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A View of the Digital Engineering Process.

A simple definition of the problem DE is solving, how DE can be used to solve the problem, and an overview of the needed technologies required to implement the solution.

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Presentation Introduction

- Digital Engineering is a methodology that can be used to solve many different kinds of problems.
- In this presentation we will discus:
  - **What is the problem the DoD is trying to solve?**
  - **How can Digital Engineering support the effort to create the solution.**
  - **What is require for a Digital Engineering environment to be successful in solving the DoD's problem**

What is the problem the DoD is trying to solve?

- I have seen the following goals identified:
  - "Our customers are looking for faster cycle times and more affordable systems to counter rapidly evolving threats with a need to maintain capability and capacity." – Northrop Grumman
  - "we must modernize our defense systems and **prioritize speed of delivery**"-DoD National Defense Strategy of 2018
  - "In our industry, success isn't just about speed on the battle-field, but speed to the battlefield" *Wes Kremer : National Defense Magazine*
- I believe the statements above will not provide the DoD with the solutions they need.
- I believe the problem the DoD has, should be made clearer:
- We need to **"Reduce the time to solve problems of high complexity by an order of magnitude"**.
  - I have not seen this statement in any DoD, Northrop Grumman, or MBSE documentation.
  - If you can provide evidence that I am wrong, please let me know
  - If you can provide evidence that I am correct, please let me know
- For problems of "High Complexity":

If you don't define the problem that needs to be solved, you will not produce a solution to that problem.

What's the difference between these two statements

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- **Deliver solutions with the speed, agility and affordability**
  - Move my current processes to a digital environment
  - At best, this statement says if I use a digital environment, I may be able to improve my current processes
  - The actions above imply that we just need to update out processes
- ***Reduce the time to solve problems of high complexity by an order of magnitude***
  - **We must change the way that we solve problems in a significant way**
    - If this statement does not make this clear, then a statement that makes clear the significance of the problem needs to be defined

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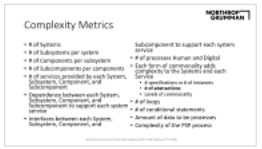
Nothing yet says
‘Use Digital Engineering’

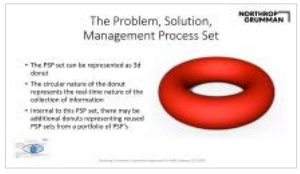
Concepts that need to be Clarified

- Commonality (Commonality is a paper/presentation by itself)
  - Commonality = A single source of record
- Complexity (this definition is a paper/presentation by itself)
  - Complexity is what drive up cost and time in solving problems.
  - There needs to be a standard way to identify, measure, and justify complexity
- Minimizing complexity
  - To ensure that the solution is not over complexity there should be an effort to ensure the complexity of the problem definition is close and directly related to the complexity of the solution definition and solution implementation



More Concepts

- **Problem Definition, Solution, Process** (PSP) set
  - The basic three actions required to solve a problem of high complexity are:
    - Define the problem
    - Create the solution (this includes verification)
    - Manage the process
- **Extendibility** = a single system of partial record. The single source is definition for a common ‘type’ of problem and is expected to have additional information/data/definition defined for a specific problem



What is a problem of High Complexity

- From Chaos theory, there are four types of problems identified:
  - Ordered
  - Complex
  - Chaos
  - Disordered
- When we analyze the four types it can be argues that there are really only two forms of problems
  - Static
  - Dynamic (Complex, Chaos, Disordered)
- From this analysis it can be argued that a complex problem is a problem where the definition of the problem and the implementation of the solution are expected to change over time.
- A problem of high complexity is a problem that contains 2 or more internal problems of complexity
- The problem to '**Reduce the time to solve problems of high complexity by an order of magnitude**' is itself a problem of high complexity


Complexity of the solution

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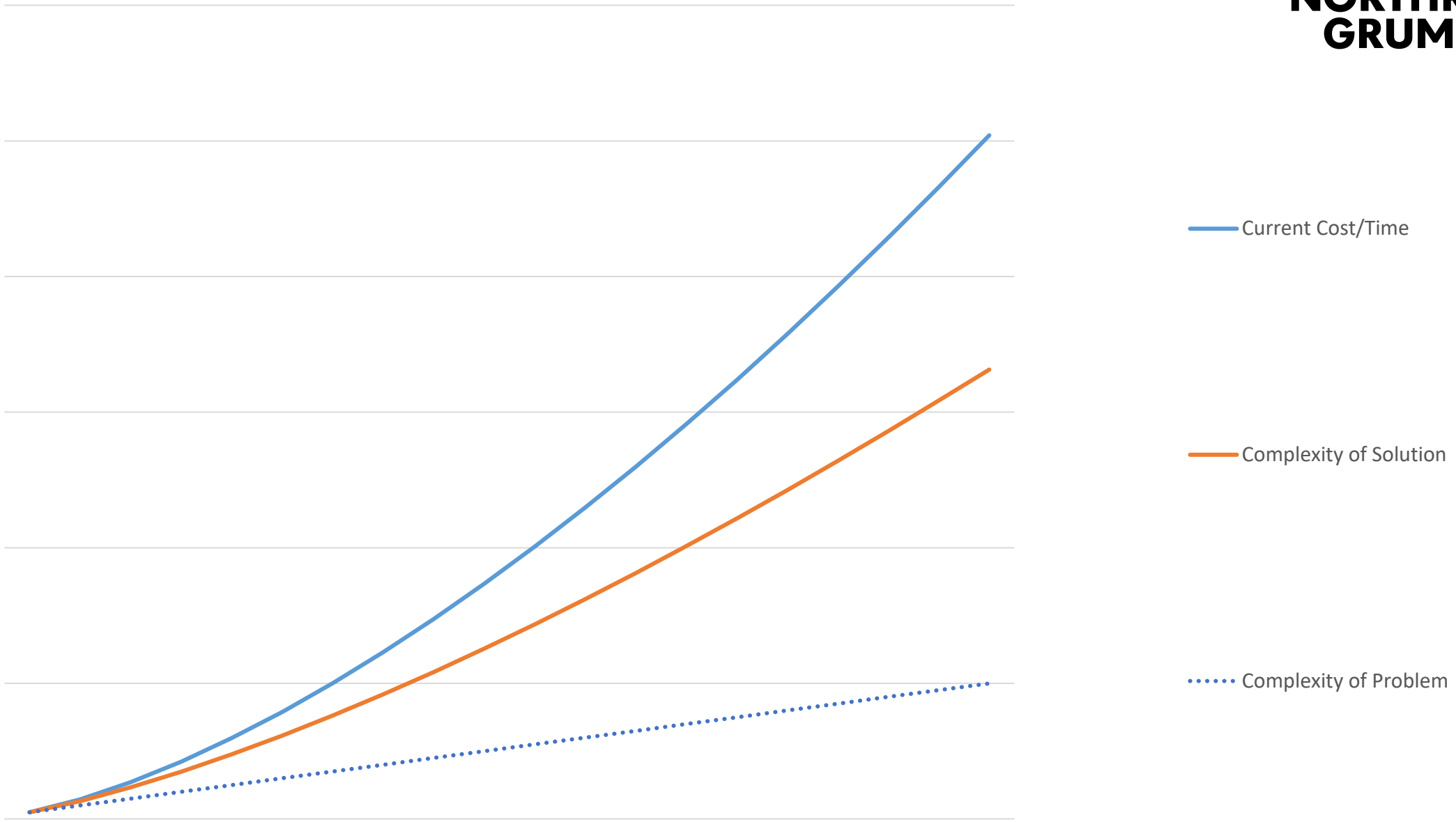
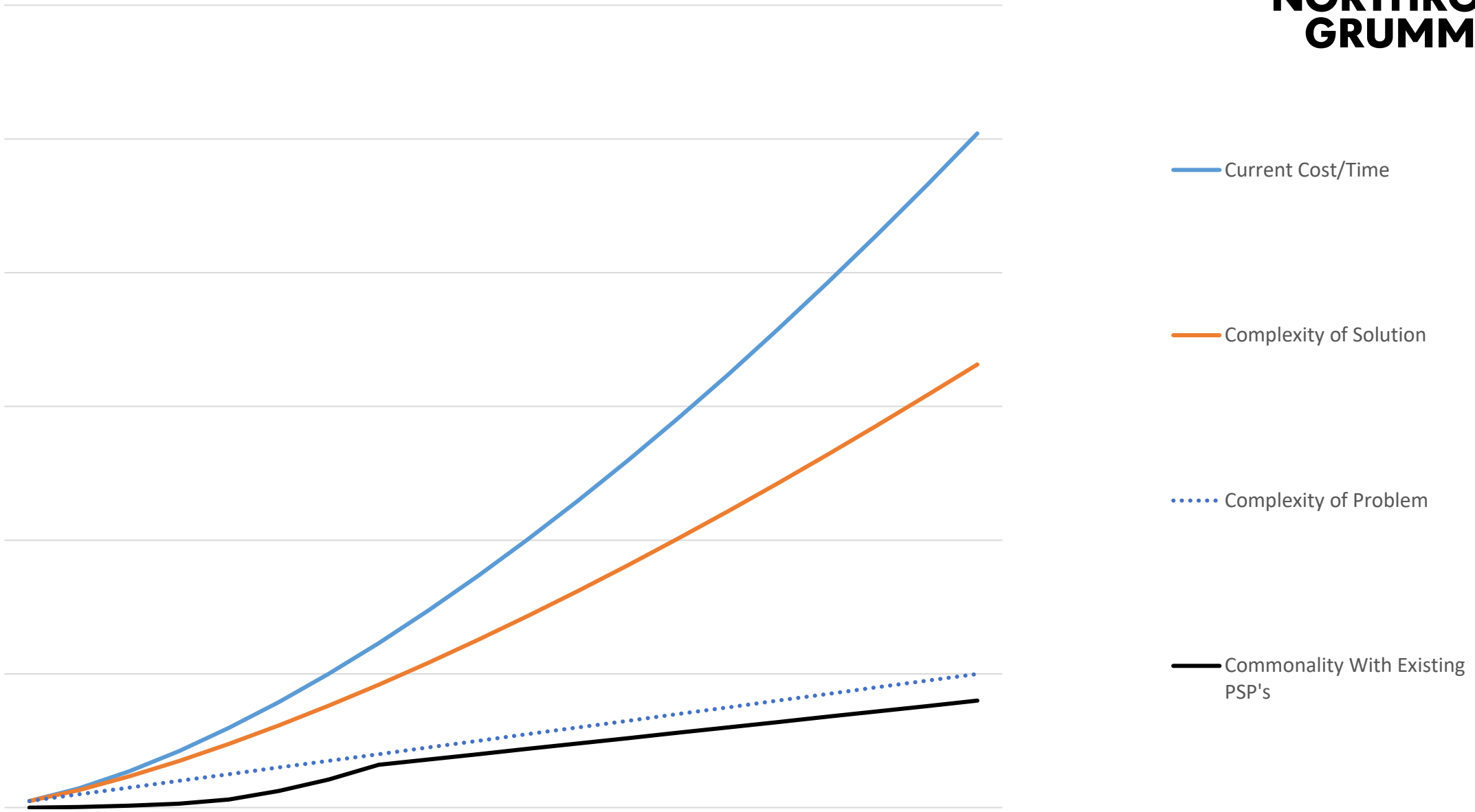
How can we solve the time reduction problem

- There are many ways to try to reduce the time to solve these complex problems
- But we can't get there by reducing the time by 5% or 10%.
- We need a path/vision that allows us to solve problems that currently take 10 year, now in 1 year (Order of Magnitude)
- How? What is the vision?
    1. **Minimize the complexity of the Problem Definition, Solution, Process (PSP) set <u>that must be solved</u> by maximizing the commonality of the parts of the PSP that have <u>already been solved</u>**
    2. I need to ensure that the complexity of the solution is minimized





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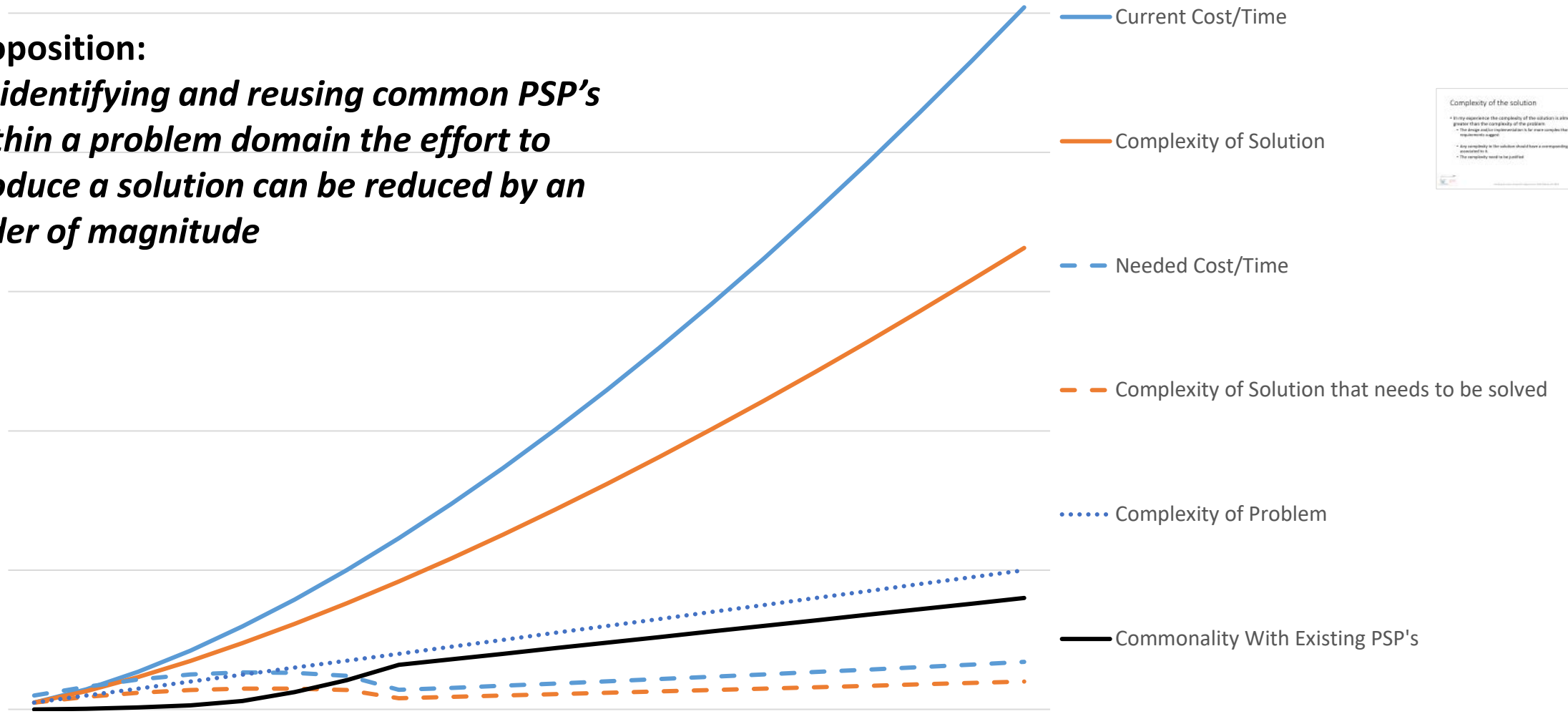
Proposition:

By identifying and reusing common PSP's within a problem domain the effort to produce a solution can be reduced by an order of magnitude



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Forms of Commonality and types Reuse

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Reuse Type\Commonality Form		False	Reference	Pattern	Variable Pattern	Static Design	Dynamic Design
Copy & Paste		X					
Reference			X				
Recursion			X				
Pattern/Encapsulation	Service or Capability via Specification/Instantiation			X			
Service (parameterized)	Configurable			X	X		
Template (parameterized)	Configurable			X	X	X	
Extendable (Inheritance)	Extendable			X	X	X	
Overloading (Static Polymorphism)	Extendable			X	X	X	
Abstraction (RunTime Polymorphism)	Extendable			X	X		X

Now we see a clear need for a Digital Engineering Environment

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- A Digital Engineering Environment can provide a means of defining, creating, linking and managing these common engineering artifacts in a problem domain centered portfolio
- This Digital Engineering Environment can also add additional benefits
  - Identification of the impact of change
  - A portfolio's history of commonality and reuse
  - An automated way of identify and compare complexity
  - An automated way of insuring consistency
  - An automated way of insuring commonality

What is require for a Digital Engineering environment to be successful in solving the DoD's problem

- First - Clearly identify the problem that we are trying to solve is.
  - **Reduce the time to solve problems of high complexity by an order of magnitude**
- Second - There need to be a clear understanding on why Digital Engineering is being used to solve this problem (The vision needs to be clear). What are the goals of using Digital Engineering.
  - **Minimize the complexity of the Problem Definition, Solution, Process (PSP) set that needs to be solved by maximizing the commonality of the parts of the PSP that have already been solved**
- Third - All types of reuse and commonality need to be clearly understood.
- Fourth - **The Digital Engineering Environment needs to support all forms of commonality.**

The current Digital Engineering Environment does not support all forms of commonality

- The DEE's I have seen are dependent (or should be) on a relational database.
  - All the artifacts, links, data mining activates justify the usage of an underlying database.
- There are current efforts to attempt to link and share model artifacts across models and tools.
  - These databases are all based on different designs making a translation effort the only viable means of sharing information

Translation if not a form of commonality

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We need a new type of Database Environment

- We need a database environment that allows us to utilize all forms of commonality.
- At a minimum, the database environment would need to encapsulate the database schema, rules, and query logic (SQL) into a single **Database Specification** that then can have all forms of commonality applied to it.
- The basic forms of commonality (reference, recursion, encapsulation) support all the advance forms of commonality.
  - A foundation database specification might define a common modeling language (CML).
  - That CML database specification might then be extended with different forms of commonality to define more specific modeling language databases
  - Because there is a common database specification some data, analysis, and/or behavior would be common to all version of these models regardless of how the tools are implemented.

Summary

- **The DOD need to clearly identify the problem needs to be solved.** *"Reduce the time to solve problems of high complexity by an order of magnitude"*
- **The DOD needs to identify and documentation their 'Vision' of how Digital Engineering should be used to solve this problem.**
- *"Minimize the complexity of the problem (PSP) that must be solved by maximizing the commonality of the parts of the problem (PSP) that have already been solved"*
- **The industry need to migrate form a start/stop (Linear) engineering process's to engineering process's that are based on Finite State Machines (Cyclic)**
- **An environment that allows for the utilization of all forms of commonality need to be created and used**