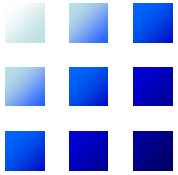


A MATERIAL DISTRIBUTION SCHEDULING FOR RIGGING SHIP-HULL BLOCKS WITH PIPES

K Noda, S Shindo, H Kimura

Kyushu University, Japan

Outline

1. Background and Purpose
2. Expression of the Pipes
3. Pipe Assembly Order
4. Simulation
5. Discussion
6. Conclusion and Future Works

Background

- In the precedence rigging of shipbuilding, most of the man-hour of rigging consists of piping work.

- About 1,000 pipes only in an engine room
- The assembly order is decided by skilled workers.
- The period of assembly : about six days

When all pipes are set in the same place…

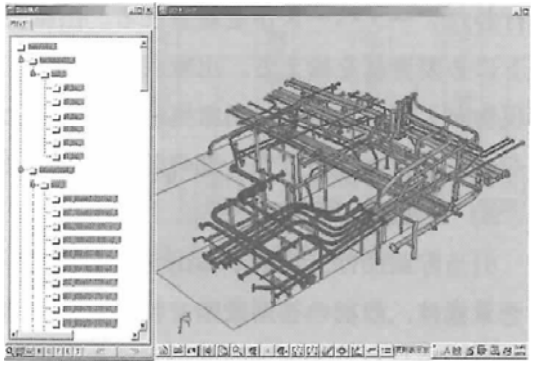
⇩

⊖ Wide space needed

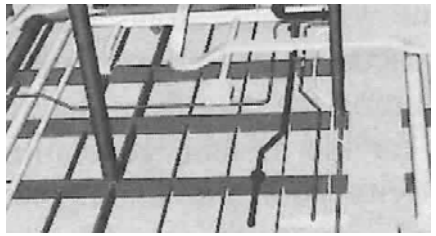
⊖ Taking long time to find objective pipes

Related Works

- An assembly simulation system
  (Y Okumoto, 2009)
  - Very standard method
  - Confirming procedure of installation with animation



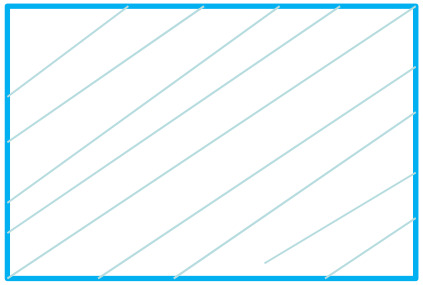
- Automatic scheduling system of outfitting process planning
  (Y Wei and U Nienhuis, 2009)
  - Automatic scheduling system of outfitting process planning
  - Components' position, material, weight, … is considered.
  - Deciding pipe assembly order automatically



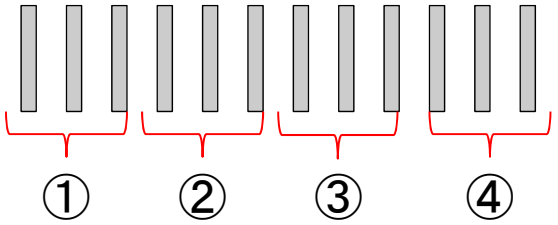
Our System: dividing the pipes into several groups automatically

Purpose

- Dividing the pipes into several groups automatically assembly order depends on the period of the piping works



Temporary space



- Distributing pipes which assembly in one or two days at temporary space placed pipes

To reduce the burden of workers
To reduce temporary space which placed pipes

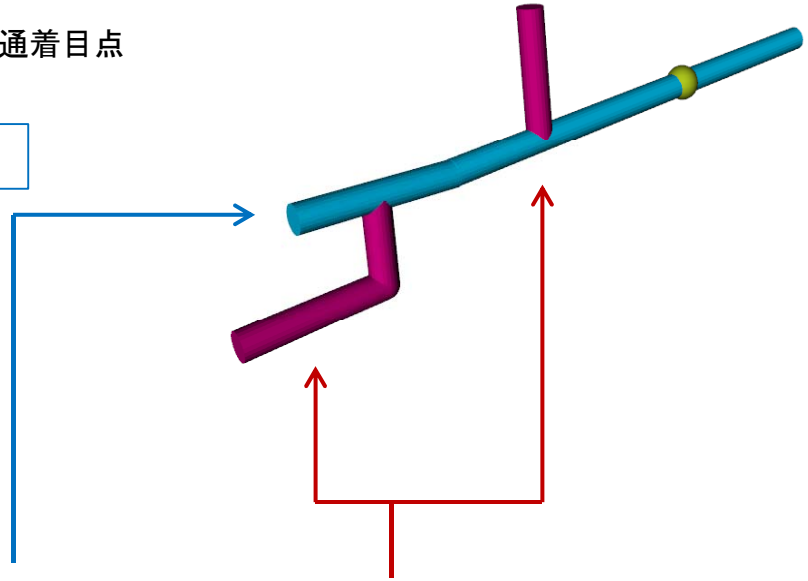
Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

```
PipeN = 48
YD027 2  40  5.5  2  11950.00 -5800.00 9141.17 バカ穴貫通着目点
    KeiroN = 1, TenQt = 3
      11568.60  -5800.00   9154.30   40
      11799.90  -5800.00   9154.30
      12550.60  -5800.00   9088.63   40
    KeiroN = 2, TenQt = 3
      11679.90  -5800.00   9154.30
      11679.90  -5800.00   9277.41
      11480.24  -5800.00   9289.02   40
    KeiroN = 3
        ⋮
```

Main pipe

Branch pipe

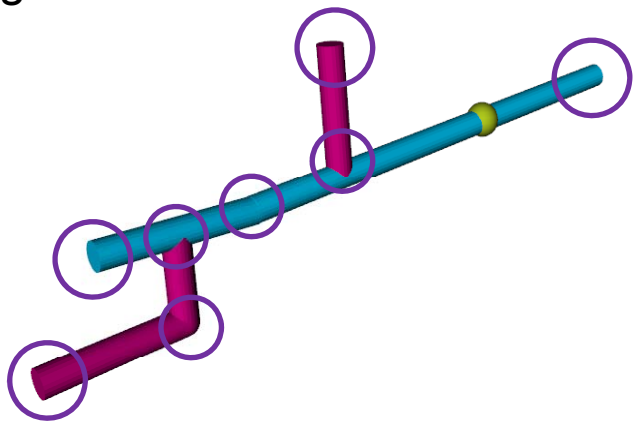


- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration

Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

```
PipeN = 48
YD027 2  40  5.5  2  11950.00 -5800.00 9141.17 バカ穴貫通着目点
    KeiroN = 1, TenQt = 3
      11568.60  -5800.00   9154.30   40
      11799.90  -5800.00   9154.30
      12550.60  -5800.00   9088.63   40
    KeiroN = 2, TenQt = 3
      11679.90  -5800.00   9154.30
      11679.90  -5800.00   9277.41
      11480.24  -5800.00   9289.02   40
    KeiroN = 3
          ⋮
```

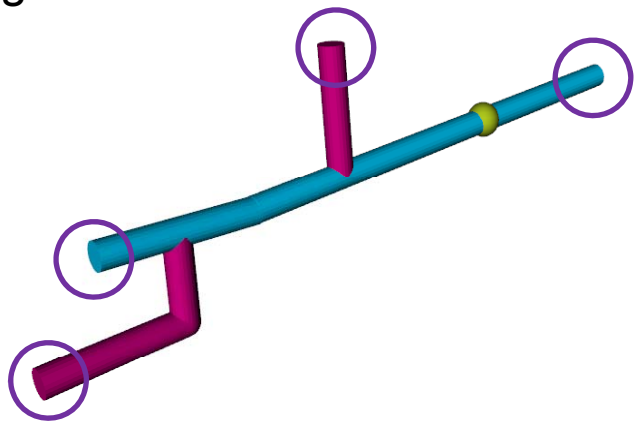


- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration

Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

```
PipeN = 48
YD027 2  40  5.5  2  11950.00 -5800.00 9141.17 バカ穴貫通着目点
    KeiroN = 1, TenQt = 3
      11568.60  -5800.00   9154.30  40
      11799.90  -5800.00   9154.30
      12550.60  -5800.00   9088.63  40
    KeiroN = 2, TenQt = 3
      11679.90  -5800.00   9154.30
      11679.90  -5800.00   9277.41
      11480.24  -5800.00   9289.02  40
     KeiroN = 3
          ⋮
```

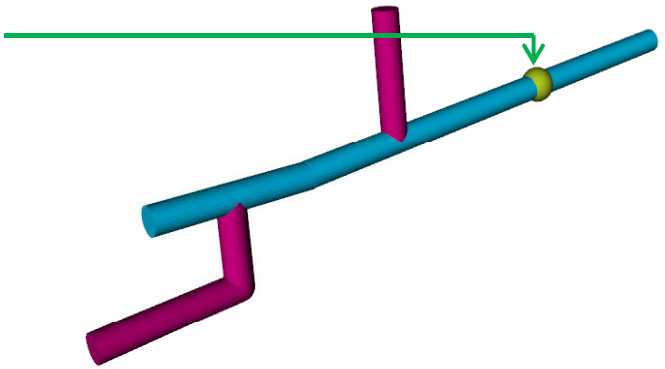


- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration

Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

```
PipeN = 48
YD027 2  40  5.5  2  11950.00 -5800.00 9141.17 バカ穴貫通着目点
    KeiroN = 1, TenQt = 3
      11568.60  -5800.00   9154.30   40
      11799.90  -5800.00   9154.30
      12550.60  -5800.00   9088.63   40
    KeiroN = 2, TenQt = 3
      11679.90  -5800.00   9154.30
      11679.90  -5800.00   9277.41
      11480.24  -5800.00   9289.02   40
    KeiroN = 3
        ⋮
```



- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration

Pipe Data

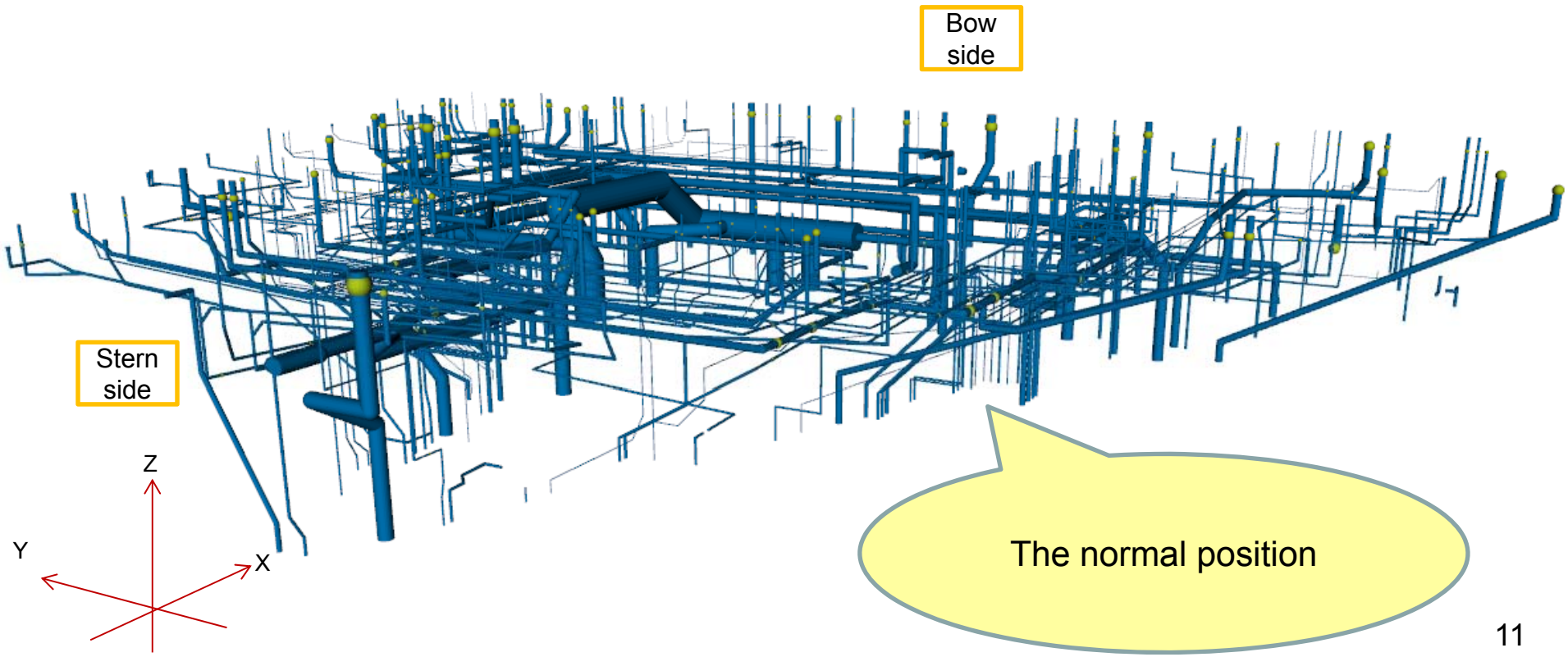
The type of penetration

- Tight hole penetration or loose hole penetration

- penetrating sleeves
- pass through sleeves
- socket with inside screw
- scuppers
- side deep deck pieces
- doubling plates
- high pressure pipe penetration pieces
- focus points of tight hole penetration
- focus points of loose hole penetration

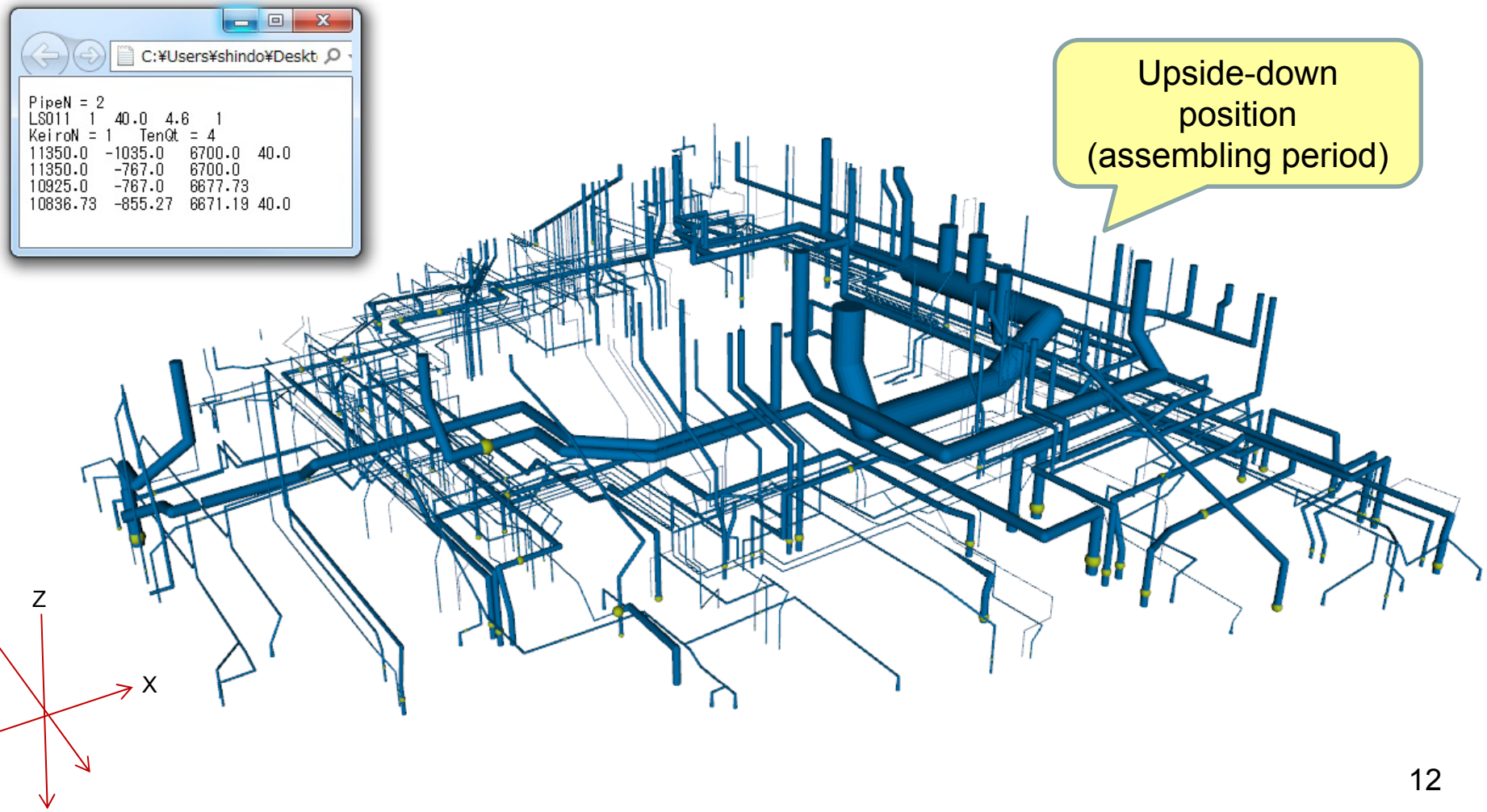
3D-Expression of the Pipes

- To understand pipes' information visually
- Data converter that loads pipes' data and generates X3D file
- X3D files are available with X3D viewer for free (e.g. Flux Player).



3D-Expression of the Pipes

function : Displaying the data of the pipe on which is clicked on the screen



Pipe Assembly Order

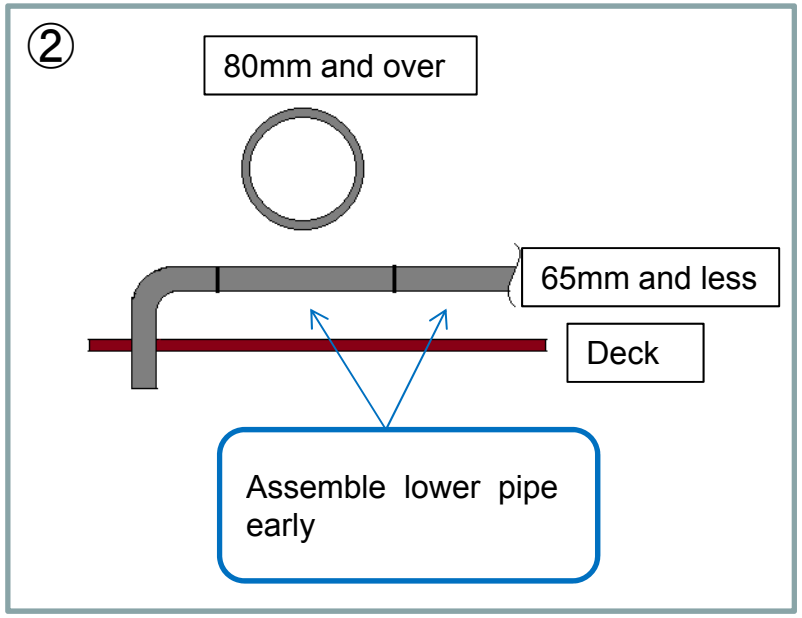
it is difficult to decide detailed assembly order…

Priority

1. Pipes penetrating/fixed on deck
2. Pipes located lower

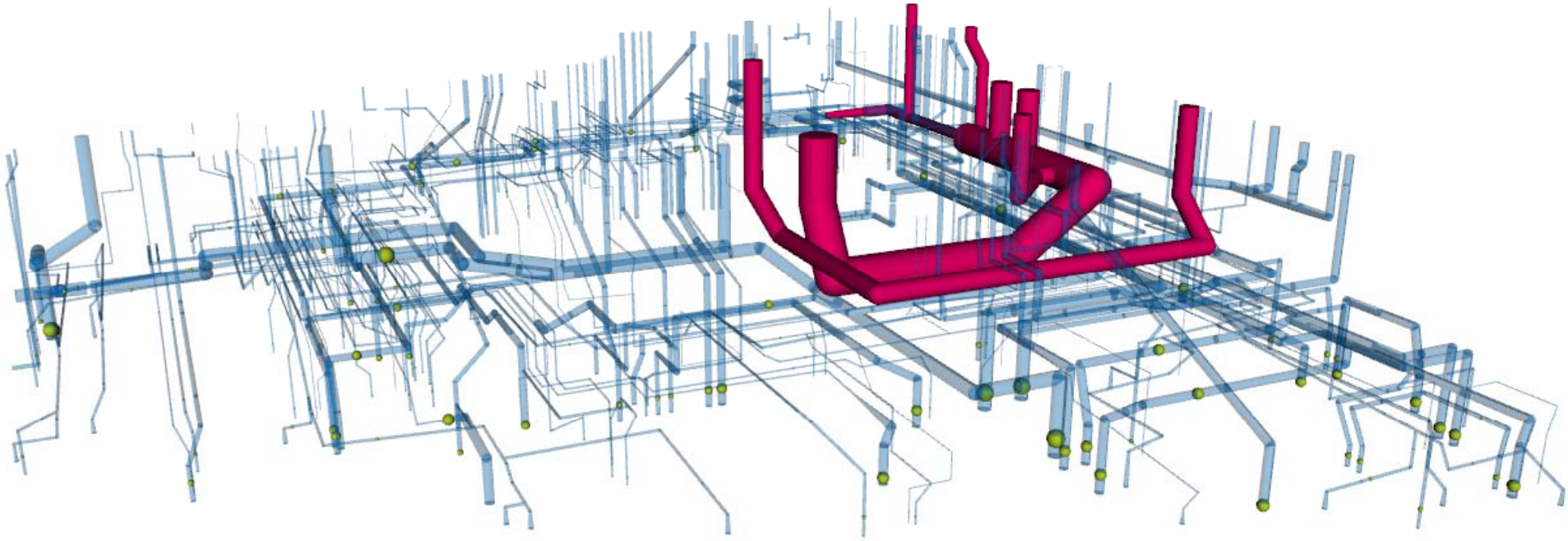
If pipes have the same value of Z…

3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter



Distribution Plan（Model Ship A）

- 250 mm and over pipes（red ones）



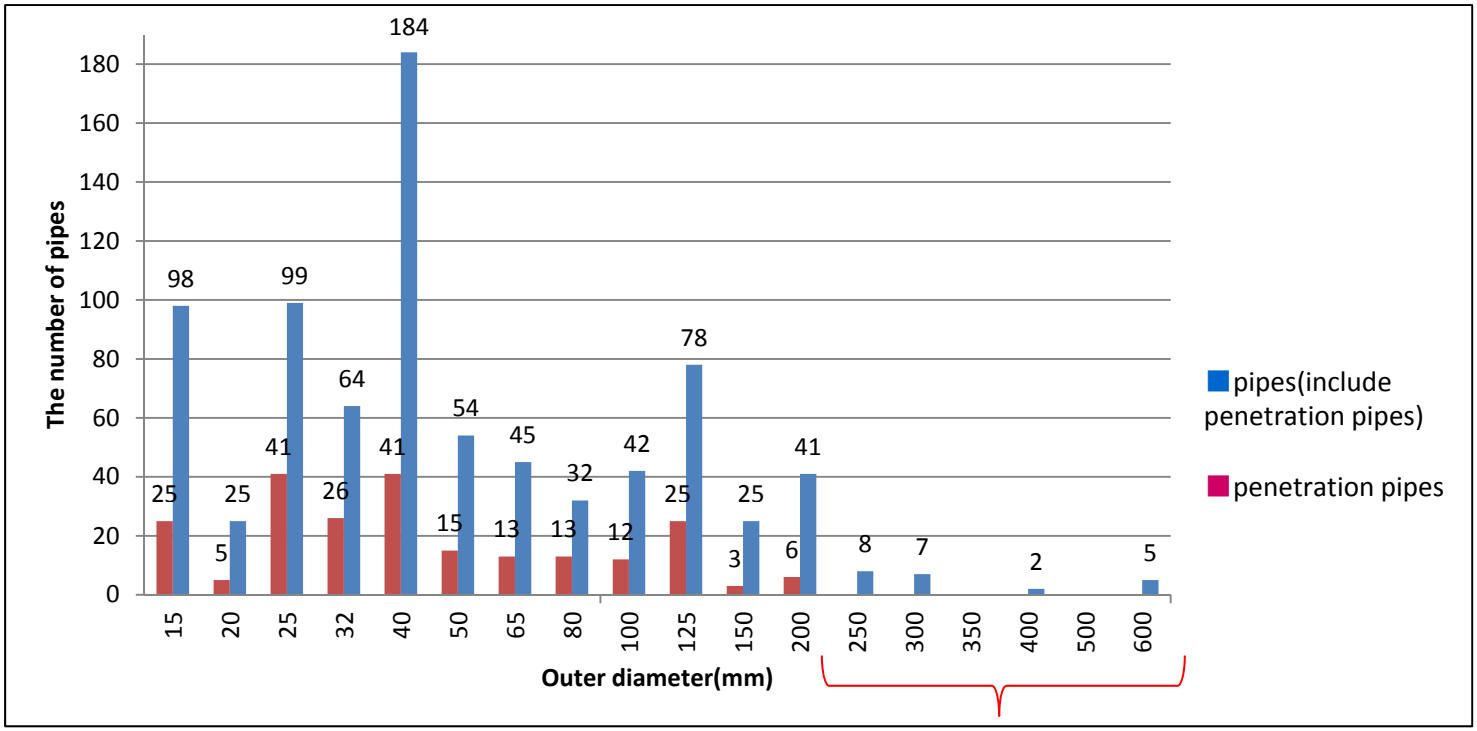
250 mm and over pipes later

→Positioned high place, the pipes are assembled last
These pipes distributed different space from other pipes

Analyzing of Pipes

- Model ship A

  The number of pipes by diameter



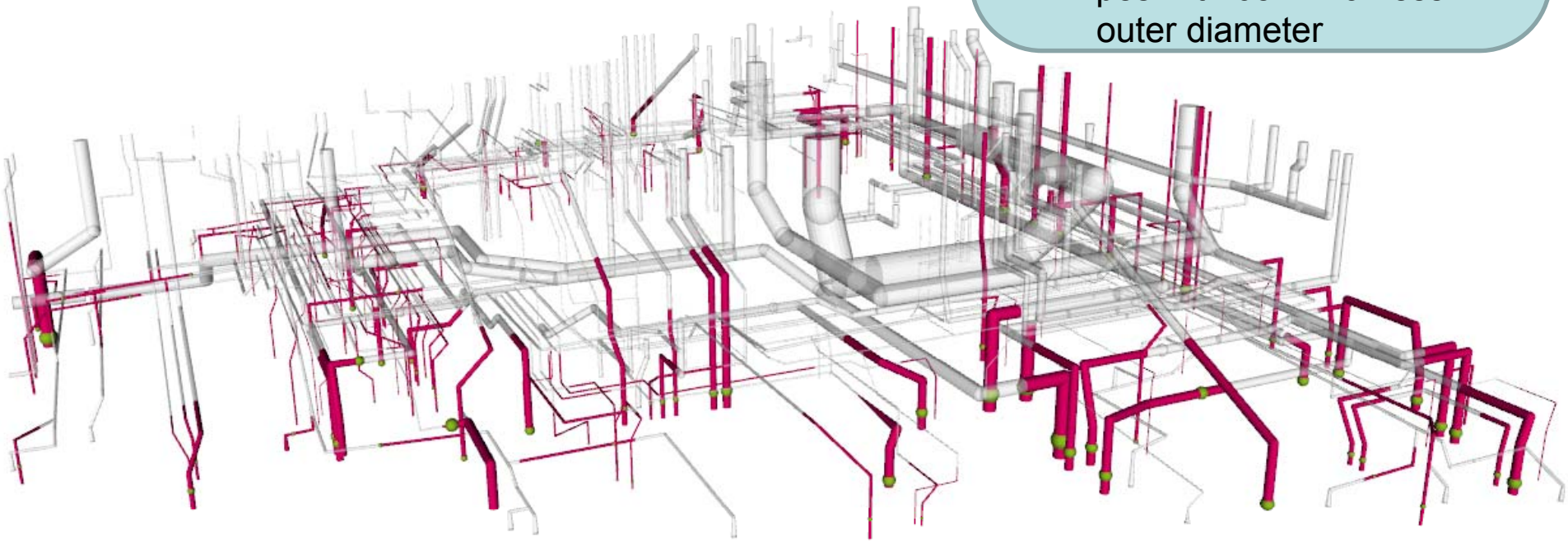
250mm and over pipes：22（2.7% of the whole pipes)
80-200mm pipes: 218（26.9% of the whole pipes)
65mm and less pipes：569（70.3% of the whole pipes)
Total of penetration pipes：225（27.8% of the whole pipes)

Distribution Plan(Model Ship A)

- Distribution: 1/4

Red pipes: Pipes which attached at the current step
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

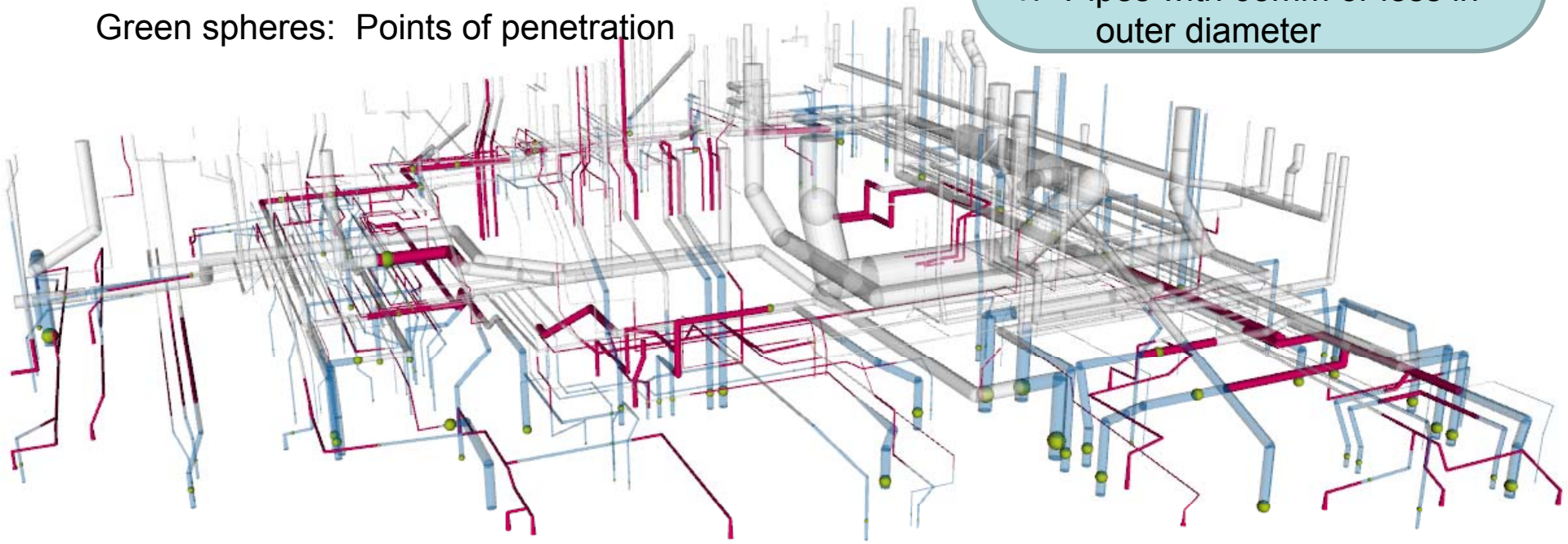


Distribution Plan(Model Ship A)

- Distribution: 2/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

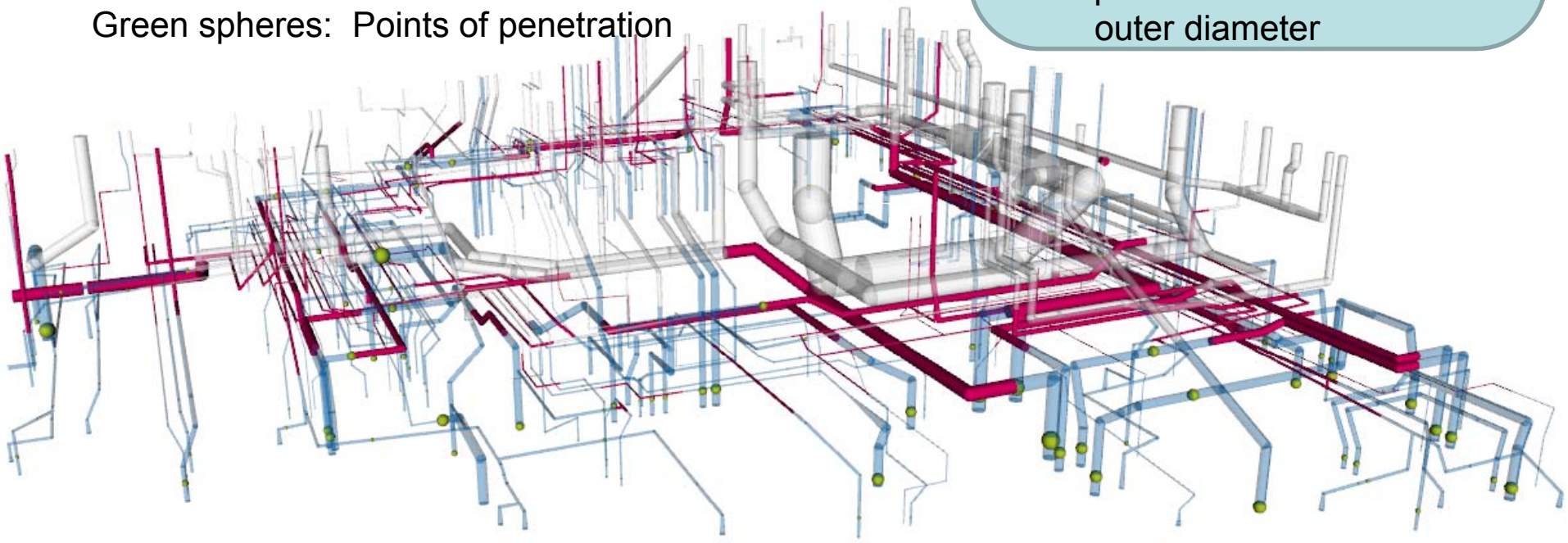


Distribution Plan(Model Ship A)

- Distribution: 3/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

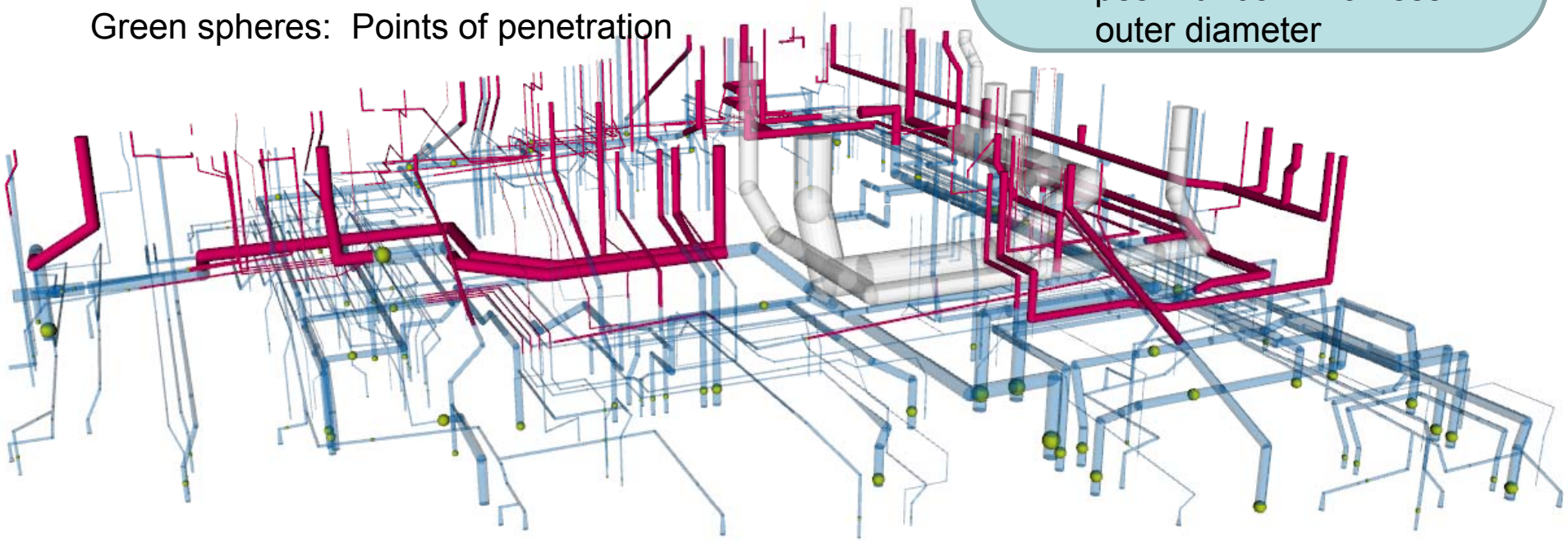


Distribution Plan(Model Ship A)

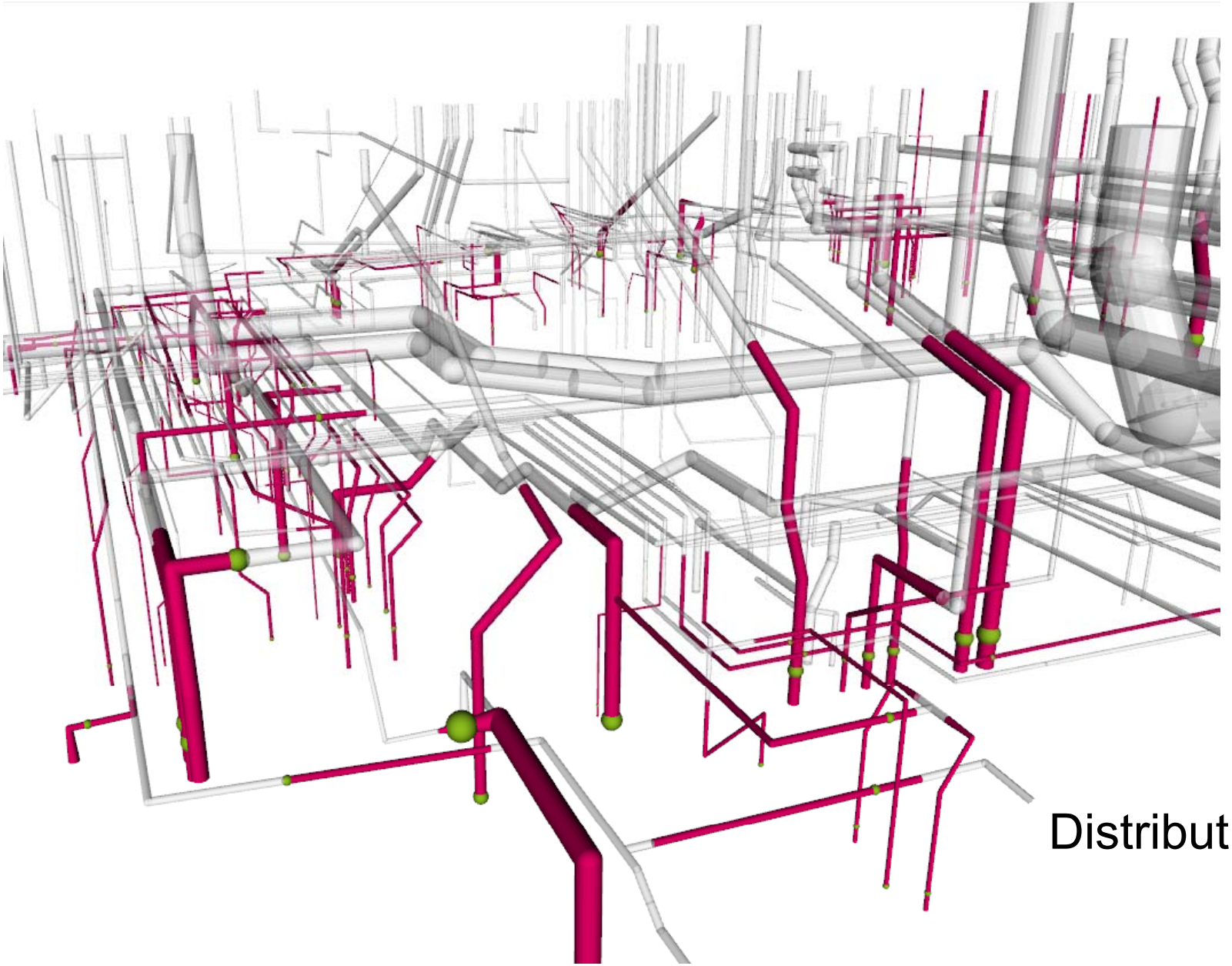
- Distribution: 4/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

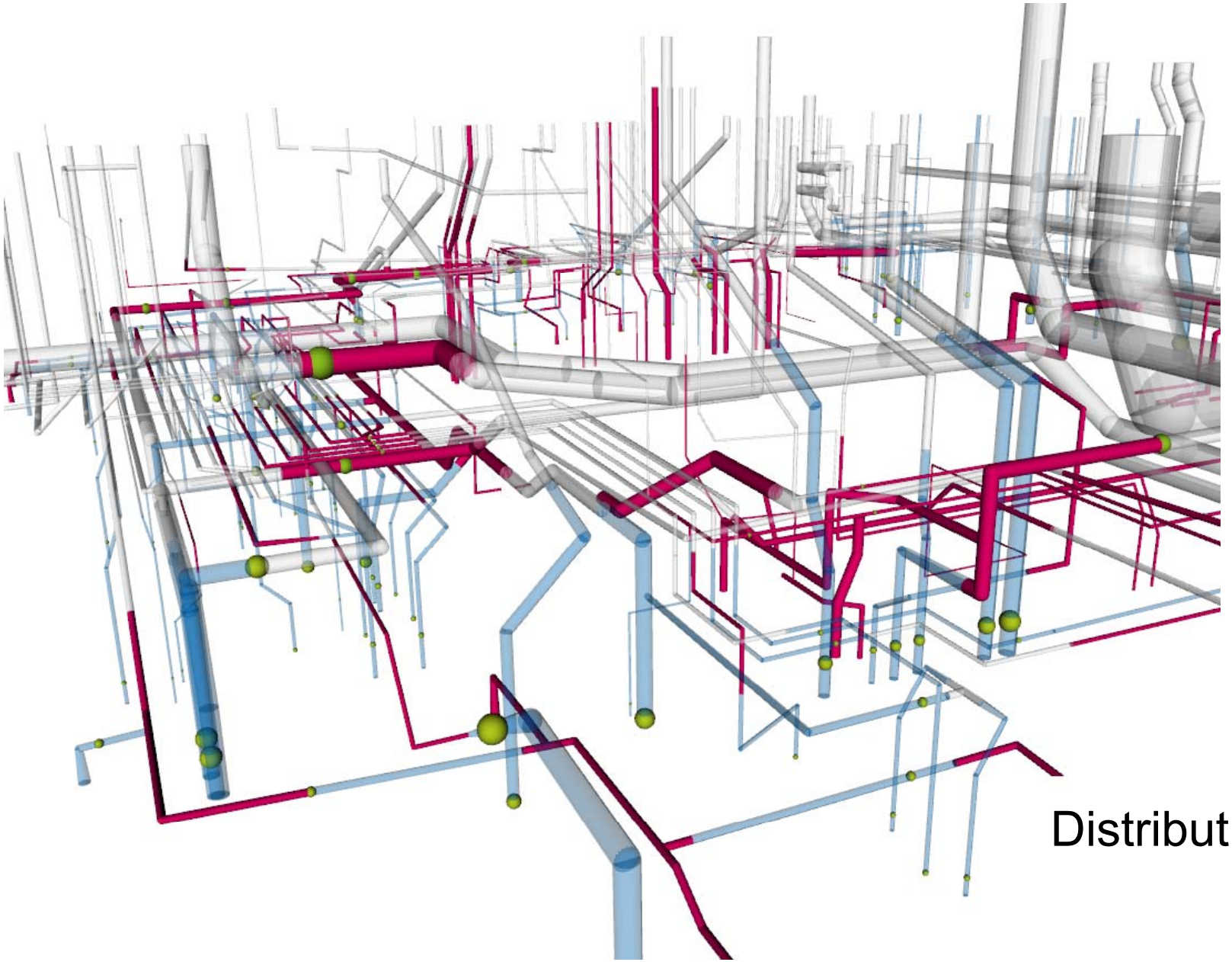


Enlarged View of Model Ship A



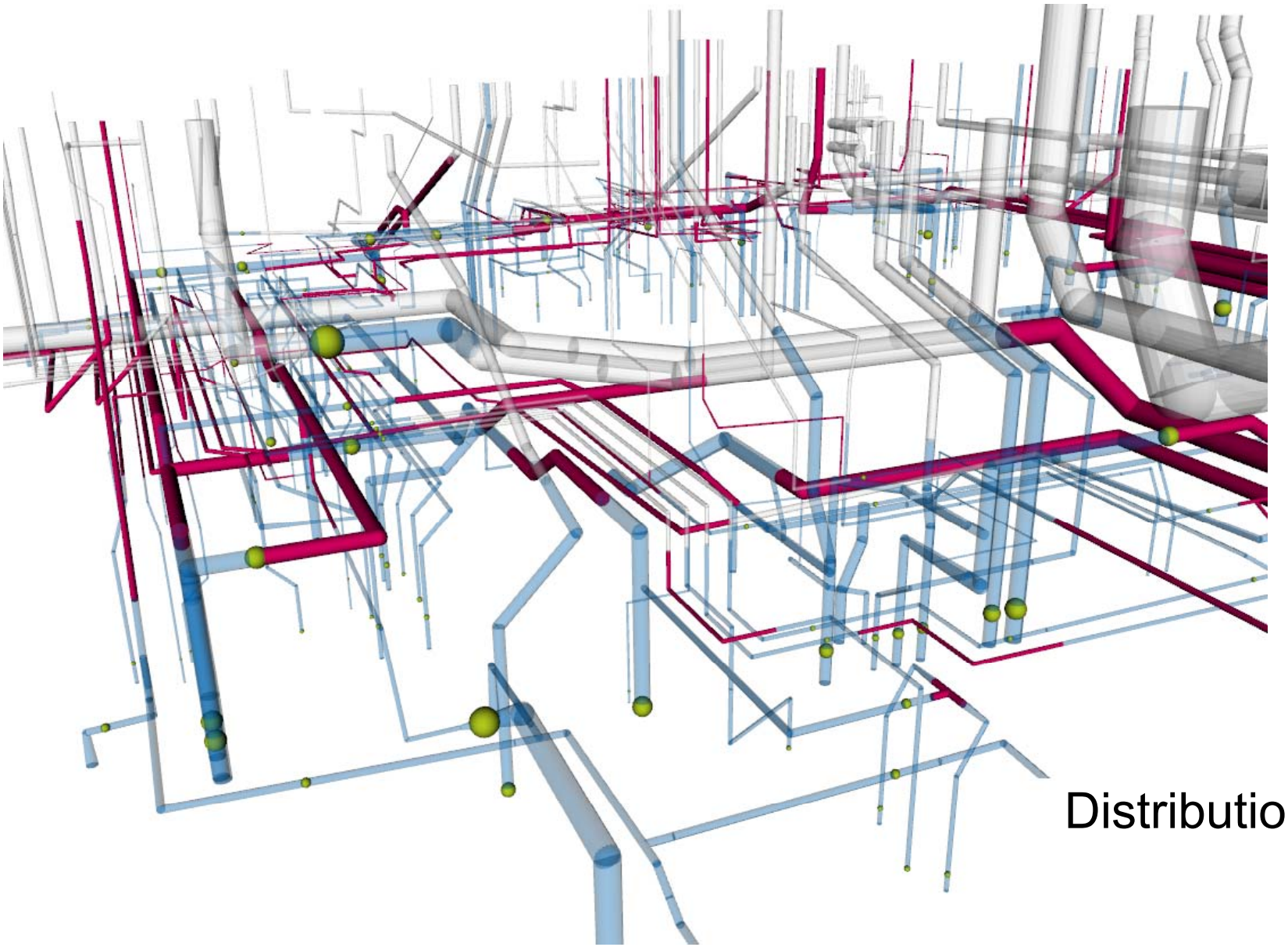
Distribution: 1/1

Enlarged View of Model Ship A



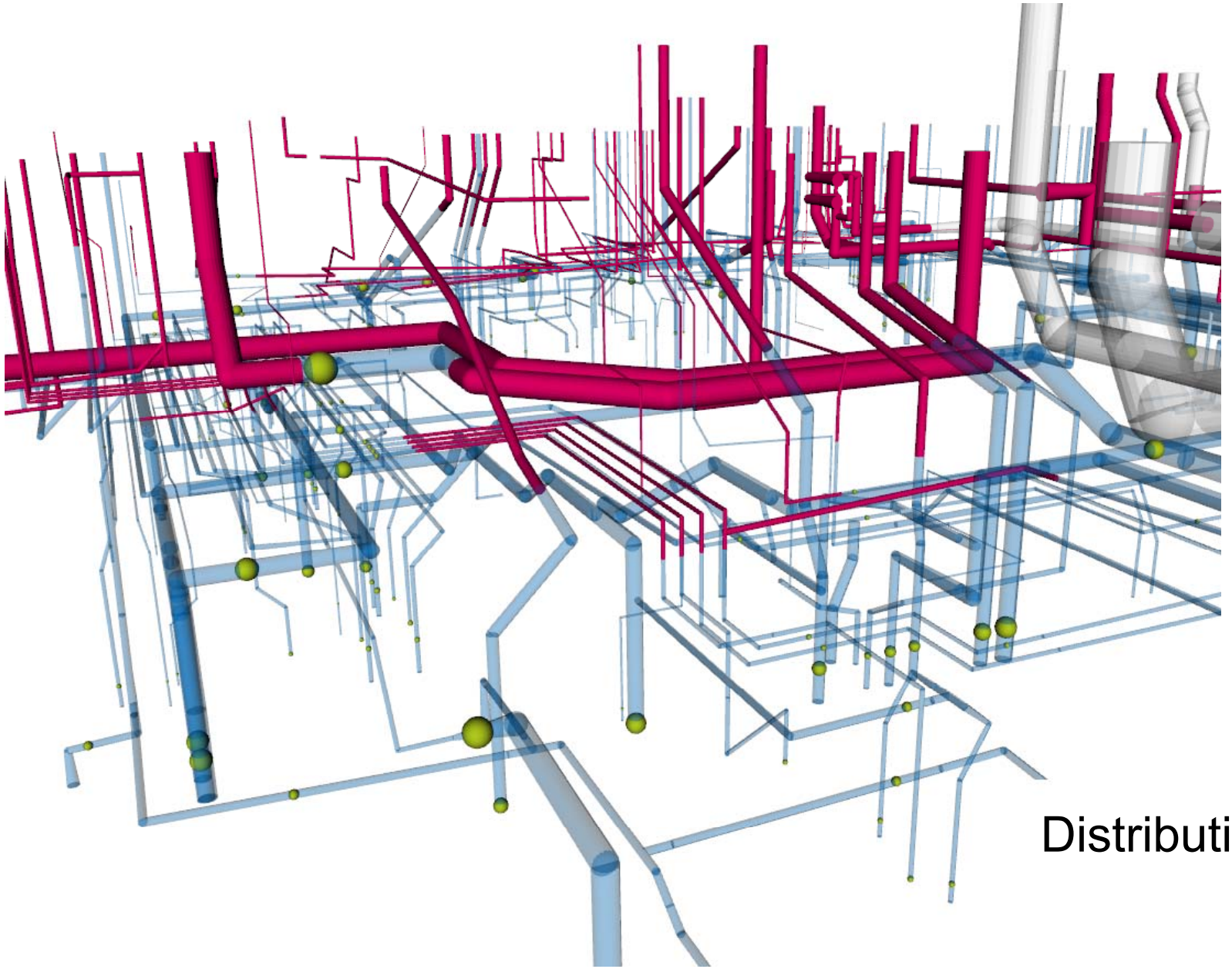
Distribution: 2/4

Enlarged View of Model Ship A



Distribution: 3/4

Enlarged View of Model Ship A



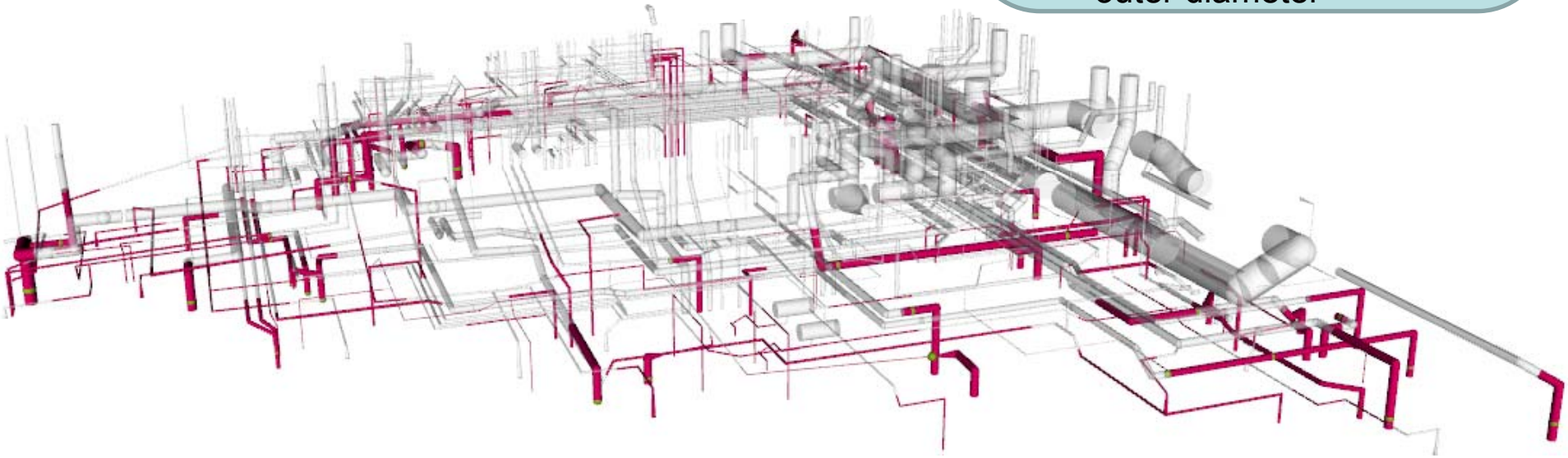
Distribution: 4/4

Distribution plan(Model ship B)

- Distribution: 1/4

Red pipes: Pipes which attached at the current step
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

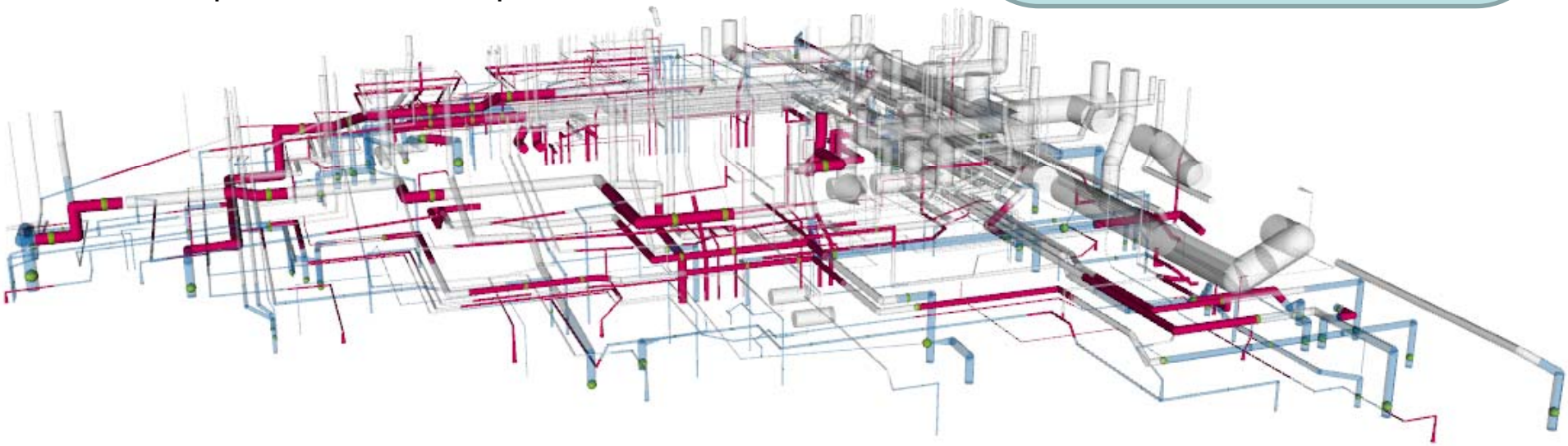


Distribution plan(Model ship B)

- Distribution: 2/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

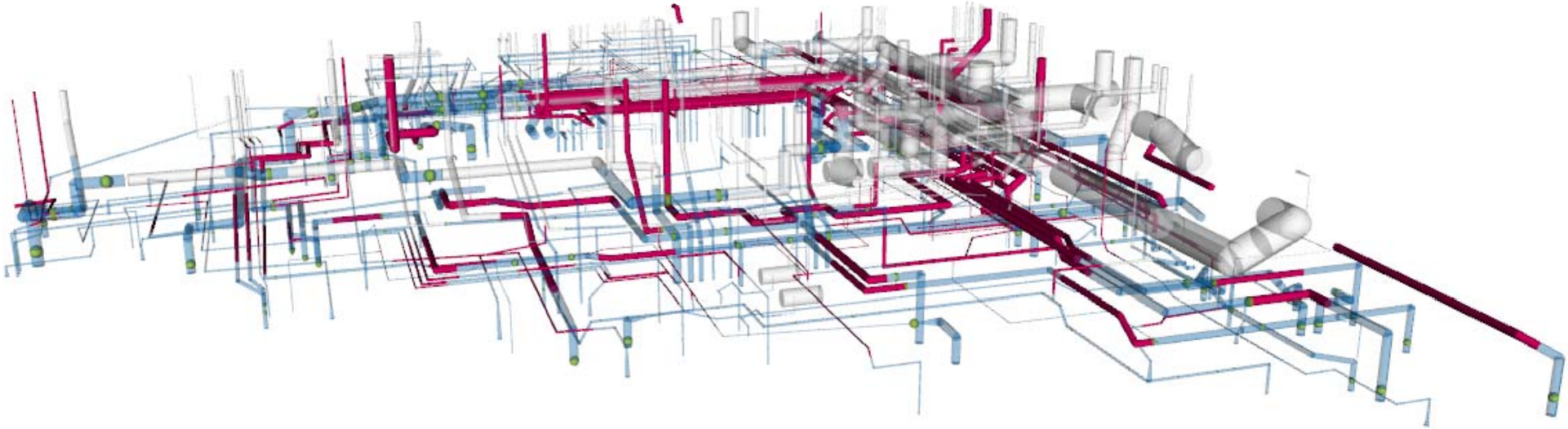


Distribution plan(Model ship B)

- Distribution: 3/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter

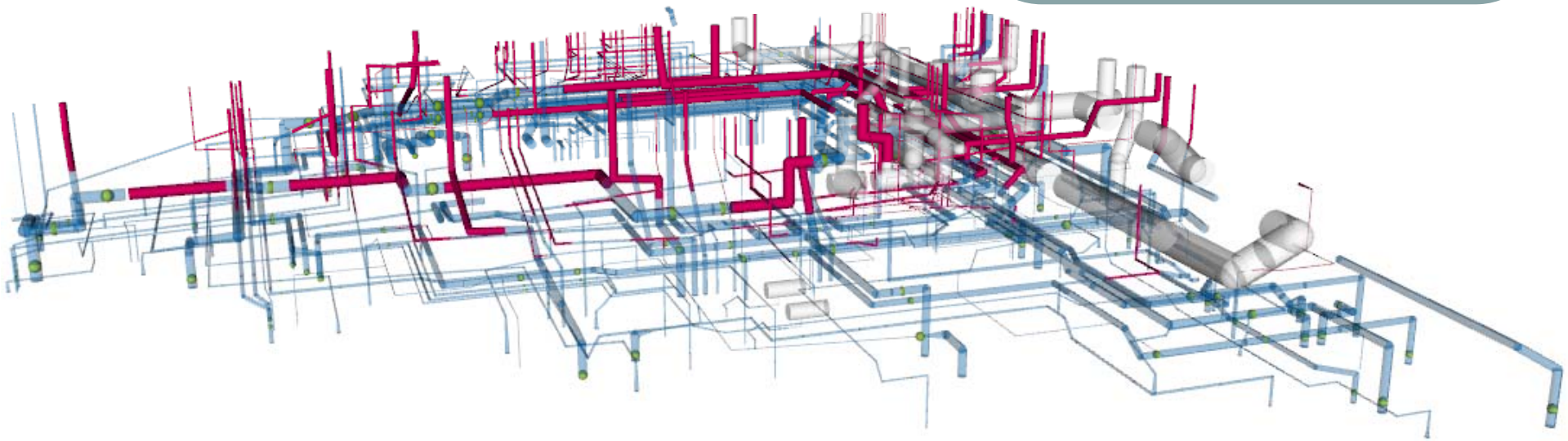


Distribution plan(Model ship B)

- Distribution: 4/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）
(If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter



Distribution plan（Model ship B）

- The pipes with over 250 mm in diameter

Red pipes: Pipes which attached at the current step

Blue pipes: Installed pipes

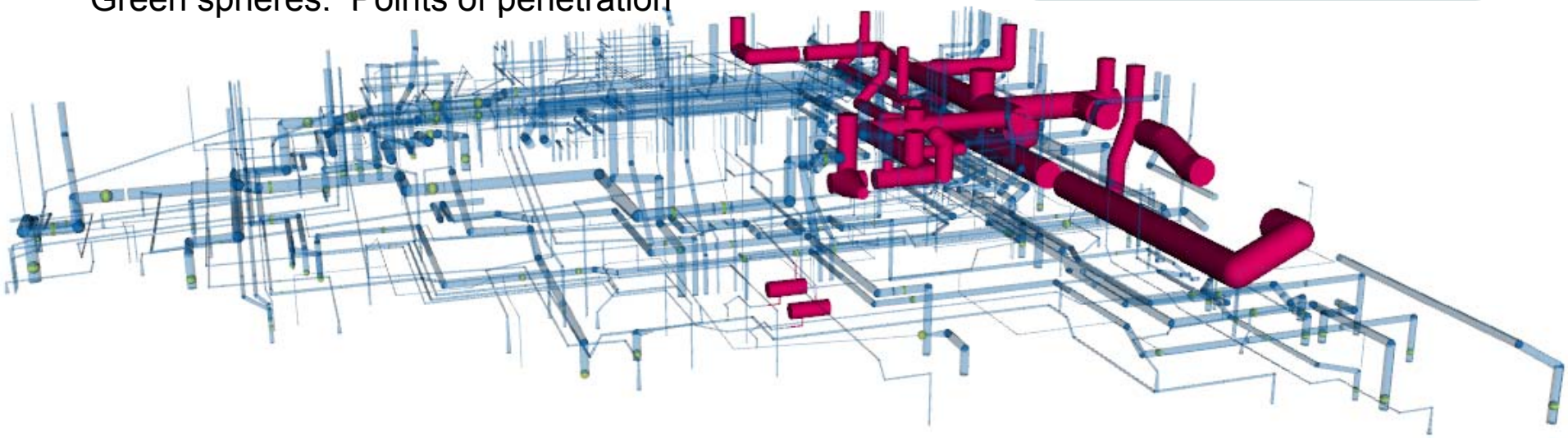
Transparent pipes: The pipe which attached at the subsequent steps

Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower（Pipes have higher value of Z）

(If pipes have same value of Z…)

3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter



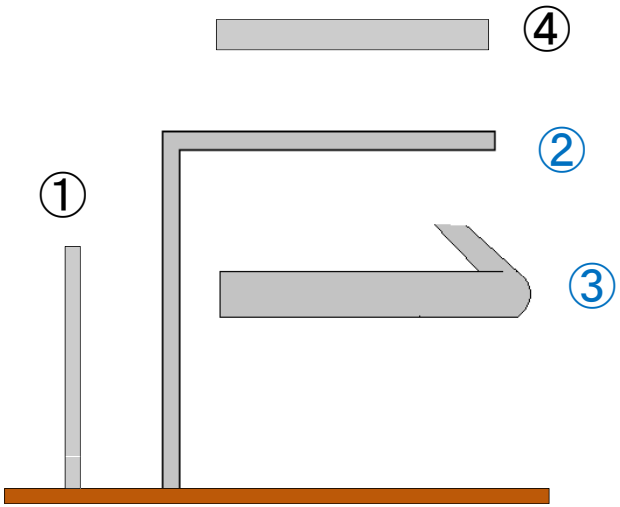
This study's features and the evaluation

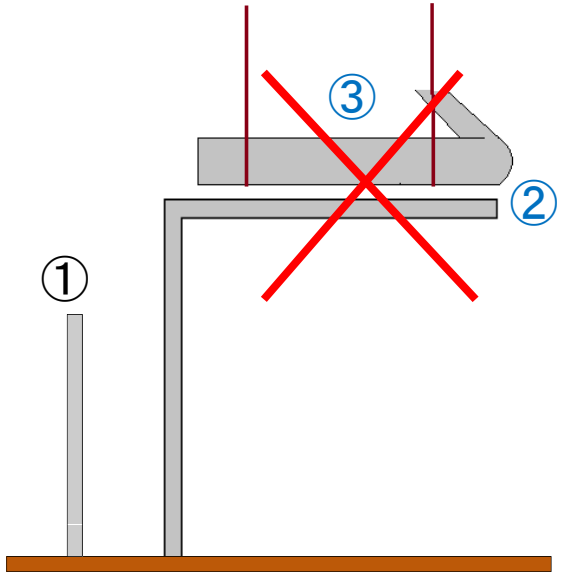
- Loading pipes' data
- Distribution according to the priority
- Generating X3D file

◆ The on-site supervisors in this shipyard comment…

- Almost practical level
- Preferable to use it for free
- Trying it in practice and confirming usefulness

Interference of pipes and handling of it



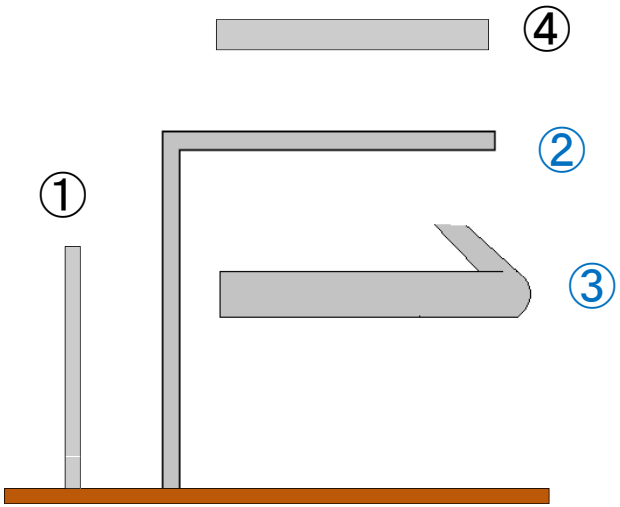


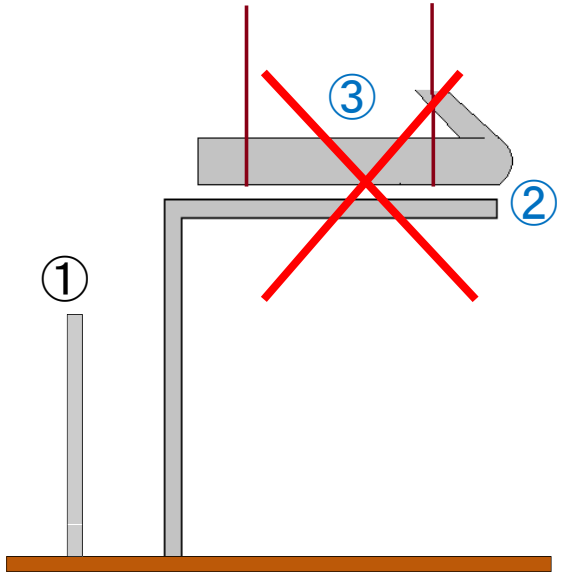
Assembly order

①→②→③→④

when pipe ② is assembled earlier, pipe ③ cannot be assembled with cranes

Interference of pipes and handling of it





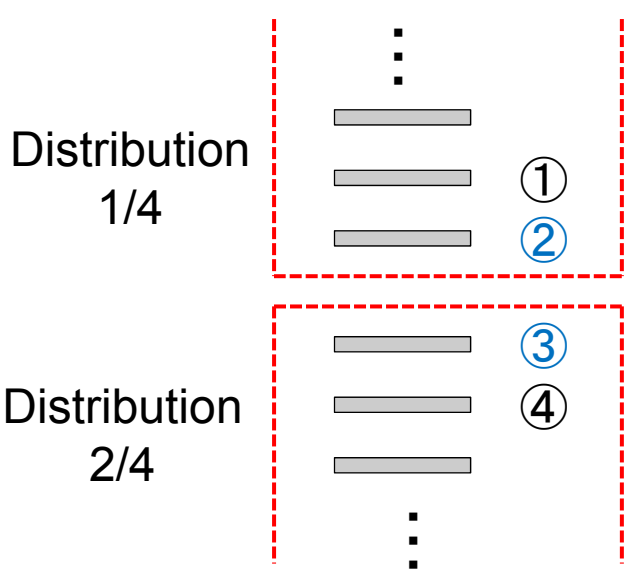
Assembly order

①→②→③→④

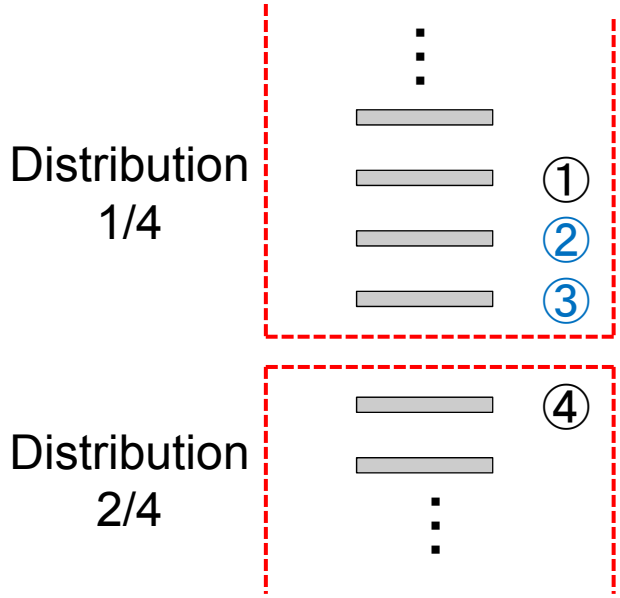
when pipe ② is assembled earlier, pipe ③ cannot be assembled with cranes

It is desirable to be possible to change order of pipe ② with that of pipe ③

Interference of pipes and handling of it



impossible to exchange ② and ③ order



possible to exchange ② and ③ order

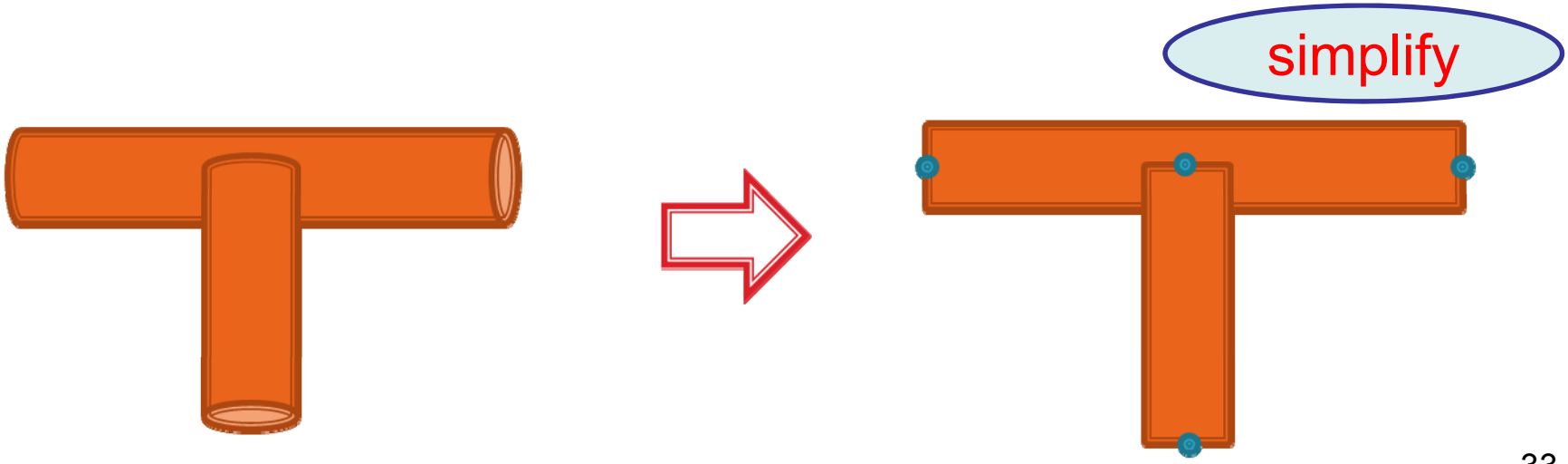
- The pipe which it is hard to attach later have to be grouped with interfered pipes

Pipes interference check function

the assumption that pipes are installed by cranes

projecting pipes on the X-Y plane

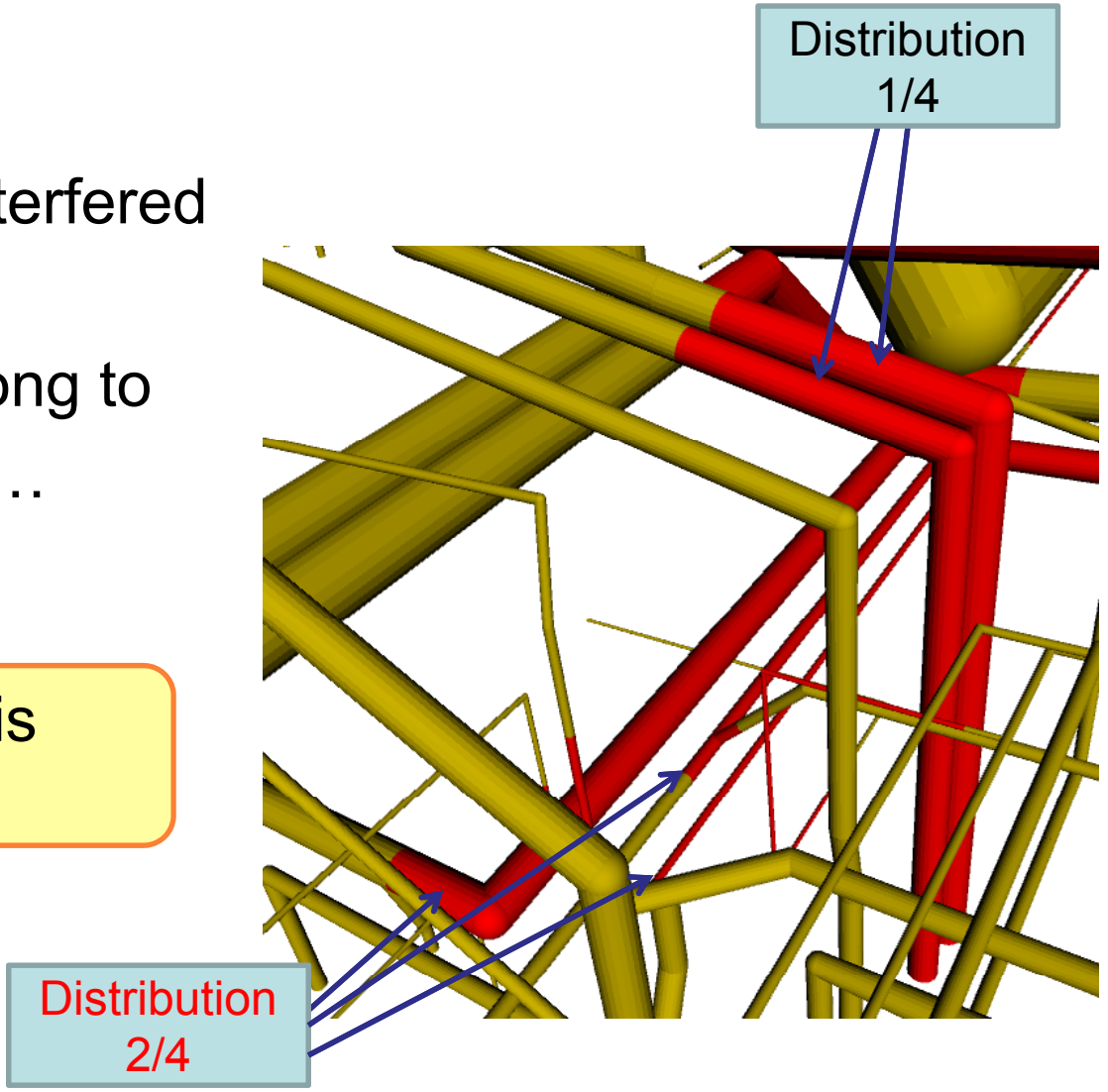
- 3-D interference problem into 2-D problem
- Cylinders into rectangles



Test of this function

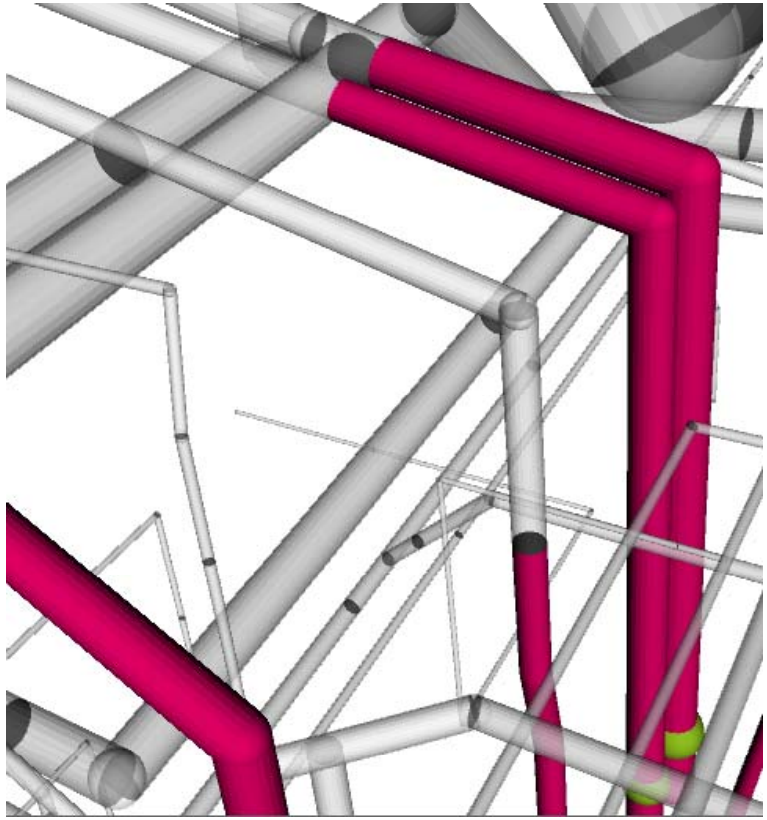
- Model ship A
- Red pipes are interfered
- These pipes belong to different groups…

The same group is preferable

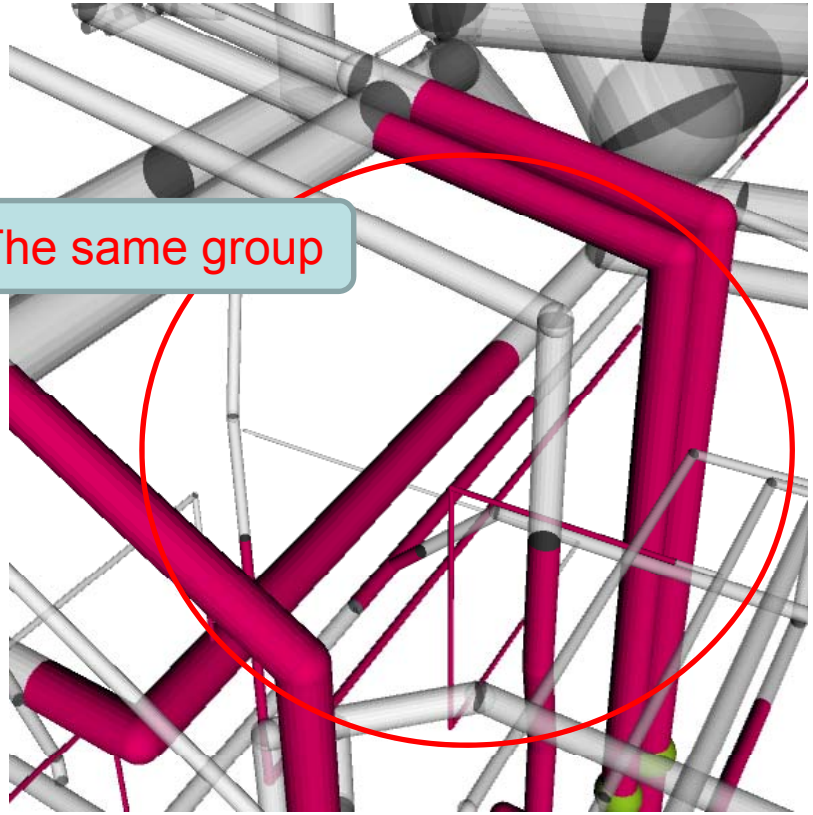


Test of this function

Before → after



Distribution 1/4



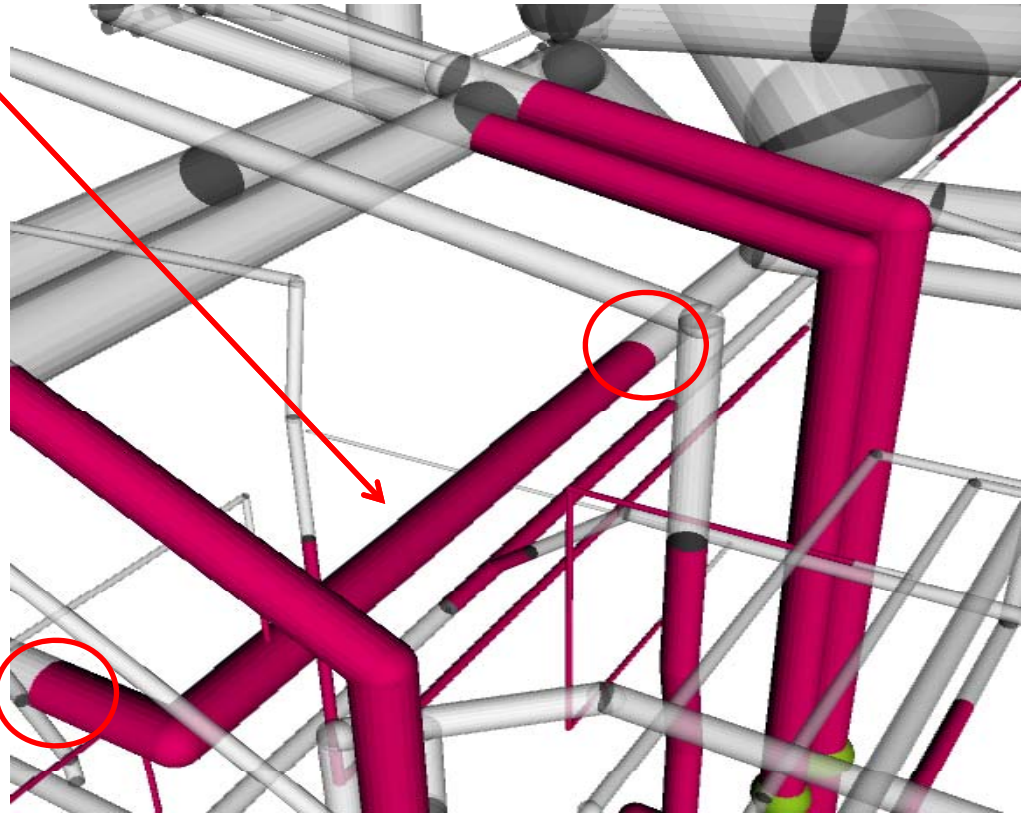
Distribution 1/4

An Issue of this function

Pipes are floating in the air

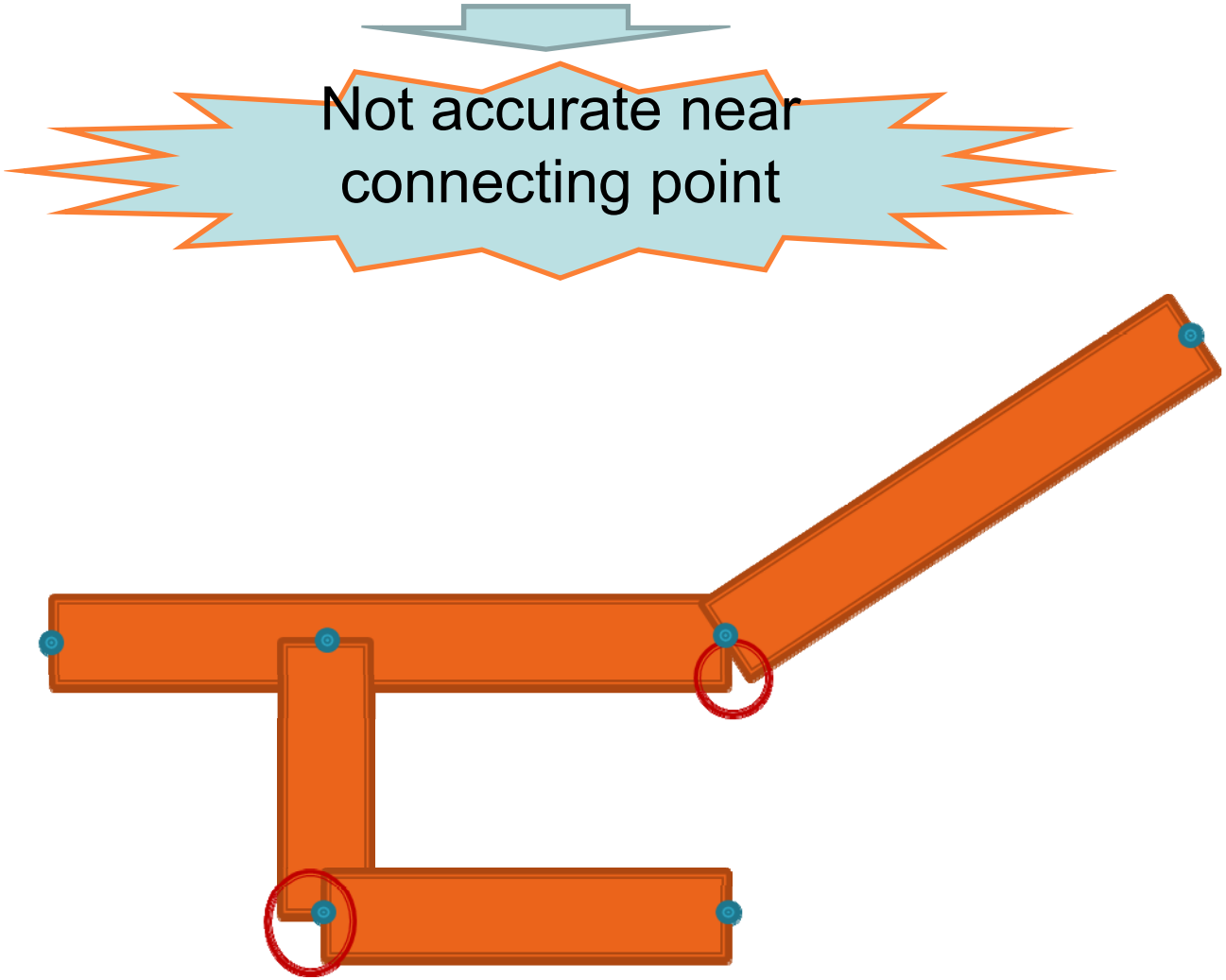
Fixed pipe group as the same group too

Pipe support information is needed



Precision of approximation

- Pipes are approximated as aggregate of rectangles

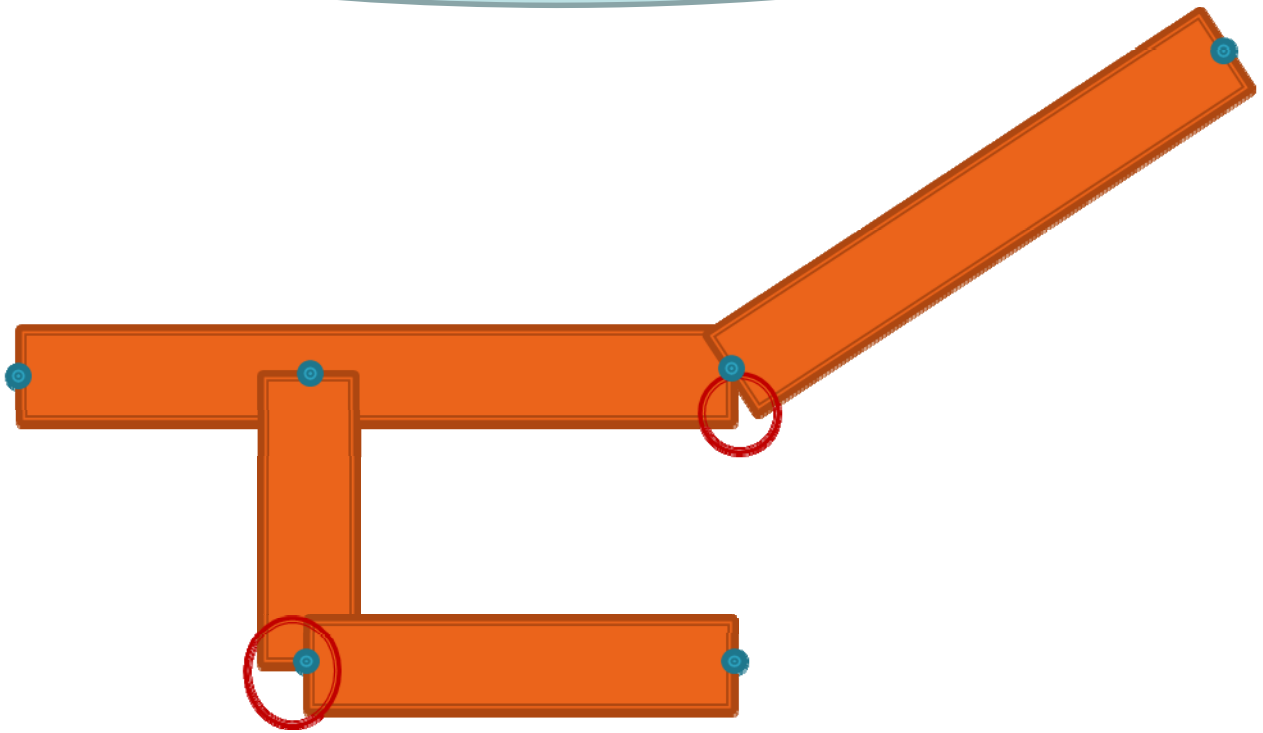


Precision of approximation

- Pipes are approximated as aggregate of rectangles

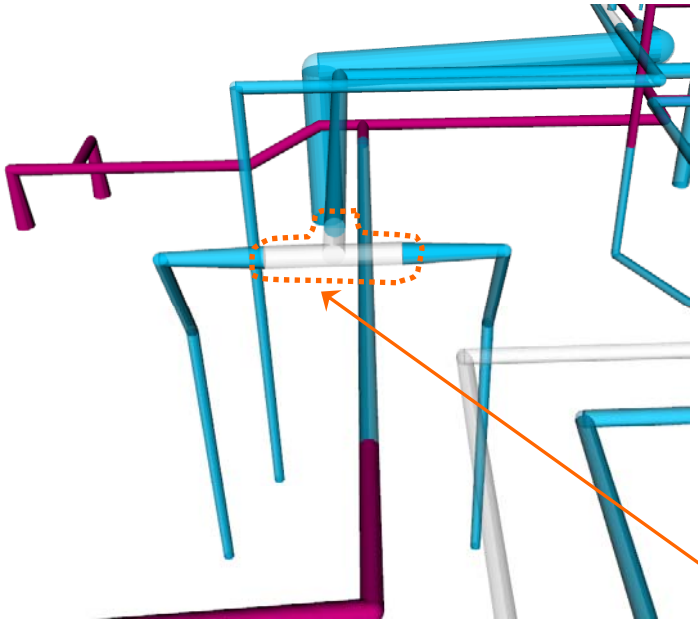
But…

On-site workers deal with pipes are a little interfered



Discussion 1. Problem of assembly order

Figure of Distribution 2/4



Blue pipes: pipes assembled at distribution 1/4

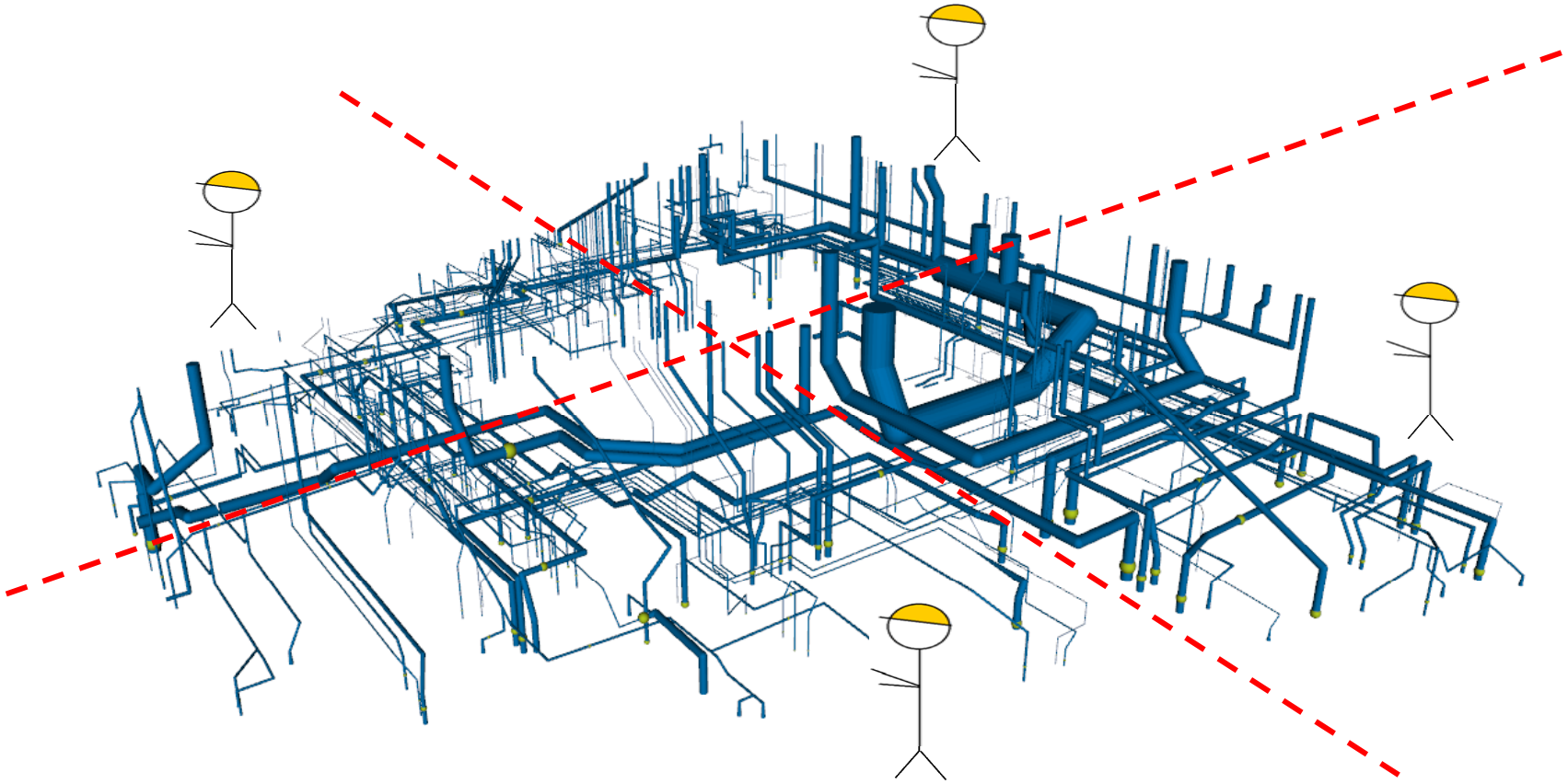
Red pipes: pipes assembled at distribuyion 2/4

Transparent pipes : pipes assembled at after 2/4

- Only this pipe belongs to distribution ¾
- This pipe should be in same group as the right and left pipes
- We need the system that last pipe is grouped as the other pipes

Discussion 2. Area division

- Dividing an engine room to some parts (4-6)
- Assign one worker to one area
- Work in parallel

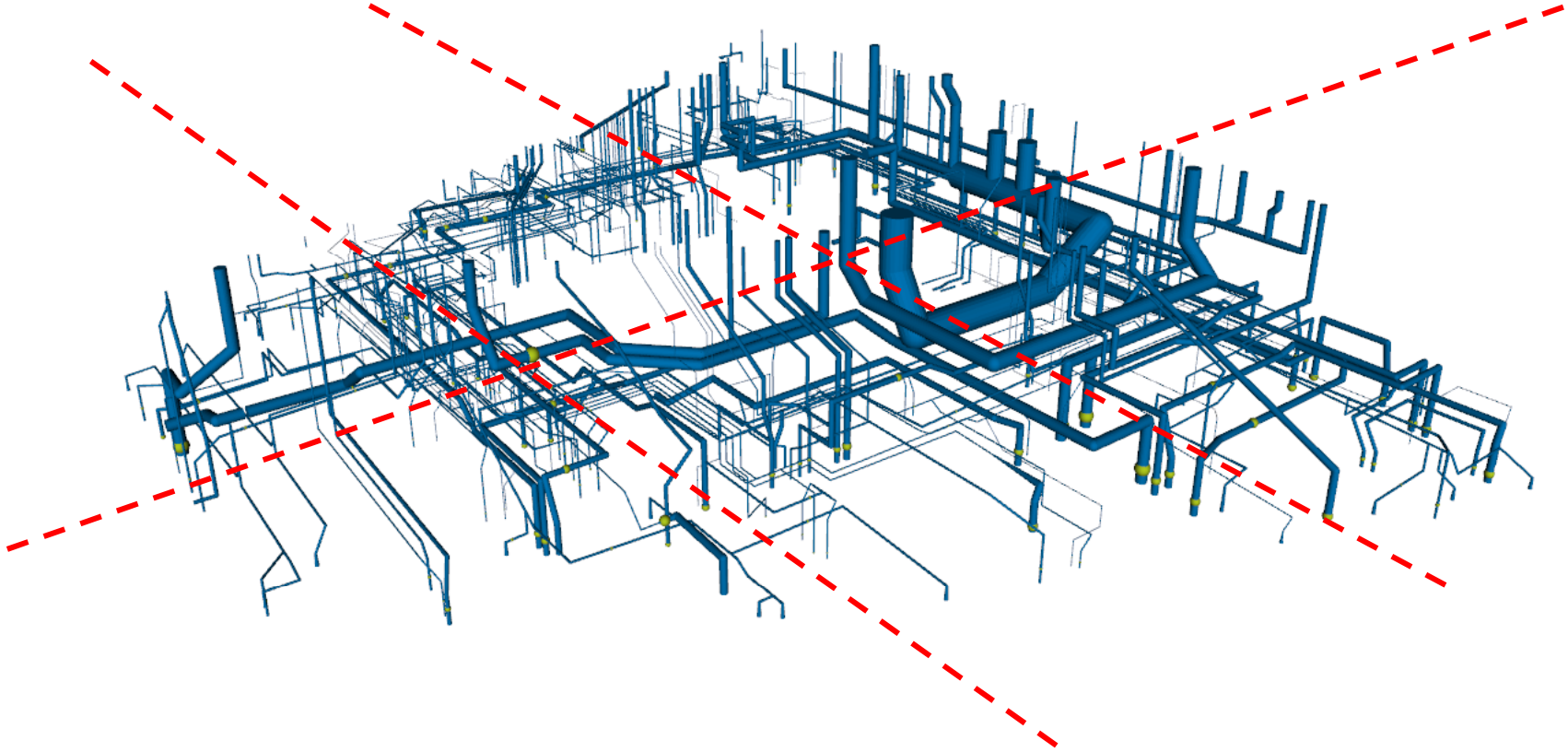


Discussion 2. Area division

- Positions of division borders are depend on positions of bulkheads

It varies according to ships

- It is favorable to be able to deside the number of partitions and position of theirs manually



Conclusion & future works

Conclusion

- A new system that divides the pipes into several groups considering the assembling order that skilled workers adopt
- Pipes interference check function
- 3-D display of distributed pipes

the burden of workers is reduced

Future works

- Blushing up pipes interference check function
- Study of further rules of grouping
- Area division
- Discovering further problems in practice