Achievable Engineering Management for New Product Development in Hardware Startups

Contents

Introduction

Hardware startups are typically made up of enthusiastic engineers with varying levels of skill and knowledge in their area of expertise. In such teams the first instinct is usually to dive straight into product development with only a general idea of what they are trying to create.

The problem with this approach is that the scope and viability of the product is never established. In a worst-case scenario this can mean the team develops a product that has no business case. Even when a product has a business case, failing to clearly define a product scope can cause development to take too long or cost too much meaning the business case is no longer viable.

Australia has a history of failing to commercialise new innovations, with many startups choosing to move overseas to access markets with better funding, talent and experience available (Engineers Australia, 2022). Australian entrepreneurs are described as having good technical skills but lacking focus, which can be attributed to a lack of the business skills required to bring a new product to market (McLeod, 2017).

To be successful in this environment, startups need to minimise waste and maximise their resources. Most startups can only afford a small number of engineers, so each member needs to be utilised as efficiently as possible. This means that a set of management tools are needed to assist teams who are lacking in management expertise and are unable to dedicate significant time to learning or applying these tools.

The purpose of this project is to identify the most appropriate engineering management tools to help hardware startups determine a products requirements, scope, and business case. These tools need to be simple enough that small teams with no management experience can implement them.

The scope of this project has been deliberately targeted at the early stages of new product development as improvements made here will flow on through the rest of the product development process.

Aims and Objectives

Aim

This project aims to determine and provide an example of the best engineering management tools for startups to use before beginning new product development and recommendations on how each tool should be used.

Objectives

1. Research existing cases of hardware development in startups to establish a baseline which the engineering management tools can be evaluated against. Evaluate and create weightings for each source based on credibility and applicability. Identify common issues and their typical effect on product development success.
2. Perform a qualitive analysis on the issues identified to rank their likelihood of occurring and the severity of their effects on product development performance. Assign numerical rankings to each issue to allow impacts of management tools to be better assessed.
3. Apply the engineering management tools to a theoretical product using our baseline research and then evaluate them by their:
    - Ease of use and skill requirements.
    - Investment required to make use of them in terms of time, resources, and data.
    - Potential benefit to project timelines and costs.
4. Develop recommendations and best practices to improve the application of the engineering management tools for startups. This can include modifying the tools to tailor them better for the target audience and environment, recommending which tools to prioritise, and what steps to take following the initial stages.

Literature review

Developing a new product is a risky endeavour. For most businesses, only one in every 9 new product ideas result in success (Barczak et al., 2009). A startup business cannot afford to fail several times before finding success; therefore, it is critical to ensure a new product idea has the highest chances of success before committing to it.

Data shows that Australia has one of the worst startup ecosystems in the developed world for science, technology, engineering and maths (Engineers Australia, 2022). There are several reasons given for Australia's poor performance, such as poor government funding models and complicated regulations, but we are choosing to focus specifically on a lack of knowledge and skills required to successfully start new businesses.

An article published by the University of Melbourne also asserts that a lack of business skills is a key reason Australian startups struggle (McLeod, 2017). From this we can assert that introducing some simple engineering management tools may help address the lack of management skills which contributes to the high rate of failures among startups.

PESTLE

PESTLE is an acronym for: Political, Economic, Social, Technological, Legal, and Environmental. A PESTLE analysis helps brainstorm the various factors affecting a project by looking at the project through different lenses. For new product development, PESTLE is useful for exploring the market environment and determining what advantages or disadvantages the product will have.

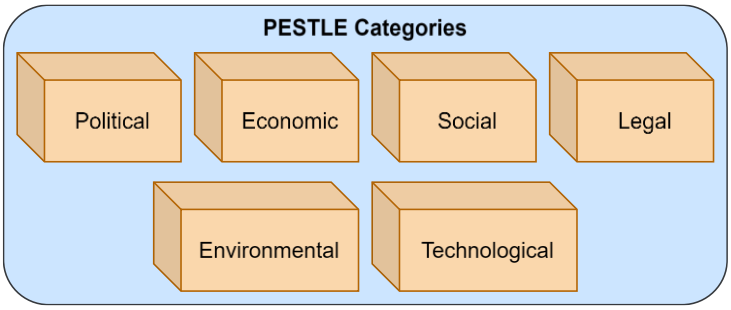

Figure 1 PESTLE analysis categories.

The PESTLE analysis does not help the user gauge the importance of each factor identified, therefore it is important to combine a PESTLE analysis with another tool such as SWOT in order to assess the impact of each factor on the project (Helmold, 2019).

With a PESTLE analysis it is very important to not treat it as a single activity which is completed once and then action taken based on its results. It is important to periodically update a PESTLE analysis to take into consideration changes in the operating environment of a business. The Oxford Handbook of Strategy recommends that a PESTLE analysis be combined with quality forecasting to ensure that a business is analysing the environment it will be operating in and not the environment it has previously and is currently operating in (Pitkethly, 2006).

House of Quality

A house of quality (HoQ) is a type of matrix diagram used as part of a Quality Function Deployment analysis. A HoQ is used to identify both negative and positive correlations between customer demands and product characteristics (Maritan, 2015).

For new product development a HoQ can be a very powerful tool for determining which aspects of a product are important. For inexperienced teams however, it can be a more complicated option requiring more investment to make use of than other tools.

A major drawback in the use of the HoQ tool is its tendency to lull the user into a false sense of security. As we will see with other tools such as the risk matrix, the HoQ usually sits somewhere in between a qualitive and qualitative method. The danger comes from the user assuming the results of a HoQ are more quantitative than they are and not taking into consideration the biases input by the user (Olewnik & Lewis, 2008).

SWOT

A SWOT analysis is helpful because it helps quantify factors for and against a project. As a tool it guides the user through the process of identifying organisational strengths and weaknesses in relation to the product being developed. The user then identifies and opportunities and threats which stem from the strengths and weaknesses respectively (*A guide to the project management body of knowledge (PMBOK guide)*, 2017).

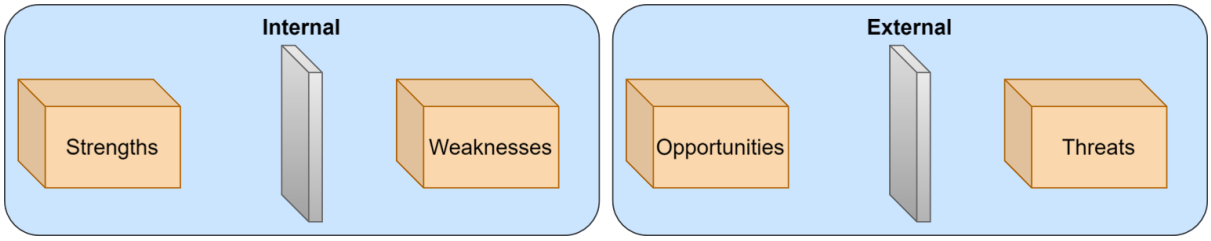

Figure 2 SWOT analysis internal and external factors.

For small and inexperienced teams, the SWOT analysis can help prompt the user to look objectively at their own capabilities or product idea and clearly justify the business case for it. The SWOT analysis is only as good as the data it is based on, and the user needs to be careful not to feed their own biases into the tool.

A SWOT analysis is best paired with other tools to help expand or compare the factors identified and gain a better understanding of the importance of each one. A key limitation of a SWOT analysis is its lack of a method to rank or evaluate the importance of each factor by itself, meaning it is best paired specifically with tools which aid in performing this (Helms & Nixon, 2010).

Delphi

In the Delphi method, experts are asked for their response to a question in rounds. Between rounds feedback is provided to the experts so they can adjust their answers. Ideally the answers will begin to converge, and a consensus can be obtained, or lack of consensus highlighted.

The Delphi method is considered more accurate than a single expert opinion because it sources from a large group while avoiding the effects of dominant personalities or group think (Khodyakov et al., 2023). For small teams the Delphi method may help to explore decisions and challenge rationales, providing more confidence in any choices made in relation to a new product.

The largest drawback of the Delphi method comes from its reliance on opinions. Despite what has been said above, when trying to reach a consensus it is not necessarily the most correct answer which is reached, but a compromise of the differing opinions. In most cases a person's personality can affect how likely they are to concede to other opinions and social power dynamics can bleed through into the Delphi process (Jünger, 2023).

The result of these issues can be a suppression of the best answer for the least controversial answer. These problems may be mitigated by larger group sizes and a conscious effort to include participants with balanced viewpoints.

Risk Matrix

The previous tools can be thought of as risk identification tools. A risk matrix is a tool which allows the user to make a judgement on the importance of each risk. A risk matrix takes each factor and gives it a likelihood and impact rating, this can be done quantitatively or qualitatively depending on if accurate data is available or just expert opinion (Edwards et al., 2019). Multiplying the likelihood and impact ratings gives each risk a severity rating which allows the user to better understand their relative importance.

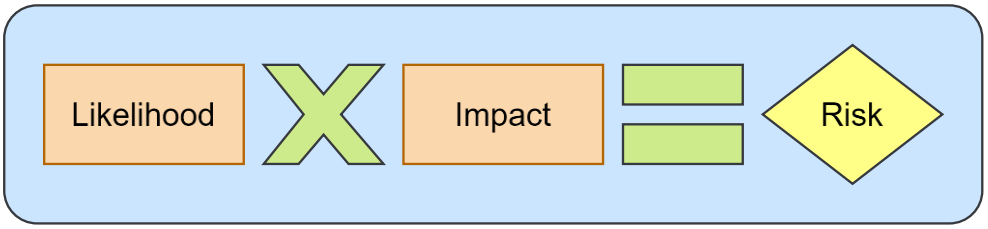

Figure 3 Risk matrix formula.

As this project is focused on tools with a low barrier to entry, the risk matrix fits well as a tool which can provide a more quantitative approach with simple inputs. However, it is important for a user not to become overly confident in the results of a risk matrix.

Risk matrices are heavily influenced by the ability of the user to accurately quantify likelihood and impact ratings, or even to correctly identify and understand risks. It is very common for different users to arrive at different conclusions for the same issues based on their subjective interpretation of each risk (Cox, 2008). In these situations, using a risk matrix can provide false legitimacy to incorrect assumptions and masquerade as quantitative data supporting an incorrect course of action.

Porter's Five Forces

Porter's Five Forces refers to the five competitive forces which influence a business as stated by Michael E. Porter in 1979. These forces are shown to the right.

Porter asserted that all industries are subject to these same five forces, and that by analysing a business's operating environment through the lens of these forces executives can determine how attractive an investment that business will be.

For a startup this tool can be used to establish the business case for a new product. It shows the user which forces pose the highest threat to the product and forces them to address how they will tackle these forces better than their competitors.

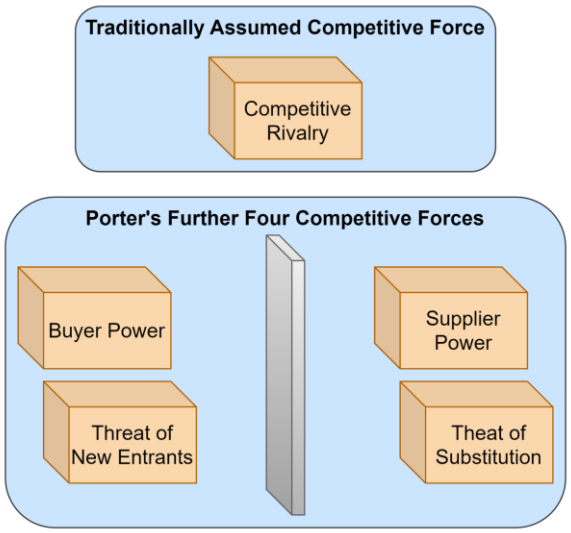

Figure 4 Porter's Five Forces.

Porter's Five Forces suffers from similar shortcomings to other tools such as PESTLE. The main problems occur when the user lacks the experience or strategic insight to properly identify the forces applying to their industry, only apply the tool in a shallow way, or do not use enough quantitative measures (Dobbs, 2014). Addressing these common shortcomings requires the user to be conscious of their own limitations and apply a more structured approach. Like all tools, the output of a Five Forces analysis depends on the quality of the information input into it.

Design Thinking

Design Thinking is an approach to problem solving or product development which focuses on the human element. It places more emphasis on solutions than the actual problem itself.

An example of Design Thinking is the Four Phases of Innovation taught by Harvard Business School Dean Skrikant Datar (Han, 2022). This method breaks down the development process into the four stages: Clarify, Ideate, Develop, and Implement. The main characteristic of this method is that problem definition is not treated as a firm step, instead there is a focus on "solidifying" the problem into an abstract statement or question and then moving on to the idea creation and development phases. During later stages the user may refine the problem further and choose to step back to an earlier stage and repeat steps. The goal is to stimulate creative thinking and rapid iteration through ideas.

Design thinking is a good overall concept for trying to stimulate creative thinking and problem solving. It is a loose process that tries to break assumptions and search for innovative ideas, but this flexibility means that the user needs to make an external effort to check their progress and ensure that they are converging on a more concrete problem definition and solution. The risk is that a user can lose track of how much time they are spending on this process if they keep moving backwards to earlier stages.

Customer Needs Analysis

One of the most important aspects of new product development is in defining customer needs. Without a clearly defined set of criteria for customer defined value from the very earliest stages, valuable resources can be wasted developing features or solutions which add no value to the final product.

A good Customer Needs Analysis is an empathetic process. The goal is to understand the problem from the perspective of the customer. This is best done by observing and communicating with the customer, and by experiencing their situation firsthand. This is covered succinctly by the “Look, Ask, Try” framework taught as part of the Design Thinking and Innovation course at the Harvard Business School (Gibson, 2022).

The Look, Ask, Try framework is almost self-explanatory. It takes the person applying the tool from an objective third person perspective (where they observe the customer to identify issues they are not aware of), to a second person perspective (where they attempt to get the unbiased views of the customer themselves), and finally to a subjective first person perspective (where they can develop their own experience of the problem). Each step increases empathy with the customer experience and importantly approaches the problem from a different environment.

Customer Needs Analysis can be useful to gain an overall understanding what constitutes customer defined value, but without extensive data on sales and pricing it does not help to develop a business case for the proposed solution. It is still possible that a solution can satisfy all the customer needs, but not be economically viable.

Methodology

The original methodology of this project involved evaluating the potential benefits of Porter's Five Forces, and the PESTLE and SWOT tools, against a theoretical example of a product development project. From this we would provide best practice recommendations on when and how each tool should be used for maximum benefit. After collecting data and doing an initial surface level analysis it became apparent that the existing tools alone would not satisfy our aims and objectives and so the methodology evolved to develop a custom tool based on what we had learnt.

Data Collection

Due to the limited scope and resources for this project, a literature review was performed to identify common issues and their effects on performance of product development projects in startups. Priority was given to academic papers focusing specifically on the reasons startup companies fail, but other sources such as journal articles were also used to help increase the sample size.

Sources for the literature review were weighted according to their relevance and credibility. This was a qualitive process assessing things such as the reputation of the source and whether it is peer reviewed, whether the source covers an Australian context or similar countries, and the size of the dataset the source uses and how closely it aligns with our target of small engineering hardware startups.

Each source was then evaluated to create a list of issues. The issues were ranked and assigned a point value based on their risk. The final step in data collection was to then combine the lists of issues from each source, modifying the point values based on the source's weighting.

By comparing several sources, we determined the most common and impactful issues. Originally the final list of issues was to be used to create an example theoretical project which the management tools can be applied and evaluated against. However, when doing an initial evaluation of the tools against the list of issues it became apparent that they would not produce a satisfactory result and so a new management tool was developed instead.

Management Tool Application & Evaluation

We evaluated three different tools in the following order:

1. Porter's Five Forces
2. PESTLE
3. SWOT

After applying and evaluating each tool we drew conclusions on their relative cost-benefit and the optimum combination of tools to use. From this we determined that a custom tool was required to satisfy our aim.

Porter's Five Forces

We began by analysing the list of issues we identified using the Porter's Five forces method. We determined which issues would be identified by this tool and which would be missed. We then compared how many issues were identified versus missed and the sum of all rankings for those issues. We considered what data, knowledge and experience is required to make use of this tool to assess the cost or difficulty in using it.

PESTLE

The next tool analysed was the PESTLE tool. We applied this tool in a similar fashion as Porter's Five Forces. We evaluated which issues are captured by this tool, and what is required to use it. This tool was directly compared with Porter's Five Forces to determine where the tools overlap and if there is any cost-benefit advantage to using one tool over the other.

SWOT

The results of the Porter's Five Forces and PESTLE analyses was used to evaluate the SWOT tool. We compared which issues (if any) the SWOT captured that were not captured by the previous tools respectively. Using the point rankings of each issue we evaluated how much additional benefit the SWOT tool added.

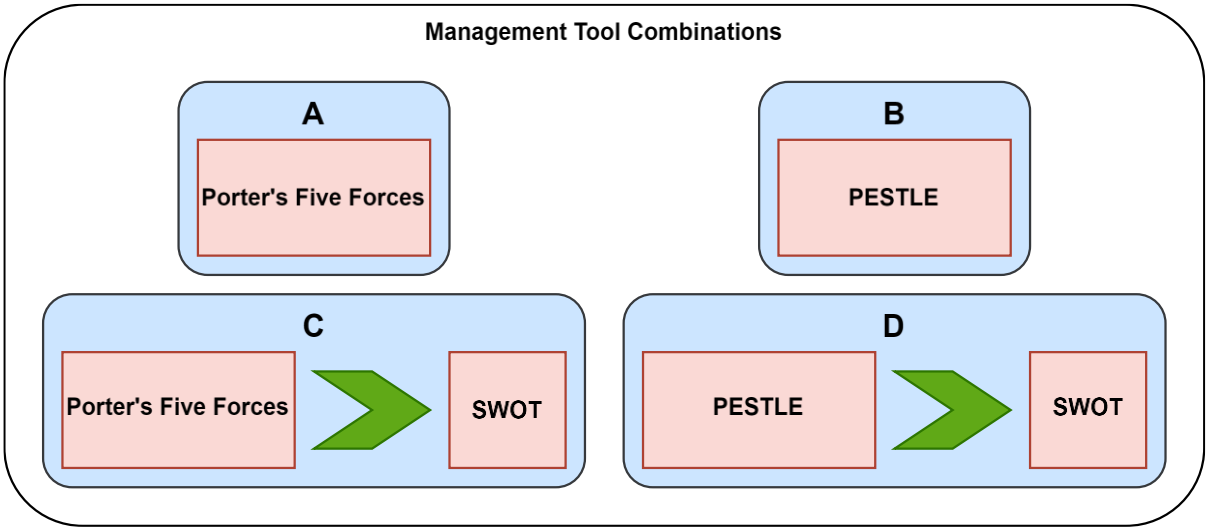

Figure 5 Combinations of Management Tools to be Analysed

Development of a Better Suited Engineering Management Tool

From analysing the previously selected management tools it was determined that none of them were particularly effective for our target use case. They did not provide enough guidance for a novice user and required too much investment to produce useful insight.

A new approach was decided after recognising that the list of issues we had created could be phrased as a series of questions. The reasoning being that by answering each question, the user can identify and address any of the common issues which they might fall victim to.

Management tools such as flowcharts and decision trees were recognised as the best tools to base our new tool on as they revolve around discrete questions. Comparing against the list of issues generated previously and their relative percentage scores it made sense give each question a corresponding score based on these percentages which could be used to evaluate how important each question was to overall success.

Reviewing the list of questions, it became further apparent that it was possible to separate them into roughly chronological stages. A draft tool was made at this point. Reviewing the draft tool led to further refinements to include additional suggestions and recommendations for complementary management tools for each question. This was all included in the final revision of the tool.

Results

Most Common Issues Affecting Startups

Five existing sources which analyse the most common causes of failure in startups have been compared. For each source a weighting was determined based on a subjective assessment of:

- Reputation of source or author(s).
- Is the source peer reviewed and how rigorously?
- How close is the source to the Australian context?
- Size or quality of the data the source uses.
- How closely does the data or examples in the source align with our target of small engineering startups?

The source was given a score of 1 to 10 on each factor, the sum of these scores gives the overall weighting.

A risk matrix format was then used to list the causes of failure or issues found in the source with their relative likelihood and severity. Likelihood and severity were again scored from 1 to 10 and these two numbers multiplied to give an importance value. If a source provides no indication of differences in likelihood or severity between issues, then the issues are simply listed and a middle value of 5 used for both values.

Once each source was assessed and a list of issues for each identified, the issues were combined into a master list. The master list applies the source weighting to the importance value for each issue from each source which features it. The sum of these weighted importance values gives us an overall score for the issue. The final list was condensed to combine similar issues to ensure that the scores are not diluted across multiple similar issues giving a false impression of a lack of importance.

At the end we are left with a final ranked list showing the nine most common identified issues and their relative importance against each other. Applying a 5th percentile cutoff to the importance scores removed any issues which do not have a high enough score to be treated as significant. This left us with eight issues in the final list shown below (See Appendix A – Data Collection for full data).

Table 1 Ranked list of most common identified issues for new startups.

Condensed List (Sorted)	**Total**	**Percentage**
Market for product not defined or product doesn't match requirements	10270	25.56
Difficulty scaling or cash flow issues	6715	16.71
Interpersonal or cultural problems and disagreements among team	5910	14.71
Communication problems with customer, mismatched goals and values	4480	11.15
Competition in the market	3570	8.89
Regulatory, legal, or governmental hurdles	3445	8.57
Skill or capability issues	3215	8
Technical or timing problems	2400	5.97
~~Problems with where company is located~~	~~170~~	~~0.42~~
Total	***40175***	***100***
Median	***3570***	***8.89***
5th Percentile	***1062***	***2.64***

There is some difficulty in assessing sources such as these where data is based on subjective experiences and individual cases which are hard to compare quantitatively. We cannot guarantee that we have identified all of the most important issues, or accurately gauged their relative importance. Our results still have utility, so long as we remain conscious that other issues can exist on a project-by-project basis.

Assessment of Management Tools

Once we had our list of issues and a relative importance for each one, we attempted to assess the management tools chosen in our methodology section against the list to see how well the tools identify and address each issue. The scores assigned to each issue give us an approximation of how much benefit each tool yields.

Porter's Five Forces

Comparing the five forces to our list above it becomes apparent that most of the issues will not be covered. Of the list above, only three of the issues are even partially addressed by a Porter's Five Forces Analysis. Combining their scores gives us a total of 18320 out of 40175, or 45.6%. Meaning a Five Forces Analysis by itself will at best help tackle less than 50% of the most common issues a startup may face when weighted by importance.

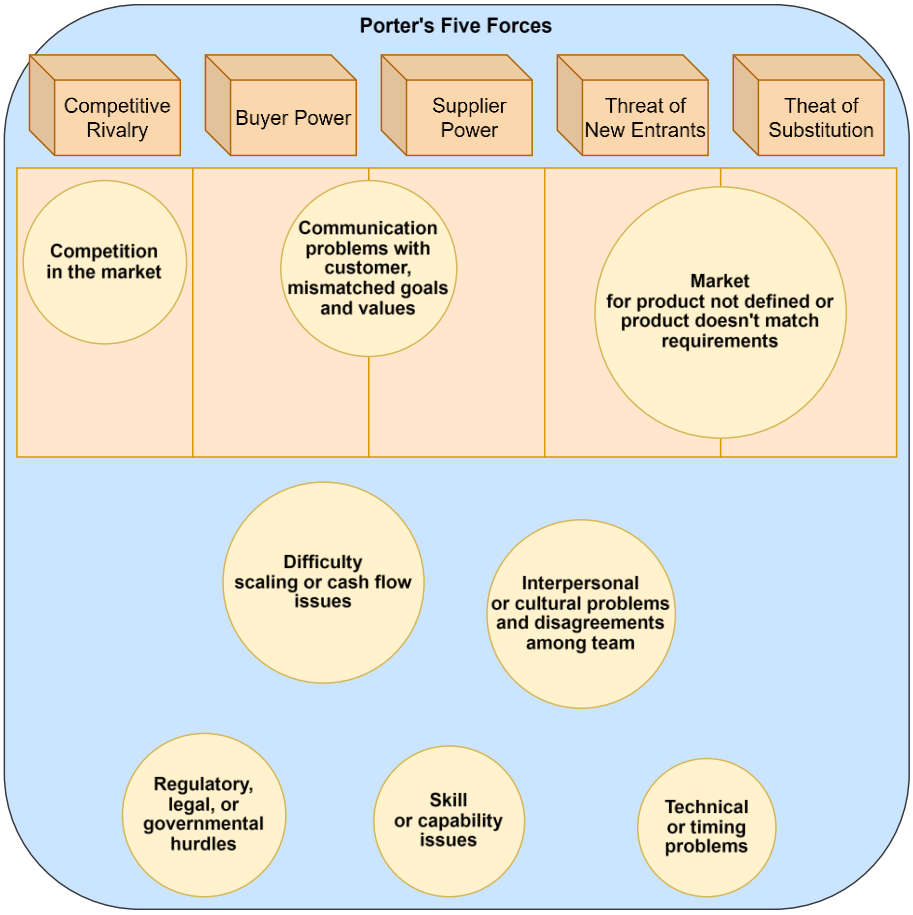

Figure 6 Issues applied to Porter's Five Forces

Porter's Five Forces are all external influences, it is also a very focused tool. With larger projects and teams this is acceptable, however in our case we are targeting small teams with limited experience and resources. For our purposes a broader tool would be more useful.

PESTLE

Trying to categorise our issues using a PESTLE framework looks positive. From a shallow perspective it looks as though it can address all of our most important issues. In practice though this relies heavily on the user to self-identify issues from a broad prompt such as “Political factors affecting your product”.

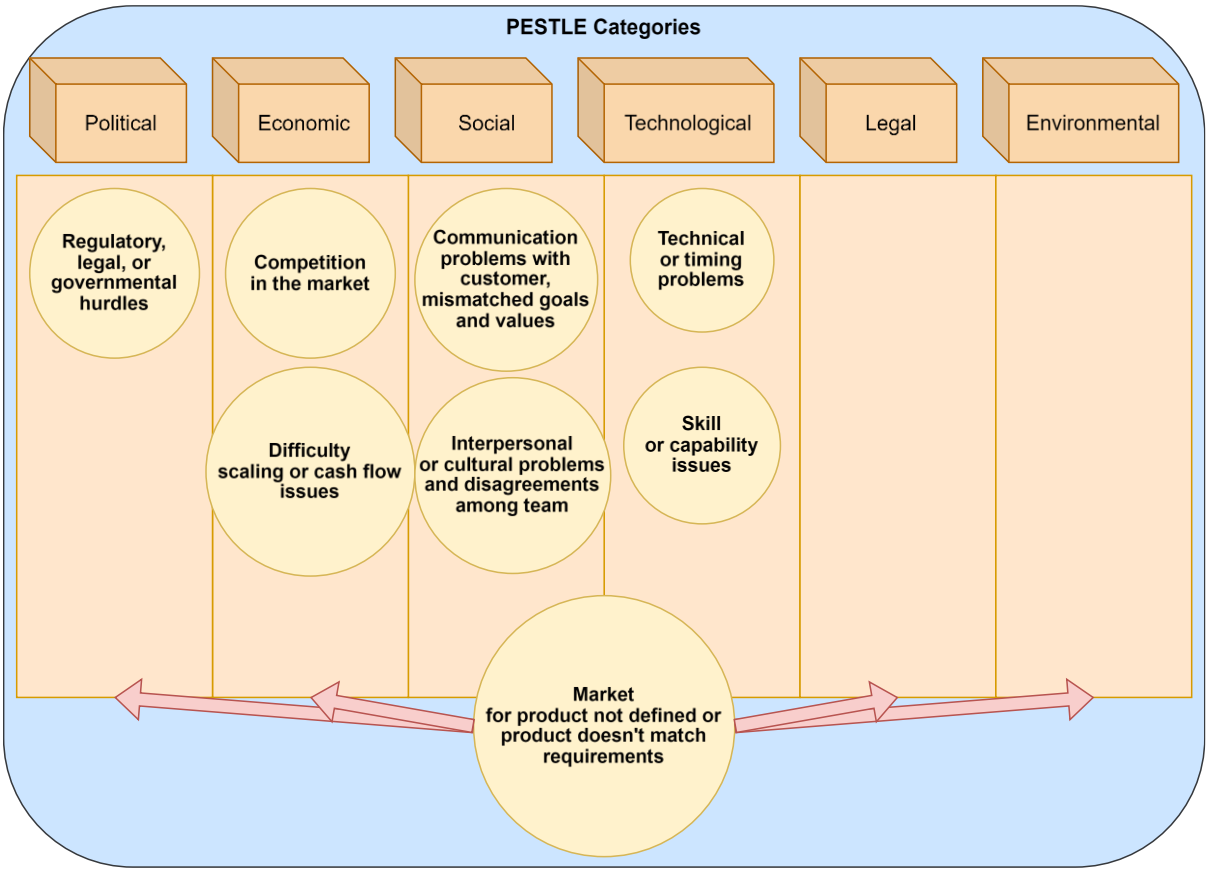

Figure 7 Issues applied to PESTLE

When starting a new product development, a PESTLE analysis might be useful to give an early impression of the operating environment and market, but it can be difficult to evaluate a product which is not yet well defined. In combination with other tools to help focus the analysis on answering specific questions, it may prove more useful.

SWOT

A SWOT analysis alone is not very useful at addressing any of our identified issues. Looking at our limited assessment of Porter’s Five Forces and PESTLE it would be most beneficial when combined with a PESTLE analysis to help further sort and compare factors falling into the six categories.

Our original methodology would call for a comparison between a combined Five Forces with SWOT analysis and a combined PESTLE with SWOT analysis. The data we have collected does not support this and it would not yield useful results, so we have instead focused on developing a more applicable engineering management tool.

Development of a Better Suited Engineering Management Tool

First Draft – New Product Development Score Card

Our brief examination of our intended management tools highlights that they are either too targeted, or not guided enough to ensure the user identifies the right information and avoids bias. We therefore need a different tool to form the core of our Engineering Management process.

Looking at our identified issues, each one could be approached as a question. For example, “Who is your target market or customer?” or “Have you determined what the customer requirements of your product are?”.

Approaching from this angle, a more appropriate tool to help guide new teams in determining the viability of their new product idea or startup business, would be a flow chart or decision tree. Using our list, we can further break down the issues into a series of associated questions with a weighting applied to each.

Where applicable, each question can recommend a tool which should be performed to generate an answer, such as PESTLE or SWOT. The overall guiding principle behind this tool is that it must be simple enough that a novice user can quickly and with minimal data make a decision on the viability of their product.

A draft tool is shown below. The following aspects were identified as shortcomings requiring further refinement in the final version:

- Ensure that each question prompts the user to consider the right factors.
- Recommend tools which can be used to answer each question if applicable.
- Assist the user in determining what is a pass/fail score for each stage.
- Include further questions to assist the user in determining their options should they decide not to proceed past a stage.

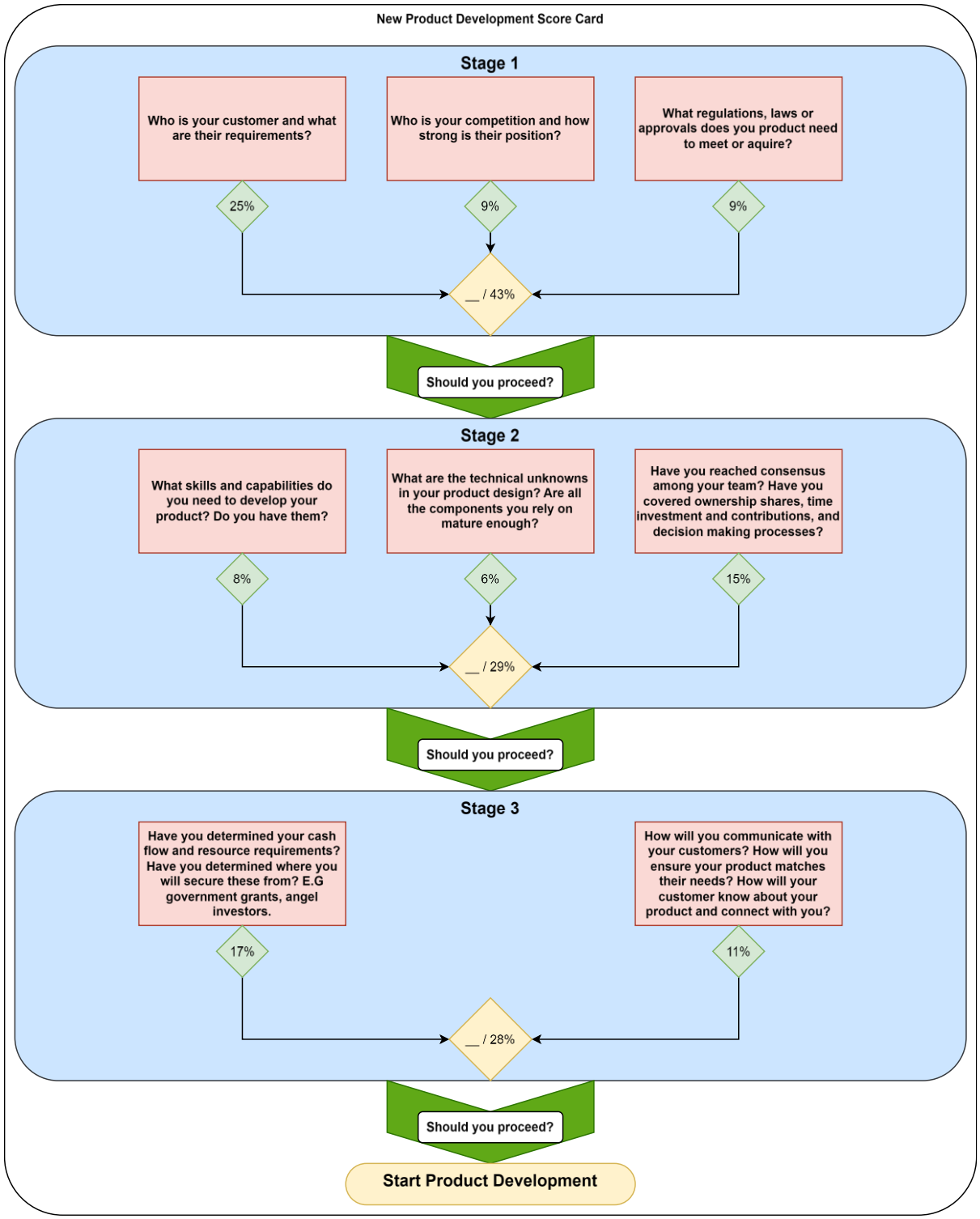

Figure 8 Draft "New Product Development Score Card" Flowchart Tool

Final Form – New Product Development Score Card

The final form of the New Product Development Score Card is shown below. It has been updated to include extra suggestions to help the user answer each question. Some of the suggestions include recommendations for simple management tools which can help, such as the “Look, Ask, Try” framework for determining customer requirements, or the Delphi method for reaching consensus on issues such as ownership among the team.

Many of the suggestions are simply further questions which help to focus on some aspects of each main question. The goal of these suggestions is to get the user started with the hope that answers will flow more easily once they are actively thinking about each issue.

The tool itself does not offer any further help in determining what is a pass/fail score for each stage. These scores are themselves very subjective and really only serve to draw attention to whichever section the user is least confident in answering. Generally anything less than 50% of the available marks for a question should warrant more attention and a justification as to whether it is acceptable or not.

In the case where the user decides that they should not proceed based on their scoring for a stage, the new tool includes some broad questions and a NOTES section to make the user articulate what the problem is and what could they do to change it. In many cases this might be as simple as finding more information but, in some instances, it might be the case that nothing can be done, in these instances the user can at least be conscious of the weakness if they still wish to proceed.

This final tool also does not implement any clearly defined mitigations when the user has decided they have failed a question. The suggestions section offers some of the same effect by suggesting some options in some cases. It became apparent when exploring the options that any mitigations that would fit within a simple tool such as this, would be too vague and general to offer much benefit.

With the goal of keeping this new score card tool simple enough for anyone to use a limit had to be set on the amount of information to include and the level of complexity.

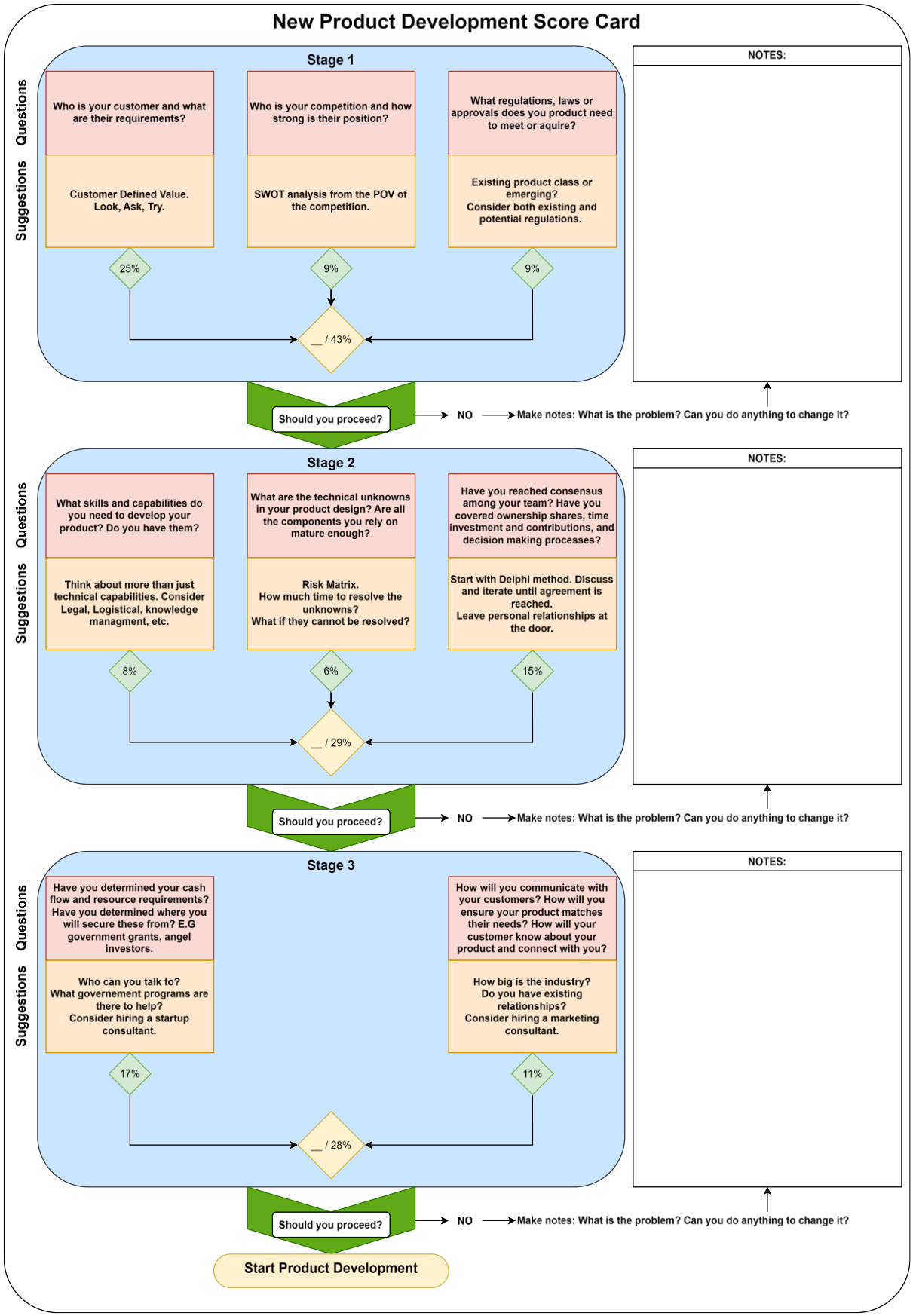

Figure 9 Final "New Product Development Score Card" Flowchart Tool

Discussion and Conclusion

The original aim of this project was to determine and provide examples of the best engineering management tools for small startups to use at the beginning of their new product development journey. After performing our research and assessing the tools we selected for this purpose it was determined that they did not satisfy our aim. The project then evolved to develop a new tool, based on our research, that would better suit small inexperienced teams.

While researching common issues faced by startups most sources agreed on a few key problems. Although there were some issues which were not common across all sources, there was a clear separation between the most and least important issues once we applied our ranking methodology to determine score values. This provides us with confidence that the list of issues we finalised is a good representation of what most small teams will face when developing a new product.

The new Score Card tool which this project has created provides a low barrier to entry for new startups to gain some of the benefits of effective engineering management. Unlike other tools it is general enough to cover all the most common issues faced, whilst being constrained enough to ensure the user satisfactorily answers each question.

Although it represents a good starting point, the new tool is quite limited in the accuracy and depth of the conclusions or insights it helps generate. It lacks some of the more in depth and data driven insights which can be attained from using tools such as a House of Quality analysis. It also does not offer the same brainstorming benefits of tools such as Porter's Five Forces or PESTLE. All these other tools however either require more resources or are more focused on specific areas of product development.

This leads to the conclusion that the Score Card tool works well as an easy all-rounder. If a team is only going to dedicate the time to using one tool, this tool will help address the most important pitfalls for the least amount of effort. As a team grows in size and experience, they will be well served by exploring some more complex management tools on an as needed basis.

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Appendix A – Data Collection

Issue Master List

	Source Weighting	157	24	30	33	36	34
	Sources	Total	Why Most Product Launches Fail	The Top 12 Reasons Startups Fail	Why Start-ups Fail	Failure in Startup Companies: Why Failure Is a Part of Foundi	Failure of Tech Startups: A Systematic Literature Review
Issues	Market for product is not defined	4095	840	2430	825		
	Product doesn't match customer demand or requirements	4075	1080	810	825		1360
	Difficulty ramping up scale	3825	600	2400	825		
	Competition provides better or cheaper product	3570		2160		900	510
	Regulatory or legal barriers and challenges	3445		1260	825		1360
	Disharmony among team or investors	2650		540		1260	850
	Team doesn't have the skills required to develop product	2365		1200	825		340
	Flawed business model, no customer defined value	2100		2100			
	Customer is not aware of product benefits or use case	2080	840			900	340
	Failure to secure capital as company grows	2065			825	900	340
	Product costs too high compared to what customers are willing to pay	1500		1500			
	Launching before the product is ready	1320	600	720			
	Disagreements on strategic decisions	1260				1260	
	Disagreements on individual contribution and relative importance or share of ownership in company	1260				1260	
	mismatch between supplier capacity and market demand	900				900	
	Cost of ICT and perceived benefits	850					850
	Difficulty hiring key positions as company grows	825			825		
	Other social or cultural issues	680					680
	Pivot to new market or use case gone wrong	540		540			
	Technology not mature enough	540				540	
	Bad location where company is founded	170					170
	Burned out/lack of passion among team	60		60			

Condensed List (Sorted highest to lowest)

Condensed List (Sorted)	Total	Percentage
Market for product not defined or product doesn't match requirements	10270	25.56
Difficulty scaling or cash flow issues	6715	16.71
Interpersonal or cultural problems and disagreements among team	5910	14.71
Communication problems with customer, mismatched goals and values	4480	11.15
Competition in the market	3570	8.89
Regulatory, legal, or governmental hurdles	3445	8.57
Skill or capability issues	3215	8
Technical or timing problems	2400	5.97
Problems with where company is located	170	0.42
Total	**40175**	100
Median	3570	8.89
5th Percentile	1062	2.64

Individual Source – Why Most Product Launches Fail

Source Ranking Matrix			
Use this table to rank the source in terms of its relevance and credibility. Rank each aspect from 1 - 10.			
Aspect	**Ranking**	**Reasoning**	
Reputation of source or author(s)	8	Harvard Business Review is a respected publication and the authors are professionals in their field.	
Is the source peer reviewed and how rigorously?	5	Not peer reviewed but subject to editorial standards.	
How close is the source to the Australian context?	5	Based on American experiences.	
Size or quality of data the source uses	3	Based on cherry picked historical examples.	
How closely does the data or examples in the source align with our target of small engineering startups?	3	Does not focus on small tech or engineering startups specifically.	
TOTAL	**24**		

Issue Ranking Matrix			
Use this table to rank issues identified in the source in terms of how often they occur or how common they are, and how severe the consequences of the issue are. Then multiply the two numbers to get an importance ranking. Ranking is on a scale of 1 - 10.			
Issue	**likelihood**	**severity**	**importance**
Difficulty ramping up scale	5	5	**25**
Launching before the product is ready	5	5	**25**
Product doesn't match customer demand or requirements	5	9	**45**
Customer is not aware of product benefits or use case	5	7	**35**
Market for product is not defined	5	7	**35**

Individual Source – The Top 12 Reasons Startups Fail

Source Ranking Matrix		
Use this table to rank the source in terms of its relevance and credibility. Rank each aspect from 1 - 10.		
Aspect	**Ranking**	**Reasoning**
Reputation of source or author(s)	7	Company which specialises in tech industry research.
Is the source peer reviewed and how rigorously?	1	Source is not peer reviewed and self published.
How close is the source to the Australian context?	8	Based on global examples, mostly USA and Europe.
Size or quality of data the source uses	7	Based on results of reading 111 post-mortems on startup failures.
How closely does the data or examples in the source align with our target of small engineering startups?	7	Based mostly on technology startups.
TOTAL	**30**	

Issue Ranking Matrix			
Use this table to rank issues identified in the source in terms of how often they occur or how common they are, and how severe the consequences of the issue are. Then multiply the two numbers to get an importance ranking. Ranking is on a scale of 1 - 10.			
Issue	**likelihood**	**severity**	**importance**
Burned out/lack of passion among team	1	2	**2**
Pivot to new market or use case gone wrong	2	9	**18**
Disharmony among team or investors	2	9	**18**
Poor product quality or product doesn't meet customer requirements	3	9	**27**
Product released too early or too late	4	6	**24**
Team doesn't have the skills required to develop product	4	10	**40**
Product costs too high compared to what customers are willing to pay	5	10	**50**
Regulatory or legal barriers and challenges	6	7	**42**
Flawed business model, no customer defined value	7	10	**70**
Competition provides better or cheaper product	8	9	**72**
No market or customer demand	9	9	**81**
Company runs out of money before product launches	10	8	**80**

Individual Source- Why Start-ups Fail

Source Ranking Matrix			
Use this table to rank the source in terms of its relevance and credibility. Rank each aspect from 1 - 10.			
Aspect	**Ranking**	**Reasoning**	
Reputation of source or author(s)	9	Author is a Prof of business admin at the Harvard Business School and faculty chair of the Harvard Innovation Labs.	
Is the source peer reviewed and how rigorously?	5	Not peer reviewed but subject to editorial standards.	
How close is the source to the Australian context?	7	Based on global examples.	
Size or quality of data the source uses	7	Based on large number of interviews and surveys from primary sources.	
How closely does the data or examples in the source align with our target of small engineering startups?	5	Does not focus on small tech or engineering startups specifically. But includes a good number.	
TOTAL	**33**		

Issue Ranking Matrix			
Use this table to rank issues identified in the source in terms of how often they occur or how common they are, and how severe the consequences of the issue are. Then multiply the two numbers to get an importance ranking. Ranking is on a scale of 1 - 10.			
Issue	**likelihood**	**severity**	**importance**
Wrong people in Team	5	5	**25**
Lack of market research or business case	5	5	**25**
Early success misleads on market demand or desired features	5	5	**25**
Growth is not profitable and company runs out of cash	5	5	**25**
Difficulty hiring key positions as company grows	5	5	**25**
Failure to secure capital as company grows	5	5	**25**
Product success relies on too many external influences to succeed. i.e government support.	5	5	**25**

Individual Source- Failure in Startup Companies: Why Failure Is a Part of Founding

Source Ranking Matrix			
Use this table to rank the source in terms of its relevance and credibility. Rank each aspect from 1 - 10.			
Aspect	**Ranking**	**Reasoning**	
Reputation of source or author(s)	9	Authors are management professionals from reputable institutions in Germany.	
Is the source peer reviewed and how rigorously?	5	Not peer reviewed but subject to editorial standards.	
How close is the source to the Australian context?	8	Based on data primarilly from Germany, but also the USA and globally.	
Size or quality of data the source uses	9	Based on data collected from several different studies, each containing hundreds to thousands of examples.	
How closely does the data or examples in the source align with our target of small engineering startups?	5	Does not focus on small tech or engineering startups specifically. But includes a good number.	
TOTAL	**36**		

Issue Ranking Matrix			
Use this table to rank issues identified in the source in terms of how often they occur or how common they are, and how severe the consequences of the issue are. Then multiply the two numbers to get an importance ranking. Ranking is on a scale of 1 - 10.			
Issue	**likelihood**	**severity**	**importance**
Different expectations or levels of commitment among team members.	7	5	**35**
Disagreements on strategic decisions	7	5	**35**
Disagreements on individual contribution and relative importance or share of ownership in company	7	5	**35**
mismatch between supplier capacity and market demand	5	5	**25**
Failure to manage customer expectations	5	5	**25**
Lack of capital / cash flow problems	5	5	**25**
Technology not mature enough	3	5	**15**
Strong competition	5	5	**25**

Individual Source- Failure of Tech Startups: A Systematic Literature Review

Source Ranking Matrix		
Use this table to rank the source in terms of its relevance and credibility. Rank each aspect from 1 - 10.		
Aspect	**Ranking**	**Reasoning**
Reputation of source or author(s)	7	Authors are academics, but not specialising in management
Is the source peer reviewed and how rigorously?	7	Source is a from conference proceedings, and also subject to review before publishing.
How close is the source to the Australian context?	7	Based on global examples
Size or quality of data the source uses	5	Based on small number of primary studies
How closely does the data or examples in the source align with our target of small engineering startups?	8	Based almost exclusively on tech startups
TOTAL	**34**	

Issue Ranking Matrix			
Use this table to rank issues identified in the source in terms of how often they occur or how common they are, and how severe the consequences of the issue are. Then multiply the two numbers to get an importance ranking. Ranking is on a scale of 1 - 10.			
Issue	**likelihood**	**severity**	**importance**
Product does not match customer needs	8	5	**40**
Government support or approval required	8	5	**40**
Cost of ICT and perceived benefits	5	5	**25**
Characteristics of founders. Personality or skills	5	5	**25**
Other social or cultural issues	4	5	**20**
Competitors in the market	3	5	**15**
Lack of resources	2	5	**10**
Lack of skills within team	2	5	**10**
Use of product not clearly conveyed to customer	2	5	**10**
Bad location where company is founded	1	5	**5**