

APPENDIX I: ACTIVITIES AND OUTCOMES OF TRL 3 AND 4

Step	Description	Key Activities	Outcome/Product
Concept Formulation	This step involves defining the concept and investigating its technical validity, the potential stumbling blocks to production, and the levels of customization to complete the project. To have commercial potential, the product or service to be developed must solve a real-world problem and/or respond to a market need, and should do so in a manner that is better, cheaper or faster than existing solutions. This step is usually associated with basic and applied research.	<ul style="list-style-type: none"> Define the concept. Demonstrate the viability of the performance assumptions. Identify critical hurdles to production. Determine the ideal state of the technology. 	Verbal description, schematic, formula, conceptual model or paper design
The Conceptual Prototype	Conceptual Prototypes, or sometimes known as a Mock-Up prototype are made using state of the art Rapid Prototyping and 3-D Printing Equipment that truly brings your product to life. This tangible prototype is strong yet durable, but is limited on some functional characteristics. Standard available colors include, white, red, yellow, blue and green. The conceptual prototypes can also be sanded and painted to any color desired. These prototypes use a variety of materials, but ABS is typically preferred for its strength.	<ul style="list-style-type: none"> Define the problem/product. Perform preliminary analysis and identify the most pressing features/functions of the product that the prototype needs to reflect. Prepare a first draft of the prototype and build it. Identify prototype strengths and weaknesses (preferably with a possible end user). Test the prototype main functions/features. Modify the prototype to reflect the user's suggestions and the user interacts with the new, improved version. (usually, the refine-and-test cycle continues until the user is satisfied that the prototype meets his or her requirements. 	Conceptual Prototype
Market Needs Assessment	This step aims to answer questions such as: "Does the concept meet a market need?", "Who will buy the product?", "How many customers/clients will buy it?", and "How much will they pay for it?" At this stage, the information will come primarily from secondary sources, such as market studies, interviews and trade literature.	<ul style="list-style-type: none"> Determine the top features and benefits of the product. Identify competitors. Determine customers' requirements for the product (direct engagement with potential customers is recommended). Identify potential barriers to commercialization. Determine market distribution channels. Identify criteria for product pricing. 	Short summary of the information collected.
Commercialization Path Assessment	After confirming that the product can be made (proof of concept) and there is a sufficient demand for it (market-needs assessment), an investigation into the most plausible path to commercialize the product should commence. Different commercialization paths should be considered by answering the following questions: Collaborating with industry to develop the technology: Will industries be interested in collaborating with the university to develop the technology jointly? At what stage it would be possible to engage the industry? Licensing the technology: Who are the potential licensees? How much additional development work and resources are needed to secure a license? Startup formation: What expertise is needed? How much and what financial resources are required? Will the venture generate sufficient profit to justify the risk?	<ul style="list-style-type: none"> Critically review existing capability and capacity, and identify any additional financial, physical and human resources (expertise and experience) needed for each commercialization path investigated. Establish IP requirements. Determine a preliminary profit potential. 	Description of the business model.

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The Technical Viability (Functional Prototype)	This involves developing a working model for the product to be developed, and aims to demonstrate that the product is functional and producible. It also provides a visual means to introduce the concept to others.	<ul style="list-style-type: none"> Test the technical feasibility Identify the operational requirements Determine potential safety and environmental hazards. Undertake a preliminary production feasibility assessment Undertake a preliminary manufacturing assessment Estimate the cost of an engineering prototype. 	Working model of the product.
The Engineering (Development) Prototype	The finished product prototype – in the form of a single part, assembly, system or service – should provide an accurate representation of what the final product will be in terms of material content, physical configuration and function. This provides the basis for the final analysis of the technical, cost and market acceptance of the product, as well as for establishing final design and production specifications. Developing an engineering prototype is usually expensive because of the lack of economies of scale in production, and the disproportionate costs of design and testing.	<ul style="list-style-type: none"> Determine the materials, components, processes and manufacturing steps needed to meet technical performance and specifications. Test materials, components and processes. Design and develop an engineering prototype or pilot process. Optimize the design iterations. Undertake final tests. Estimate a preproduction prototype costs for the product unit. 	Engineering prototype or pilot process.
The Technology Market Study	The market study focuses on quantifying the market assumptions developed in the concept phase. It includes answers to the following questions: <ul style="list-style-type: none"> Who exactly is the target market? What product does it currently use (including units sold and price)? How is the industry structured? What are the distribution channels? What is the market environment? What will make the product competitive? 	<ul style="list-style-type: none"> Quantify the size of the market (including international markets). Identify its segments. Analyse the market segments, including size, growth rate and competitive environment. Analyse business capabilities for market share, competitive position, and product and resource capabilities. Describe the market environment, including economic industry trends, the regulatory framework, and possible barriers to entry. Obtain customer feedback. 	Thorough quantitative analysis.
The Economic Feasibility	Economic feasibility aims to provide facts and analytical rigor to inform the decision of which commercialization path to follow, and facilitates determining the economic benefits of the venture. Economic feasibility covers: <ul style="list-style-type: none"> demand forecast; supply analysis; competition assessment; analysis of regulatory environment; cost-benefit analysis 	<ul style="list-style-type: none"> Undertake a financial analysis of the business venture, including break-even scenarios based upon the product unit price, sales volume, and cost (goods, capital, management and administration). Determine, based on the financial projections, whether sufficient profit margins will be generated to justify the venture. Determine whether it is more sensible to license or assign the IP. 	Integration of the technical product information and the market study into breakeven financial models.