

Defence Research and Development Canada Recherche et développement pour la défense Canada



vVICTORIA Shell

A Submarine Control Room Mockup

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Project Manager: Keith Bowden Contract Number: W7707-098243 Contract Scientific Authority: Mark Hazen, 902-426-3100 x176

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Defence R&D Canada – Atlantic

Contract Report DRDC Atlantic CR 2010-342 July 2011



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Abstract

This report describes the work done by ADGA Group Consultants Inc. to fabricate a Submarine Control Room Mock-up for DRDC Atlantic. The starting point commenced with a design supplied by DRDC from a previous contract. A trial section was constructed and demonstrated to DRDC, at which point minor changes were discussed and approved before completing the total fabrication. The whole mock-up was constructed in components that could be handled by two people and fit through an eight foot garage door, in order to facilitate delivery, assembly, disassembly and portability. The components were delivered to DRDC in the spring of 2010 and placed in a lay apart area until the target building was upgraded. In the fall of 2010 the final assembly was completed and the whole structure was finished with fire retardant paint.

Résumé

Le présent rapport décrit les travaux réalisés par ADGA Group Consultants Inc. relativement à la fabrication d'une réplique de la salle de commande de sous-marin pour RDDC Atlantique. Le point de départ a commencé avec une conception fournie par RDDC lors d'un contrat précédent. Une section d'essai de la réplique a été construite et on en a fait la démonstration devant RDDC; des changements mineurs y ont ensuite été proposés et approuvés avant de terminer la fabrication. L'ensemble de la réplique a été construite en composants qui pouvaient être facilement transportés par deux personnes et qui passaient sous la porte de garage haute de huit pieds, afin de faciliter la livraison, le démontage et la portabilité. Les composants ont été livrés à RDDC au printemps de 2010 et disposés en pièces détachées jusqu'à ce que le bâtiment cible soit mis à niveau. À l'automne de 2010, l'assemblage final a été réalisé et l'ensemble de la structure a été peinturée avec de la peinture ignifuge.

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vVICTORIA Shell: A Submarine Control Room Mockup

Earl Gosse; Keith Bowden; DRDC Atlantic CR 2010-342; Defence R&D Canada – Atlantic; July 2011.

Introduction: As part of an applied research project to investigate submarine control room processes DRDC Atlantic is developing a full scale VICTORIA class submarine control room emulation. A key component of the vVICTORIA is a representation of the control room shell to represent the constraints imposed by the submarine pressure hull, bulkheads etc. Essentially the shell supplies the "stage" within which human factors informed experimentation can take place. In a previous contract a CBC set designer was engaged to design a shell that would be modular, flexible and allow the conduct of experimentation. ADGA Group Consultants Inc. was then contracted to fabricate a full-scale mock-up of the structure based on that design. This document reports on the results of that implementation.

Results: Using the design a trial section of the mock-up was constructed and demonstrated to DRDC, at which point minor changes were discussed and approved. The rest of the components were then fabricated and delivered to DRDC Atlantic in early 2010. Due to scheduling the full assembly was not conducted until renovations to the target laboratory space were completed in October 2010. Once started the shell was assembled in approximately two weeks by three contractor personnel. Finally, to comply with fire regulations the mainly plywood structure was painted with fire retardant paint. The design and fabrication can be considered as successfully executed.

Significance: This mock-up provides the critical "stage area" within which experimentation on novel submarine C2 concepts can be conducted. It provides a purpose-built enduring capability which exactly emulates the physical constraints of the VICTORIA class control room, while providing all around access for data recording sensors and installation of new equipment. This is the first step in the development of this prototype for future Canadian naval capability evaluation laboratories.

Future plans: The VICTORIA class C3 HSI Optimization Study aims at conducting experimentation in late 2011. Over the intervening period the shell will be outfitted with consoles and other infrastructure to complete the emulation of the control room physical constraints and system capabilities.

vVICTORIA Shell: A Submarine Control Room Mockup

Earl Gosse; Keith Bowden; DRDC Atlantic CR 2010-342; R & D pour la défense Canada – Atlantique; Juillet 2011.

Introduction : Dans le cadre d'un projet de recherche appliquée visant à étudier les processus employés en salle de commande de sous-marin, RDDC Atlantique est en train de mettre au point une réplique pleine échelle de la salle de commande des sous-marins de classe VICTORIA. Une composante clé du vVICTORIA est une représentation de la salle de commande illustrant les contraintes imposée par la coque épaisse du sous-marin, les cloisons, etc. Essentiellement, la coque sert de « scène » pour réaliser une expérimentation éclairée sur les facteurs humains. Dans le cadre d'un contrat antérieur, un décorateur de la SRC a été embauché pour concevoir une coque modulaire et flexible et qui permettrait de réaliser des expériences. Un contrat a été signé par la suite avec ADGA Group Consultants Inc. pour fabriquer une réplique pleine échelle de la structure basée sur cette conception. Le présent document fait état des résultats de cette mise en œuvre.

Résultats : Pendant la conception, une section d'essai de la réplique a été construite et on en a fait la démonstration devant RDDC; des changements mineurs y ont ensuite été proposés et approuvés. Le reste des composants ont ensuite été fabriqués et livrés à RDDC Atlantique au début de 2010. En raison de l'échéancier, l'assemblage complet n'a pas été effectué avant la fin des rénovations à l'espace de laboratoire cible, en octobre 2010. La coque a été assemblée en environ deux semaines par trois employés. Enfin, pour respecter la réglementation en matière de lutte contre les incendies, la structure essentiellement constituée de panneaux de contreplaqué a été peinturée avec de la peinture ignifuge. La conception et la fabrication peuvent être considérées comme réussies.

Portée : Cette réplique constitue la « zone de scène » critique à l'intérieur de laquelle on réalisera les nouvelles expériences sur les concepts de sous-marin C2. Elle a été construite spécialement pour imiter exactement les contraintes physiques de la salle de commande des sous-marins de la classe VICTORIA, tout en servant d'accès multiple pour les capteurs et enregistreurs de données et pour l'installation de nouvel équipement. Il s'agit là de la première étape de l'élaboration de ce prototype pour les nouveaux laboratoires d'évaluation de la capacité navale canadienne.

Recherches futures : L'étude sur l'optimisation des IHM VICTORIA de classe C3 vise à réaliser des expériences à la fin de 2011. Au cours de la période intermédiaire, des consoles et d'autres infrastructures seront installées sur la coque pour simuler les contraintes physiques dans la salle de commande et les capacités des systèmes.

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1 Introduction

1.1 Subject of Report

This report describes the work done by ADGA Group Consultants Inc. to fabricate a Submarine Control Room Mock-up for DRDC Atlantic.

1.2 Outline of Report

This report is structured with an introduction, covering some of the background information, motivation for undertaking the work, the methods used, results, analysis of results, along with a summary covering conclusions and recommendations.

1.3 Background

It is understood that the submarine community has, for some time, demonstrated an interest in having the benefit of a submarine control room mock-up that would aid in developing future concepts. This initiative by the Maritime Command & Control Concept Development (MC2CD) group at DRDC Atlantic is of significant interest and has potential to provide a very positive outcome for the Submarine Fleet. Under a previous contract, a design for the shell structure for Deck 1, frames 34 to 55, was developed and preliminary costing completed in order to determine the scope for the research project. The modularity of the design allows the flexibility to support experimentation. The background information supplied as part of the RFP indicates that the original concept of a mock-up to cover frames 34 to 55 was to be reduced to frames 34 to 46, which is the key operational space of the control room area.

1.4 Motivation for Undertaking the Work

Typically it is extremely difficult to experiment with future concepts or even new equipment fits on a real platform because the submarine is frequently on operational commitments or in harbour, at which time it is often undergoing maintenance and repairs, causing many of the equipment spaces to be totally congested with ships staff and repair agencies. The need for a full scale mockup to serve as a vehicle for development of new C2 concepts for the VICTORIA Class submarine control room is well established. Development of new C2 concepts can fall into two broad areas, verification of adequacy of space and mounting arrangements for equipment fit, and optimization of space and equipment display accessibility for the submarine crew to effectively carry out its role. At the time of delivery the submarines had been "moth-balled" for some time without equipment updates. This, combined with a requirement to change some equipment in order to "Canadianize" the fleet, means that some of the fitted equipment will need a significant update; either in a piecemeal fashion or as a total upgrade in an overall program. This is particularly the case in the areas of data fusion and Combat System equipment operating displays and controls, which in particular need updates to enable the extraction and compilation of information from data that is available through both organic and remote sensors. The mock-up will assist in the effort to develop new concepts in how these equipment updates will be implemented and configured.

2 Methods Used

2.1 Background

From the outset DRDC indicated that it would house the mock-up in Building 3 for which renovations were being made to accommodate the structure. The work was divided into two phases, I and II. Under phase I the modular elements of the shell were constructed and delivered to DRDC Atlantic for storage until Building 3 renovations were completed. Phase I was completed by end March 2010. Upon completion of renovations ADGA, under phase II, installed and finished the shell structure within Building 3 at DRDC Atlantic. This occurred in the fall of 2010.

2.2 Work Approach

ADGA carried out the contract under the steps outlined in the RFP's Phase I, Tasks 1 - 4 and Phase II Tasks 1 - 2. For this work ADGA used a local team made up of employees, consultants and subcontractors. To keep the overall budget within manageable scope the team members were only called upon as needed for execution of their particular tasks. The ADGA head office is in Ottawa, but a local manager was available at all times to consult with the Project Authority as necessary.

2.2.1 Phase 1

2.2.1.1 Task 1 - Acquire materials

Following a validation of the mock-up design, ADGA, in coordination with the DRDC Project Authority (PA), acquired the majority of the materials required to complete the construction of the mock-up. The validation consisted of a thorough review of the design, in order to ensure there were no obvious flaws in the original model. Any deviations to the design were agreed to by the PA.

These deviations were minor and included:

- Substituting metal hatches with wooden hatches to reduce weight and improve safety on the upper level;
- An alternate arrangement for securing the side panels used for access;
- A better method of locking the two sides of the frames together to improve the strength of the structure;
- Finishing the edge of the frames to make it resemble a true T frame such as on the submarine;

- Alternate materials for access between frames thin wooden panels (and some plastic) were used for creating the curved hull shape between the frames in lieu of the foam originally specified in the design. A couple were completed with foam. This item arose for discussion at the time of assembly; and
- The upper level railing was modified to fit around the building roof beams. This was also an item that arose a time of assembly.

The result of the validation process constituted the final mock-up design. This was then used to establish a bill of materials. The majority of the items were ordered and acquired in Phase 1, leaving a small fraction of materials to be acquired in Phase 2.

2.2.1.2 Task 2 - Construct modular sections

Following establishment of the final design, ADGA, as outlined by the RFP SOW, constructed modular sections of the mock-up, such that individual modules could be handled by a maximum of two people and fit through an 8'x6' standard roller door opening. The construction was restricted to the design for frames 34-46. This was carried out in local facilities and open to viewing by DRDC at any reasonable time. Care was taken during the construction phase to ensure that appropriate construction standards were met and that quality fastening methods were incorporated to ensure that the modules would assemble easily and with overall integrity after assembly.

2.2.1.3 Task 3 - Assemble sample sections

ADGA assembled one 8 foot section of the mock-up at a local facility to demonstrate assembly process to the Project Authority.

2.2.1.4 Task 4 - Deliver modules and finishing materials

Upon completion of the acceptance by the Project Authority at the ADGA local facility, ADGA delivered all modules and finishing materials to DRDC Atlantic for storage.

2.2.2 Phase 2

2.2.2.1 Task 1 - Acquire remainder of materials

As the first task of Phase 2 in fiscal year 2010/11 ADGA acquired the remainder of materials required to complete construction of mock-up.

2.2.2.2 Task 2 - Complete assembly and finishing of mock-up

As the final task of the contract, ADGA completed the assembly of the mock-up and finished work in accordance with the final design. This was carried out at the DRDC selected site (Building 3).

3 Results

This section will largely convey the outcome of the work by showing some of the pictures captured at various stages of the work.

3.1 Demonstration Section

The photograph below shows the demonstration module fabricated in Phase I that was set up at a local facility and made available for the Project Authority and his team to view.



Figure 1: Demonstration section

At that meeting it was agreed with the PA that:

- a. The Grates/Hatches indicated in the design would constitute unnecessary weight, unnecessary cost, and introduce a safety hazard rather than solve any, hence wooden hatches with small access/lighting holes would be fabricated instead;
- b. The side Panels would be modified to add strength to the structure as well as facilitate the ease of removing some of the panels;
- c. The Overhead Beams would be braced/splined to add strength to the beam/arch/frame. This was an item that ADGA picked up in the original design as an

area of possible weakness, and in fact one of the frames broke during disassembly of the demonstration module; and

d. The number of Ladders would be reduced to one and located on the end of the structure with access from the platform.

Following the acceptance of the first section the remaining modules were manufactured in a similar manner to the first one with the exception that the changes discussed above were incorporated where appropriate. The manufacture of the remaining modules was completed without difficulty and completed and delivered on time.

3.2 Delivery

Upon completion of the acceptance by the Project Authority at the ADGA local facility, ADGA delivered all modules and finishing materials to DRDC Atlantic for storage in one of their shops. Method of delivery is depicted in the image below.



Figure 2: Delivering vVICTORIA components for temporary storage at DRDC

3.3 Assembly at DRDC Site

The images below show the various stages of assembly at the DRDC site, in the newly renovated building. The assembly phase was delayed after delivery of components in order to carry out building modifications to accommodate the structure. Some rework of the building modifications had to be carried out. The first modification was based on DRDC staff noting the interference of ventilation trunking. The second modification was picked up at the commencement of the assembly, when it was realized that additional ventilation trunking rerouting was required and that the upper deck railing would need to be cut in order to fit around roof beams. The specification by the DRDC customer that the structure would need to be finished with fire retardant paint, to comply with the Fire Marshal's requirements, also added to the scope of work during the assembly phase. The time and material to assemble and paint exceeded the original estimates, and a contract amendment was approved. This amendment covered the cost of the fire retardant paint and the services of a painter. However the final assembly was satisfactorily completed.



Figure 3: Initial sections being assembled



Figure 4: Further progress and discussions with the customer



Figure 5: Assembly stage shortly after installation of ladder and rails

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Figure 6: Detail showing where the upper level rail needed to be cut for roof beam



Figure 7: View underneath depicting the leg support arrangement



Figure 8: Final structure assembly



Figure 9: Internal view showing console mock-ups located on the left side of the shell.



Figure 10: Showing access from above through frames



Figure 11: Internal view showing console mock-ups located on the right side of the shell.

This work has pointed to the following lessons.

- 1. A set designer can be effective in thinking through some of the valuable features of such a mock-up. Some scepticism was initially met in having such a mock-up designed by someone who was neither a carpenter nor a submariner. However the team endeavoured to follow the design and model as closely as possible; and only made some structural changes where it was clear that the design was inadequate. One can observe that the final structure very closely resembles the small scale model built under a previous contract (model depicted below).
- 2. The search for material sources can be quite time consuming. One would think that materials for such a structure would be readily available in any building supply store. This was not the case. Some of the items were not easily located, and any of the common items such as screws and bolts are only stocked in limited quantities at building supply outlets, requiring visits to multiple outlets simply to get the necessary quantities.
- 3. Dimensions of the structure needed to be carefully taken into account when modifying the building to accommodate the shell. At the time of assembly it was necessary to have the ventilation rerouted, and to cut the upper level rails in order to fit around the building roof beams.
- 4. Fire retardant paint is expensive and has less coverage than one would estimate considering that it was being applied to smooth hardwood plywood.



Figure 12: Picture of model constructed under a previous contract

5 Summary

5.1 Summary of Results

ADGA Group Consultants Inc. fabricated a Submarine Control Room Mock-up for DRDC Atlantic. The starting point commenced with a design supplied by DRDC from a previous contract. A trial section was constructed and demonstrated to DRDC, at which point minor changes were discussed and approved before completing the total fabrication. The whole mock-up was constructed in components that could be handled by two people and fit through an eightfoot garage door, in order to facilitate delivery, assembly, disassembly and portability. The components were delivered to DRDC in the spring of 2010 and placed in a lay apart area until the target building was upgraded. In the fall of 2010 the final assembly was completed and the entire structure was finished with fire retardant paint. The final result was the successful completion of a submarine control room mock-up that will have valuable future significance to DRDC scientists as well as the submarine community.

5.2 Conclusions

It is concluded that:

- 1. The vVICTORIA Shell was successfully completed, largely adhering to the DRDC supplied design;
- 2. Some lessons were learned in executing the job, mainly related to minor design details and sourcing materials; and
- 3. The vVICTORIA Shell has potential to be of value to DRDC as well as the submarine community.

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Le présent rapport décrit les travaux réalisés par ADGA Group Consultants Inc. relativement à la fabrication d'une réplique de la salle de commande de sous-marin pour RDDC Atlantique. Le point de départ a commencé avec une conception fournie par RDDC lors d'un contrat précédent. Une section d'essai de la réplique a été construite et on en a fait la démonstration devant RDDC; des changements mineurs y ont ensuite été proposés et approuvés avant de terminer la fabrication. L'ensemble de la réplique a été construite en composants qui pouvaient être facilement transportés par deux personnes et qui passaient sous la porte de garage haute de huit pieds, afin de faciliter la livraison, le démontage et la portabilité. Les composants ont été livrés à RDDC au printemps de 2010 et disposés en pièces détachées jusqu'à ce que le bâtiment cible soit mis à niveau. À l'automne de 2010, l'assemblage final a été réalisé et l'ensemble de la structure a été peinturée avec de la peinture ignifuge.

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