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

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SUMMARY

In the precedence rigging of shipbuilding, most of the man-hour of rigging consists of piping work. Therefore it is important how the rigging of pipes is performed efficiently. Currently, all pipes which rigged in the engine room are distributed on the same working space in the target shipyard. There are two problems; One is the distributed pipes occupy a wide space to stock until installation, the other is it takes long time to find target pipes from distributed pipes. We propose a new system which divides the pipes into several groups considering the assembling order that skilled workers adopt. The number of the groups depends on the period of the piping works. Our system enables to reduce the burden of workers, reduce temporary space which placed pipes, and improve efficiency of the piping work. We show a demonstration of the proposed system through simulation using real ships' data.

1. INTRODUCTION

In the precedence rigging of shipbuilding, most of the man-hour of rigging consists of piping work. Therefore it is important how the rigging of pipes is performed efficiently. Since there are about 1,000 pipes only in an engine room, the rigging of shipbuilding need training and experience. It takes about six days to assemble pipes in a target shipyard, and all pipes which rigged in the engine room are distributed on the same working space. Therefore, large space to put pipes and long time to find an objective pipe is needed.

In previous works, an assembly simulation system is presented [1]. Workers can confirm procedure of installation with animation on a computer display. Then, we can extract some problems of installation and check the procedure of the installation in advance. His system improves work efficiency in comparison with conventional works using only pipe drawings. However, in the assembly simulation, order for piping is still generated manually. For that reason expert knowledge is still necessary.

Y Wei and U Nienhuis developed an automatic scheduling system of outfitting process planning [2]. In this system, components' position, material, weight, size, productivity and strategy is considered.

In this paper, we introduce a new system which divides the pipes into several groups considering assembling order that skilled workers adopt, and we show a demonstration of the proposed system through simulation using real ships' data.

2. REPRESENTATION OF PIPES

We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co. in this study. Figure 1 shows an example of the data format, and corresponding 3-D form of the pipe is shown in Figure 2. The pipes are illustrated by a "main pipe" and "branch pipes". The data for one pipe gives coordinates of the start point, the end point, the point(s) of bend(s), and 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 are included in the data.

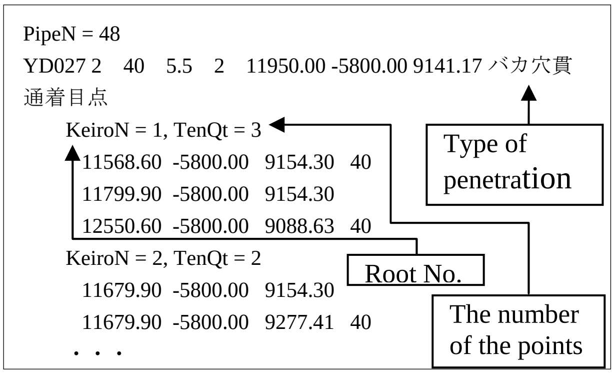

Figure 1: Example of pipe data

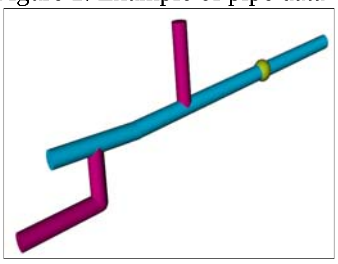

Figure 2: Figure of a pipe

3. 3D-EXPRESSION OF THE PIPES

We developed a data converter that loads pipes' data and generates X3D file. It enables us to understand easily what shape the pipes are, where they are and how to assemble them. X3D files are available with X3D viewer for free (e.g. Flux Player). We added functionally for displaying the data of the pipe on which is clicked on the screen. Figure 3 shows an example of the pipes with Flux Player.

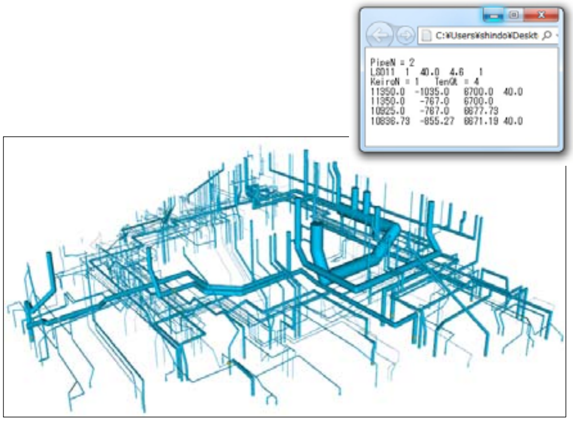

Figure 3: 3-D display of all pipes and data of a pipe

4. ORDER FOR ASSEMBLING PIPES

The order for assembling pipes is a little different depending on the pipers. The rough outline of the decision is following [3]:
Priority1: Pipes penetrating /fixed on deck
Priority2: Pipes located lower
Priority3: Pipes with 80-200 mm in outer diameter
Priority4: Pipes with 65 mm or less in outer diameter
In precedence rigging, construction work is carried out with the block flipped upside down. The pipes located lower have higher value of Z. The pipes with over 250 mm in diameter are usually assembled last. However these are distributed other space for considering the case that these pipes cannot be assembled because of other pipes. Pipes with 80 mm or over in diameter is assembled earlier than the ones with 65 mm or less in diameter because these pipes with 80 mm or over in diameter is assembled with cranes.
We developed the scheduling program loading pipes' data, dividing the pipes with the way that pipers decide order for assembling, and displaying the divided pipes. Figure 4 shows the flowchart of our system and Figure 5 shows divided pipes in a block of the underside of an engine room and Figure 6 shows enlarged views of them. There are 809 pipes in the engine room.
The supplementation of Figure 5 and Figure6 is as follows:
Blue pipes: Installed pipes
Red pipes: Pipes which attached at the current step
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

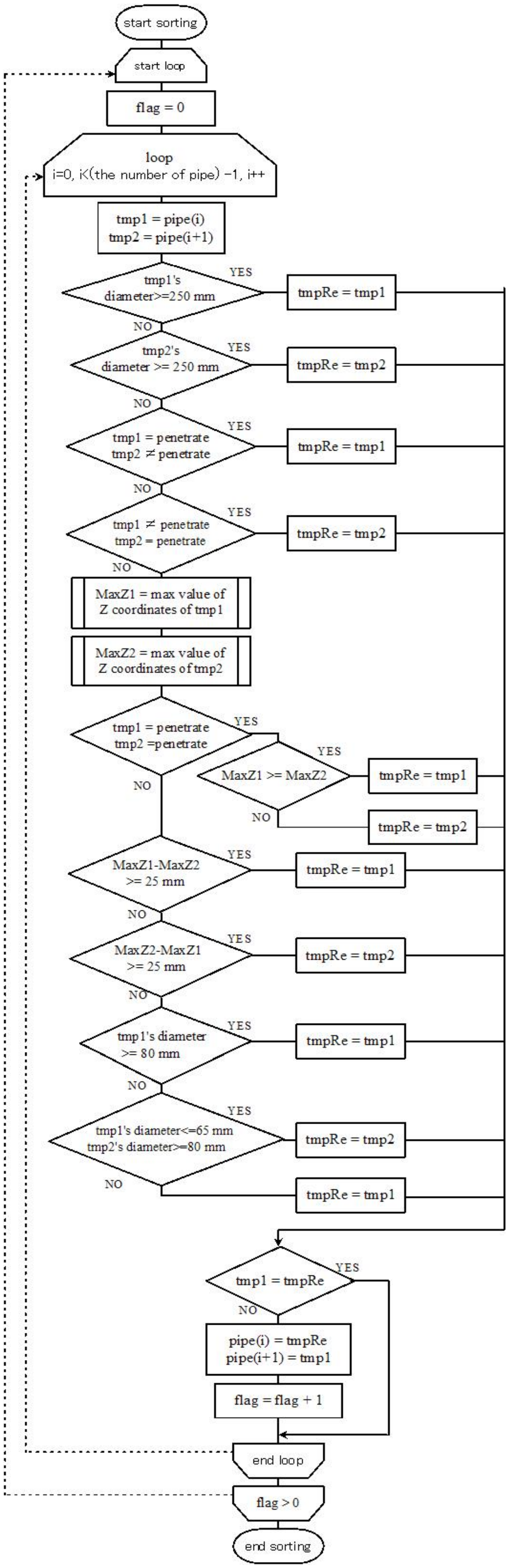

Figure 4: The flowchart of our system

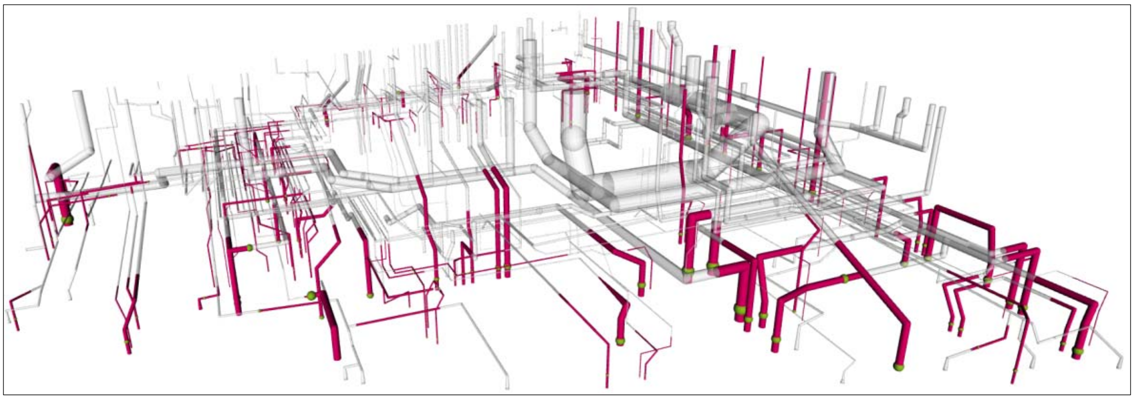
Figure 5a: Material distribution 1/4

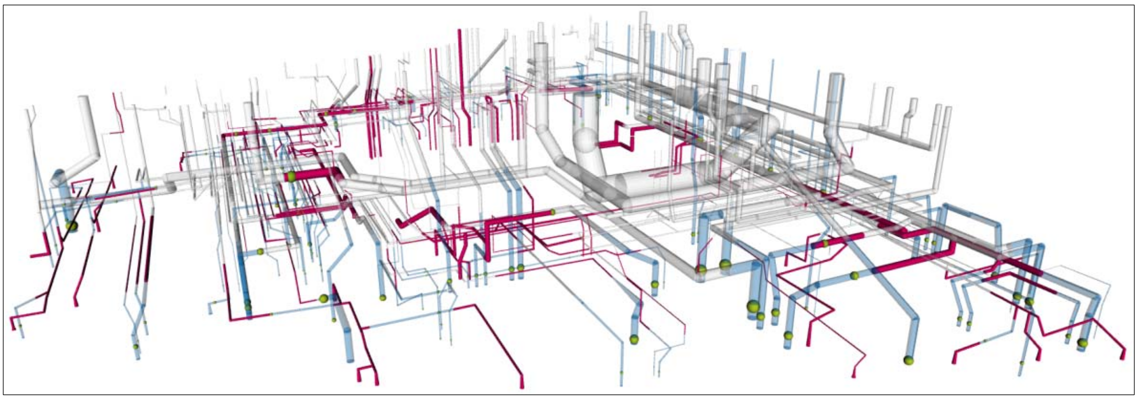
Figure 5b: Material distribution 2/4

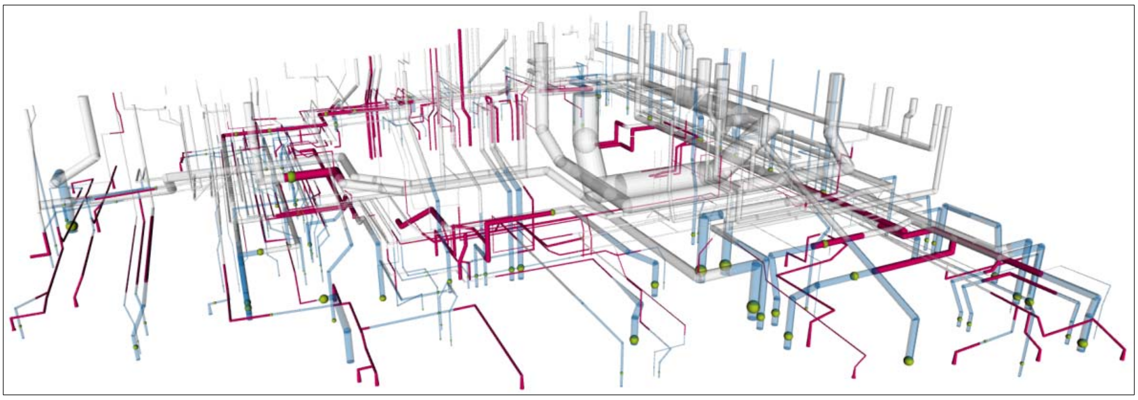
Figure5c: Material distribution 3/4

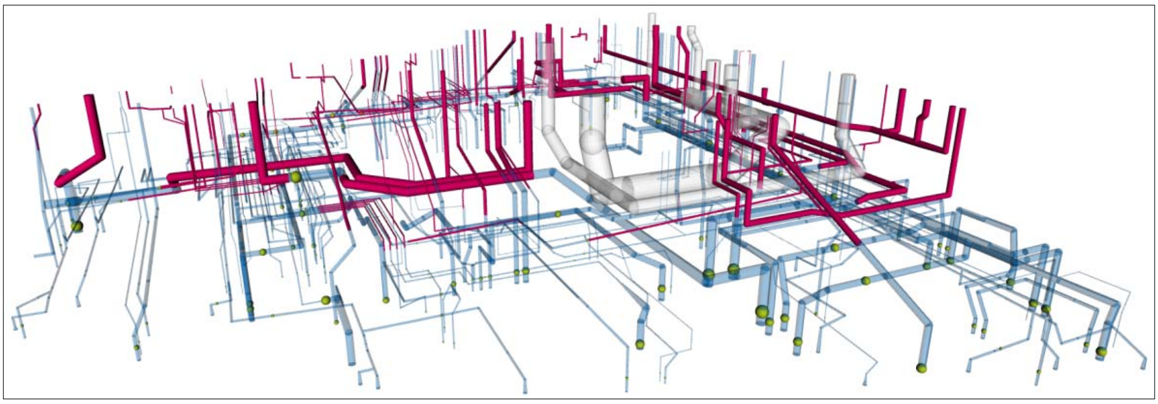
Figure 5d: Material distribution 4/4

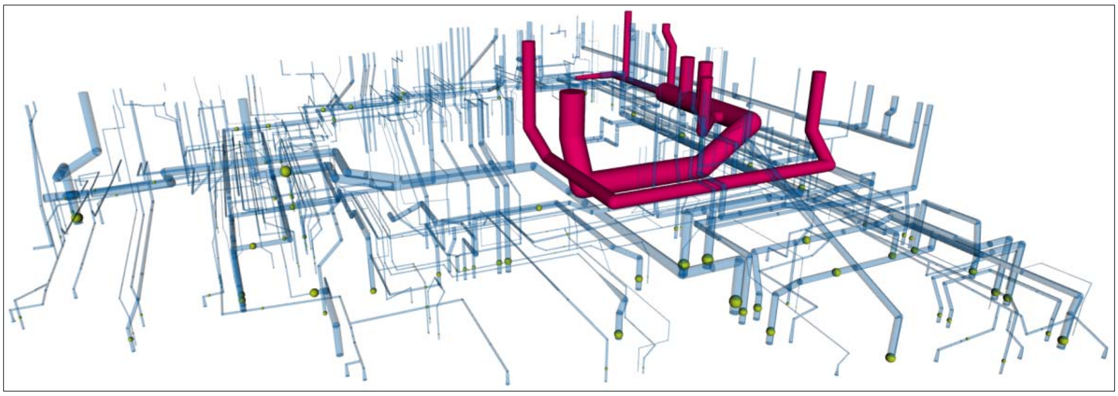

Figure 5e: More than 250 mm diameter pipes

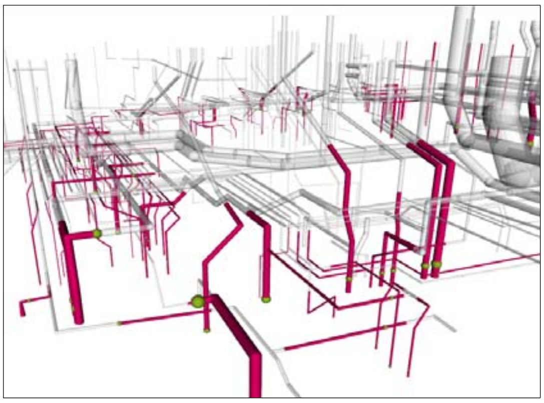

Figure 6a: Material distribution 1/4

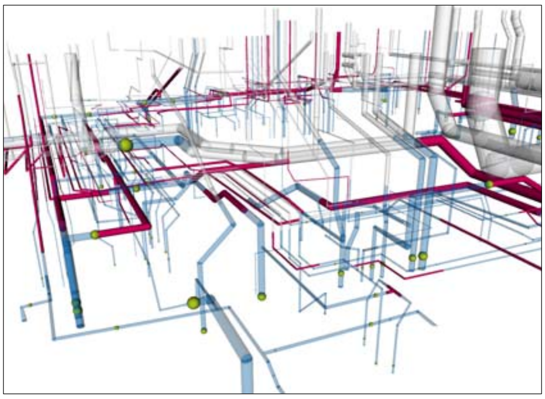

Figure 6c: Material distribution 3/4

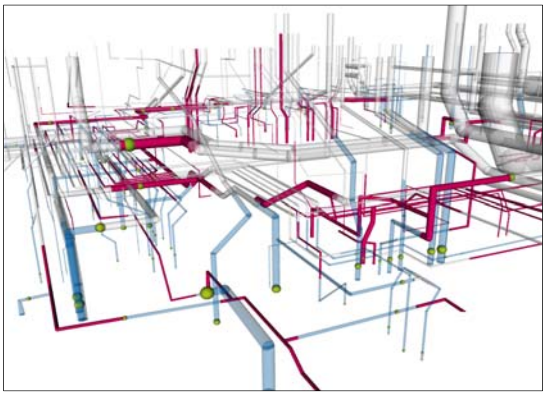

Figure 6b: Material distribution 2/4

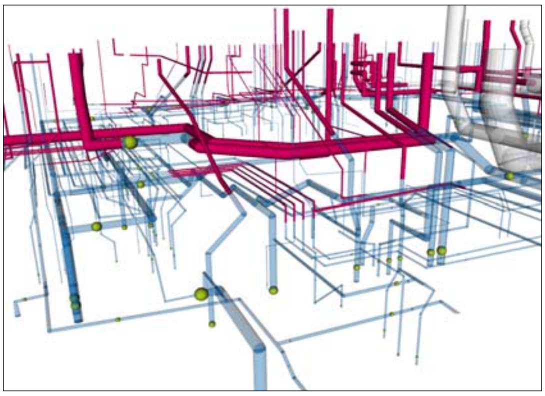

Figure 6d: Material distribution 4/4

5. INTERFERENCE OF PIPES

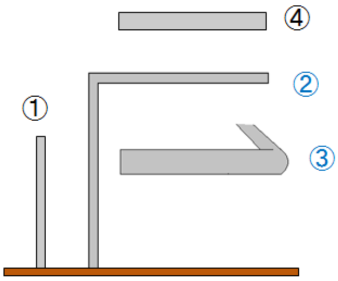

Figure 7: Problem of workability

In Figure7, order of piping is 1-2-3-4 following the way introduced in the section 4. However, When Pipe-2 is assembled earlier than Pipe-3, there is a risk that Pipe-3 cannot be assembled with cranes due to geometric reason. These pipes should be grouped into the same distribution in order to change assembly order manually. We added functionally for detecting interference between pipes during the transference of the pipes. This function is based on the assumption that pipes are installed by cranes. That allows considering the 3-D interference problem as a 2-D problem by projecting pipes on the X-Y plane. In this function, we approximate pipes with rectangles as Figure 8. Then this function judges interference by the positions of the sides of the rectangles. The result of interference judge of the engine room introduced in prior section is shown in Figure 9. Red pipes are interfered pipes.

Figure 8: Approximation of a pipe

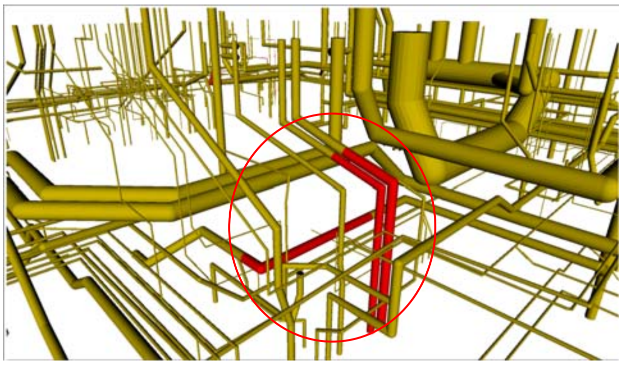

Figure 9: Interfered pipes

6. DISCUSSION

We tested our system with another data that has 1020 pipes.

Y Wei and U Nienhuis developed an automatic scheduling system of outfitting process planning. In their system order for piping is decide clearly. However, as mentioned in the section 4, the order for assembling pipes is different depending on the pipers, and unexpected problems may occur. Therefore it is difficult to decide detailed assembly order automatically. In our system, we consider that dividing pipes following order estimated roughly allows improvement of work efficiency without degrading on-site flexibility.

In the section 5 we approximate pipe with rectangles. For that reason parts of bends cannot be approximated accurately. However, it is no problem because on-site workers deal with the problem that pipes are a little interfered.

As a demand of the target shipyard, when the compartment is complete except for only one pipe, it is preferable to assemble the pipe regardless of its height (Figure7).

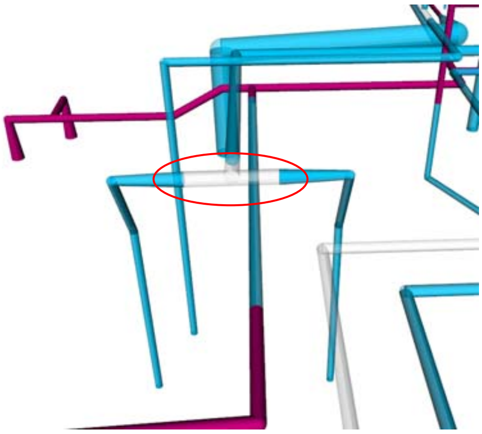

Figure 10: Problem of productivity

On-site supervisors in the target shipyard gave us quite positive comments. They judged that this system is so useful that they want to try it in practice and to confirm usefulness.

7. CONCLUSION

In this paper, we introduced the system which divides the pipes into several groups considering the assembling order that skilled workers adopt.The evaluation of this system in practical use is a future work.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

1. Y Okumoto, ’Shipbuilding Technology & Production System’, *Seizando-shoten publishing*, 2009 in Japanese

2. Y Wei and U Nienhuis, ‘An Automatic Schedule Generation System of Outfitting Process in Shipbuilding’, *International Conference on Computer Applications in Shipbuilding (ICCAS), 2009*

3. S Shindo and H Kimura, ‘A Material Distribution Scheduling for Rigging Ship-hull Blocks with Pipes’, *Conference Proceedings of the Japan Society of Naval Architectures and Ocean Engineers*, 2013 in Japanese

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