Configuration Control of W7X. Lessons learned

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Outline

- Already presented
  - W7X
    - Thomas Klinger. Status of Wendelstein 7-X
    - Thomas Rummel . The Superconducting Magnet System of the Stellarator Wendelstein 7-X
    - Torsten Braüer. Progress and Challenges in the Assembly of W7-X
    - Stephan Bosch. Lessons Learned from Fabrication and Assembly of Wendelstein 7-X
    - Axel Lorentz Implementation of Earned Value Management Tools in the Wendelstein 7-X Project
    - Didier Chauvin. Lessons Learned from Designing and Manufacturing of the Coil Support Structure of W7-X
    - Sébastien Renard. Space Reservations for the Peripheral Components of W7-X
    - Konrad Risse. Purpose and design of trim coils for the W7-X stellarator experiment
    - Torsten Koppe. Overview of main mechanical components and critical manufacturing aspects for the W7-X cryostat
    - Alan T. Peacock. A proposed scraper element to protect the end of the W7-X divertor target elements
  - Configuration control (SOFE 2009)
    - R. Brakel. Configuration Management
    - T. Dodson Configuration Space Control for Wendelstein 7-X
- Configuration space control of W7X cryostat
  - Principle
  - One example of a as-built model
  - Lessons learned

Configuration Control: principles

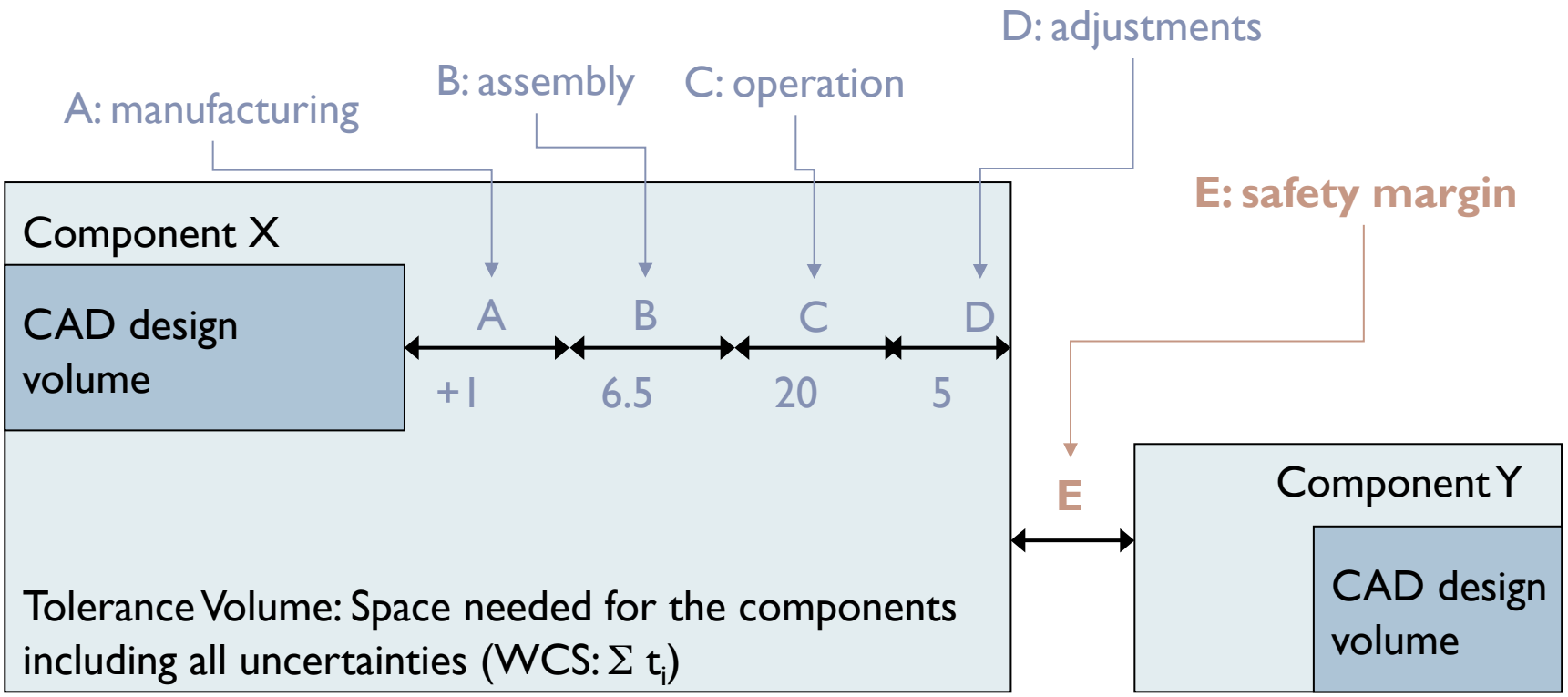
- To face the challenges of the design in the cryostat
  - Lack of space
  - 3D very complex form
  - Only the magnet system is fully symmetrical
  - Displacements/Movements of coils during operation
  - Deviation as-built/as-design

Configuration Control: principles

- To face the challenges of the design in the cryostat
- W7X's project team developed advanced method to reduce the tolerance chain (without increasing too much the risks)
  - as-built models
  - in-operation models

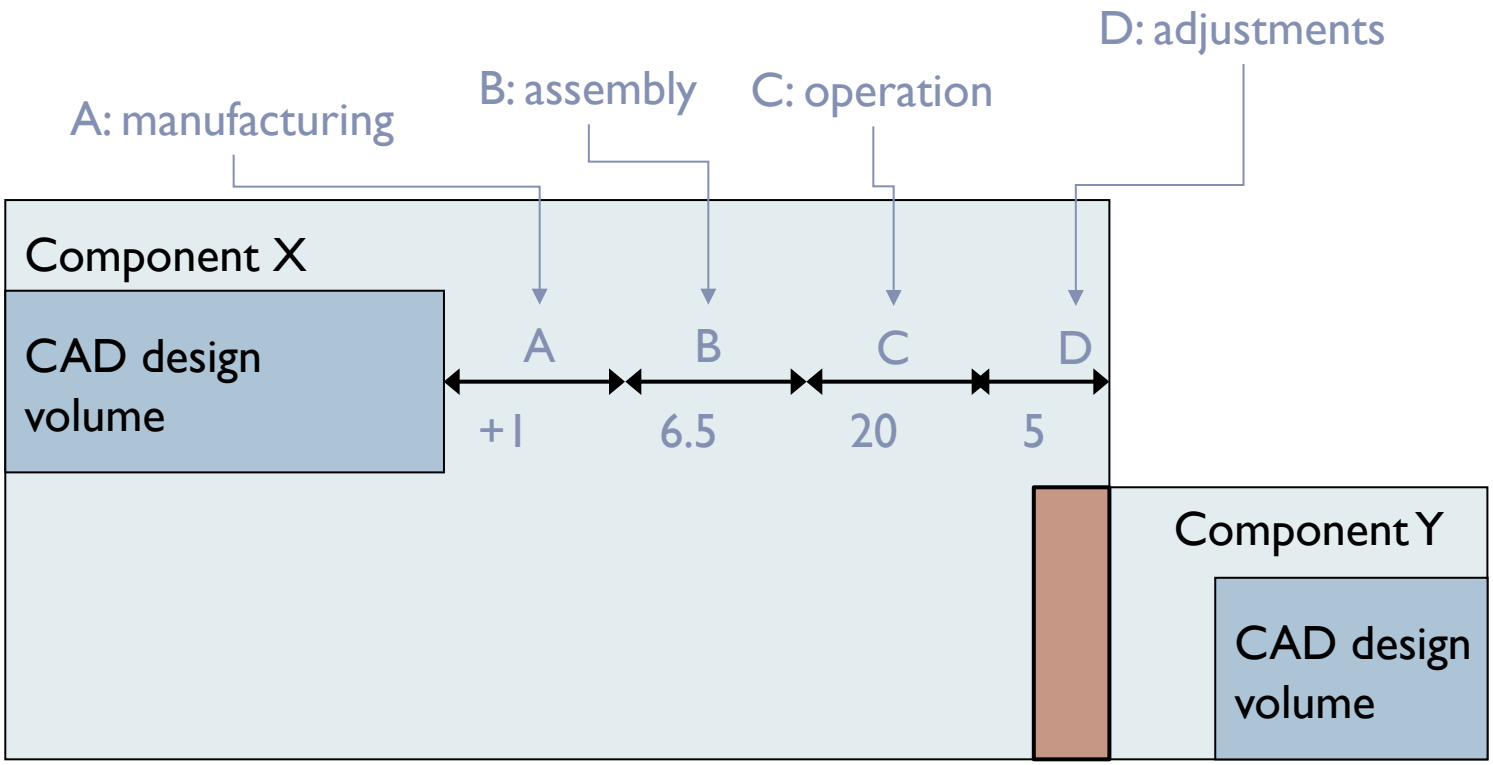
Configuration Control: principles

- In general



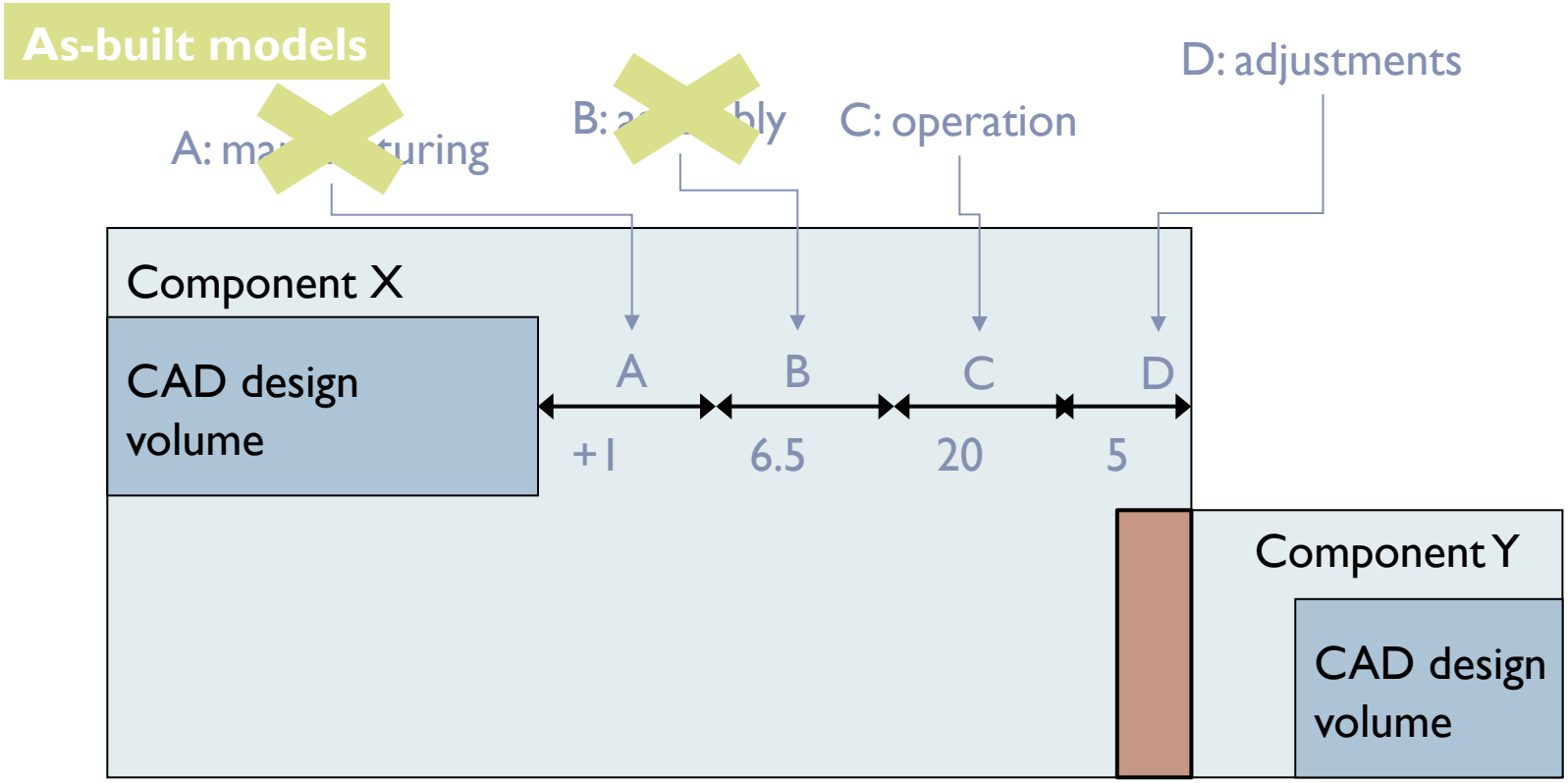
Configuration Control: principles

- In general
- The situation in the cryostat



Configuration Control: principles

- In general
- The situation in the cryostat
  - Using as-built models



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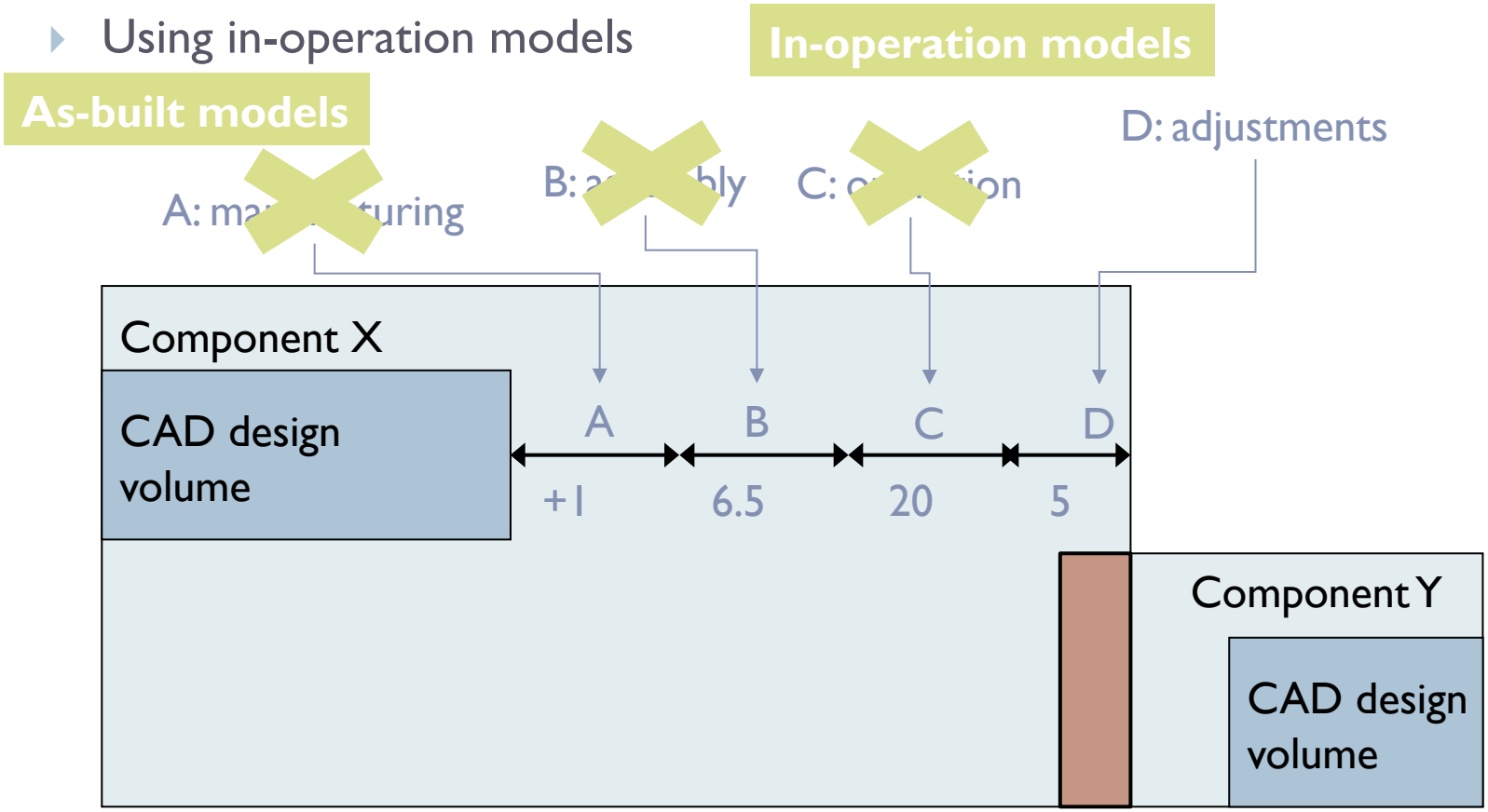

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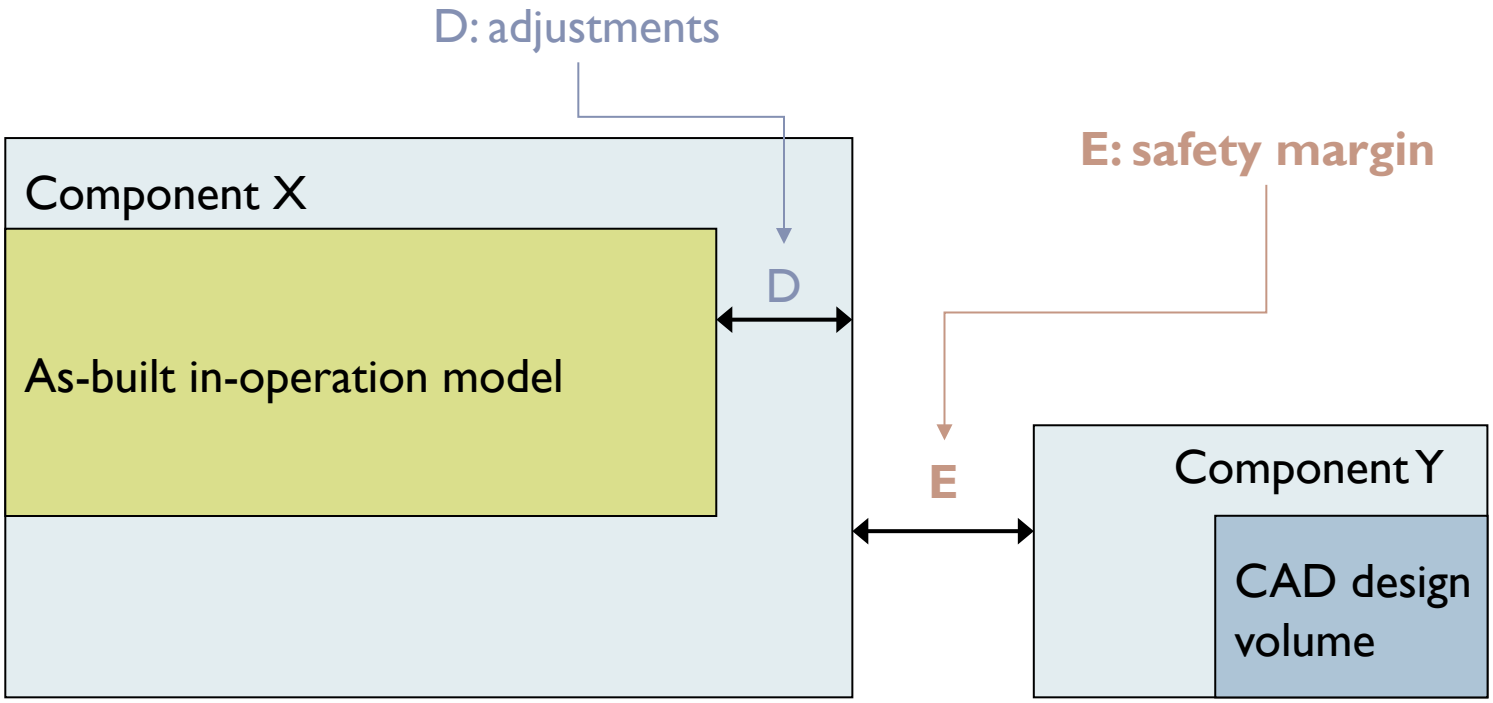
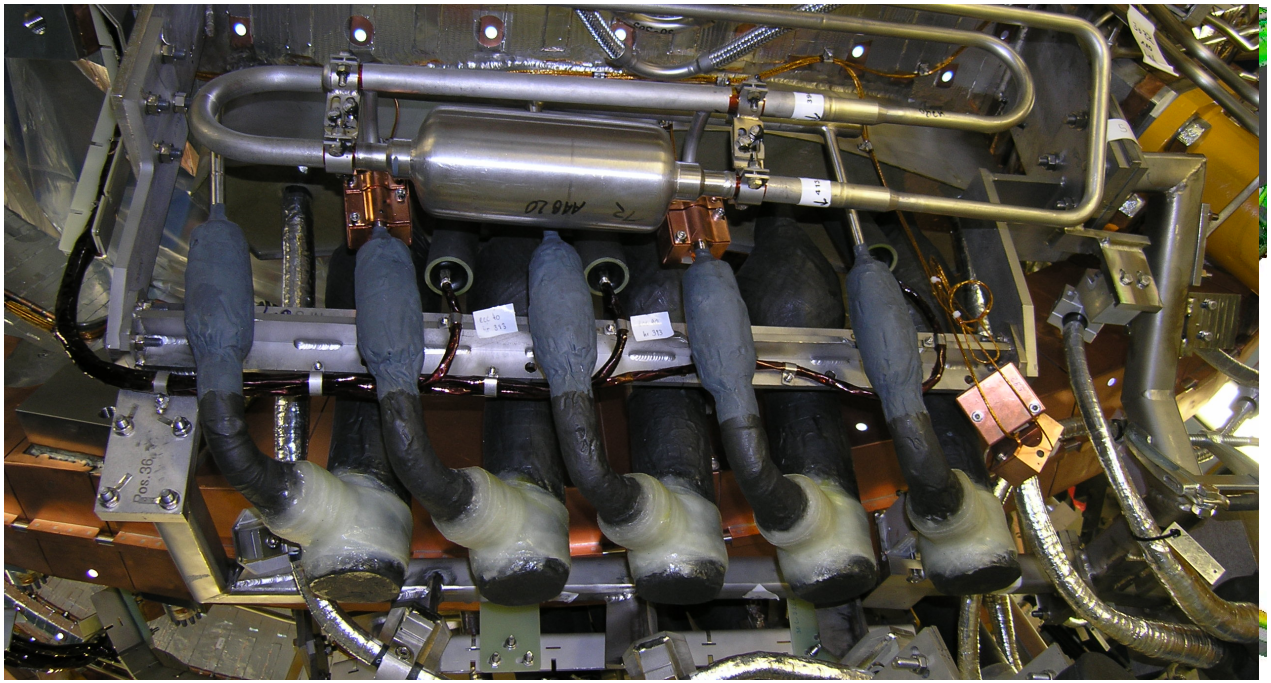


Example of laser scan and as-built models



Lessons learned about configuration control

- Configuration Space Control works
  - Assembly of the magnet system in outer vessel without any collision in a couple of hours
  - But it is quite expensive (department up to 34 Engineers and Draftsmen)
  - Requires advanced methods and tools

- Our experience
  - Outer vessel 500mm bigger (radius) and a bigger torus hall would have saved time and money
  - The key point is the assessment and the conflict mitigation: good configuration control reports (collision checks with agreed action item) are indispensable

- Our recommendation
  - Anticipate sufficient place
    - price of buildings or vessel are predicable, price of engineering and design iterations are unpredictable and often underestimated
    - "periphery" components (like cables, pipes, etc.) do count and need place
    - help to have clear and simple design, easier maintenance, etc.
  - Prepare efficient mitigation procedures

Lessons learned

- Tolerance chain: a key element for configuration space control
  - In CAD everything looks fine, but the reality is far different
  - A good "feeling" for tolerance chains and how to handle them is important

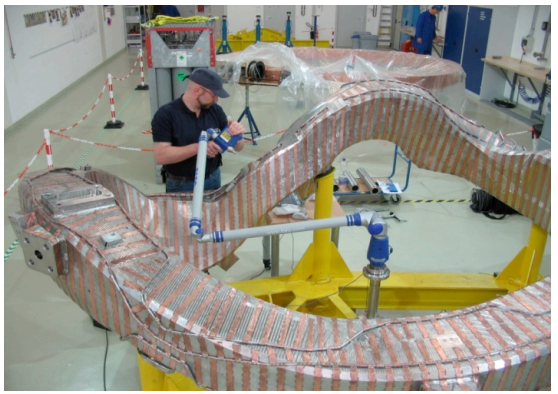
- Our experience
  - Designers always tend to neglect tolerances (at least the tolerance of component 2)
  - Assumed tolerances in conceptual phase are almost always too small:
    lack of place for preliminary or detail design

- Our recommendations
  - Document the tolerance chains in "binding" reports involving all concerned department **in particular assembly** and make these documents easy to read
  - Don't focus only on manufacturing. Reserve space for assembly, maintenance, not yet designed components, etc.

Lessons learned

- Good Geometrical Measurements are indispensable
  - Can save a lot of time and money: margin often represents unknowns

- Our experience
  - Can save a project
  - Best measurement tools
    - Laser scan for as-built geometries
    - Photogrammetry for positioning
  - Back office: team with experience in CAD and measurements



- Our recommendation
  - Think about measurements during the design (reference points, etc.)
  - Try to have a global "measurement and assessment" concept (in call for tender, specify the deliveries: type and format of measurement, assessments, etc.)
  - Specify needs and assessment before defining the type of measurement

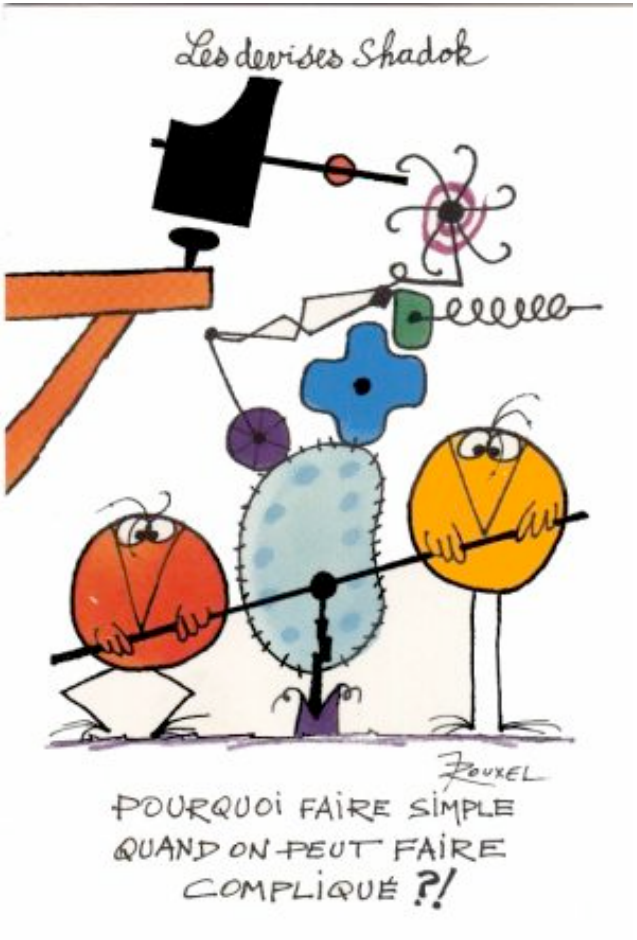
Conclusion

- Complex system: all about integration and interface
  - Technical problems: easy ⊥ Communication and interface problems: difficult
  - Install a strong experienced system integration team

- To cope with communication and interface problem: tools and organization
  - Tools and information management:
    constant struggle between centralization and flexibility
    - Stay reactive, implement flexible system and with a lot of adaptation possibilities
  - Organization
    - Clear responsibilities (who's is the "owner")
    - Need of fast decisions

- Help your designers and promote reusable design
  - Good tools (CAD reference, easy PLM, easy collision checks, etc.)
  - Easy procedures and clear recommendations
  - Good specifications (use system analysis methods)

Conclusion



Thank you for attention