

# **STATUS 2025: VMAP WORKING GROUP FULL MODEL STORAGE**

**VMAP User Meeting 2025**



# Content



- Introduction to WG Complete Model Storage
  - Recap status at user meeting Feb 2024
  - Developments in 2024
    - Concepts
    - Comparisons
    - Voting
    - Discussion points
  - Next steps and open questions
- 
- Note: examples in this presentation are based on VMAP 1.0.0

# Introduction to WG Complete Model Storage



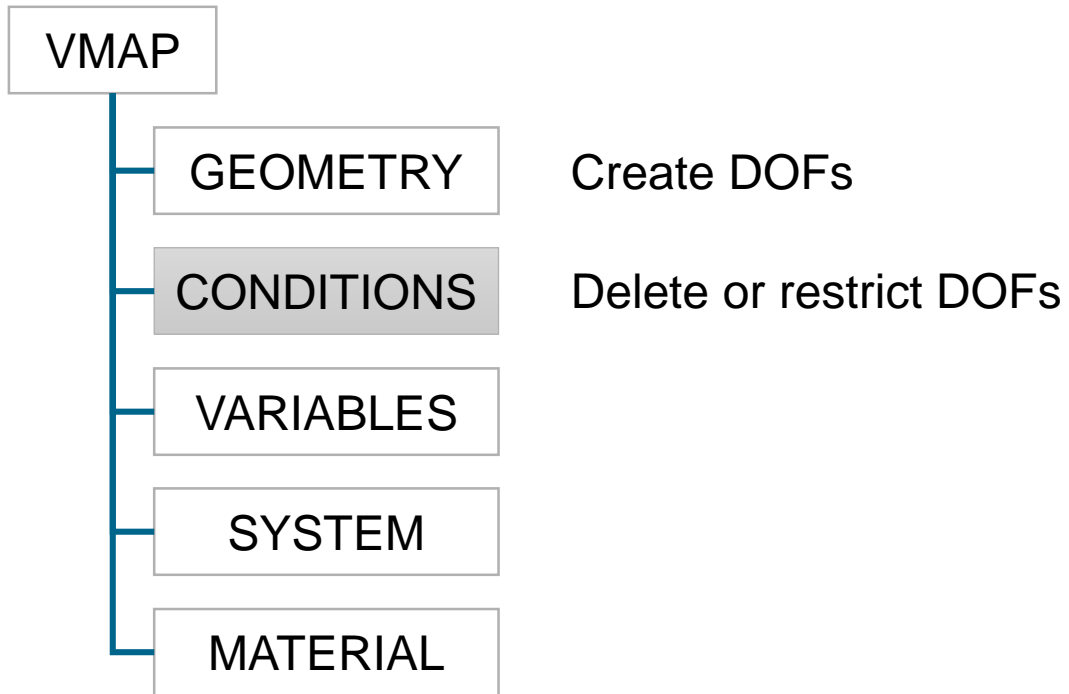
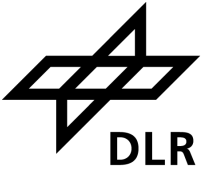
Institutions
Fraunhofer SCAI
BETA CAE
Key to Metals
BMW
HTW Berlin
BAM
DLR BT
DLR SY

# Introduction to WG Complete Model Storage

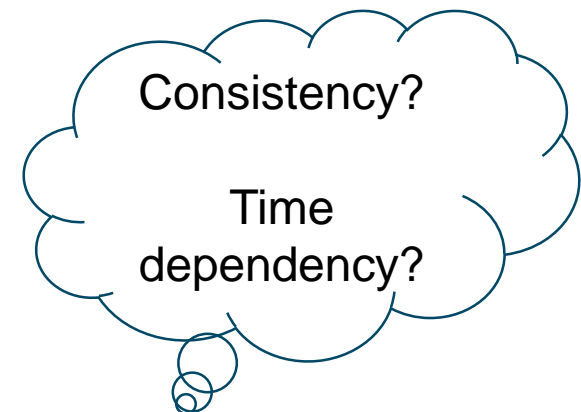
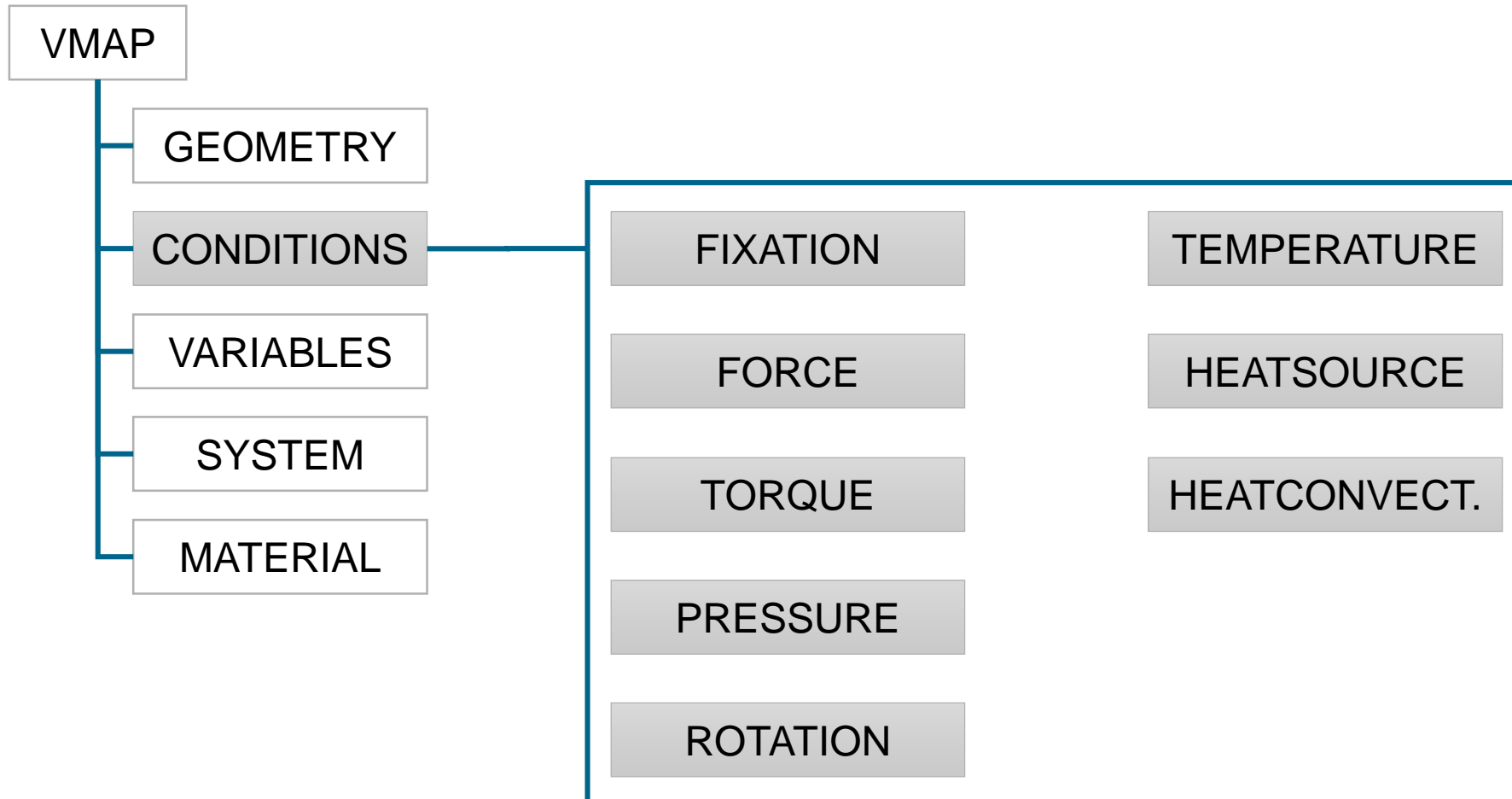


- Original goals of VMAP ITEA Project (2017-2021):
  - CAE workflow interface for passing results between diverse software
  - Multi-disciplinary use cases
  - Meshes + results
- Complete Model Storage
  - Meshes + results + all information needed to produce the results
  - Boundary conditions, loads, etc.
  - Reproducibility
  - Collaboration (exchange of (almost) full model)

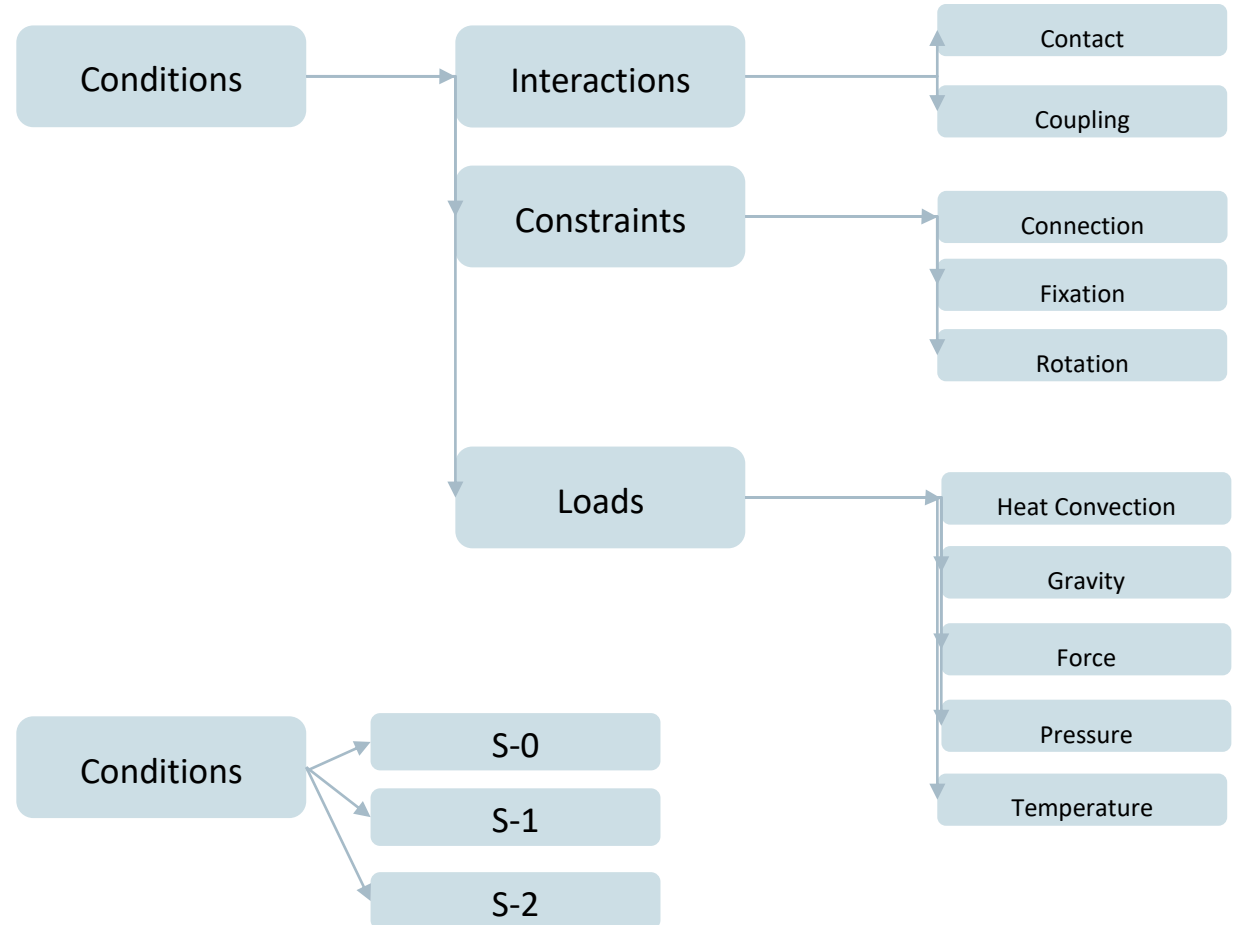
# Recap state of complete model storage at UM 2024



# Recap state of complete model storage at UM 2024



- How to group conditions?
  - *Engineering* hierarchy?
  - *Mathematical* hierarchy?
  - Group *loads* by kind
  - Group *constraints* by kind
  - Easy *re-use* in ...
  - ... *analysis steps*: different conditions in steps?
- How do other projects solve this?

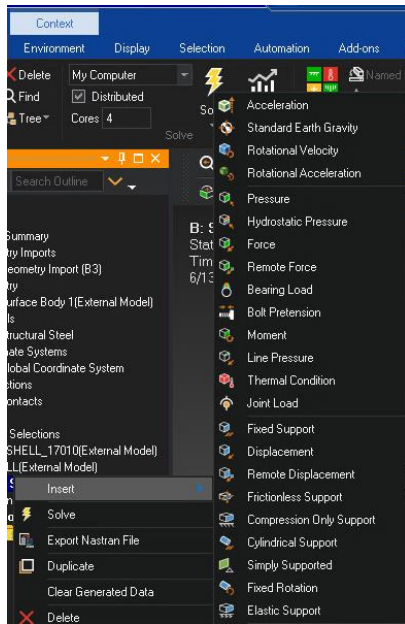
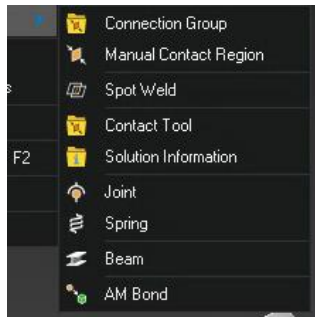


Numerous contributions by WG members for comparisons:

- ABAQUS (general)
- ANSA (general, in numerous solver modes)
- ANSYS (general)
- HyperMesh (turbine use case in ABAQUS mode)
- SMILE (full vehicle crash case with ABAQUS and LS-DYNA translations)



# WG Developments 2024



- Parts (1)
- Materials (1)
- Calibrations
- Sections (1)
- Profiles
- Assembly
- Steps (3)
- Field Output Requests (1)
- History Output Requests (1)
- Time Points
- ALE Adaptive Mesh Constraints
- Interactions
- Interaction Properties
- Contact Controls
- Contact Initializations
- Contact Stabilizations
- Constraints
- Connector Sections
- Fields
- Amplitudes
- Loads
- BCs**
- Predefined Fields
- Remeshing Rules
- Optimization Tasks
- Sketches

## Nastran

B.C. SETS		INFO
SPC	MPC	LOAD
DLOAD	NSM	FILE LOAD.
THERMAL	MFLUID	
BCs		INFO
SPC	MPC	FORCES
PLOAD	DAREA	DOFsets
ACMODL	PANELS	NSM
TEMPBC	TEMP	THERMAL
TEMPRB	BOLTFOR	DELETE

BCs		INFO
DMIG	SUPORT	NOLIN
GRAV	TIC	TEMPP1
RFORCE	SESET	RVDOF
SLOAD	VCCT	ACCEL1
TF	MFLUID	IPSTRAIN
ISTRESS		

## Abaqus

CONSTRAINTS		INFO
COUPLI	MPC	EQUATI
FASTEN		DELETE
BOUNDARY		INFO
BOUNDA	CON.MO	IMPEDA
AC.VELO	EULERIA	DELETE
FLUID B.		
LOADs		INFO
TRANSP	CFILM	DELETE
CECURR	DLOAD	CLOAD
INIT.CONDIT.		INFO
INIT.CO.	IMPERF.	DELETE

## ANSYS

CONSTRAINTs		INFO
CERIG	RBE3	CE/CP
D	DJ	DELETE
LOADs		INFO
F	BF	BFE
SFE	ACEL	CMACEL
SLOAD	FJ	OMEGA
GOMGA		DELETE

## PAMCrash

CONSTRAINTS		INFO
CNTAC	NODCO	RWALL
RBODY 0	RBODY 2	RBODY 3
MTOCO	OTMCO	DELETE
LOAD		INFO
CONLO	PREFA	TR3DBC
ACFLD	INVEL	HTSURF
DISLIM	PRESBC	ACTUA
HFLUX	BFLUX	DFLUX
INTEM	TEMB	DELETE

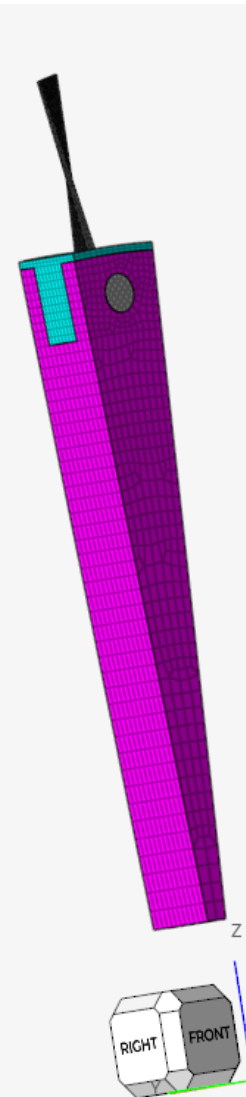
## Marc

BCs		INFO
POINT LO.	DIST LOA	FIXED DI
INITIAL T.	DIST FLU	POINT FL
INIT STR.	INITIAL P.	TEMP
DELETE		

## LSDyna

CONSTRAINED		INFO
JOINTs	ND_R_BD	EXT_NOD
RIGBOD	SPR2	DELETE
IN_SOLID	TIED_NO	
BOUNDARY		INFO
SPC	MOTION	ACCEL
ORIENT	SPC_SY	AMBIENT
TEMP		DELETE
LOAD		INFO
LOAD	BEAM	SHELL
BODY	THERMA	DELETE
INITIAL		INFO
VELOCIT.	STRAIN	INTEMP
STRESS	STRSECT	DELETE

- Cards (1)
- Components (4)
- Elements (13737)
  - 3D (13737)
    - Hex8 (5996)
      - C3D8I (5996)
    - Tetra10 (7741)
      - C3D10 (7741)
- Groups (7)
  - \*CONTACT PAIR (5)
  - \*TIE (2)
  - Load Collectors (2)
    - HISTORY (1)
    - INITIAL CONDITIONS (1)
  - Load Steps (1)
    - \*STEP (1)
  - Loads (2)
    - \*BOUNDARY (1)
    - \*DLOAD (Pressure) (1)
  - Materials (3)
    - \*MATERIAL (3)
  - Nodes (22070)
  - Output Blocks (1)
  - Parts (5)
    - Part Assemblies (1)
    - Parts (4)
  - Properties (5)
    - \*FRICTION (1)
    - \*SOLID SECTION (3)
    - \*SURFACE INTERACTION (1)
  - Sets (20)
    - \*ELSET (5)
    - \*NSET (2)
    - \*SURFACE (13)
  - Titles (1)



## SMILE

```
<INITIAL.CONDITIONS>
<VELOCITY id="VEL-1" Ref="FZG" Values="15555.556 0.0 0.0">
  Ref_Ori="ORI-Global"/>
</INITIAL.CONDITIONS>
```

## Abaqus

```
*INITIAL CONDITIONS, TYPE = VELOCITY
FZG_NSET,1,-15555.555556
FZG_NSET,2,0.0
FZG_NSET,3,0.0
```

## LS-DYNA

```
*INITIAL_VELOCITY
$# nsid nsidex boxid irigid icid
59000300 0 0 0 0
$# vx vy vz vxr vyr vzr
-15555.556 0.0 0.0 0.0 0.0 0.0
```

- First conclusion:

*Separate conditions in Boundary Conditions (BC) and Initial Conditions (IC)*

- Exactly how to group conditions?

➤ Vote

- WG voting on the following options:
  1. separation of conditions into **IC & BC**
  2. separation of conditions into **IC & BC**. Separation of **BC** into two further groups **Dirichlet BC** and **Neumann BC**
  3. separation of conditions into **IC & BC**. Placing **Dirichlet BC** and **Neumann BC** as an attribute to the **BC**

More discussion points:

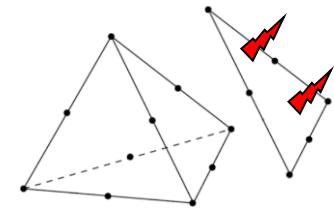
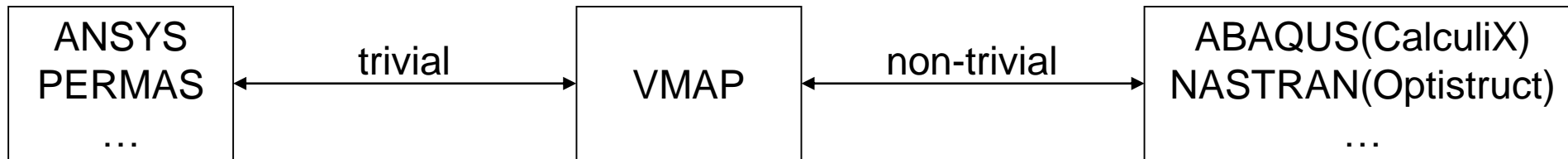
- Still no full definition on how to group conditions
- BC fields possible
- Temporal BC (fields) possible via tables
  - Still, IC stand out from an engineering perspective
- Consistency of IC & BC (logical, chronological) should not be part of VMAP, which should just provide a language for description.
- Consider simple, universal use cases ...

- Suggestions for simple thermal and mechanical problems:
  - Plate with hole under tension (2D)
  - Three-point bending truss (3D)
  - Heat conduction through plate (2D)
  - Heat convection of brick in air (3D)
  - Rotating bladed disk (3D, includes CONNECTION)
  - ...?
- Consensus: no 1D use cases
- Important: possibility to store solver specific data not covered by use cases
- Besides grouping of conditions, modelling approaches need to be chosen ...

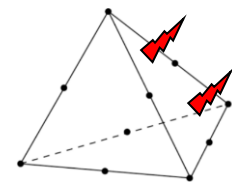
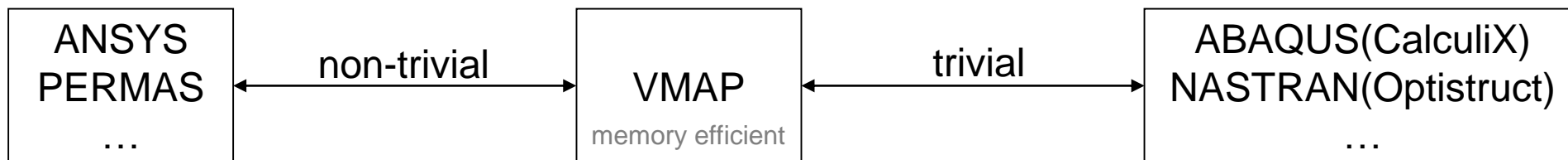
# Example of established modelling approaches and VMAP integration options

Exemplary condition: heat convection. Options: VMAP uses ...

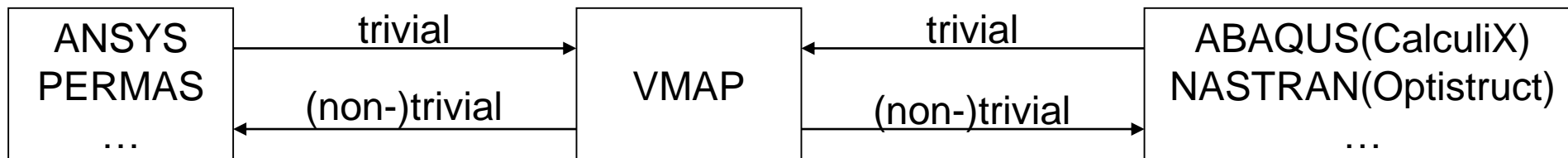
1. ... ANSYS/PERMAS standard



2. ... ABAQUS/NASTRAN standard



3. ... a „Double Standard“



# Requirement Analysis

## Suggested additional requirements:

- „VMAP should be capable of storing **model setup information in detail for standard examples.**“
- „VMAP should be capable of storing **static and transient analyses.**“
- [..., modal analysis, ...]

## Chapter 3

### Requirement Analysis for VMAP

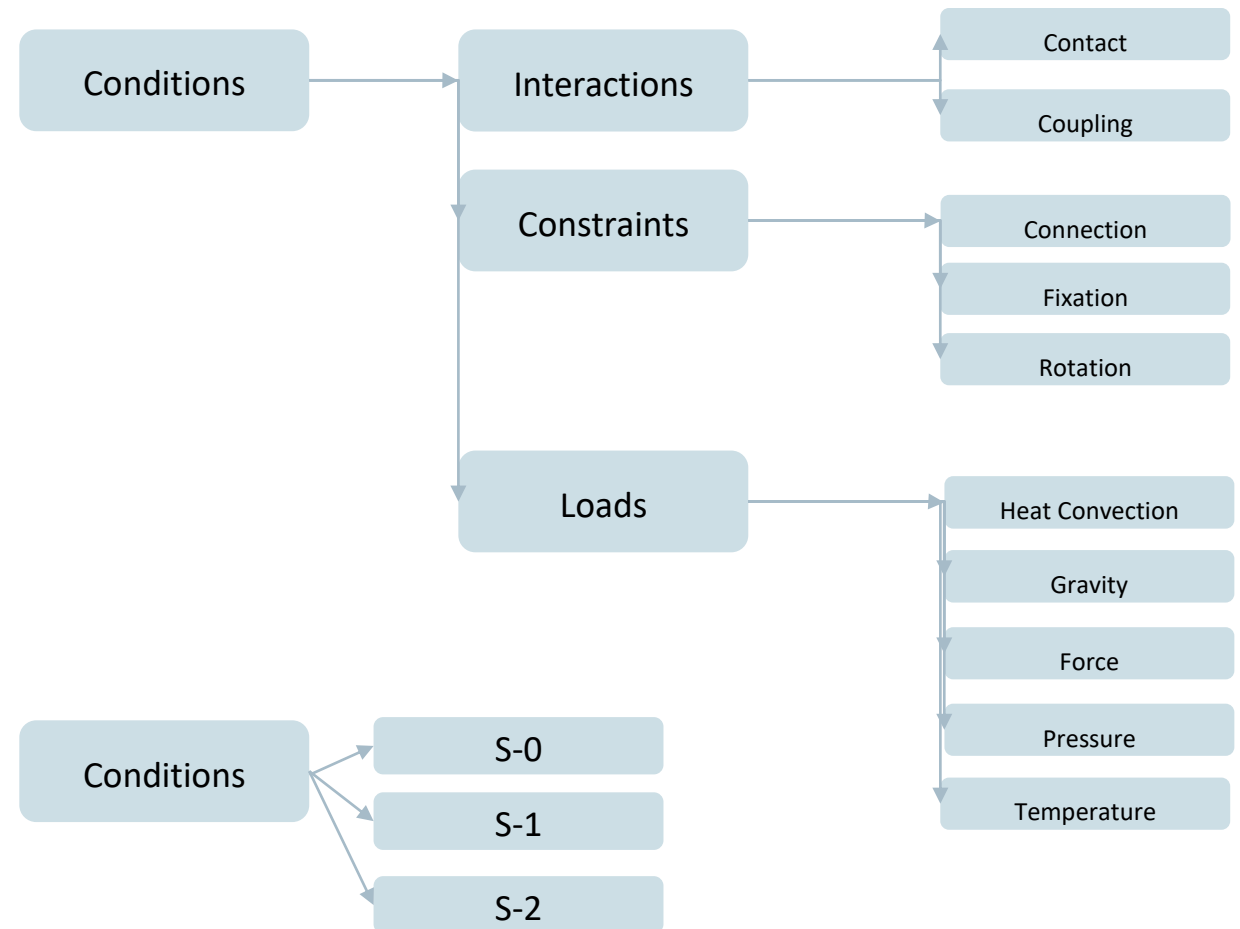
The VMAP consortium involves more than 30 companies from all over Europe and North America. This includes the 10 manufacturing industries and the rest are CAE software developers. All the members of the consortium offer different industrial use cases, hence making VMAP a wholesome standard covering a vast variety of materials used for manufacturing. Based on this vast majority of use cases, some of the critical requirements for VMAP are listed below:

1. VMAP should contain result information in detail.
2. VMAP should contain all data necessary to map the results.
3. VMAP should be capable of storing transient analyses.
4. VMAP should be able to use any of the standard unit systems.
5. VMAP files should be useful for both batch and automatic execution modes.
6. VMAP should be capable of storing custom coordinate systems, both local and global.
7. VMAP should be useful for all known operating systems.
8. VMAP files should be accessible with the help of free/open source tools.
9. A service and support community should exist, even after the project ends.
10. Software maintenance should be carried out on a regular basis.

These are few of the very basic requirements, which form the building blocks of VMAP. These critical requirements and many others formed the basis of VMAP and led to a standard which covers the geometrical and material domain in CAE.

# Open Questions

- How to reflect the outcome of the voting in the concept?
- How to model each condition?
- What about the analysis layer?
- HDF5 $\leftrightarrow$ JSON
- ...





# Imprint



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Image sources: DLR and VMAP WG Full Model Storage

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