Systematic Conceptualizing – A Case Study

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ABSTRACT

Just over a year ago, I was given a design task – a gangway for the Caravan Stage Barge. Several restrictive requirements were stated, e.g.: 0.7 m (28") wide; two lengths (3 m or 10 ft, and 6 m or 20 ft reach from barge to land) should be readily available from the unit, but maximum length for storage should be no more than 3 m (10 ft); minimum weight and thickness were desirable.

Progress on designing this gangway is shown, starting from defining the requirements, using sketches and the thoughts and discussions (with the Stage Barge personnel) that accompanied them. Relationships of these thoughts and discussions, especially during conceptualizing, to existing design theory are shown. Emphasis is placed on how the models from the Theory of Technical Systems, and the procedures from Engineering Design can be used to make designing more effective. The role of calculations based on engineering sciences is also shown. The design process was necessarily iterative, but showed many signs of systematic procedure.

The resulting gangway has been fully detailed for manufacture, and can readily be seen as the result of innovative, and even creative activity.

1. INTRODUCTION

Just over a year ago, I was given a design task -- a gangway for the Caravan Stage Barge. This project has been under construction for four years, based on volunteer labour, many donations from companies and individuals, and highly artistic direction. The Caravan Stage Barge is a steel-hulled replica of a Thames river (London, England) cargo barge, with full sail rigging. It also contains two Diesel motors for propulsion, two Diesel motors for auxiliary power, living quarters for the actors, who also run the vessel, and full environmental waste treatment. As a main difference to the Thames barge, the former cargo space is decked over, with a raised section to give internal head-room. It has already been used for two different stagings, and many performances, of stage works written for this barge and its acting company.

One of the last tasks to be recognized was that the actors must easily and safely be able to move from the barge to the shore during a performance, and at other times. A dock-section was borrowed from a local marina for this purpose, but had to be returned before the Stage Barge left Kingston. A purpose-built gangway was desired, to be carried aboard and deployed when needed.

2. DESIGNING – GENERAL

Relationships of the thoughts and discussions involved in this design project to the existing design theory [1-5] are indicated in this paper, especially those that occurred during conceptualizing. Emphasis is placed on how the models from the Theory of Technical Systems [2], and the procedures from Engineering Design [3] were used to make designing more effective. The role of calculations based on engineering sciences (particularly stress analysis) is also shown. My purpose is "to clarify (by duly complicating) important issues" [6] about designing, to show that systematic methods and intuitive procedures (creativity) work very effectively together.

The design process was necessarily iterative and recursive, the problem had to be broken down into smaller but interacting sections. None of the parts could be designed with a quasi-linear procedure, such as is wrongly implied from the published models of design processes. Nevertheless, the design process that resulted still showed many signs of systematic procedures and models. This shows that in designing it is important to observe the design process, but also the advances made on progressively defining the product from its requirements to the detail drawings.

This report is, of course, a post-hoc reconstruction from my records. It is necessarily subjective, anecdotal, and can hardly be verified. No attempt was made to create a formal research protocol. The process took place over a period of about four weeks, partly at the Stage Barge, partly in my office at RMC, and even partly at home. Sketches and drawings are not easy to include in the report such as this, they can be obtained from me on request.

3. DESIGNING – CASE STUDY

Progress on designing this gangway started from defining the requirements, and writing a brief design specification, in discussions with the Stage Barge people. This also involved using sketches, and developing thoughts and discussions with the Stage Barge personnel to accompany these sketches. Guidelines for the contents of a design specification are available in the diagrams about classes of properties of technical systems, and the life cycle processes and their operators (see [1,2,3]).

Several restrictive requirements were stated for this design task, e.g.: width 0.7 m (28"); to be built in two lengths (3 m or 10 ft, and 6 m or 20 ft) to reach from barge to land (either a jetty, or a sloping shore-bank), but maximum length for storage should be no more than 3 m (10 ft); minimum weight and thickness were highly desirable, it should be handled by two persons, but a gantry rig was available for hoisting if needed.

The anticipated loading was from actors walking or running up or down. A possibility existed that the Stage Barge could be open to visitors to view the facilities. This would imply that a line-up of people could occur. We agreed on an assumption that three persons per meter (one person per foot) should be accommodated.

Following the proposed models of technical systems and the recommended procedure for conceptualizing a solution (see [1, 3]), examples for which are published in [4], the first consideration was about the processes of using this gangway, which added some items to the design specification

and prepared further work on designing. From its storage location on deck, the gangway must be either assembled on deck and then lifted out, or sections lifted out onto shore and assembled there. The barge end had to be fitted to the railing such that it could rotate through small angles, say 10° horizontal, 30° vertical. The hazard of people tripping at the ends of the gangway should be minimized. Protective safety ropes must be attached to avoid people falling off sideways.

The main functions of the gangway could be derived:

- support the people-load, react it at the ends to the shore and the barge;
- permit joining in the middle;
- permit attaching to the ends;
- permit erecting the safety ropes;
- permit rotations;
- permit hoisting;
- etc.

Each of these functions could be solved in various ways, and these were explored as principles, as organs (in this case single-degree-of-freedom or rigid joints), and then (or at the same time) in layouts of possible components [3].

For instance, supporting the people-load implies a bending stress. With that load and the full length of the gangway, the thickness of a four-in-parallel extruded channel section in aluminum would need to be about 200 mm (8"), compared to 100 mm (4") maximum as desirable. If the length of each bending section can be reduced to 1 m (3 ft), the thickness need only be 100 mm (4"). This can be achieved by a steel pre-tensioning cable taken round supports below the gangway deck. Using a computer program, I was able to establish that the supports needed to be 75 mm (3") high, the cable could thus be permanently installed inside the thickness of the gangway for each 3 m (10 ft) length. Pre-tensioning by turn-buckles was decided as best. Short end sections were also needed at the barge and at the shore, with hinged ramp pieces. All joints between the lengths needed to be pulled tight, which could be achieved by turn-buckles. A similar arrangement of pre-tensioning can be used at the joint between the two lengths. In order to ensure that this jointing pre-tension cable is always attached, a short center-section was included to carry this cable. This also meant that the two ends of each length, and of the center-section had to be different, so that wrong assembly could be excluded. This could be done by two plugs in the barge ends and two holes in the shore-ends, but at two different spacings to ensure correct placing.

The uprights to hold the safety barriers could be hinged to the gangway, or plugged in. The latter solution was chosen to maintain the 100 mm (4") thickness without protrusions. Each upright has two short horizontal tubes to allow threading two ropes at suitable heights, which seems to be acceptable for marine use.

These solutions-in-principle (an organ structure) had to be translated into preliminary layouts (mainly sketches) and full dimensional layouts. For this project, the layouts and the detail drawings were produced by hand -- pencil on paper. CAD could have been employed, but offered no real advantages, only one set of gangway was ever likely to be made, no alterations or updating was anticipated.

The resulting gangway has been fully detailed for manufacture. Fabrication took place in the summer of 1997, but was not completed before the Caravan Stage Barge motored out of Kingston Marina harbor. Tests and adjustments were specified to ensure that the gangway was serviceable. Whether these were performed, and what results of usage were (if any) has still not been transmitted to me.

Nevertheless, the product, the gangway, can readily be seen as the result of innovative, and even creative activity. The aspects of systematic processes and theoretical models which guided my work have entirely disappeared in the final product, they only exist in my records. This is one reason why design work and the use of systematic methods is generally misunderstood.

REFERENCES

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