Optimisation of the Neutron Beam Slit Aperture Assembly for an Ultra Narrow Design

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Introduction

To optimise the available space along neutron beamlines at the Australian Centre for Neutron Scattering (ACNS), ANSTO have sponsored a project to reduce the width of several neutron slit aperture assemblies. Previous assemblies vary from 50mm up to 100mm along the beamline and each B4C blade is individually controlled by four stepper motors. The following project goals were identified to guide the development of a new prototype assembly design:

1. Reduce the assembly width along the beamline (chassis width) to below 50mm,

2. Actuate the blades in symmetric pairs using one stepper motor per pair,

3. Provide the same performance metrics as the previous assemblies (Table 1).

Standard ANSTO design practices were followed to ensure due diligence in design and justification. The key stages of this project are outlined in Figure 1.

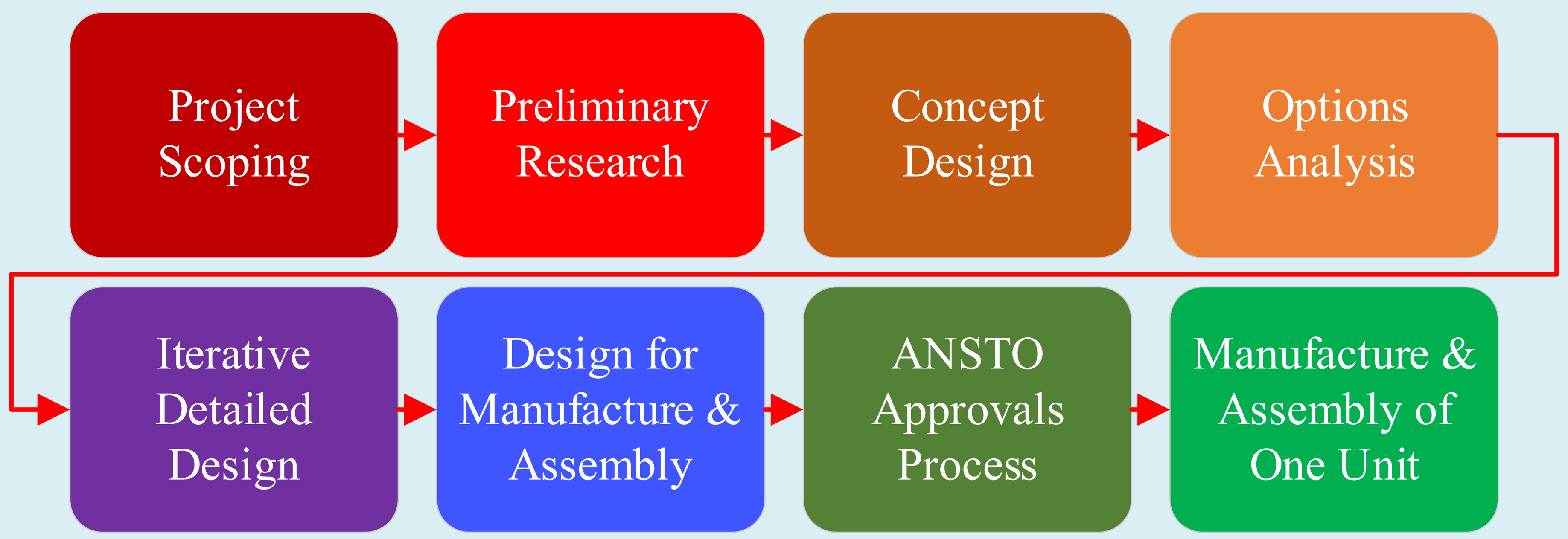

Fig. 1. Project Design Process

Design Process

Five concept designs were developed which underwent a comprehensive options analysis selection process to obtain the best-fit design. Several detailed design iterations were completed to obtain the final prototype design shown in Figure 2.

To actuate the blades in symmetric pairs, 6 mm bi-directional ball screws were selected from KSS Japan. This precision product gives symmetric functionality and has negligible axial play with sufficient resolution for this application.

The broad process for modelling the optimised assembly was to place the smallest suitable components (motors, ball screws, encoders, etc.) close together and then fit a complex chassis structure around them. This chassis is the blue piece shown in Figures 2 & 3.

Material selection for components is limited because of radiation constraints so aluminium 6061-T6 was used for all bespoke components. By reducing the size of each critical component a substantial reduction was achieved.

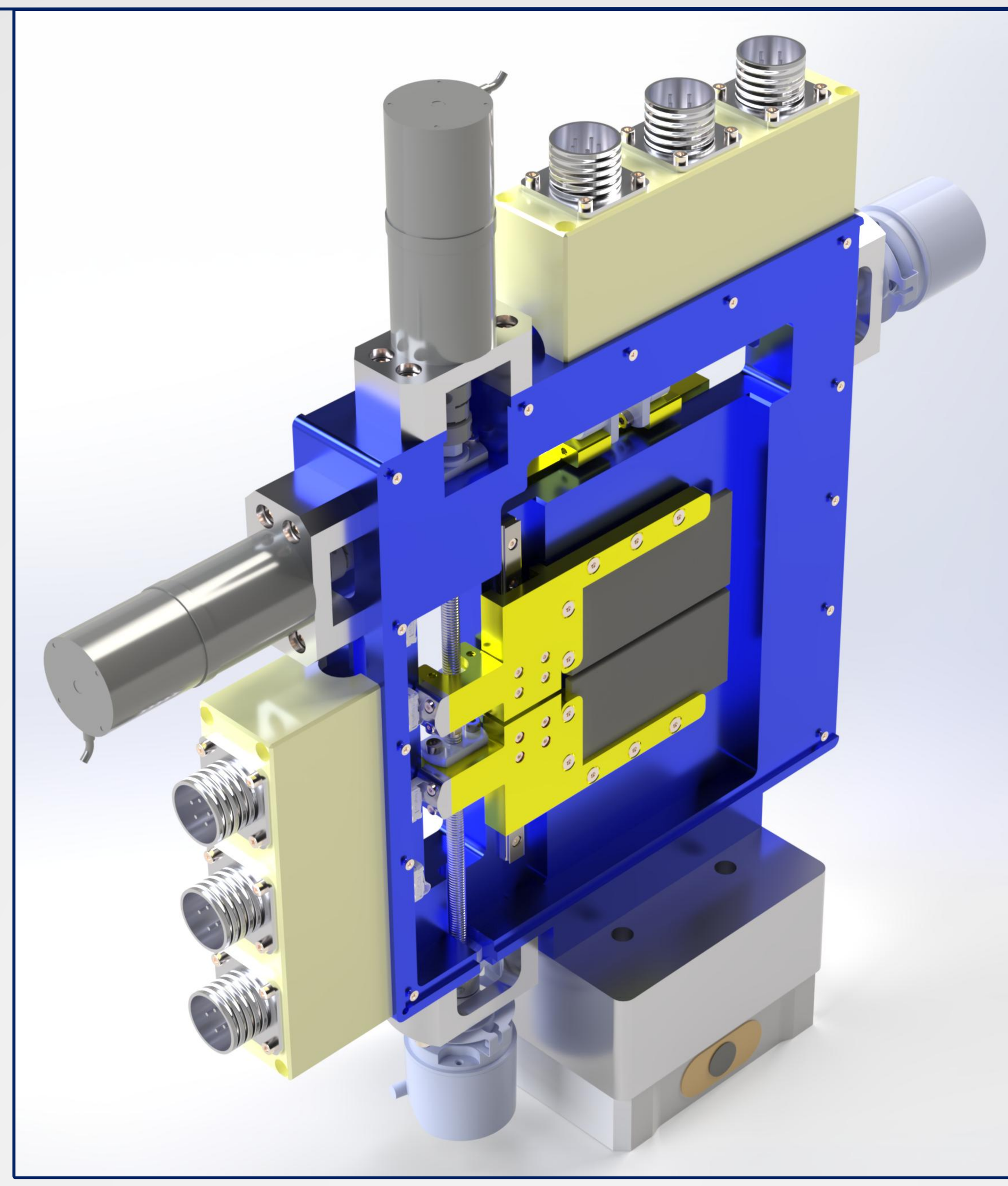

Fig. 2. Design For Manufacture and Assembly - Prototype CAD Model Rendered

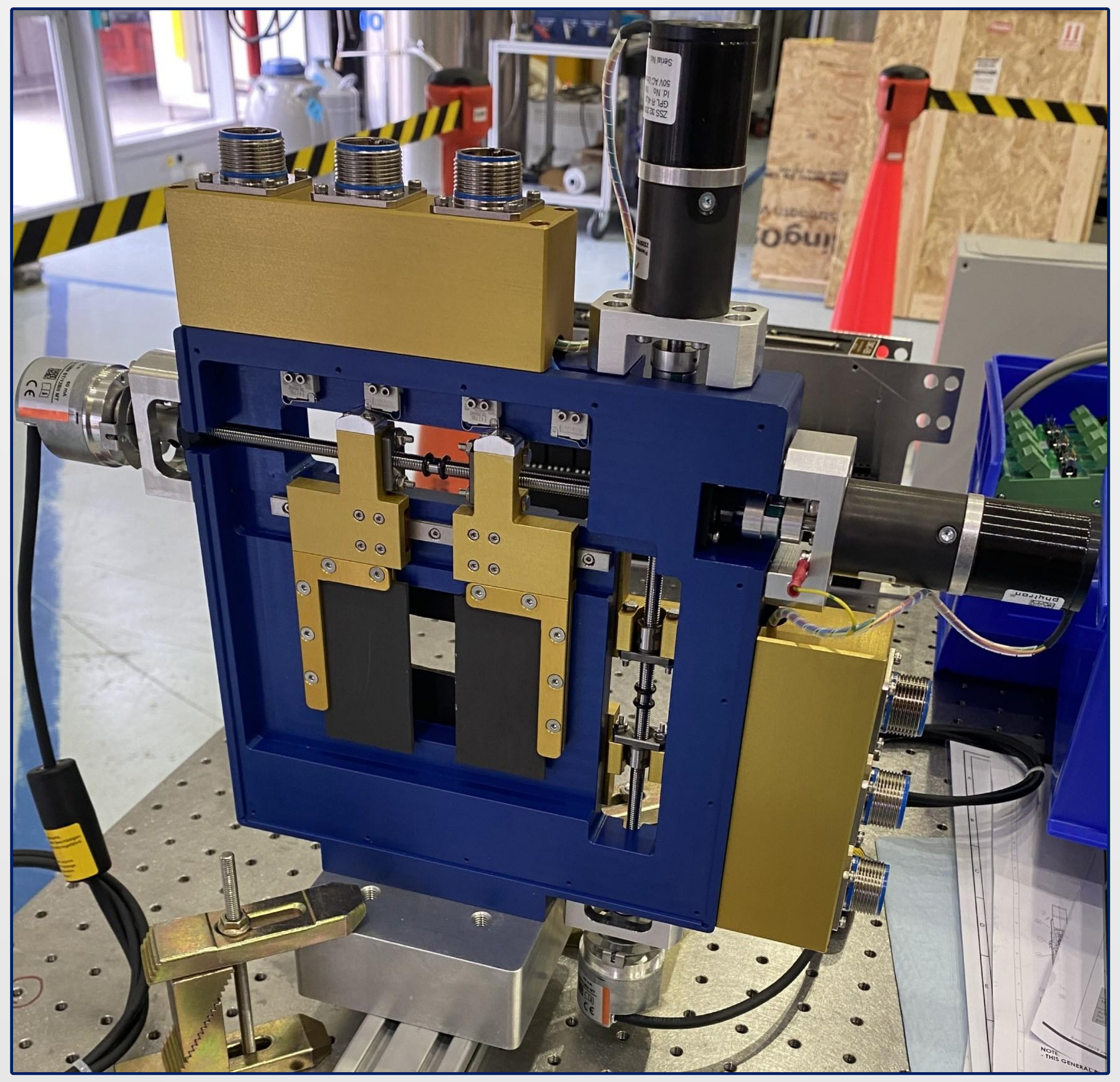

Fig. 3. As-Built Prototype Model

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Results

Table 1 compares critical parameters of the new design to the previous design and Figure 4 illustrates the progression of the slit assembly designs.

Table 1. Key System Parameters Comparison

Item	*Spatz 4-Axis Slits*	*Prototype Slits*
Bounding Box	493.24 x 492.47 x 116.18 mm	393.38 x 366.73 x 105 mm
Chassis Width	50 mm	38 mm
Mass	10.20 kg	6.24 kg
Cost (AUD)	$ 46,140.15	$ 23,187.27
Accuracy	1.0 µm	1.0 µm
Resolution	0.1 µm	0.1 µm
Repeatability	0.5 µm	< 0.3 µm

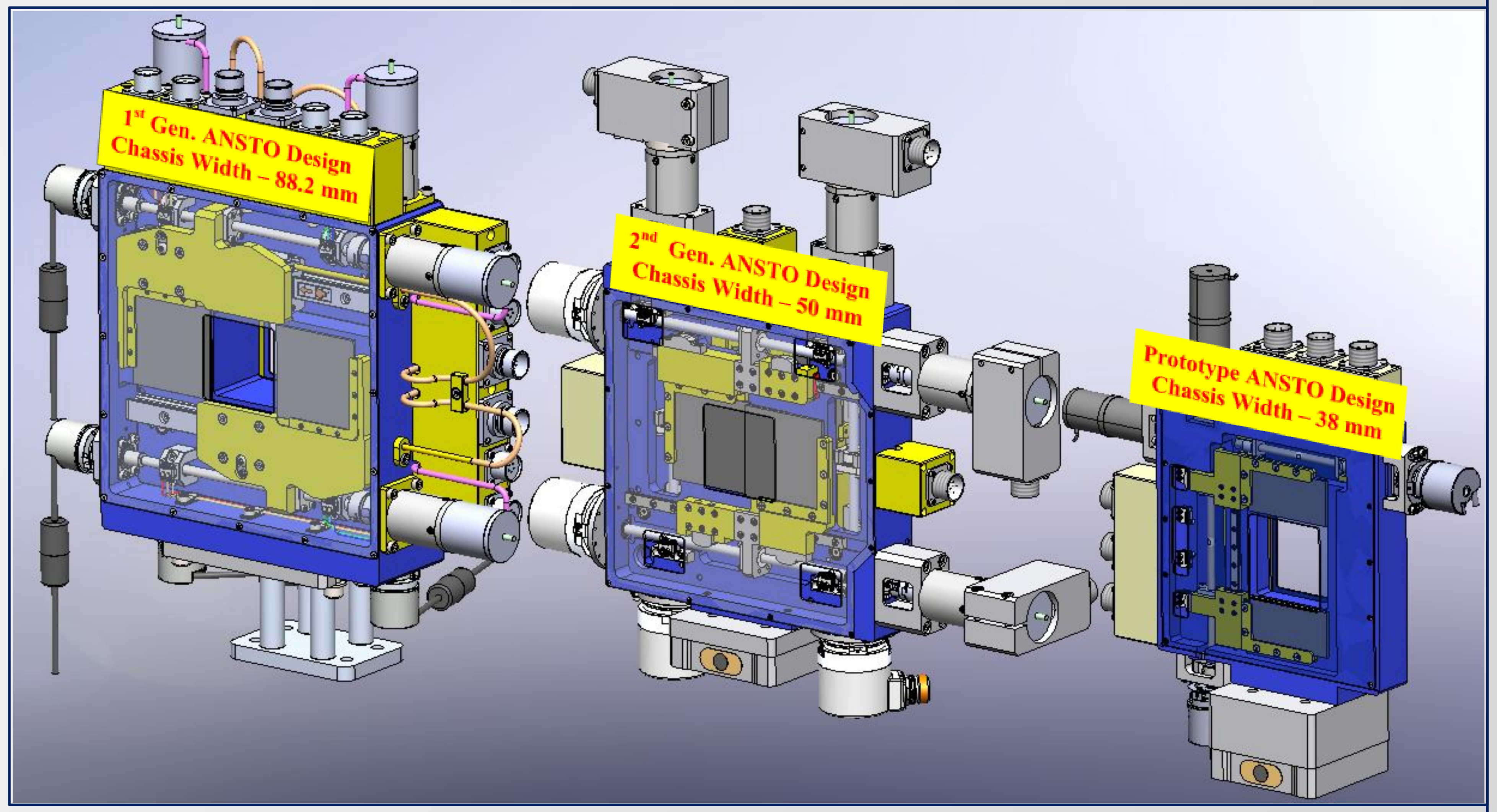

Fig. 4. Footprint Reduction Comparing Previous Generation Designs

Conclusion

The prototype assembly was designed, manufactured, assembled, and tested on schedule according to standard ANSTO practices. The new design reduced the chassis width to 38mm which is a 24% decrease at a 49.7% cost reduction.

Bi-directional ball screws allow the vertical and horizontal slits to move in symmetric pairs. Some minor items were identified during assembly for drawing updates drawings before manufacturing more of these assemblies in the future.

The precision metrics of the motor/ball screw motion were taken from the encoder and statistical analysis was undertaken to find the repeatability. The resolution was the same as the screw pitch and micro-steps were unchanged. The movement accuracy tested within 1.0 µm and the repeatability tested better than the previous design based on the std. deviation of the mean.

Based on these results and the significant footprint reduction achieved, this prototype is an excellent solution to this project and is suitable for use at ACNS.