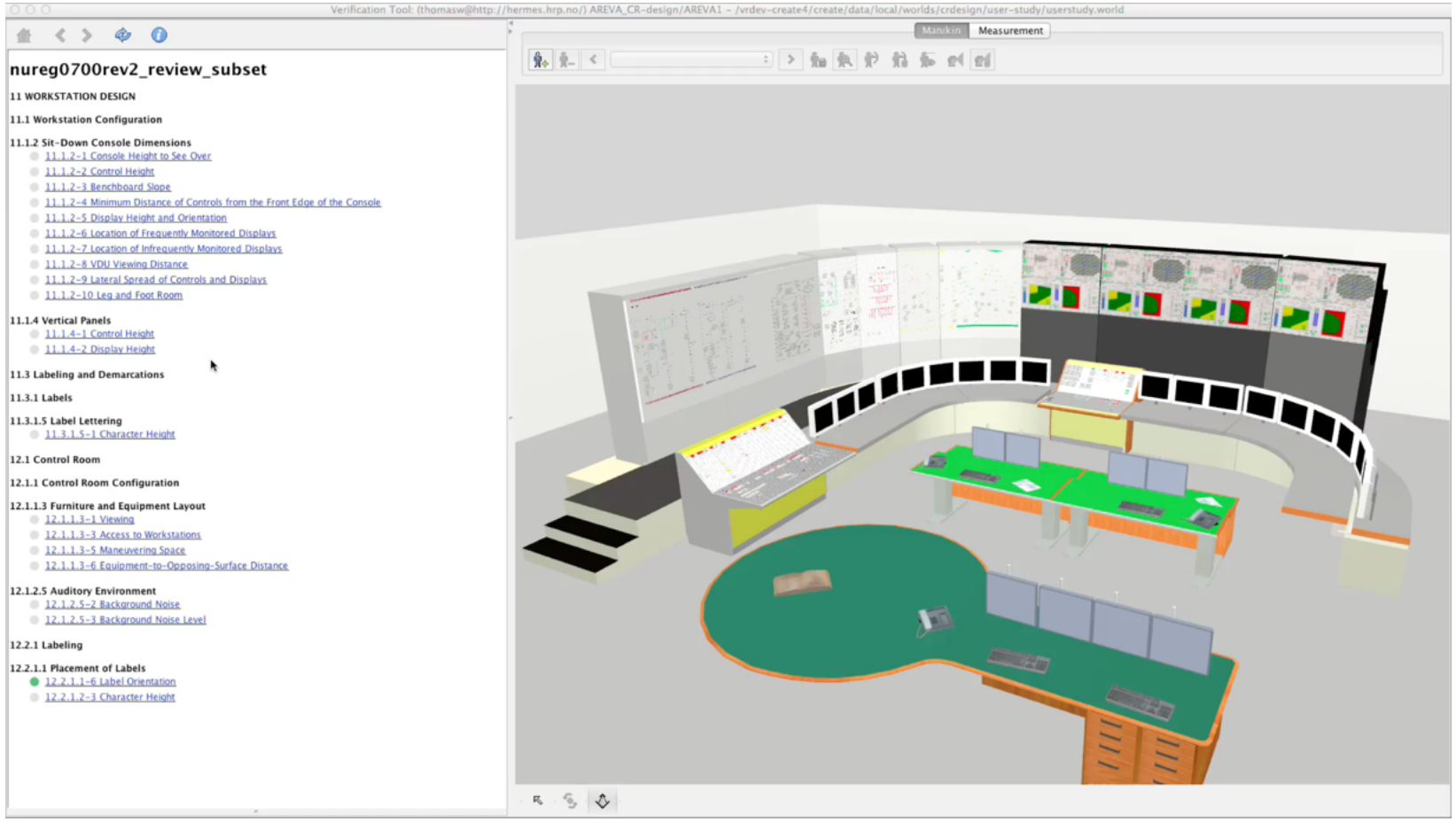
Viewing Angle



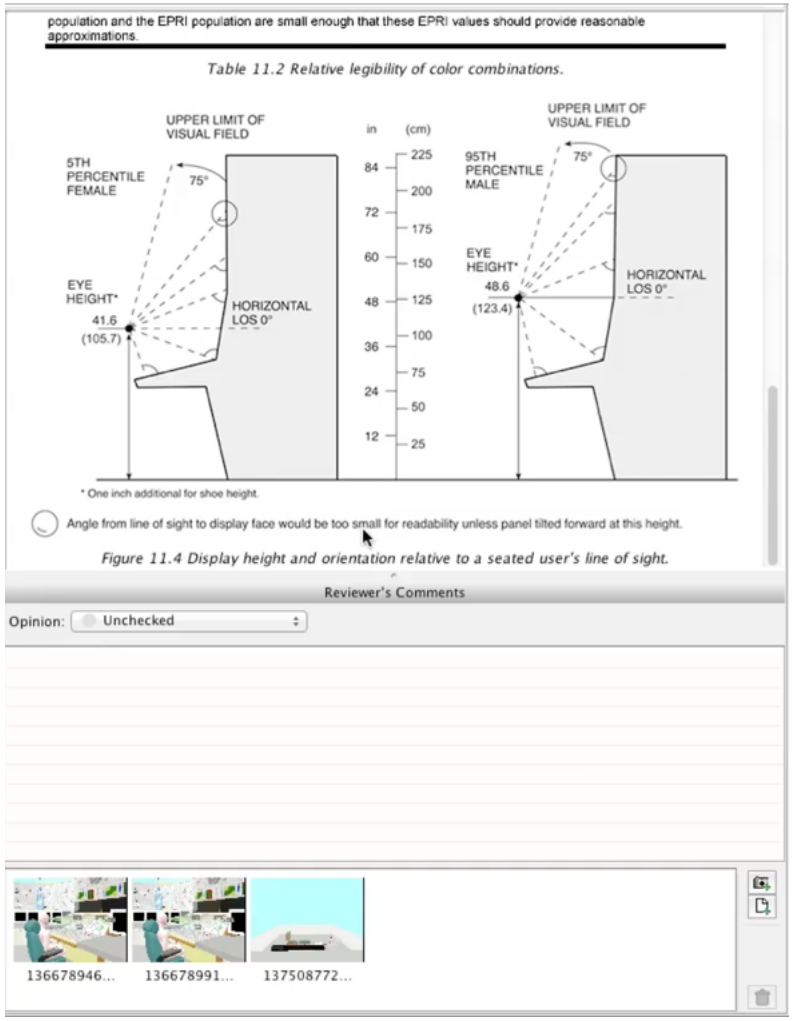
Sit-down Console Control Height



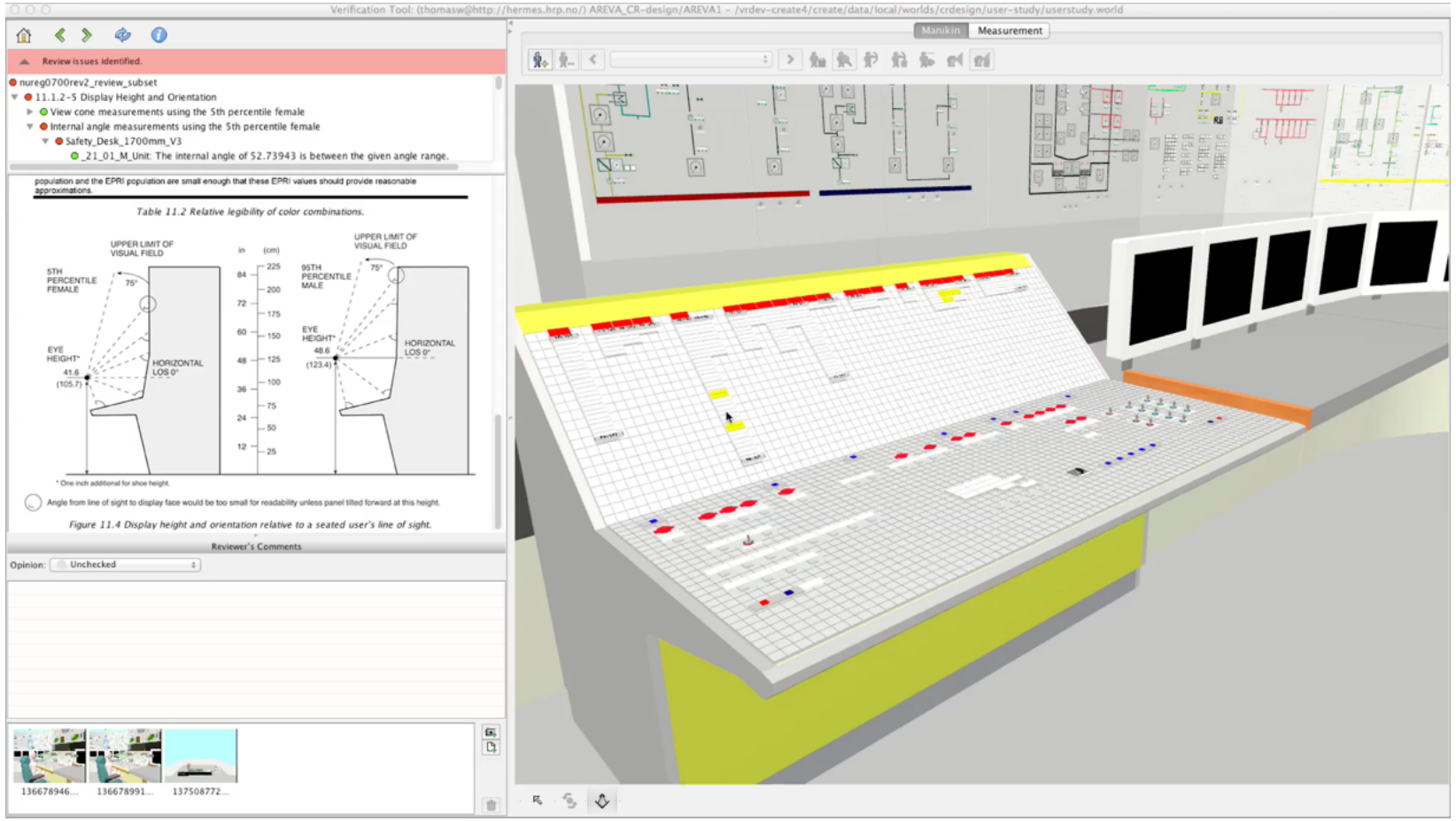
Vertical Panels Control Height



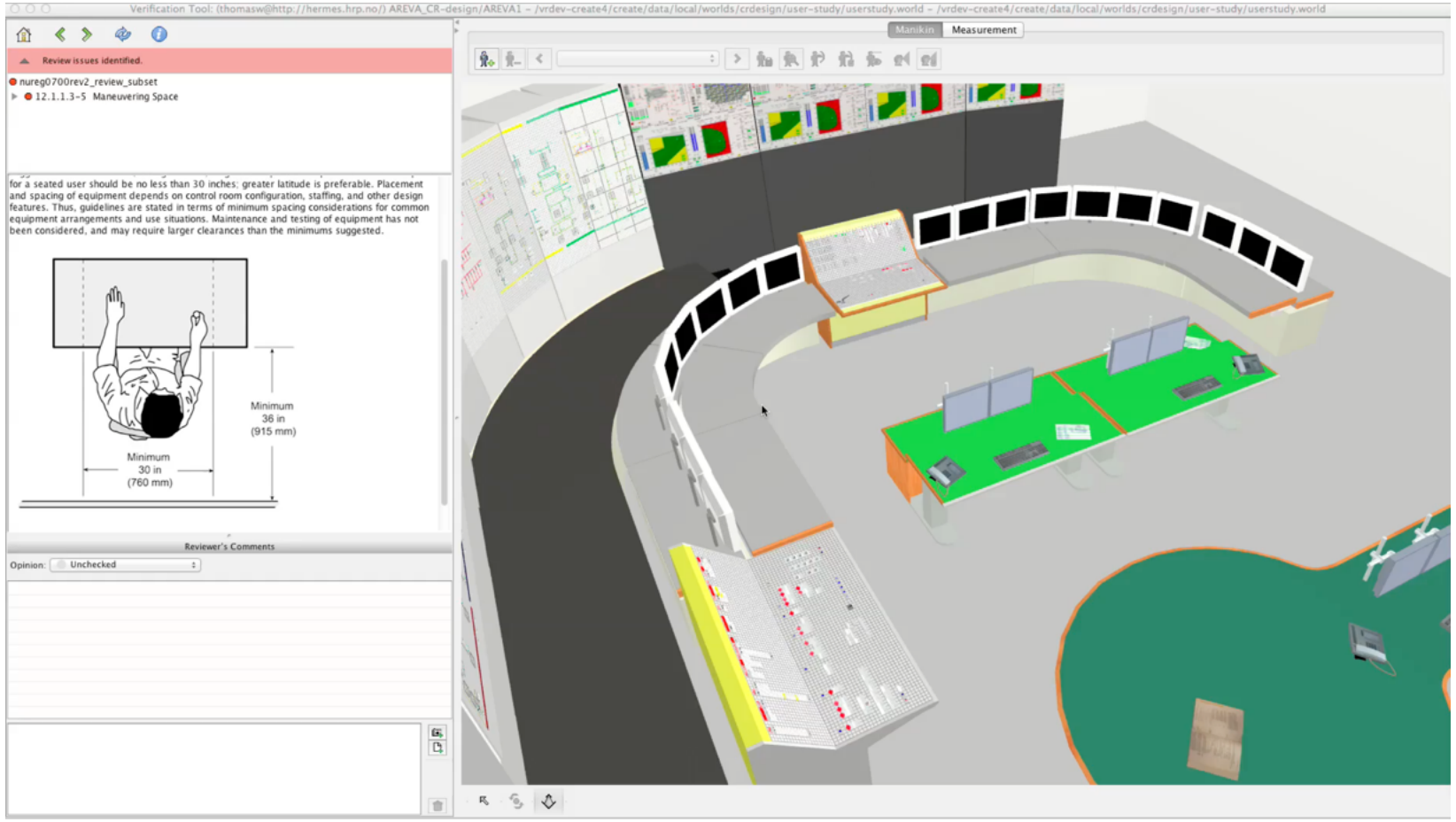
Interior Angles



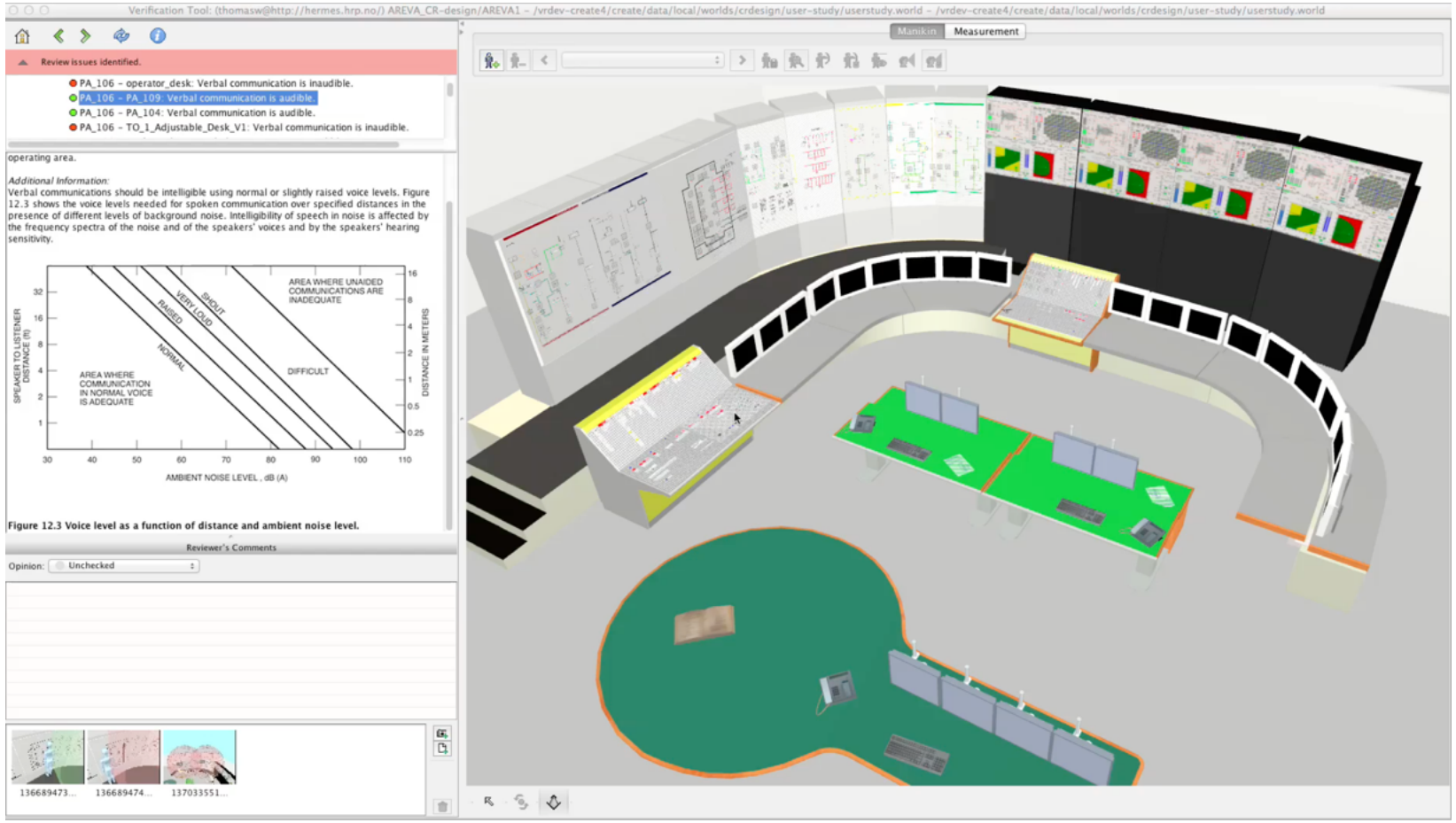
Console Display Height & Orientation



Operator Manoeuvring Space



Auditory Environment



Summary of Results of Validation Study

- Good agreement between subjects for tasks with automated assistance
- Some guidelines were considered difficult to understand
- Automated assistance helpful for most tasks where it was available
  - Time saving potential was frequently highlighted
  - Important to be able to see an explanation of how the software came to its recommendations with as much detail as possible.

Our plans/needs regarding decom

- Define/Standardise to support interchange of data between systems:
  - Discipline profiles for BIM/IFC
  - Ontologies for data objects that support the disciplines
- Will enable these types of analyses and more advanced risk (including radiological risk) analyses to be done using the shared BIM model and integrate with planning/optimisation
  - In addition, for decom we can also leverage the rule-checking in BIM tools intended for construction
    - Mostly focussed on collision checking and rules about objects