

Open Source Framework RCE: Integration, Automation, Collaboration

4th Symposium on Collaboration in Aircraft Design

27.11.2014, Onera, Toulouse

Doreen Seider



Knowledge for Tomorrow



Outline

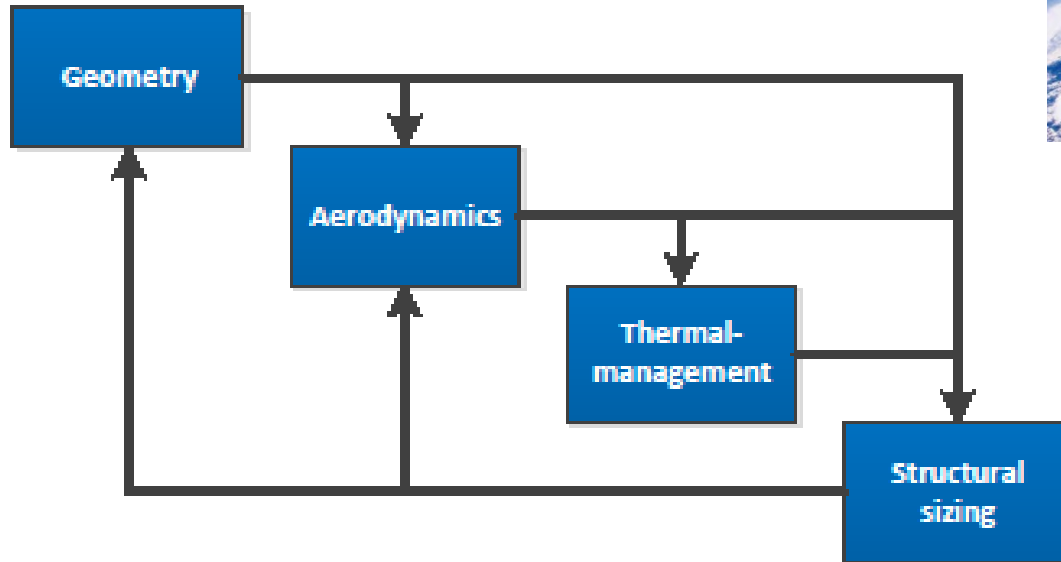
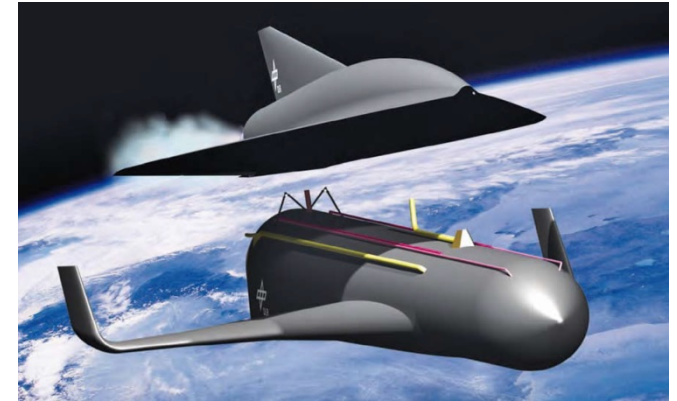
Implementing Multidisciplinary Design Processes in RCE

Collaboration in RCE

Outlook



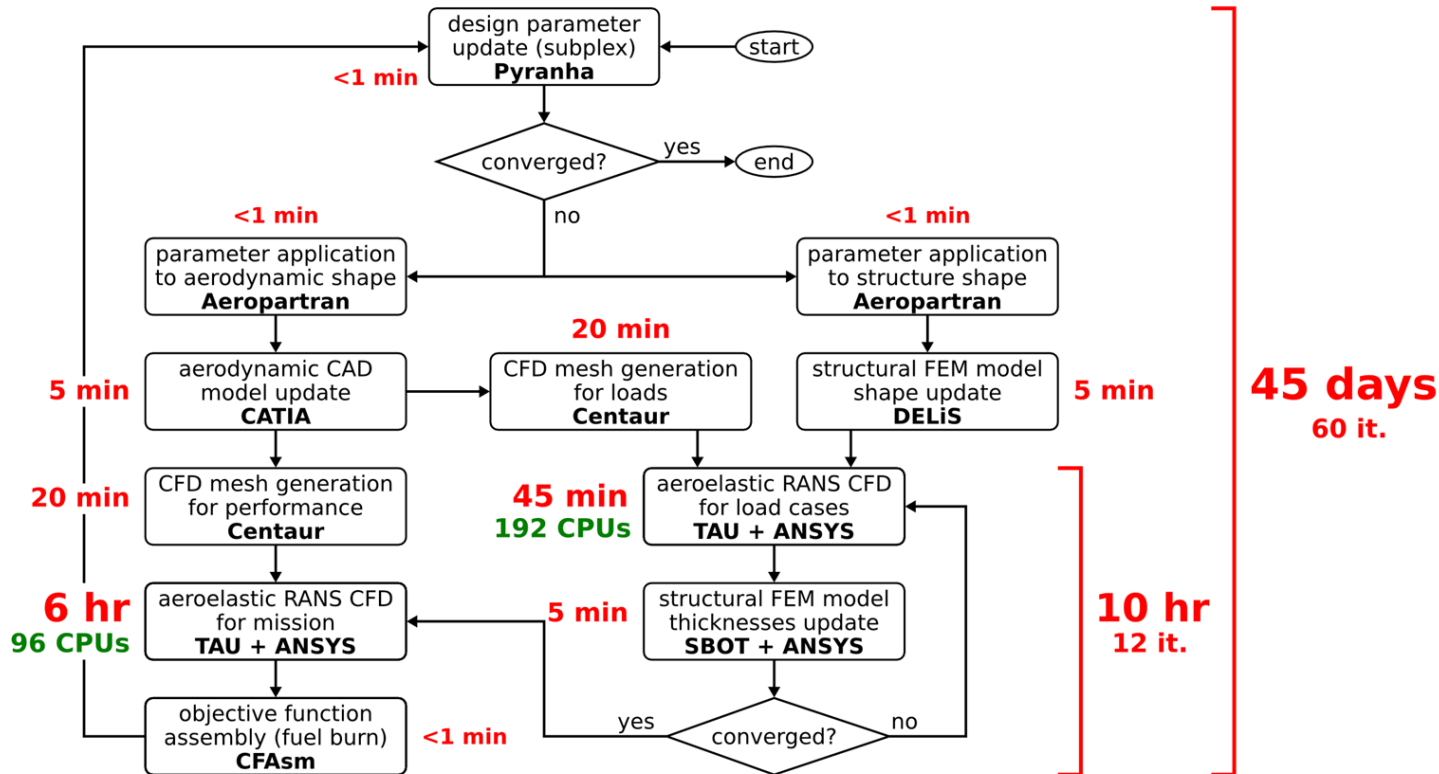
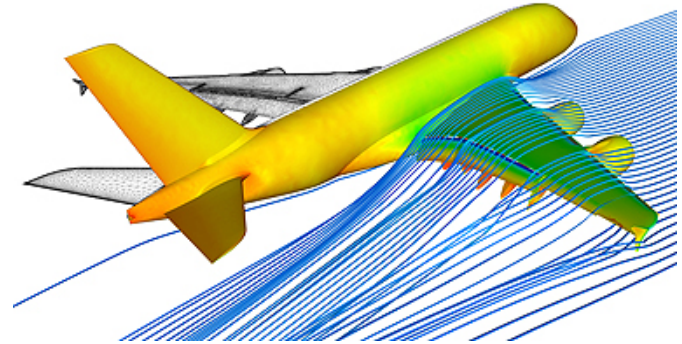
MDO: Thermal Management of SpaceLiner Process Chain



Source: A. Tröltzsch



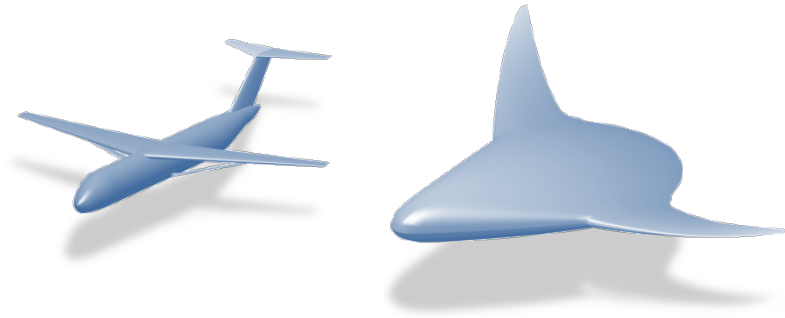
MDO: High-Fidelity Aircraft Design Process Chain



Source: C. Ilic



MDA: Preliminary Aircraft Design Dependencies in N2 Chart



TLAR			TLAR								
	FuCD		Geometrie Rumpf, Payload-masse				Sekundärmas sen Rumpf, Payloadmasse	Payload-masse		Sekundärmas sen Rumpf, Payloadmasse	
		TWDat	Triebwerks-Masse					Schub-kennfeld		Triebwerk-masse	
			VAMPzero	Geometrie	Struktur, Geometrie	Geometrie	Geometrie, mass-Breakdown, Struktur	Mass-Breakdown	Klappen	Mass-Breakdown	
				Liftingline & Handbook-Aero			Aero Lasten	Aero Kennfeld			
					PESTsewi		Sekundärmas sen Flügel			Sekundärmas sen Flügel	
						WingMass Surrogate				Primärmasse Flügel + Strebe	
							DELIS			Primärstruktura massen	
		Triebwerks-skalierung	Treibstoff-Verbrauch					FSMS			Treibstoff-Verbrauch
									Paradise		
			Mass-Breakdown							CMU	

Source: D. Böhnke, E. Moerland

RCE is a Integration Framework for MD Design Processes

Graphical User Interface

The screenshot displays the RCE for CPACS (RCE Client 1) graphical user interface. The main window shows a workflow diagram with components like Aerodynamic, Optimizer, CoG cons, Mass model, Water mass, ThermoRAD, ThermoISO, Mesh, and Trajectory. A TIGLViewer window on the right shows a 3D model of an aircraft wing. The bottom panels show the Workflow Data Browser and Network views.

Workflow Diagram Components:

- Aerodynamic
- Optimizer
- CoG cons
- Mass model
- Water mass
- ThermoRAD
- ThermoISO
- Mesh
- Trajectory
- Structure
- Tempfilter
- TIGL Viewer

Workflow Data Browser:

- mdo_v1.8.1_with_water_n3_4cons_60.wf_2014-08-27_15:24:57_01 (2014-08-27 15:25:13) <local>
- Timeline
- Timeline by Component
 - Mass model
 - Mesh
 - Run 3 (2014-08-27 15:27:18)
 - Inputs
 - Outputs
 - 1 CoAx_body: '34.01227'

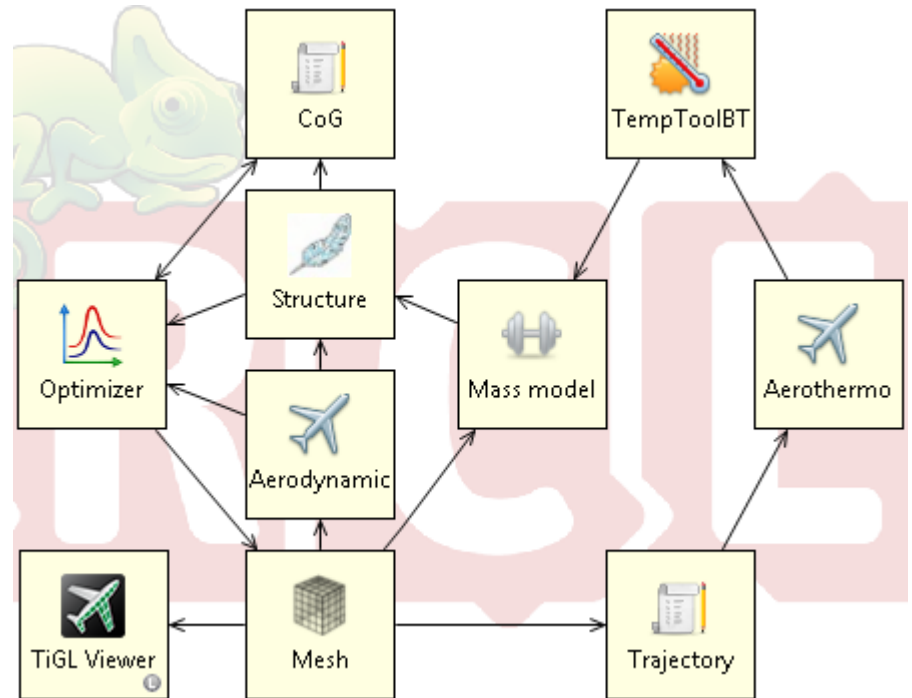
Network View:

- RCE Client 1 <Self>
- RCE Relay Server
- RCE Server 1 <Workflow Host>
- Published Components
 - GGHv3 (1.05)
 - Hysap1_nobatch (1.0)
- RCE Server 2 <Workflow Host>
- Published Components
 - STSMv10 (1.0)
 - Tempfilter (1.0)



RCE is a Workflow-driven Integration Framework From Design Processes to RCE Workflows

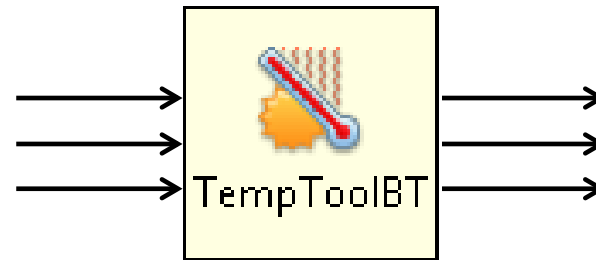
- Multidisciplinary design processes means multiple disciplines and multiple tools
- Tools need to be executed multiple by considering their dependencies between each other
- To model a design process in RCE the tools involved need to be integrated into RCE first



Tool Integration in RCE

Integration Concept

- Prerequisites a tool must fulfill
 - Runs without any user interaction
 - Is executable from command line
- Tools are black boxes for RCE with inputs and outputs (texts, floating point numbers, files, directories...)



Tool Integration in RCE

How the User does it?

- Graphical dialog guides through the integration process
- Tool is immediately integrated in RCE

Integrate a Tool as a Workflow Component

Tool Description
Define some information for the tool

Tool characteristics

Name*:

Icon path: ... Copy into configuration folder

Group name: ...

Description:

Contact Information

Name:

E-Mail:

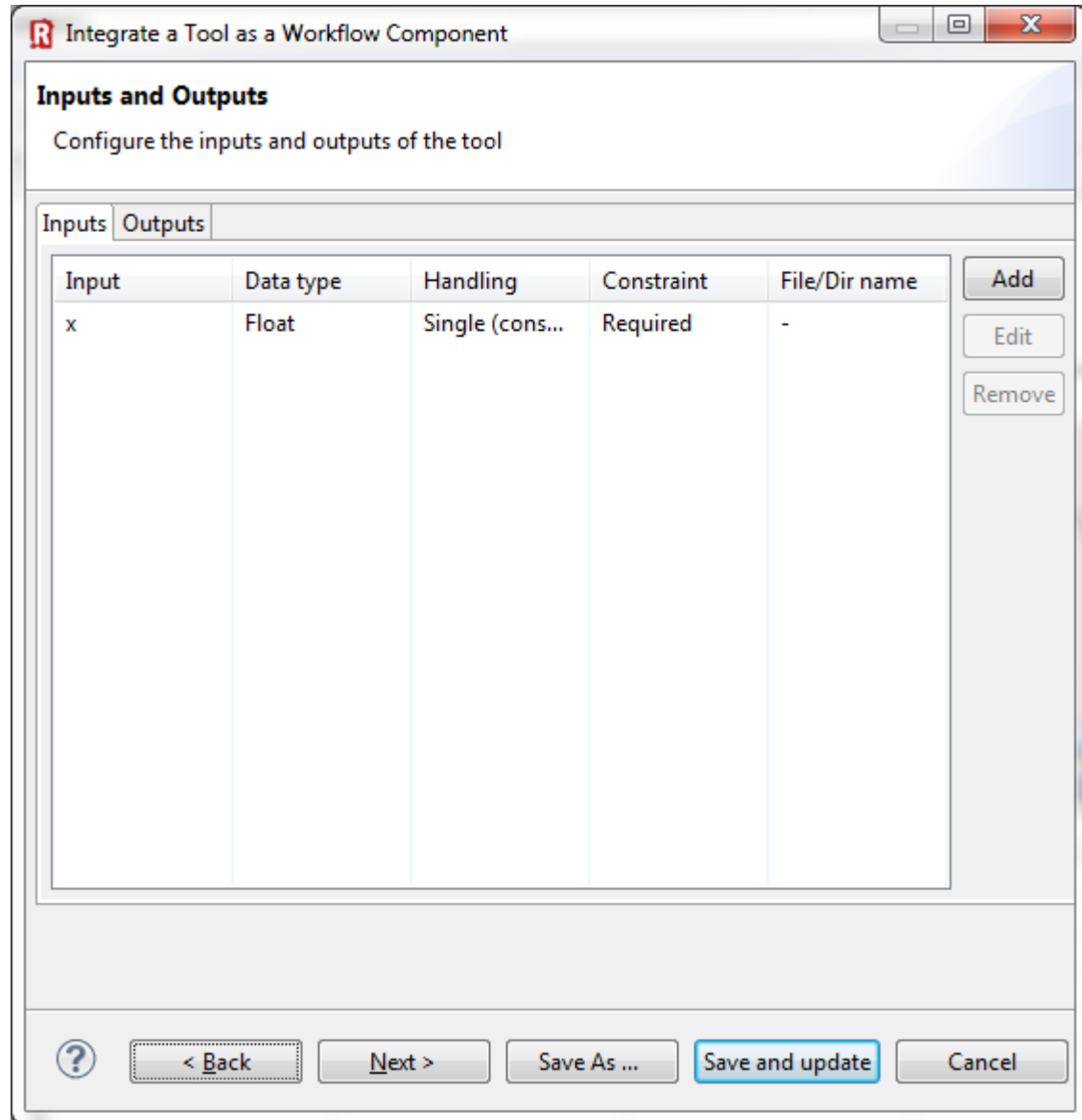
? < Back Next > Save As ... Save and update Cancel



Tool Integration in RCE

How the User does it?

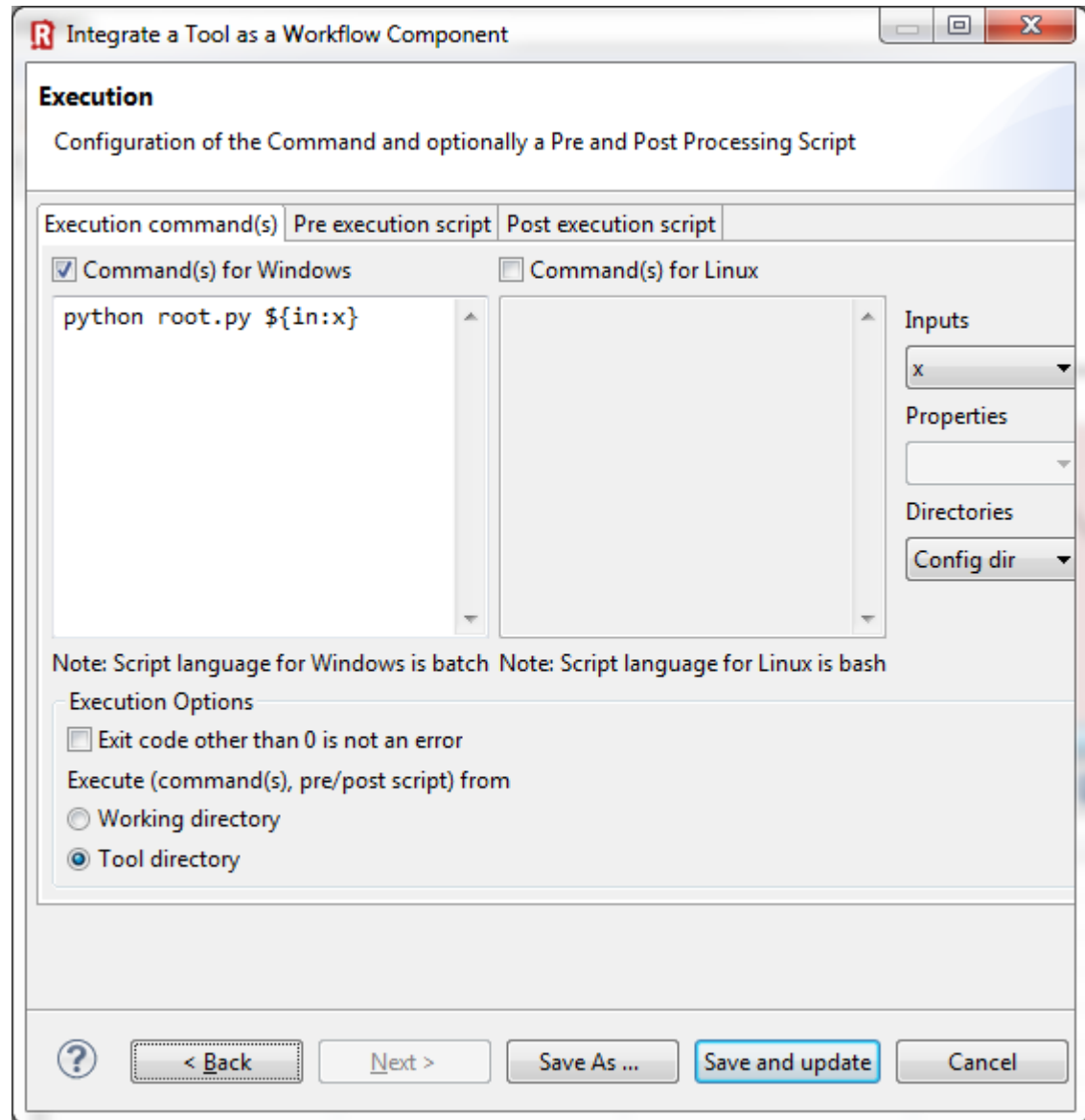
- Graphical dialog guides through the integration process
- Tool is immediately integrated in RCE



Tool Integration in RCE

How the User does it?

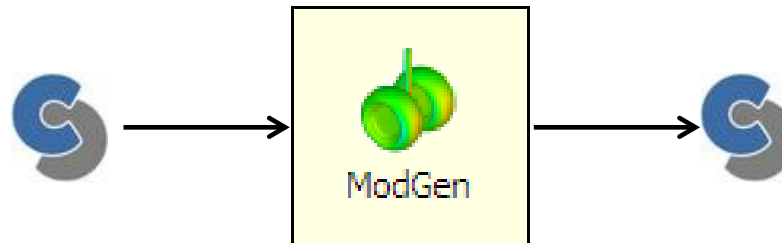
- Graphical dialog guides through the integration process
- Tool is immediately integrated in RCE



CPACS-specific Tool Integration in RCE

Integration Concept

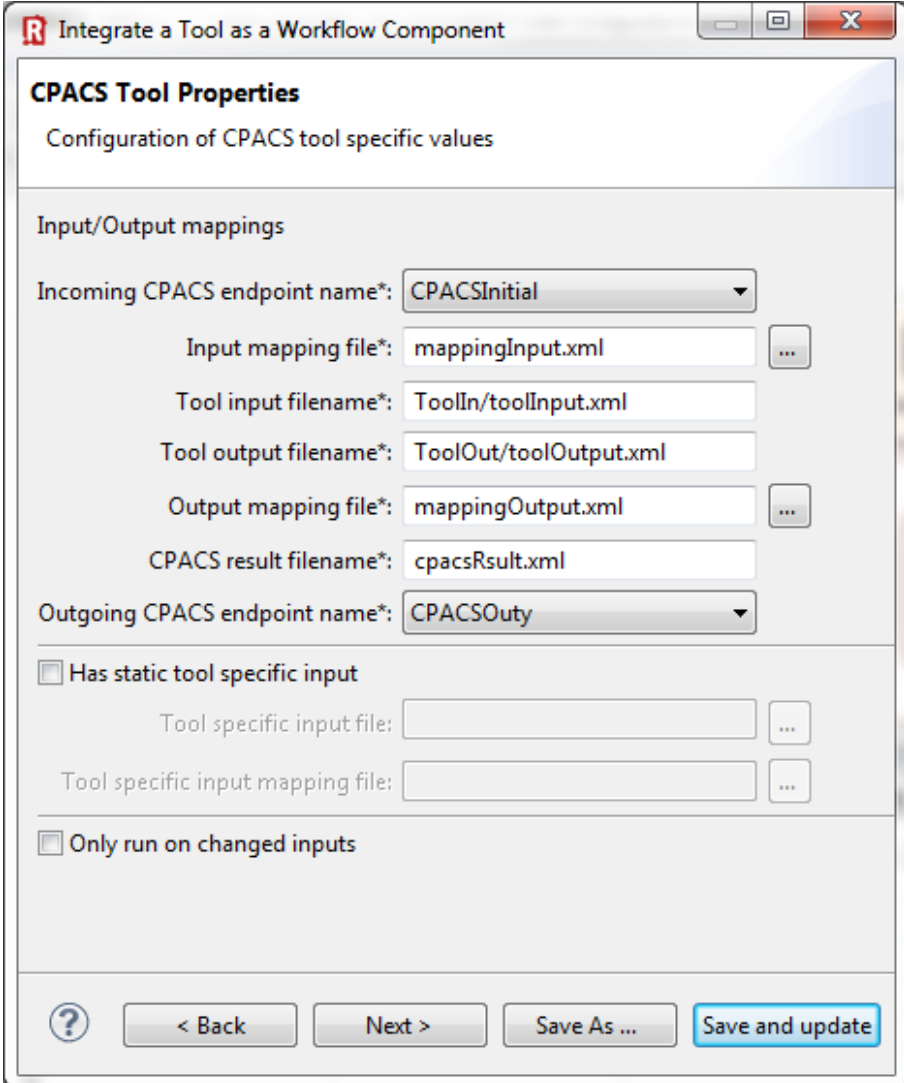
- Reading from CPACS before tool execution
- Writing back into CPACS after tool execution
- Use provided mapping file



CPACS-specific Tool Integration

How the User does it?

- Extended integration dialog
- Defining mapping files, tool input files, CPACS result files, etc.



Integrate a Tool as a Workflow Component

CPACS Tool Properties
Configuration of CPACS tool specific values

Input/Output mappings

Incoming CPACS endpoint name*: CPACSInitial

Input mapping file*: mappingInput.xml ...

Tool input filename*: ToolIn/toolInput.xml

Tool output filename*: ToolOut/toolOutput.xml

Output mapping file*: mappingOutput.xml ...

CPACS result filename*: cpacsRsult.xml

Outgoing CPACS endpoint name*: CPACSOuty

Has static tool specific input

Tool specific input file: ...

Tool specific input mapping file: ...

Only run on changed inputs

? < Back Next > Save As ... Save and update

Workflow Execution

From the Graphical User Interface

The screenshot displays the RCE for CPACS (RCE Client 1) graphical user interface. The main window shows a workflow graph with the following components and dependencies:

- Aerodynamic** and **Mesh** feed into **Optimizer**.
- Optimizer** feeds into **CoG cons**, **Mass model**, and **Water mass**.
- CoG cons**, **Mass model**, and **Water mass** feed into **ThermoRAD** and **ThermoISO**.
- ThermoRAD** and **ThermoISO** feed into **Tempfilter**.
- Tempfilter** feeds into **Structure**.
- Structure** feeds into **Trajectory**.
- Mesh** and **Trajectory** feed into **TIGL Viewer**.

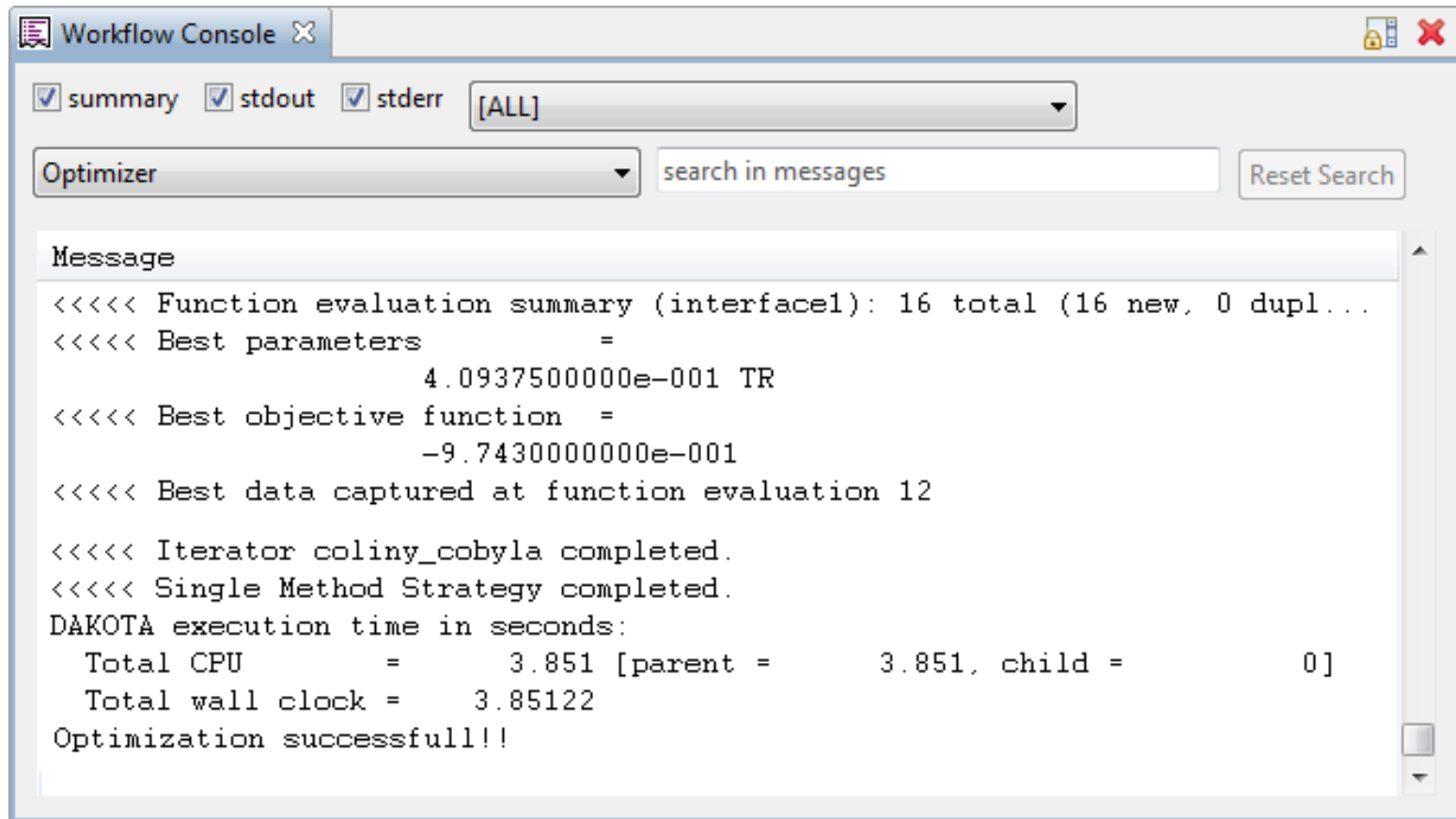
The **Workflow Data Browser** at the bottom left shows the execution timeline for the workflow `mdo_v1.8.1_with_water_n3_4cons_60.wf_2014-08-27_15:24:57_01`. The current run (Run 3) shows the **Mesh** component is active, with an output `CoAx_body: '34.01227'`.

The **Network** view at the bottom right shows the system architecture, including the RCE Client 1, RCE Relay Server, and RCE Servers 1 and 2, along with various published components like `GGHv3 (1.05)`, `Hysap1_nobatch (1.0)`, `STSMv10 (1.0)`, and `Tempfilter (1.0)`.



Monitoring Workflow Execution

Console Output of Tools



The screenshot shows a 'Workflow Console' window with a search bar and a message log. The log contains the following text:

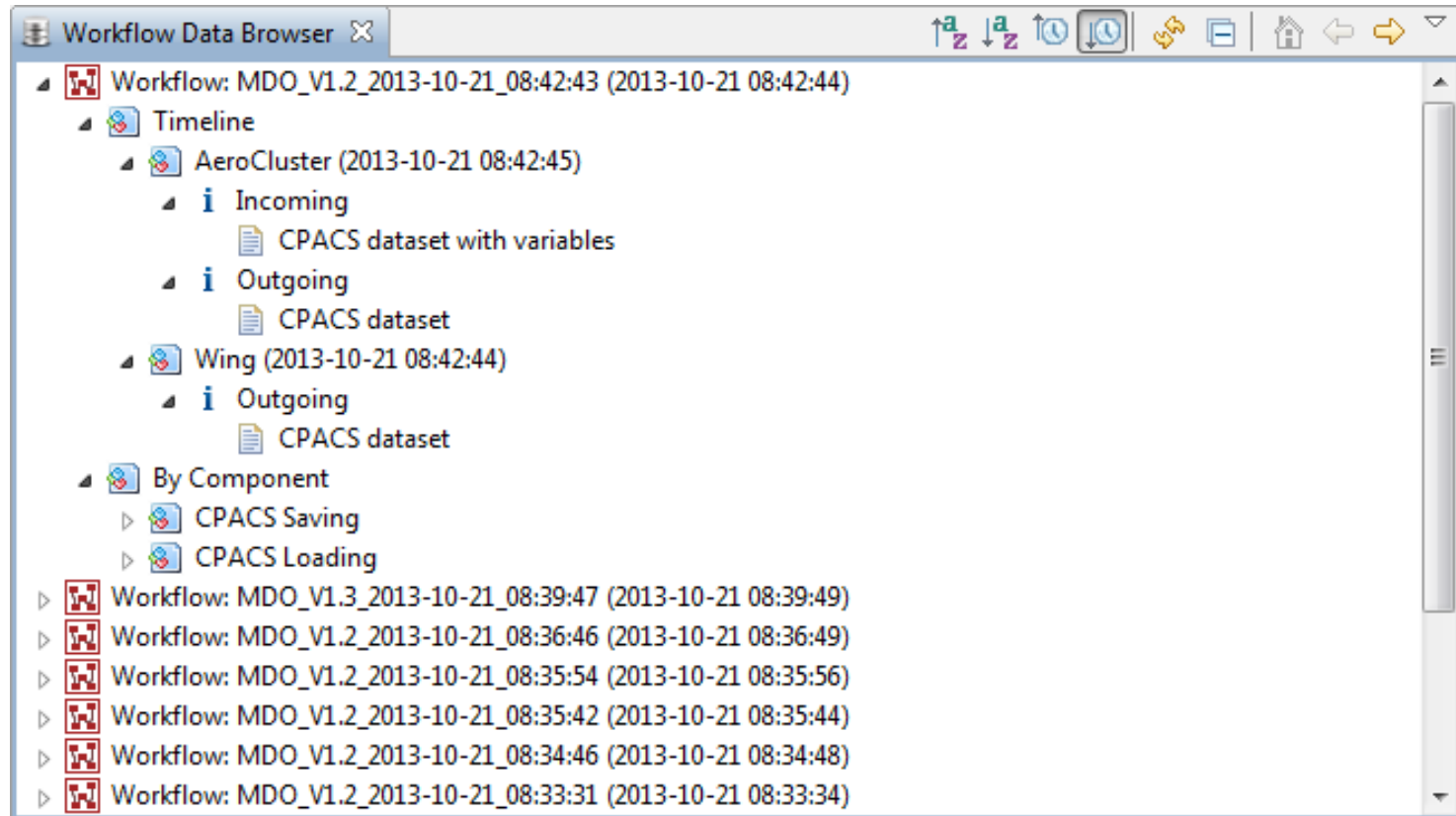
```
Message
<<<<< Function evaluation summary (interfacel): 16 total (16 new, 0 dupl...
<<<<< Best parameters =
                4.0937500000e-001 TR
<<<<< Best objective function =
                -9.7430000000e-001
<<<<< Best data captured at function evaluation 12

<<<<< Iterator coliny_cobyla completed.
<<<<< Single Method Strategy completed.
DAKOTA execution time in seconds:
  Total CPU      =      3.851 [parent =      3.851, child =      0]
  Total wall clock =      3.85122
Optimization successfull!!
```

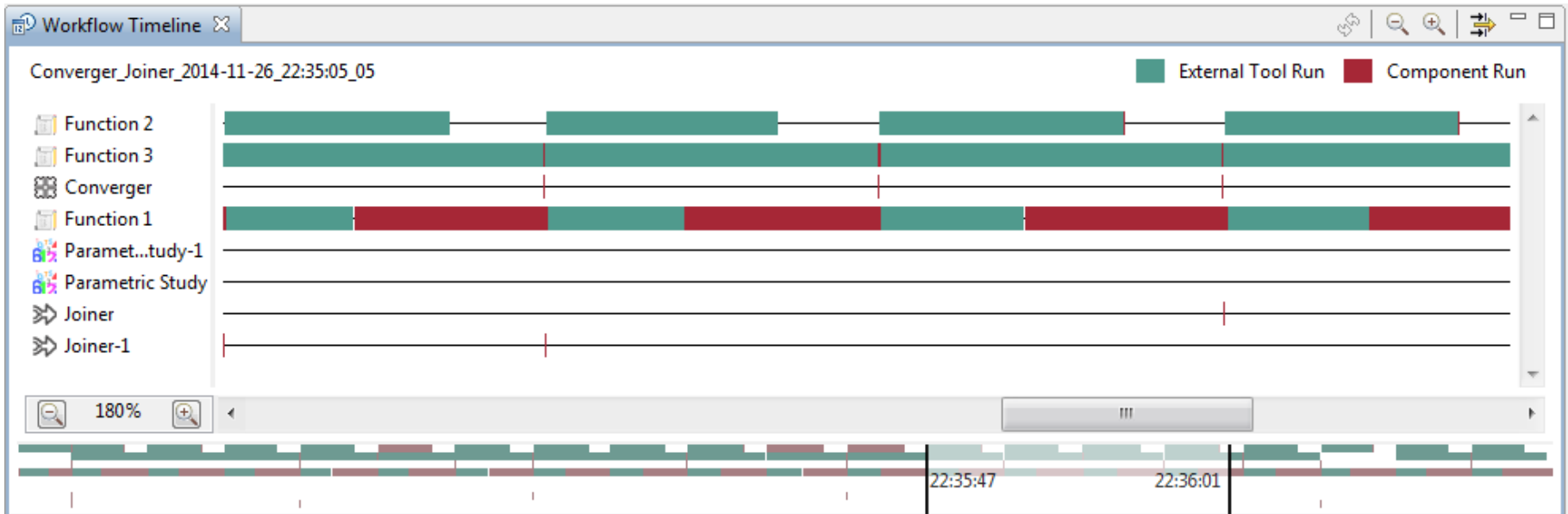


Monitoring Workflow Execution

Result Files and Data Sent



Monitoring Workflow Execution Timeline on Workflow Run



Multidisciplinary Desing Processes and Collaboration

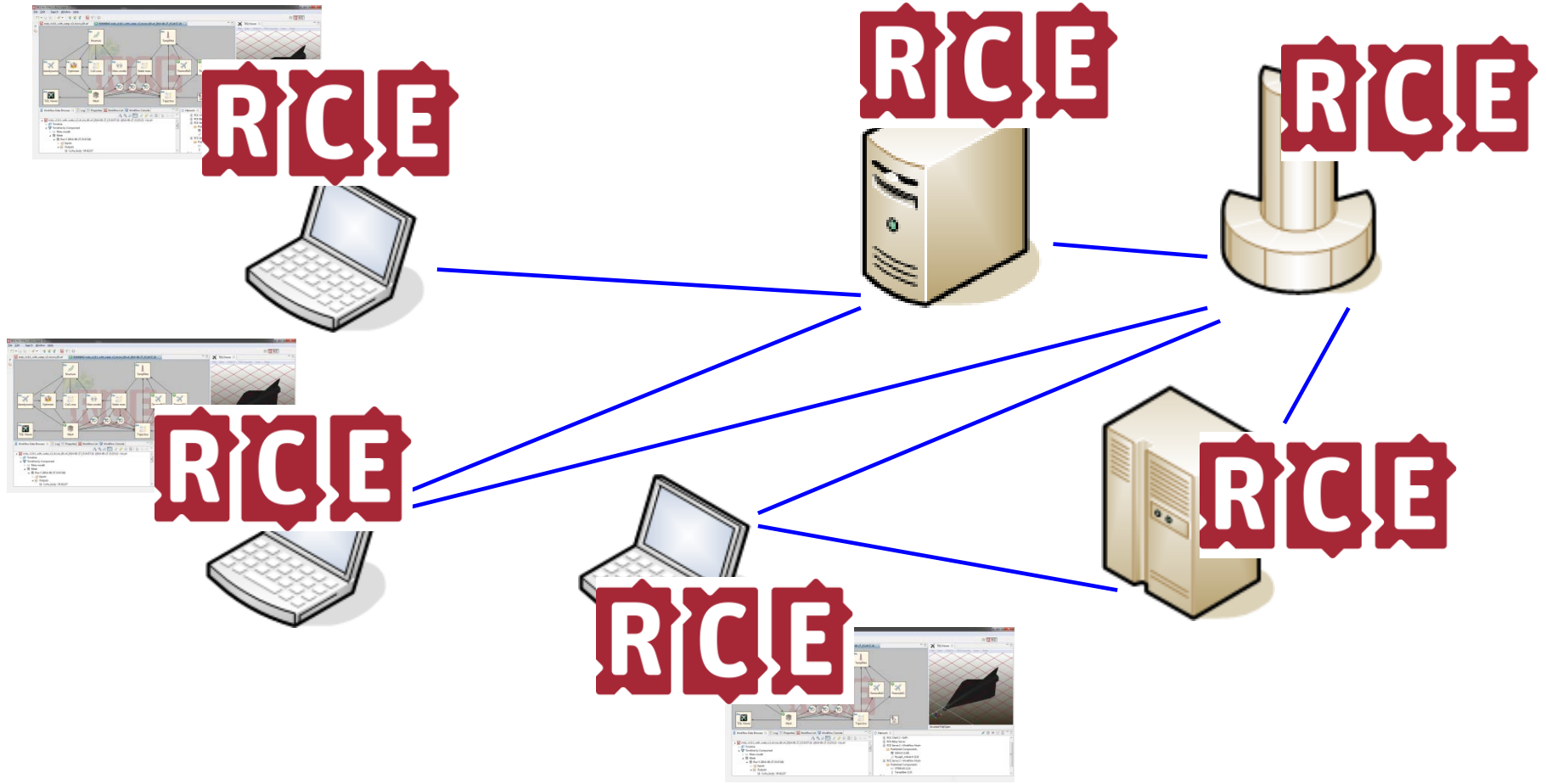
- MDO means multiple disciplines, multiple tools, and multiple people
- People are often located on different sites
- Tools often run on different machines

- How does RCE support collaboration?



RCE is a Distributed Integration Framework

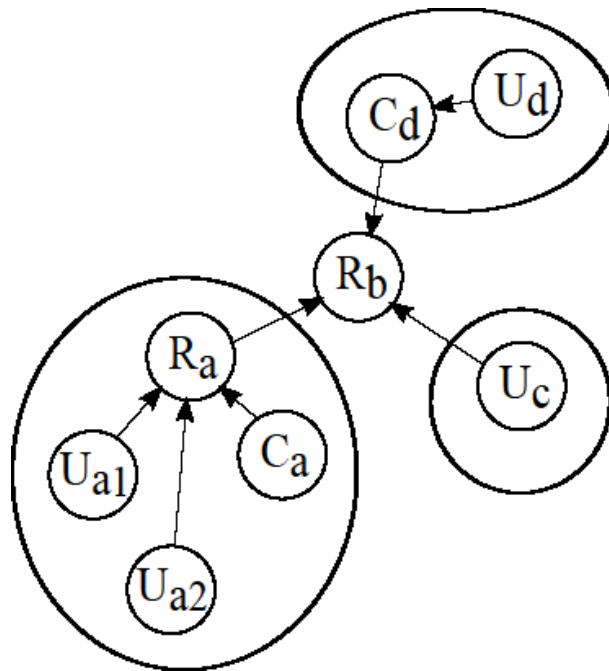
RCE Instances Build a Network



RCE is a Distributed Integration Framework

RCE Instances Build a Dynamic Network

- Network structure is fully flexible and dynamic
- RCE instances can have different roles: relay, compute, user frontend node, ...



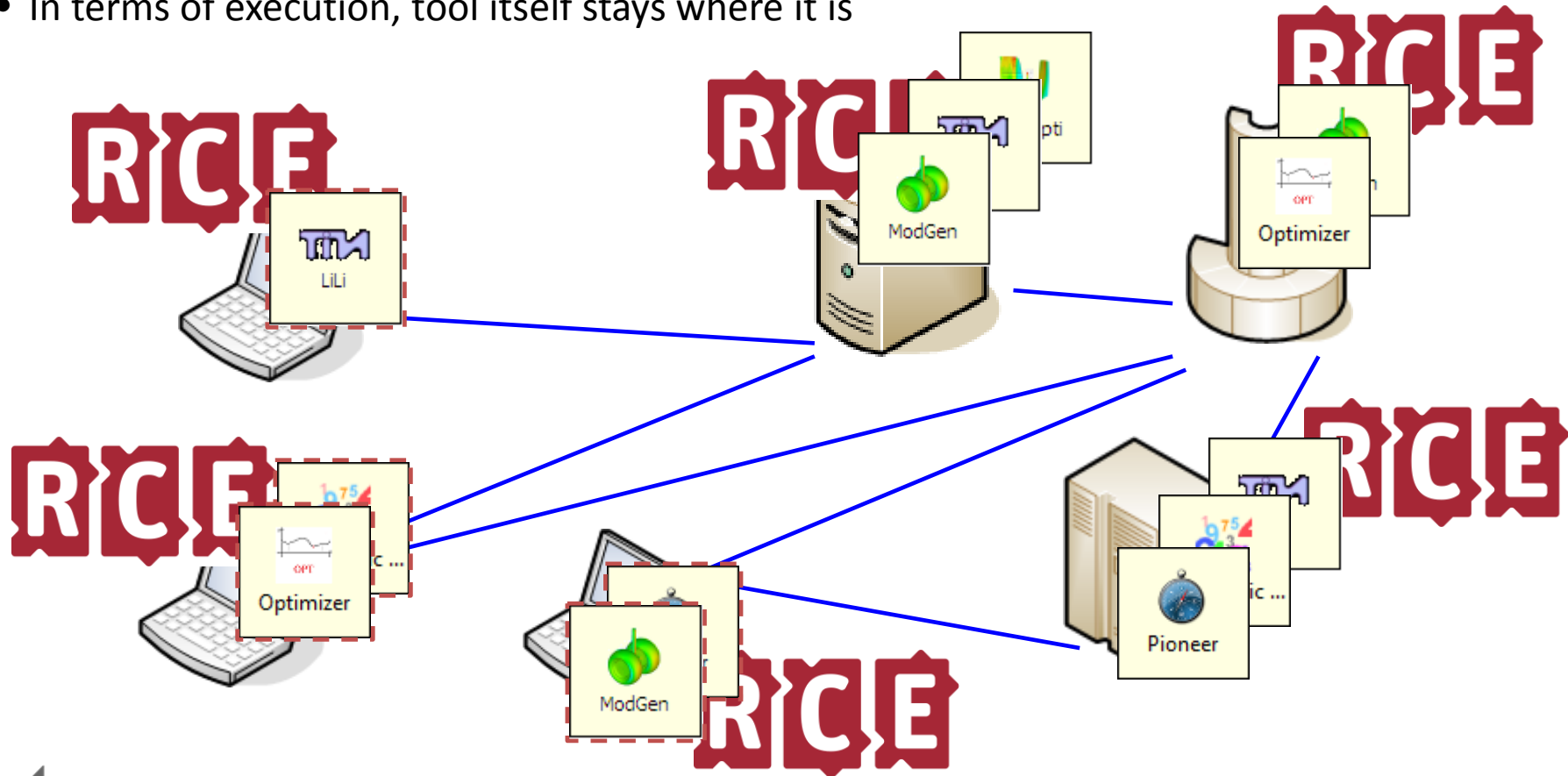
○ RCE instance
→ Direction of initialization

C...Compute node
R...Relay node
U...User frontend node



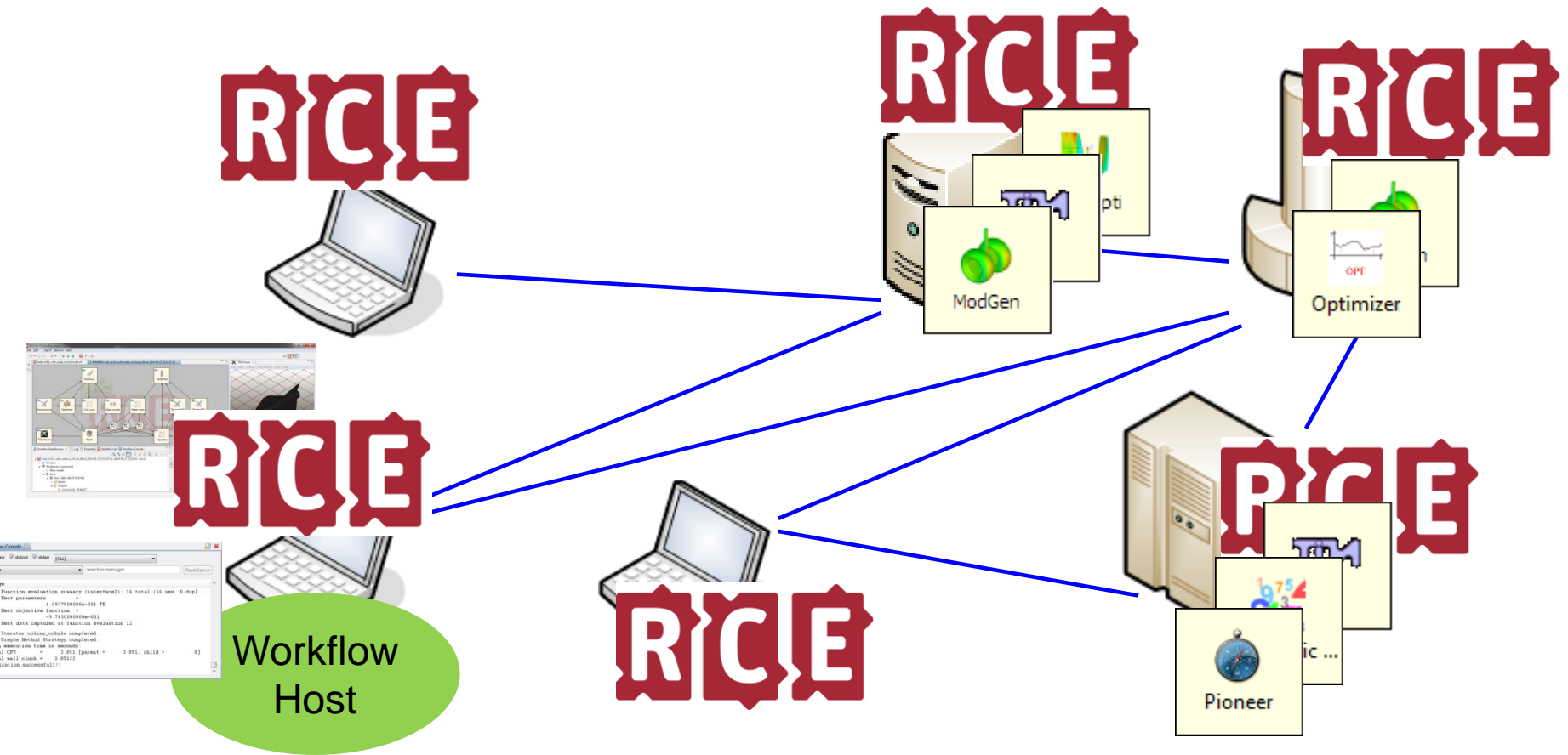
Collaboration in RCE (Ad-hoc) Distribution of Tools

- Tools, which are integrated into RCE, can be provided to others in the network
- In terms of execution, tool itself stays where it is



Collaboration in RCE

Shared Workflow Execution Monitoring

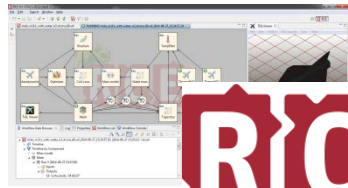


Collaboration in RCE

Shared Workflow Execution Monitoring

```
WorkflowControl
-----
Message
=====
Function evaluation history (interface): 16 total (16 new, 0 dupl)
Best parameters
=====
4 037510010e-001 TR
Best objective function
=====
-0.742000010e-001
Best data captured at function evaluation 12
=====
Iteration collatz_cubola completed
Single Method Strategy completed
RASPOTA execution time in seconds
Total CPU
-----
3.851 (parent) 3.851 (child) 93
Total wall clock
-----
3.85122
Optimization successful!!
```

RCE



RCE



RCE

```
WorkflowControl
-----
Message
=====
Function evaluation history (interface): 16 total (16 new, 0 dupl)
Best parameters
=====
4 037510010e-001 TR
Best objective function
=====
-0.742000010e-001
Best data captured at function evaluation 12
=====
Iteration collatz_cubola completed
Single Method Strategy completed
RASPOTA execution time in seconds
Total CPU
-----
3.851 (parent) 3.851 (child) 93
Total wall clock
-----
3.85122
Optimization successful!!
```

RCE

Workflow Host

RCE



RCE



Collaboration in RCE

Shared Workflow Execution Monitoring

Workflow Data Browser

- Workflow: MDO_V1.2_2013-10-21_08:42:43 (2013-10-21 08:42:44)
 - Timeline
 - AeroCluster (2013-10-21 08:42:45)
 - Incoming
 - CPACS dataset with variables
 - Outgoing
 - CPACS dataset
 - Wing (2013-10-21 08:42:44)
 - Outgoing
 - CPACS dataset
 - By Component
 - CPACS Saving
 - CPACS Loading
- Workflow: MDO_V1.3_2013-10-21
- Workflow: MDO_V1.2_2013-10-21
- Workflow: MDO_V1.2_2013-10-21
- Workflow: MDO_V1.2_2013-10-21
- Workflow: MDO_V1.2_2013-10-21
- Workflow: MDO_V1.2_2013-10-21

Workflow Console

summary stdout stderr [ALL]

Optimizer search in messages Reset Search

Message

```
<<<<< Function evaluation summary (interface1): 16 total (16 new, 0 dupl...
<<<<< Best parameters =
                        4.0937500000e-001 TR
<<<<< Best objective function =
                        -9.7430000000e-001
<<<<< Best data captured at function evaluation 12

<<<<< Iterator coliny_cobyla completed.
<<<<< Single Method Strategy completed.
DAKOTA execution time in seconds:
  Total CPU      =      3.851 [parent =      3.851, child =      0]
  Total wall clock =      3.85122
Optimization successfull!!
```

Workflow Timeline

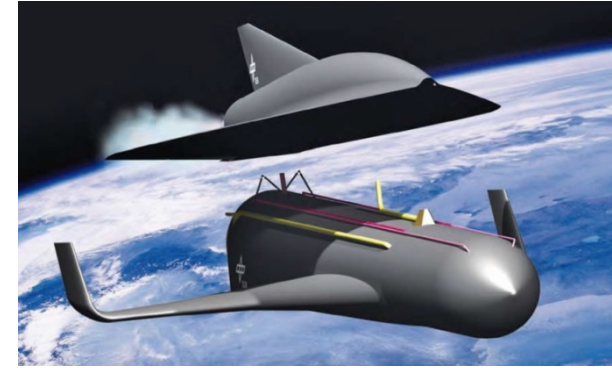
Converger_Joiner_2014-11-26_22:35:05_05

- Function 2
- Function 3
- Converger
- Function 1
- Paramet...tudy-1
- Parametric Study
- Joiner
- Joiner-1

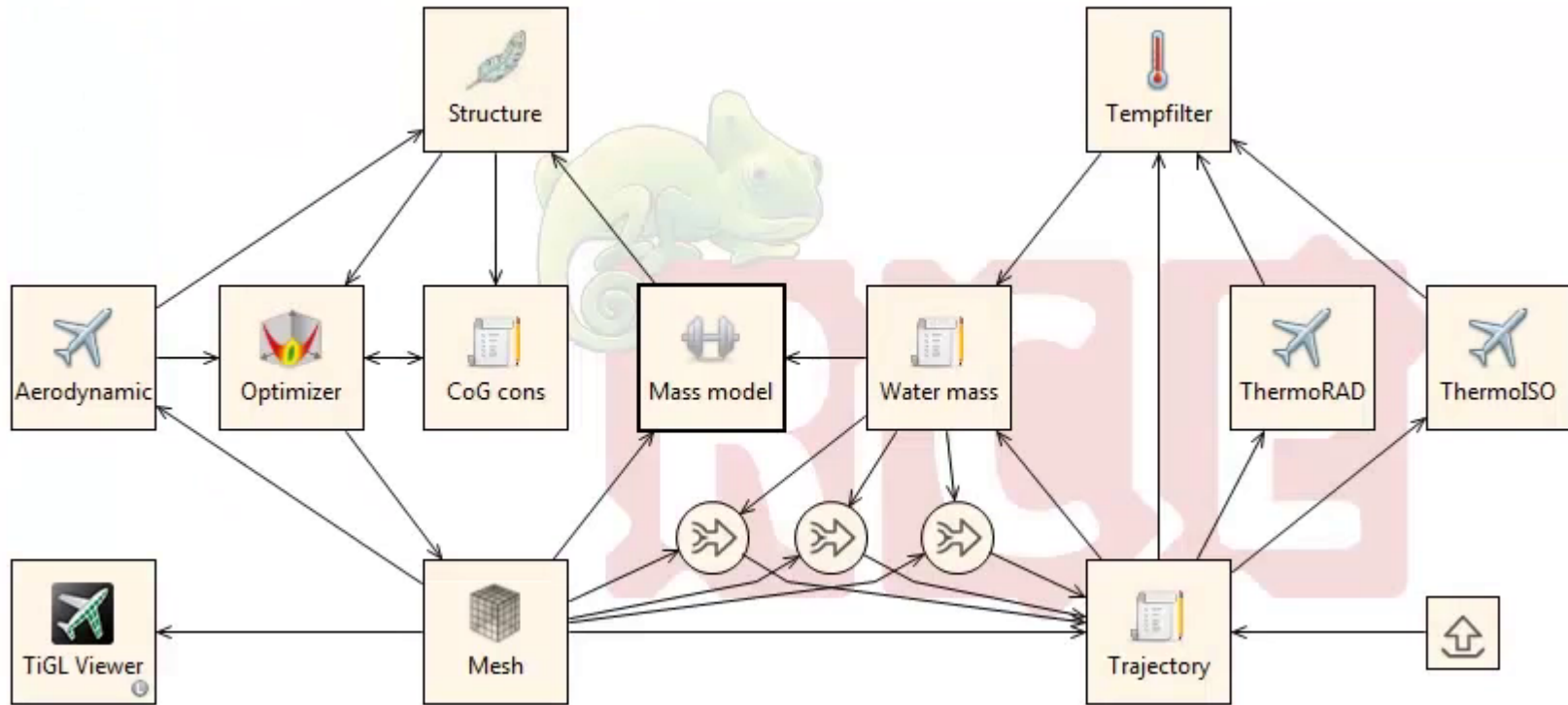
180%

22:35:47 22:36:01

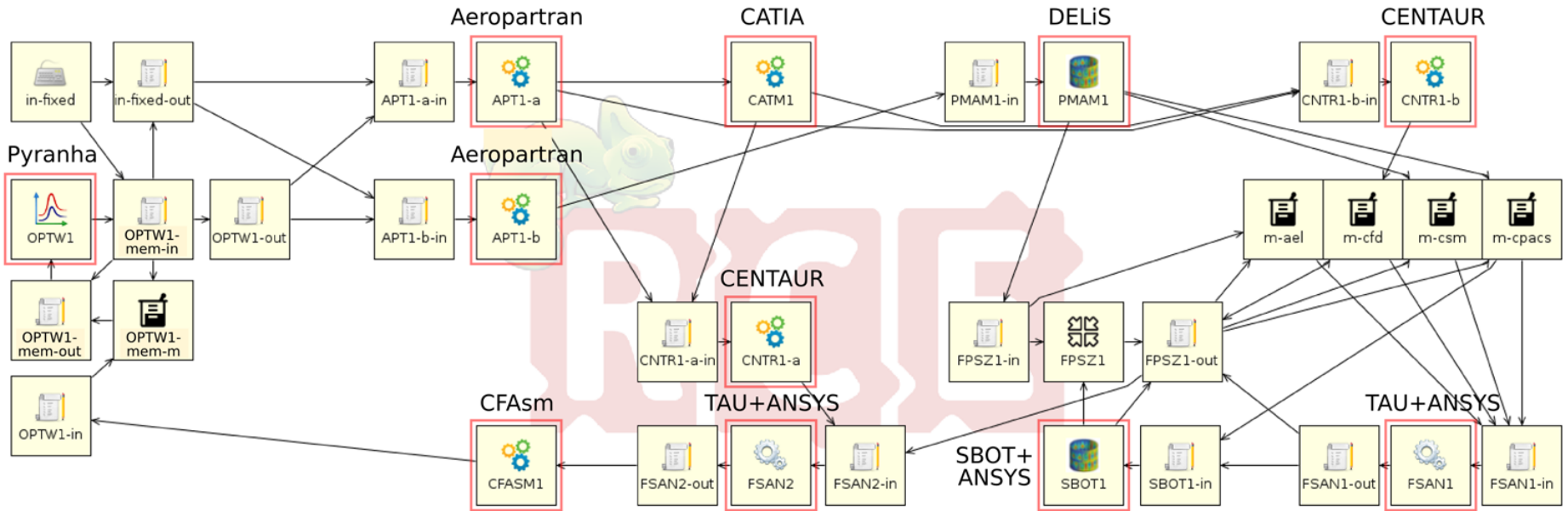
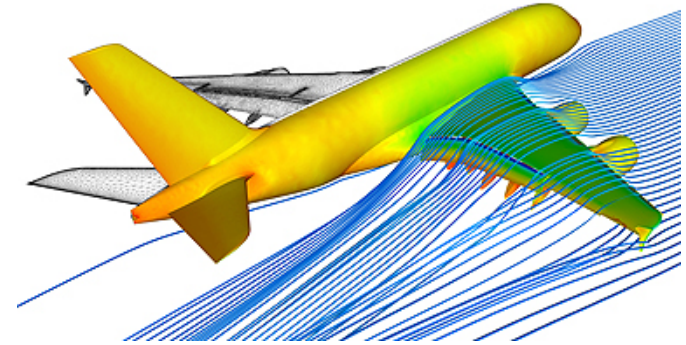
MDO: Thermal Management of SpaceLiner RCE Workflow



Source: A. Tröltzsch



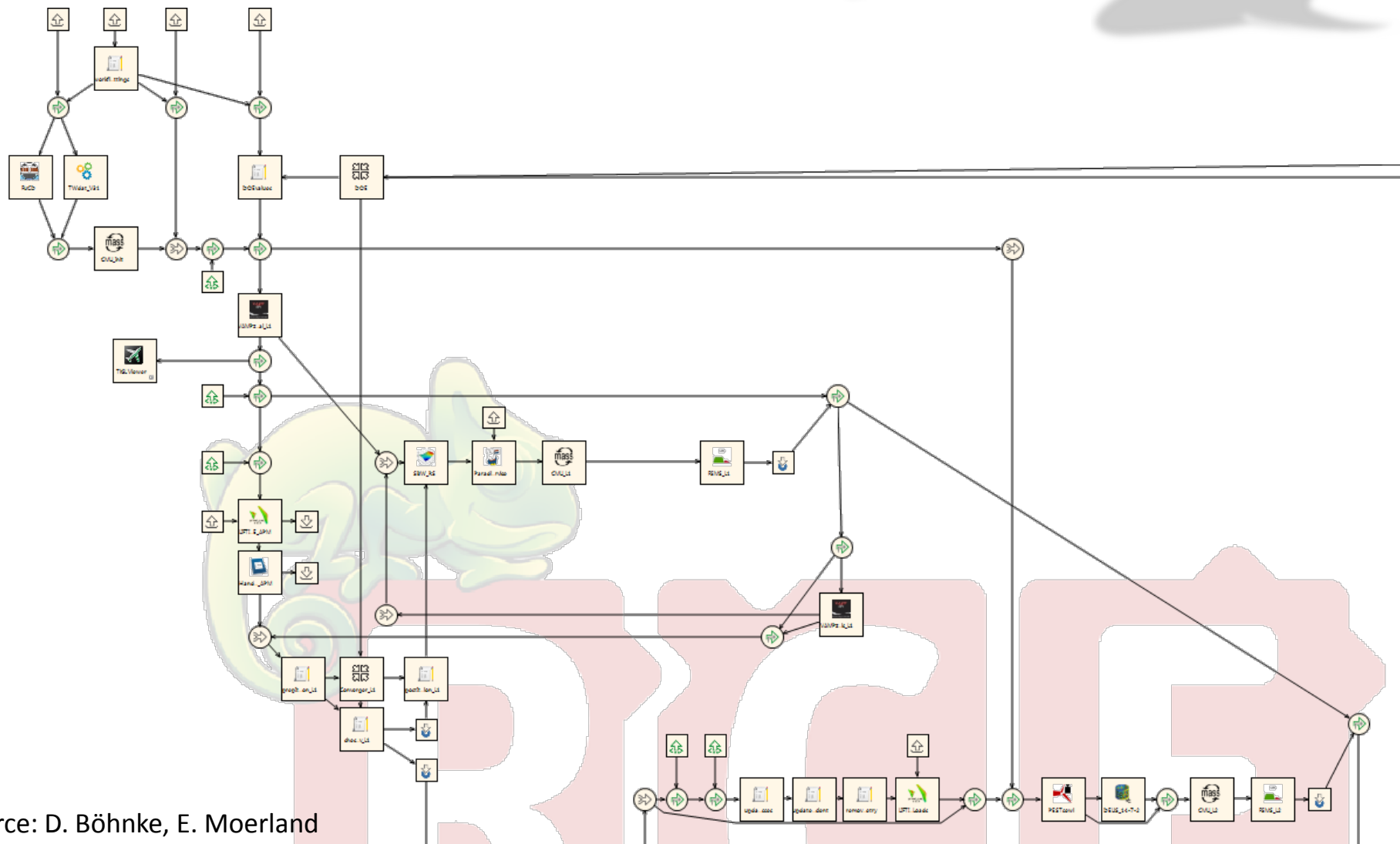
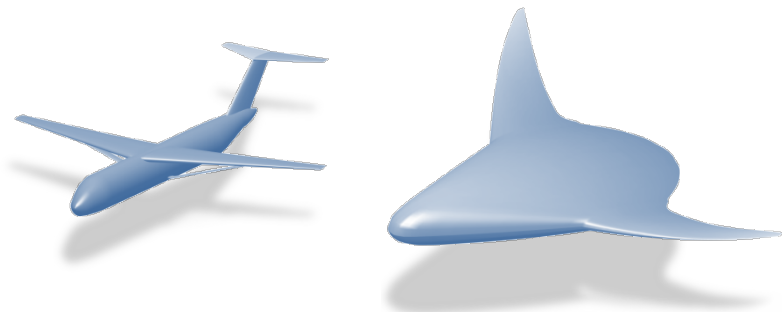
MDO: High-Fidelity Aircraft Design RCE Workflow



Source: C. Ilic



MDA: Preliminary Aircraft Design RCE Workflow

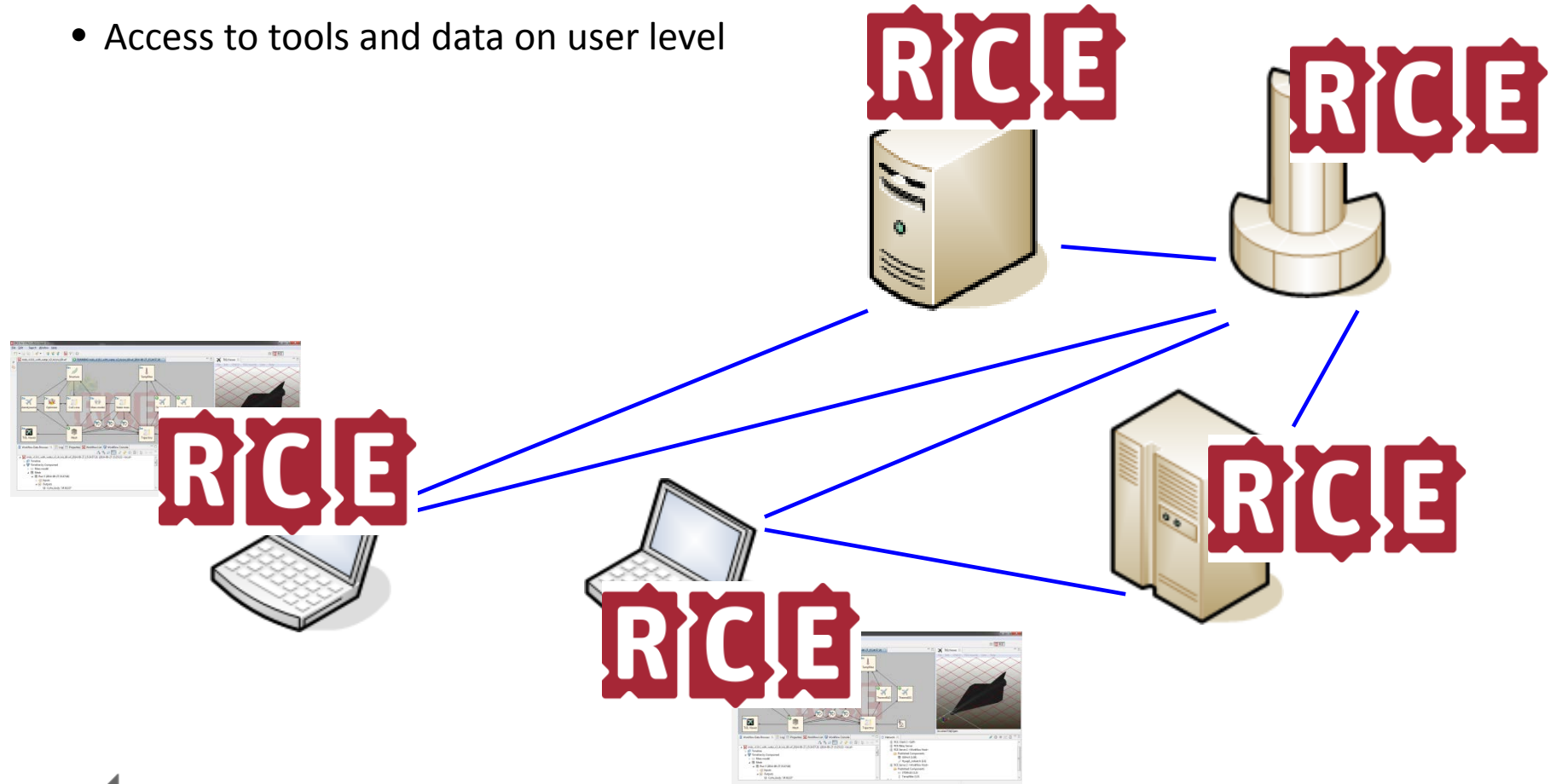


Source: D. Böhnke, E. Moerland

Outlook

Multi User Concept

- Shortterm to midterm
- Access to tools and data on user level



Conclusion

- RCE is a workflow-driven integration framework for MDO processes (among others)
- It is distributed and allows collaboration

- RCE is Open Source
- Contributions are welcome
- Not only in terms of code, but also in terms of feedback, ideas, concepts
- RCE is developed by developers and by users



<http://rcenvironment.de>

@rcenvironment

<http://youtube.com/rcenvironment>

RICE