Implementing the Complete Digital Thread

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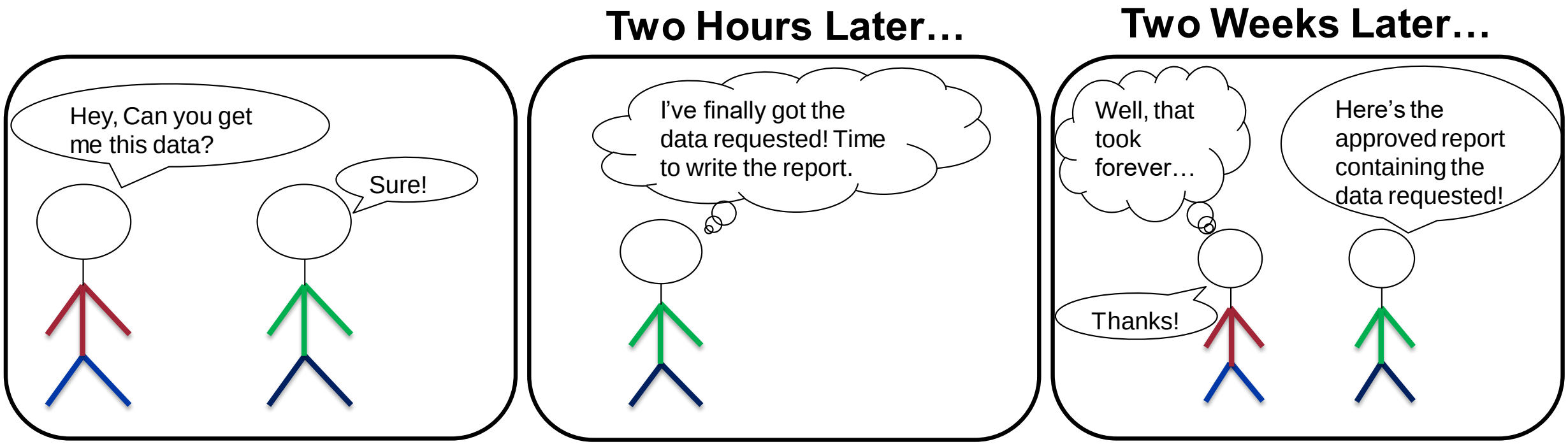
Northrop Grumman

GLOBAL PRODUCT DATA INTEROPERABILITY
SUMMIT
2019

Background

Cory Kinsel, Systems Engineer
Northrop Grumman Innovation Systems

- **Member of MBSE Solutions Team**
  - **Supported 6+ Programs/Teams**
- **Trained Engineers in MBSE Methodology and Tools**
- **4+ years of Modeling and Simulation Experience**
- **B.S. AAE from Purdue University**



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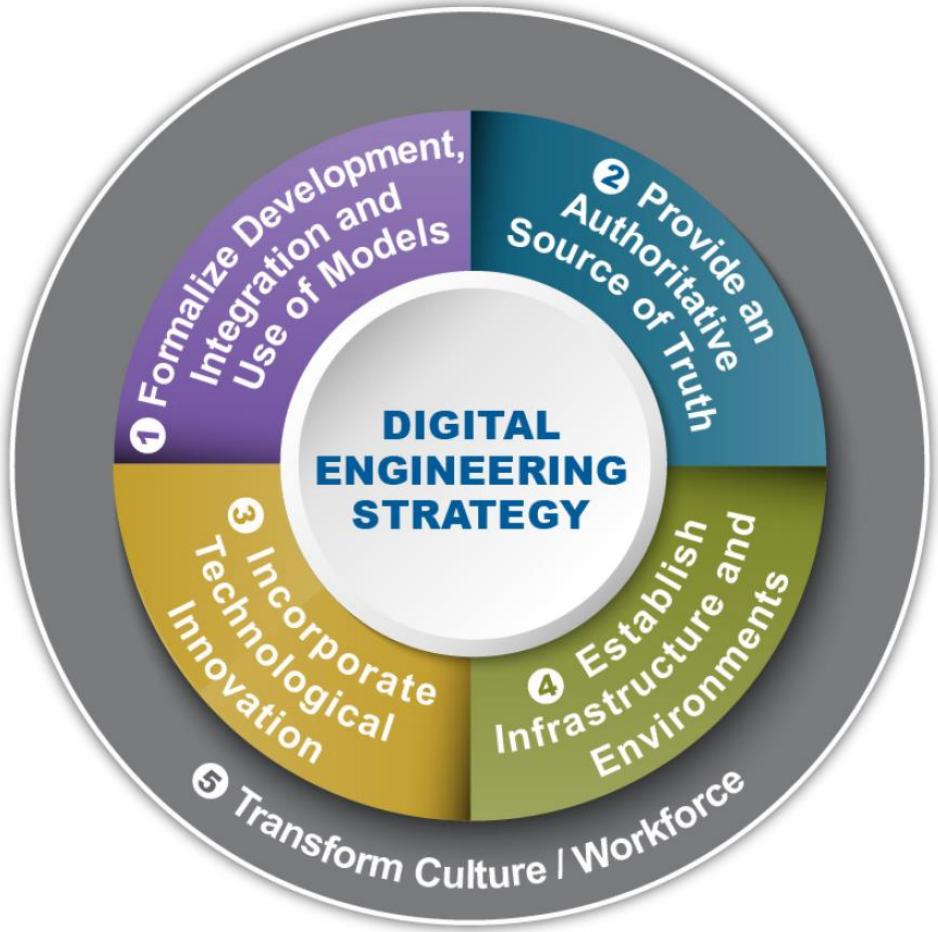
Engineering Silos

Reality: Silos are NOT going away

Connotations	Possibilities
• Separate Methods • Lacking Communication • Minimal Collaboration	• Understood Unified Method • Instant Notification of Results • Leverage Skills and Knowledge

Challenge: Integrating Silos into a Cohesive Team

Method


DIGITAL ENGINEERING STRATEGY
1 Formalize Development, Integration and Use of Models
2 Provide an Authoritative Source of Truth
3 Incorporate Technological Innovation
4 Establish Infrastructure and Environments
5 Transform Culture / Workforce

Communication

Sources of Truth

Accessibility to Data

Minimize Time to Answer

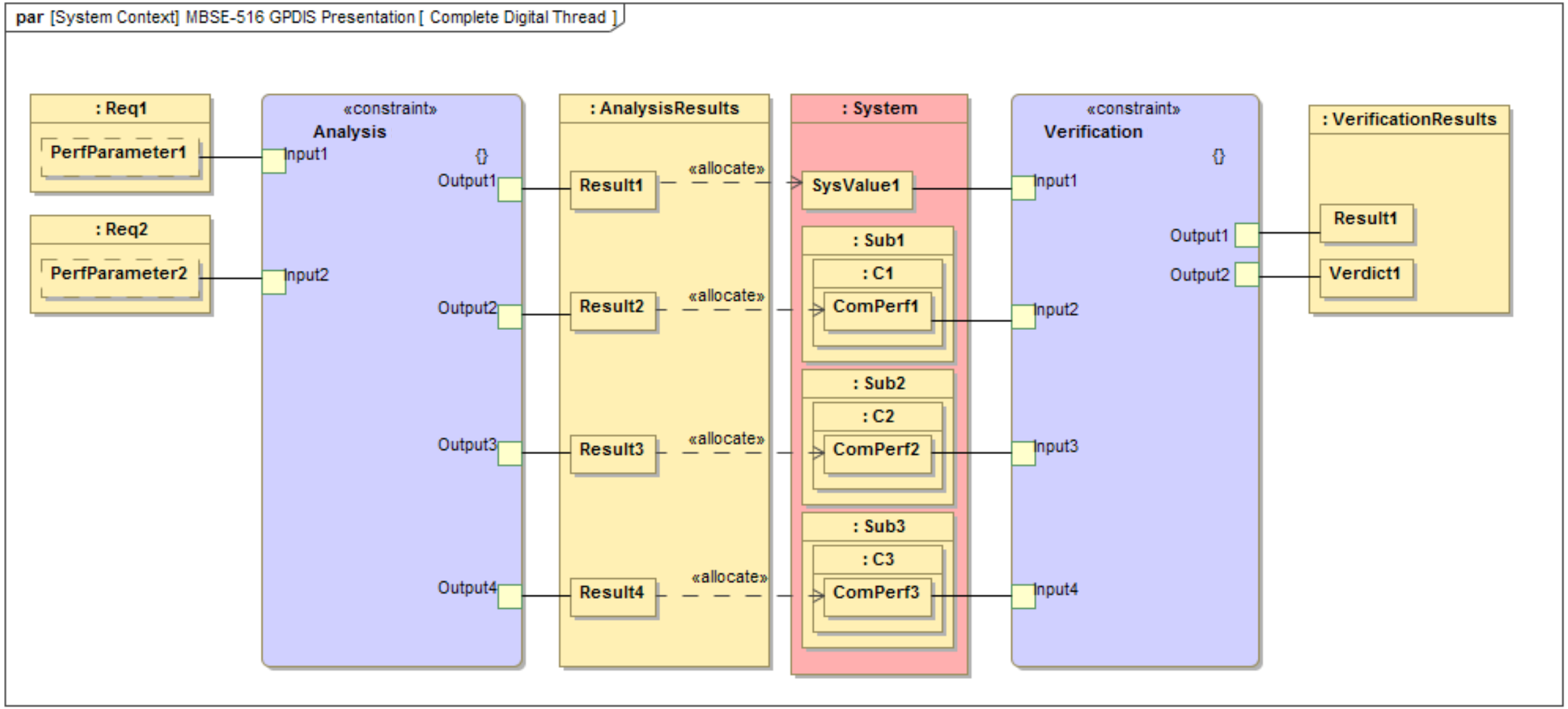
Standardize Views

Collaboration is Team-Centric

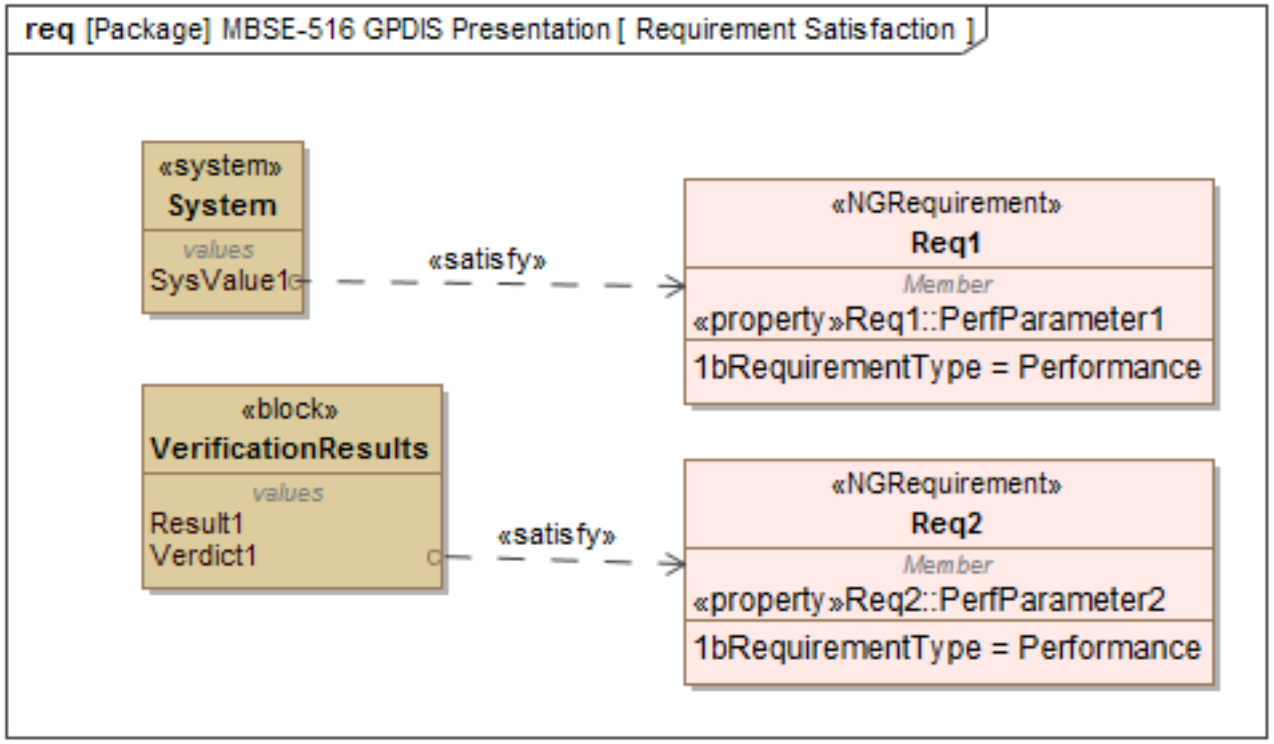
SysSpec-3.1 States and modes		
SysSpec-3.1.1 Non-Operational States	The system shall have non-operational states for maintenance and diagnostic testing.	Functional
SysSpec-3.1.2 Operational States	The system shall have operational states for Standby, Ready for Launch, In-Flight and Aborted.	Functional
SysSpec-3.1.3 Ready for Launch Time	The system shall transition from Standby to Ready for Launch in less than 120 seconds.	Performance

How do you turn silos into an efficient team?

The Digital Thread



Completing the Circle



	1990's	2010's
Email	Install and Manage Thunderbird	Log into Gmail
Office Productivity	Go buy and install MS Office	Log into Google Docs
Media Consumption	Install WinAmp	Log into Spotify
Gaming	Go buy and install Baldur's Gate	Log into Farmville

Software as a Service

WolframAlpha computational intelligence.

x^2+y^2 = 9

x^2+y^2 = 9

WolframAlpha computational intelligence.

x^2+y^2 = 9

Browse Examples Surprise Me

Input:

$x^2 + y^2 = 9$

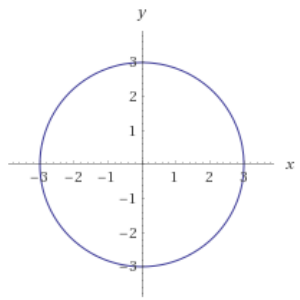
Open code

Geometric figure:

Properties

circle

Implicit plot:



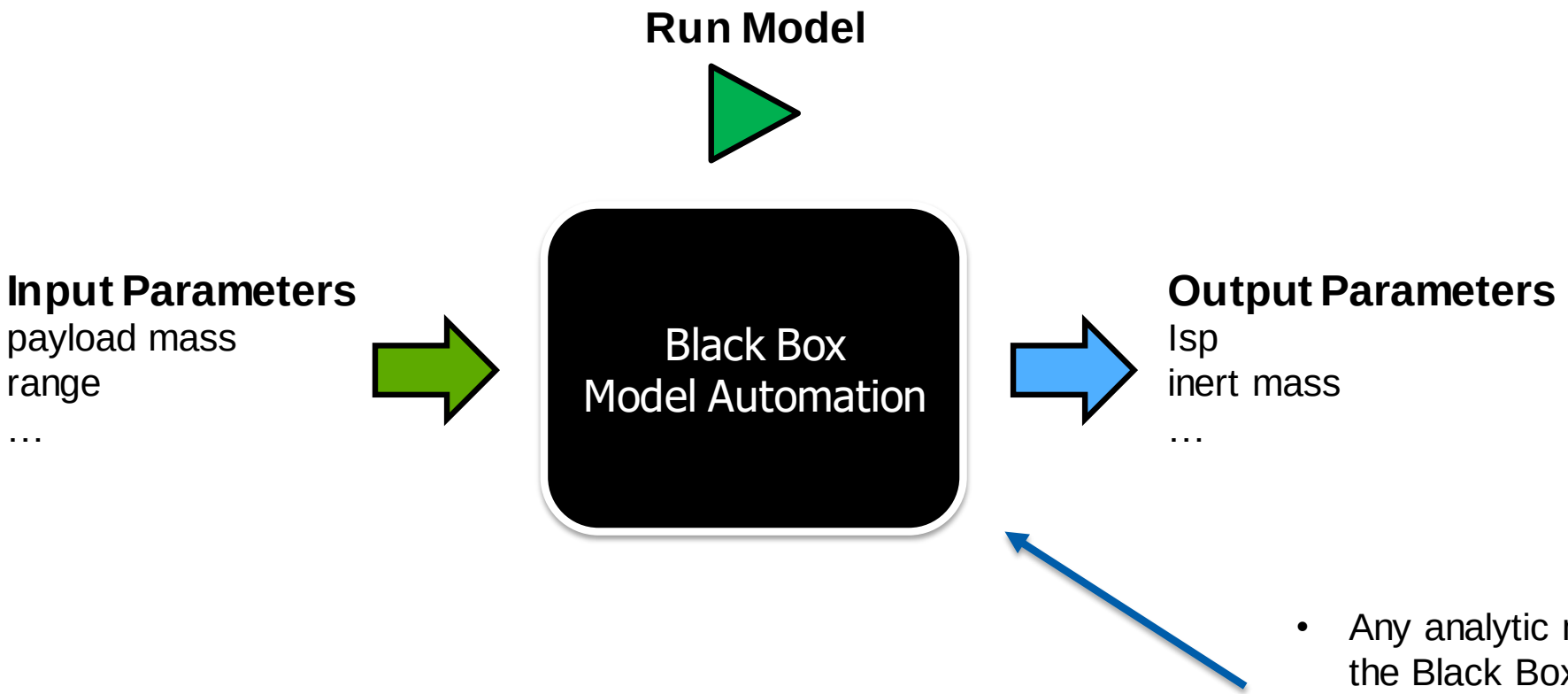
Alternate form:

$x^2 + y^2 - 9 = 0$

Benefits of SaaS/MaaS + DevOps

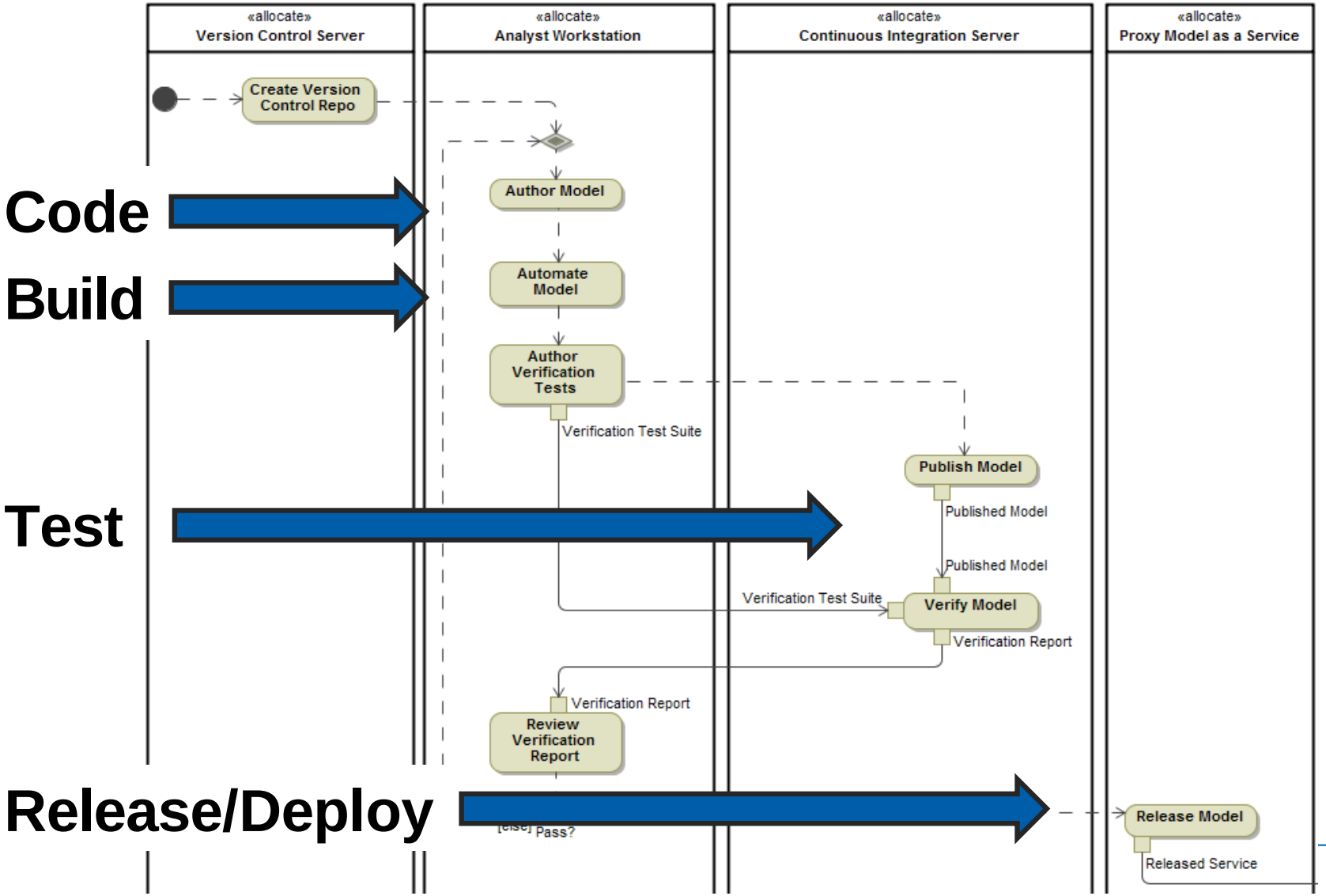
- **Provide on-demand access to models**
  - **Model suppliers own the source**
  - **Model suppliers set the bounding box for model accuracy**
- **Access Control**
  - **Owned by model suppliers**
  - **Model Visibility**
- **Model Releases**
  - **Supplier controls approved version**
  - **Quality control for models**
- **Access > Distribution**
  - **Maintain IP**
  - **Ensures Consistent Results**

MaaS



- Any analytic model can go in the Black Box
- Models run on remote server
- Access models over network

DevOps


«allocate»
Version Control Server
«allocate»
Analyst Workstation
«allocate»
Continuous Integration Server
«allocate»
Proxy Model as a Service
Create Version Control Repo
Author Model
Automate Model
Author Verification Tests
Verification Test Suite
Publish Model
Published Model
Published Model
Verification Test Suite
Verify Model
Verification Report
Verification Report
Review Verification Report
[else] Pass?
Release Model
Released Service
Code
Build
Test
Release/Deploy

746 **Olympia**

Praxiteles. The originals of all discoveries remained in the possession of Greece. The Germans reserved the right to take casts from sculptures, coins, or other discoveries. A museum with Olympian relics stands at the modern town of Olympia at the edge of the ruins. The modern town provides hotels and other services to the many tourists who visit the ruins. John J. Rawcarnes

See also **Olympic Games**.

Olympia, *oh LIHM pee uh* (pop. 46,478; met. area pop. 252,264), is the capital of the state of Washington. An important port city, it lies at the southern tip of Puget Sound. For location, see **Washington** (political map).

Pioneers first settled the area in 1845. Edmund Sylvester founded Olympia in 1850. It became the capital of the Washington Territory when the territory was created in 1853. The city was incorporated in 1859. Olympia was named the state capital when Washington became a state in 1889. The city is the seat of Thurston County and has a council-manager form of government.

For hundreds of years, the Squaxin, Nisqually, Chehalis, Suquamish, and Duwamish Indians shared access to abundant shellfish and salmon in the area. Today, the Olympia oyster is an important local export.

Olympia began as a shipping center for the area's products, including lumber, sandstone, coal, and grain. Over the years, lumber mills and fruit canneries developed, attracting new immigrants as workers.

Today, many Olympians work for the state government. The State Capitol sits on a bluff above Budd Inlet, south of downtown. Completed in 1927, the Capitol's 287-foot (87-meter) white dome towers over the area. Area schools include the Evergreen State College and St. Martin's University. Joint Base Lewis-McChord, a combined U.S. Air Force and Army base, lies between Olympia and Tacoma. Edward L. Lobb, Jr.

Olympiad, *oh LIHM pee ad.* In the Greek system of telling time, an Olympiad was the period of four years that elapsed between two successive celebrations of the Olympian, or Olympic, Games. This way of figuring time became common about 300 B.C. All events were dated from 776 B.C., the start of the first known Olympiad.

This method of counting time ceased about A.D. 440, after the 304th Olympiad. The Olympiads were used as measures of time by later Greek historians and other writers to refer to preceding centuries, but they were never in everyday use, as were months and years.

The beginning of the year of the Olympiad was determined by the first full moon after the *summer solstice*, the moment when the sun reaches its northernmost position in the sky. The first full moon after the solstice occurs about July 1. Bruce F. Field

Olympians. See **Mythology** (Greek mythology).

Olympias, *oh LIHM pih uhs* (373?-316 B.C.), was the wife of Philip II of Macedonia and the mother of Alexander the Great. She had much influence on Alexander. She told him that his real father was the god Zeus-Ammon, not Philip. She feared that Philip might choose another heir. Many people believe she had Philip killed to ensure that Alexander would become king. After Alexander's death in 323 B.C., Olympias tried to keep the empire for her grandson, Alexander IV. She failed, and in 316 B.C. was captured by Cassander, a Macedonian prince. Olympias was eventually killed. See also **Alexander the Great** (His youth); **Philip II.** Judith P. Hallett

Olympic Games

Olympic Games are the most important international athletic competition in the world. The Olympics bring together thousands of the world's finest athletes to compete against one another in a variety of individual and team sports. Millions of people have attended the games, and more than 1 billion people throughout the world watch the Olympics on television.

The Olympic Games originated in ancient Greece and were held from 776 B.C. to A.D. 393. The modern games began in 1896. The organizers revived the games to encourage world peace and friendship and to promote healthy sporting competition for the youth of the world.

The Olympic Games consist of the Summer Games and the Winter Games. From 1896 to 1992, the Olympics were held every four years, except in 1916 during World War I, and in 1940 and 1944 during World War II. The Winter Games, which were established in 1924, took place the same year as the Summer Games. Beginning in 1994, the Winter and Summer Games were divided and scheduled on four-year cycles two years apart.

Olympic ceremonies and symbols

Colorful ceremonies combine with thrilling athletic competition to create the special feeling of excitement in the Olympics. The Opening Ceremony is particularly impressive. The Olympic athletes of Greece march into the stadium first, in honor of the original games held in ancient Greece. The other athletes follow in alphabetical order by country according to the spelling in the language of the host country. The athletes of the host country enter last. The president or other head of state of the host country opens the games. The Olympic flag is raised, trumpets play, and cannons boom in salute.

The most dramatic moment of the Opening Ceremony is the lighting of the Olympic flame. The flame symbolizes the light of spirit, knowledge, and life; and it is a messenger of peace. The fire is ignited in Olympia, Greece, by using a mirror to concentrate the rays of the sun. Runners transport the flame in a torch relay from Greece to the site of the games.

Most runners carry the Olympic flame on foot. But many other kinds of transportation, including airplanes, horses, and skis, have been used. The final runner lights a huge *caldron* (kettle). The Olympic flame burns throughout the games and then is extinguished during the Closing Ceremony.

The Olympic symbol, created in 1913, consists of five interlocking rings that represent the continents of Africa, Asia, Australia, Europe, and the Americas. The colors of the rings, from left to right, are blue, yellow, black, green, and red. The flag of every nation competing in the games has at least one of these colors. Under the rings is the Olympic motto, the Latin words *Citius, Altius, Fortius.* The words are translated as *Swifter, Higher, Stronger.*

The International Olympic Committee

The International Olympic Committee (IOC) is the governing body of the Olympic Games. The IOC has headquarters in Lausanne, Switzerland. The committee approves the sports and events to be included in the games. The IOC also selects the host cities for the Summer Games and Winter Games, seven years in advance. The cities bidding for the games must prove they can provide athletic facilities for the games and housing for the athletes, coaches, officials, and visiting spectators. Host cities provide a special housing compound called the Olympic Village for the athletes and coaches. The

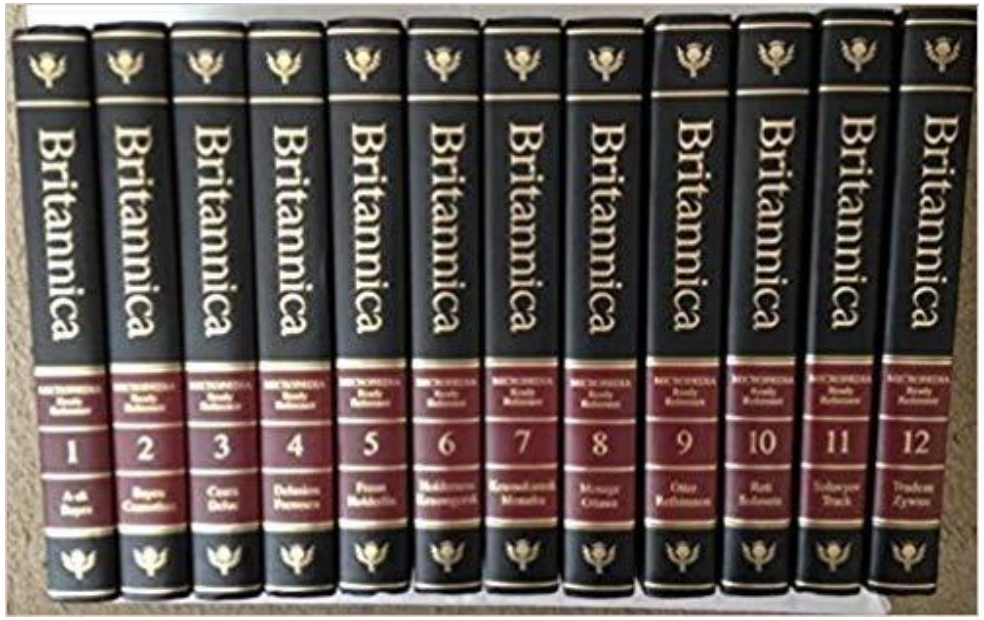
Sites of the Olympic Games

Year	Summer	Winter
1896	Athens, Greece	Not held
1900	Paris, France	Not held
1904	St. Louis, U.S.	Not held
1908	London, U.K.	Not held
1912	Stockholm, Sweden	Not held
1916	Not held	Not held
1920	Antwerp, Belgium	Not held
1924	Paris, France	Chamonix, France
1928	Amsterdam, the Netherlands	St. Moritz, Switzerland
1932	Los Angeles, U.S.	Lake Placid, U.S.
1936	Berlin, Germany	Garmisch-Partenkirchen, Germany
1940	Not held	Not held
1944	Not held	Not held
1948	London, U.K.	St. Moritz, Switzerland
1952	Helsinki, Finland	Oslo, Norway
1956	Melbourne, Australia	Cortina, Italy
1960	Rome, Italy	Squaw Valley, U.S.
1964	Tokyo, Japan	Innsbruck, Austria
1968	Mexico City, Mexico	Grenoble, France
1972	Munich, West Germany	Sapporo, Japan
1976	Montreal, Canada	Innsbruck, Austria
1980	Moscow, Soviet Union	Lake Placid, U.S.
1984	Los Angeles, U.S.	Sarajevo, Yugoslavia
1988	Seoul, South Korea	Calgary, Canada
1992	Barcelona, Spain	Albertville, France
1994		Lillehammer, Norway
1996	Atlanta, U.S.	
1998		Nagano, Japan
2000	Sydney, Australia	
2002		Salt Lake City, U.S.
2004	Athens, Greece	
2006		Turin, Italy
2008	Beijing, China	
2010		Vancouver, Canada
2012	London, U.K.	
2014		Sochi, Russia
2016	Rio de Janeiro, Brazil	
2018		Pyeongchang, South Korea
2020	Tokyo, Japan	
2022		Beijing, China

Olympic Games 746a

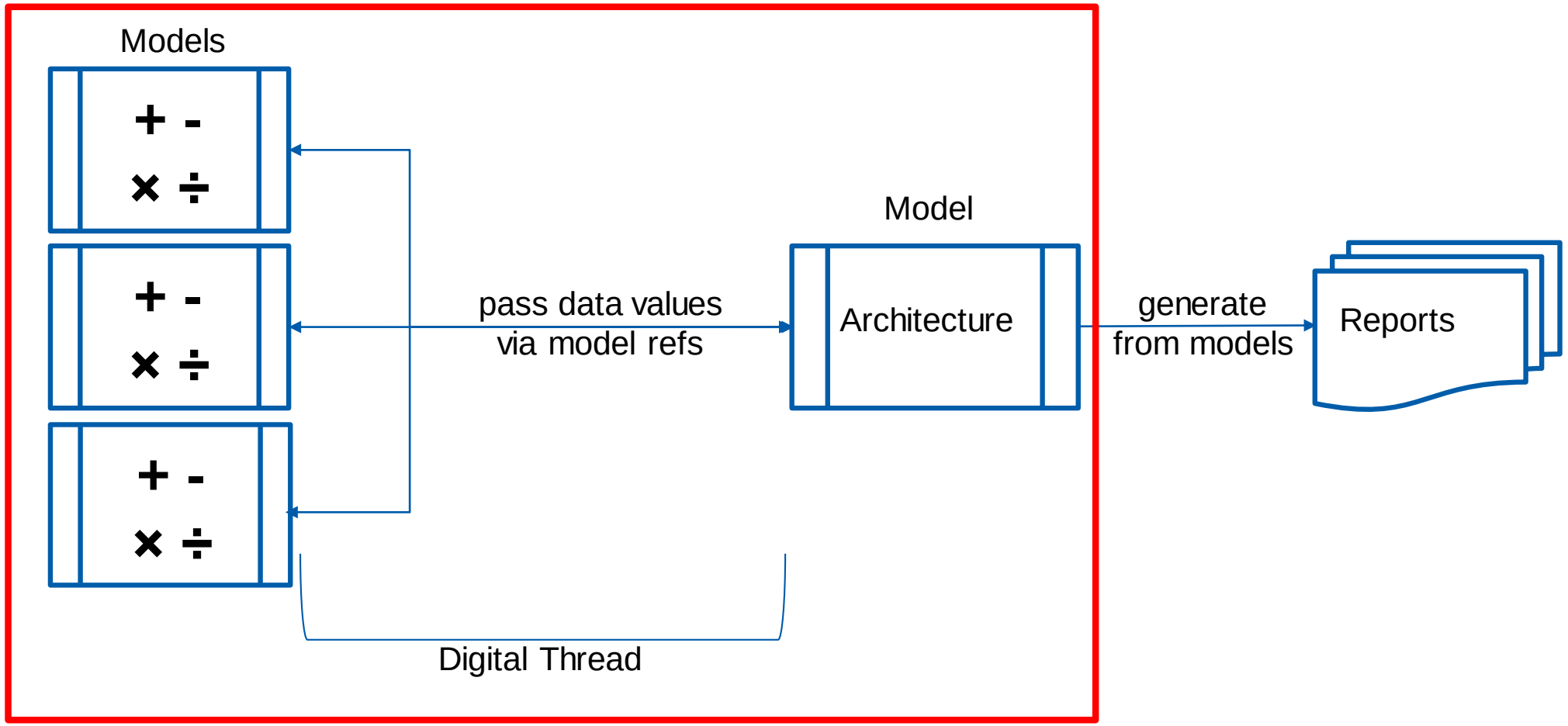
The Opening Ceremony of the Olympic Games features the entry of the athletes into the stadium. Thousands of athletes, grouped by country, marched into the stadium to begin the 2016 Summer Games at Rio de Janeiro, Brazil.

The Olympic symbol consists of five interlocking rings that represent Africa, Asia, Australia, Europe, and the Americas.



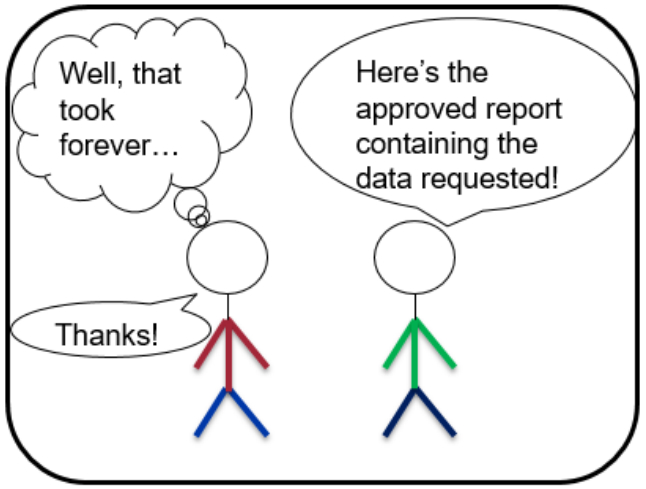
Source of Truth

- **There isn’t a single model to rule them all**
  - **Product Lifecycle Management**
  - **Computational Fluid Dynamics**
- **Truth Comes in different shapes**
  - **Descriptive Truth**
  - **Mathematical Truth**
- **Let each model act to its strengths**
  - **Each tool has a specific purpose**
  - **Optimize the infrastructure**
- **Integration is the core of MBSE**
  - **Ensure data used is authoritative**
  - **Create the collaborative engineering space**



Federated Engineering Environment

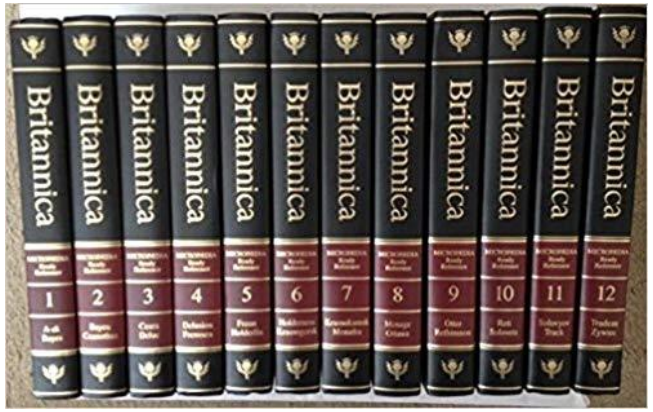
Summary



Engineering Silos

	1990's	2010's
Office Productivity	Go buy and install MS Office	Google Docs

Model as a Service



Federated Source of Truth