

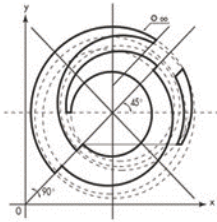


September 2001

ICTB2 proposal

Internal Cooling Turbine Blade 2

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ICTB2 technical objective

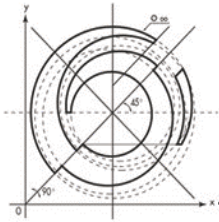
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Novel European internal cooling concepts

- Leading-edge
- Trailing-edge
- Bends
- 3D ribs

Increase European internal cooling research and design capability

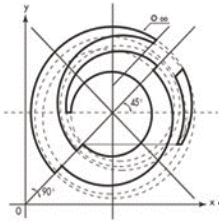
- Test rigs (stationary/rotating)
- Excellent engineers formed to the latest techniques
- Network University / Industry



ICTB2 concept

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- ✍ Brainstorming for novel internal cooling techniques
- ✍ CFD to test/optimize new cooling concepts and to define experimental configurations
- ✍ Experiments
 - check performance of these concepts
 - develop correlation for them
 - show applicability on real blade cooling design
 - validate *a posteriori* CFD



ICTB2 key features

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✍ 3 years program

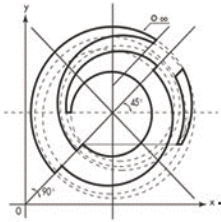
✍ Matrix organization

✍ CFD issue

- Use of ICTB1 experience for optimizing test-geometries
- CFD-work in Industry
- Academy: eventually only test of modern existing models

✍ Experimental issues

- Limit risks: no absolutely new test-rig
- Good balance in tasks
(stationary/rotating, heat transfer/flow)



Technical program

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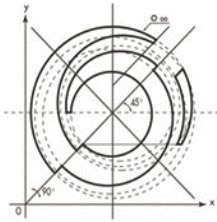
Maximal program

- Task 1: Bends in rotation
- Task 2: Advanced leading-edge cooling
- Task 3: Trailing-edge cooling
- Task 4: 3D-ribs
- Task 5: Validation of new technology on Realistic cooled blade

Experts from academy

- CFD
- Experiment
- Multi-disciplinary design

Exploitation and coordination



Matrix organization



PM program manager

TL task leader

E expert

TL

TL

TL

TL

TL

Task 1

Task 2

Task 3

Task 4

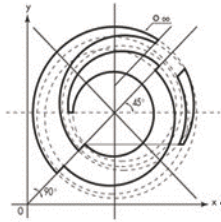
Task 5

PM Exploitation
guide implementation
results dissemination
results secrecy
inter-task communication

E Experimental techniques
expertise
data management
correlation

E 3D CFD
expertise
data management
new models and process

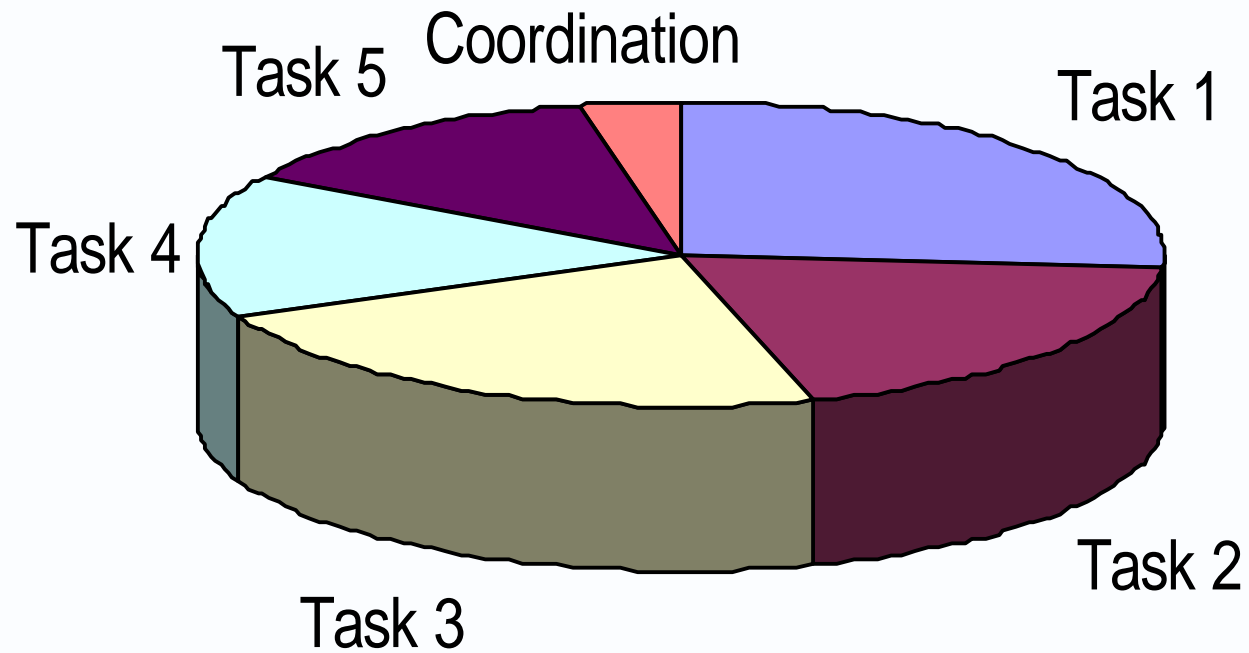
E Multi-disc. design
expertise
link with other disciplines

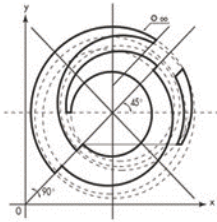


Global budget



a good balance between tasks

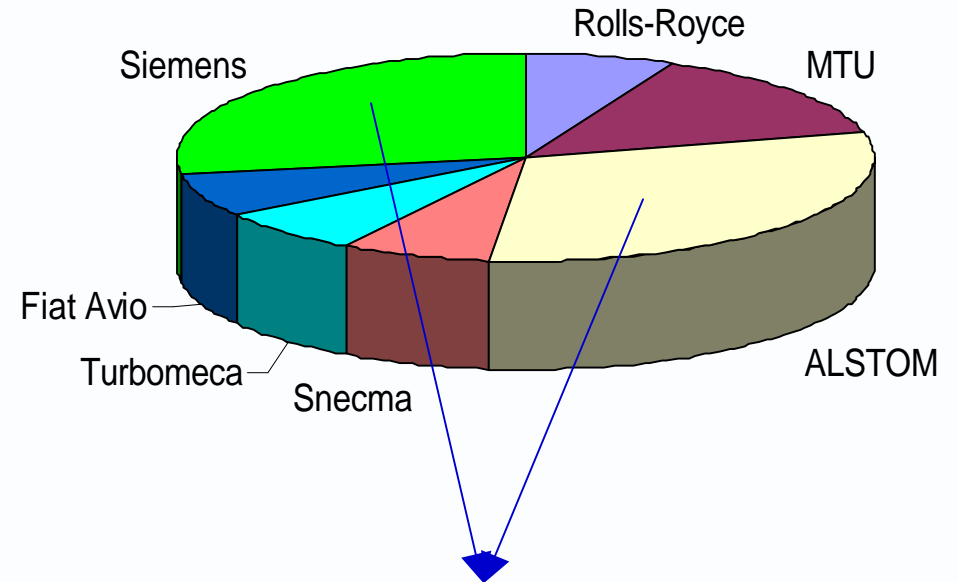
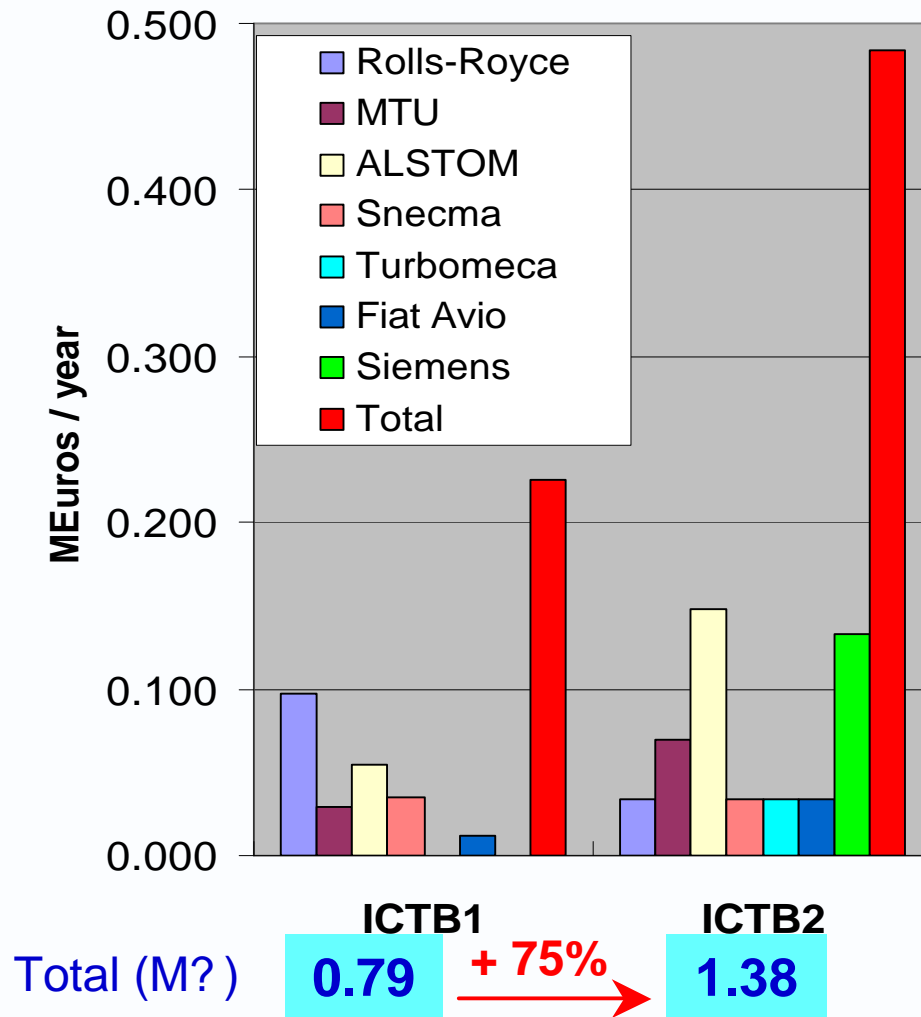




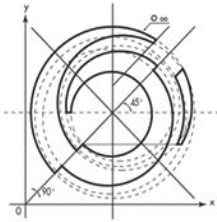
Industrial investment



A strong increase



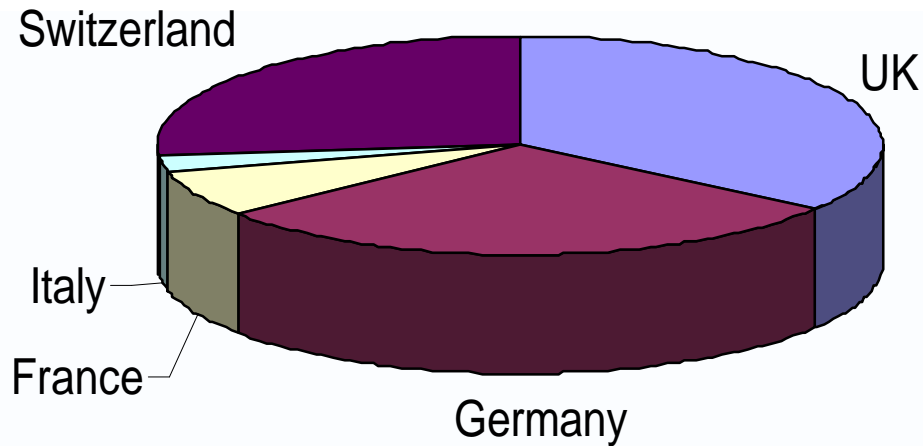
A strong commitment from land-based gas turbine industry



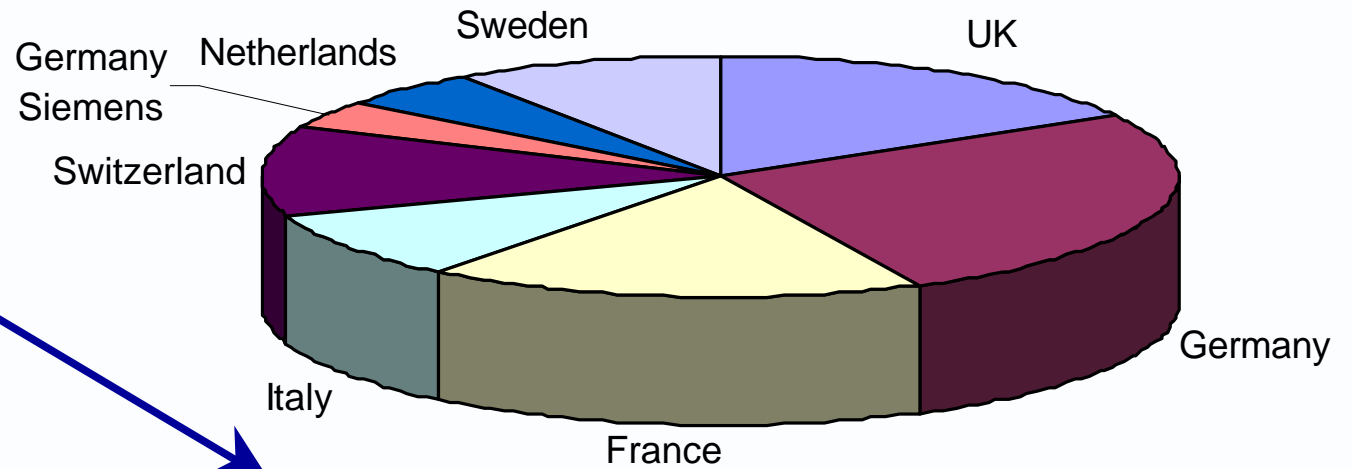
governmental funding



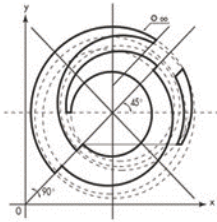
A Europewide geographic repartition



ICTB 1



ICTB 2



Global budget



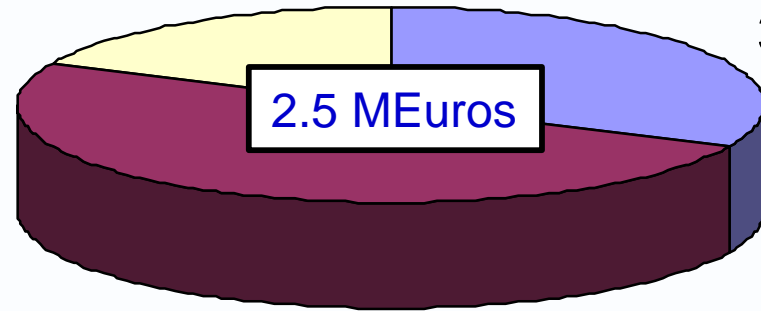
non.E.C.

18%

Industry

32%

2.5 MEuros



E.C.

50%

ICTB 1

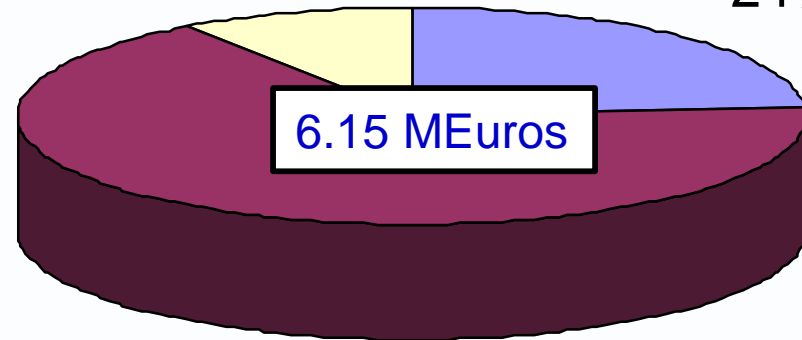
non.E.C.

10%

Industry

24%

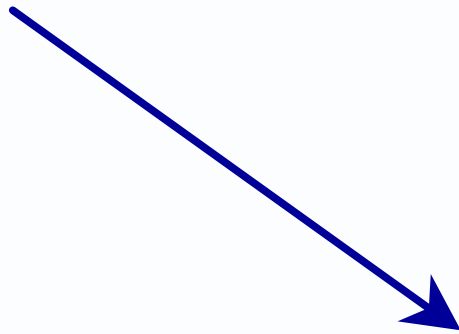
6.15 MEuros

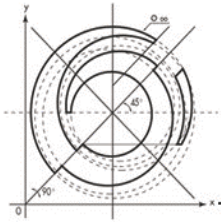


E.C.

66%

ICTB 2



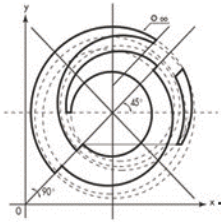


GROWTH program

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March 2001

ICTB 2 is rejected



ICTB2 evaluation

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Scientific / Technological quality & innovation

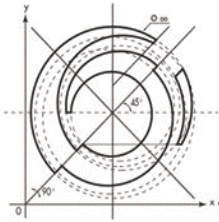
- final objectives are clear although some depend on brainstorming at initial phase of the project
- proposer's plan to achieve new breakthrough sounds a too ambitious denomination
- the project is rather confined to achieve a better knowledge of well known technologies

Threshold: 3

Final Mark: 3.2

Maximum: 5

✍ achieved



ICTB2 evaluation

ALSTOM

Partnership, management & resources

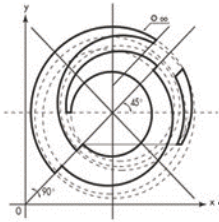
- opinion, that WP 5 is not needed for the success of the project, hence it should be deleted
- quality of the partnership is adequate
- matrix organisation looks good to assure control of quality, timetables as well as high number of partners

Threshold: 3

Final Mark: 3.6

Maximum: 5

✍ achieved



ICTB2 evaluation

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Community added value & contribution to E.U.

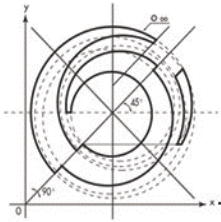
- large trans-European consortium with a very strong participation of research oriented organisations
- further involvement of e.g. engine turbine blade suppliers would have further increased the community added value

Threshold: 3

Final Mark: 3.3

Maximum: 5

✍ achieved



ICTB2 evaluation



Community social objectives

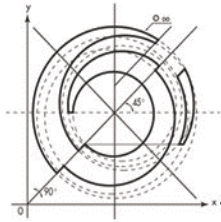
- while aiming at facilitating a higher cycle efficiency, the consortium does not quantify the expected benefits in fuel savings

Threshold: 3

Final Mark: 3.3

Maximum: 5

 achieved



ICTB2 evaluation

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Economic development and scientific/technological prospects

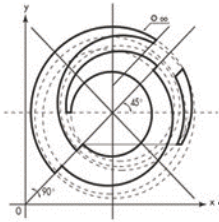
- cooperation of different industrial sectors (propulsion & power generation) is rated very positive
- the expressed need for the protection of results may hamper the use of scientific and technological results by universities representing 40% of partnership

Threshold: 4

Final Mark: 3.7

Maximum: 5

 failed

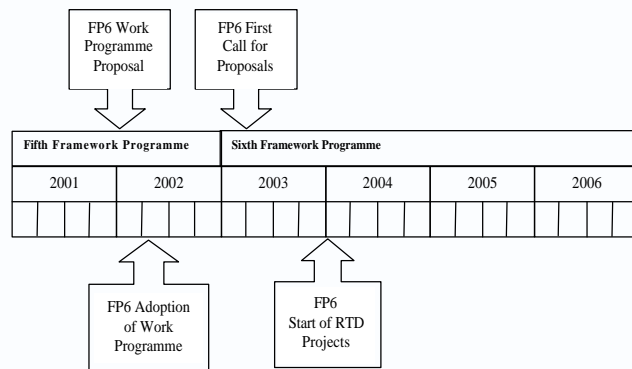


ICTB2 evaluation



Possible re-submission

✍ Resubmission to the “Growth follow-up” Call FP 6



FP 6 Calls earliest in March 2003

Start of FP 6 RTD projects in Jan. 2004

✍ Resubmission to the Energy Call FP 5

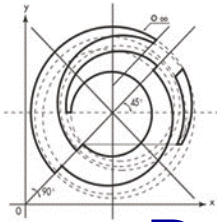
FP 5 Energy Call December 2001

Rework of proposal necessary

The graphic features a blue background with diagonal lines. A large red curved shape, resembling a stylized 'A' or a swoosh, is positioned above the text. The text 'ALSTOM' is centered below the swoosh. The letters 'A', 'L', 'S', 'T', and 'M' are in a bold, blue, sans-serif font. The letter 'O' is a red circle with a white center, containing a smaller red circle, creating a circular logo element.

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Program & task leaders



Program coordinator

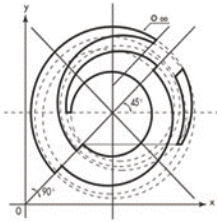
- ALSTOM
 - UK: administrative
 - CH: technical

Task leaders:

- Task 1: MTU
- Task 2: SNECMA
- Task 3: ALSTOM (CH)
- Task 4: FIAT-AVIO
- Task 5: Rolls-Royce

Experts

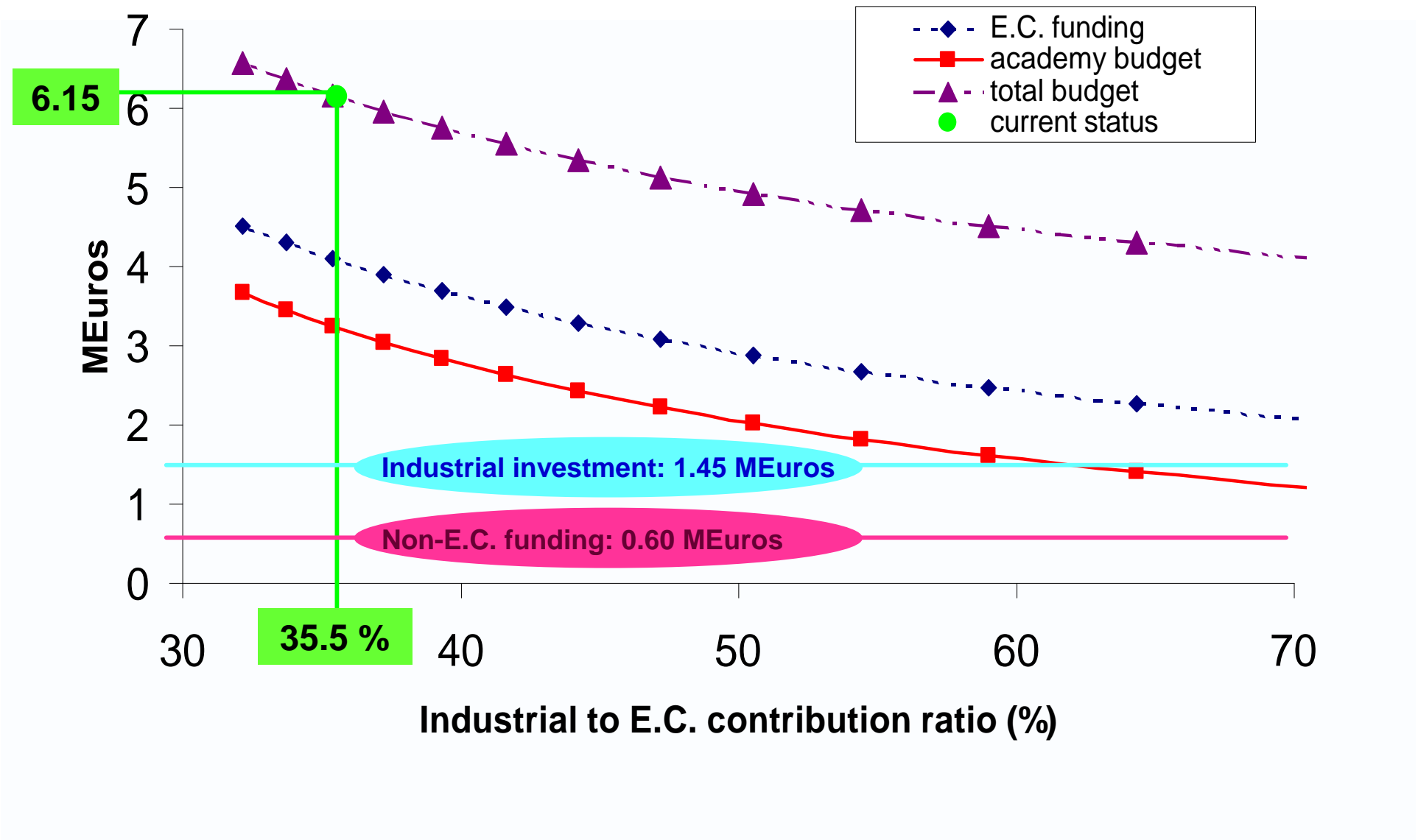
- *CFD*: Prof. Sunden (Lund Inst.)
- *Experiments*: Prof. Hanjalic (TU Delft)
- *Multi-disc. design*: Prof. Weigand (Uni. Stuttgart)

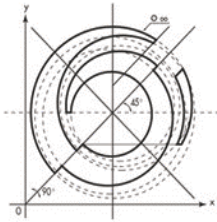


Total budget



Switzerland inside E.C.



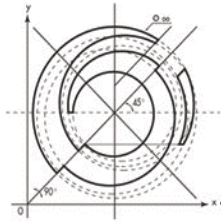


Other FP5 Brite-Euram programs



	AITEB	ICAS-GT2	AD-Comb	ICTB2
total budget (MEuros)	5.6	6.4	4.5	6.15
EC contribution (MEuros)	3.7	4.3	2.6	4.01
EC to total budget ratio	66	67	59	65
industry to EC ratio (estimate)	52	49	71	35.5
Man-Month	645	819	430	770

- ✍ Numbers similar to current ICTB2 proposal
 - E.C. contribution of around 2/3 of total budget
 - man months higher in ICTB2, but rough estimate only
- ✍ Industry-to-E.C. contribution ratio for other programs only estimated: (total-E.C.)/E.C. and with swiss funding outside of the E.U.



Task 1

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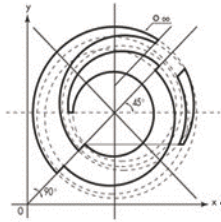
Rotating bends

Goal

- Extend correlation (pressure loss, heat transfer, rotation)
- Novel European bend designs
- Physical understanding (flow / turbulence / heat transfer)
- Define European design rules/tool

Impact

- Pressure loss: a global impact on overall cooling system
- Heat transfer: a local impact on tips, fillets
- Local heat transfer: a better prediction of hot spots



Task 2

ALSTOM

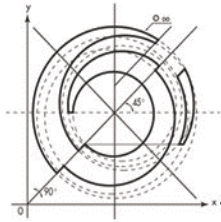
Advanced leading-edge internal cooling

Goal

- Novel European LE design philosophy
- Create correlation (with rotation) for it
- Physical understanding (flow / turbulence / heat transfer)
- Evaluate and define design rules/tools

Impact

- HP-turbines: reduces (removes) the need for LE film cooling
 - less losses
 - maintain hot gas T°
 - avoid Back-flow Margin
 - improve Mechanical Integrity
- LP-turbines: optimizes cooling consumption



Task 3

ALSTOM

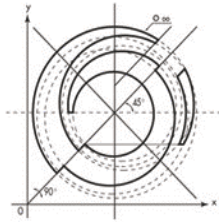
Trailing-edge internal cooling

Goal

- Consolidate trailing edge technology
- Extend correlation for selected cooling philosophy
- Physical understanding (flow / turbulence / heat transfer)
- Evaluate and define design rules/tools

Impact

- Thinner trailing-edges possible
(for highly loaded transonic turbines)
- Accurate prediction of coolant mass-flow control
(TE pin-fins / ejection slots)



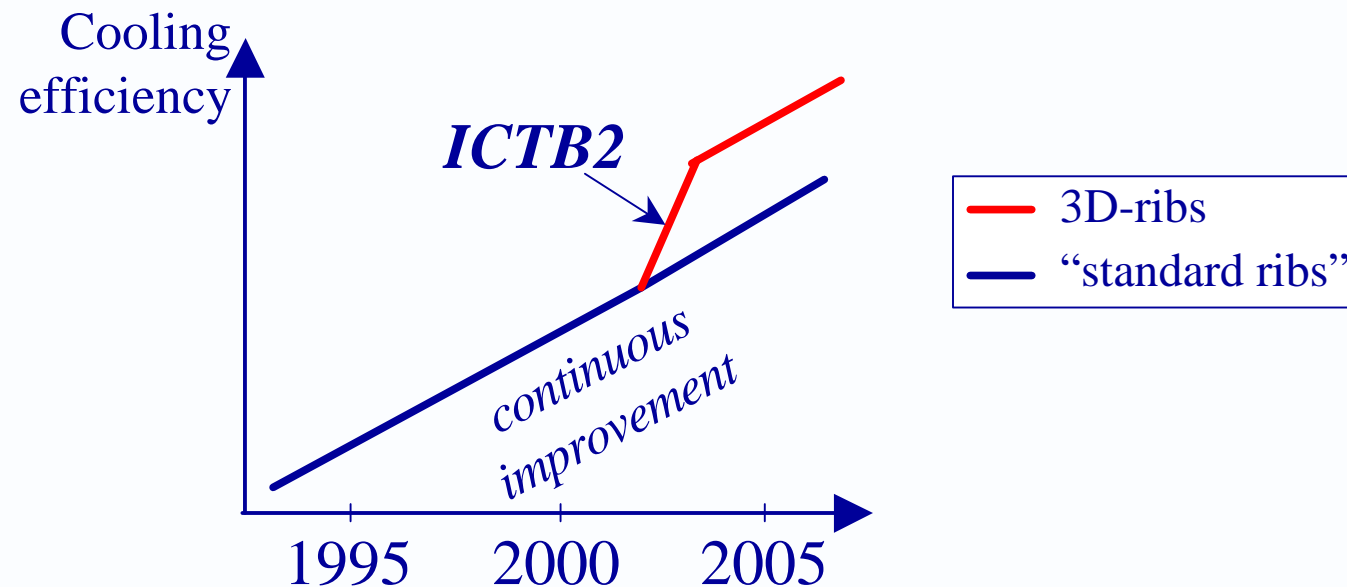
Task 4

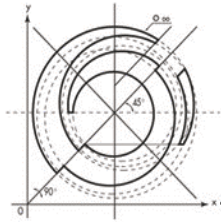
3D-ribs

Goal

- A breakthrough in ribbed-cooling technology
- Create correlation for it
- Physical understanding (flow / turbulence / heat transfer)
- Evaluate and define design rules/tools

Impact





Task 5

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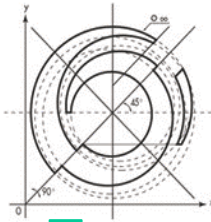
Realistic cooled blade

Goal

- Get full heat transfer AND pressure loss data on realistic geometry (same than ICTB1?) with novel cooling features
- Show overall impact of ICTB2
- Test, validate, calibrate design systems
- Evaluate and define design rules/tools

Impact

- Check correlation on real-engine data
- Show local and global impact of novel cooling features
- Increase experience and confidence in design systems
- A realistic full test-case for training / improvement / validation of 3D CFD-process

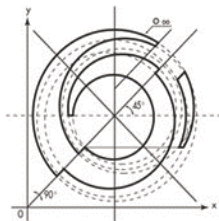


Program structure



- S** Stationary test-rig
- R** Rotating test-rig
- PM** Program manager
- TL** Task leader
- E** Expert

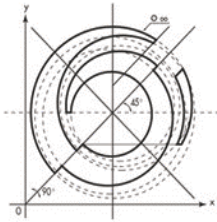
		Coordination	Exploitation, experiments, CFD	Task 1	Task 2	Task 3	Task 4	Task 5
<u>Industrial</u>	Rolls-Royce				X	X	X	R TL
	MTU			TL		X	X	X
	ALSTOM POWER (UK)	<i>admin.</i>			S X		X	X
	ALSTOM POWER (CH)	<i>technical</i>	PM	X		TL		
	SNECMA				TL		X ?	
	TURBOMECA			X	X			
	FIAT-AVIO						TL	X
<u>Academy</u>	ONERA							R X
	TU Delft		E			S X		
	Uni. Stuttgart		E				S X	
	Lund Institute.		E	X	X	X	X	
	UMIST			R X				
	Uni. Naples						R X	
	CEAT Poitiers				S X			
	DLR							R X
	TU Darmstadt				R X			
EPFL					S X			



Activity summary



Consortium	Total costs	Partner contribution	E.C. contribution	non E.C. contribution	Man Months
<i>Industry</i>					
Rolls-Royce	0.200	0.100	0.100	0.000	46.5
MTU	0.415	0.208	0.208	0.000	36.0
Snecma	0.200	0.100	0.100	0.000	18.0
Turbomeca	0.200	0.100	0.100	0.000	18.0
ALSTOM (UK)	0.520	0.260	0.260	0.000	40.0
Fiat Avio	0.200	0.100	0.100	0.000	18.0
Siemens (ticket incl.)	0.800	0.400	0.400	0.000	27.0
Non-EC partners					
ALSTOM (CH)	0.370	0.185	0.185	0.000	24.0
Total	2.905	1.453	1.453	0.000	227.5
<i>Academic institutions</i>					
TU Delft	0.400	0.000	0.200	0.200	54.0
Uni. Stuttgart	0.270	0.000	0.270	0.000	36.0
Lund Institute	0.275	0.000	0.275	0.000	45.0
UMIST	0.320	0.000	0.320	0.000	63.0
Uni. Naples	0.260	0.000	0.260	0.000	63.0
Onera	0.400	0.000	0.200	0.200	42.0
ENSMA Poitiers	0.300	0.000	0.300	0.000	108.0
DLR	0.400	0.000	0.200	0.200	36.0
TU Darmstadt	0.240	0.000	0.240	0.000	48.0
Non-EC partners					
EPFL	0.370	0.000	0.370	0.000	48.0
Total	3.235	0.000	2.635	0.600	543.0
Total global	6.140	1.453	4.088	0.600	770.5



Academic budget

