Engineering Challenges In ITER

Cave mali in loco pactum

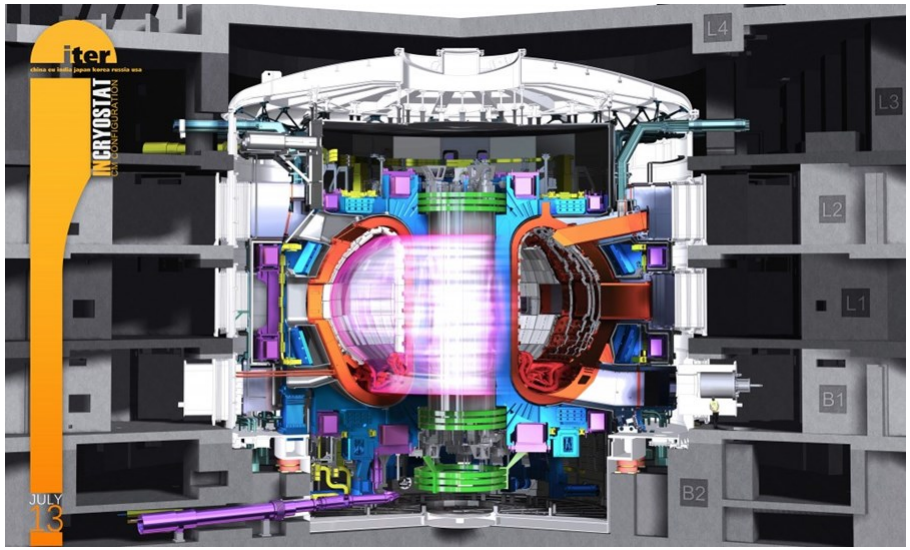
Beware of the unkind “in kind” agreement

Lessons from ITER are opportunities for ESS

- What is ITER
- Why consider ITER
- Warnings to ESS
- Systems engineering challenges of in kind agreement
- Major lessons learnt

ITER will the world's largest fusion reactor

In southern France, 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.



1) Produce 500 MW of fusion power
2) Demonstrate the integrated operation of technologies for a fusion power plant
3) Achieve a deuterium-tritium plasma in which the reaction is sustained through internal heating
4) Test tritium breeding
5) Demonstrate the safety characteristics of a fusion device

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Despite differing technologies similarities exist

- First of a kind
- Biggest, brightest, and best
- Large scale constructions
- Challenging technology
  - High power densities
  - High radiation levels
  - Vacuum
  - Precision control…
- International Collaboration
- In-kind funding

ITER 2016

ESS 2016

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ITER has had a challenging time

In Kind Collaboration Create More Demands on Systems Engineering

- Segregated responsibilities
- Frequent staff changes and information transfer
- Systems engineering challenges of in kind agreement
  - Requirements management
  - Interface management
  - Configuration management

Issues with ITER Requirements Management

- Different departments create requirements “buried” within own documentation
  - Vacuum Handbook
  - Remote Handling Code of Practice
  - Design Description Documents
- Applicability of requirements not always clear
- Revision control not cascaded
- Language ambiguous
- F4E applied massive effort to clarify[2]

1st Step – Identification of applicable docs

PA

AxB

IO ADMx

AD

1280

≈200 AD

≈400 RD

≈300 tbd

≈420 DUP

671

F4E docs added

FW

578

Still a challenge!!!

Supplier ADMx

= 671 ITER docs + 50 F4E docs

Flatten the list

Categorization

Supplier Applic

153 AD

518 RD

190 NA 22%

Statement of Work

27 AD-Work

45 RD-Work

System

25 AD-Sys

91 AD-IR

390 RD-Sys

143 NA 19%

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2nd Step – Requirements Analysis & Organization

1 – Identification of Applicable Docs

2 – Identification of Requirements

3 – Analysis of Requirements

4 – Tender

5 – Follow-up of Contract

6 – Contract/PA close-out

12 AD

AxB, SRD, VH, LS, IPR, SPR

RHCSDH, PCDH

2490

Rqs Identification
Rqs Analysis

1601 rqs

889 N/A

35%

160 1

Categorized

Regrouped

Reworded Supplier applic

≈1275

Statement of Work

SoW rqs

Doc rqs

System

Syst rqs

Interf rqs

Statement of Work Specs (SoW)

Technical System Specs (TSS)

Control System Specs (CSS)

330 rqs

945 rqs

326 rqs

20%

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Information and requirements needs active management

Still lots of documents -> need of **organization** and **context**

Still lots of requirements -> need of **prioritization** and **structure**

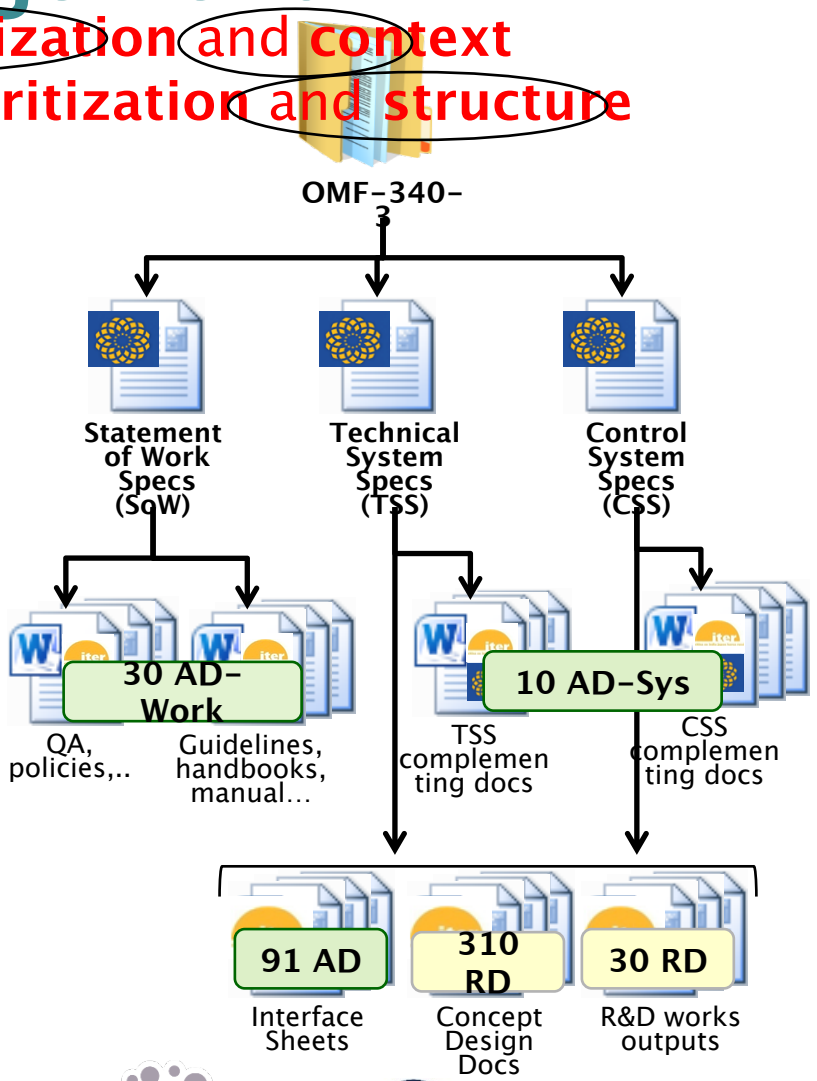
- **Impact on F4E Technical Specs**

New structure based in 3 '**Main Docs**':

- Statement of Work Specifications (SoW)
- Technical System Specifications (TSS)
- Control System Specifications (CSS)

'**Complementing Documents**' to be invoked from the requirements in the main docs, giving **context** to them, possible **constraints** on its applicability…

- Guidelines, Handbooks, Manuals, Templates
- QA Documents, Policies
- Docs complementing TSS and CSS
- Interface Sheets
- Concept Design Docs
- Codes, Standards



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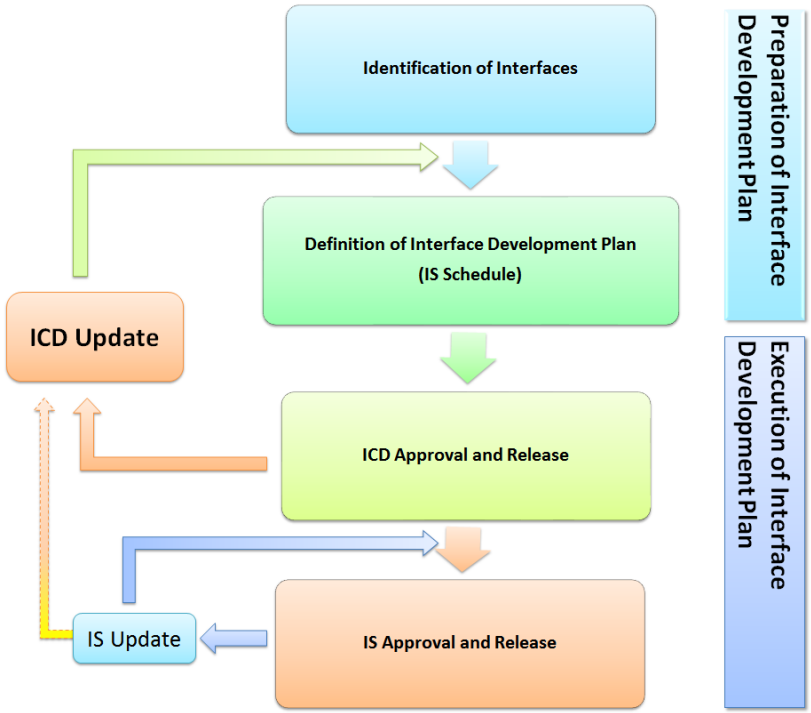
Interface control vital in complex projects

- Interface management critical to concurrent projects
- ITER has a interface control procedure[3]



F4E cite lack of interface data as the cause for 30 months delay (and considerable cost increase) of the ITER Tokomak building[4]

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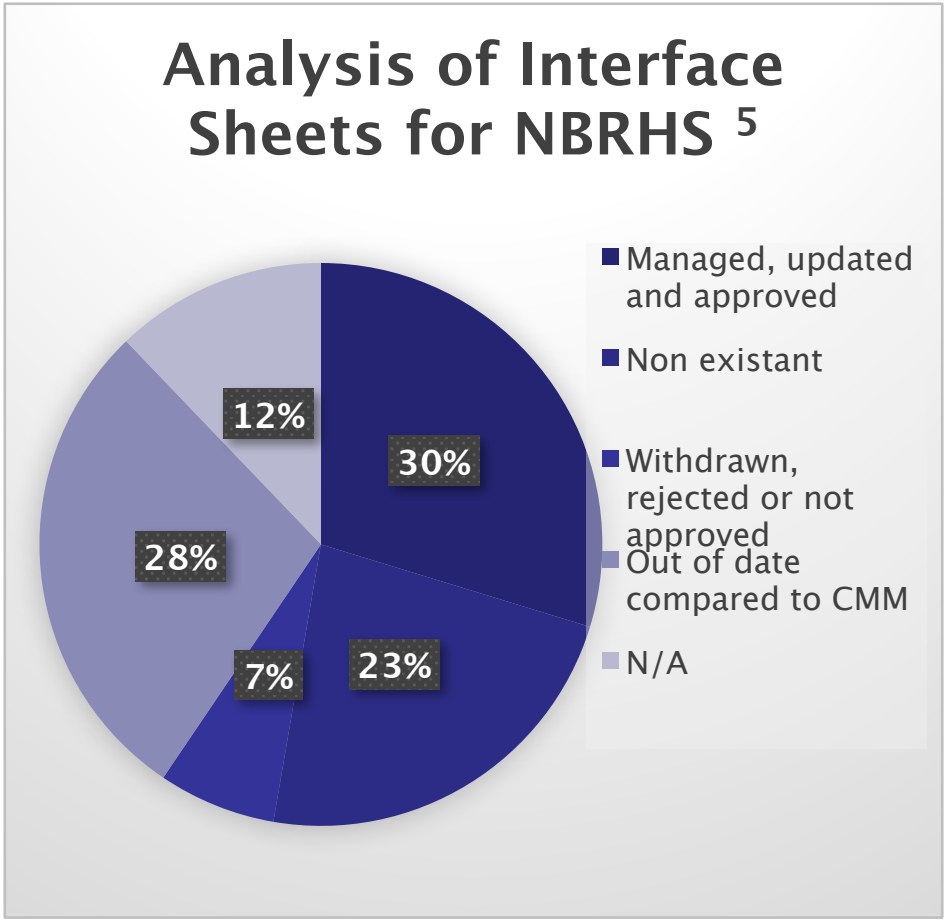
Experience of ITER ICD not always positive



Opportunities for Improvement

- Effort needs to be allocated to maintain interface information.
- Interfaces need to be "policed"
- Change control group needed to arbitrate between conflicting priorities
- Capacity should be built into design to expand

ITER uses different systems of configuration management

- CAD Configuration systems at ITER
  - A Synchronous (using Data Exchange Transfer process)
  - Synchronous using remote desktop technology[6]

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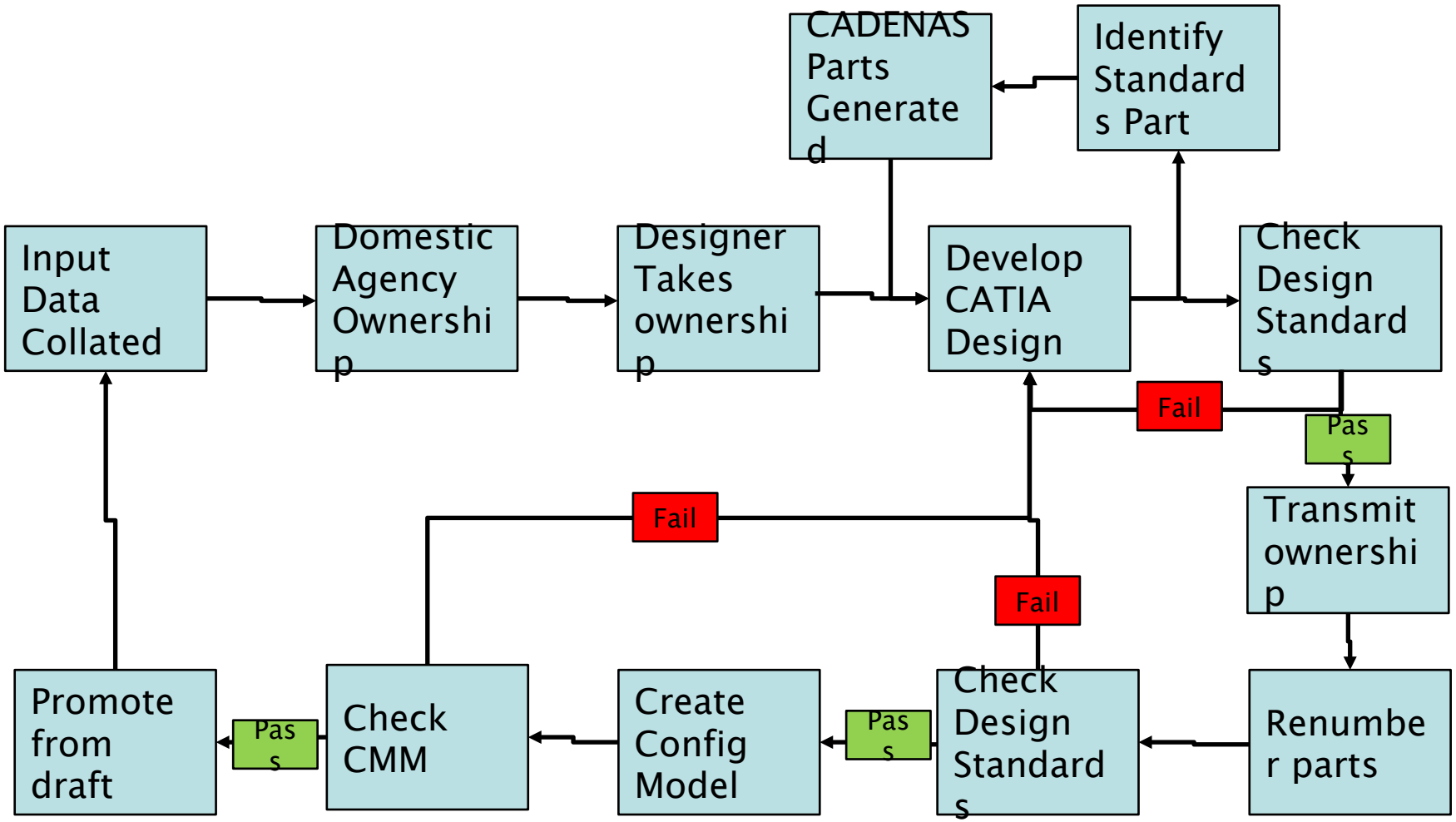
CAD exchange adds cost



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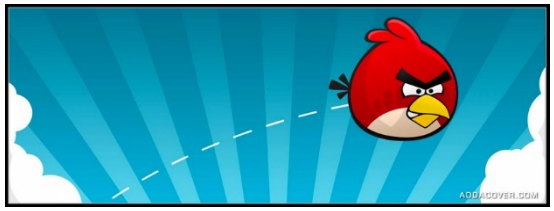
System support and training are important

- Organised Structures of documentation and requirements promote technology and transfer and reduce downstream risk
- Robust systems need to be supported by allocated staff to train in-kind partners and enforce compliance
- Build capacity into the system at early design stage



Acknowledgements and References

Special Thanks To

- Susagna Balagué
- Mark Sherrat

References

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