



# Open Source in der Luft- und Raumfahrt-Forschung

## FrOSCon 2010

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<http://www.dlr.de/sc>

The image features a stylized white logo on a black background, resembling a rocket or a stylized 'A' with a horizontal bar. The logo is positioned on the left side of the frame. The background is a satellite image of Earth, showing the curvature of the planet, the blue oceans, and the green and brown landmasses. The text 'DLR' is overlaid on the satellite image in a bold, white, sans-serif font.

**DLR**



# Das DLR Deutsches Zentrum für Luft- und Raumfahrt



- Forschungseinrichtung
- Raumfahrt-Agentur
- Projektträger

# Standorte und Personal

6.500 Mitarbeiterinnen und Mitarbeiter arbeiten in 29 Forschungsinstituten und Einrichtungen in

- 13 Standorten.

Büros in Brüssel,  
Paris und Washington.





# Leitbild - Vision

- Das DLR - die führende und richtungsweisende öffentliche **Forschungseinrichtung** in Europa für seine **Forschungsbereiche Luftfahrt, Raumfahrt, Verkehr und Energie**
- Das DLR - die gestaltende Kraft für die europäische Raumfahrt in seiner Funktion als **Raumfahrt-Agentur**
- Das DLR - die Dachorganisation für die wirkungsvollsten und effizientesten **Projektträger**



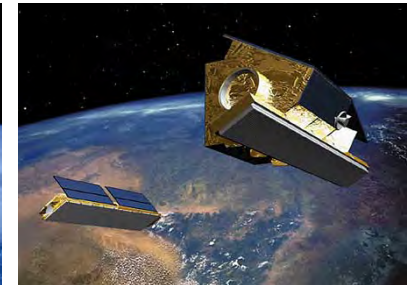
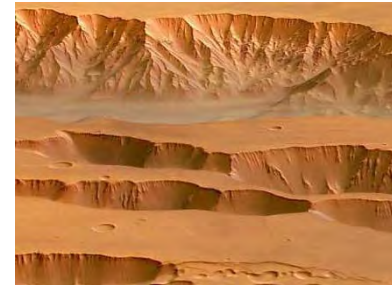
# DLR Forschungsbereich Luftfahrt

- Optimierung der Leistung und der Umweltverträglichkeit des Gesamtsystems „Flugzeug“
- Erweiterung des Flugbereichs von Hubschraubern auf alle Wetterbedingungen
- Effiziente und umweltfreundliche Flugtriebwerke
- Sicherer, umweltfreundlicher und effizienter Luftverkehr (Flugsicherung, Flugbetrieb)



# DLR Forschungsprogramm Raumfahrt

- Erforschung des Weltraums
- Forschung unter Schwerelosigkeit
- Erdbeobachtung
- Kommunikation & Navigation
- Raumtransport
- Technik für Raumfahrtsysteme



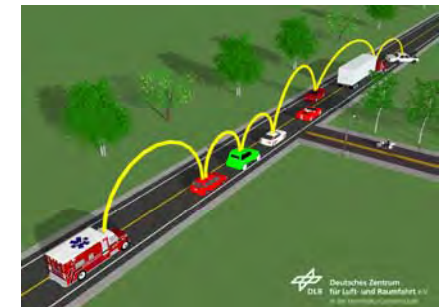


# Herausforderungen im Geschäftsfeld Verkehr

- Nachhaltige Mobilität erreichen in einer Balance von
  - Ökonomie
  - Gesellschaft
  - Ökologie

## durch

- Sicherung der Mobilität für Menschen und Güter
- Schutz von Umwelt und Ressourcen
- Verbesserung der Sicherheit

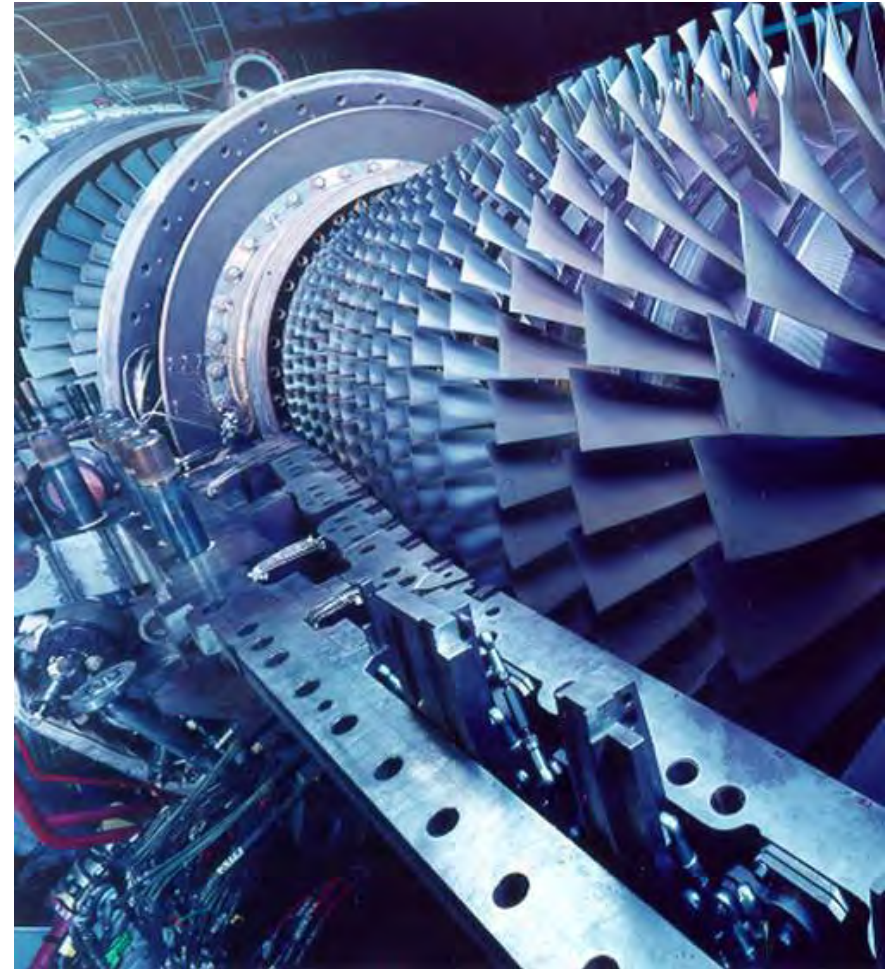




# DLR Forschungsprogramm Energie

Die DLR-Energieforschung konzentriert sich auf

- CO<sub>2</sub>-Vermeidung durch Effizienz und Erneuerbare Energien
- Synergien im DLR
- energiewirtschaftlich relevante und großforschungsspezifische Themen.





# Software im DLR





## Software im DLR

Größenordnung der Software-Entwicklung

**Über 1000 Mitarbeiter des  
DLR entwickeln Software**

**Das sind >100 Millionen EUR  
Vollkosten pro Jahr**

**DLR ist eines der größten  
Software-Häuser Deutschlands**

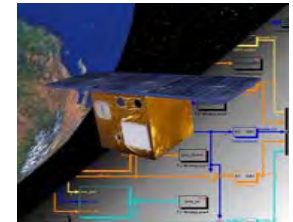


# Software-Entwicklungen in Luft- und Raumfahrt

## Klassifizierung

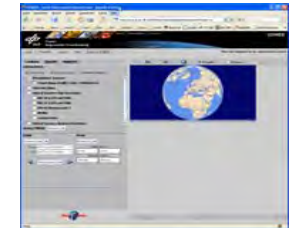
### Software für missionskritische Systeme

- Embedded Software und Real-Time-Software in Flugzeugen, Satelliten, Raumfahrzeugen, ...



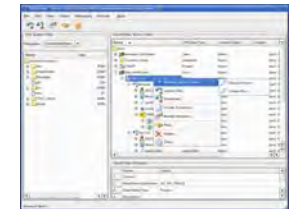
### Software mit großen Userzahlen

- Internet/Intranet/Email, Webshop für Satellitendaten



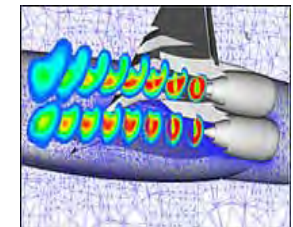
### Software zur Unterstützung

- Prozessunterstützung, Datenmanagement, Modellierungs- und Simulationsumgebungen, ...



### Software deren Effizienz wichtig ist

- Numerische Simulationscodes



# Freie Software in der Luft- und Raumfahrt

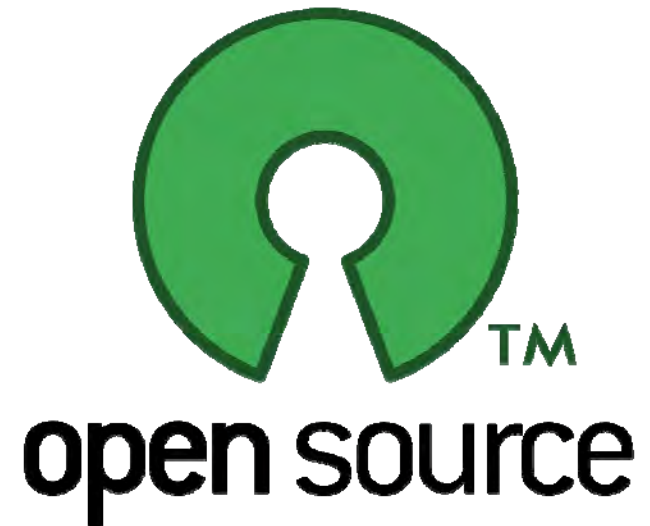
## Nutzen von Open-Source-Software

### Reduktion des Entwicklungsaufwands

- Weniger eigener Source-Code
- In manchen Projekten wird nur ca. 10% neu programmiert

### Profitieren von der Stabilität

- Open-Source-Software ist vielfach getestet
- ... und wird ständig weiterentwickelt





# Nutzung von Open-Source-Software

## In der Forschung wird unterschiedlichste freie Software genutzt

- Anwendungssoftware
  - z.B. Textverarbeitungen LaTeX oder Open Office
- Betriebssystem Linux
  - Desktop & Server
- Programmiersprachen und Compiler
  - GNU Compiler, Python, ...
- Bibliotheken
  - Datenbank-Zugriff, XML-Verarbeitung, Numerik, ...
- Web-Frameworks
  - Zope, Plone, Django, Liferay, MoinMoin-Wiki, ...
- Entwicklungs-Tools
  - Eclipse, Subversion, Mercurial, ...





# Bereitstellung von Open-Source-Software

## Forschungseinrichtungen stellen eigene Entwicklungen zur Verfügung

- Simulationssoftware
- Datenverwaltungssoftware
- Bibliotheken

## Beteiligung an Open-Source-Projekten

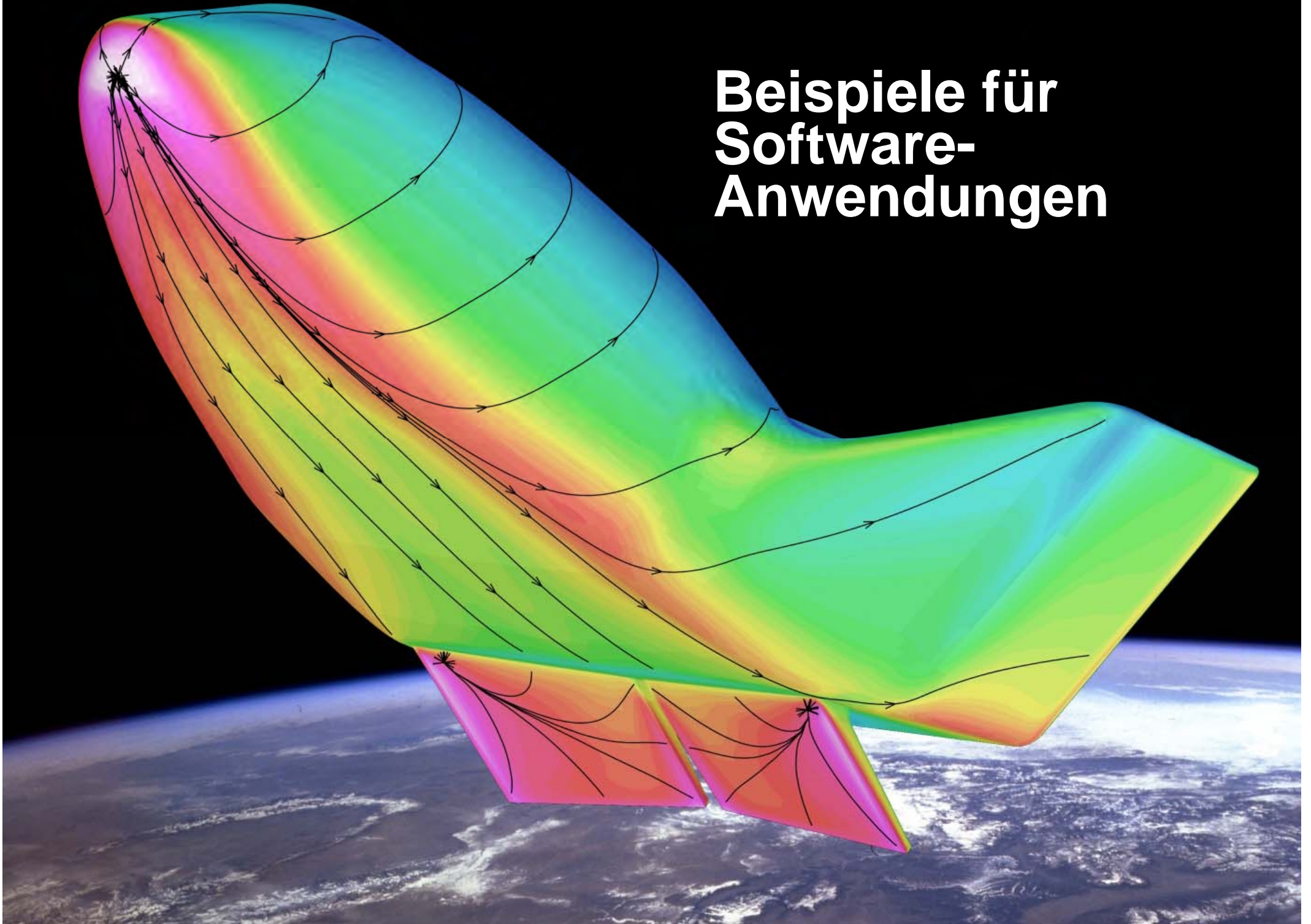
- Mitarbeit bei existierenden Projekten
- Gemeinsame Entwicklungen in Forschungsprojekten



# Lizenzen

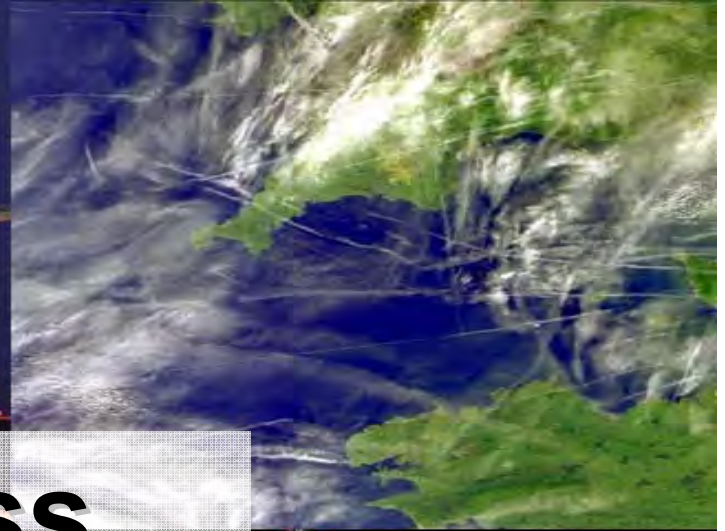
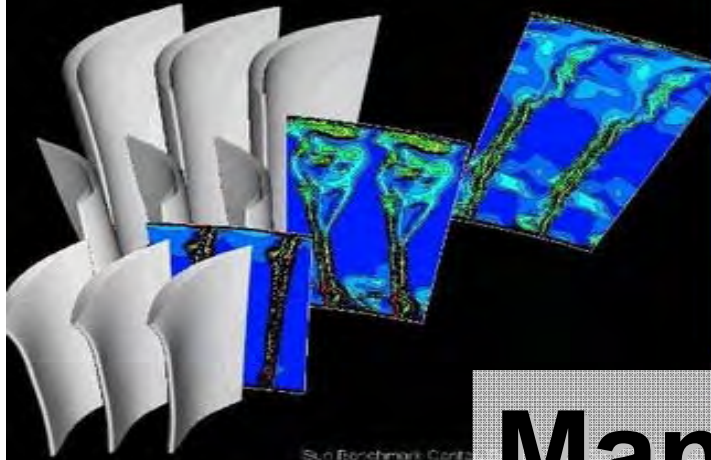
- Häufig verwendete Lizenzen
  - Apache License 2.0
  - BSD License
  - Eclipse Public License
  
- Überprüft von der DLR-Rechtsabteilung
  
- Ähnlich auch in vergleichbaren Organisationen
  - ESA
  - NASA

# Beispiele für Software- Anwendungen

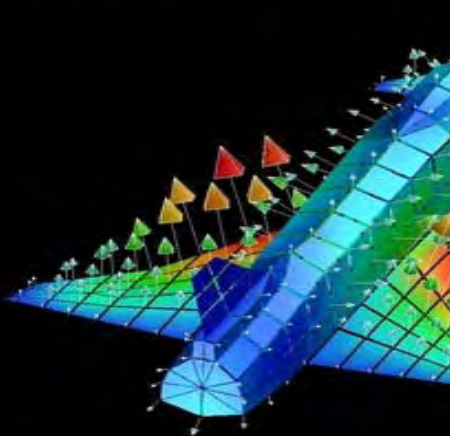




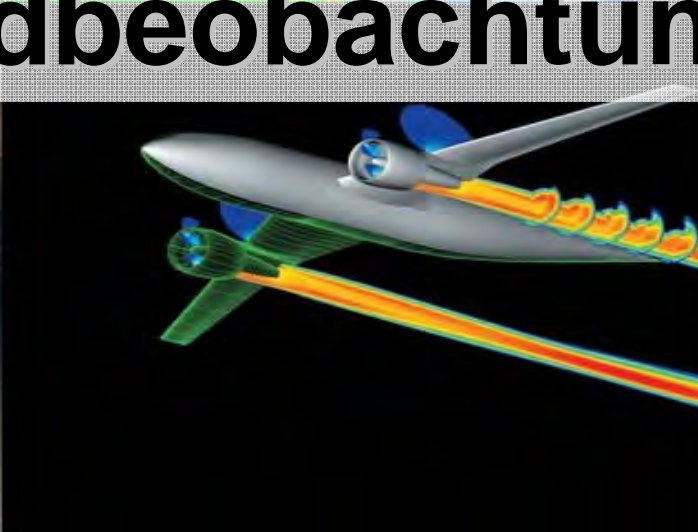
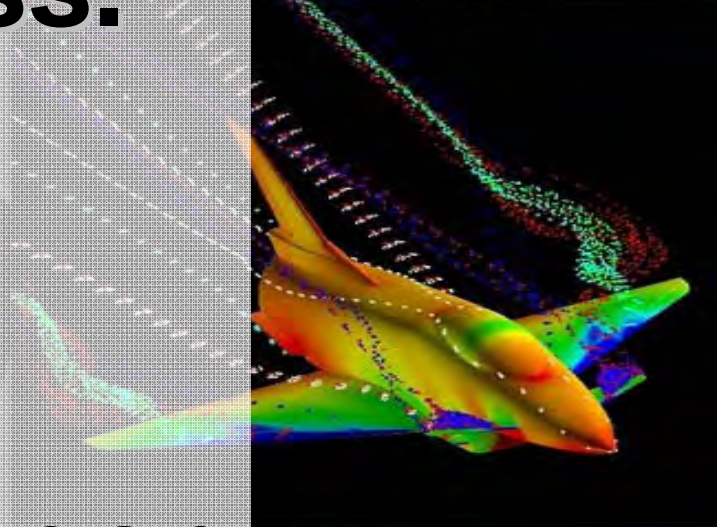
Unsteady CFD of a Low Pressure Turbine



Sun Benchmark Contour



**Management wiss.**  
**Daten von**  
**- Simulationen**  
**- Experimenten**  
**- Erdbeobachtungen**





# Open-Source-Software DataFinder Implementiert in Python und Qt

File System

Drives: C:\

Name Size

- RECO (directory)
- RHD (directory)
- System Volume Information (directory)
- tmp (directory)
- trace\_63 (directory)
  - cgns (directory)
    - BALANCE\_PROC 15 Byte
    - input.cgns 135.289 MByte
    - input.cgns.backup 135.289 MByte
  - input (directory)
    - trace.input 3.418 KByte
    - trace.solverinfo 1.442 KByte
    - TRACE\_entry.input 898 Byte
    - TRACE\_exit.input 25 Byte
    - TRACE\_S2.input 174 Byte
  - post (directory)
  - residual (directory)
    - blk.0 12.152 KByte
    - blk.1 12.040 KByte
    - blk.2 12.042 KByte
    - blk.3 12.033 KByte
    - blk.4 12.085 KByte
    - blk.5 12.060 KByte
  - run.sh 1.129 KByte
  - run.sh.e1235 24 Byte
  - run.sh.o1235 17.616 KByte

trace

- MTU\_12
- BC\_Fourier
  - Monitoring
  - SystemInfo
  - TRACE
    - Input
      - BALANCE\_1PROC TRACE-Info application/octet-stream 15 Byte 17. Feb, 11:51 17. Feb, 11:51
      - stcf10\_1.cgns CGNS application/octet-stream 135.289 MByte 17. Feb, 11:51 17. Feb, 11:51
      - TRACE\_control.input TRACE-Parse application/octet-stream 3.334 KByte 17. Feb, 11:51 17. Feb, 11:51
      - TRACE\_entry.input TRACE-Entry application/octet-stream 898 Byte 17. Feb, 11:51 17. Feb, 11:51
      - TRACE\_exit.input TRACE-Exit application/octet-stream 25 Byte 17. Feb, 11:52 17. Feb, 11:52
      - TRACE\_S2.input TRACE-S2 application/octet-stream 174 Byte 17. Feb, 11:51 17. Feb, 11:51
    - Output
  - BC\_Giles1 Run
  - BC\_Giles2 Run
  - BC\_Riemann Run

Name	Value
1 CPUs	5
2 Data Type	TRACE
3 Version	6.3.72

**Start Run**

Resource

Back-end: UNICORE 6

Machine to run the job: aerogrid.dlr.de:443/AEROGRID

TRACE

Compile from source

Use existing executable

\$HOME/trace\_63/TRACE

OK Cancel

Log Search Results Script Output

16:33:35: INFO: Search results for [Data Type == Run]:

16:33:35: INFO:

- /datafinder/data/trace/Müller/Verdichter/BC\_Fourier
- /datafinder/data/trace/Müller/Verdichter/BC\_Riemann
- /datafinder/data/trace/Müller/Verdichter/BC\_Giles1
- /datafinder/data/trace/Müller/Verdichter/BC\_Giles2

4 item(s) found.



# Datenmanagement-Webportal Liveray Portal-Framework



The screenshot displays the AERO GRID web portal interface. At the top left is the AERO GRID logo. A navigation bar contains a 'Welcome' button. In the top right corner, a user is logged in as 'Test Test!'. The main content area features a 'DataFinder Portlet' window. This window contains a search interface with the following elements:

- Navigation: Browse, Upload, Search, DataStores, Logout, /data/trace
- Server: http://192.168.138.134/datafinder (admin)
- Start search at: [root]http://192.168.138.134/datafinder/data/trace/Test/TestProjekt/testRun
- Conditions:  ONE of the following  ALL of the following
- Search query: DataFinder TypecontainsProject (with a red X icon)
- Generate search term section with two rows:
  - Row 1: DataFinder Type (dropdown), contains (dropdown), Project (text input), Add Term (button)
  - Row 2: <Custom attribute> (text input), == (dropdown), (text input), Add Term (button)
- Buttons: Find, Reset

Below the search form, a table displays search results:

creationdate	2009-06-16T08:59:09Z
--------------	----------------------

Buttons 'Ok' and 'Edit' are visible below the table. A 'DataFinder Portlet' sidebar on the left lists 'Monitoring', 'SystemInfo', and 'TRACE'.



# Sicherung und Nutzung von Expertenwissen





# Wissensmanagement für Berechnungsingenieure

The screenshot displays the TAU Expertensystem interface. The main window shows a scenario titled "Mesh Generation Centaur" with a "Scenario short description" and "Enter further information" section. It includes a checkbox for "Please select this field if you discovered too much chopping" and two images of a meshed airfoil. Below the images are "Advanced explanations" buttons: "Start context-sensitive search", "Why do I have to provide this information?", "Previous step", and "Next step". A search window on the right shows "XPS Search" results for "chopping mesh surface generation", listing 36 results in 1 ms. The first result is a PDF titled "odas\_optimization\_brezz-brod-ea\_2006.pdf".

1. Start a scenario

Mesh Generation Centaur

Scenario short description  
This scenario guides the user through the process of creating a mesh for a Centaur model.

Enter further information  
Required information: Too much chopping in the generated mesh?

Did you discover too much chopping? The picture below shows the effect of too much chopping. You are going to iterate back to remove chopping.

Please select this field if you discovered too much chopping.

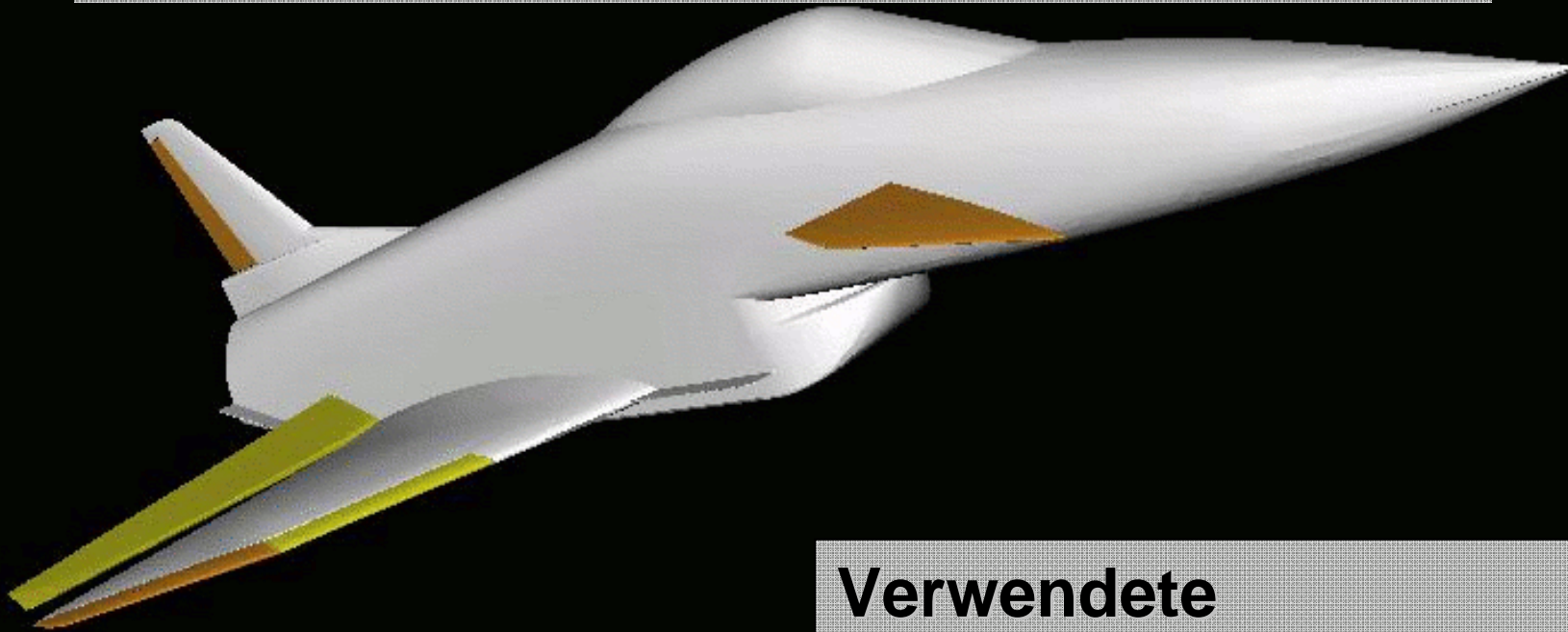
Advanced explanations:  
Start context-sensitive search  
Why do I have to provide this information?  
Previous step Next step

XPS Search  
chopping mesh surface generation  
Show max Results 0  
Search Advanced Search  
36 Results (1 ms)  
odas\_optimization\_brezz-brod-ea\_2006.pdf  
into the DLR mesh generation system MegaCads, which provides a broad palette of functionalities for CAD and structured mesh generation [4]. MegaCads is also well suited for the construction ... resolution, 5.1. Hybrid Mesh Generation The hybrid meshes, consisting of prismatic, pyramidal ... for the automatic, non-interactive generation of a hybrid mesh. In addition a tool is available to update ... that a fully automatic mesh generation becomes possible which is necessary for the optimisation loop.

title :  
author :  
id :  
Thu Jun 26 10:42:52 CEST  
length : 720kb  
filetype : pdf  
tau/TAU\_Data/NEAR/TAU-Publications/odas\_optimization\_brezz-brod-ea\_2006.pdf

Verwendete  
Open-Source-Software:  
- Eclipse  
- JBoss Drools  
- Apache Lucene

# Software für den Entwurf von Flugzeugen aller Art



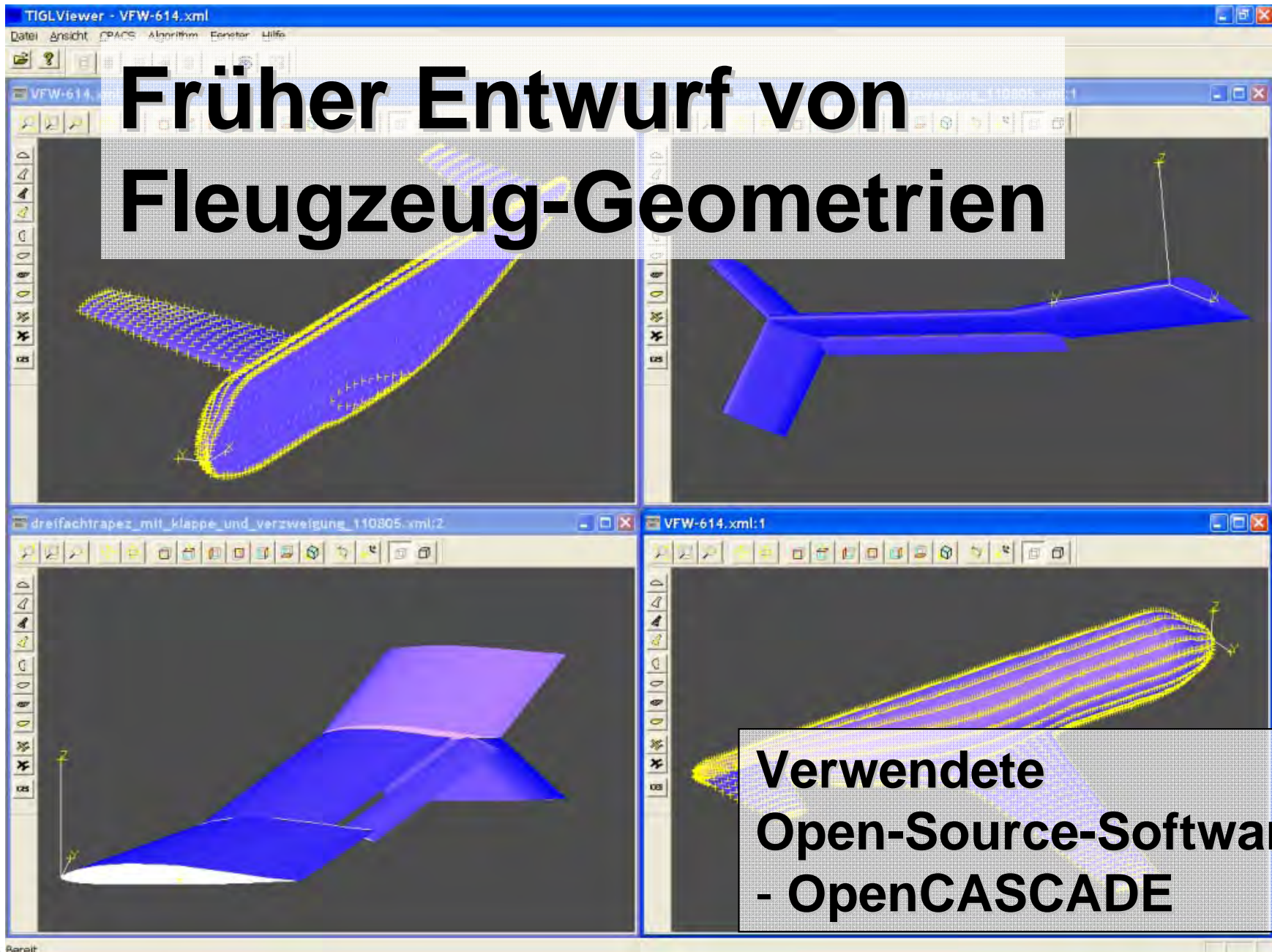
Verwendete  
Open-Source-Software:  
- Open Inventor  
- Qt

Rotx Roty

Dolly



# Früher Entwurf von Flugzeug-Geometrien



Verwendete  
Open-Source-Software:  
- OpenCASCADE



# Open-Source-Software RCE (Remote Component Environment)

Name	Status	Platform	User	Time	Addit
Geometry	FINISHED			2010.04.17 19:47:20	
Drei	FINISHED			2010.04.17 19:35:43	
Geometry	FINISHED	kpssc01.in.intra.dlr.de:1	CN=Chief Engineer,O=RC...	2010.04.17 19:49:43	
Drei	CANCELED	kpssc01.in.intra.dlr.de:1	CN=Chief Engineer,O=RC...	2010.04.17 19:35:02	
Geometry	FINISHED	kpssc01.in.intra.dlr.de:1	CN=Chief Engineer,O=RC...	2010.04.17 19:48:48	
Geometry	CANCELED			2010.04.17 19:48:48	

**Verwendete  
Open-Source-Software:**  
- Eclipse  
- VTK



# Virtuelle Produktentwicklung ... von Schiffen



**Bild: Flensburger Schiffbau Gesellschaft**





Propeller - ex.pff - Reconfigurable Computing Environment

File Edit Navigate Project Propeller Window Help

Propeller Lightship Weight RCE Default

\*UND SKAL. D=5.7M \*ex.pff

baute Propeller  
propeller  
Ship1  
SHIPDATA  
cfdd.lock  
cfdd.mos  
complete  
geom.loc  
geom.mc  
load.lock  
load.mos  
main.lock  
main.mos  
prop.mos  
Cosn  
Prop  
L  
resi.lock  
resi.mos  
room.loc  
room.mo  
wght.loc  
wght.mo  
Ship 2  
SHIPDATA

Number of blades: 4  
Clockwise orientation:   
Radius: 3,050 m  
Volume: 0,456 m<sup>3</sup>  
Volume moment of inertia: 1,446 m<sup>3</sup> m<sup>2</sup>  
Design pitch ratio: 1,160 1  
Design chord: 2,836 m  
Design rake: 0,076 m  
Disc area: 29,225 m<sup>2</sup>  
Developed area ratio: 0,696 1  
Projected area ratio: 0,597 1  
Skew: 44,798 °

General Profiles Extended PFF

Problems: 0 errors, 2 warnings, 0 infos (Filter matched 2 of 35 items)

Description	Resource	Path	Location
Maximum relative profile radius > 1	ex.u	Prop	down
Profile.relRadius > 1	ex.u	Prop	down

Blade Characteristics Chart: ex.pff

Blade Comparison Chart

3D Propeller

Operation Toolbox

- Propeller
  - blade
    - pitch
    - rake
    - scale
    - add
    - chord
    - chi
    - camber
    - thickness

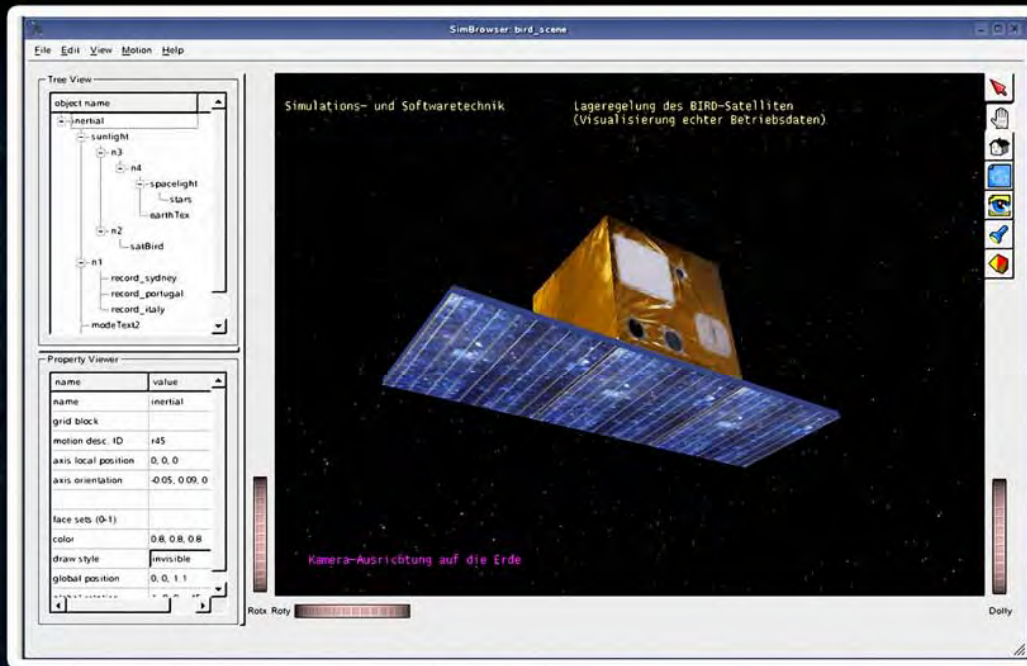
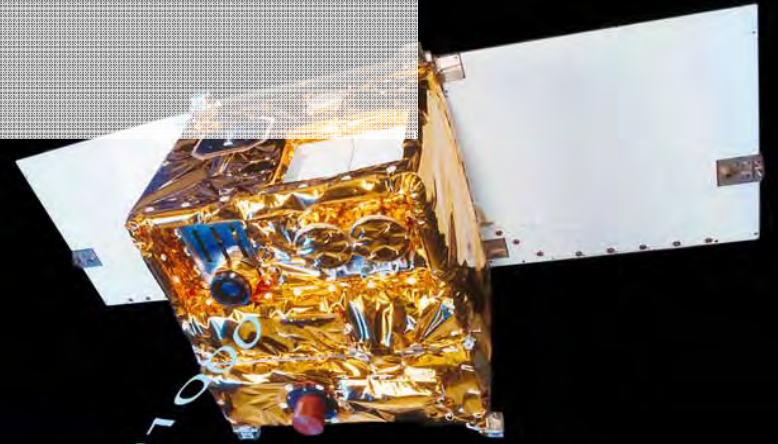
Restore Defaults Perform

44M of 124M

# ... mit modernen Software-Systemen (Eclipse-basiert)



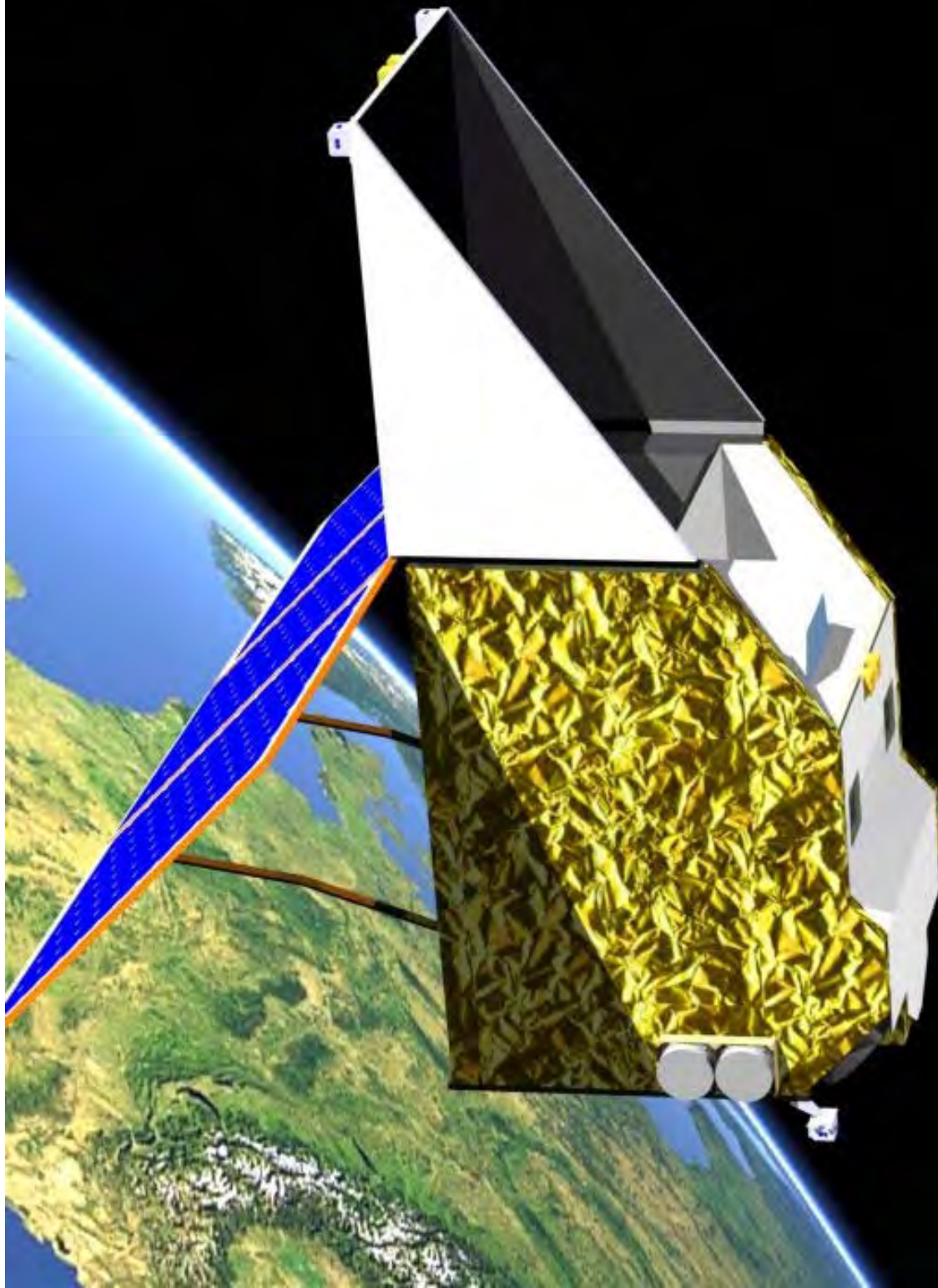
# Virtuelle Produktentwicklung ... von Raumschiffen



01000101010

0000101010





# RODOS

In C++ implementiertes,  
hochzuverlässiges Echtzeit-  
Betriebssystem für eingebettete  
Systeme.

Einsatz in Satelliten



An aerial, top-down view of a long, single-file line of commercial airplanes on an airport runway. The image is rendered in a monochromatic blue color scheme. The perspective is from directly above, showing the wings, engines, and fuselages of the aircraft. The runway markings are visible on the ground. In the bottom right corner, a portion of another aircraft's tail fin with a circular logo is visible.

# **Simulation und Management ... von Luft-Verkehr**

# Datenbank für Luftverkehrsbeobachtung Mit Open-Source-Software DataFinder

The screenshot shows the DataFinder web interface. The left pane displays the local file system (D:\), and the right pane shows the DataFinder Server View. The server view is a table with columns: Name, DF Data Type, Content Type, Length, Modified, and Created. The data is organized into a hierarchy starting with 'ifw' and 'A1 Air Transport Demand'.

Name	DF Data Type	Content Type	Length	Modified	Created
ifw					
A1 Air Transport Demand	Knowledge Area	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
01 Demand Volume	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
01 Germany	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
02 Europe	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
03 World	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
02 Demand Structure	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
01 Germany	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
02 Europe	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
03 World	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
03 Mobility Trends	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
01 Germany	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
02 Europe	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
03 World	Geographical Scope	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
A2 Air Transport Supply - Airlines	Knowledge Area	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
01 Flights	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:43	11. Jan, 09:43
02 Market structure	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
03 Aircraft fleet	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
A3 Air Transport Supply - Airport and ATM Knowledge Area	Knowledge Area	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
01 Movements	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
02 Runways	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
03 Terminals	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
04 Airport Vicinity	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
05 ATM Infrastructure	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
06 Airport Business Models	Research Field	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44
A4 Technologi	Knowledge Area	httpd/unix-directory	(Collection)	11. Jan, 09:44	11. Jan, 09:44

Below the table is a section for 'DataFinder Attributes' with a table:

Name	Value
1	<no DataFinder-specific attributes>



# Datenbank für Luftverkehrsbeobachtung

## Import von Daten

- Import aller Datenquellen (PDF/Word/Text-Dateien, Excel, Access, ...)
- Klassifikation
- Verhinderung doppelter Daten

**Import Document Wizard**

Category Specification

Please select at least one category that fits the file you want to import!

A1 Air Transport Demand    A2 Air Transport Supply - Airline    A3 Air Transport Supply - Airport    A4 Technology

01 Demand Volume 02 Demand Structure 03 Mobility Trends	01 Flights 02 Market structure 03 Aircraft fleet	01 Movements 02 Runways 03 Terminals 04 Airport Vicinity 05 ATM Infrastructure 06 Airport Buisness Models	01 Aircrafts and Components 02 Aircraft Market 03 Technology Development 04 Non-aviation Technology
---	--	--	--

A5 Environment    A6 Air Transport Policy    A7 Framework Developments    A8 Sustainability Indicators

01 External Pressure 02 Local Air Quality 03 Climate Impact 04 Noise and Acoustics	01 Efficiency of Measures 02 Regulations and Laws 03 Goals and Agreements	01 Economy 02 Population 03 Energy 04 External Pressure 01 Climate Change 02 Security 03 Diseases 04 Others 05 Traffic - rail and road	<b>01 Kompass data</b> 02 Indicators
---	---	--	---

< Back    Next >    Cancel

**Import Document Wizard**

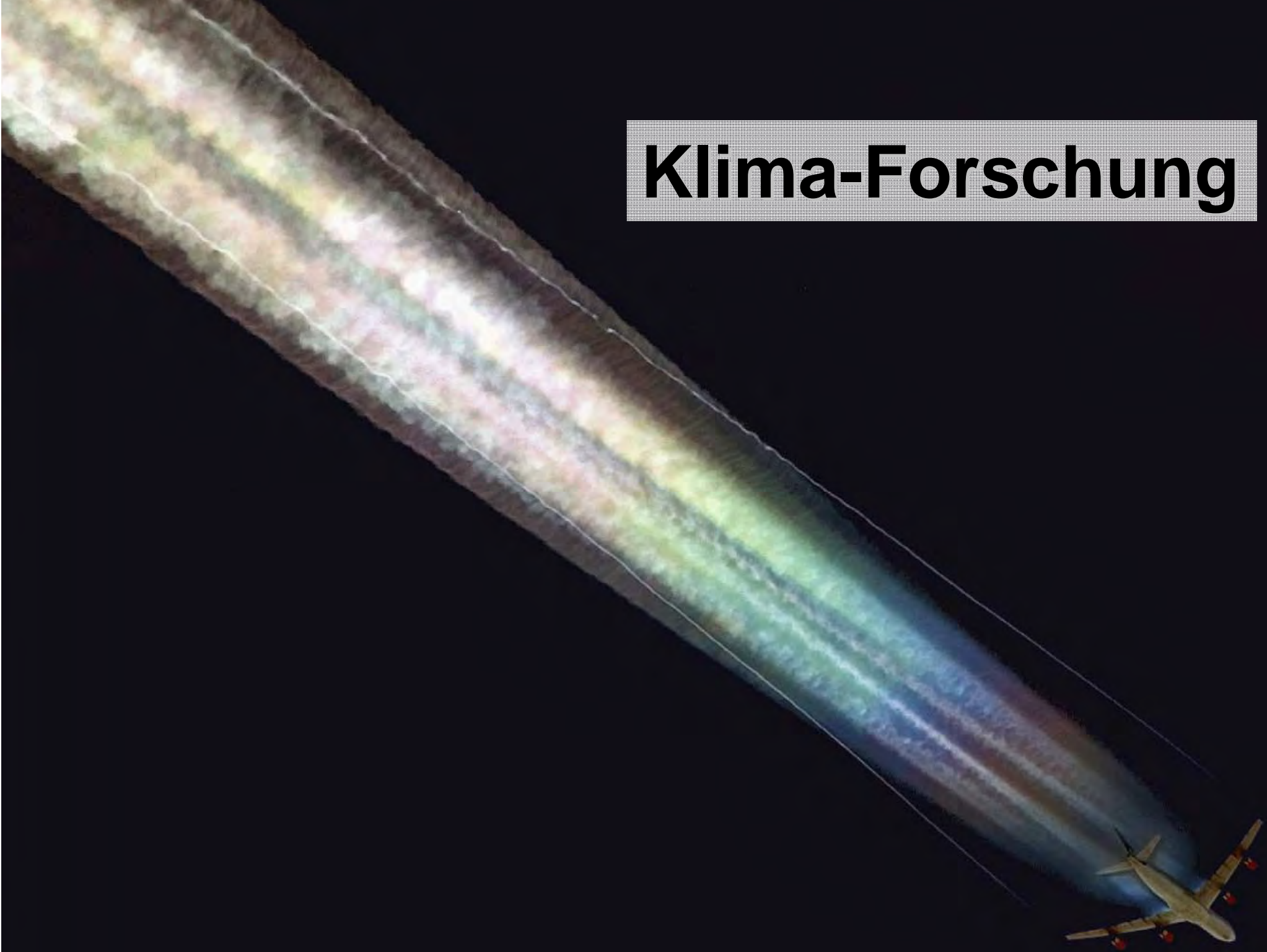
Property Specification

At least you have to provide the properties that are marked "Required"!

	Name	Value
Required	Quelle	
Required	Bezeichnung	
Required	Status	
Required	Ansprechpartner_bei_FW	
Required	Erscheinungsjahr	
Required	Geographical Scope	
Optional	Dokumentart	Daten
Optional	Datenzustand	Daten
Optional	Internetquelle	Projektbericht
Optional	Aktualisierung	Fachliteratur
Optional	Zeitraum	Artikel / Informationen
Optional	Keywords	Dissertationen / Diplomarbeiten
Optional	Kosten	frei verfügbar
Optional	Datenformat	

< Back    Finish    Cancel

# Klima-Forschung





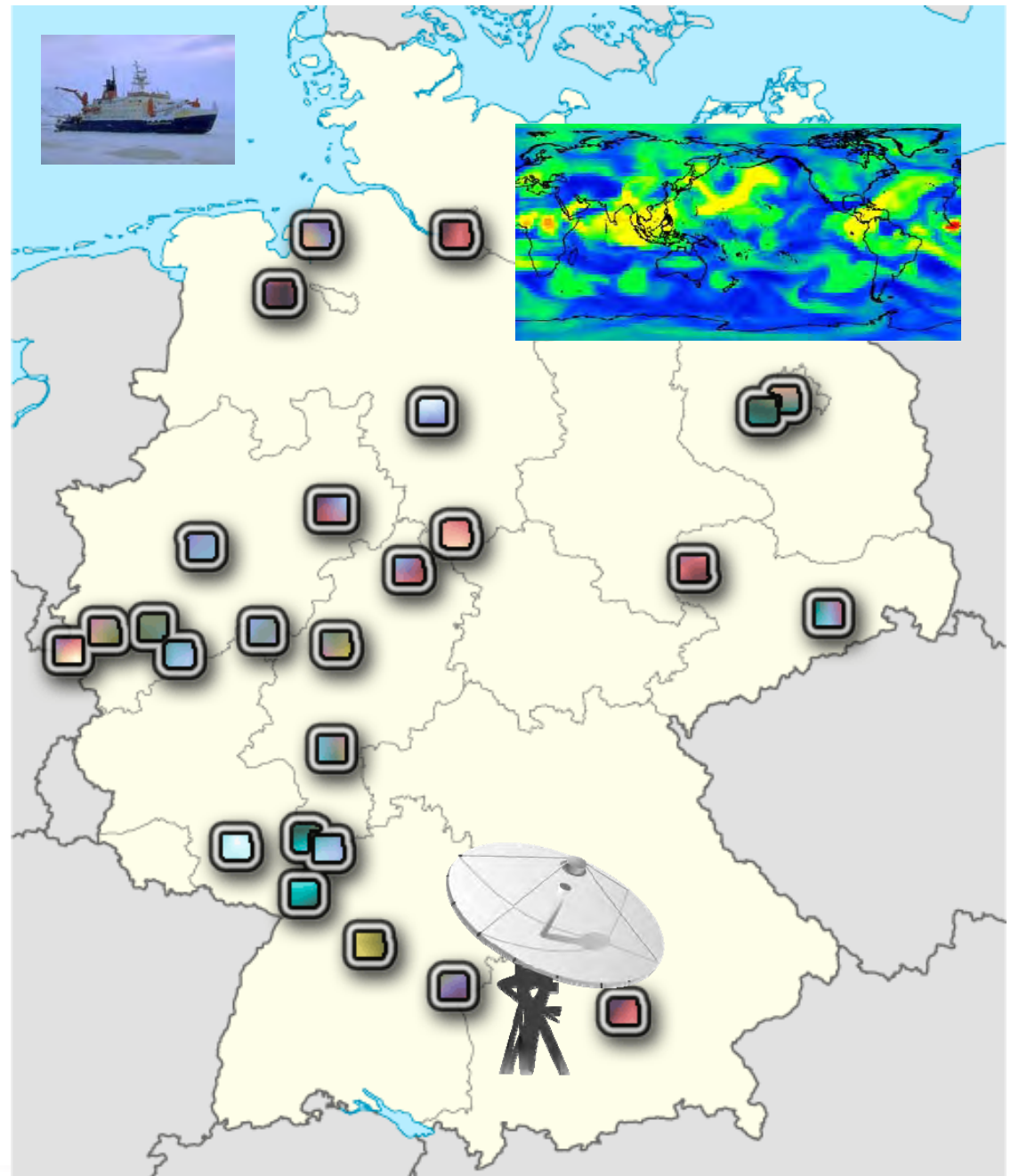
# Beispiel: Klimadaten

## Verteilte Datenarchive

- Riesige Datenmengen (Petabytes)
- Speicherung bei den Datenquellen (Sensoren, Institute)

## Verschiedene Datenformate

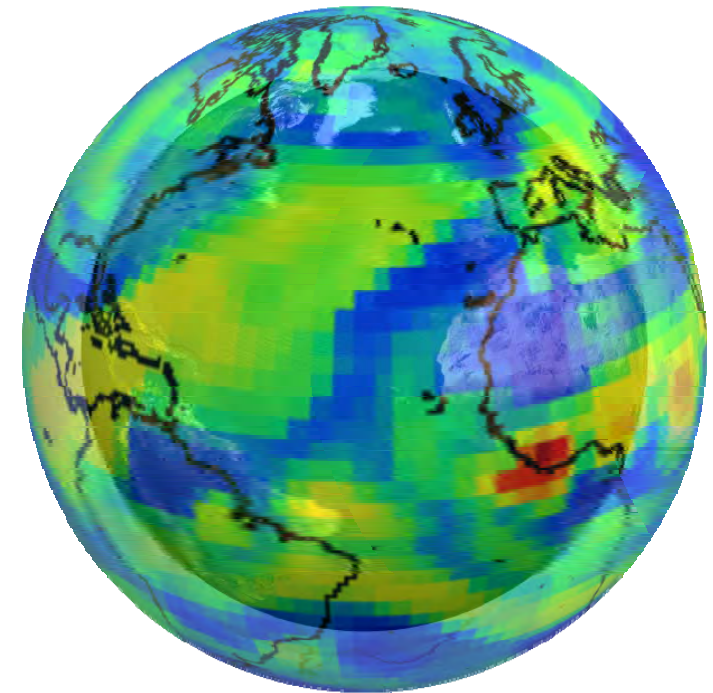
- Bedingt durch Art und Zweck der Daten
- Historische Gründe



# Auswahl und Zugriff auf Klimadaten

## Open-Source-Software (Python)

- Auswahl von Daten-Sets
- Auswahl einzelner Daten

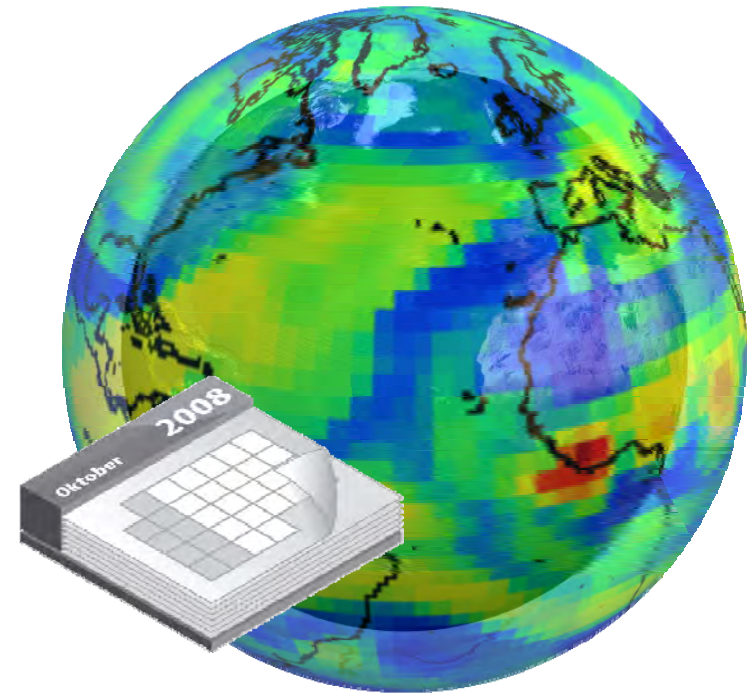




# Auswahl und Zugriff auf Klimadaten

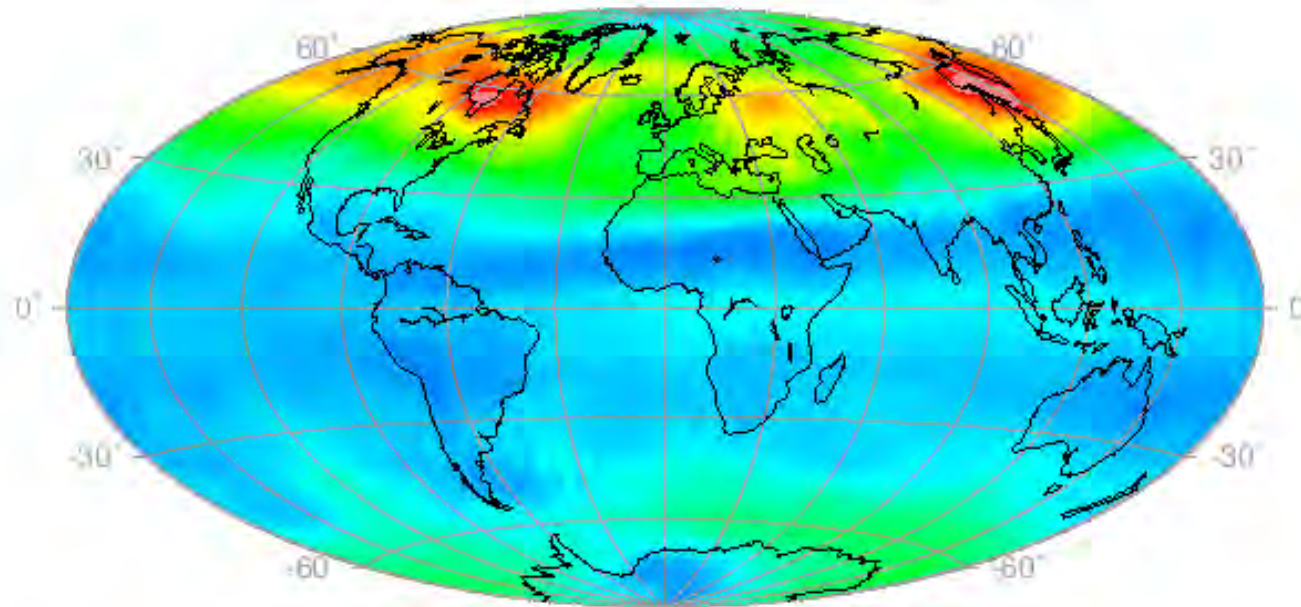
## Open-Source-Software (Python)

- Auswahl von Daten-Sets
- Auswahl einzelner Daten
- Auswahl der Regionen (Längengrad, Breitengrad)
- Auswahl der Höhe
- Auswahl von Zeiträumen

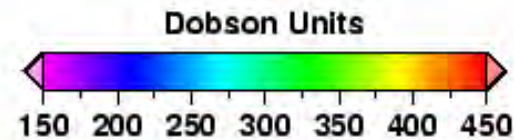


**ERS-2 GOME**  
**Total Column Ozone**

**Mar 1997**



<http://wdc.dlr.de/sensors>  
L3 Version 2.0/ L2 Version 4.0 / ESA

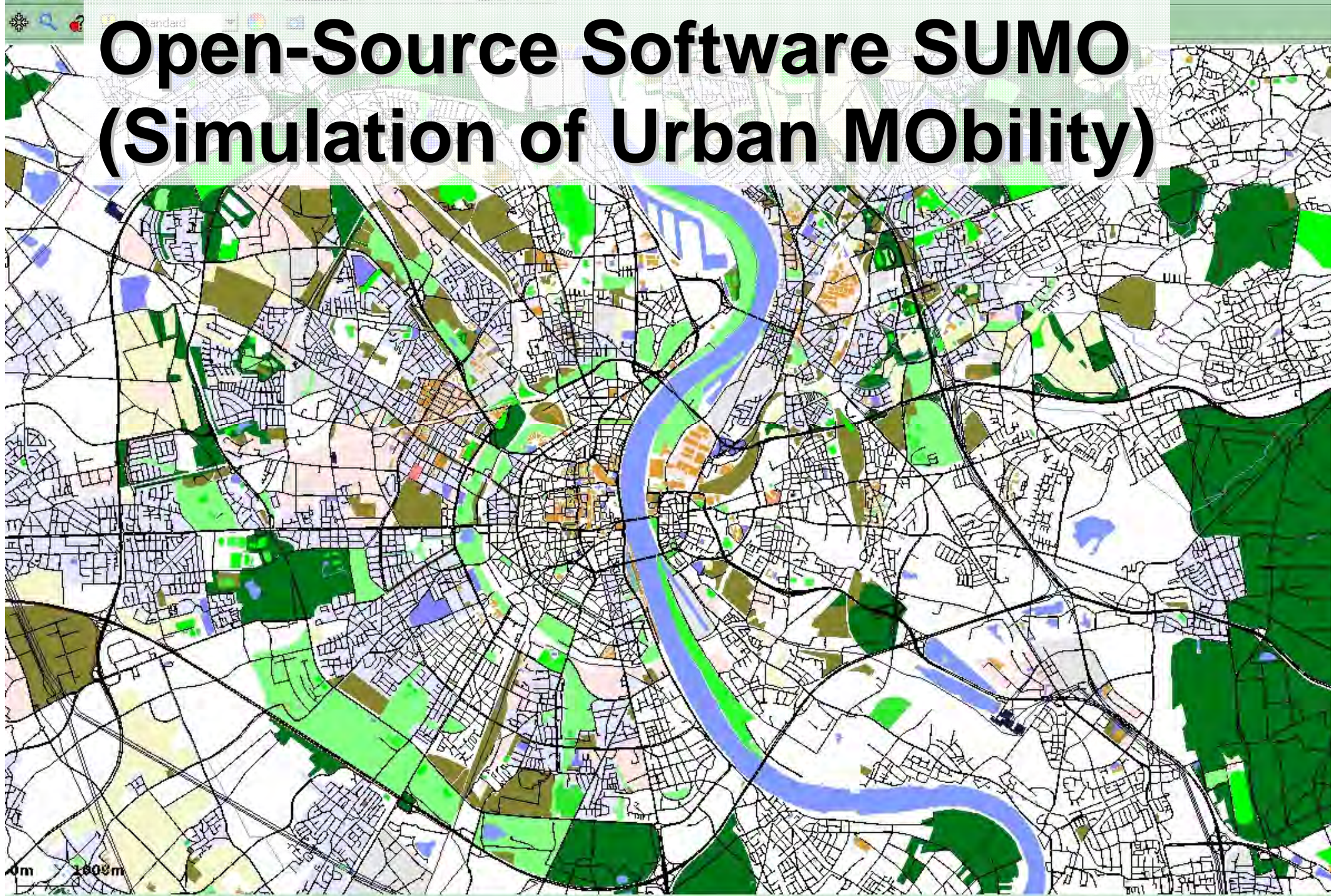




# Simulation und Management ... von Strassen-Verkehr



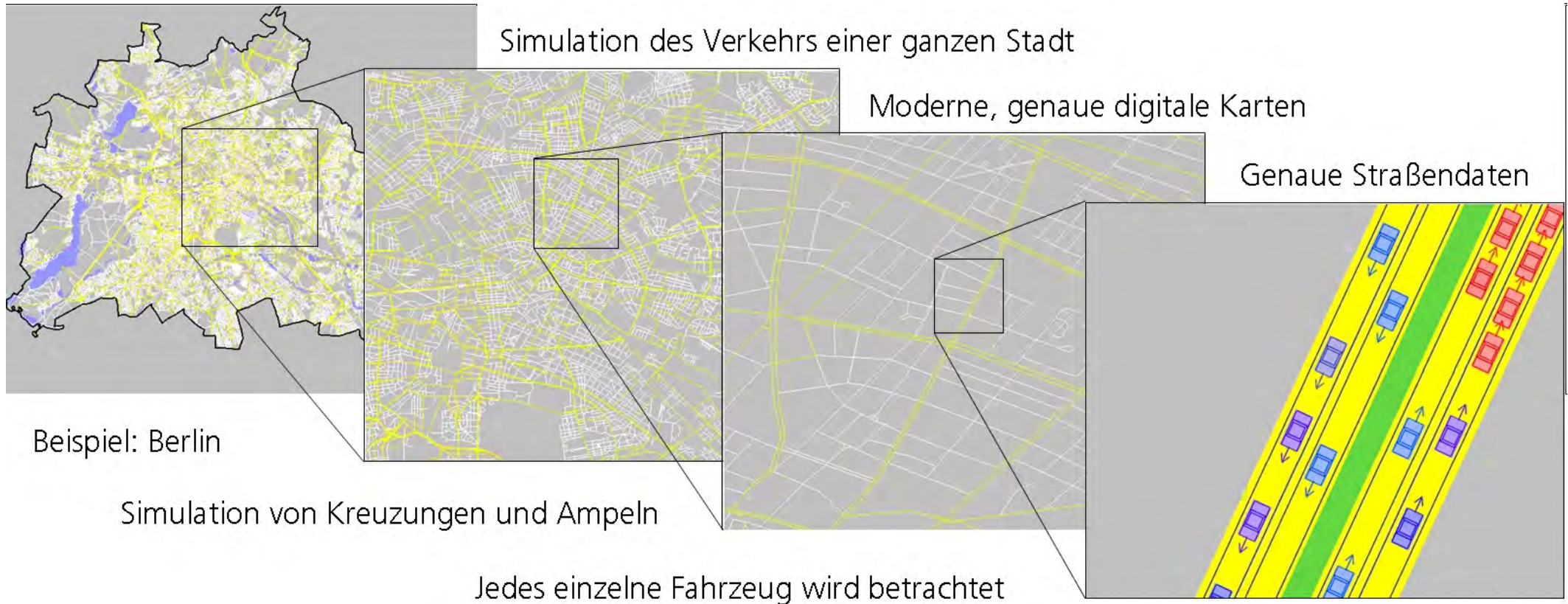




# Open-Source Software SUMO (Simulation of Urban MObility)



# Verkehrssimulation



# Anwendungsbeispiel

## WJT2005 / Soccer2006

### Einsatz in Köln

- Papst-Besuch (Weltjugendtag 2005)
- Fußball-WM 2006

### Verkehrserfassung

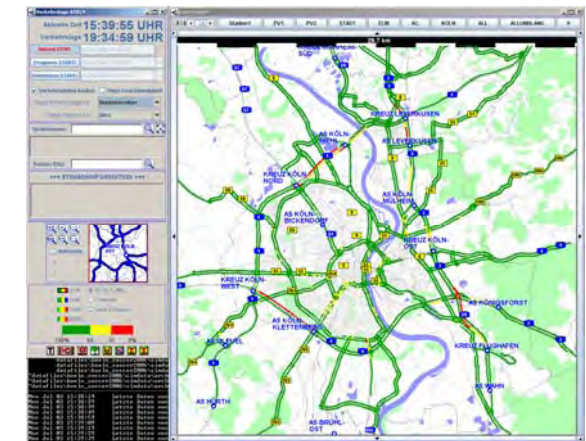
- Induktionsschleifen auf Autobahnen
- Induktionsschleifen in der Stadt
- Erfassung aus der Luft (Zeppelin)

### Verkehrsvisualisierung

- Zusammenfassung aller Daten
- Präsentation bei der Polizei

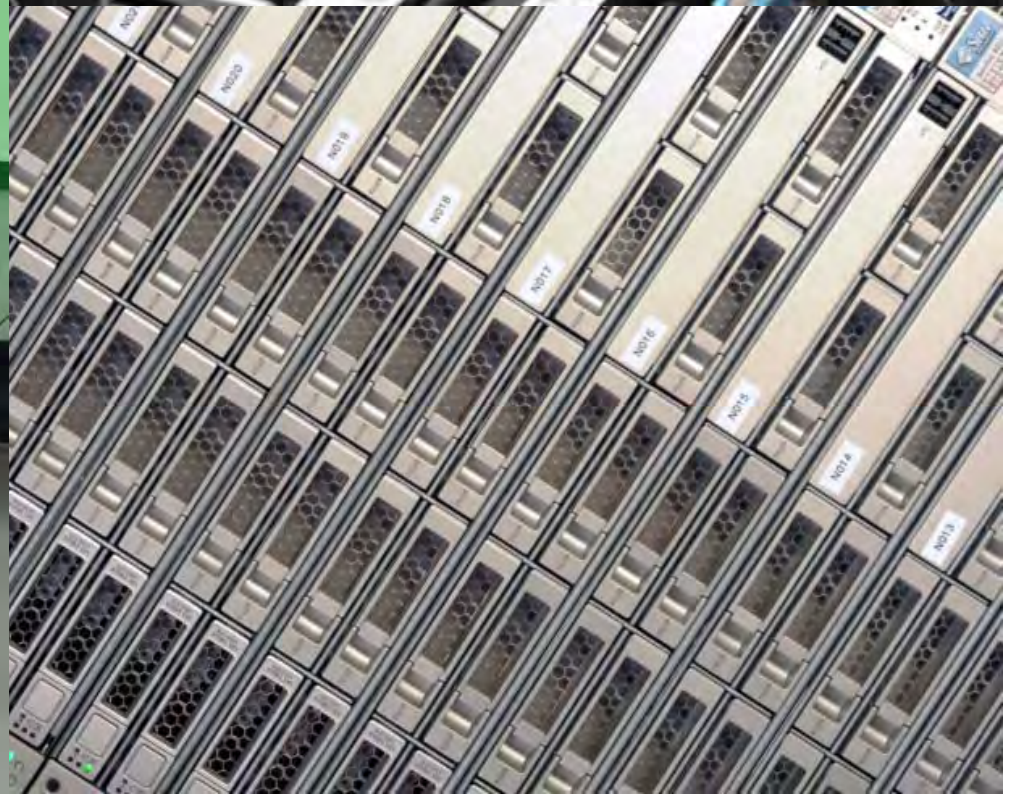
### Verkehrsvorhersage

- 30 Minuten in der Zukunft (mit SUMO)





# High-Performance Computing





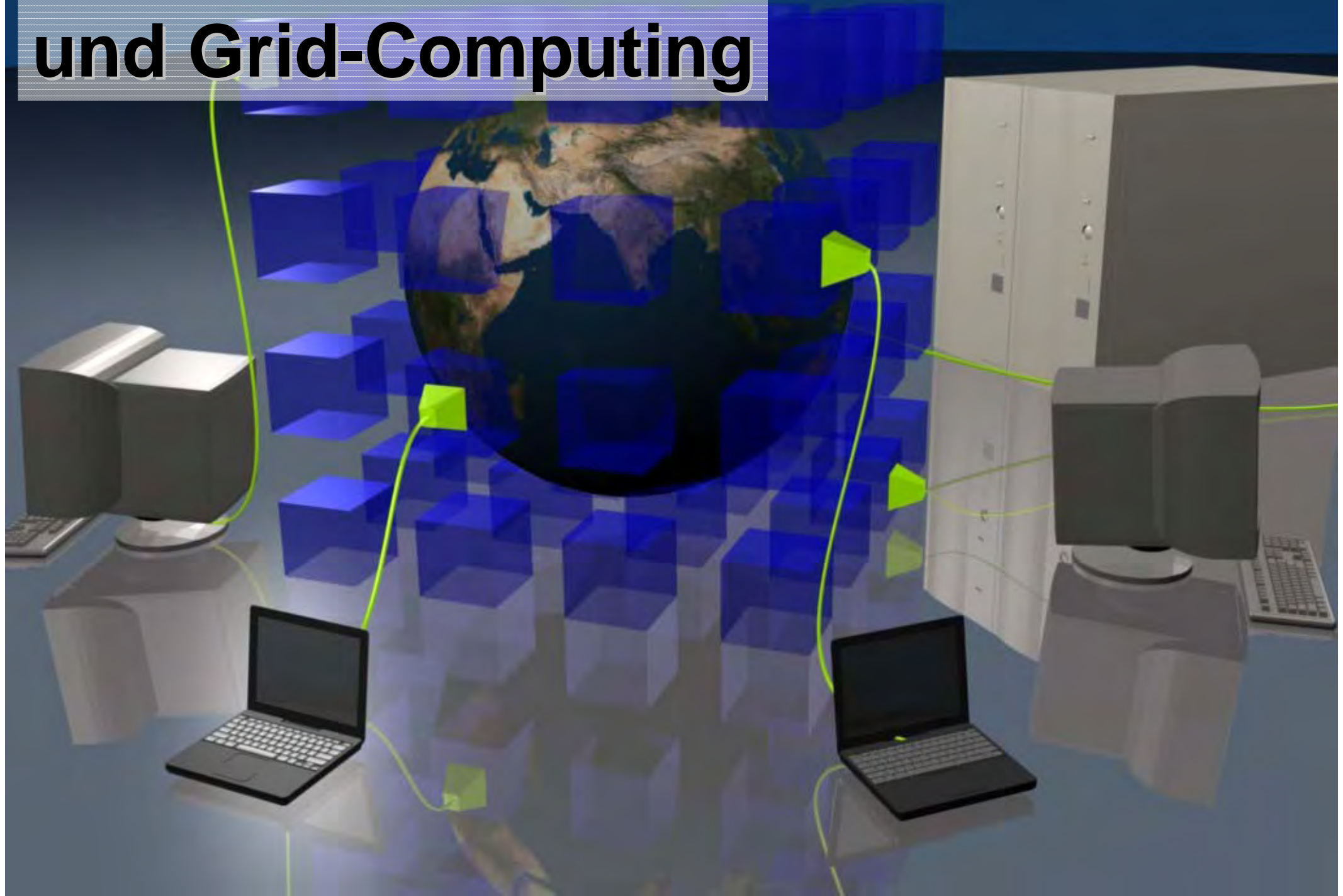
**Linux**

Verwendete Distributionen





# Verteiltes Rechnen und Grid-Computing





# Verteiltes Rechnen und Grid-Computing

## Freie Middleware

Forschungszentrum Jülich u.a.

# UNICORE

Argonne National Laboratory u.a.



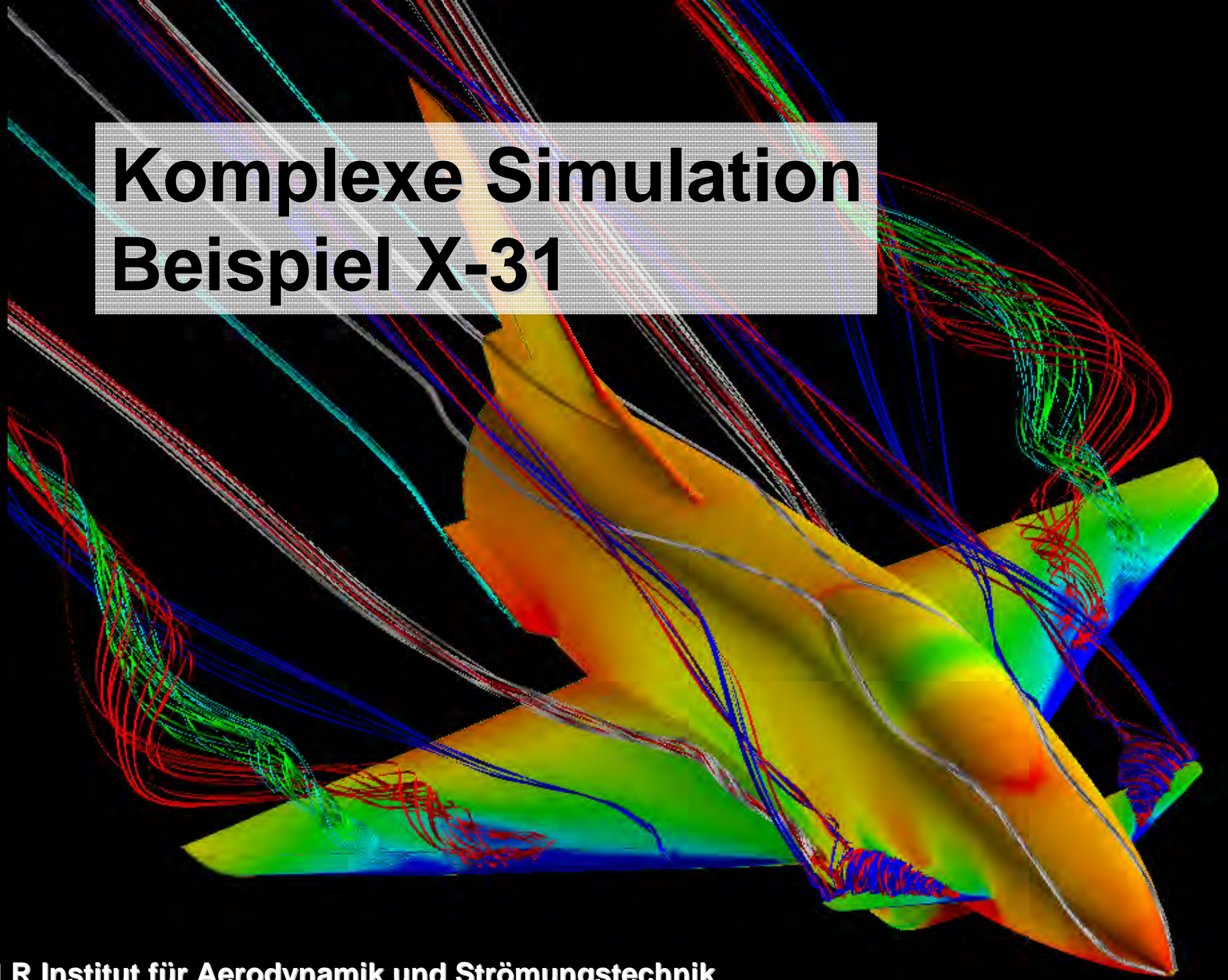
the globus<sup>®</sup> toolkit

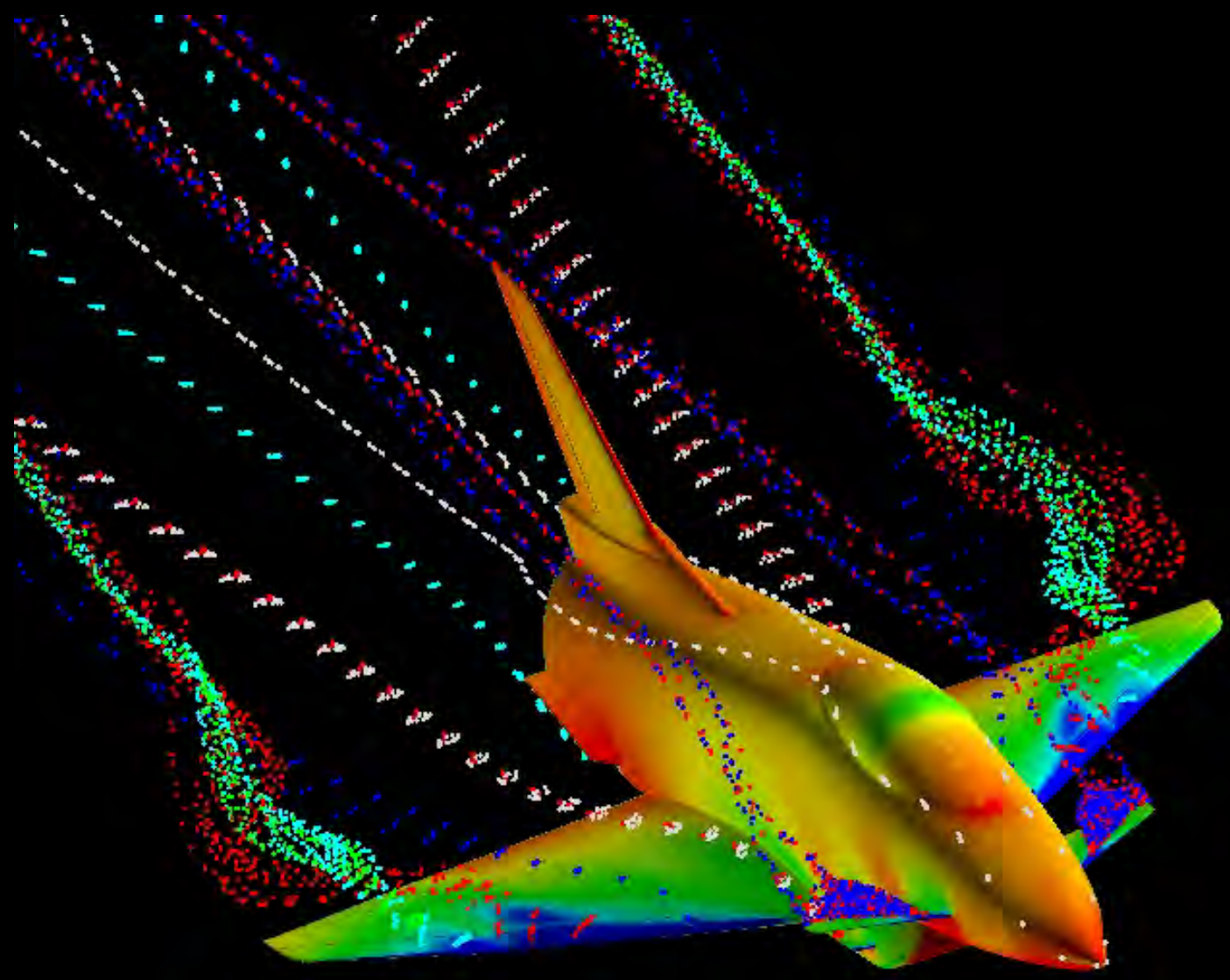
[www.globustoolkit.org](http://www.globustoolkit.org)





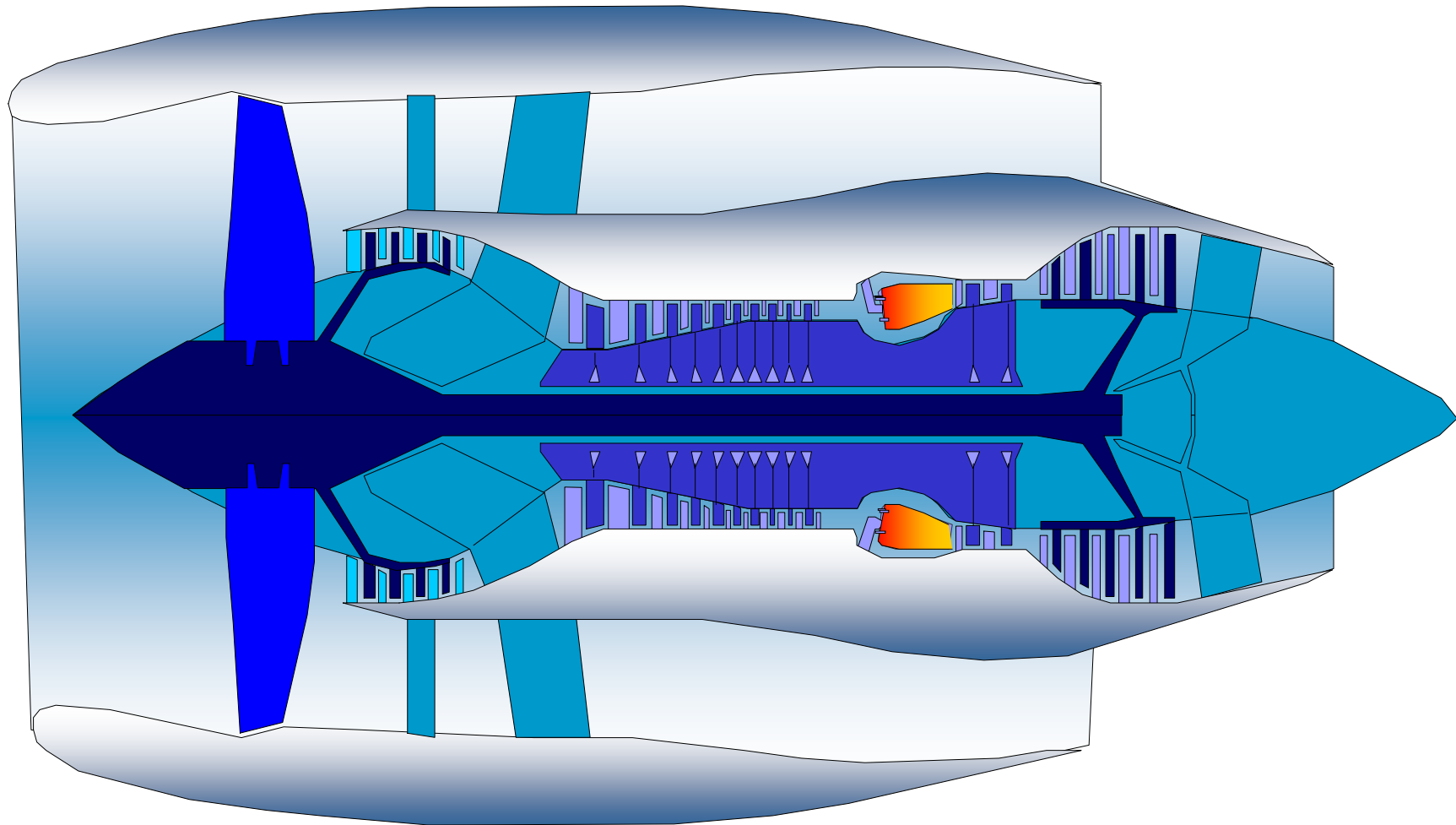
# Komplexe Simulation Beispiel X-31



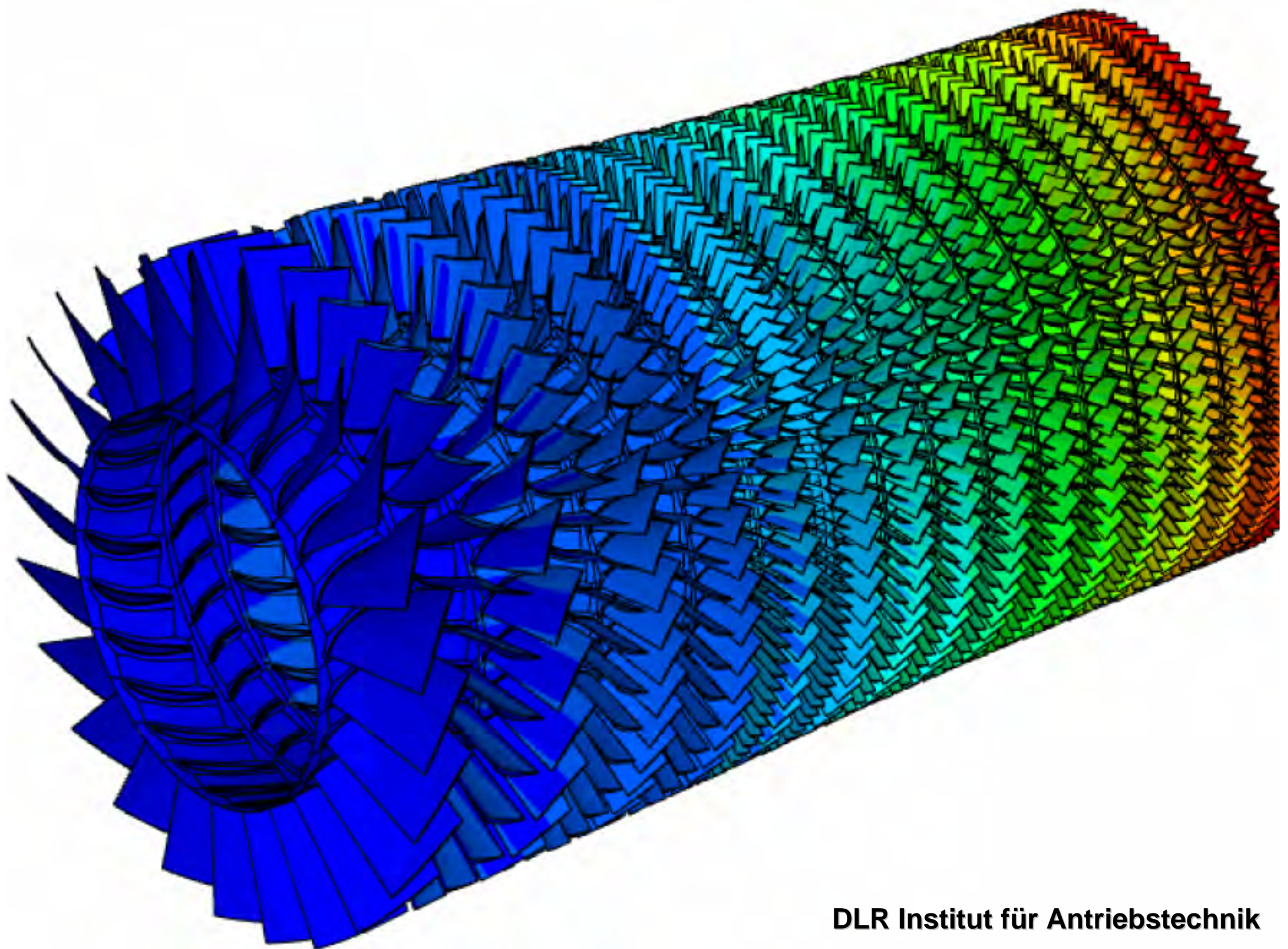




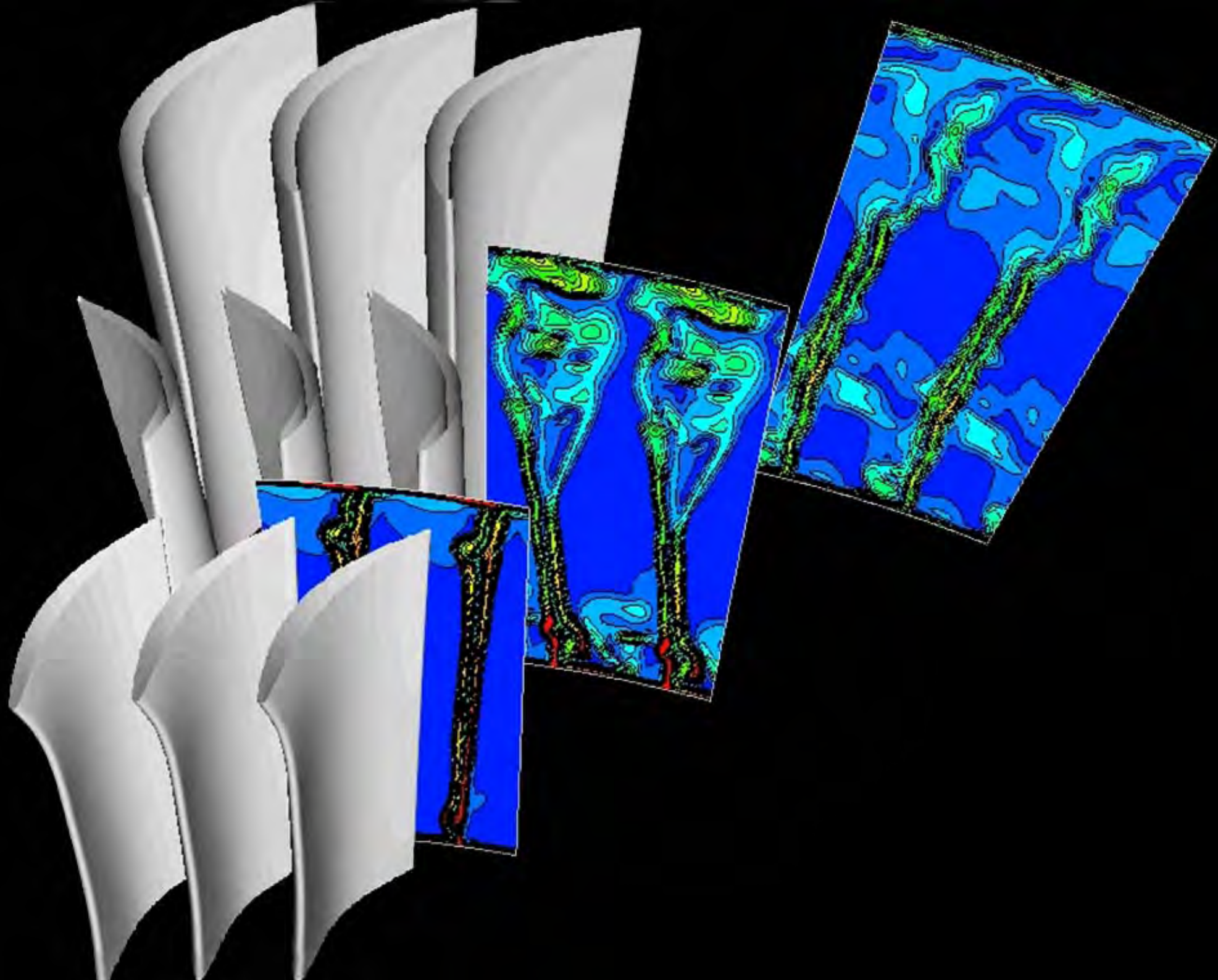
# Die Turbomaschine



**DLR Institut für Antriebstechnik**









# Virtual Reality

Bild: P. Winandy





**Verwendete  
Open-Source-Software:  
- ViSTA VR Toolkit**



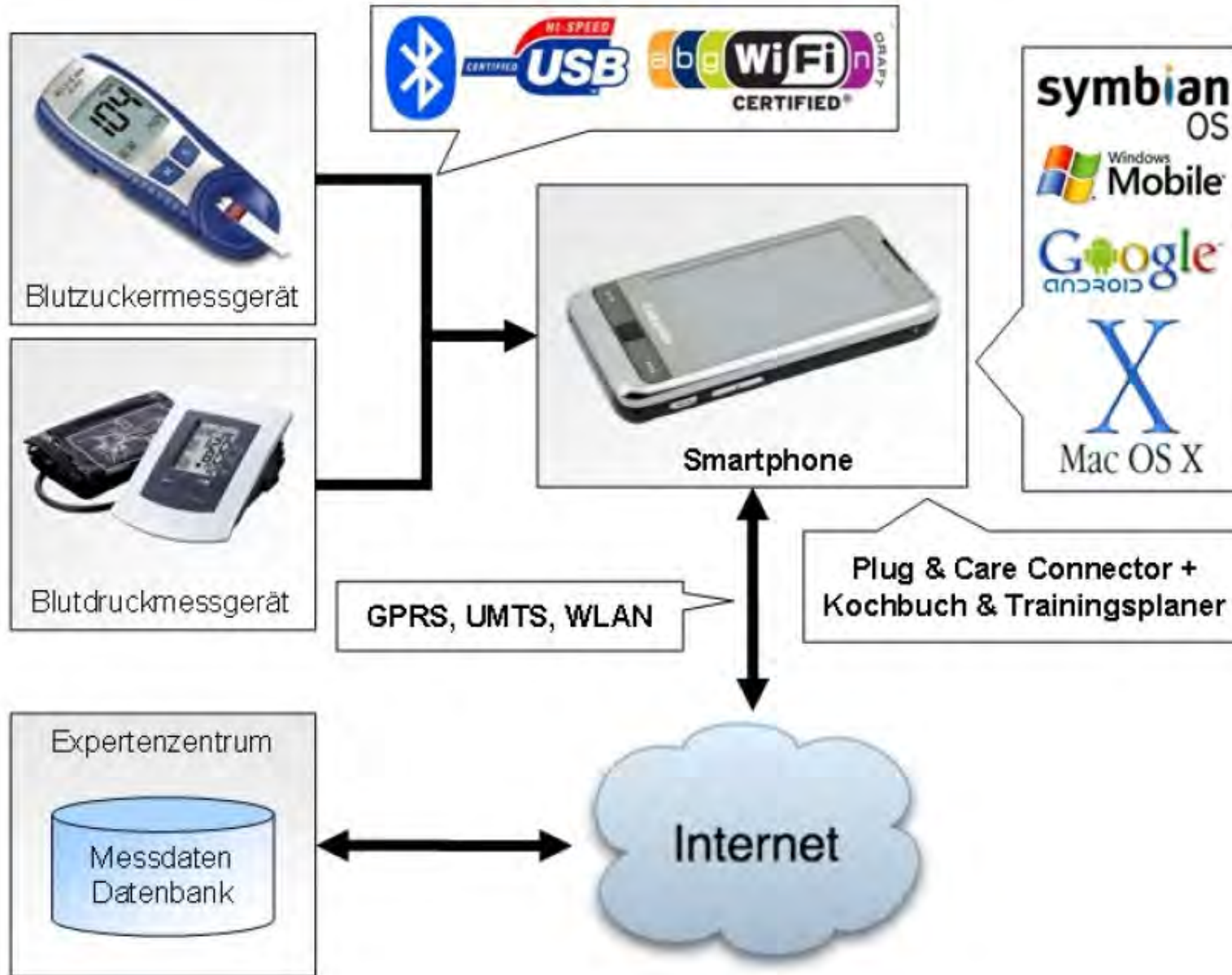


# Mobile Anwendungen



# Telemedizin







# Fragen?

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