Individual Progress Development and Project Planning (IPDPP)

Dextrous robotic hand with multi modal sensing

Mechanical design and prototype manufacturing

Author:

Shannen Venethethan

Student ID: 210478226

Group 239

Project Supervisors / Advisors:

Dr Ketao Zhang

Dr Arsen Abdulali

Jianlin Wang

Chen Liu

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Record of Continuing Project Progress and Development

Entries in this table have been assigned the identifier EN which will be used in section following this one.

TABLE 1: Continuing Project Progress and Development Log

Entry No. (EN)	Date	Summary of Actions	Next Steps
1	23/09/2025	Project allocation was confirmed based on previous project selections. The team was formed, a formal communication route on Microsoft Teams and WhatsApp group were created. An initial meeting with Dr Katao was scheduled for 25/09/2025.	Attend supervisor meeting and confirm project brief
2	26/09/2025	The whole team in person joined a MS Teams meeting with project supervisor Dr Katao Zhang and the advisors Dr Arsen abdulali, Jianlin Wang and Chen Liu whom will aid and guide us during the project. The initial brief was given and sections allocated. I was assigned the design/mechanical stream. Internal task of 2 pages of condensed info with references was set for the following Thursday. Bi-weekly advisor meetings were agreed.	Complete internal task mainly focusing on the most up to date project and designs
3	02/10/2025	Completed the initial research into existing robotic hand designs in the agreed two pages of condensed notes with links to relevant papers format. This helped build early understanding of current designs, possible design directions and the technical context for the project.	Use research findings to support CW1 RAO planning.
4	04/10/2025	Completed the initial research into existing robotic hand designs in the agreed two pages of condensed notes with links to relevant papers format. This helped build early understanding of current designs, possible design directions and the technical context for the project.	Use research findings to support CW1 RAO planning.

5	07/10/2025	The scheduled meeting was attended by all members and CW1 RAO requirements were discussed and task were allocated. The orca files were examined to assess whether the open-source design could be adapted for the project's mechanical and sensor-integration requirements.	Continue ORCA CAD review and raise issues with advisors.
6	09/10/2025	Attended an online advisor meeting and confirmed that a follow-up internal team meeting would be held the following Tuesday. This helped to ensure communication was maintained between advisor feedback and internal team planning.	Prepare for internal meeting on motor count, finger count and part list.
7	14/10/2025	Held an internal team meeting where the initial motor count, finger count and V1 part list were discussed and finalised for submission. These decisions provided an early mechanical architecture for the hand and helped define procurement and design constraints.	Test whether ORCA STEP files can be edited for the required design changes.
8	17/10/2025	The first step in this process is to attempt to utilize the publicly accessible ORCA STEP files as an editable base model for the project. Repeated attempts were made at converting these models to a reliable parametric solid body that would allow for the necessary design modifications. The decision was then made to move forward with an entirely new original CAD model redesign of the entire system. This decision was also discussed with Dr Katao and all members of the team. While utilizing an entirely new design will increase both the amount of work to be completed and extend the time needed to complete the project, the resulting model will include an editable assembly that supports the addition of sensors, routing of tendons, future modification and the potential for academic reuse.	Validate the redesign decision by studying ORCA finger kinematics.

9	20/10/2025	To grasp an understaning of the kinetamtics of the Orca hand fingers 2 complete fingers were printed from their publicially available files in PLA using the a Bamboo LAB A1	Discuss redesign justification and actuation strategy with Dr Katao.
10	21/10/2025	Met with Dr Katao to justify the move from ORCA adaptation to a from-scratch mechanical redesign. The professor supported the redesign approach and suggested underactuating two fingers to reduce motor count and cost, lowering the expected motor requirement from 16 to 10.	Begin V1 CAD development using revised actuation strategy.
11	28/10/2025	Started V1 Cad Development. Developed the Fingertip Geometry First as it will directly effect sensor Placement, Tendon Anchors, Joint Layout and Phalanx Proportions . This allowed the design to develop from the contact/sensing end of the finger rather than only from the base structure.	Continued Development of V1 Finger and Check How Tip Affects Middle/Proximal Phalanges
12	31/10/2025	Held an internal meeting to discuss the costed bill of materials and complete the order form. The motor count, bearings, tendon material and prototype consumables were considered against the project budget and expected design requirements. This helped connect the mechanical design direction to procurement and cost constraints.	Continue CAD development using confirmed/expected hardware constraints.
13	06/11/2025	Continued V2 CAD development, building on the initial fingertip and finger layout. The aim was to progress from isolated part modelling towards a more complete finger assembly that could be reviewed for printability, assembly and actuation feasibility.	Prepare V2 CAD for supervisor/team review.

14	13/11/2025	Completed my allocated CW1 RAO presentation slides. These slides communicated my mechanical design responsibilities, early design direction and how my work package supported the wider team aims.	Rehearse RAO presentation with team and refine content.
15	14/11/2025	Took part in an internal RAO presentation polishing a session. The team reviewed slide flow, speaking order and consistency between individual sections to improve the clarity of the group presentation.	Complete final checks before CW1 RAO submission/presentation.
16	17/11/2025	Completed final internal checks of the RAO presentation, scripts and coursework submission as a group. This ensured the project aims, objectives, responsibilities and early design direction were presented consistently before submission.	Continue developing the mechanical CAD.
17	25/11/2025	I presented my current V2 CAD design to gain feedback on it. The idea we had at that time for the joints were based on using socket button fasteners and although the fingertip shape was designed with similar curves as the original ORCA fingertip, I received advice from Dr Katao, to not use an identical ORCA fingertip shape. As a result of this I conducted a further critical evaluation on how much of the inherited geometry would be beneficial for our needs with regards to sensor integration, printing and assembling.	Start V3 CAD using supervisor feedback to revise fingertip and joint geometry.
18	28/11/2025	Started V3 CAD development based on the feedback from the V2 review. The next design iteration aimed to move further away from ORCA-derived geometry and towards a more original, manufacturable and sensor-compatible finger structure.	Arrange internal meeting to confirm motor/sensor constraints for V3.

19	01/12/2025	Scheduled an internal team meeting to confirm hardware and sensor requirements before continuing with the next CAD iteration. This was needed because motor count, fingertip sensor size and sensor location would affect the mechanical packaging.	Hold meeting and confirm motor count, sensor location and usable fingertip area.
20	02/12/2025	Held an internal meeting to confirm how many motors had been ordered and to discuss the fingertip sensor size, usable sensing area, expected number of sensors and possible sensor locations. These decisions helped tailor the CAD around the sensing subsystem rather than treating the fingertip as a purely mechanical part. This improved interface management between mechanical design and sensing/electronics requirements.	Update CAD to reflect confirmed sensor and motor constraints.
21	05/12/2025	Rehearsed the CW1 presentation on Teams with the group. My section covered the introduction, RAO and sub-RAO, so the rehearsal was used to improve timing, flow and consistency between my mechanical design section and the wider team project aims.	Present CW1 RAO and early mechanical direction to Dr Ketao.
22	08/12/2025	Presented the CW1 RAO in the meeting with Dr Ketao. I also presented the V2 CAD assembly, which showed the early overall hand geometry and part layout. At this stage the assembly was still at an initial level of detail and did not yet include full tendon routing, as the design was being developed from broad geometry towards detailed actuation features. Dr Ketao advised that the carpal geometry should move closer to the ORCA thumb-holder angle.	Use feedback to progress V3 CAD and improve carpal/thumb geometry.

23	15/12//2025	Agreed on the FSR fingertip sensing concept with Sahimaa. The proposed sensor is to be a moulded FSR with a max circular diameter of 6mm located at the fingertip, as it is here that natural contact will occur when pressing against objects. A suitable mechanical mounting for the sensor was agreed upon by brainstorming to enable a realistic fingertip design.	Model the sensor mounting feature into the fingertip design.
24	17/12/2025	Shared the final V2 CAD with Dr Ketao and the advisors on Teams. The main limitation of V2 was the joint concept, which had not yet moved to a bearing-supported approach. Feedback was that the work was a good start, but progress was understandably slow because this was my first time modelling a robotic hand. I began V3 CAD with the aim of improving the geometry and adding sensor-mounting features.	Develop V3 CAD with improved joint geometry and sensor mounting
25	18/12/2025	Ordered hardware for next-day delivery, including ORCA-reference bearings, nylon fishing line and PLA, to keep mechanical development moving quickly. I used the ORCA bearing sizes as a reference point while continuing to develop our own geometry. I also raised a concern that Richard’s software training model and my redesigned CAD used different pivot points. This was clarified early to prevent the mechanical/software difference becoming an integration issue later.	Continue CAD development while monitoring software/mechanical compatibility.

26	19/12/2025	Reflected on the sustainability implications of the modular fingertip and hand design while preparing CAD/STL files to support the in-house FSR sensor work. The design had moved away from a single fixed hand structure towards replaceable fingertips, split phalanx parts and detachable subassemblies, meaning that damaged or unsuitable parts could be replaced without reprinting the subassembly . I also considered printing waste during prototyping. I tested the idea of using multi-filament support material, but decided against it because it would increase material waste and complexity. Instead, I used slim tree supports where possible because they were easier to remove and reduced unnecessary support material. I finally made the decision to use PLA for prototyping because it was reliable, low-cost, recyclable in principle and suitable for rapid iteration. however I do recognise that failed prints and long-term PLA durability remain sustainability limitations.	Continue V3/V4 development while keeping modularity and print waste in mind
27	27/12/2025	Continued V3 CAD work on the fingertip, middle phalanx and routing. This was the first stage where tendon routing was being implemented rather than only developing the outer part geometry. The main challenge was creating an internal tendon path through the hand and fingers.	Refine fingertip routing and check early actuation path.
28	05/01/2026	Developed the early V3 fingertip routing. The tendon path and anchor position were explored at a very early stage, while also keeping space for the fingertip sensor. The tip was not yet split into separate printed parts, so this stage was mainly used to test routing ideas before committing to a more manufacturable structure.	Continue routing development into the middle phalanx.

29	10/01/2026	Worked on routing the V3 middle phalanx tendon. I had to remove the hard-stop for now in order to make it easier to judge the route of the tendon. Before I add additional constraints back into the design, I wanted to have a clear route of the tendon first. After seeing how tight areas of the finger were, I realized there will need to be additional clearance added so the tendon can move easily.	Continue the same routing approach into the proximal/end section and check whether the path still lines up with the carpal.
30	15/01/2026	Developed the V3 routing through the proximal/end section and into the carpal. This was an important change because the design started moving away from the earlier V2 joint approach and towards bearing-supported joints. I also had to think about how the proximal section would transfer movement between different planes, since one joint direction did not line up directly with the next. The carpal routing was started for the fully actuated fingers, with separate tendon paths planned to avoid the lines crossing or rubbing unnecessarily.	Review the full V3 routing as one system and start work on the fingertip sensor/casting concept.
31	18/01/2026	Started the first fingertip casting idea for the FSR cover. I did not want the sensor to look like it had just been stuck onto the outside of the finger, so I began modelling a moulded silicone cover around it. I made a negative mould in CAD to test how the soft cover could be formed and how the FSR could sit inside the fingertip without being directly exposed.	Build the next fingertip CAD around this mould idea and check whether the sensor insert can still be removed if it needs replacing.
32	22/01/2026	Started the V4 CAD assembly. The move from V3 to V4 was needed because the routing became more complex; instead of a simple single-channel route, the design needed separate up/down tendon paths in several sections. V4 also began moving towards split parts so the design could become more printable and suitable for one-finger testing.	Complete V4 as the first testable one-finger design.

33	02/02/2026	33 Sent Jian the full assembly, fingertip, mould negative and STL files so the in-house FSR sensor work could be assessed and manufactured around the current mechanical design. I explained my idea for a removable tip module instead of the professors suggestion of a ring like assembly as looked more like a research attachment than an integrated prototype and was less well packaged. The alternative integrated fingertip design was more product-like and easier to replace.	Use feedback from Jian to refine the fingertip and mould design.
34	04/02/2026	Printed the V4 fingertip and first negative mould for review. I also met with Jian, confirmed that the printed tip and mould fitted as expected, and sent him the current CAD version. After this stage, the design direction was adjusted so the thumb part could be detachable.	Update CAD based on printed fit and detachable thumb requirement.
35	05/02/2026	Suggested an internal deadline for the following Wednesday to produce a one-finger assembly for testing, which the team agreed. This was chosen as a validation step before committing to a full-hand print. The V4 one-finger rig was completed for first test printing and shared with the team and Dr Ketao for feedback.	Print and manually test the V4 fingertip/finger rig.
36	08/02/2026	Carried out manual V4 tip-only actuation testing, focusing mainly on the tendon anchor. The test showed that the anchor could transmit motion, but also revealed coupled motion that needed to be considered in later design iterations.	Test the full one-finger rig manually.
37	10/02/2026	Carried out manual wire actuation testing on the V4 one-finger rig. The finger flexed correctly, but the test showed that slightly larger tolerances would improve assembly and motion. It also showed that the ORCA-reference bearings were too small for the developing design, so larger and thinner 1063ZZ bearings were selected from V5 onward.	Update tolerances and bearing choice for the next iteration.

38	13/02/2026	Assembled and printed a one-finger rig with 0.5 mm clearances and handed it over to the electronics and software team members with the tendon, motor, spool, frame and test rig. I explained the intended actuation method and clearly stated the known limitations. This allowed electronics/software testing to begin before the full hand assembly was complete.	Use feedback from electronics/software testing to guide the next design iteration.
39	16/02/2026	Organised a Teams meeting to coordinate the upcoming coursework work. This helped keep the group aligned before the CW2 poster tasks and internal deadline were finalised.	Assign CW2 poster sections and agree internal deadline.
40	17/02/2026	CW2 A1 poster sections were assigned and the internal deadline was set for 19/02/2026 ahead of the final due date. I was assigned the mechanical design section, which required summarising the CAD development and mechanical contribution clearly for a poster format.	Complete mechanical design content for the CW2 poster.
41	20/02/2026	Completed final team checks for the CW2 poster submission. I contributed to reviewing consistency, figures, formatting, references and technical content before the document was submitted as a group.	Return focus to mechanical CAD and underactuation development.
42	23/02/2026	Proposed adding another motor for the underactuated fingers to improve control. The idea was accepted conceptually, but was not implemented because it would have increased cost without enough performance benefit for the project scope. This helped confirm that the reduced-actuation strategy was still the better compromise.	Continue underactuated finger development within motor-count limits.

43	24/02/2026	Attended a team meeting with Dr Ketao. Dr Ketao suggested rotating the thumb joint to improve reach towards the little finger, improving opposition and grasp posture. A copper tube was also suggested as a possible tendon guide in the carpal; this was purchased but not implemented. The thumb angle feedback influenced the next hand geometry decisions.	Apply thumb-angle feedback to the next CAD iteration.
44	24/02/2026	Assembled V5 with two underactuated fingers. During an unplanned meeting with Jian, hard stops were suggested because the fingers were able to move backwards further than required. This feedback was used to improve the next iteration by limiting unwanted extension and making the motion more natural.	Integrate hard stops into the next finger iteration.
45	27/02/2026	A revised one-finger thumb rig was tested and assembled mainly by the software and electronics colleagues. This helped continue subsystem testing while I focused on the main hand design, although this rushed thumb rig did not directly feed into the V7 design.	Continue main-hand CAD development towards V7.
46	06/03/2026	Progressed V7 CAD with the index and middle finger MCP joint designed to allow approximately 135 degrees of movement. This was selected to allow the hand to lie flat when open while still allowing the fingertip to reach towards the carpal area when flexed. Hard stops were used to prevent excessive backward motion and improve human-like opening/closing behaviour.	Complete V7 CAD and motor mount for ILF preparation.
47	09/03/2026	Completed the full V7 CAD, including the hand assembly and motor mount, at 2.46 am to meet the ILF preparation deadline. This stage involved strong time pressure because the design had to be printable, assembled and ready for demonstration.	Print V7 hand assembly and motor mount for ILF.

48	10/03/2026	Printed the full V7 hand assembly and motor mount ahead of the ILF. The aim was to produce a physical assembly that could demonstrate the mechanical architecture and show the latest carpal routing development. Several print failures occurred during this stage, requiring rapid troubleshooting.	Finish printing remaining V7 parts and prepare ILF assembly.
49	11/03/2026	After many print failures, all required parts were successfully printed by 0.33 am. A key issue was attempting to print too many parts at once, which increased the risk of print failure and affected the schedule. This highlighted the importance of print planning and risk management when manufacturing a large multi-part prototype under time pressure	Assemble printed parts and prepare ILF demonstration.
50	11/03/2026	Presented the project at the ILF event. Most of the assembly had been completed at home, and the carpal was wired and assembled within the first 30 minutes of the event. I explained the assembly and routing to guests, supervisors and industry contacts who asked how the mechanism worked. The one-finger rig was fully actuating from the start of the event, demonstrating system feasibility, while the full hand remained at prototype assembly/integration stage.	Print additional sensor fingertips and continue final integration.
51	17/03/2026	Printed extra fingertips to house the sensor modules. These provided additional parts for sensor integration and reduced the risk that one failed sensor housing or casting attempt would delay the full hand assembly.	Prepare hand for electronics/sensing handover.
52	21/03/2026	Scheduled the handover of the assembled hand to the electronics team for continued integration and testing. This ensured the mechanical assembly could be passed on in time for wiring, actuator checks and subsystem testing.	Complete handover to electronics.

53	23/03/2026	I handed over the ILF Prototype to Seagull in order for continued work to occur on the Hand's electronics. The Hand contained all major components such as the Main Mechanical Assembly, Motor Hub, Tendons, Carpal Section and Fingertips. I walked through the route of the wiring with her.	Keep in contact during the electronics work and record any issues with tendon tension, motor access or wiring space.
54	23/03/2026	Concerns were raised by the sensing and electronics team during integration, mainly around tendon tightening and how the motors were orientated in the hub. Since the hand had not yet been fully actuated, I treated this as a mechanical interface issue rather than a failure of the design. We discussed the concerns internally and agreed that I should take the hand back to make small improvements before powered testing continued.	Update the motor hub and tendon access points so that the next handover is easier for the electronics team to work with.
55	24/03/2026	Held an internal meeting to address the concerns raised after handover, followed by a meeting with Dr Ketao. I took the hand back for mechanical improvements rather than continuing with unresolved integration concerns. This allowed the design to be improved before further testing.	Update the motor hub/routing and prepare revised assembly.
56	25/03/2026	After the first handover issues, I agreed with the team when the improved prototype should be handed over again. I also ordered more PLA and replacement fishing line, because I did not want small material shortages to delay the next build or stop me replacing any damaged parts. This was mainly a recovery and preparation step so the next integration attempt would be smoother.	Finish the motor hub/mount updates and prepare the hand for the next integration handover.

57	27/03/2026	Agreed the next handover date for the assembled hand. I also ordered additional materials, including PLA and new fishing line, after advice from Dr Ketao. This reduced the risk of material shortages delaying the next assembly and testing stage.	Complete updated motor mount and assembly preparation.
58	28/03/2026	Completed and assembled the V3 motor mount, which combined with the V7 hand assembly. This continued development of the actuator mounting system needed to support the motor/spool layout for testing.	Finish full system assembly for testing.
59	29/03/2026	Prepared the fully assembled system for testing, with the main remaining task being attachment and routing of the tendons to the motor spools. Testing was paused until the movement direction and tendon/spool arrangement could be confirmed, reducing the risk of incorrect actuation.	Complete tendon wiring as a team before powered testing.
60	30/03/2026	The mostly completed hand was brought in and tendon spool wiring orientation was set as a team in person and was final tendon wiring was completed and handed the system over to Seagull for electronics testing. This marked the transition from mechanical assembly to integrated mechatronic testing.	Carry out first powered movement test of the assembled V7 hand.
61	31/03/2026	Conducted the first powered movement test of the assembled V7 hand. This provided initial validation that the mechanical assembly could move under actuator control, while also identifying areas requiring further tuning and inspection.	Review actuation issues and collect feedback from electronics/software testing.
62	01/04/2026	Richard supported Seagull with daisy-chaining motor 9. This highlighted the dependency between software/control, electronics wiring and mechanical access to the motor hub. It also showed that future mechanical layouts should continue to consider maintenance and wiring access, not just compact packaging.	Continue integration checks and identify any mechanical actuation issues.

63	06/04/2026	Issues were raised during testing: the thumb was not actuating as required, and the middle finger had a twisted tendon/wire that caused more friction than intended. These issues showed that tendon routing, inspection and assembly quality directly affected actuation performance. The problems justified further mechanical improvement rather than continuing with the existing V7 routing unchanged.	Hold internal meeting and plan carpal/routing redesign.
64	07/04/2026	Dr Ketao's meeting was cancelled shortly before it was due to take place, so an internal meeting was held instead. I took the hand back with a rough one-week timeline to address the actuation concerns. I used the opportunity to redesign the carpal to reduce the bend the tendons needed to pass through, while Sahimaa continued progressing the sensing work separately. This became a key example of parallel multidisciplinary development.	Redesign and assemble the V8 carpal with reduced tendon bending.
65	10/04/2026	Assembled the V8 carpal and designed smaller springs for the underactuated fingers. The V8 carpal was intended to improve tendon routing and reduce friction compared with V7, while the smaller springs improved the packaging of the underactuated mechanism.	Complete final assembly using the V8 carpal.
66	13/04/2026	Completed the final assembly with the V8 carpal and routed all tendons to minimise friction. This involved reducing sharp bends, improving route clarity and checking tendon paths before the next handover.	Demonstrate the final assembly to Dr Ketao.
67	14/04/2026	Attended Meeting with Dr Ketao and handed over the hand for review. during the meeting i showed that the up to date prototype was able to actuate as intended and was able to be as dexterous as designed	Await electronics testing footage and feedback.

68	16/04/2026	Seagull shared footage of the hand being actuated after handover. This provided evidence that the integrated electronics and mechanical assembly were able to produce powered movement.	Plan final integration with the sensing subsystem.
69	17/04/2026	Held a short internal meeting to plan final integration with Sahimaa on 21/04/2026. The meeting clarified the timing and sequence for fitting the moulded sensor fingertips and completing the final prototype integration.	Integrate moulded sensor fingertips into the final hand.
70	21/04/2026	The final fingertips which included the moulded sensors were integrated realising the final prototype. During the first phase of testing after HANDOVER, the base thumb tendon slipped its routing and was trapped between the two parts that make the proximal phalanges causing friction. The thumb was then actuated before the tendon path had been fully checked, which caused the tendon at the spool side to catch and wind into the DYNAMIXEL drive shaft area. This was promptly fixed when I integrated the tips and actuation was verified. This highlighted the need for a clearer pre-test inspection process, including checks for tendon routing, spool clearance and loose wiring before powered actuation.	Add pre-test inspection checks to future handover/testing process

71	22/04/2026	I reflected on the safety of the actuated hand design, particularly the consequences of tendon failure, pinch points, rotating motor spools, exposed wiring and heat-set insert installation. I considered that the main tendon routing is internal through the fingers, carpal and hub, reducing the chance of a failed tendon whipping outward towards the user. The choice of nylon tendons was considered carefully and was over specified with a weight rating of 21 Kg meaning there was a considerable safety margin compared to the expected prototype actuation loads. I also considered that the tendon anchor may fail in a relatively controlled way before the tendon itself snaps, because the knot is held during normal actuation but the small surrounding printed walls could deform and allow slip under excessive load. This means the likely failure mode would be tendon slip or local printed-part deformation rather than a high-energy tendon snap. Preliminary test were conducted on the final prototype although no catastrophic failures were found. Further stress test remain to be conducted to validated the safety of the final product.	Complete further stress, fatigue and safety validation testing.
72	25/04/2026	Reviewed the UK-SPEC CEng requirements and IMechE professional expectations while preparing the competency mapping and ethics section of the IPDPP/report. This helped me check whether my project evidence aligned with professional engineering expectations, especially around safety, sustainability, ethics, communication and design responsibility. I realised that although I had not explicitly used the professional standards at the start of the project, many of my design decisions already followed similar principles, such as making the hand modular, serviceable, honest about limitations and safer to test. This review helped me present the work more clearly as professional development rather than only as technical project progress.	Finalise competency mapping and link evidence to UK-SPEC CEng criteria.

73	28/04/2026	The final individual report was completed ready for submission the following day the work was reviews and the technical content, figures, references, limitations and professional considerations. I ensured that the report accurately represented my own mechanical contribution and clearly stated the prototype limitations, including the need for further testing of grasp force, backlash, fatigue life and repeatability.	Submit final report and complete final IPDPP evidence checks.

Record of Continuing Professional Development (CPD)

UK-SPEC CEng (IMechE)

TABLE 2: UK-SPEC CEng (IMechE) requirement breakdown [1]

Competence		Code	UK-SPEC CEng requirements
A	Knowledge and understanding	A1	Have maintained and extended a sound theoretical approach to enable them to develop their particular role
		A2	Are developing technological solutions to unusual or challenging problems, using their knowledge and understanding and/or dealing with complex technical issues or situations with significant levels of risk.
B	Design, development and solving engineering problems	B1	Take an active role in the identification and definition of project requirements, problems and opportunities
		B2	Can identify the appropriate investigations and research needed to undertake the design, development and analysis required to complete an engineering task and conduct these activities effectively
		B3	Can implement engineering tasks and evaluate the effectiveness of engineering solutions.
C	Responsibility, management and leadership	C1	Plan the work and resources needed to enable effective implementation of a significant engineering task or project
		C2	Manage (organise, direct and control), programme or schedule, budget and resource elements of a significant engineering task or project
		C3	Lead teams or technical specialisms and assist others to meet changing technical and managerial needs
		C4	Bring about continuous quality improvement and promote best practice.
D	Communication and interpersonal skills	D1	Communicate effectively with others, at all levels, in English
		D2	Clearly present and discuss proposals, justifications and conclusions
		D3	Demonstrate personal and social skills and awareness of diversity and inclusion issues.
E	Personal and professional commitment	E1	Understand and comply with relevant codes of conduct
		E2	Understand the safety implications of their role and manage, apply and improve safe systems of work
		E3	Understand the principles of sustainable development and apply them in their work
		E4	Carry out and record the Continuing Professional Development (CPD) necessary to maintain and enhance competence in their own area of practice
		E5	Understand the ethical issues that may arise in their role and carry out their responsibilities in an ethical manner.

Competency Mapping

TABLE 3: Competency Mapping in respect with UK-SPEC CEng (IMechE)

Competence	Code	Evidence focus	Key entries (EN)	Justification
A	A1	Background technical research and ORCA understanding	3,8,9	Technical understanding developed through research into robotic hand designs, review of ORCA files and physical printing of ORCA fingers to understand kinematics.
		CAD learning and mechanical design development	17, 24, 27–31, 46	Engineering knowledge extended through CAD iteration, bearing-supported redesign, tendon routing, fingertip moulding and motion-range design.
		Professional standards awareness	72	UK-SPEC/IMechE expectations reviewed and linked to how the technical work supports professional engineering competence.
	A2	Original redesign of a challenging system	8,10,20	Complex technical challenge addressed by moving from ORCA adaptation to a new editable CAD architecture, while considering motor count, sensing and mechanical packaging.
		Sensor-compatible and modular design solutions	23, 31–34, 42–44	Practical solutions developed for FSR fingertip integration, removable sensing modules, underactuation and thumb/finger geometry improvements.
		Integrated testing and redesign under technical risk	63–68, 70	Actuation problems, tendon friction and integration risks were addressed through V8 carpal redesign, final assembly and powered movement evidence after handover.
B	B1	Defining early project/mechanical requirements	5, 7, 10, 12	Active involvement in defining mechanical architecture, ORCA feasibility, motor count, part list and procurement constraints.
		Defining sensor and subsystem requirements	20, 23, 25	Mechanical requirements shaped by sensor size, motor count, fingertip location and software/mechanical compatibility.
		Identifying integration problems and new requirements	54–55, 63–64, 70	Integration problems identified, including motor orientation, tendon access, thumb actuation, tendon friction and pre-test inspection requirements.

	B2	Research and investigation before design decisions	3, 8, 9, 17	Existing hands, ORCA editability, kinematics and inherited geometry investigated before committing to design changes.
		Testing-led investigation	36–38, 43–44	Physical testing and supervisor/advisor feedback used to change tolerances, bearing choice, hard stops and thumb geometry.
		Safety and failure-mode investigation	63–66, 70–71	Tendon friction, routing, inspection needs, tendon failure, pinch points and future stress/fatigue validation investigated.
	B3	One-finger implementation and evaluation	35–38	Testable one-finger rig planned, printed, manually tested, handed over and improved through feedback.
		Full-hand prototype implementation	46–50, 58–61	V7 CAD, printing, assembly, ILF demonstration, final motor mount and first powered testing implemented.
		Final redesign and integration evaluation	63–68, 70	Actuation issues evaluated through V8 carpal redesign, final assembly, powered movement evidence and final fingertip integration.
C	C1	Planning meetings, tasks and early resources	1–2, 6–7, 12, 19	Supervisor/advisor meetings, team communication, motor/finger count, CBOM/order form and internal coordination planned.
		Planning validation and deadlines	35, 39–41, 47–49	Internal deadline setting, coursework planning, ILF preparation, print scheduling and response to print failures planned and managed.
		Planning integration and final submission	52, 56–57, 64, 69, 73	Handover timing, material preparation, one-week redesign planning, final sensor integration and final IPDPP/report checks organised.
	C2	Resource and procurement management	12, 25, 56–57	Costed BOM decisions, bearings/tendons/PLA ordering and prevention of material shortages before integration.
		Schedule and recovery management	35, 47–49, 64–66	Deadlines, late CAD completion, print failures, short redesign timeline and final assembly managed under time pressure.
		Integration sequencing	69–70	Final sensor integration sequenced before identifying the need for clearer pre-test inspection checks.

	C3	Mechanical-specialist leadership	20, 23, 33, 38	Mechanical input provided to sensing/electronics/software colleagues, including sensor packaging and test-rig handover.
		Supporting multidisciplinary integration	50, 53, 60, 62, 69–70	Technical support provided during ILF, electronics handover, tendon wiring, motor access and final integration with sensing/electronics.
	C4	Design improvement from testing/feedback	37–38, 44, 54–55	Tolerance changes, bearing changes, hard stops and motor hub/tendon-access improvements made after feedback.
		Quality improvement and lessons learned	49, 63–66, 70–71, 73	Print-planning lessons, V8 routing improvement, pre-test inspection learning, safety validation reflection and honest final limitation reporting.
D	D1	Supervisor/advisor and team communication	2, 5–6, 10, 21–22	Communication maintained through supervisor meetings, advisor meetings, RAO rehearsal and presentation of early CAD direction.
		Technical handover and explanation	33–35, 50, 53, 67	CAD files, fingertip concept, one-finger rig, ILF explanation, electronics handover and prototype review communicated.
		Final reporting communication	69, 73	Final integration planning and final report preparation communicated clearly.
	D2	Justifying design decisions	10, 17, 22, 33	Redesign, movement away from ORCA-derived geometry, carpal/thumb feedback and integrated fingertip proposal justified.
		Presenting outcomes and conclusions	14, 21–22, 40, 50, 67, 73	RAO/CW presentation work, poster communication, ILF explanation, supervisor review and final report conclusions presented.
	D3	Collaborative working and responsiveness	15, 39–41, 53–55, 69–70	Teamwork evidenced through presentation polishing, poster coordination, electronics handover, responding to team concerns and final sensing integration.
E	E1	Standards/code awareness	72–73	UK-SPEC/IMechE expectations reviewed and final report checked to avoid overstating performance.
	E2	Safety during testing and integration	60–64, 70	Powered testing, tendon/routing issues and clearer pre-test inspection requirements considered.
		Safety reflection and future validation	71	Tendon failure, pinch points, rotating spools, exposed wiring, heat-set inserts and further stress/fatigue testing reflected on.

	E3	Sustainability through modularity and waste reduction	26, 51, 56–57	Replaceable parts, print waste, modular sensor housings and spare material planning considered to reduce unnecessary reprinting and delays.
		Cost/resource-conscious design	42, 72	Cost/performance trade-off considered when not adding another motor, alongside later reflection on modular and serviceable design.
	E4	Recorded technical development	3, 8, 17, 24, 37, 50	CPD evidenced through research, CAD learning, design reviews, testing feedback and public/technical explanation at ILF.
		Professional development reflection	71–73	Safety, standards, ethical reporting and future development needs reviewed.
	E5	Ethical engineering judgement	26, 70–71	Sustainability and safety trade-offs considered, including material choice, tendon failure behaviour and safe testing concerns.
		Honest reporting of limitations	72–73	Prototype limitations reported accurately, including grasp force, backlash, fatigue life and repeatability.

Record of Project Goals and Achievements

This section summarises the main goals achieved during the project and evaluates the extent to which each was completed. The aim is not only to record successful outcomes, but also to identify limitations, remaining work and evidence of development.

TABLE 4: Project Goals and Achievements

Project goals	Achievements	Limitation
Establish the project scope and my individual mechanical role	The mechanical/design stream was assigned to me during the early supervisor/advisor meetings.	Clear role. Unclear technical route. At this stage, too much still depended on later decisions about motors, sensors and ORCA feasibility.
Investigate whether the ORCA hand could be adapted	ORCA files were reviewed, two ORCA fingers were printed, and the limitations of adapting the original CAD were identified. A full redesign was then agreed with Dr Ketao.	This was a major turning point. The redesign made the workload much heavier, but it also removed a weak foundation from the project. The decision was correct, although the feasibility check should have been more formal and faster.
Develop a CAD architecture suitable for sensor integration	The design developed from early fingertip geometry into a more complete hand architecture, including phalanges, tendon routes, bearing-supported joints and the carpal structure.	Achieved, but messy. The architecture matured through trial, feedback and rework rather than through a clean first attempt. That is realistic for this type of design, but it meant some early CAD work was effectively learning work rather than final design work.
Create a removable fingertip sensing solution	A moulded FSR fingertip concept, removable insert and negative mould were developed, printed and reviewed for integration.	Strong mechanical solution. It solved fit, serviceability and packaging. It did not, by itself, prove sensor quality.
Validate the design through a one-finger test rig before full-hand manufacture	A one-finger rig was planned, printed, manually actuated and handed over to electronics/software colleagues for early testing.	Good checkpoint. It caught tolerance and bearing issues before the full hand was printed. The weakness was the lack of measured data; the test proved movement, not performance.
Produce a full prototype for ILF demonstration	The V7 full-hand CAD, hand assembly and motor mount were completed, printed and presented at the ILF event.	Important milestone. Also rushed. The prototype proved that the design could become a physical assembly, but the print failures showed that the manufacturing plan had too little margin.

Support electronics integration and powered movement testing	The hand was handed over for electronics work, the tendon routing was explained, final wiring orientation was completed, and powered movement was achieved.	This moved the project into real mechatronic integration. It also exposed the gap between “mechanically assembled” and “ready for another subsystem to test”. A clearer handover checklist would have prevented some of the confusion.
Improve the prototype after integration issues	Thumb actuation and tendon friction issues were identified, leading to the V8 carpal redesign, reduced tendon bending and improved routing.	Best improvement cycle in the project. A genuine problem was found, accepted and turned into a better design. Still, the improved version was only validated through short-term actuation, not repeated measured testing.
Complete final sensing/mechanical integration	The moulded sensing fingertips were integrated into the final hand and actuation was verified after correcting a tendon-routing issue.	Final integrated prototype achieved. Main lesson: assembled is not the same as inspected.
Reflect on safety, sustainability, ethics and professional standards	Safety risks, tendon failure modes, modularity, material choice, UK-SPEC/IMechE expectations and honest reporting of limitations were reviewed.	This strengthened the professional side of the IPDPP. It made the final work more honest. The timing was the weakness; safety and standards should have been used more actively throughout, not mainly consolidated near the end.

Goals and Achievements summary

Overall, the primary objectives of this project have been achieved in a proof-of-concept form. The greatest successes were the transition from using a poorly adapted version of the ORCA system to developing an original CAD design that could be edited; the development of fingertips compatible with removable sensors; the production of a complete prototype of a robotic hand; and addressing issues associated with integrating components into the robotic hand by completely redesigning the V8 wrist component. However, there is no way to validate the functionality of the robotic hand.

Therefore, the greatest limitation of this project is the absence of qualitative assessment of many aspects of its operation grasp force, tendon friction, backlash, repeatability, fatigue life and long term durability of PLA. Therefore, the final product will be a functionally integrated research robot hand rather than a completely functionalized robotic hand.

Project Evaluation and Reflection

The purpose of this section is to reflect upon key areas within the project that influenced the direction of my work through technical decision-making, testing, **teamwork**, and/or integration. I will also reflect on what I have learned from these experiences and what improvements I may make for future engineering projects.

TABLE 5: Evaluation and Reflection

Task / situation	How was this handled?	What went well?	What would I change next time?
ORCA CAD could not be adapted easily	I first tried to use the ORCA files as the base model, then checked whether the STEP/STL files could be made useful for the level of modification needed. I also printed ORCA fingers to better understand the mechanism before deciding that a full redesign was more realistic. This was then discussed with Dr Ketao and the team.	The issue was found early enough to change direction. Although it increased the workload, it meant the final design was not limited by unsuitable inherited CAD.	I would set a formal “adapt or redesign” decision point at the start of the project, rather than letting the conclusion emerge gradually through frustration with the files.
Moving from broad design ideas to detailed tendon routing	I developed the CAD from fingertip geometry into tendon anchors, split phalanges and routing paths.	The design became real once the tendons had to physically pass through it.	I would rough out the tendon paths before modelling attractive outer geometry.
Sensor integration affected the mechanical design	The fingertip was redesigned around the FSR concept, including a removable insert and moulded silicone cover. CAD and printed mould parts were shared for review.	The sensor did not end up looking like an afterthought.	Freeze the sensor size earlier.
One-finger rig testing before full-hand manufacture	I set a short internal deadline, printed the one-finger rig, manually actuated it and passed it to the electronics/software side for early testing. It was not a perfect test setup, but it was enough to reveal whether the basic mechanical logic worked before committing to the full hand.	It exposed the tolerance and bearing issues at the right time. It also gave the team something physical to work with rather than waiting for the full system.	I would take actual measurements instead of relying mostly on “it moves” observations. Even simple values for force, friction or backlash would have made the evidence stronger.

Full-hand manufacturing under ILF time pressure	I completed the V7 CAD, printed the parts, dealt with repeated print failures and assembled the prototype in time for ILF. Some of this was done very late and under more pressure than ideal.	A physical prototype existed for the event, which was important. Being able to explain the mechanism to people also helped me understand which parts of the design were clear and which still needed better explanation.	I would not print so many parts at once. That was a clear planning mistake because one failed batch could waste too much time.
Integration concerns after handover	The electronics/sensing team raised concerns about tendon tightening and motor orientation, so I took the hand back and made mechanical improvements before continuing.	It stayed constructive. The issue was treated as an interface problem rather than a personal failure or team conflict.	I would prepare a proper handover checklist.
Powered testing revealed tendon-routing issues	Powered testing exposed thumb actuation problems and a twisted tendon causing friction. I redesigned the carpal into the V8 version to reduce tendon bending and make the routing clearer.	This was probably one of the best examples of learning from failure in the project. The problem was not ignored or hidden; it became the reason for a better final design.	I would inspect and photograph every tendon path before powered testing. I would also stop powered testing from starting until tendon routing, spool clearance and loose wiring had been checked.
Final integration of moulded sensor fingertips	The moulded sensor fingertips were fitted into the final prototype. A tendon-routing issue near the thumb/spool was corrected and actuation was verified afterwards.	The hand finally became an integrated mechanical/sensing prototype.	I would separate “final assembly” from “ready for powered testing”. They are not the same thing.
Safety reflection after actuation testing	I reflected on tendon failure, pinch points, rotating spools, exposed wiring, heat-set insert installation and likely failure modes.	This changed how I viewed the prototype. Before this, I had focused mainly on whether the hand moved; afterwards, I was more aware that a moving prototype also creates hazards during testing, handover and demonstration.	I would create a formal risk assessment before powered testing, not after.

Professional standards and honest reporting	I reviewed UK-SPEC/IMechE expectations near the end and checked that the report/IPDPP did not overstate the prototype.	The final write-up became more honest and defensible.	I should have used the professional standards as a live checklist from the start, especially for safety, sustainability and evidence recording.

Reflection summary

Overall, this project has taught me that Mechanical Design is about much more than producing CAD parts that look good. Some of the most challenging aspects were routing, tolerancing, serviceability, sensor packing, handing over the product, gaining testing access and safely actuating the device. The biggest successes have been treating all problems as design information specifically moving away from adapting to the ORCA and the subsequent redesign of the V8 carpal mechanism. One of the areas where there has been the least success has been with validation. Going forward I will implement a greater amount of quantifiable testing, better pre-testing for clarity and the use of professional standards throughout the course of my projects rather than only toward the conclusion.

Record of Project Planning

Flowchart:

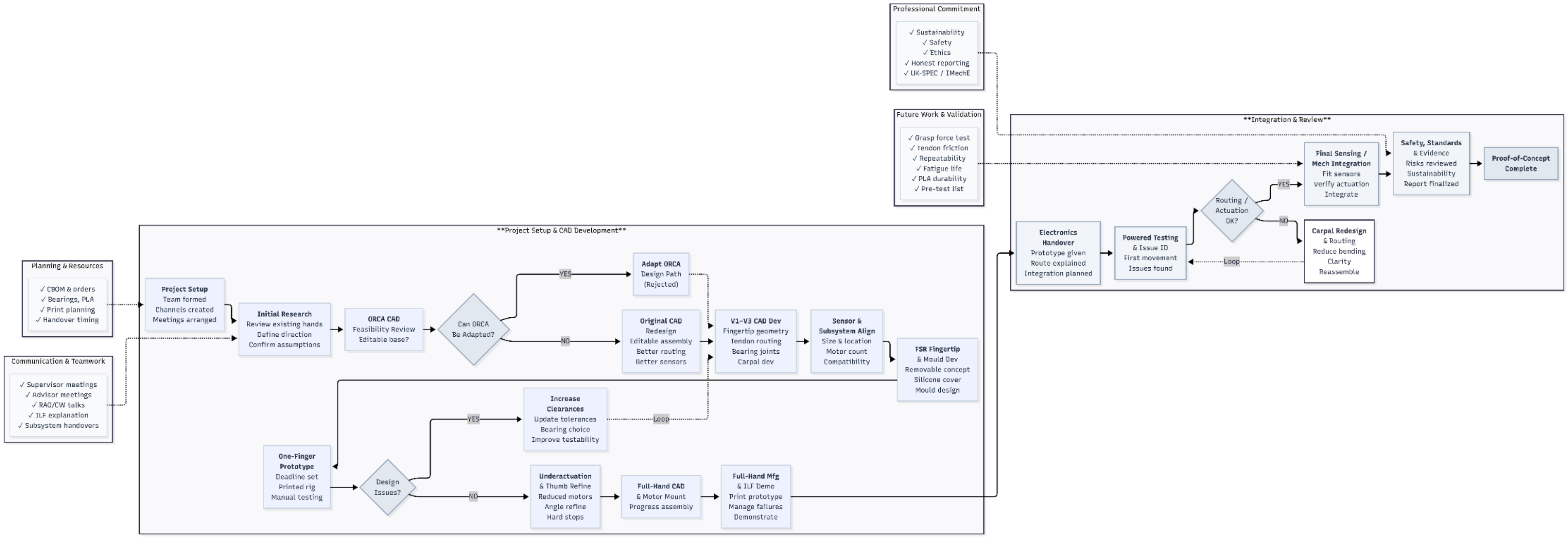

FIG 1: Overall project flowchart made with [2]

Gantt chart:

Task	Allocation	Start	Finish	Phase	22/09/2025	29/09/2025	06/10/2025	13/10/2025	20/10/2025	27/10/2025	03/11/2025	10/11/2025	17/11/2025	24/11/2025	01/12/2025	08/12/2025	15/12/2025	22/12/2025	29/12/2025	05/01/2026	12/01/2026	19/01/2026	26/01/2026	02/02/2026	09/02/2026	16/02/2026	23/02/2026	02/03/2026	09/03/2026	16/03/2026	23/03/2026	30/03/2026	06/04/2026	13/04/2026	20/04/2026	27/04/2026
Project setup and role allocation	Team	23/09/2025	09/10/2025	Initiation																																
Research and ORCA review	Team / Mechanical	26/09/2025	21/10/2025	Research																																
ORCA redesign decision	Mechanical (Lead)	17/10/2025	28/10/2025	Planning																																
Early CAD development	Mechanical (Lead)	28/10/2025	17/11/2025	CAD																																
V2/V3 CAD iteration and review	Mechanical (Lead)	25/11/2025	18/12/2025	CAD																																
Sensor requirement alignment	Shared	02/12/2025	19/12/2025	Integration																																
Tendon routing and fingertip design	Mechanical (Lead)	27/12/2025	04/02/2026	CAD																																
One-finger prototype and testing	Mechanical (Lead)	05/02/2026	13/02/2026	Testing																																
Poster / communication tasks	Team	16/02/2026	20/02/2026	Communication																																
Underactuation and thumb refinement	Mechanical (Lead)	23/02/2026	06/03/2026	CAD																																
V7 full-hand CAD, print and ILF	Mechanical (Lead)	09/03/2026	17/03/2026	Manufacture																																
Electronics handover and integration prep	Shared	21/03/2026	30/03/2026	Integration																																
Powered testing and issue review	Shared	31/03/2026	06/04/2026	Testing																																
V8 carpal redesign	Mechanical (Lead)	07/04/2026	17/04/2026	Redesign																																
Final sensing / mechanical integration	Shared	20/04/2026	24/04/2026	Integration																																
Safety, standards and final review	Mechanical (Lead)	24/04/2026	30/04/2026	Review																																

FIG 2: Gantt chart

Legend	
	Mechanical (my lead contribution)
	Team / wider project context
	Shared / integration activity
	Testing / review stage

FIG 3: Gantt chart Legend

RAID Log:

TABLE 6: RAID Log

Type	Priority	Status	Item	Impact on project	Response / mitigation
Risk	High	Closed	ORCA CAD could not be adapted reliably	The original plan depended on ORCA as a base model, but the files were not suitable for the level of sensor, tendon-routing and geometry change required.	Reviewed the files, printed ORCA fingers to understand the mechanism, then moved to an original editable CAD redesign after discussion with Dr Ketao.
Risk	Medium	Mitigated	Mechanical workload increased after the full redesign decision	A full redesign created more CAD, testing and manufacturing work than originally expected.	Prioritised the main architecture first: fingertip geometry, tendon routing, bearing-supported joints, carpal routing and motor hub.
Risk	High	Closed	Sensor integration could become an external add-on	If the FSR was added late, the fingertip could become poorly packaged or difficult to replace.	Designed the fingertip around a removable FSR insert, moulded silicone cover and negative mould.
Risk	High	Mitigated	Tendon-routing friction could reduce actuation quality	Tight bends, twisted tendons or crossed routes could stop the hand actuating correctly.	Developed separate tendon paths, changed clearances, redesigned the V8 carpal and checked routing before final handover.
Risk	Medium	Closed	Print failures could delay the ILF demonstration	Printing many parts at once increased the chance of failed batches and schedule pressure.	Reprinted failed parts, completed the V7 assembly in time and recorded print planning as a lesson learned.

Risk	High	Ongoing	Powered testing could damage tendons, spools or printed parts	Incorrect tendon routing or spool clearance could cause jamming or local damage during actuation.	Corrected the final thumb routing issue and identified the need for a formal pre-test inspection checklist.
Assumption	Medium	Ongoing	PLA was suitable for proof-of-concept prototyping	PLA allowed fast, low-cost manufacturing, but long-term fatigue and durability were not proven.	Used PLA for rapid iteration while recording durability, fatigue and long-cycle testing as future work.
Assumption	High	Ongoing	Short-term movement was enough to confirm feasibility	Movement showed the prototype worked at proof-of-concept level, but did not prove performance.	Reported the prototype honestly as functional but not fully validated. Future work includes force, backlash, friction, repeatability and fatigue testing.
Assumption	Medium	Closed	Reduced motor count would still support useful hand motion	Underactuation reduced cost and complexity, but limited independent finger control.	Kept the reduced-actuation strategy after considering the cost/performance trade-off and developed underactuated fingers accordingly.
Assumption	Medium	Closed	Sensor dimensions and location would remain compatible	Any change to sensor size or location could force fingertip redesign.	Confirmed FSR size and location with the sensing stream before developing the removable fingertip concept.
Issue	Medium	Closed	ORCA-reference bearings were too small	The early bearing choice did not suit the developing geometry.	Changed to larger and thinner 1063ZZ bearings from later iterations.

Issue	Medium	Closed	Fingers could move backwards further than required	Unwanted extension reduced natural motion and could affect safe actuation.	Added hard stops to limit backward movement and improve the motion envelope.
Issue	High	Closed	Handover raised tendon-tightening and motor-orientation concerns	The electronics/sensing team could not continue integration smoothly without mechanical changes.	Took the hand back, discussed the issue internally and improved the motor hub/tendon access before further testing.
Issue	High	Closed	Thumb actuation and twisted tendon issue found during testing	The hand moved, but routing quality directly affected actuation performance.	Planned and completed the V8 carpal redesign to reduce tendon bend severity and improve route clarity.
Issue	High	Closed	Final thumb tendon slipped during final integration	The hand was assembled, but not fully inspection-ready before powered actuation.	Corrected the tendon route, verified actuation and added pre-test inspection as a future process requirement.
Dependency	High	Closed	Mechanical design depended on sensing requirements	Fingertip geometry depended on FSR size, contact area and replacement/serviceability needs.	Held internal discussions with the sensing stream and sent CAD/STL files for review.
Dependency	High	Closed	Electronics/software testing depended on physical hardware	Without a test rig or prototype, electronics/software colleagues could not test actuation properly.	Produced a one-finger rig first, then later handed over the full prototype for integration.
Dependency	Medium	Closed	Final integration depended on cross-team timing	Final assembly required mechanical, electronics and sensing work to align near the end of the project.	Planned final integration with Sahimaa and completed fitting of the moulded sensing fingertips.

Dependency	Medium	Closed	Procurement depended on hardware availability and material stock	Lack of bearings, PLA or tendon material could stop assembly and testing.	Ordered bearings, PLA, nylon fishing line and replacement materials ahead of key integration stages.

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[1] ‘uk-spec-fourth-edition.pdf’. Accessed: Apr. 30, 2026. [Online]. Available: https://www.imeche.org/docs/default-source/1-oscar/membership/uk-spec-fourth-edition.pdf?sfvrsn=2f

[2] ‘Mermaid Chart’. Accessed: May 01, 2026. [Online]. Available: https://mermaidchart.com

[3] C. C. Christoph *et al.*, ‘ORCA: An Open-Source, Reliable, Cost-Effective, Anthropomorphic Robotic Hand for Uninterrupted Dexterous Task Learning’, in *2025 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Hangzhou, China: IEEE, Oct. 2025, pp. 8503–8510. doi: 10.1109/IROS60139.2025.11246681.

Appendix:

CAD:

This appendix shows the CAD development as the project progressed. All major iterations are included, and some minor iterations are also shown in the interest of transparency. This provides evidence of the design development process, including rework, refinement and decisions made between versions. The Final version of the parts were omitted as they are discussed in detail in CW4.

Tendon anchor:

V1:

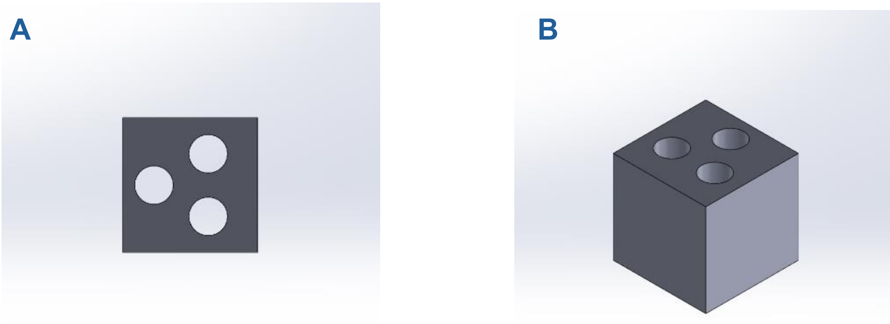


FIG 4 (A&B): V1 Tendon anchor

V2:

FIG 5 (A,B&C): V2 Tendon anchor

V3:

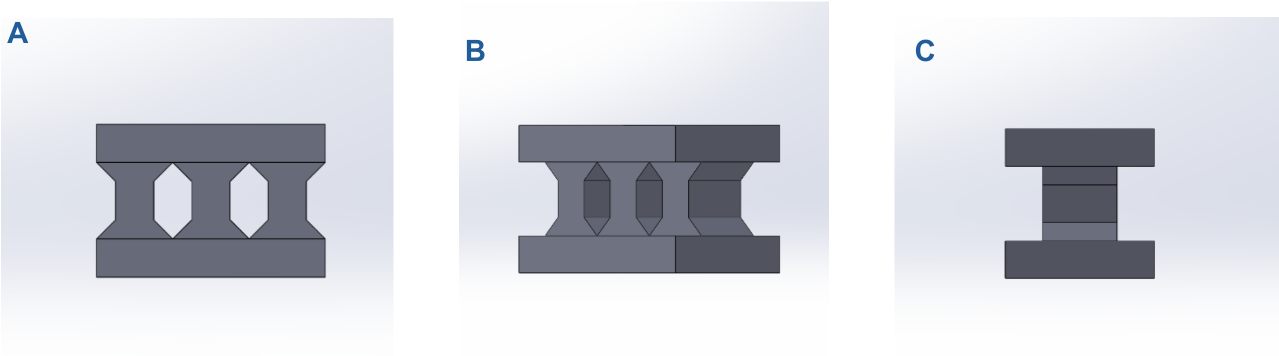


FIG 6 (A,B&C): V3 Tendon anchor

Fingertip design (DP):

V1:

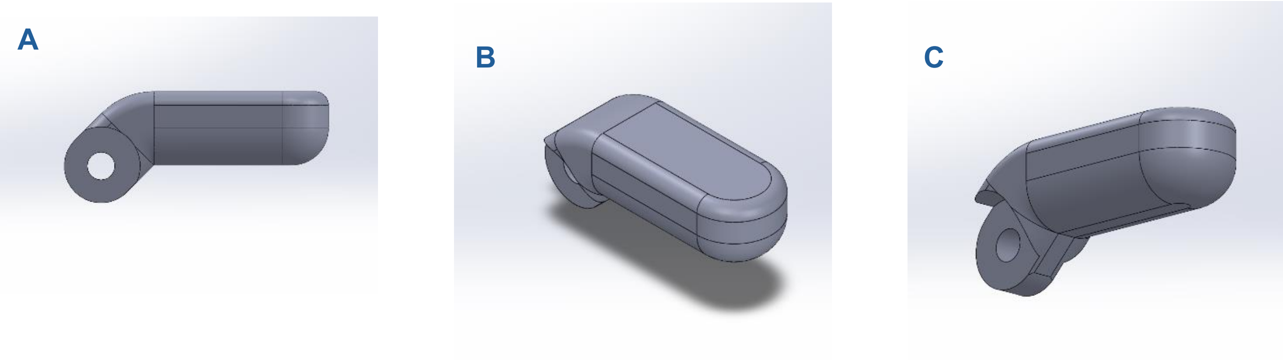


FIG 7 (A,B&C): V1 DP

V2:

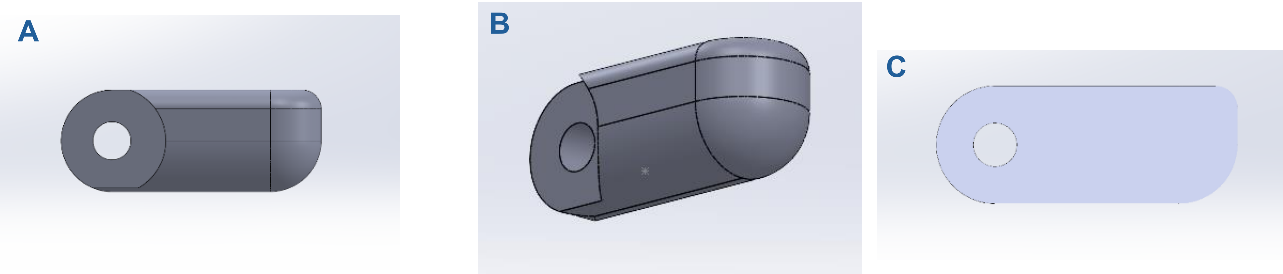


FIG 8 (A,B&C): V2 DP

V3:

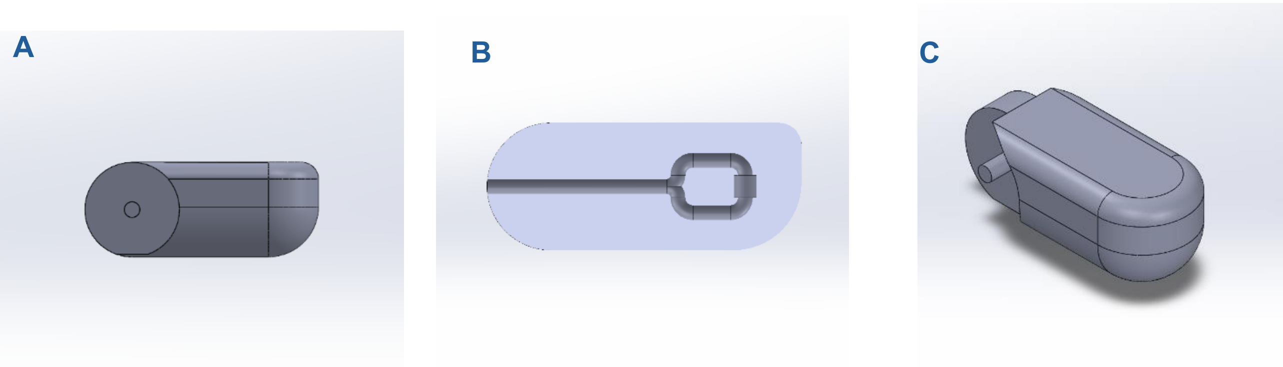
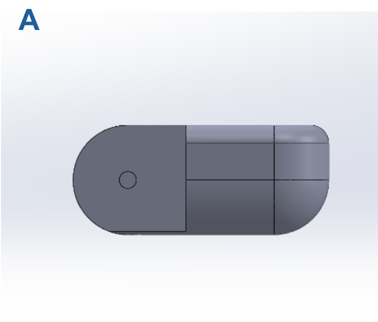
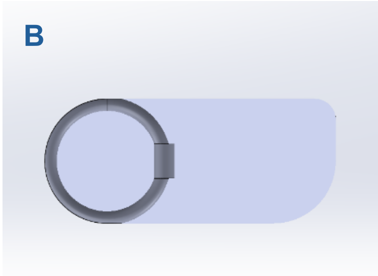


FIG 9 (A,B&C): V3 DP

V4:





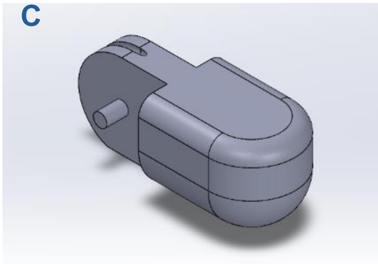
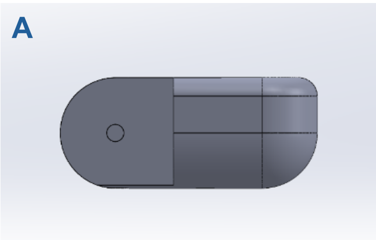
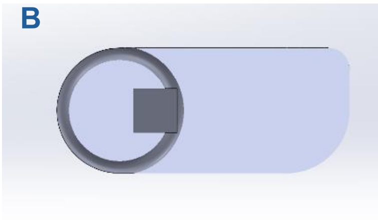


FIG 10 (A,B&C): V4 DP

V5:





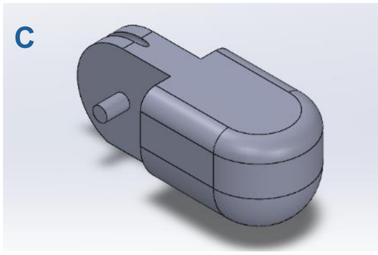
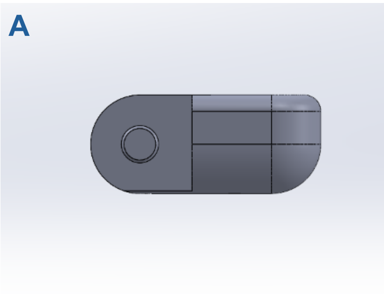
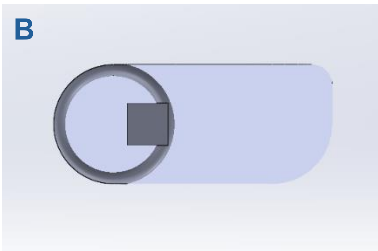


FIG 11 (A,B&C): V5 DP

V6:





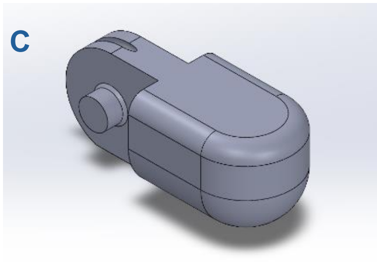
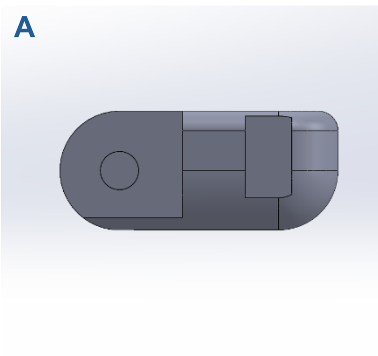
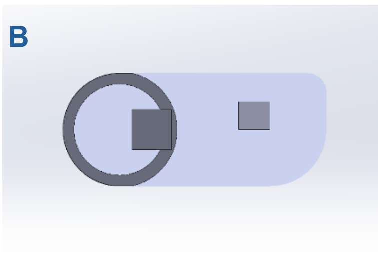


FIG 12 (A,B&C): V6 DP

V7:





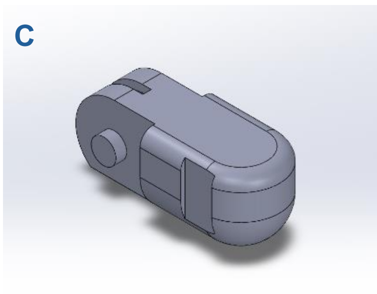


FIG 13 (A,B&C): V7 DP

Middle Phalanx Design (MP):

V1:

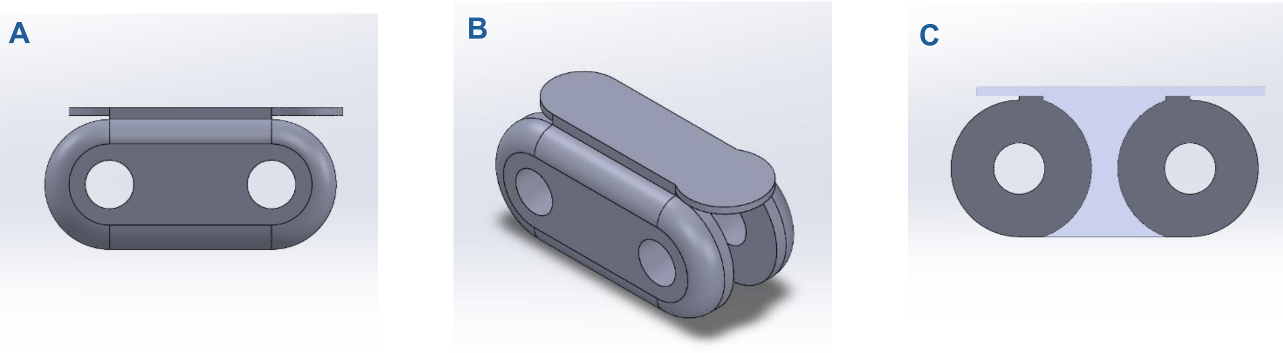


FIG 14 (A,B&C): V1 MP

V3:

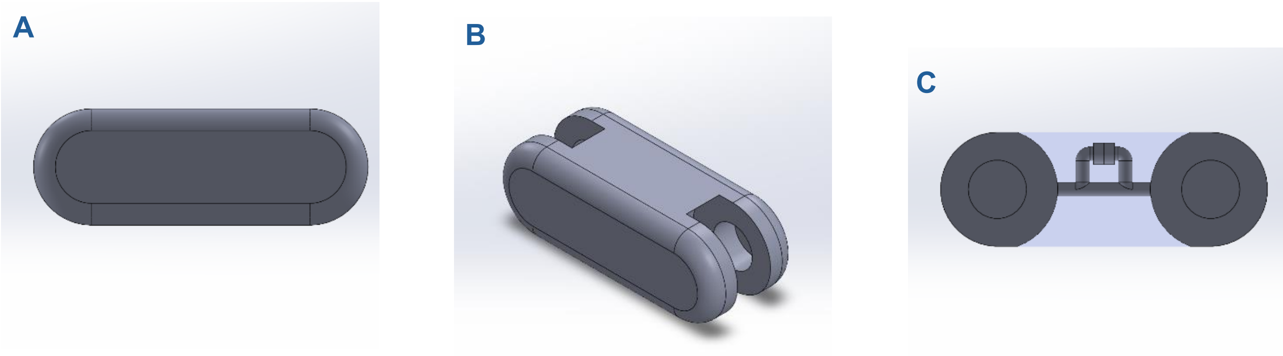


FIG 15 (A,B&C): V3 MP

V4:

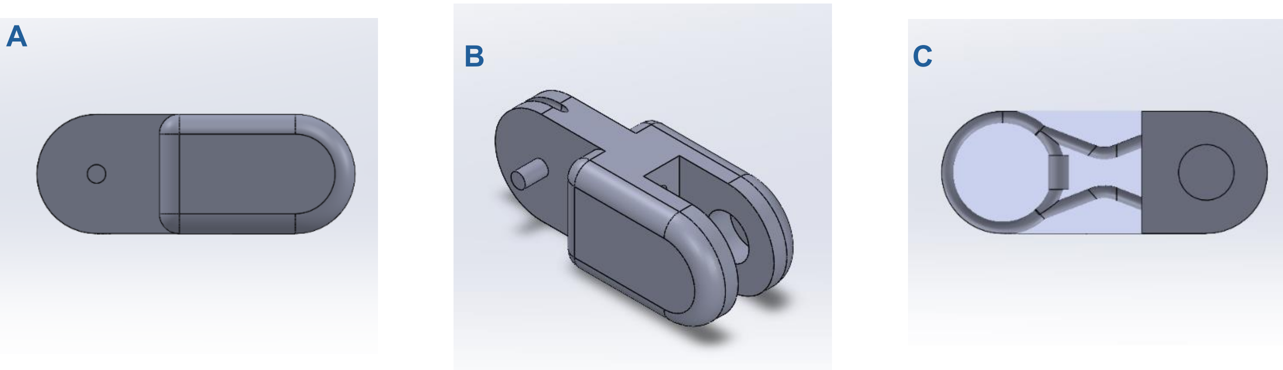


FIG 16 (A,B&C): V4 MP

V5:

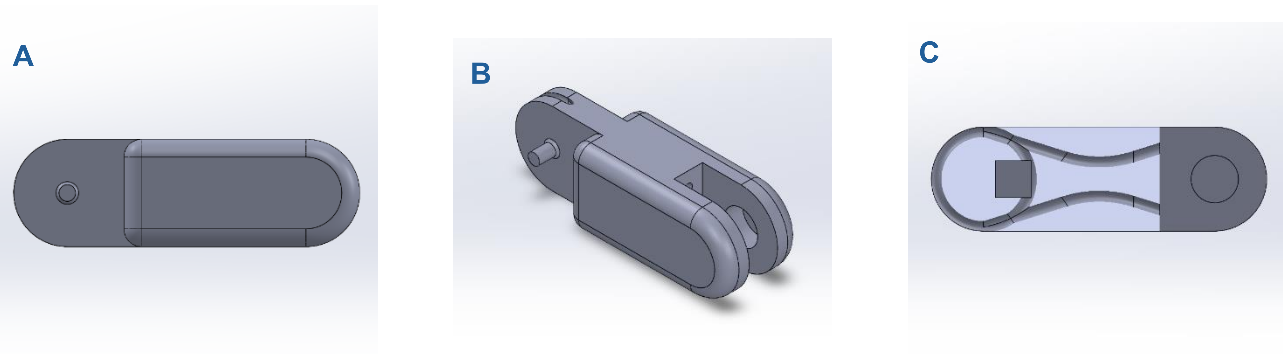


FIG 17 (A,B&C): V5 MP

V7:

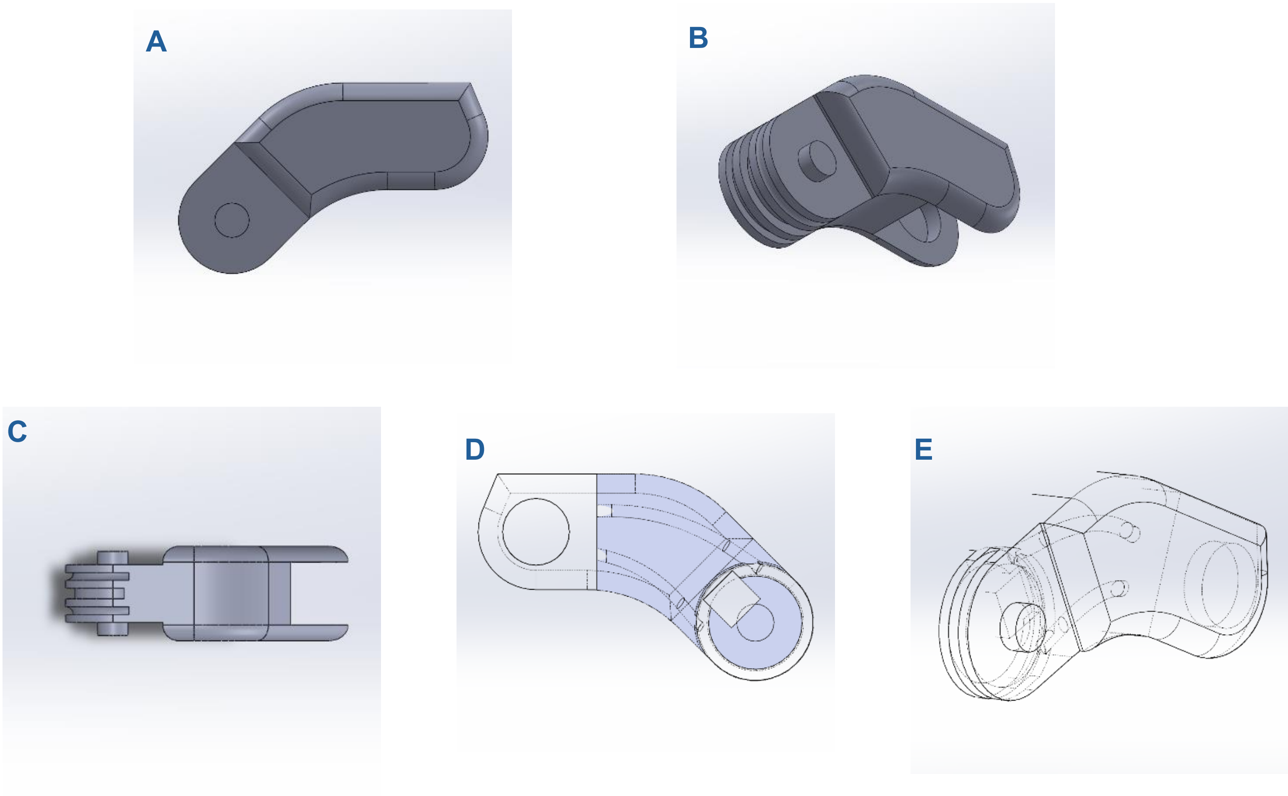
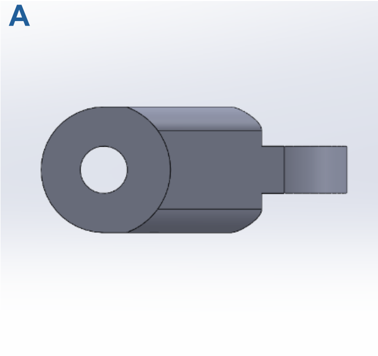
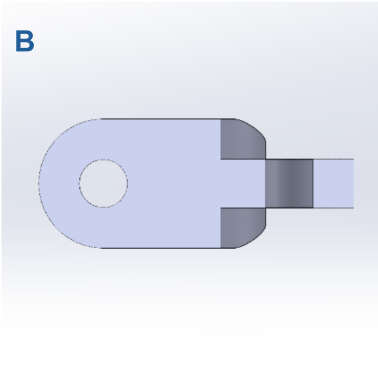


FIG 18 (A,B,C,D&E): V7 MP

Proximal/end segment design (PP) :

V1:





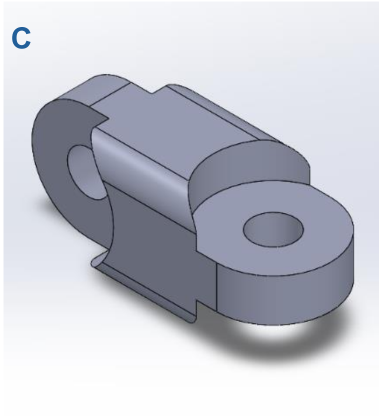
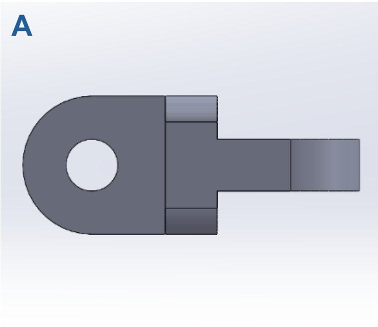
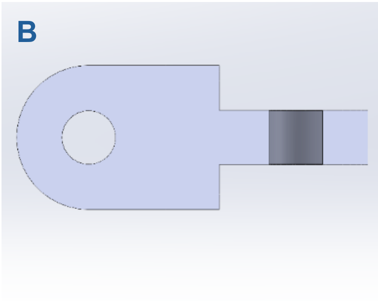


FIG 19 (A,B&C): V1 PP

V2:





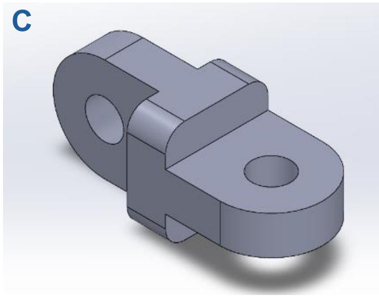
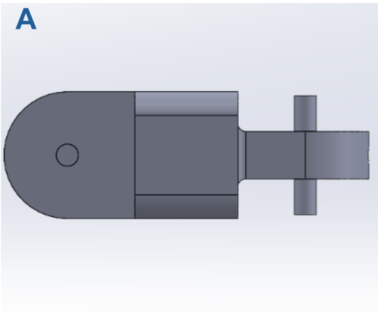
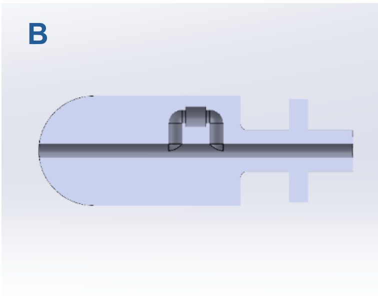


FIG 20 (A,B&C): V2 PP

V3:





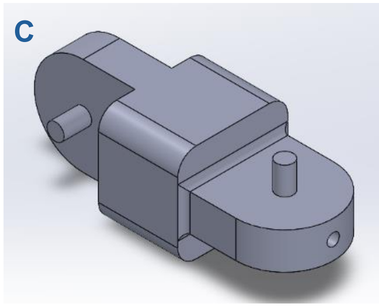


FIG 21 (A,B&C) V3 PP

V4:

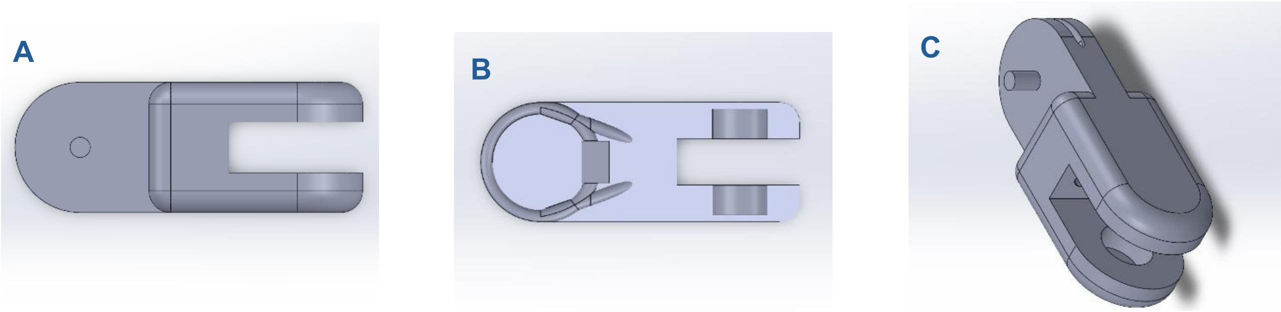


FIG 22 (A,B&C): V4 PP

V6:

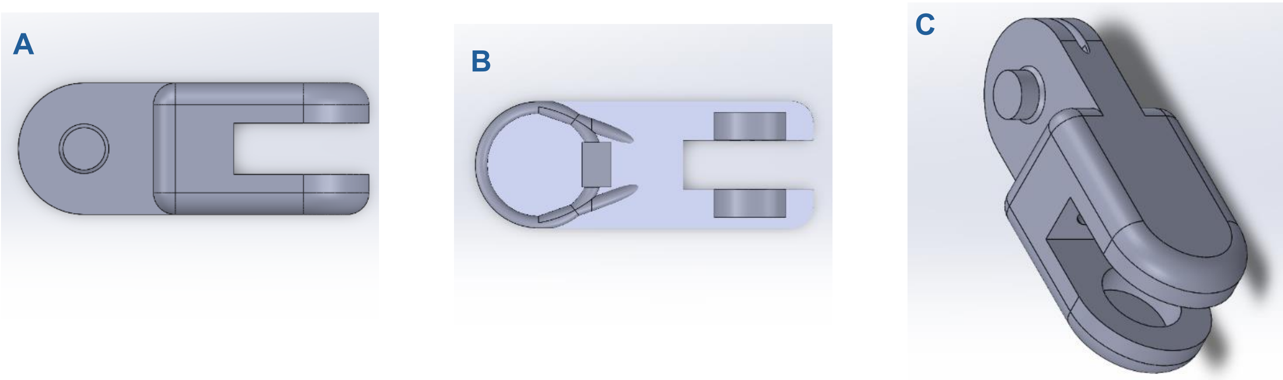
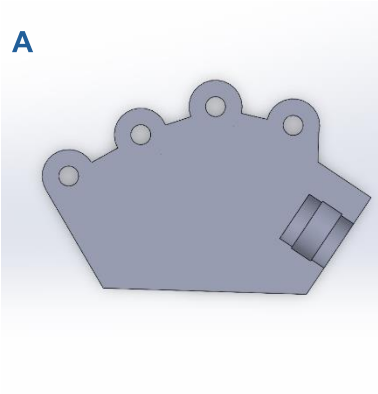


FIG 23 (A,B&C): V6 PP

Carpal architecture and tendon routing:

V1:



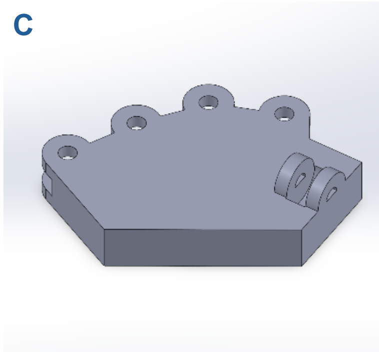
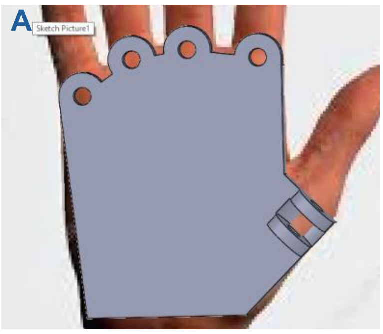


FIG 24 (A,B&C): V1 Carpal

V2:



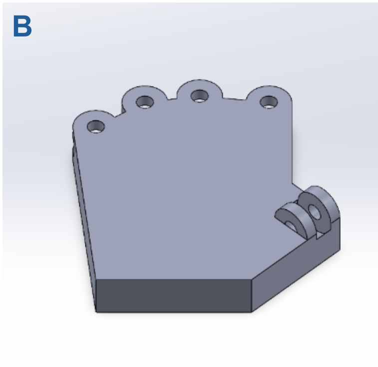
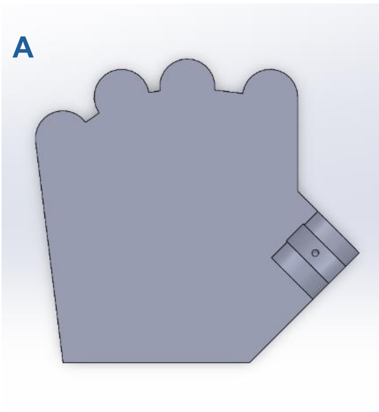


FIG 25 (A&B): V2 Carpal

V3:



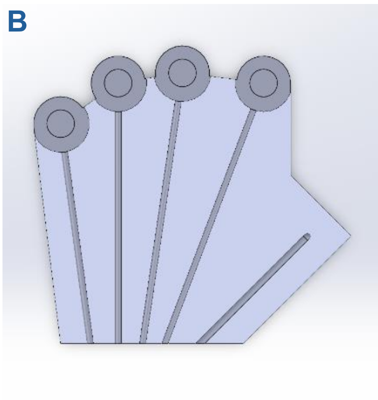


FIG 26 (A&B): V3 Carpal

V4:

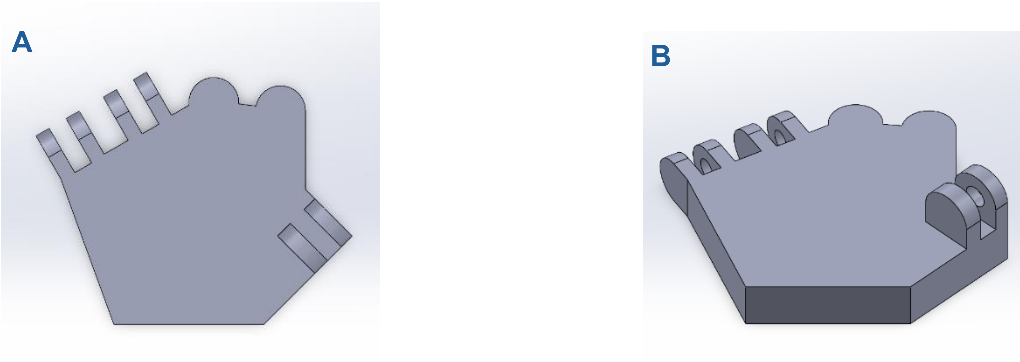


FIG 27 (A&B): V4 Carpal

V5:

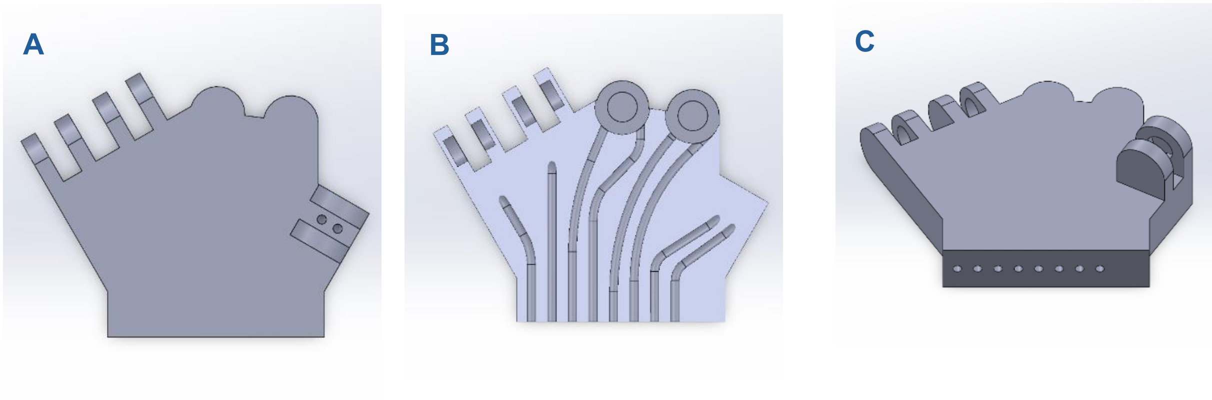


FIG 28 (A,B&C): V5 Carpal

V7:

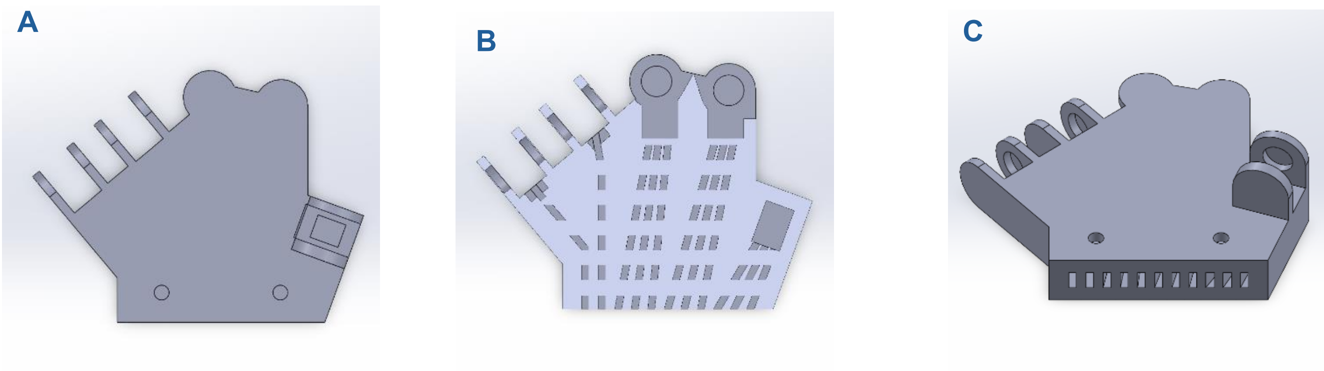


FIG 29 (A,B&C): V7 Carpal

Meeting Scheduling:

Hi Shannen,

The following booking has been confirmed:

Group Study Room MEL-G15: : 11:00am - 12:00pm Tuesday, October 7, 2025.

FIG 30: Email confirmation of room booking for internal meeting 07.10.25

Hi Shannen,

The following booking has been confirmed:

Group Study Room MEL-3.14: : 11:00am - 12:00pm Tuesday, October 28, 2025.

FIG 31: Email confirmation of room booking for internal meeting 28.10.25

Hi Shannen,

The following booking has been confirmed:

Group Study Room MEL-1.28: : 11:00am - 12:00pm Friday, November 14, 2025.

FIG 32: Email confirmation of room booking for internal meeting 14.11.25

Initial Print:

FIG 33: ORCA Hand [3] two finger initial print

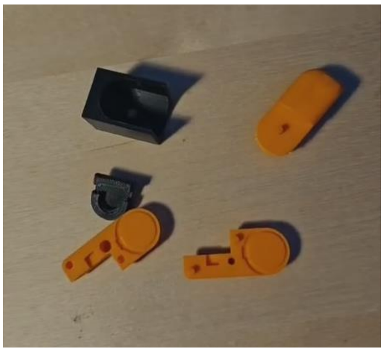


FIG 34: V4 tips and mould printed

FIG 35: V4 single finger assembly and V4 tips and mould printed

Assemblies:

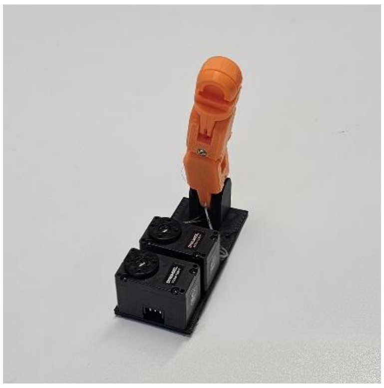


FIG 36: original single finger testing rig

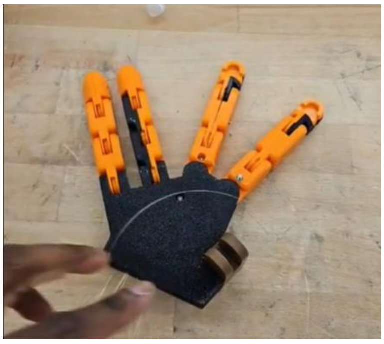


FIG 37: First full hand assembly including routed carpal

FIG 38: First full assembly including routing and V1 motor hub

FIG 39: Final carpal routing

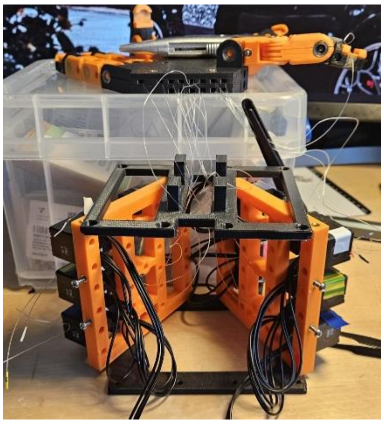


FIG 40: Final tendon routing from the carpal to the motor hub

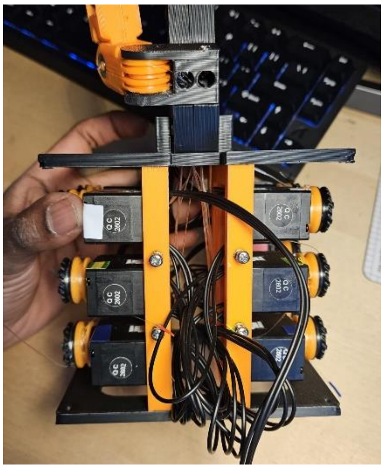


FIG 41: Completed final assembly

ILF:

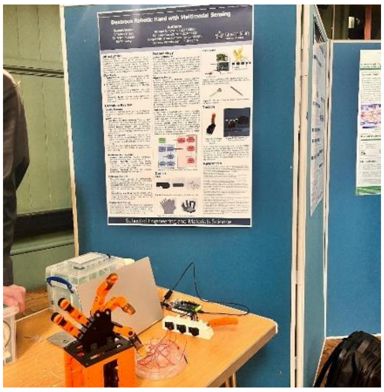


FIG 42: ILF team poster and prototypes

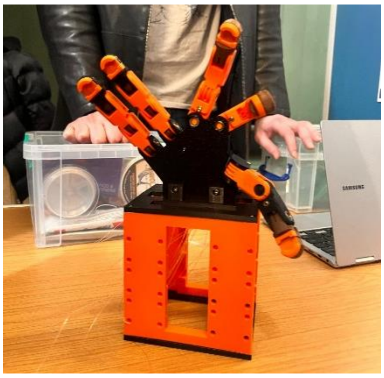


FIG 43: ILF Full assembly prototype

Final Prototype:

FIG 44: The FINAL ASSEMBLY for this project front view

FIG 45: The FINAL ASSEMBLY for this project right ¾ view