PRESAGIS

White Paper

VELOCITY: Automated Geospatial Data Analysis and Modeling Solution

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Abstract

As the amount of geospatial and geo-located intelligence drastically increases, agencies that leverage it are on the brink of being overwhelmed with too much data, too many data types, update demands, uncorrelated data, and the need to publish to multiple targets and platforms.

By bringing an automated solution to the traditional manually-intensive process of building maps, plans, charts, and simulation databases, agencies will be well positioned to receive, manage, fuse, and publish the petabytes of geospatial data they are facing.

This automated solution is VELOCITY.

In this paper, we will describe the characteristics and benefits of a potential solution – VELOCITY – to overcome these geospatial data processing challenges. The solution will need to enable the coexistence of both centralized and decentralized approaches while still converging towards an integrated foundational geospatial system.

By supporting a wide range of industry-standard data formats, image generators, and network simulation standards, VELOCITY is ideal for the automated building or reusing of virtual environments for a wide range of applications including GEOINT, defense and security, autonomous vehicles, and smart cities.

The Problem of Too Much Data

Historically, many different governmental organizations have been building maps based upon a differing collection and production/exploitation requirements. For example, the maps produced by the military to plan an offensive, would not necessarily be useful to first responders dealing with a crisis.

We are witnessing an explosion in the amount of geographical and geo-located information collected on a daily basis. Whether it is sourced from satellites, drones, mobile phones, autonomous vehicles, open or commercial sources, the sheer volume of data is forcing agencies to rethink the way they produce maps, charts, simulation databases, and single or multi-source intelligence analysis material.

The Geospatial Data Boom

In the past, GEOINT data collection was predominantly done through National Technical Means (NTM) funded and operated by governmental or para-governmental organizations.

Today, however, the task of providing the vast majority of all geospatial data necessary for government use is becoming unsustainable as the amount of geospatial data increases (e.g.: aerial/UAV data or public and commercial data sources), and more demands are placed on these organizations (e.g.: merging sensor imagery with maps). Their ability to quickly adapt or scale their processes, or integrate new data or data streams are at risk, thereby making them vulnerable to delays, mistakes, bottlenecks and inefficiencies.

Moreover, the sources of geospatial data are producing more data than ever before. As the table below illustrates, the trend is only growing:

Satellites	Since the early 2000s, an increasing number of commercial imaging satellites have been launched to make up for the absence of, or to complement NTMs at national levels. The constellation of commercial satellites will continue to grow and provide increasing resolution and update frequency. With the more recent increase of commercial spaceflights and small satellites, this trend will multiply many fold. Carolyn Bell, senior analyst at Northern Sky Research, stated that "Overall, 2017 was a very good year for smallsat launch rates", with the industry orbiting 329 smallsats (between 1 and 500 kg) in total. This is the highest number launched in one year to date, easily outstripping the mere 130 orbited in 2016. Belle believes the growing smallsat trend is here to stay[i].
Commercial Data	Geospatial Open Source data is also more widely available thanks to declassified GIS data as well as crowd sourcing. A good example of crowd-sourced GIS data is the Open Street Map (OSM) project that was created in 2004 as a collaborative effort to create a free editable map of the world. Today, there are hundreds of these public GIS data sources available. In addition, the commercial vendors frequently update the quality of their offerings.
UAVs	It is believed that today, the United States alone operates close to 3000 Unmanned Aerial Vehicles (UAV) for Intelligence, Surveillance and Reconnaissance (ISR) purposes. With a 2017 budget of over USD $4B invested in Research & Development[ii], Procurement, and Operations and Maintenance, this trend is likely to continue.

Further exacerbating the trend of a decentralized geospatial repository is the inclination of individual defense, intelligence and security agencies to seek more independence from these central geospatial agencies in order to gain agility and autonomy to reduce the time between the collection and exploitation of geospatial data.

Cause and Effect

So what are the consequences of the problems discussed above? How will they affect an agency's ability to deliver?

The challenges faced by organizations multiply as data sources and data types increase. Compounding this predicament is the demand for frequent updates and the requirement to publish to multiple targets and platforms.

Specifically, the volume of data and the inability to consume it and publish it in a systematic, logical, and repeatable manner can lead to a range of problems:

Errors and Delays	Currently, agencies are faced with too many data sources and too many data types. By adding new sources (e.g.: drone-based sensors) and new data types (e.g.: point clouds) into an established workflow, agencies risk introducing /workflow/personnel/publishing errors and/or triggering costly delays.
Mis-Correlation	Uncorrelated data sources is a typical example of just such an error. Mis-correlation can occur when two or more datasets for the same geographical coordinates are either incompatible, erroneous, or unsynchronized. In a perfect world, each dataset would contain the same buildings, trees, and rivers. However, it is common for geospatial datasets to contain differing levels of detail that might make them more difficult to correlate. It is critical that each geographical area's datasets are correlated so that features or buildings are displayed consistently across all maps – and not just when building maps, but when publishing them too.
Outdated Information	Given the proliferation of UAVs, mobile phones, satellites, and hundreds of other sources that provide up-to-the-minute geospatial and sensor data, how often should a map be updated? Yearly? Hourly? Depending on a map's purpose or function, it is very possible that most maps are outdated in the time it takes to make them – especially with regard to dense, urban environments. Add to this the increasing demand for real-time or up-to-date information and the result is an agency that, at best; cannot keep up with demand, and at worst; is completely bottlenecked.
Inconsistent Quality/Content/Production	When it comes to publishing content from a centralized (or curated) source, it is likely that agencies will need to publish multiple qualities for multiple purposes, and a range of stakeholders. By publishing to multiple targets, agencies run the risk of delivering inconsistent maps as the frequency of data updates is increased and the number of platforms grows. Without tight controls on formats, level of detail and thousands of other variables, the likelihood of producing uncorrelated or inconsistent maps rises – either from badly processed data, human error, or both.

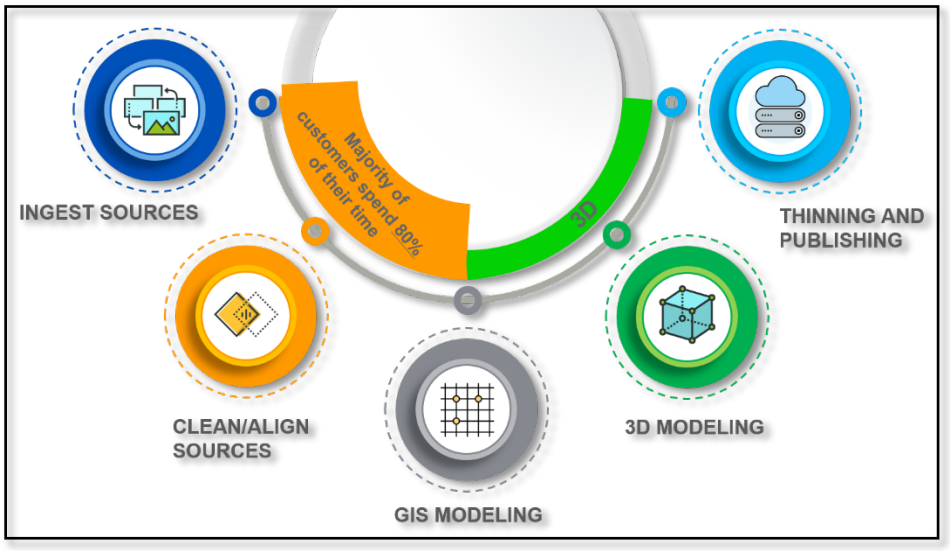
Automation is the Answer

In his GEOINT 2017 allocution, Robert Cardillo, Director of the National Geospatial Agency, stated, "We intend to automate 75 percent of the repetitive tasks our analysts perform so they have more time to analyze that last play and more accurately anticipate the next one. And then they can look much harder at our toughest problems — the 25 percent that require the most attention."

VELOCITY responds directly to the NGA's challenge by leveraging the latest technological advancements.

Simply put, automation is the key to managing, processing and publishing massive amounts of geospatial data.

By automating some or all aspects of the end-to-end workflow in the creation of maps, agencies will be equipped to manage any amount of data, from a wide variety of sources in a scalable, repeatable, and sustainable manner.



Each aspect of the end-to-end workflow in the creation of maps can be automated.

Introducing automation into the production of maps can have to the following benefits:

Scalability	With automation, it is possible to scale a workflow to thousands of machines, making results available in minutes instead of days.
Quality Assurance	By automating QA processes, workflow is executed in a deterministic way, that is, a given workflow will yield exactly the same outputs given the same inputs. Obviously, this is of particular importance to the GEOINT community.
Unbiased	An advantage to automation is the negation of variability from one human to another – for better or worse. Subjective interpretation is replaced by authoritative pre-established rules-based processes. Human bias (intended or not) inherently leads to inconsistencies. It would be counter-productive to have different biases deciding what a map's characteristics and qualities should be.
Repeatability and Traceability	Stay up-to-date with source updates. By automating data cleanup on input and formalizing transformation processes, agencies can gain traceability and repeatability and drastically reduce manual operations. Even if manual processes are necessary, as they often are, traceability meta-data permits managers to know who and when data has been modified.

Correlation	Automation enables the correlation of outputs as well as multiple outputs with the same inputs.
Reliability	Workflows, by their nature, are standardized in an automated process to ensure reliability.
Expand Workflows	Automation also allows agencies to leverage interesting powerful workflows. For example, users can enable fusion workflows where partial data updates can be integrated into existing base maps.

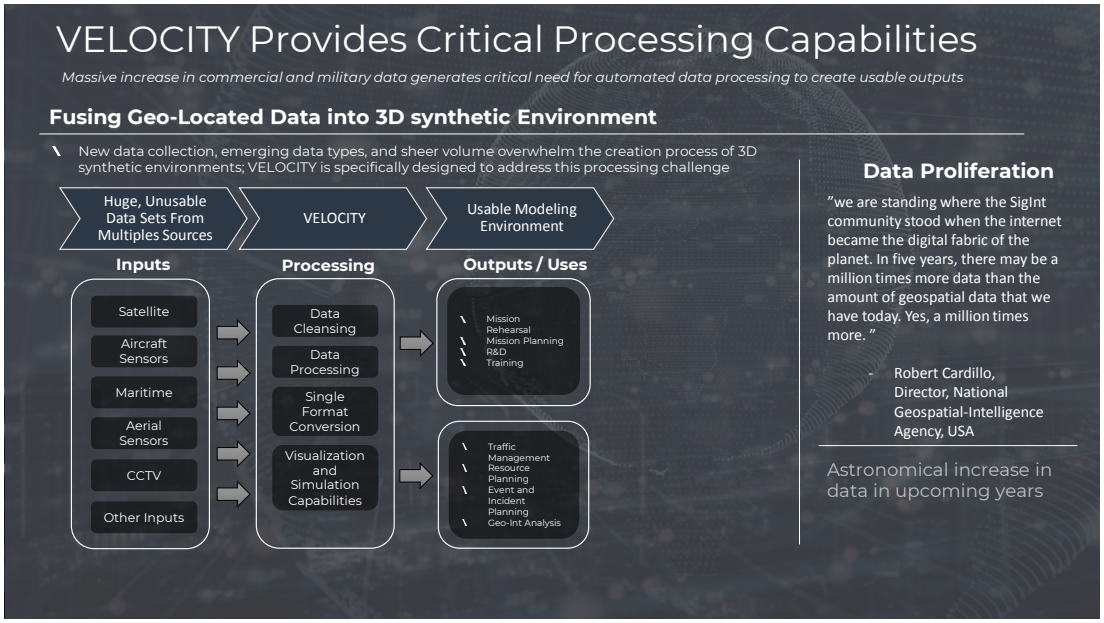
VELOCITY: An Automated Solution

To solve these challenges, Presagis created VELOCITY.

Automation is at the core of VELOCITY.

Leveraging our 20 years of experience providing geospatial processing tools and services to the defense and security industry, Presagis developed VELOCITY, a software solution that supports the continual automated processing of geospatial data, maps and 3D terrain. Uses range from geo-intelligence analysis and critical mission planning, to defense and security training.

As previously stated, the challenge of producing maps has increased as the data sources become more numerous and updates more frequent. Merging imagery, using aerial/UAV data, or including public and commercial data requires a robust production workflow that can accommodate this geospatial data.



Through automation, VELOCITY streamlines the production of rich and complex maps and can help agencies:

a) With the continual automated ingestion of geospatial data and sensor data,
b) Maintain a centrally curated foundation data repository from which the majority of derivative geospatial 2D and 3D maps, charts and simulation databases can be produced,

c) Produce derived synthetic environments in hours rather than weeks or months.

Advantages of Automation in VELOCITY

By automating data cleanup and formalizing transformation processes for all data sources, VELOCITY gives agencies and organizations the ability to produce 2D, 3D, or VR environments for a wide range of applications while providing the required traceability and repeatability. It also allows the drastic reduction – and sometimes the outright removal – of manual operations which can lead to more consistent maps that are less prone to error.

Our focus on automation allows VELOCITY to excel in the following areas:

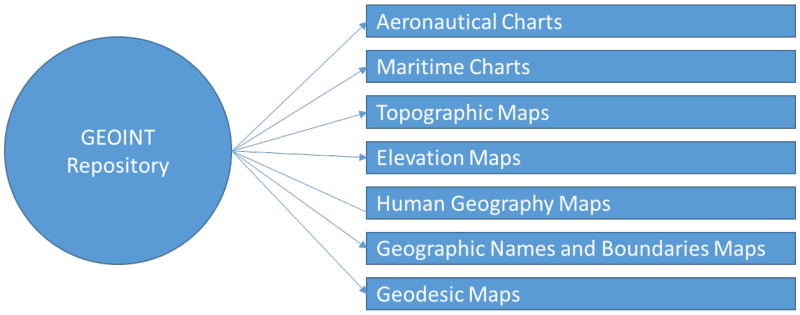
- Scalability
- One World
- Data Fusion
- Publishing
- Open Standards

Scalability

Automated and deterministic workflows are the key to massive scalability in the cloud. With automation, it is possible to scale a workflow to thousands of machine, making results available in minutes instead of days. Integration of cloud computing permits distributed processing for any sized project on public or private cloud.

One World: A Master Correlated World

VELOCITY enables and streamlines the continuous and automated consumption/ingestion of geospatial and sensor data to a single master geospatial representation of the world. The data repository or dataset may or may not be centralized, but there is only one correlated world. From this repository, agencies could very quickly generate and deliver nearly all geospatial 2D and 3D maps, charts, simulations, and derivatives to the point of need.



This one-to-many/many-to-one organization of data and workflows ensures correlation between the multiple derived datasets as they are all published from a single corrected master representation of the world.

Fusion: Many to One

To address the challenge of fusing a wide range of data types or sensors in a large-scale automated and incremental fashion, VELOCITY can create, augment and constantly maintain a current, integrated

central geospatial data repository that can be used to create a number of geospatial products to be used by geospatial, defense and intelligence organizations.

Publishing: One-to-Many

By publishing these geospatial products from a central repository in an automated manner, users can avoid the redundancies, discrepancies and inconsistencies that occur when these products are created in a non-collaborative manner or independently. In addition, this approach allows for much better productivity and scaling.

Open Standards

Data comes from anywhere and everywhere – from public, commercial, or private, all the way to government and secret. Using open standards brings a high level of inter-operability and exchange at both the data and modeling levels. Because the types and sources of data increase, along with the outputs and their platforms, VELOCITY is built to ingest and publish using open, internationally accepted standards in order to allow interoperability of different types of systems developed at different times – all in an automated manner.

Leveraging the Latest Technology for Automation

Because of its modular open architecture approach, VELOCITY's automated workflows can be customized to meet any internally- developed or third party commercial software. VELOCITY can be integrated to produce all sorts of geospatial products to be used by various intelligence, defense and security organizations.

> **Technology:** By leveraging cloud computing and artificial intelligence, in particular computer vision and machine learning, the herculean task of quickly processing, ingesting, and transforming multiple geospatial data sources into time-sensitive, useable, actionable intelligence is now possible with VELOCITY.
>
> **Architecture:** VELOCITY is an open architecture solution that is built to be accessible (through Python scripting, for example), and support a wide array of open standards (legacy and new), as well as streaming services, while remaining format agnostic.

Technology

VELOCITY is designed to be integrated with existing technology and workflows, and is perfectly aligned with the "triple-A strategy" of Automation, Augmentation, and AI[iii].

Machine Learning, and AI in Automation

In its August 2016 edition[iv], the USGIF Trajectory magazine defines some of the key artificial intelligence disciplines as follows:

- **Artificial Intelligence (AI)**: A branch of computer science focused on the development of technologies that simulate human cognition and general intelligence.
- **Machine Learning (ML)**: A multidisciplinary approach allowing computers to adapt without the need for explicit programming, i.e., the machine may modify its own rule set to learn new rules for future problems. Machine learning includes two training methods: supervised learning, in which known events are used to create models; and unsupervised learning, in which the

machine learns from naturally occurring trends, patterns, sequences, and associations. The two methods can be used alone or in parallel.

- **Deep Learning (DL)**: A branch of machine learning that attempts to mimic the architecture of the human brain by using multiple levels of highly connected simple models, i.e., a multilayer neural network. Deep learning systems can infer new insights from a large set of provided data or inputs.

Through projects with various universities, governments and private partners, Presagis is actively involved in leveraging AI/ML algorithms for the integration of Lidar, WAMI and FMV sensor data as well as a number of feature extraction processes to allow VELOCITY to further the automated curation of 3D geospatial data repositories.

Computer Vision

Computer vision allows for the acquisition, processing, analyzing and understanding of digital images, and extraction of high-dimensional data. The combination of Computer Vision and AI algorithms opens one of the most interesting avenues to automate the processing, integration and analysis of GEOINT data. Thanks to the emergence of massive storage and processing capabilities in the cloud, the field of Machine Learning is progressing more rapidly than ever and can help with the automation of numerous tasks once relegated to human manual interventions.

These tasks include:

- Digital Terrain Model (DTM) extraction
- Road network extraction
- Building footprints, height and rooftop extractions
- Vegetation extraction
- Land use classification
- Temporal Change Detection
- GIS data and Sensor fusion

Architecture

VELOCITY's open architecture brings speed, agility and innovation when adapting solutions for a new purpose. Its architecture allows it to evolve over its life cycle leveraging new technologies. VELOCITY's architectural approach is to not only integrate 3rd part software, but to embrace it.

Rather than attempt to "reinvent the wheel", Presagis believes in trying to find an existing technology in order to solve a particular problem, and integrate it in our solution. To achieve this, VELOCITY is specifically designed for easy integration with third party technologies

Virtualization & Cloud Computing

The emergence of virtualization has had a profound impact on many businesses by allowing a departure from the paradigm of processing capabilities being limited by the computing capabilities available on an individual, departmental or corporate organization basis.

Virtualization began in the 1960s, as a method of logically dividing the system resources provided by mainframe computers between different applications and has since then, been broadened to the

pooling of hardware, storage, networking, and software resources to create economies of scale through on-demand utilization.

Cloud computing allows for the storage of massive amounts of data and externalization of resources and allow leveraging of virtualization to massively scale up operations when timing is imperative. Today, computing clouds have become ubiquitous to most individual and commercial users and is rapidly coming to government users either through private, secured, restricted or public clouds depending on the sensitivity of their data and operations.

A cloud computing approach facilitates the integration and deployment of large "System of Systems" and the integration of complex Business Processes based on a wide array of technology from a disparate set of vendors that can evolve over time.

The emergence of the World Wide Web and companies such as Google™, Microsoft™ and Amazon™ have paved the way to define technologies and software architectures that facilitate the integration of System of Systems. Service-Oriented Architecture (SOA) is one of those important innovations.

SOA

SOA is a style of software design where various software services are connected through logical graphs through a communication protocol over a network.

Service-oriented architectures integrate distributed, separately maintained and deployed software components - known as Services – which can be used in conjunction to provide the functionality of a large software application but with much better ability to:

- Integrate components from multiple vendors
- Integrate components written in different computer languages or running on different operating systems
- Upgrade or replace components to fix defects or bottlenecks without having to retest the whole system
- Centrally manage Security and Governance
- Scale up processing, storage and networking as needs evolve
- Leverage mobile, browser-based or thin client applications since all the complexity and performance requirements are being handled in a centralized fashion to be shared with all users

VELOCITY has been designed from the ground up to seamlessly integrate into Service-Oriented environments allowing custom replacement and integration of new software components into VELOCITY services as well as allowing the integration of VELOCITY itself into larger business processes supporting optimal operations.

Game Engines

The ubiquity of GPU and mobile computing hardware is fueling innovation in video games as well as virtual-reality and augmented-reality (VR/AR) applications. Integrating game technology – such as Epic Games' Unreal Engine™ – into VELOCITY enables us to benefit from the innovations in photorealistic real-time rendering, character animation and environmental effects as well as innovations in VR/AR.

The Benefits of 3D

3D Maps are especially useful when trying to understand how “things travel” in space. Examples such as aerial navigation, ballistics and electro-magnetic signal propagation, including line of sights and viewsheds.

The dynamic nature of digital maps allows better tracking and measurement of changes in land use and land cover and, of course, a third dimension.

Aside from the obvious visual appeal of 3D representations, 3D maps give the ability to represent and navigate complex datasets and concepts. Whether it be the trajectory of an aircraft, line of sights, electro-magnetic signals, or the verticality of a dense urban environment, 3D maps are extremely effective at helping visualize space and relativity in an intuitive and natural way.

Instrumenting 3D maps also opens the door for simulation. The instrumentation of roads and lanes allows the simulation of ground vehicles on streets, the identification of sidewalks and pathways permits the simulation of crowds, adding airport runways, signage and navaid let virtual aircraft take off and land, while material definitions of terrain and features allow physics-based sensor simulations, such as IR, or night-vision. The possibilities are virtually endless.

Conclusion

The problems facing the agencies that build maps, plans, charts, and simulation databases are growing:

- Too many data sources
- Too many data types
- Mis-correlation of sources and outputs
- Unmanageable frequency of updates
- Need to publish to multiple targets/platforms

Whether it be from satellites, drones, mobile phones, autonomous vehicles, or open and commercial sources the amount of geospatial and geo-located intelligence data grows on a daily basis. Agencies are at a crossroads and need to introduce automation to the manual processes that exist as soon as possible.

Through its ability to continually combine geospatial data and fuse various data types and sensors into a central 3D geospatial data repository, VELOCITY is able to support the automated production of maps, charts, and simulation databases in hours rather than weeks or months.

By automating data cleanup on input and formalizing transformation processes, VELOCITY provides traceability and repeatability and allows to significantly reduce – and sometimes even remove – manual operations.

The benefits of this automated approach are multiple:

- **Increase Quality and Accuracy** through the fusion of multiple sources, automated maps can provide better situational awareness through access to the latest picture of the mission theater. For example, firefighters will have the most recent information to plan firebreaks, or national emergency management agencies can more accurately plan disaster assistance.
- **Faster production** with the application of these technologies will allow for augmented throughput of geospatial data and allow agencies to provide a better quality of service to its stakeholders. Tasks that once took weeks or months can now be accomplished in hours.
- **Less expensive:** This new approach requires less manual intervention, thereby permitting a strategic uses of your workforce. Additionally, the automation of tasks renders maps less prone to errors and ensures a more consistent quality.
- **Scalable:** Integration of cloud computing permits distributed processing for any sized project on public or private cloud. VELOCITY is infrastructure agnostic and makes use of scripting and virtualization.
- **Integrates** with customer technology, processes, and data by using SOA.
- **Supports** all major industry formats.

A convergence of cloud computing, computer vision, and AI in solutions like VELOCITY can accommodate the coexistence of both centralized and decentralized approaches while still converging towards an integrated geospatial system.

From its inception, VELOCITY was designed with an emphasis on automation. Presagis also prioritized VELOCITY's ability to support third party software in order to directly address the challenges present in the field today and provide a solution that has no equal in the industry.

By leveraging widely used and recognized automation technologies[v] such as Python™ and HTCondor™, and by integrating market best solutions from the geospatial, simulation, gaming, architecture and entertainment industries such as GDAL, Terra Vista™, Unreal Engine™, CityEngine™ and Cinema4D™, VELOCITY promises important productivity gains through automation and scalability and the assurance of coherent situational awareness at the point of need. VELOCITY supports all standards (legacy and new) – CDB, VBS, FBX, OFT/MFT, OBJ as well as the new streaming services from ESRI (I3S) and Cesium (3D Tiles).

If you are interested in learning more about VELOCITY and how automation can help your agency cope with the surge in geospatial data, Presagis would be pleased to schedule a call with you in order to ascertain your project needs, scope, and deliverables.

Whether you would like try VELOCITY to build a specific, localized area, or an entire continent, Presagis stands at the ready.

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