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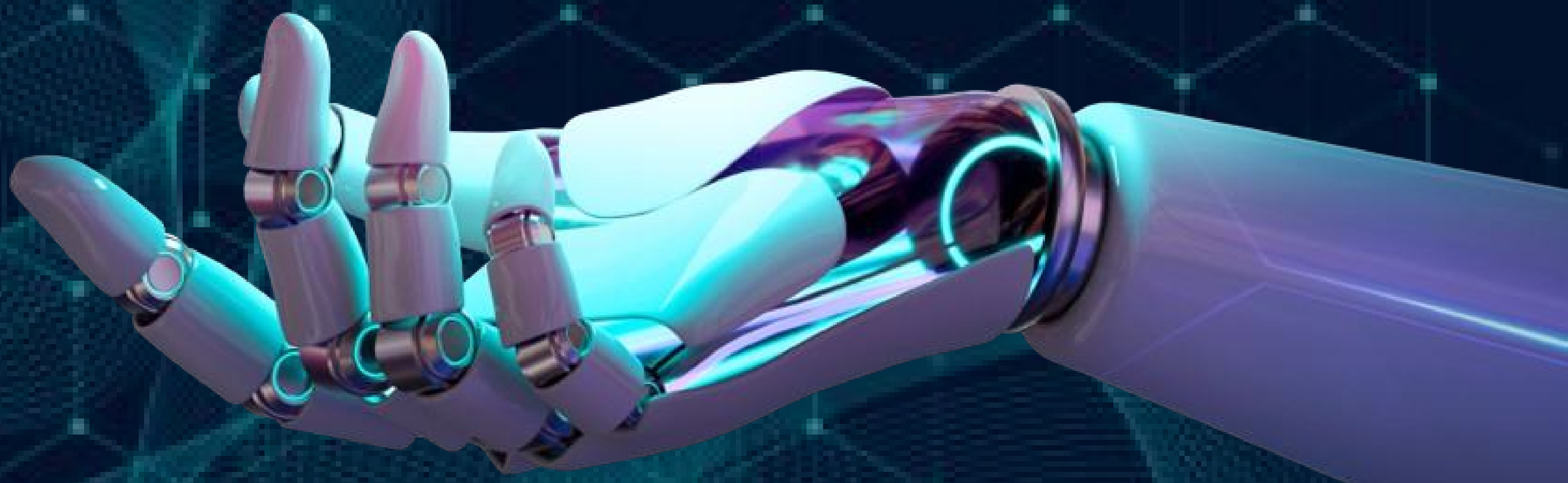
Understanding the Capability Growth Curve of AI systems



PRAGMATIC AI FOR FOUNDERS & INDUSTRY LEADERS

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YOUR JOURNEY TO PRAGMATIC AI

In the rapidly evolving Artificial Intelligence (AI) driven landscape, Generative AI vows to revolutionize businesses like never before. Despite offering unparalleled opportunities, it also presents intricate challenges in transforming this disruptive technology into successful business endeavors. The goal is not merely to navigate these challenges but also to elevate your organization's AI practices to achieve the pinnacle of 'Pragmatic AI."

We define **Pragmatic AI** as the AI that **outlines a clear path** for **translating AI efforts** into **tangible business successes** leading to **increased revenues** and **market dominance**, rather than just being **obsessed with (superficial) model metrics**.

This paper serves a dual purpose: highlight the fact that creating the model is not the hardest part for AI-first businesses and getting to it is often a long journey; and second, layout the right way to develop AI systems.

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Note from the CEO'S DESK

Dear Reader, Greetings!

Thank you for stopping by to read this. It is worth pausing for a moment to contemplate the significant opportunity that lies before us – the realm of **Artificial Intelligence (AI)** and the countless possibilities it offers. This is akin to the revolutionary impact of electricity or industrialization, each of which reshaped many aspects of human existence, redefining industries, streamlining processes, and fostering unparalleled levels of innovation.

In today's rapidly evolving business landscape, incorporating AI into your business is no longer a luxury but a necessity to stay competitive and relevant. Each of us is taking our respective organizations on a transformative path, aiming to harness the boundless potential of one of the most disruptive technologies of the 21st century. I firmly believe that this journey will shape the future of countless organizations.

Having said this, with every groundbreaking technology comes a set of challenges. AI is no different. ***Understanding the intricacies of AI is crucial to successfully adopting and fully unlocking its potential.*** At Gradient Advisors, ***our philosophy has always centered on demystifying AI, cutting through noise and lofty claims, enabling its optimal utilization and create impact.***

While there is a wealth of content on AI tailored for developers and practitioners, there remains a noticeable gap for founders, leaders, executives, and investors seeking guidance to navigate this complex landscape and make informed decisions. It is with this ethos in mind that, drawing upon our two decades of extensive experience in AI, we are embarking on a series of articles under the umbrella of 'Pragmatic AI,' aimed at supporting Founders, VCs, CXOs, Executives, and the broader AI community.

We sincerely hope you will find value in this initiative. Your feedback and engagement will be greatly appreciated.

Best Regards,

Anuj Gupta
Founder & CEO
Gradient Advisors

AI Capability Continuum: A Three Step Framework to Understand the Capability Growth of AI systems

In recent years, the field of Artificial Intelligence (AI) has witnessed remarkable progress, with many breakthroughs now accessible through APIs and open-source solutions. Thanks to this increased accessibility and ease of implementation, it has led organizations, ranging from fledgling startups to Fortune 100 MNCs, to actively integrate AI into their products and services.

However, amidst this surge in adoption, significant challenges remain. ***One major hurdle is the high failure rate of AI projects in the industry.*** According to a recent survey [1], a staggering 96% of AI projects encounter data issues during the training phase, preventing them from progressing further. Another survey [2] reveals that despite substantial investments, 8 out of 10 companies reported minimal or no Return on Investment (RoI) from their AI efforts. ***These findings underscore the need for addressing critical issues in AI implementation to ensure successful outcomes and maximize the potential benefits of this rapidly evolving technology.***

In this article, we present *"**AI Capability Continuum**", **a three-step framework tailored to help you conceptualize the development and assess the capability growth of AI systems.*** To elucidate this framework effectively, we will utilize the *capability curve*.

Executive Summary

- *The article introduces a three-step framework for developing AI systems in industry the right way so as to maximize ROI from AI efforts.*
- *Interestingly, the shape of the capability growth curve for AI systems differs significantly from that of traditional software systems !*
- *The reason for this lies in the distinct needs of developing AI systems; best described by the three phases of the proposed framework.*
- *The first phase involves laying the foundations and not focusing on model building.*
- *The second phase focuses on quickly moving from 'a' AI system to a 'very good' AI system.*
- *The third phase is about pushing boundaries, get to 'The' system.*
- *We also explore how off-the-shelf LLMs such as ChatGPT effect the capability curve, enabling rapid sales & testing the markets.*

CAPABILITY CURVE OF TRADITIONAL SOFTWARE SYSTEM

Consider the following: as one implements more n more parts of a software system, its capabilities (things it is able to do) keep on increasing. If one were to draw a 2D curve with Y-axis as capability and X-axis as time, and draw growth in software's capability with time, How would that curve look like?

Engineers started writing software in the 1970s. Over the past five decades, humans have deeply understood and mastered every aspect of software development right from requirements gathering to development, all the way to on-premise deployment and maintenance. Given mankind's mastery of the software development process, *the capability curve for standard software projects/systems is illustrated in Figure 1.*

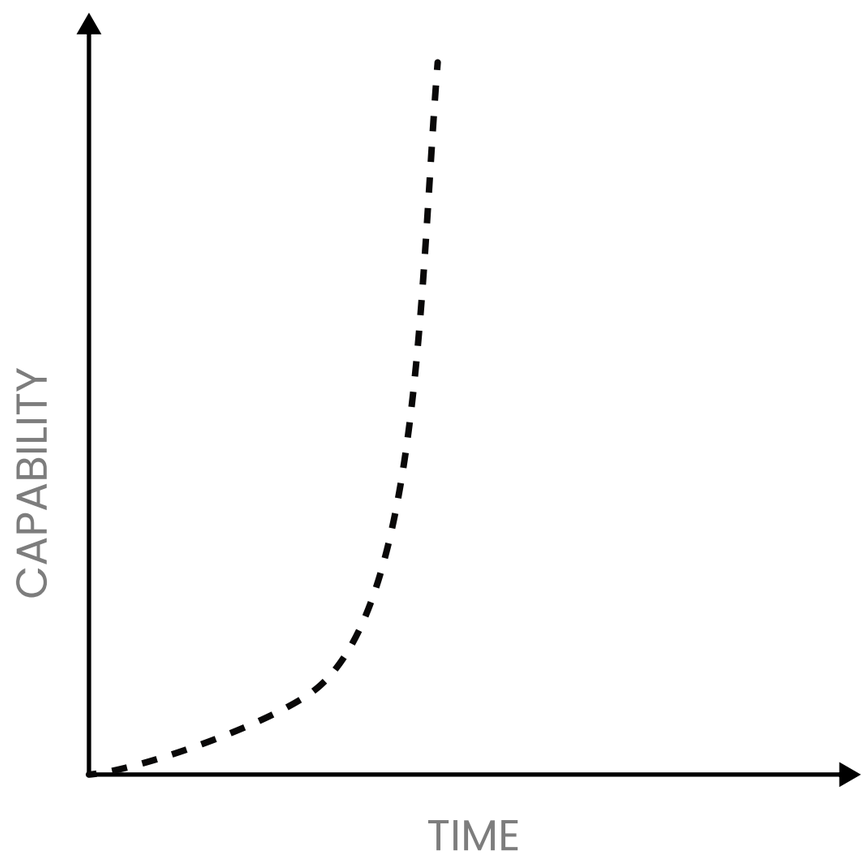

Fig 1: Capability curve for a typical software/IT system

Let us now understand the why the shape of this curve is the way it is :

Initially, starting a typical IT/software development project demands time and effort—gathering requirements, scoping, budgeting, and assembling the right team. During this inception phase, the capability grows slowly, resulting in the capability curve with a flat slope. But once we are past this initial stage, the capability curve of the software system rises steeply. Within a few days/weeks of starting the development, one starts to see the gains materialize pretty quickly, creating a steep rise in the curve. Powerful and efficient development tools, frameworks, programming languages, agile methodology, tools, extensive software development experience, cloud computing, collaborative development platforms coupled with automation and DevOps have contributed significantly to the hockey stick shape of this curve.

CAPABILITY CURVE OF AI SYSTEM

When it comes to the capability curve of a typical AI project/system, any guesses what the shape might look like? it is very different:

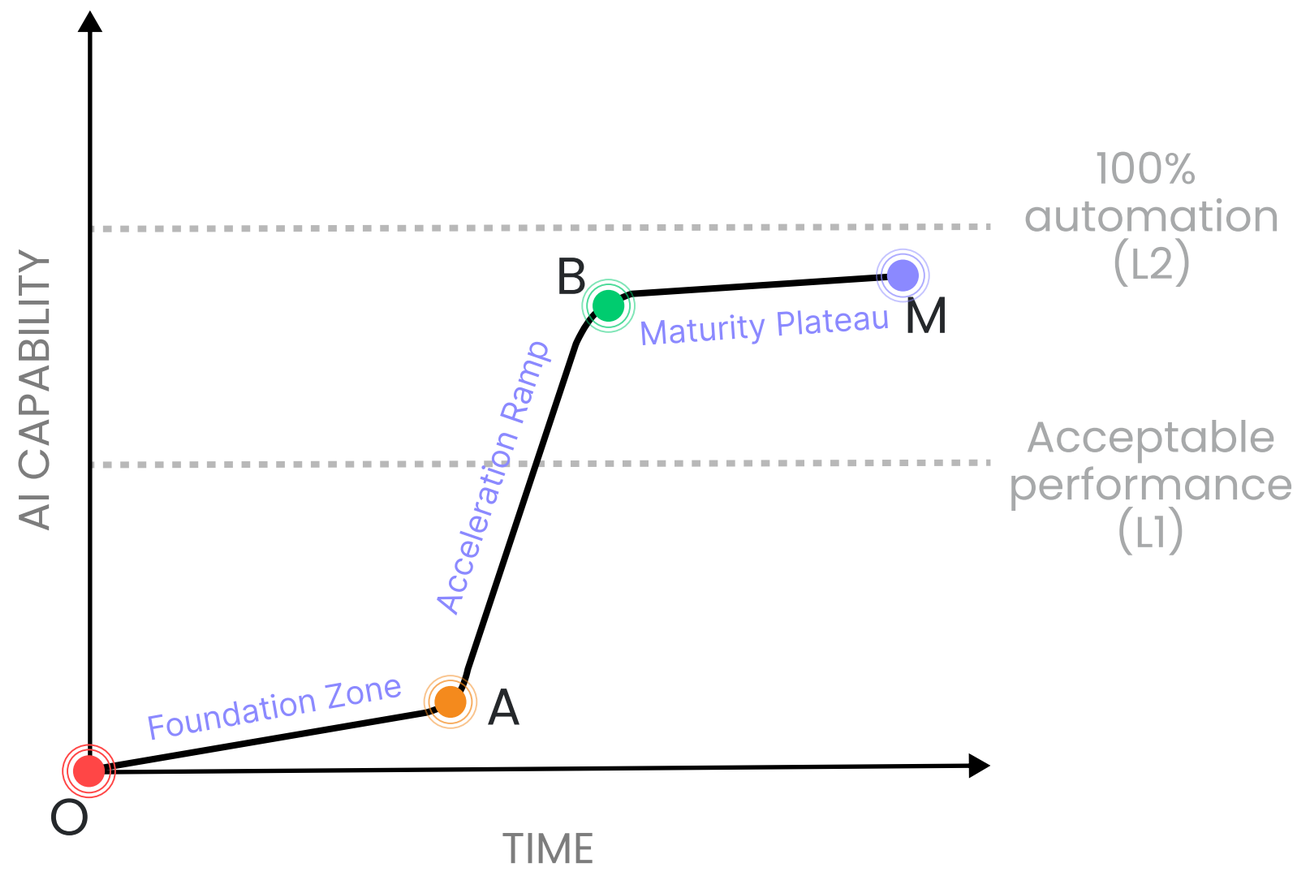

Fig 2: Capability curve for a typical AI system

Immediately one sees distinct similarities and notable differences between this curve and previous one. In contrast to Fig 1 (on previous page), the initial segment of the curve in Fig 2 remains remarkably flat for an extended duration, resulting in a more elongated form. Subsequently, it ascends fast, albeit not as sharply as in Fig 1. Most intriguingly, towards the conclusion, the curve stagnates sharply.

This shape of capability curve for AI surprises many industry practitioners, especially those with extensive software engineering background. Founders, CXOs, leaders, and managers often anticipate an AI system's capability curve to mirror that of software systems, (resembling a hockey stick). However, this is far from reality.

Reason? *The long-standing, well-understood playbooks of software development do not work for AI development*. This greatly impacts the capability curve for AI. Let us try to understand this better and uncover why the shape of the curve changes. To do so, we divide the curve into three main segments: *Foundation Zone* (O-A), *Acceleration Ramp* (A-B), and *Maturity Plateau* (B-M) and then look at each segment in detail as under. The attempt is to better understand AI development and write its playbook.

Foundation Zone (O-A)

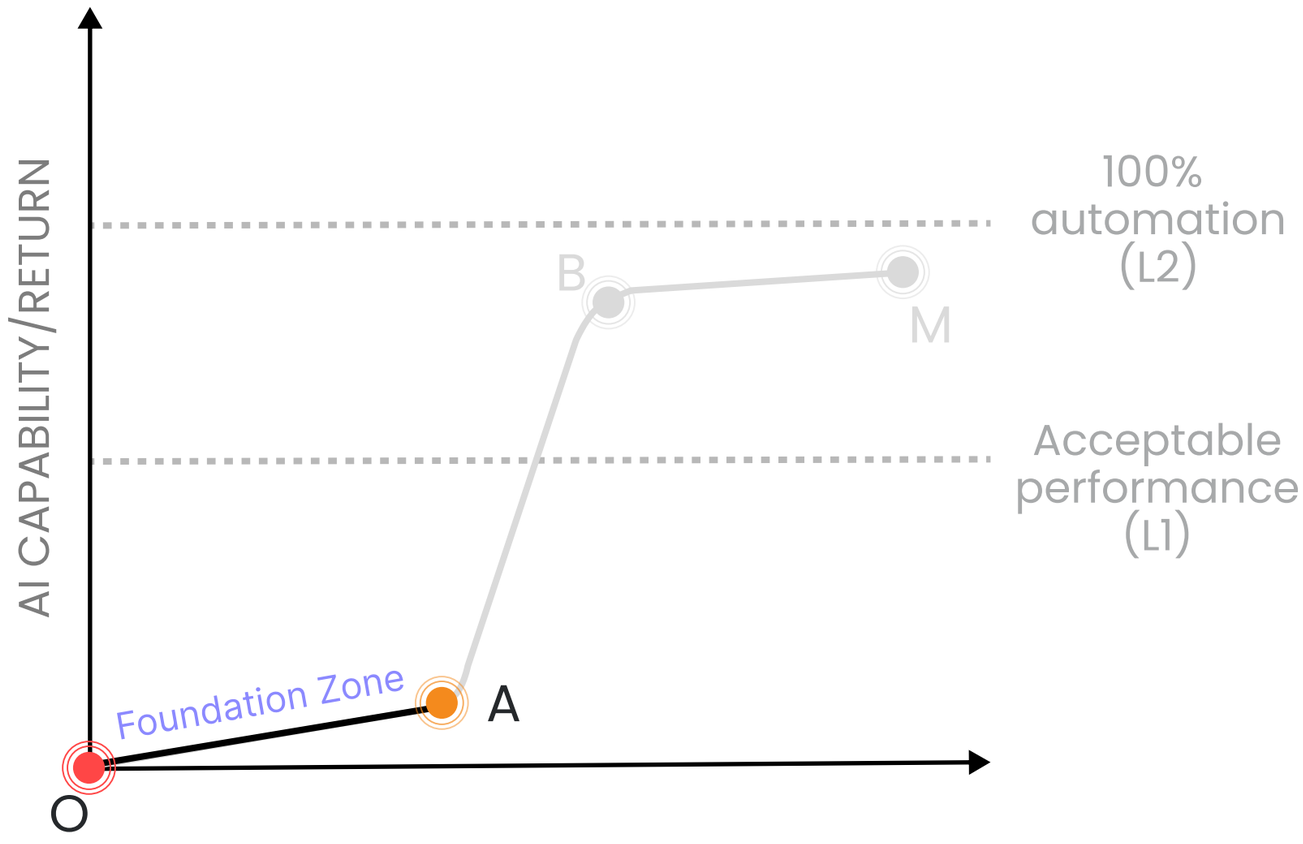

Fig 3: Foundation Zone Phase of capability curve for a typical AI system

In *Foundation Zone*, the focus should be solely on setting up the game correctly. The following are the major steps involved:

1. Develop a better understanding of the (vague) business problem
2. Convert the (often vague) business problem statement into a well-defined business problem statement
3. Evaluate if the problem statement (in 2) is even an AI problem or not
4. Define the success metrics of the solution - both business and ML metrics
5. Understand the kind & quantity of data that needed to solve the AI problem
    a. Understand if your organization has the kind & quantity of data needed in the preceding step
    b. Get the data needed, preprocess & clean it, and create *a v0* dataset from it
6. Understand the broader kind of AI problem at hand - supervised, unsupervised, reinforcement learning etc
    a. In case of supervised learning, get the v0 dataset labeled.
7. Understand the constraints your solution must adhere to:
    a. Cost of mistake/wrong prediction
    b. Prediction time - Real-time or batch?
    c. Compute location - cloud or edge?
8. Any other constraints the solution *must* adhere to
    a. Time to prediction, explainability of prediction etc
9. Build *a* model - **often a simple model/baseline, even 3rd party API**
10. ***Quickly get to test the core business hypothesis*** - does your solution solve a major pain point for the end user (or business unit) or not? how likely it is to see PMF?
    a. If yes, how much market is willing to pay for it?

Depending on the difficulty of the problem at hand, the AI maturity/literacy within the organization and the time to test the core thesis, typically this phase can take anywhere between 30 days to even 6 months! Typically the hardest pieces in this phase often proves to be aspects around dataset preparation and testing the core hypothesis.

Observations:

- ***The most common mistake that a lot of teams/organizations make is that from day 1, they get down to building 'the' model. They believe anything less than state of the art Large Language Models (LLMs) is unacceptable. This should never be the aim of this phase.***

  The purpose of Foundation phase is to understand the fundamental aspects of the problem - **are we solving the right problem, is the problem at hand is even an AI problem or can be solved using traditional approaches, do we have the kind of data that is needed to solve the problem well. Most importantly:** *is our overall solution/product/service a pain killer or a vitamin for the market, and what kind of price market is willing to pay for it*[1]*?*

  Why do we say so? Because AI is an expensive technology - massive datasets, hardware for compute, AI talent; none of it comes cheap. There is no point in building a *state-of-the-art model for a problem* where each prediction costs you $3 but the market is not willing to pay you more than $1 per prediction (or worst - market shows no interest in your solution). There is no way you can build a viable business from it[2].

  Also, building a great model is hard and takes time. You need a very good understanding of the problem, great team in terms of skillset, even greater datasets and heavy compute (in case of deep learning). You should not invest time & resources of this level, unless one is *very sure* of being able to build a viable business from it.

  Any seasoned entrepreneur knows that building a business from scratch is extremely challenging (which is why successful ones are called unicorns). Numerous variables affect success. So, why obsess over having a state-of-the-art model from the start?

- The objective of this phase must be to attack the hardest part of the problem - it is not building the best model (unless you are a pure research lab). The hardest part is answering questions about the business direction:

  1. Are we building something that solves a major pain point (pain killer vs vitamin)
  2. Does the AI system seem to meet its business objectives? Ex: Alexa was a great AI product but failed to meet its business goals i.e. power more orders from Amazon.com
  3. Would users/clients be willing to pay for it ? If yes, then how much?

1 For internal products, this is a cost benefit analysis

2 This does not hold true if you are part of research lab and not product team

4. Do you think you can extract enough LTV to offset the high dev cost, indirect costs and margins to build a long term profitable business?

This is a fundamental difference when doing AI in product companies vs academia/ research labs. Academia/Research Labs are focused on advancing state-of-the-art. To drive home the point check 'thought experiment' on the next page

- In mature organizations, data is systematically organized for quick access by internal consumers like AI teams. This is akin to a well-organized pantry in a professional kitchen, enabling chefs to create dishes swiftly. Conversely, in organizations lacking data strategy, data is stored haphazardly, akin to dumping ingredients into cold storage. Retrieving specific data becomes a time-consuming project in itself, greatly hindering AI projects, a common oversight among founders and executives.

  In most organizations that lack data maturity, most AI projects die in the *Foundation* phase itself! *Thus, if you are serious about AI, getting your data strategy right is very important.*

- Many teams, founders, and executives often overlook the vital step of establishing appropriate success metrics and measurement methods, fixating solely on the model. It's crucial to systematically define AI and business metrics, ensuring their correlation. Getting this right from day one is akin to building a rocketship without a control panel, especially in AI, where systems are stochastic and prone to errors, impacting the quantification of accuracy and effectiveness.

- You may wonder, we never talked about the model or underlying algorithm. Use any model/algorithm that gets the job done - 3rd party API, open-source, or even humans producing predictions in real-time! As we argued earlier, it is wrong to invest in building a great model in this phase. Aim should be to quickly assemble a system and test the markets right-away.

- If you are not training your own v0 model, you can *downplay* the dataset creation & labelling steps. *But do keep in mind that once your project goes beyond point A, you will need good dataset to train models - it is always best to start this early to better understand the risk to the project.*

This phase also explains why the age old corporate wisdom of getting some "early wins" does not hold true in AI projects/systems. As evident, *Foundation* is a hard phase and getting early wins is super hard.

To summarize, the mantra for this phase should be "Quickly make it work & test the markets"

3 "Starting a company is like jumping off a cliff and assembling a plane on the way down" - Reid Hoffman

Acceleration Ramp (A-B)

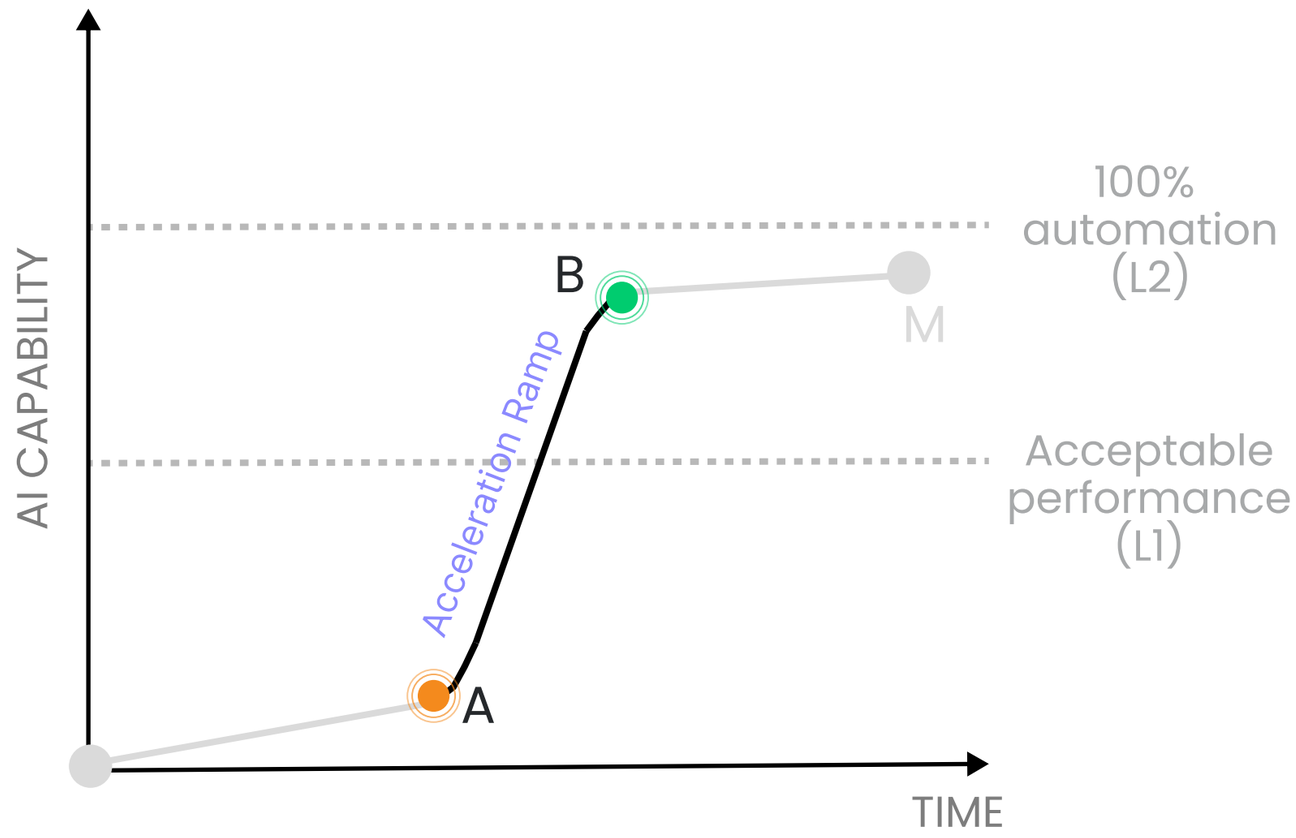

Fig 4: Acceleration Ramp Phase of capability curve for a typical AI system

This is the middle part of the curve in Fig. 4 - Acceleration Ramp. Here you get the highest progress/capability per unit effort.

A lot of hard work is already done into Foundation. You have already put in place a lot of key ingredients - refining problem statement, collecting data, operationalizing metrics & measurement methodology, and early validation from stakeholders (internal/external). In the next phase one focuses mainly on improving the model - going from *a* model to *the* model. Key steps in this phase:

1. You try various algorithms and build various models.
2. Rigorously benchmark the performance of every model built
3. Once your system crosses the acceptable performance level (L1), you take your AI system to production and expose predictions to end users
4. As you keep improving, you keep pushing out best model so far to production.
5. Test the new model and system thoroughly, replace the existing model with the new model, and monitor the gain in ML metrics and business metrics.

Keep Iterating previous steps. You will start moving quickly from a model to much better models. At some point, your gains will start to saturate. This is when you know that you are at point B. Depending on the problem at hand and AI maturity within the Org/Team, this phase can typically last from 3-12 months.

Observations:

- This phase starts, when your product/offering's value proposition starts to find traction in the market. The carefully orchestrated demos with which you tested the market landed well. Early customers have started to come, some even paid customers.

  Now, given the traction, it is crucial that you must greatly ramp up the AI capabilities of your system. This is a great time to usher Acceleration Ramp phase. This is where you focus on the core - model!

- Note that this phase has a lot of iterations within it.

- This phase is all about going from *a* model (simpler approaches) to *the* model(complex approaches).Why not try the best algorithm upfront? Occam's razor - a fundamental tenet of AI. The objective is to find the simplest model that works the best.

- Since comparing 2 or more candidate models is a key part of this phase, the ground work we did on metrics, measure methodology & rigorous test sets in the previous phase forms the bed rock of this phase & comes super handy. Without that it becomes hard to critically compare various models.

- At each step, you closely analyze the kind of mistakes your model is making. Often, it is in this analysis lies the genesis of the next model.

- As you get to better models, you keep taking them to production. This is where you go from 1st version of your AI system to maybe 3rd or 4th version of your AI system.

- At some point, your gains will start to saturate, thats when you know you are close to point B.

Briefly, this phase is all about "Make it Better"

Maturity Plateau (B-M)

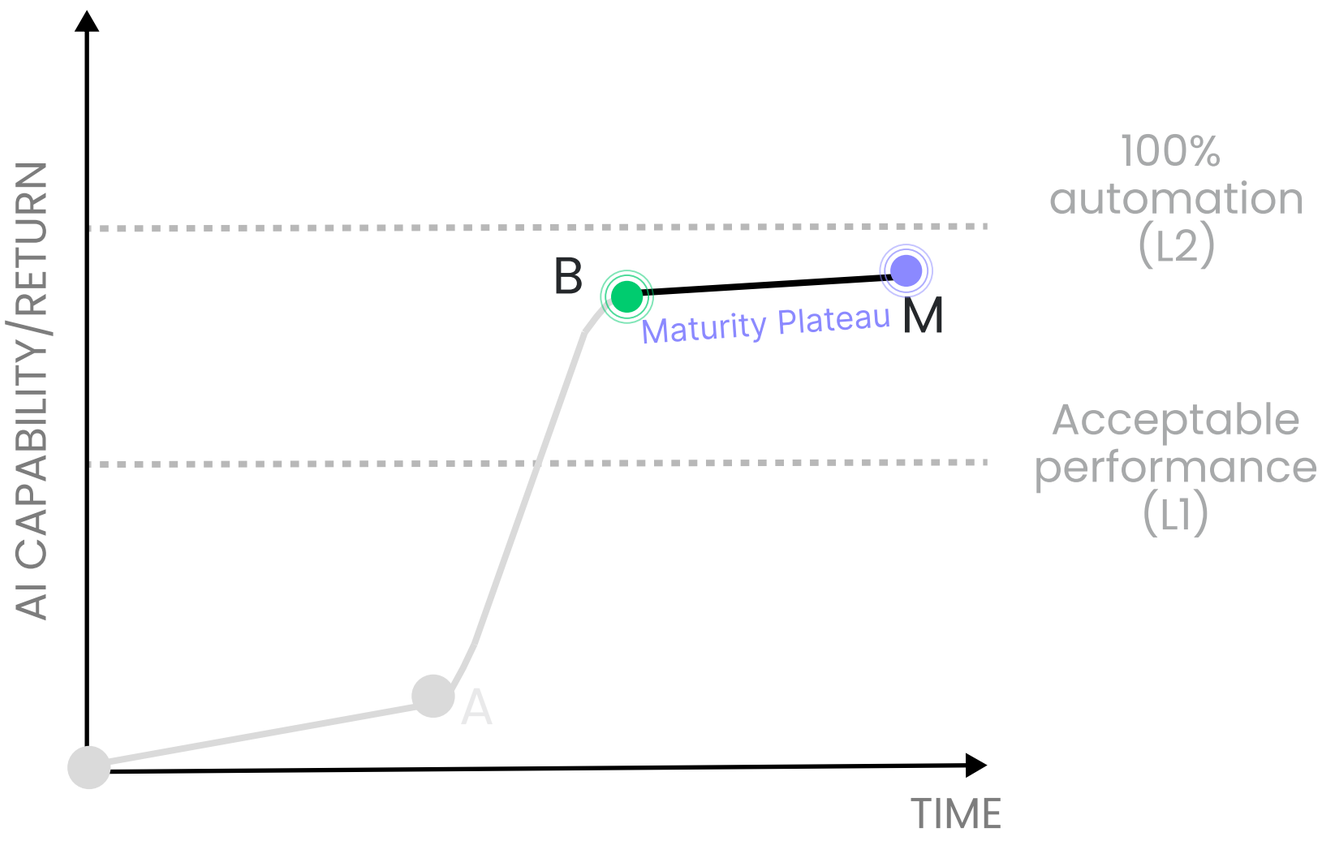

Fig 5: Maturity Plateau Phase of capability curve for a typical AI system

This is the tail end of the journey. The curve starts to tapper - your gains again start to move very slowly. This phase is about pushing the system to its limits:

1. Your team is building 20/30/40th model; 5th/7th/10th version of system.
2. You try to push systems performance to its limits.
3. Your team is looking into every single edge case that your AI system is getting wrong.
4. Your team is tweaking n trying new approaches/algorithms/neural network architectures and not just applying known AI algorithms.
5. Your team is tinkering with the very underlying mathematics of the AI algorithms and coming up with new mathematical formulations.
6. After a lot of efforts, typically the model performance improves only by 1-2%.

This phase is typically can last from 6 to 24 months depending on the difficulty of the problem at hand.

Observations:

- **This phase mostly happens only when the AI problem at hand is at the very core of your business and your business is doing very well - you have a lot of traction, a lot of paying customers, who not only love your product but also refer it to others (networkeffect).**
- **Even 1-2% gain in the AI capability will move your business numbers significantly.Say, 10-20% growth in revenue or the number of paying customers etc.**

- Most AI projects seldom get to this stage.
- This phase is all about first principles approach to model building - opening and rebuilding the very underlying math of the model grounds up.
- Notably, ***capability curve beyond M never touches L2 (100% automation)***. This is because today's AI is far from AGI - missing the ability to learn from its mistakes and keep improving.

  No matter what use case you are solving for, and how good a model your team builds, you will always have a long tail of edge cases your system will keep getting wrong. AI lives in long tail of these edge cases. ***This has huge implications on your company's profit margins, but we will cover this some other day.***
- **AI lives in the long tail of edge cases**: progress comes very slowly. Why? Complexity of handling edge cases. More advanced the model, greater its accuracy; necessitating higher-quality and more accurate data for further enhancements.
- ***Instead of exponential improvement in performance, paradoxically one sees exponential increase in the expenses and efforts required for further.*** *Ex: Self Driving Cars*

In one line, this phase is about "Make it Great".

Interestingly, depending on which of the three phases your AI project is in, it has huge implications on the kind of AI talent you need for that phase. We will cover this in another article.

Now that we fully understand AI Maturity Continuum, let us look back at our original expectations on life cycle of a typical AI project. Our expectation:

- Take a business problem statement
- Build state of the art model, deploy it
- Done.

Reality: far from above! Fig. 6 sums this up:

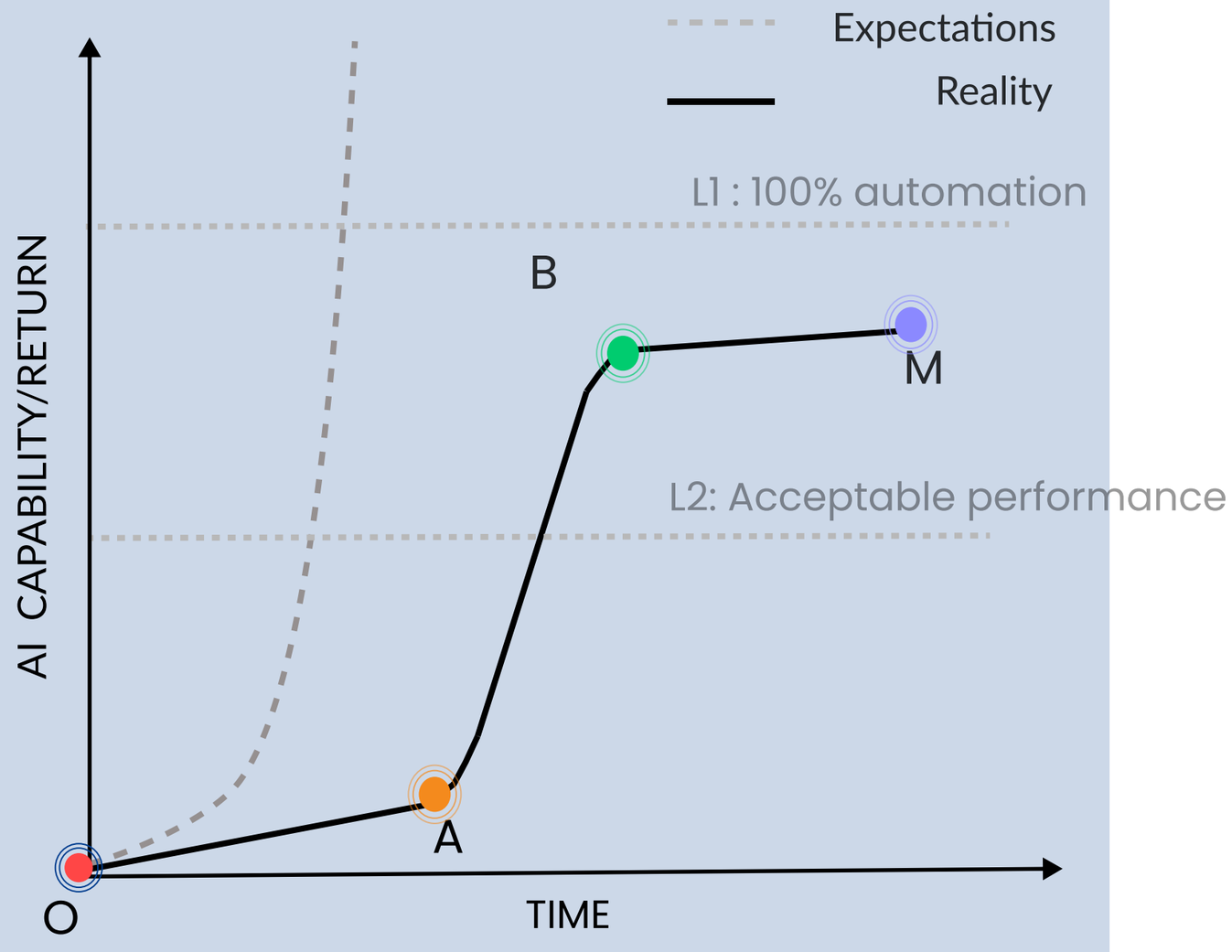

Fig 6: Capability curve for AI systems: Expectation vs Reality

Impact of chatGPT/LLMs

Let us now understand how LLMs (chatGPT, Claude, Cohere etc) or any off the shelf foundational models has impacted this curve. Now owing to commoditization of chatGPT/ LLMs, (via APIs), one gets high degree of “intelligence” off the shelf (but not 100% - even these systems make a lot of mistakes) without any training what so ever.

This means, using any of these off the shelf solutions, today a smart Product Manager (PM) with an hungry Business Leader (BL) can assemble a v0 solution without necessarily involving an AI team. They along with a street smart aspiring engineer can do enough prompt engineering to quickly assemble together an AI system within 7-10 days which good enough to demo in the market. Recall, this was the very objective of foundation phase.

They can now use the demo sell their ‘solution’ aggressively and test the market - are your users loving the solution? Are they willing to pay for it? How much are they willing to pay etc which is one of the most impotent parts of the foundation phase .

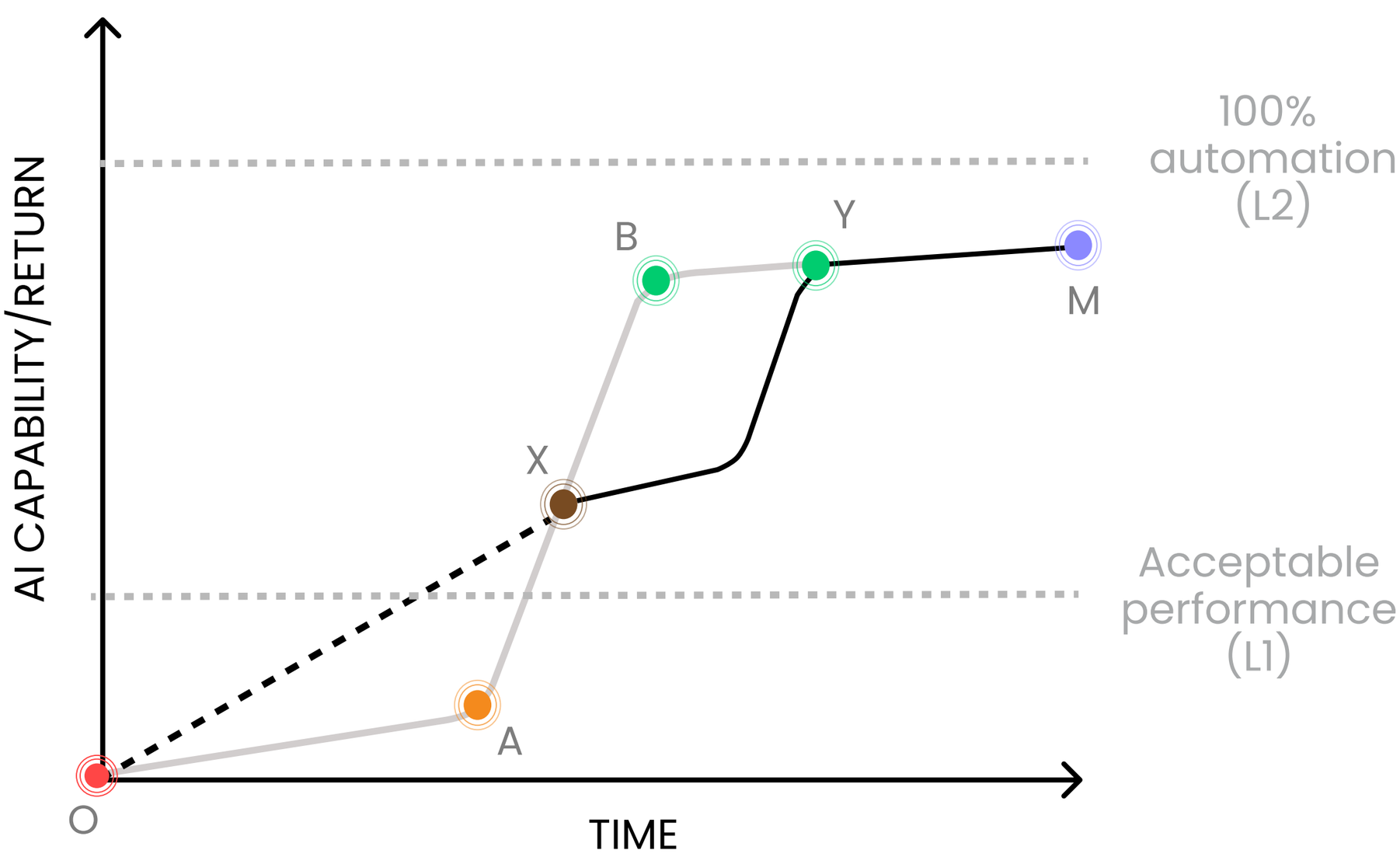

Fig 7: Impact of Off-the-shelve-LLMs on the capability curve

Let us understand the above in terms of the curve. Using chatGPT/off the shelf LLMs via API - one can get fairly high intelligence. This is represented by point ‘X’ in Figure 7. And since one can get to it very quickly, we have a straight line from pt ‘O’ to pt ‘X’. In most

cases, this much intelligence is good enough to start selling your product/offerings in the market.

At some point in time, as your paying customers go up, they will be more demanding in term of model accuracy. Now chatGPTs of the world are generic systems trained on generic data, hence no matter how much prompt engineering you do, they will take you only so far. To improve your systems further, your next logical choice will be to fine tune open source foundational models on your data. This will require you to gather data, build your own datasets. What after that? trained your own foundational models from scratch. Note this exactly the journey we saw from *Foundation Zone*, *Acceleration Ramp & Maturity Plateau* (O-A-B-M) in Fig 4. only difference now will be the accuracies/ML metric values will be much higher, hence the curve now takes the same shape beyond 'X'.

It is important to call out that today AI is niche technology and is a rapidly evolving landscape. In times to come, owing to commoditization, both cost and time to develop AI systems will come down drastically. Then the curve could look very different.

It turns out that using this curve one answer some very crucial questions - what is the right process to develop AI systems, from a talent acquisition purpose when is the right time to bring in AI scientist with PhD pedigree, why profit margin of AI companies will never be more than 40% unlike SaaS companies that have 80-85% margins and many more.

We will answer these and many more in next set of articles. Adios until then.

***

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