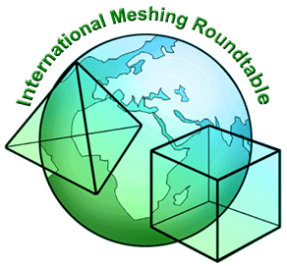
Powered by SurveyMonkey




# Survey on the situation, needs and trends of meshing algorithms in the industry

Professional Development Session

Contact : mark.loriot@distene.com

24th International Meshing Roundtable Conference

October 11th-14th, 2015 - Austin, Tx, USA

Conference sponsored by:

Sandia National Laboratories

NSF

COVENTOR

WHAT'S NEXT. AND NEXT. AND NEXT.

CST

NUMECA INTERNATIONAL

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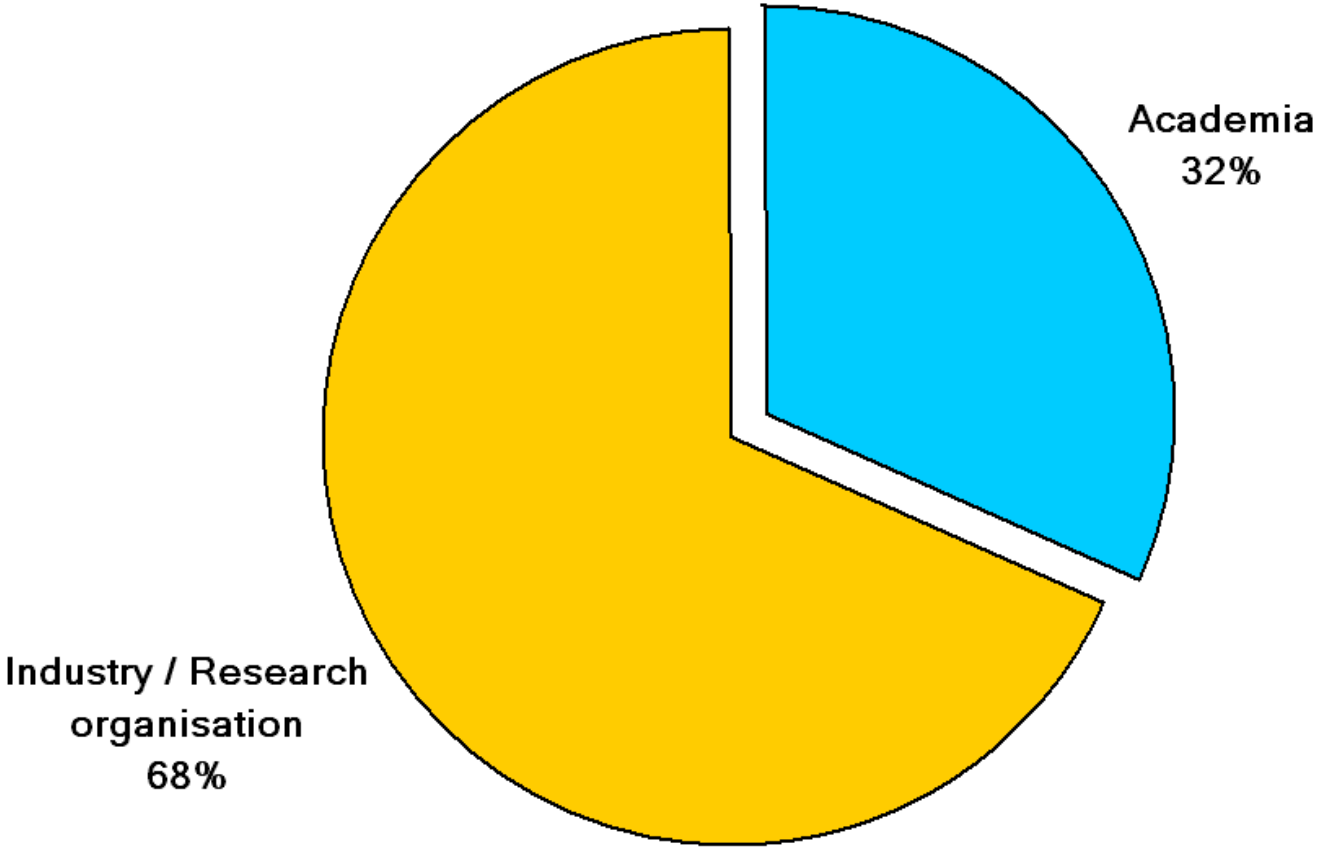
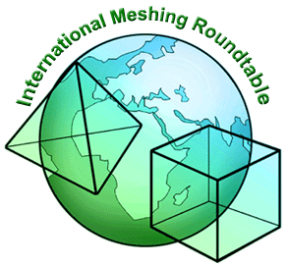
# General data

- Survey conducted between Sept 14th and Oct. 9th (2015)
- Aim : provide guidance to students and engineers considering making a career in this field by providing information on the current status and needs in meshing
- ~1500 selected persons contacted directly + survey advertized in Linked-In meshing groups.;
- 354 participants to survey (of which 82% totally anonymous) ;
- Survey split in two subsets: academia and industry/research centres.
    - same questions, but some of them removed for academia
    - ~150-170 answers from industry/research centres;
    - ~70 answers from academia

# Q1: your type of organisation?

Answered: 354

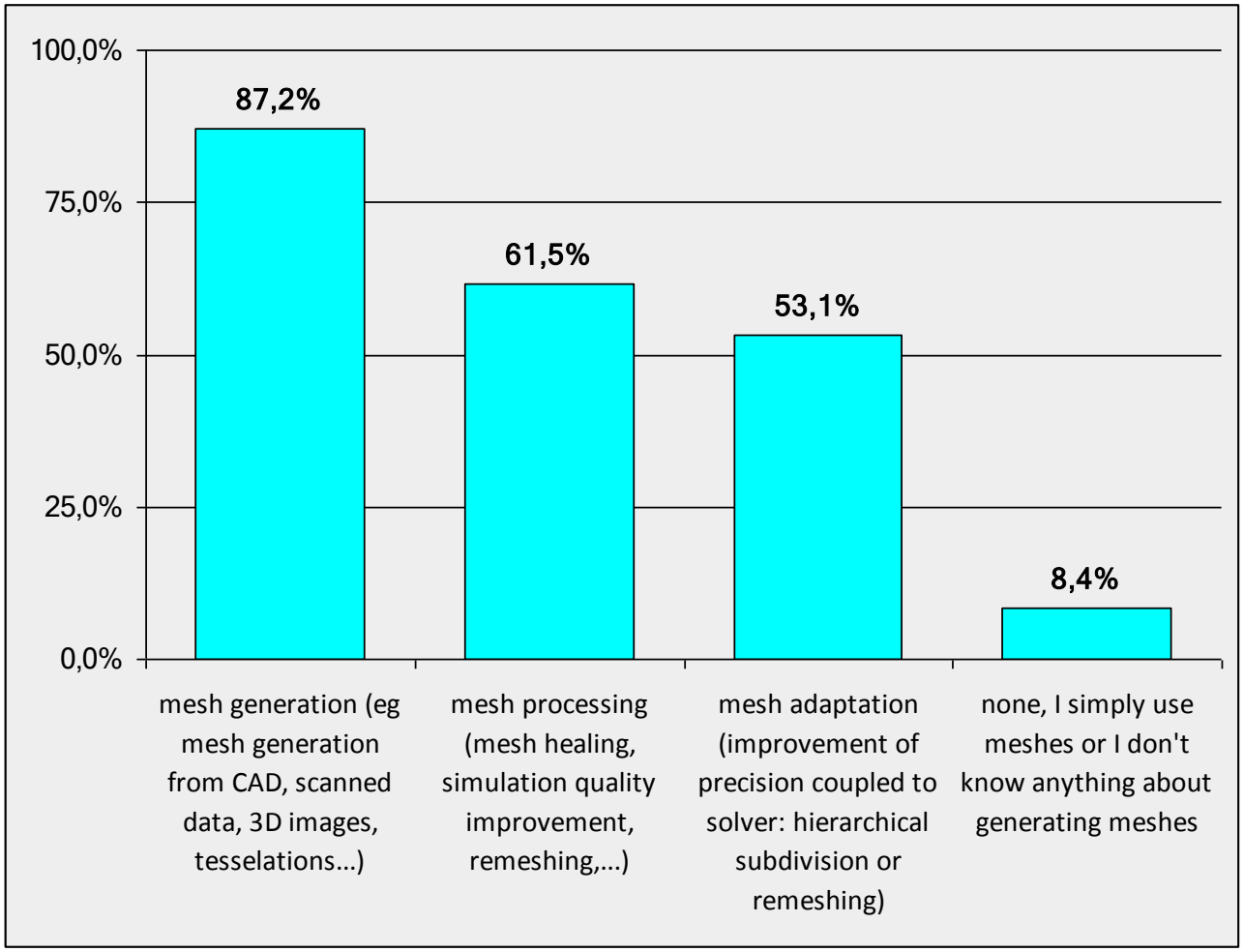





# « Industry/Research centres »
# subset of questions/answers

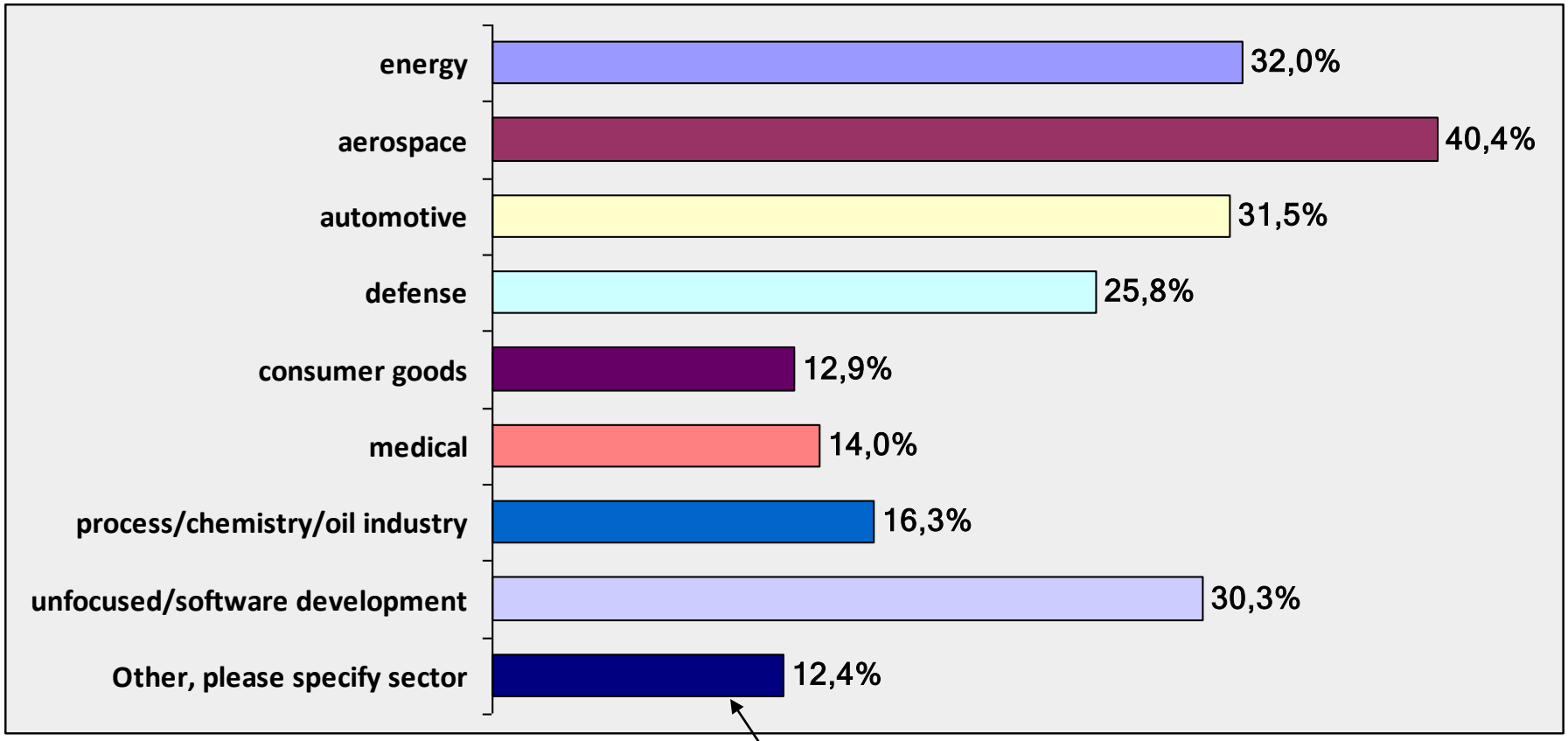
# Q2: What is your - or your company's - meshing field? [Industry and RCs]

Answered: 179 (I & RC)



# Q3: What is your company's or organisation's focus? [Industry and RCs]

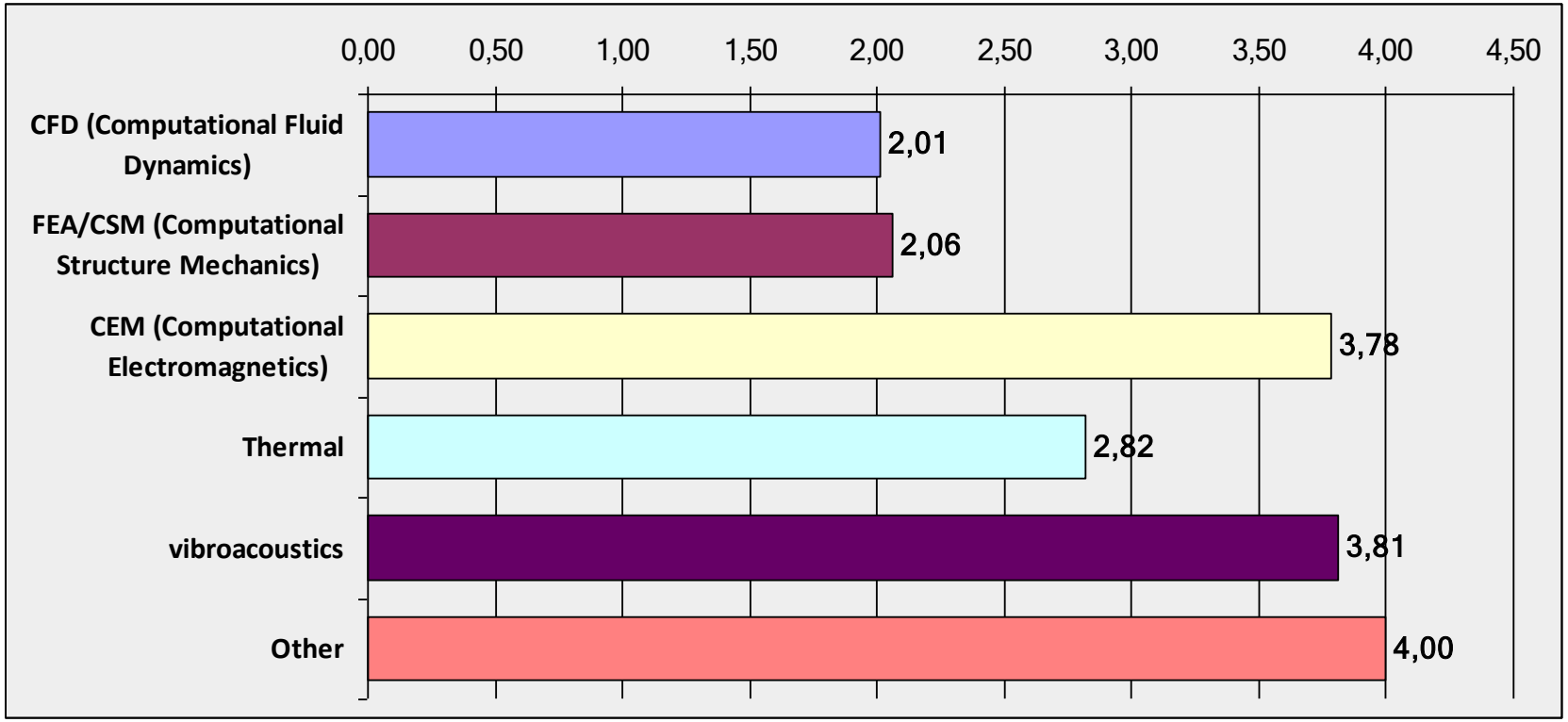
Answered: 178 (I & RC)




Electronics, civil engineering, marine, architecture, environmental, mining, machine tools…

# Q4: What simulation field (s) do you target? Which are primary areas of focus and which are secondary? [rank priorities] [Industry and RCs]

Answered: 176 (I & RC)




**Lower value means higher average priority**

# Q4: What simulation field (s) do you target? Which are primary areas of focus and which are secondary? [rank priorities] [continued]

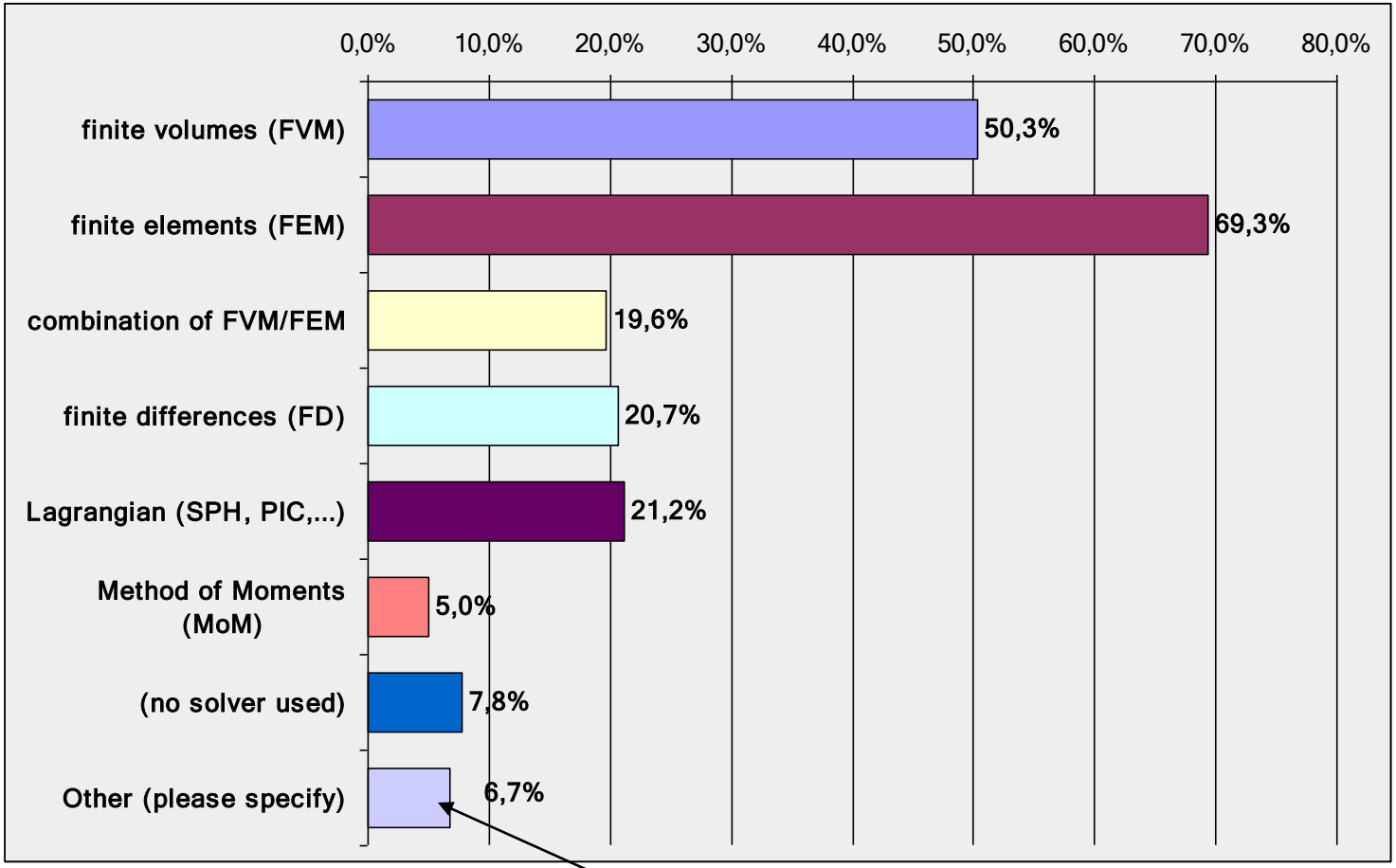
Answered: 176 (I & RC) ***(priorities ranked)***

| | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|
| CFD (Computational Fluid Dynamics) | **52.90%** 73 | **21.01%** 29 | **10.87%** 15 | **7.25%** 10 | **2.90%** 4 | **5.07%** 7 | 138 |
| FEA/CSM (Computational Structure Mechanics) | **43.80%** 60 | **27.74%** 38 | **16.06%** 22 | **5.84%** 8 | **4.38%** 6 | **2.19%** 3 | 137 |
| CEM (Computational Electromagnetics) | **12.05%** 10 | **7.23%** 6 | **14.46%** 12 | **30.12%** 25 | **28.92%** 24 | **7.23%** 6 | 83 |
| Thermal | **3.20%** 4 | **44.80%** 56 | **29.60%** 37 | **12.80%** 16 | **8.00%** 10 | **1.60%** 2 | 125 |
| vibroacoustics | **4.82%** 4 | **16.87%** 14 | **22.89%** 19 | **16.87%** 14 | **25.30%** 21 | **13.25%** 11 | 83 |
| Other | **23.73%** 14 | **3.39%** 2 | **13.56%** 8 | **11.86%** 7 | **3.39%** 2 | **44.07%** 26 | 59 |

# Q5: What main methods do your solvers use?

## [Industry and RCs]

Answered: 179 (I & RC)

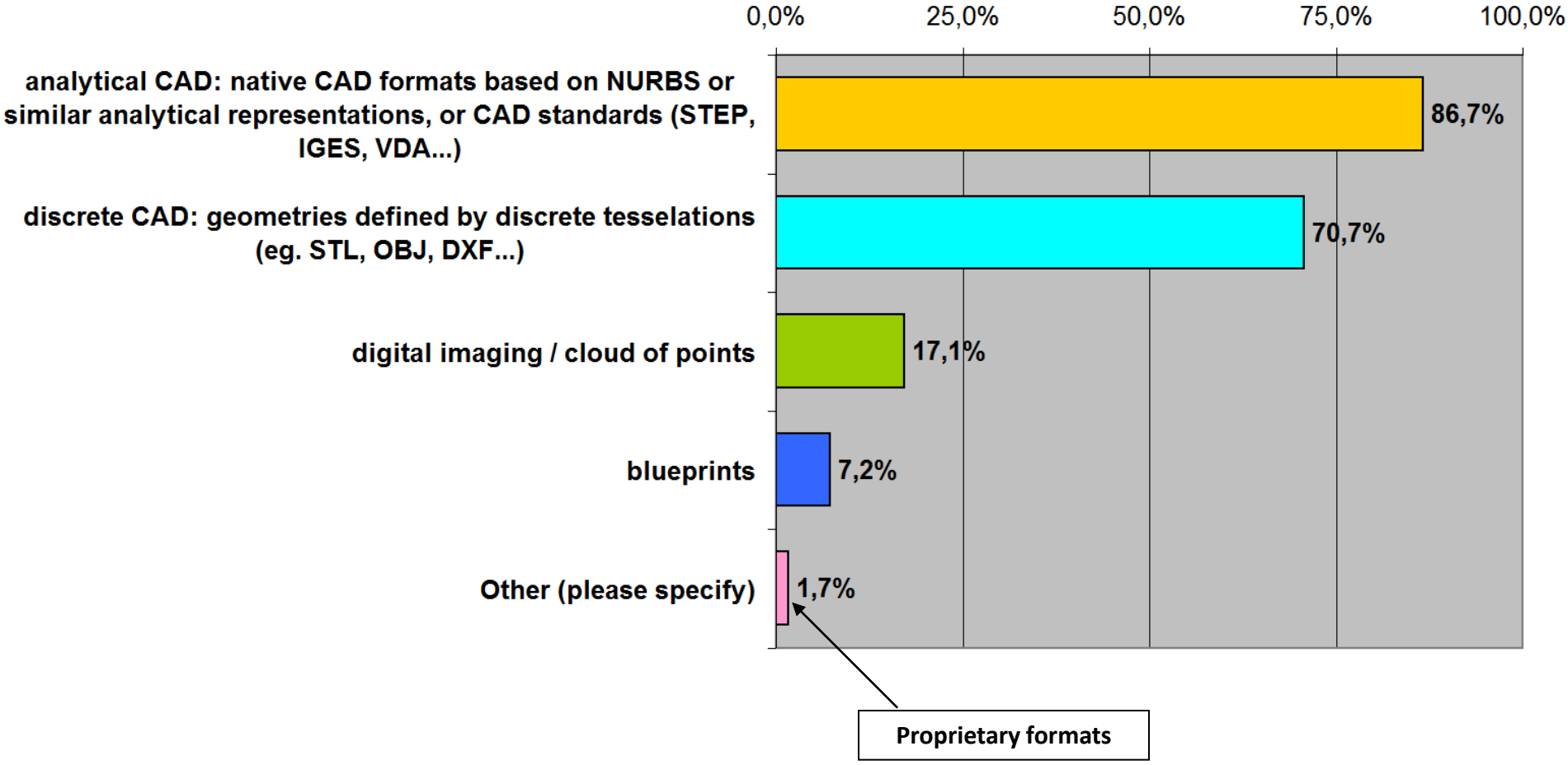



**DG, BEM**, hybrid MoM/FEM, potential method

# Q6: How are your geometries defined?

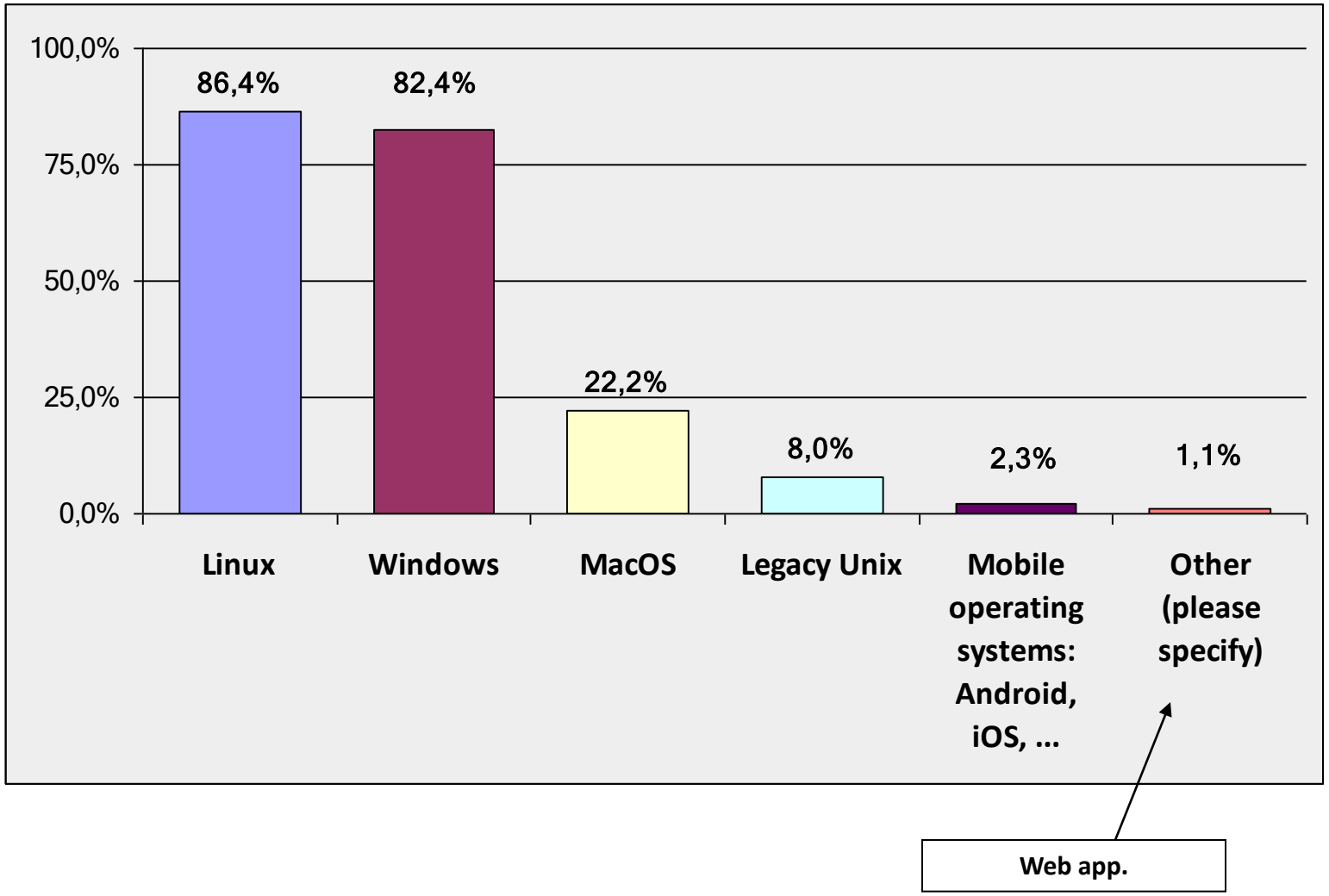
## [Industry and RCs]

Answered: 181 (I & RC)



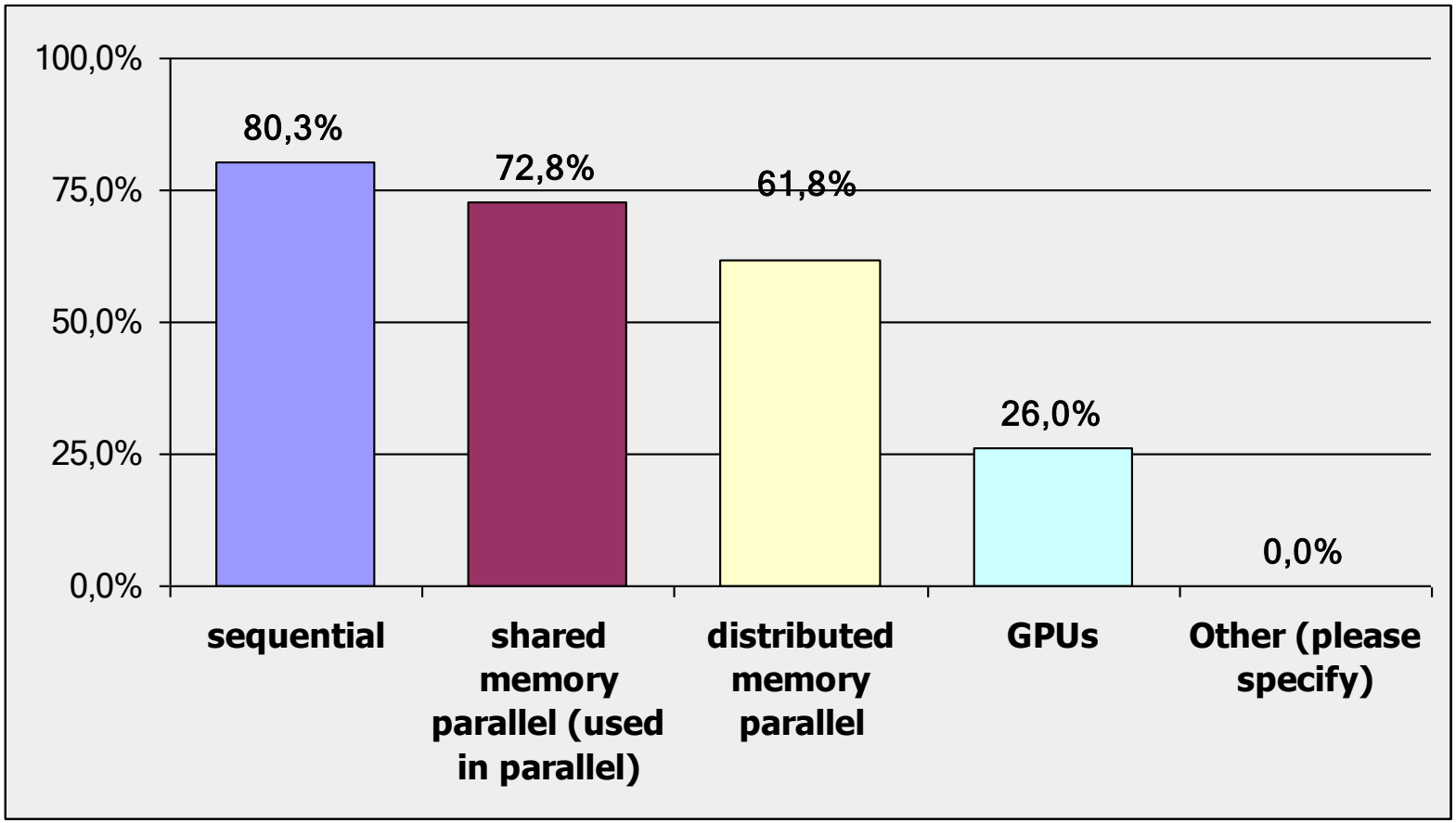
# Q7: What Operating system(s) do you use/support? [Industry and RCs]

Answered: 176 (I & RC)



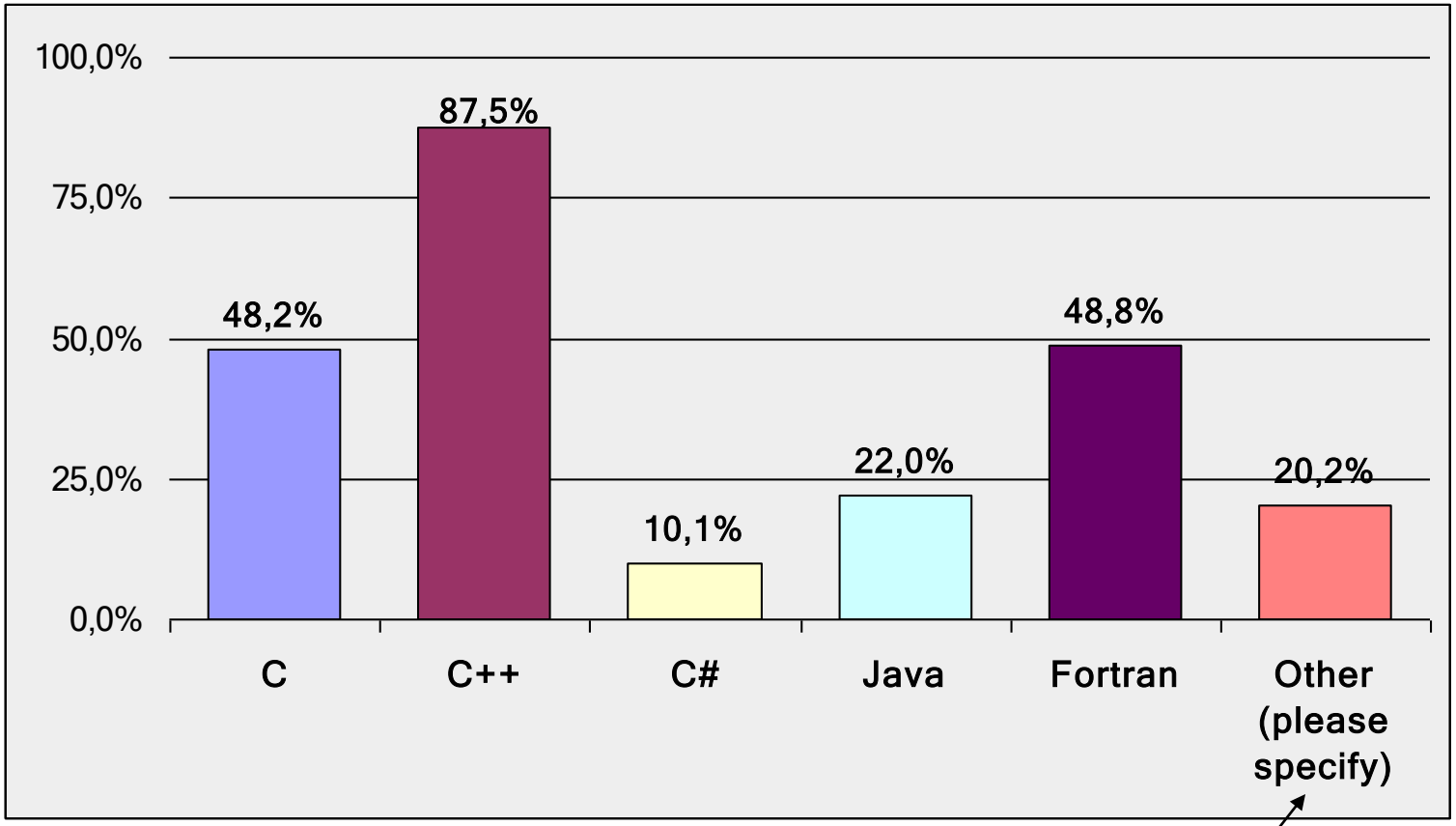
# Q8: What hardware environment(s) do you use/support? [Industry and RCs]

Answered: 173 (I & RC)



# Q9: What programming language(s) do you use/support? [Industry and RCs]

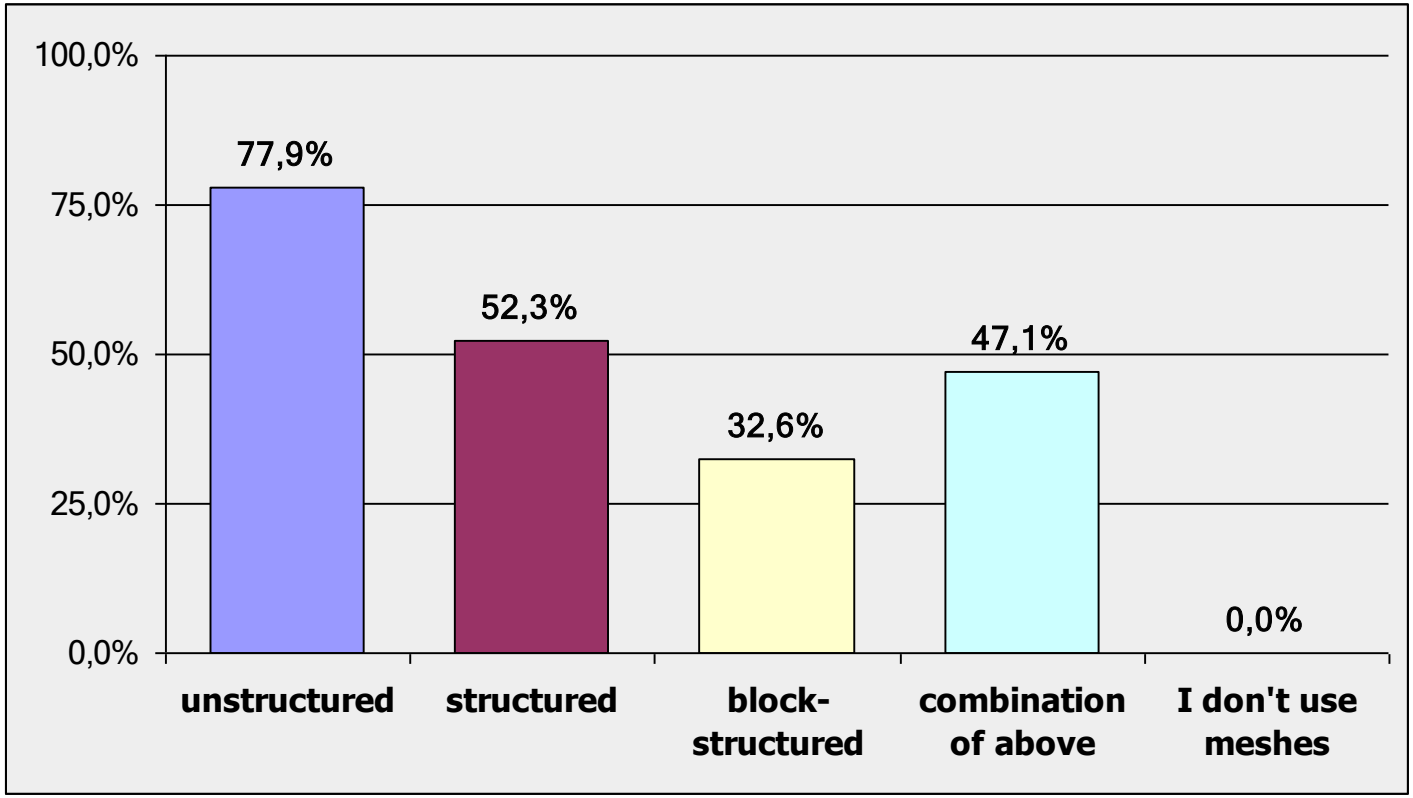
Answered: 168 (I & RC)




**Python,** VB, F#, C++/CLI , Scala/Octave

# Q10: What kinds of meshes do you create/require? [Industry and RCs]

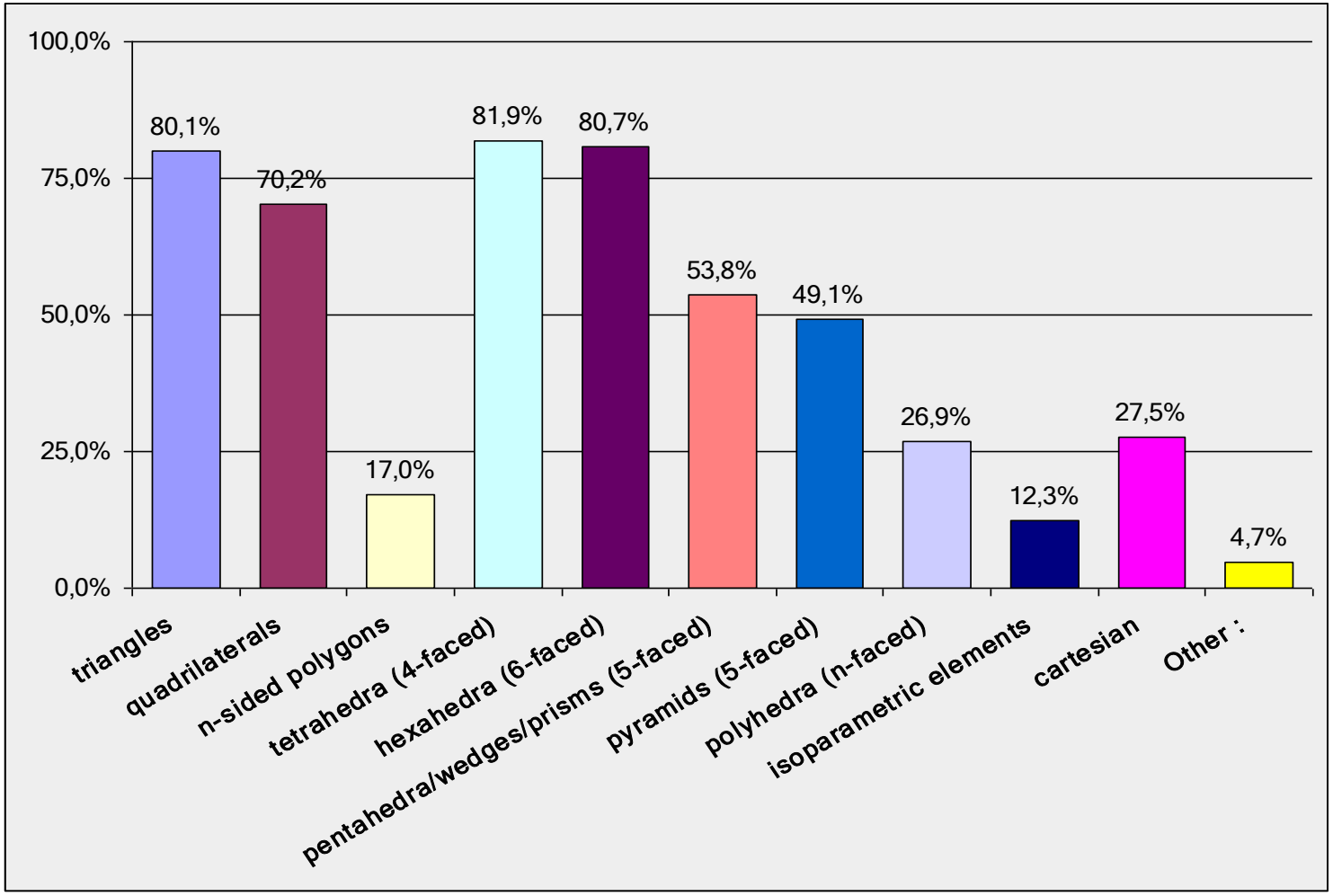
Answered: 172 (I & RC)




Note : The « Unstructured » term is ambiguous and may have been misinterpreted (was meant to refer to « single block structured » in CFD)

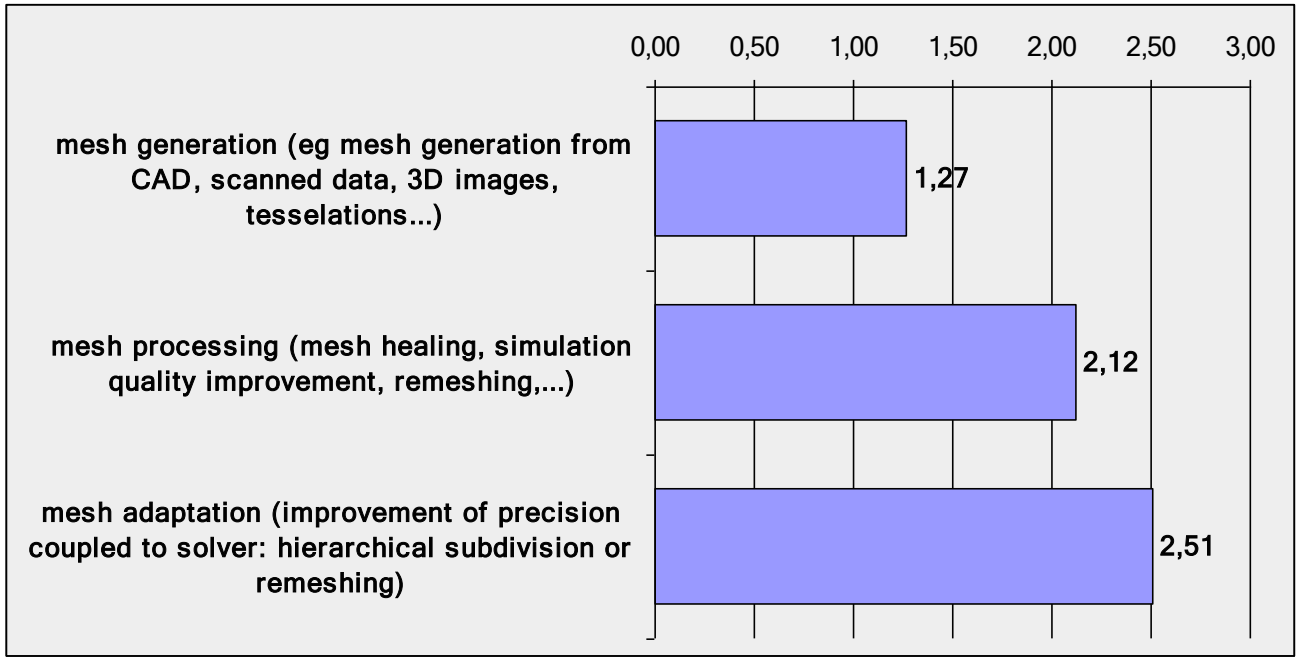
# Q11: What are the element types your meshers create or support (may be linear or isoparametric)? [Industry and RCs]

Answered: 171 (I & RC)



# Q12: What are your needs regarding meshing and which are the most important? [rank priorities]

Answered: 174 (I & RC) [Industry and RCs]

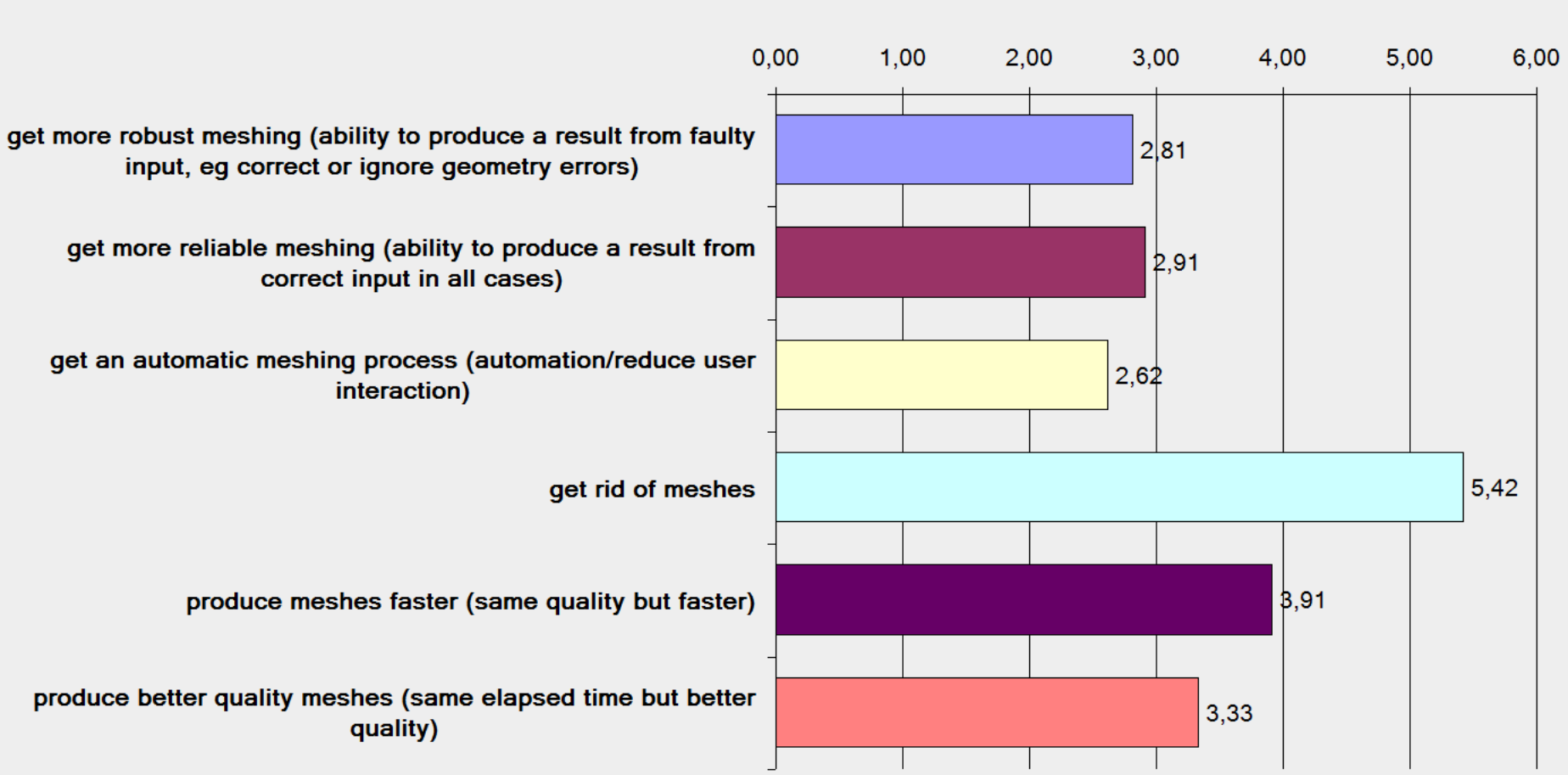



**Lower value means higher average priority**

| | 1 | 2 | 3 | N/A | Total |
|---|---|---|---|---|---|
| mesh generation (eg mesh generation from CAD, scanned data, 3D images, tesselations...) | **79.31%** 138 | **11.49%** 20 | **7.47%** 13 | **1.72%** 3 | 174 |
| mesh processing (mesh healing, simulation quality improvement, remeshing,...) | **12.07%** 21 | **56.32%** 98 | **22.99%** 40 | **8.62%** 15 | 174 |
| mesh adaptation (improvement of precision coupled to solver: hierarchical subdivision or remeshing) | **7.47%** 13 | **27.01%** 47 | **51.72%** 90 | **13.79%** 24 | 174 |

# Q13: How would you rate your priorities **in meshing process**? [rank priorities] [Industry and RCs]

Answered: 149 (I & RC)




**Lower value means higher average priority**

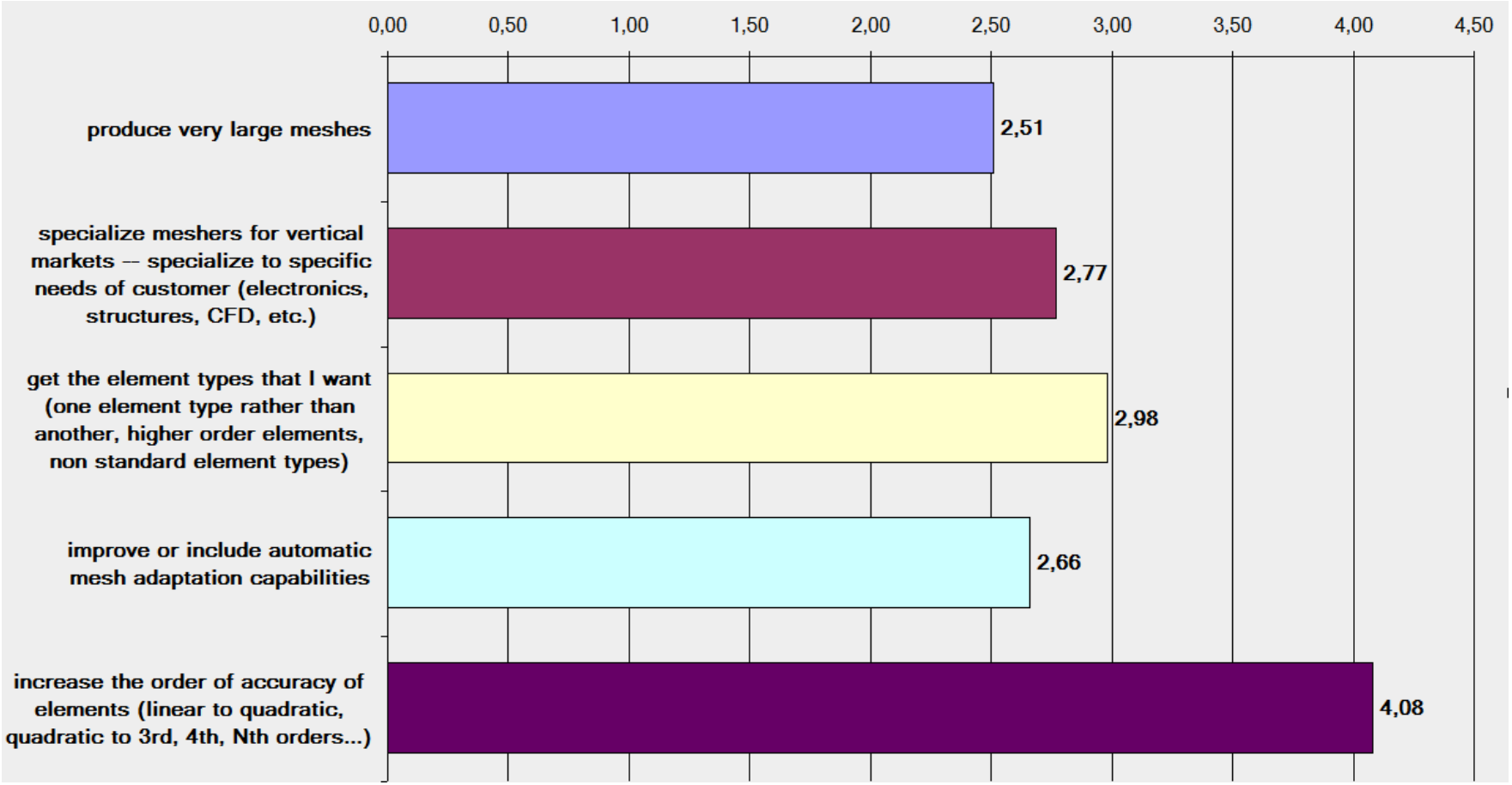
# Q13: How would you rate your priorities in meshing process? [rank priorities] [continued]

Answered: 149 (I & RC) **(priorities ranked)**

| | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|
| get more robust meshing (ability to produce a result from faulty input, eg correct or ignore geometry errors) | **28.86%** 43 | **19.46%** 29 | **18.79%** 28 | **10.74%** 16 | **18.79%** 28 | **3.36%** 5 | 149 |
| get more reliable meshing (ability to produce a result from correct input in all cases) | **17.45%** 26 | **26.85%** 40 | **20.13%** 30 | **21.48%** 32 | **10.74%** 16 | **3.36%** 5 | 149 |
| get an automatic meshing process (automation/reduce user interaction) | **29.53%** 44 | **20.13%** 30 | **22.15%** 33 | **15.44%** 23 | **12.08%** 18 | **0.67%** 1 | 149 |
| get rid of meshes | **6.71%** 10 | **1.34%** 2 | **2.01%** 3 | **4.03%** 6 | **5.37%** 8 | **80.54%** 120 | 149 |
| produce meshes faster (same quality but faster) | **6.04%** 9 | **14.09%** 21 | **14.77%** 22 | **20.81%** 31 | **36.91%** 55 | **7.38%** 11 | 149 |
| produce better quality meshes (same elapsed time but better quality) | **11.41%** 17 | **18.12%** 27 | **22.15%** 33 | **27.52%** 41 | **16.11%** 24 | **4.70%** 7 | 149 |

# Q14: How would you rate your priorities in **mesh quality/density**? [Industry and RCs]

Answered: 149 (I & RC)




**Lower value means higher average priority**

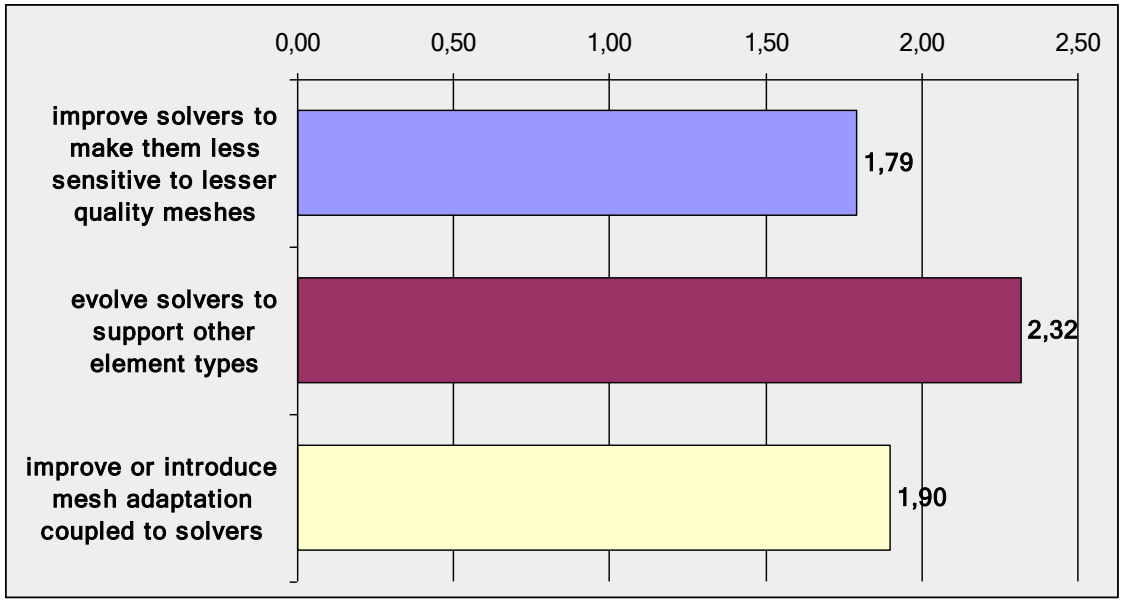
# Q14: How would you rate your priorities in meshing process? [rank priorities] [continued]

Answered: 133 (I & RC) **(priorities ranked)**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| produce very large meshes | **32.89%** 49 | **24.16%** 36 | **14.09%** 21 | **16.78%** 25 | **12.08%** 18 | 149 |
| specialize meshers for vertical markets -- specialize to specific needs of customer (electronics, structures, CFD, etc.) | **23.49%** 35 | **26.17%** 39 | **19.46%** 29 | **12.08%** 18 | **18.79%** 28 | 149 |
| get the element types that I want (one element type rather than another, higher order elements, non standard element types) | **19.46%** 29 | **17.45%** 26 | **23.49%** 35 | **24.83%** 37 | **14.77%** 22 | 149 |
| improve or include automatic mesh adaptation capabilities | **19.46%** 29 | **27.52%** 41 | **26.17%** 39 | **20.81%** 31 | **6.04%** 9 | 149 |
| increase the order of accuracy of elements (linear to quadratic, quadratic to 3rd, 4th, Nth orders...) | **4.70%** 7 | **4.70%** 7 | **16.78%** 25 | **25.50%** 38 | **48.32%** 72 | 149 |

# Q15: How do you see the priorities for **evolution of your simulation chain** which impact meshing in your organisation [rank priorities]? [Industry and RCs]

Answered: 149 (I & RC)

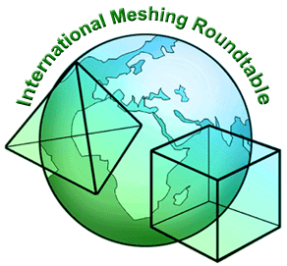



**Lower value means higher priority**

| | 1 | 2 | 3 | Total |
|---|---|---|---|---|
| improve solvers to make them less sensitive to lesser quality meshes | **44.97%** 67 | **31.54%** 47 | **23.49%** 35 | 149 |
| evolve solvers to support other element types | **17.45%** 26 | **33.56%** 50 | **48.99%** 73 | 149 |
| improve or introduce mesh adaptation coupled to solvers | **37.58%** 56 | **34.90%** 52 | **27.52%** 41 | 149 |

# Q16: Do you plan on recruiting meshing developers? [Industry and RCs]

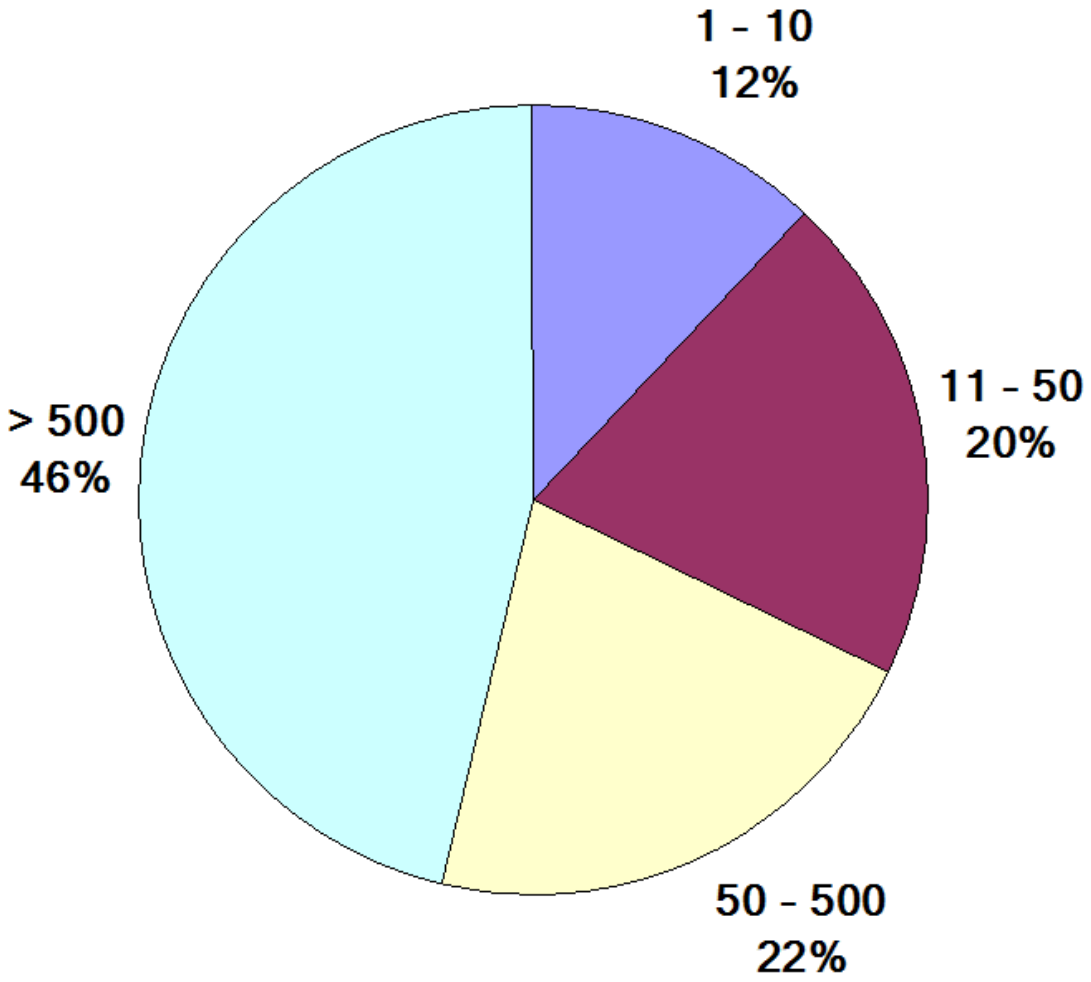
Answered: 149 (I & RC)

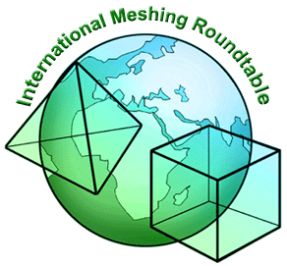



See last slide of this presentation…

# Q17: size of organisation?
## [Industry and RCs]

Answered: 149 (I & RC)

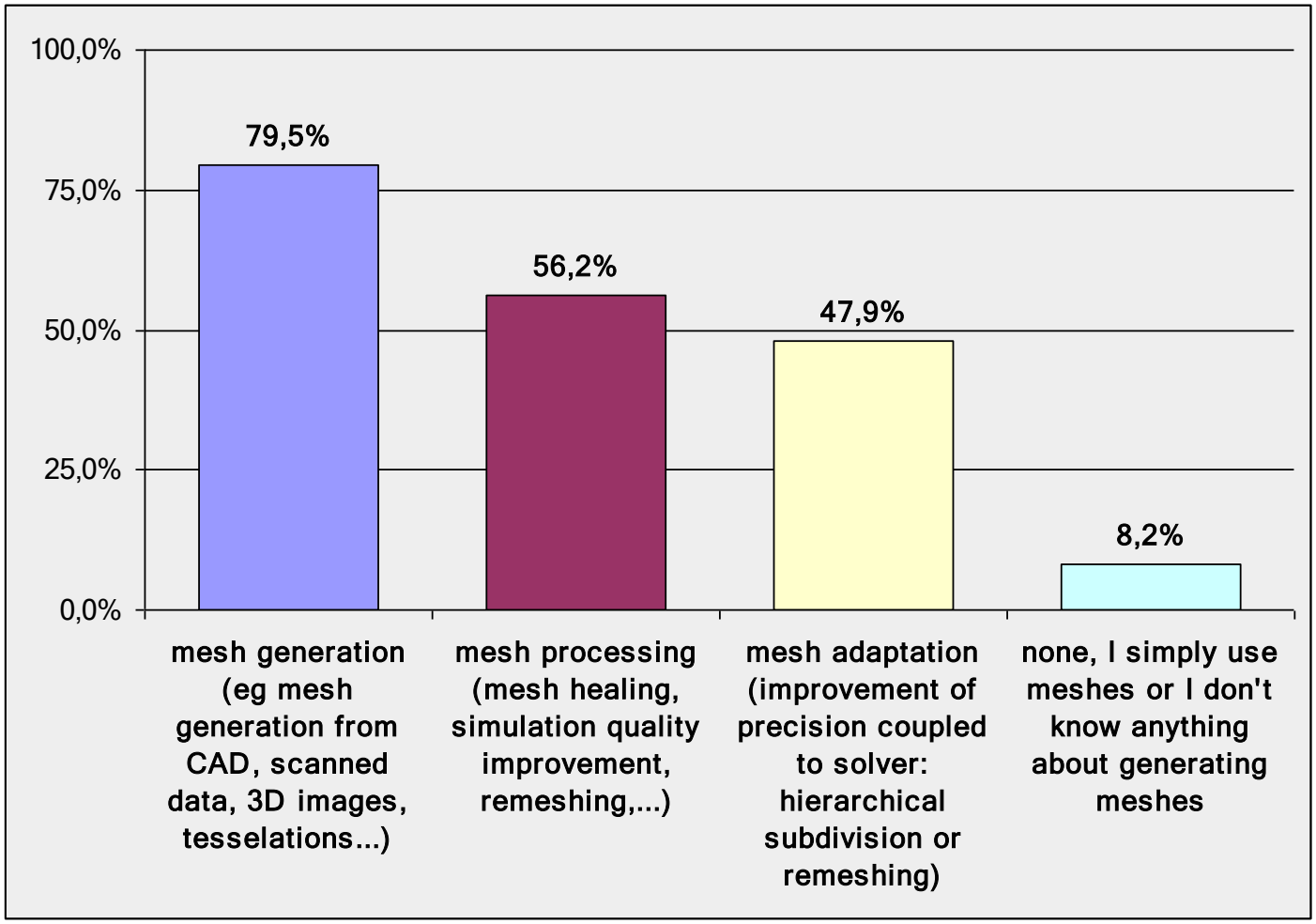





# « Academia » subset of questions/answers

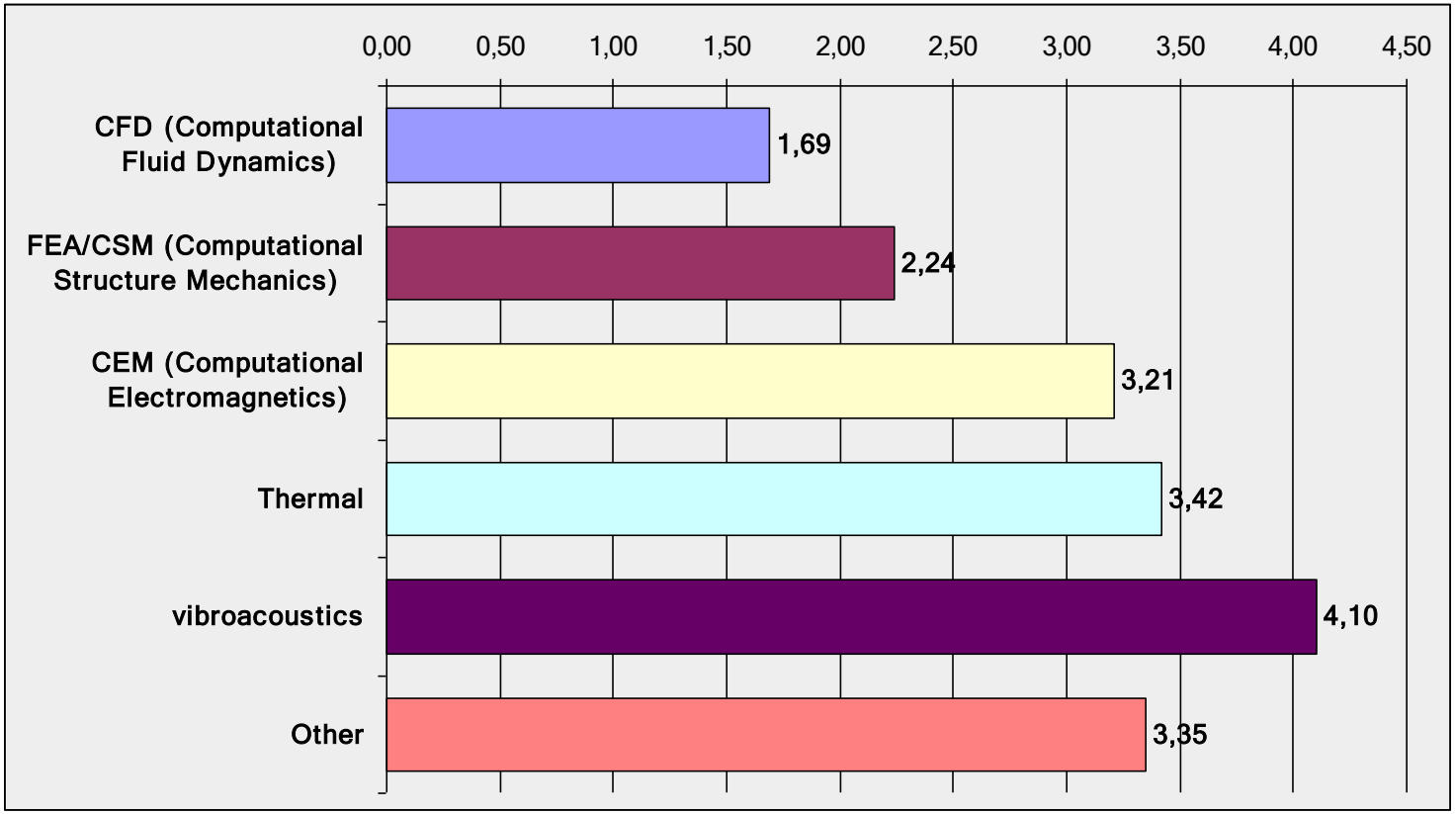
# Q21: What is your - or your organisation's - meshing field? [Academia]

Answered: 73 (Acad)



# Q22: What simulation field (s) do you target? Which are primary areas of focus and which are secondary? [rank priorities] [Academia]

Answered: 69 (Acad)




**Lower value means higher priority**

# Q22: What simulation field (s) do you target? Which are primary areas of focus and which are secondary? [rank priorities] [Academia] [cont.]

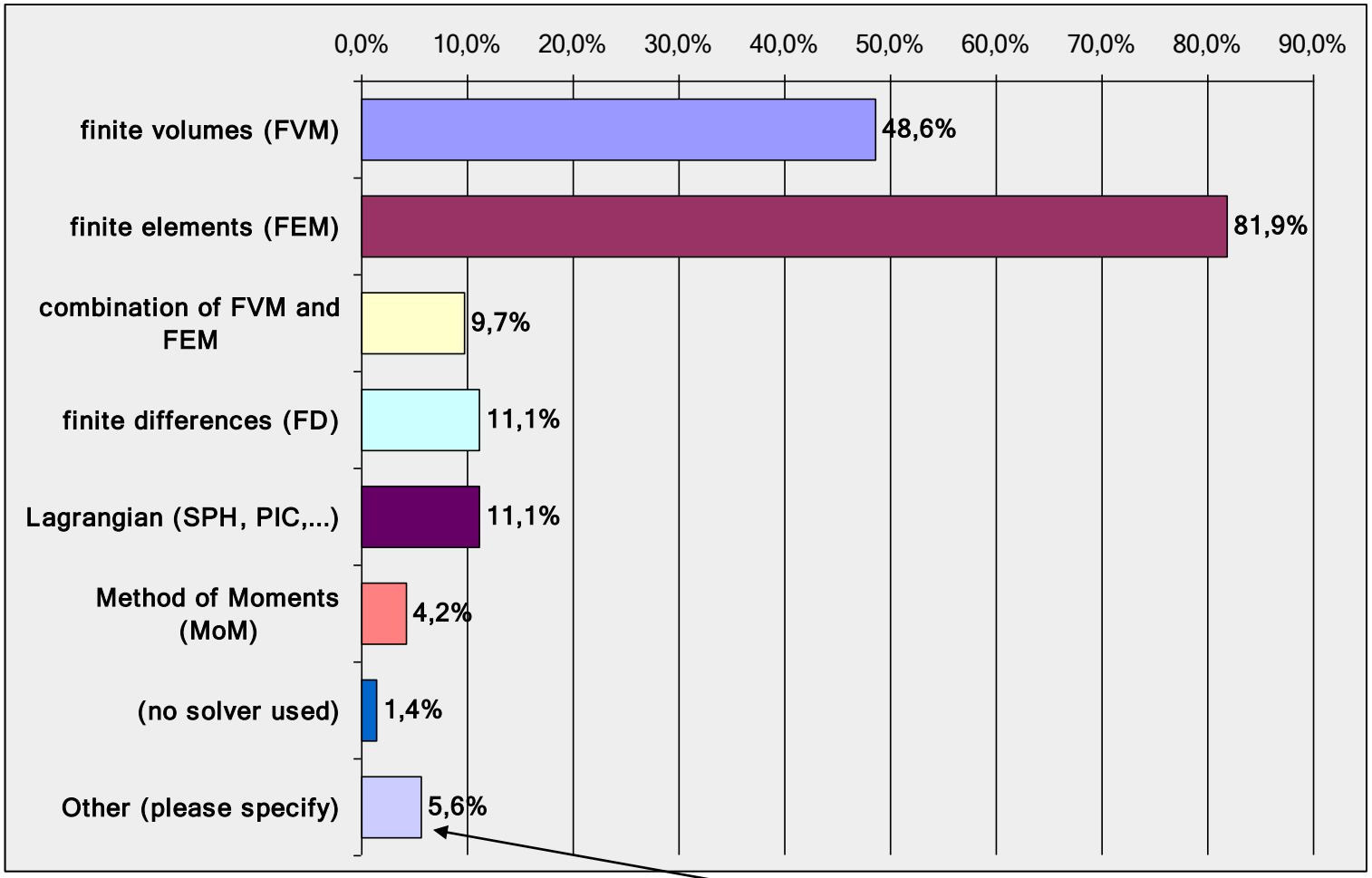
Answered: 69 (Acad) ***(priorities ranked)***

| | 1 | 2 | 3 | 4 | 5 | 6 | Total | Score |
|---|---|---|---|---|---|---|---|---|
| CFD (Computational Fluid Dynamics) | **62.96%** 34 | **22.22%** 12 | **5.56%** 3 | **5.56%** 3 | **0.00%** 0 | **3.70%** 2 | 54 | 5.31 |
| FEA/CSM (Computational Structure Mechanics) | **36.00%** 18 | **38.00%** 19 | **10.00%** 5 | **6.00%** 3 | **2.00%** 1 | **8.00%** 4 | 50 | 4.76 |
| CEM (Computational Electromagnetics) | **10.71%** 3 | **10.71%** 3 | **42.86%** 12 | **17.86%** 5 | **17.86%** 5 | **0.00%** 0 | 28 | 3.79 |
| Thermal | **6.06%** 2 | **18.18%** 6 | **27.27%** 9 | **27.27%** 9 | **18.18%** 6 | **3.03%** 1 | 33 | 3.58 |
| vibroacoustics | **0.00%** 0 | **15.00%** 3 | **20.00%** 4 | **20.00%** 4 | **30.00%** 6 | **15.00%** 3 | 20 | 2.90 |
| Other | **34.78%** 8 | **8.70%** 2 | **17.39%** 4 | **0.00%** 0 | **4.35%** 1 | **34.78%** 8 | 23 | 3.65 |

# Q23: What main methods do your solvers use?

## [Academia]

Answered: 72 (Acad)

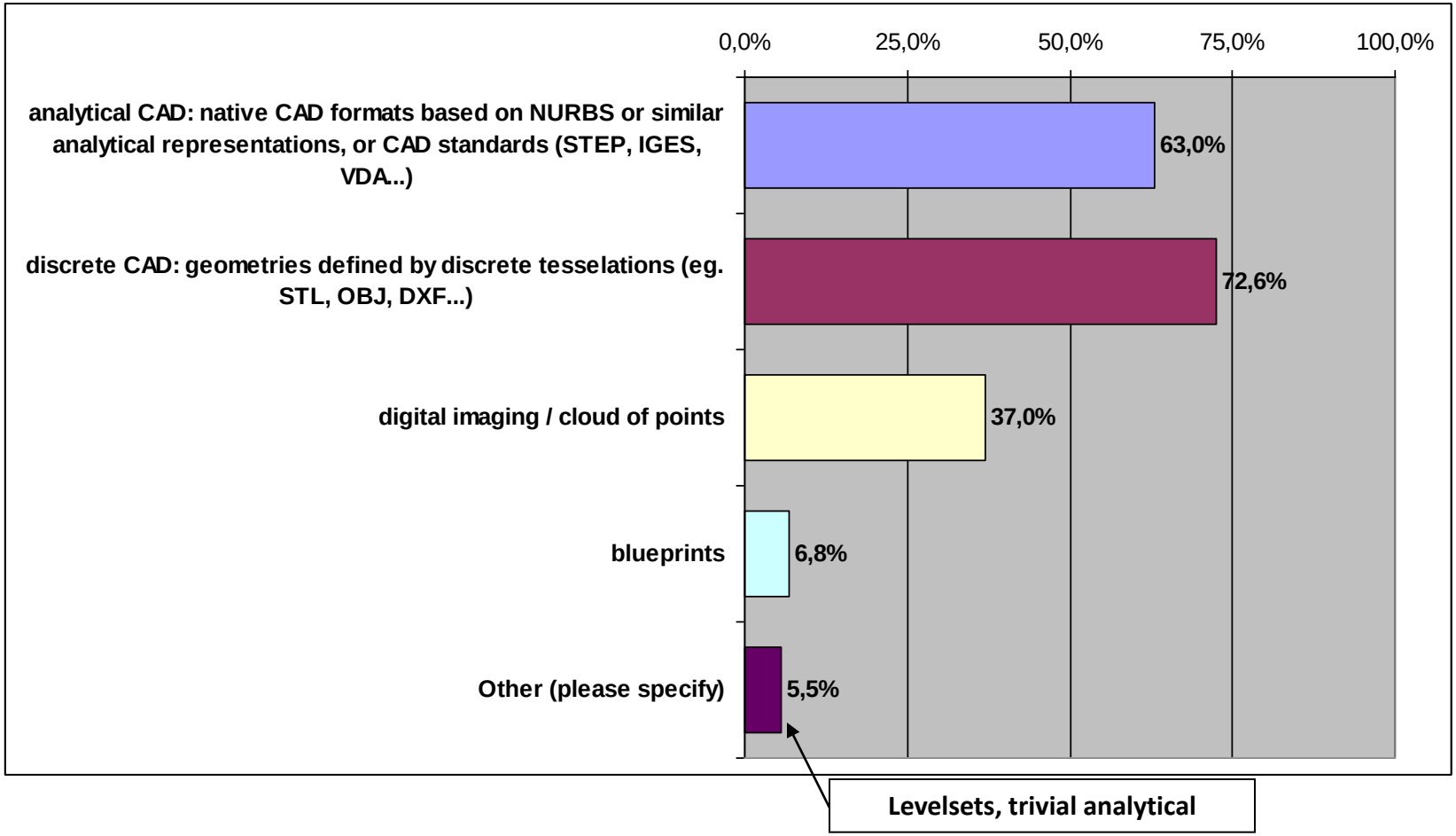



**BEM**, High-Order Flux Reconstruction, Spectral

# Q24: How are your geometries defined?

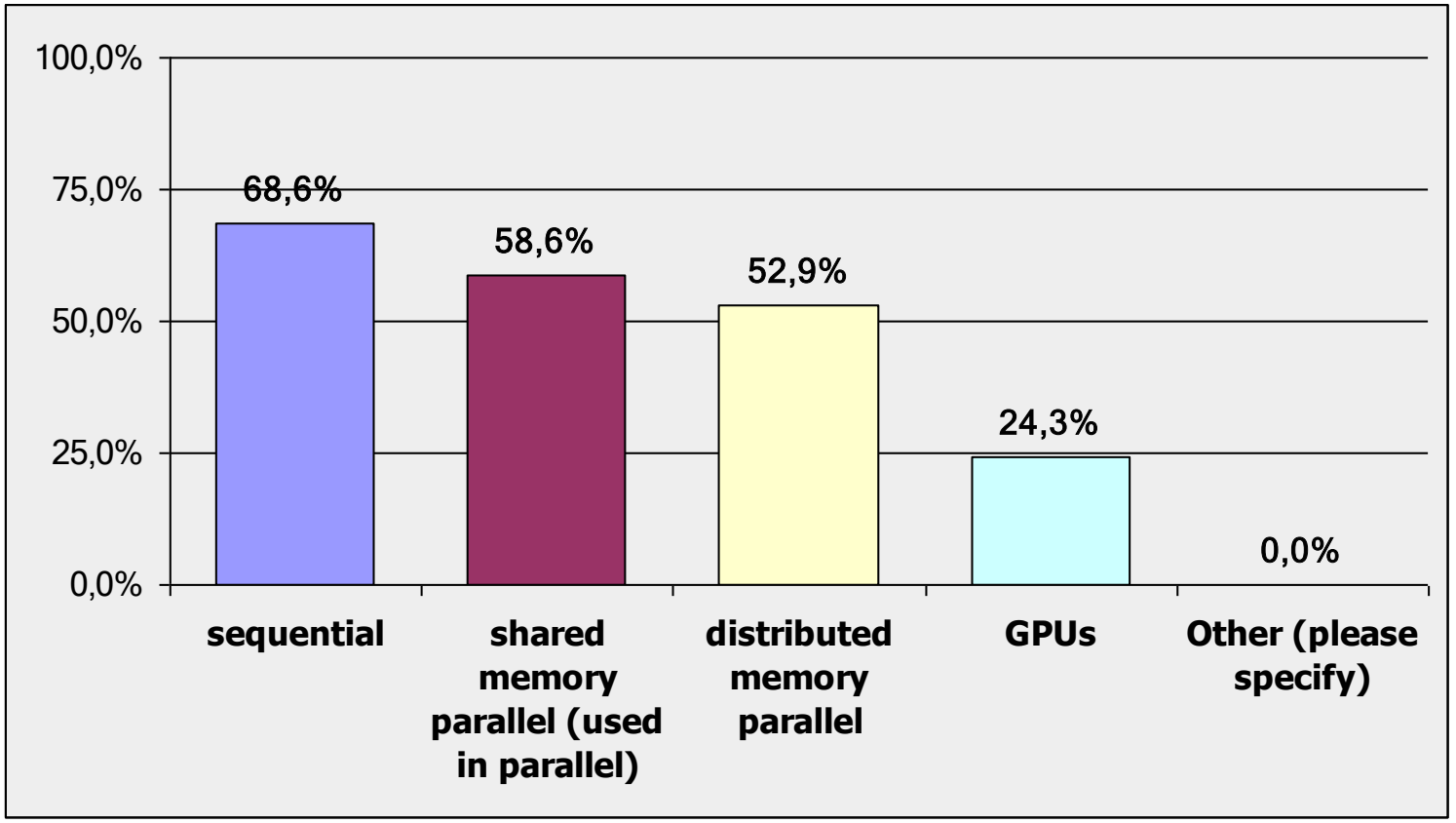
## [Academia]

Answered: 70 (Acad)



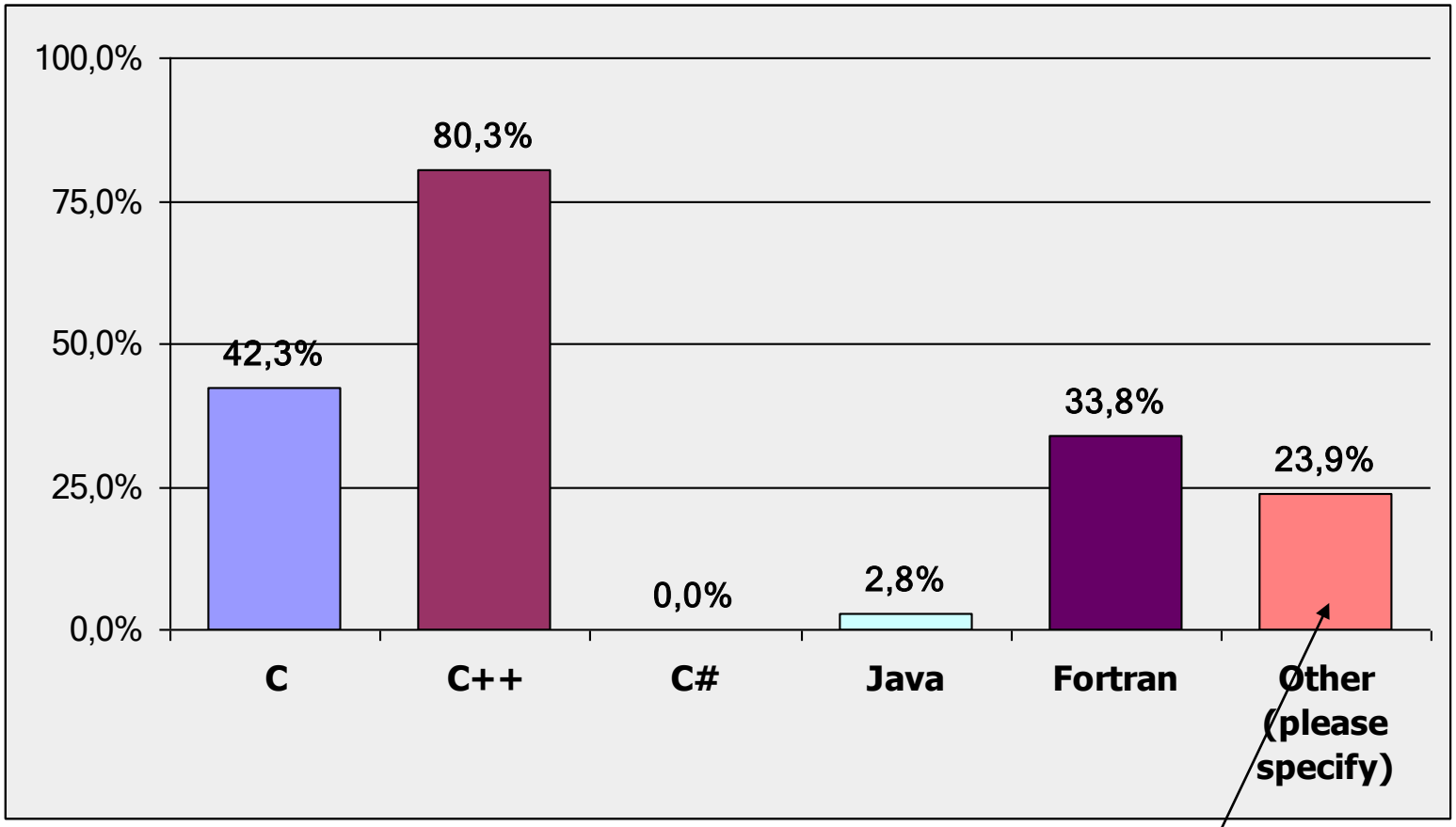
# Q25: What hardware environment(s) do you use/support? [Academia]

Answered: 70 (Acad)



# Q26: What programming language(s) do you use/support? [Academia]

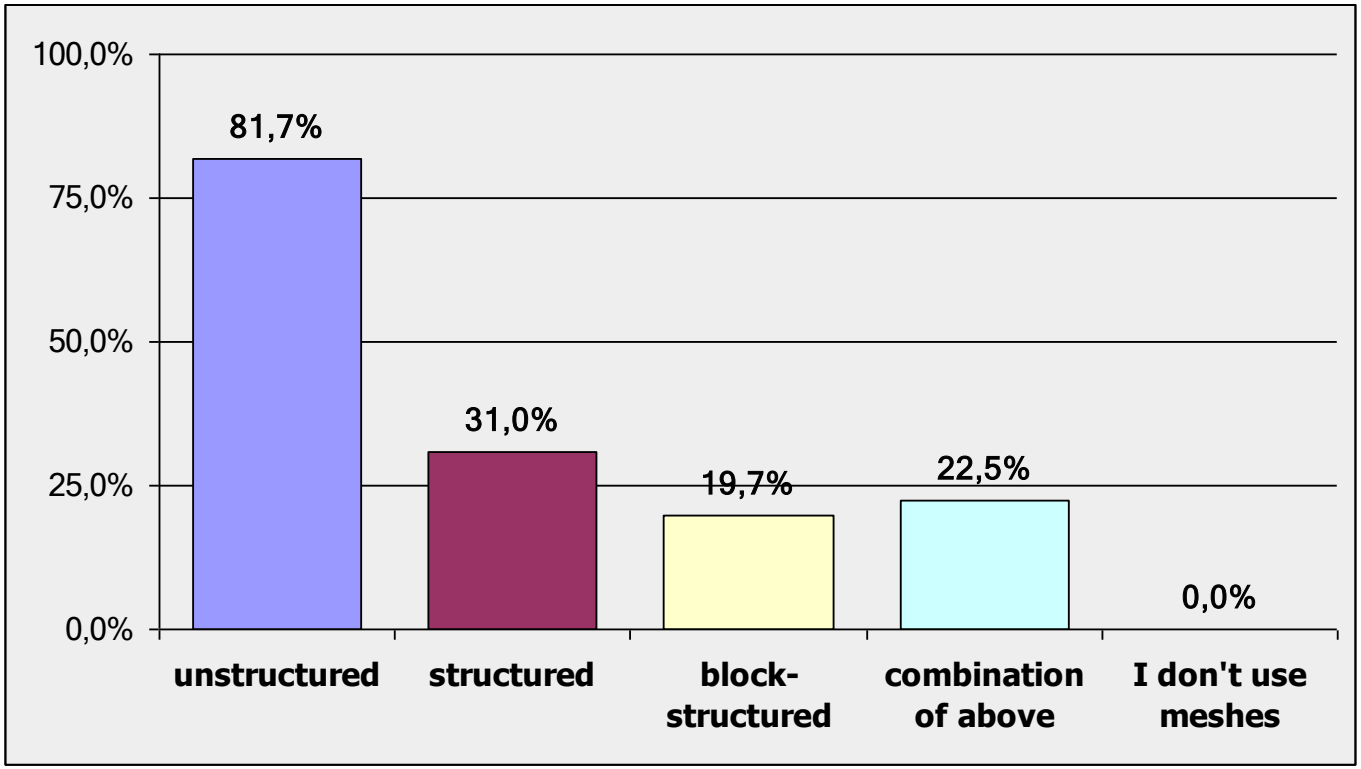
Answered: 71 (Acad)




**Python,** VB**,** Matlab, mathematica, CUDA, OpenCL, …

# Q27: What kinds of meshes do you create/require? [Academia]

Answered: 71 (Acad)

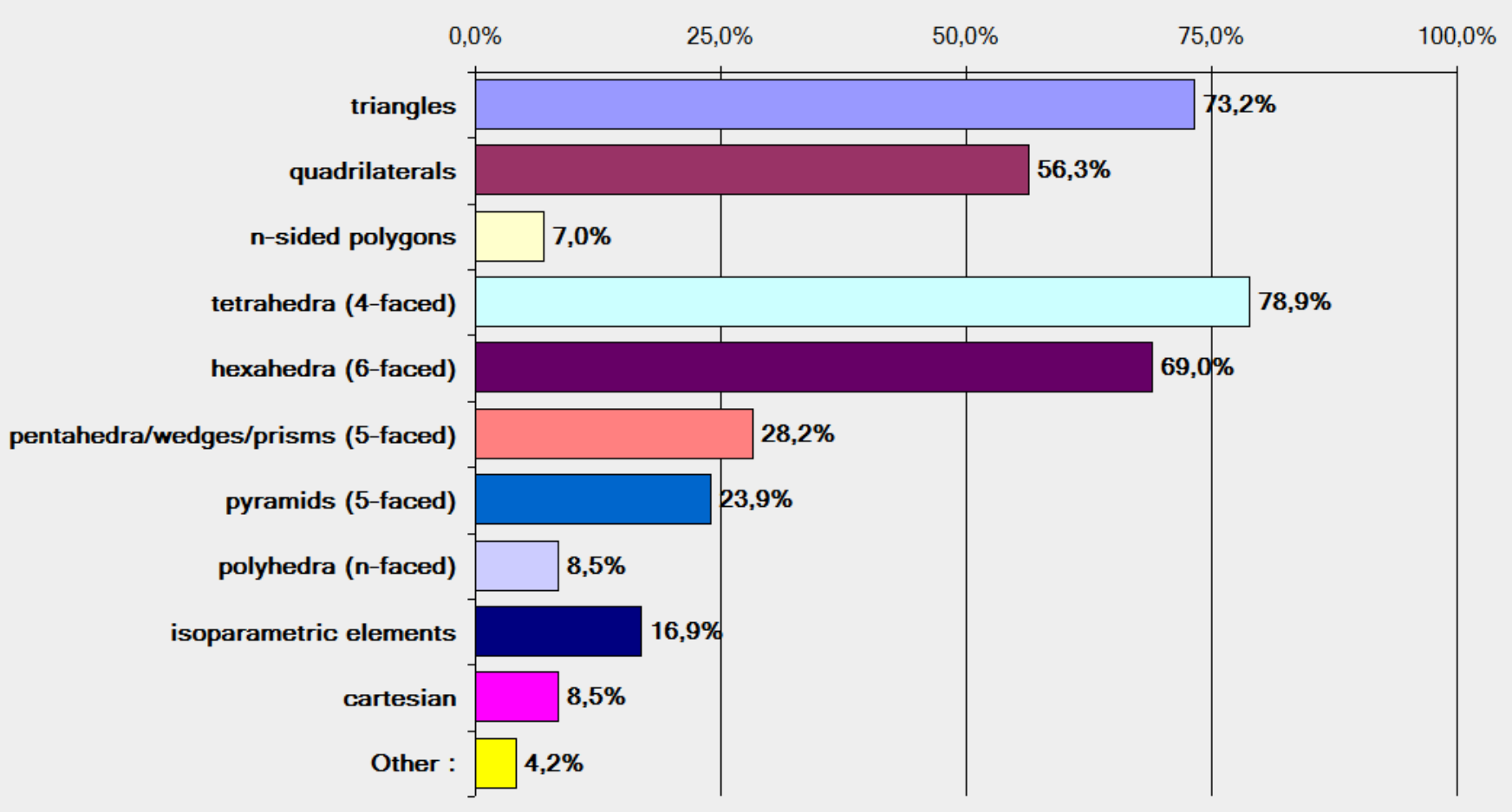


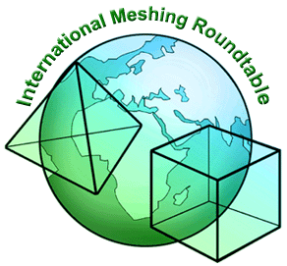

Note : The « Unstructured » term is ambiguous and may have been misinterpreted (was meant to refer to « single block structured » in CFD)

# Q28: What are the element types your meshers create or support (may be linear or isoparametric)?

## [Academia]

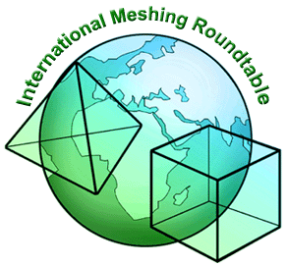
Answered: 68 (Acad)





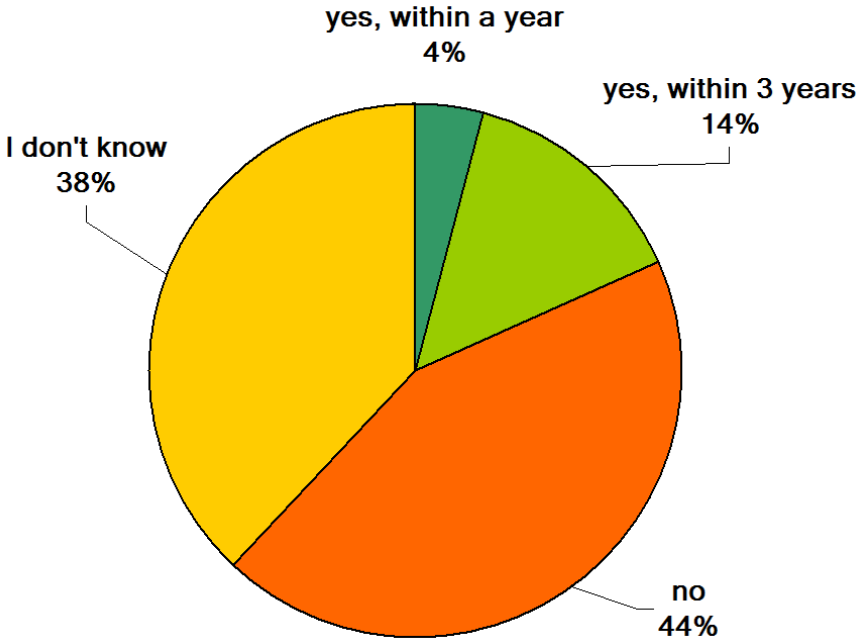

# General comments / conclusions

# General comments from contributors



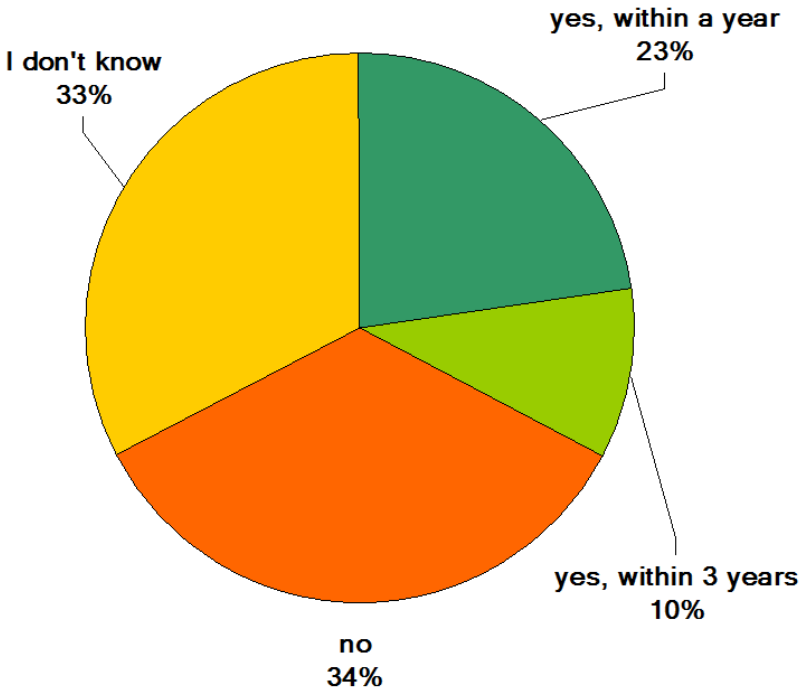

- **Generally speaking, many requested more progress on hexahedral meshing to be made, as this is reported to be a strong demand in industry**
- Funding of mesh generation research is reported to be difficult for academia
- Physics should be more closely linked to mesh (mesh would be a fit-for purpose instance of the discretised problem)
- The meshing process should be cost effective, robust, and cheap
- Meshers should provide the best (*quality of simulation* vs *computing resources involved*) compromise.

# Q16/29: Do you plan on recruiting meshing developers?




**Academia**

Answered: 71




**Industry/ Research centres**

Answered: 149