EFDA

EUROPEAN FUSION DEVELOPMENT AGREEMENT

Task Force
INTEGRATED TOKAMAK MODELLING

Overview of the European Integrated Tokamak Modelling Task Force

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EU Integrated Tokamak Modeling Task Force

The Integrated Tokamak Modeling Task Force (ITM-TF) was set up in 2004 to coordinate the European modeling effort with the ultimate target of providing a complete European modeling structure for ITER, with the highest degree of flexibility, confidence and reliability.

AIM: coordinate the development of a coherent set of validated simulation tools

PURPOSE: benchmarking on existing tokamak experiments

ULTIMATE AIM: provide a comprehensive simulation package for ITER plasmas

REMIT: development of the necessary standardized software tools for interfacing code modules and for accessing experimental data

Medium term: support the development of ITER-relevant scenarios in current experiments

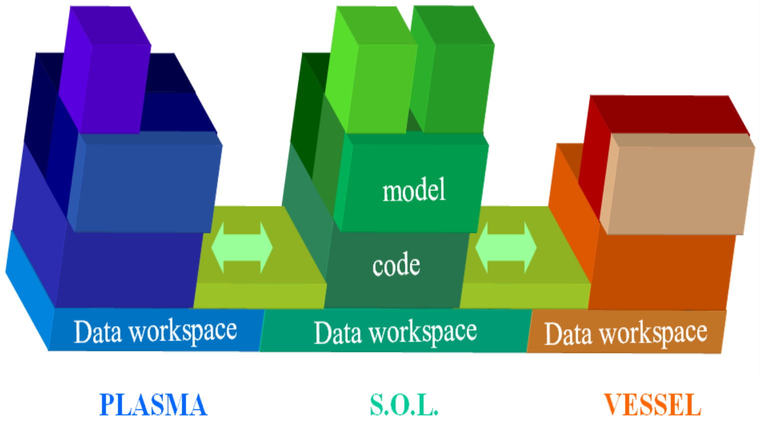
Long term: provide a validated set of European modelling tools for ITER exploitation

EFDA SC (03)-21/4.9.2 (June 24th, 2003)

ITM TF philosophy and objectives

Comprehensive integrated tokamak modelling:

- complete description: physics+machine
- standardized interfaces
- completely generic workflow



[A. Bécoulet et al EFPW 2003]

Objectives

- Develop an ideal framework for validation and integration of tokamak models
- Develop and validate models and tools (simulation platform) on the existing experiments, in view of the exploitation of ITER
- Use the developed tools for modelling ITER

➔ ambitious Integrated Modelling effort on a wide scale

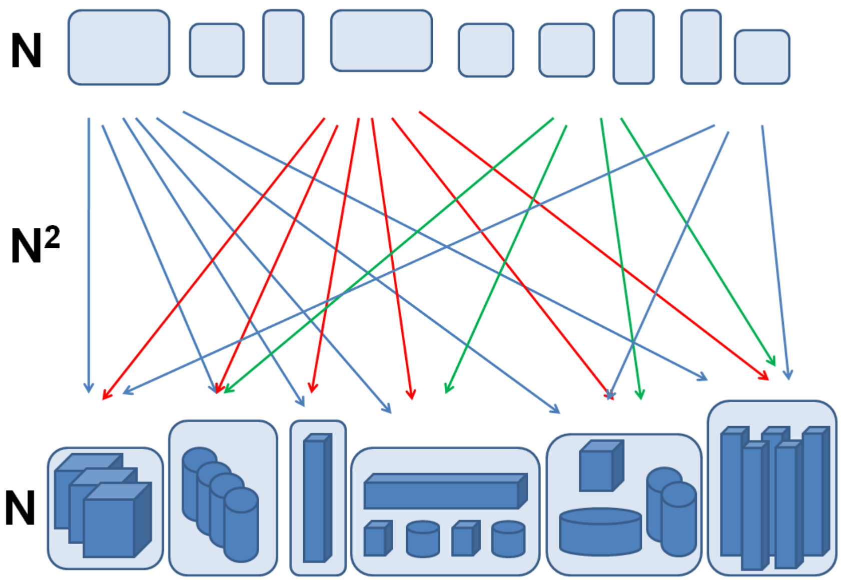
The EU ITM-TF approach

- Infrastructure describing the tokamak physics AND technology within a unique framework
- A new paradigm for integrated modelling : the physical/technological problem solved by the Simulator is defined by graphical workflows
- Fully modular and flexible simulation platform
  - Modularity : Integrates together modular pieces of physics and technology
  - Flexibility : simulator can be used for a variety of applications
  - Independent of programming language (F90, C++, Java, Python, Matlab)
  - Link to High Performance Computing / GRID

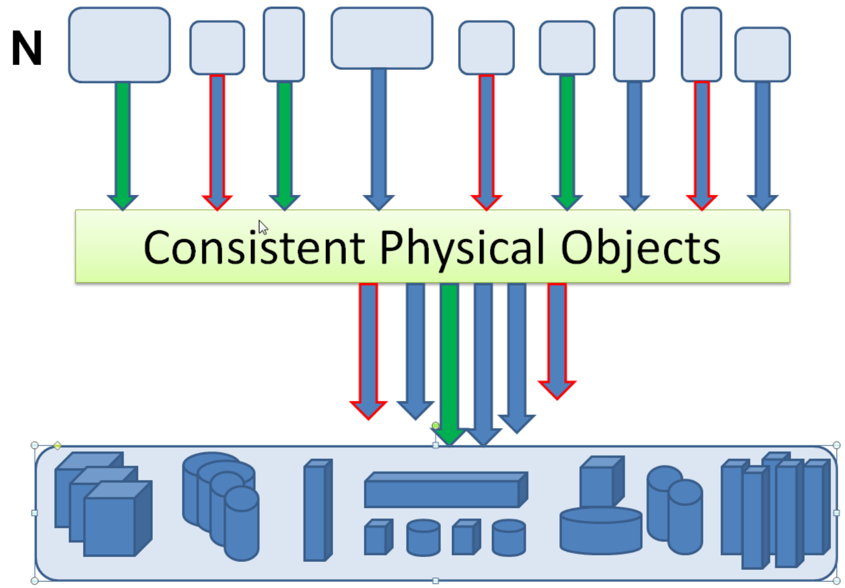
- Standardized interfaces for physics (transport, equilibrium, MHD, turbulence, …) and technology (PF systems, antennas, diagnostics)
  - Abstract and generic machine description → generic data structure relevant for all tokamaks
  - Consistent Physical Object concept (CPO) [F.Imbeaux et al, Comp. Phys. Comm. 2010]
- Completely generic workflow: much more versatile than present transport codes

Coupling codes and applications

N modules integrated in N different applications



N modules coupled into a dynamic application framework



Adapted from David De Roure

Work balance is different:

- Incremental exploitation possible in N*N approach → scales poorly with project size and has sustainability issues
- Payoff in efficiency, usability, manpower cost and increased collaborations is large for 2*N (ITM) approach BUT requires an operational framework for exploitation.

Generic Application Structure

Workflow Orchestration

- I/O
- Organisation
- Resource Interfaces (cluster, grid, HPC,...)

"Global" Ontology

- Code Interfaces
- Data transport
- Data structures

Modelling Tools/Modules

- Physics
- Statistics
- Numerics

ITM Implementation

KEPLER

- I/O
- Organisation
- Resource Interfaces (cluster, grid, HPC,...)

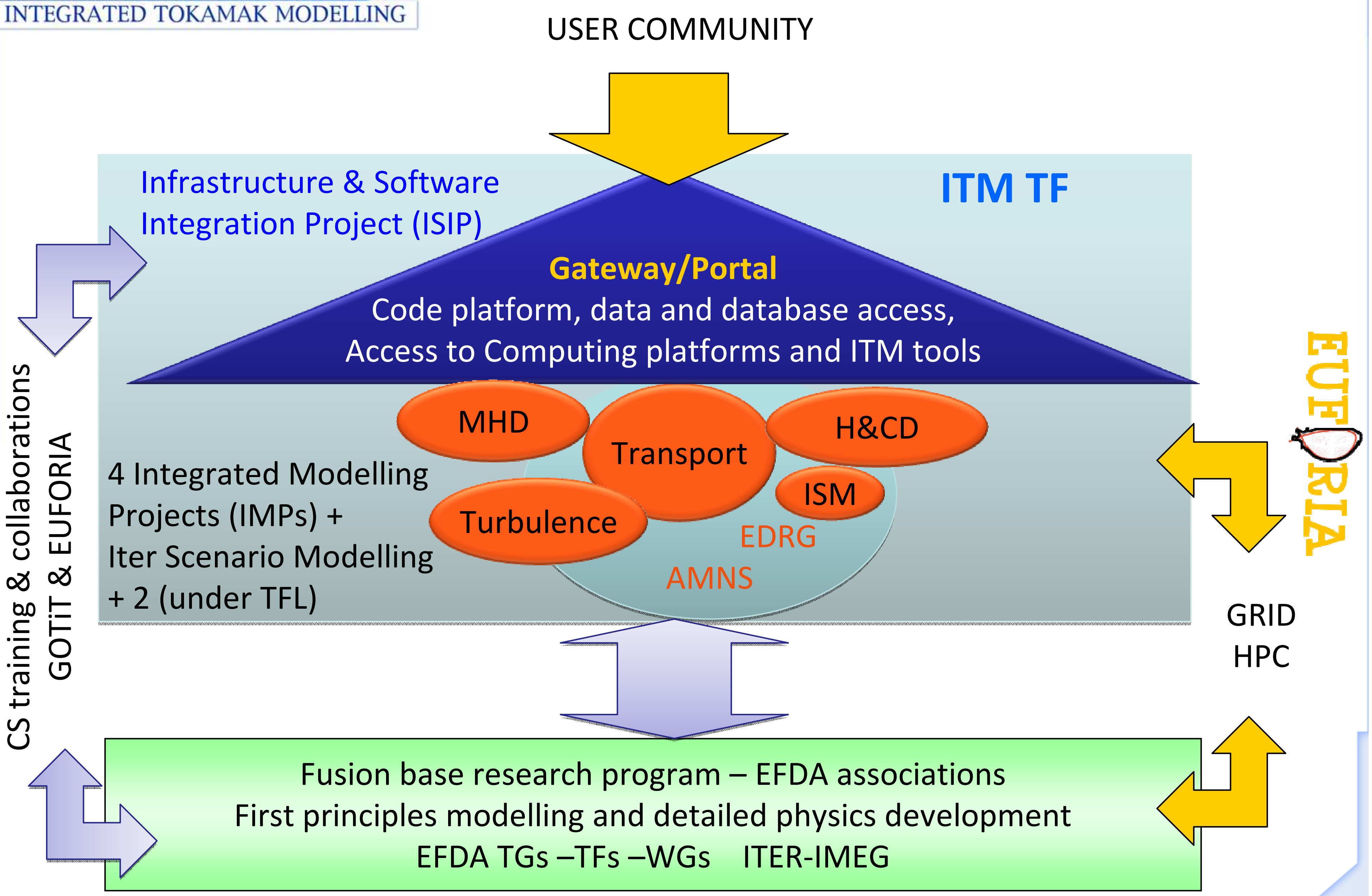
UAL/CPO

- Code Interfaces
- Data transport
- Data structures

Integrated Modelling Projects

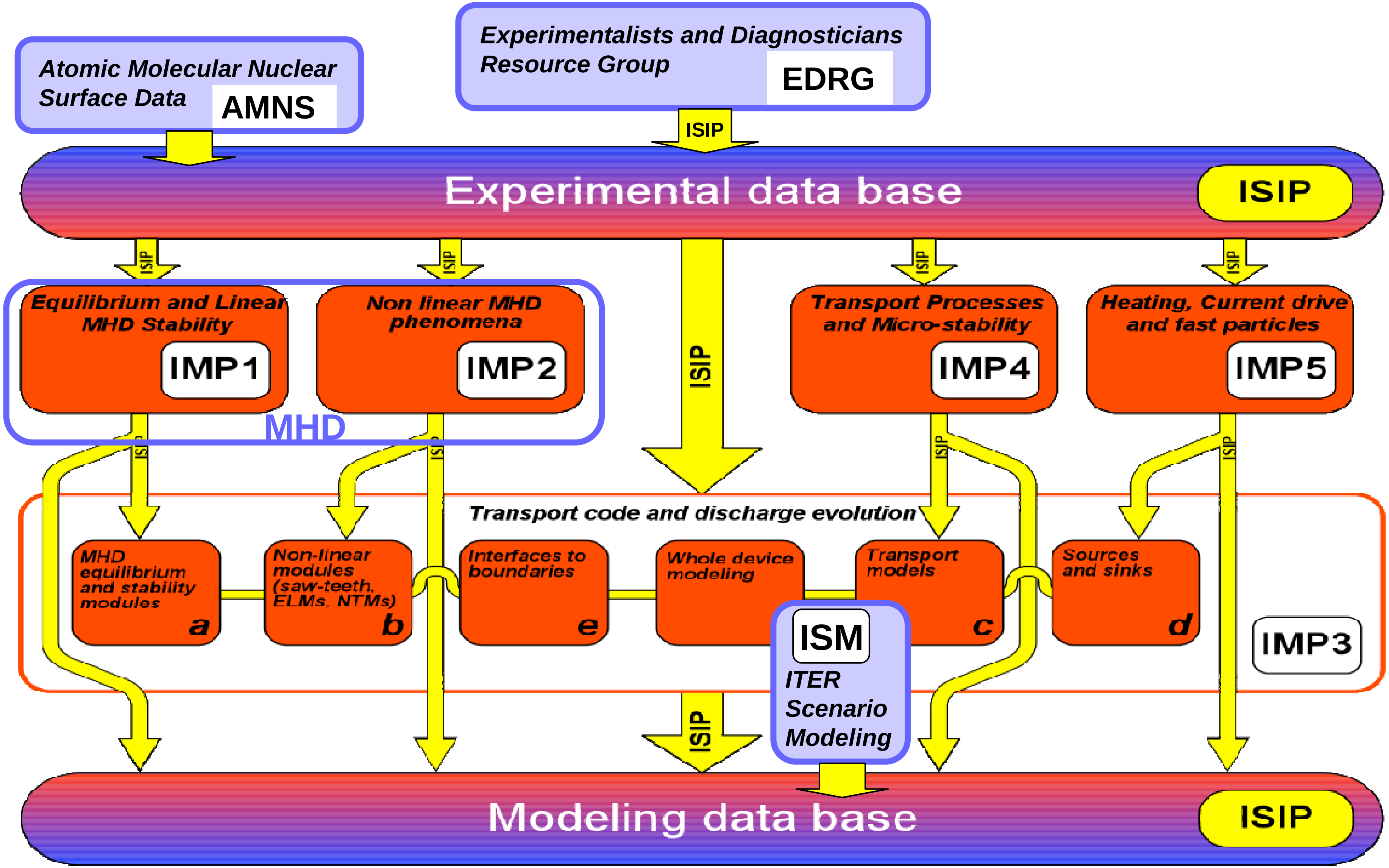
- Physics
- Statistics
- Numerics

ITM schematics



Strand, Falchetto

Integrated workflow



Elaborated from Denis Kalupin 2008

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ITM-TF timeline

2004

Preparatory phase
~50 people 14 Associations
2004: Expert Working Groups
2005: 5 IM +data coord.+platform projects

2006

Development Phase
EURATOM funding schemes
"Task Agreement"

first prototype version of a working platform 2009

ITM server (EFDA CSU, Garching)

2008

GATEWAY ENEA/CRESCO,IT

HPC-FF FZJ,DE

EUFORIA
2009: 15ppy, 45 individuals
I3- INFSO FUNDING SCHEMES

2010

Deployment phase
Starting
2010: 60ppy, 240 individuals

2012

EU review of ITM & fusion modelling

New implementation?

Elaborated from P. Strand

ITM-TF Overall Milestones

2009

- Extended set of platform tools forming a predictive core physics capacity for ITER

2011

- Whole device modelling capability including comprehensive core-edge coupling and first principles elements

2014

- A complete modelling platform and integrated modelling structure for fusion plasmas capable of full range whole device modelling as well as detailed physics studies employing a comprehensive range of validated physics models.

ITM Achievements

- **What has been provided:**
  - ✓ An advanced set of data-structures (**Ontology**)
  - ✓ A structured approach to standardized code interfaces (**CPO's**)
  - ✓ A tool set/structure for **language agnostic** physics code integration
  - ✓ A suite of access tools and technologies (**Universal Access Layer**)
  - ✓ A workflow technology (**Kepler+ ITM & EUFORIA extensions**)
  - ✓ Transparent access to both grid and HPC resources (**EUFORIA**)
  - ✓ A robust infrastructure – local clusters, grid and HPC access.
  - ✓ Provisions for advanced visualization (**EUFORIA**)
  - ✓ Basic toolset for exploitation of ITM tools on experimental devices (**exp2ITM, Machine descriptions, data mappings,..)**
  - ✓ A first set of "Release Candidate" codes – **ready for V&V**
    - ✓ ~65 codes in the ITM catalogue, being adapted to CPO interfaces
  - ✓ An emerging exploitation component **(with experiments):**
    - ✓ Full equilibrium, MHD analysis chain
    - ✓ ETS (European Transport Solver)
  - ✓ A user community – actively trained

Summary

- ✓ A first mature installation of the code platform is available
- ✓ Physics components are becoming available. Now in a position to push ahead on physics exploitation and V&V
  - Associations support and commitments needed
    - ✓“Code camps” and Working sessions key
    - ✓Training and exploration
  - Experiments support / strong collaborations necessary for utilization
    - Machine independence – test bed (MD, DM and Data Access)
    - V&V – supporting a predictive capability
- ✓ Coordination with Associations, EFDA Topical Groups, International partners - synergy and “dual” support
  - Building a broadened user community
  - Promoting EU toolset on ITER and ITER partner level

ITM-TF Framework

A pan-european simulation environment:

- Open ended, flexible and extensible simulation framework (ISIP – Kepler)
- Multi device databases (ISIP – EDRG)
  - “Closer” to experiments – improved V&V,
  - Assisting Experimental campaigns
  - Allowing for synthetic diagnostics
- Device independent State of the art physics modules
  - Broad application basis – Broad user base
- Proper V&V basis to secure quality and applicability

EFDA based:

- A jointly owned and operated infrastructure
- A jointly developed physics capability
  - Organic growth towards improved state of the art tools
  - ”Darwinian” selection and development of models

Courtesy of P. Strand