

Unmanned Aircraft Systems (Drones) in Surveying

NYSAPLS Annual Conference 2021

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Drones Are Fun

- Also dangerous
- Require skill to operate
- Require skill to plan
- Require an FAA license
- Require extreme planning
- Requires training and re-training
- Requires process-oriented crew
- Requires even more process-oriented management

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Objectives

- Types and applications of drones
- Legal and safety ramifications
- Business practices

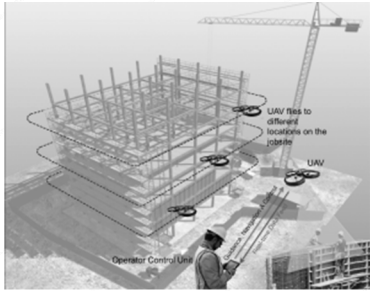
Surveying Tools?



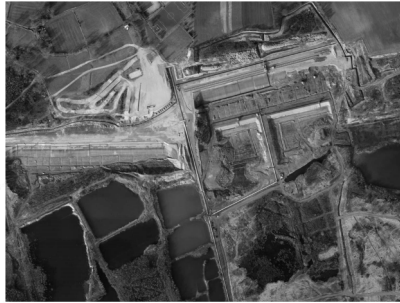
3 Ds to 3 D

1. Dull
2. Dirty
3. Dangerous

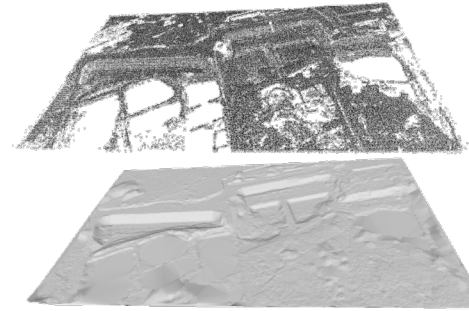
- Three-Dimensional (3D) Survey/Mapping Products



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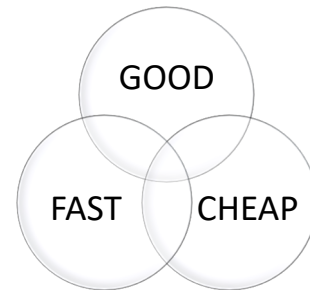
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Professional Decisions

- Cheap?
 - GOOD system \$15,000 PLUS
 - Services/Support....Not necessarily
- Fast?
 - Possibly
- GOOD?
 - Requires professional intervention
- Better data?
 - MAYBE (But there are limitations with pixel matching)
 - LiDAR is here!
 - But a little scary to put \$100k in the sky!



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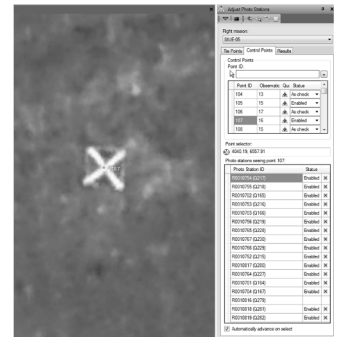
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Dispelling Myths?

- More survey control/targets than you think!
 - It actually happened, for first project:
 - 4 ft vertical error
 - How was it caught?

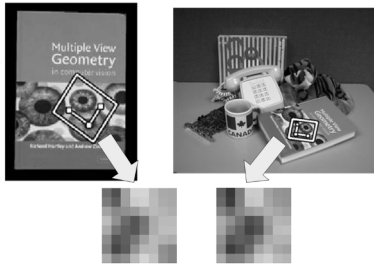


Knowledge

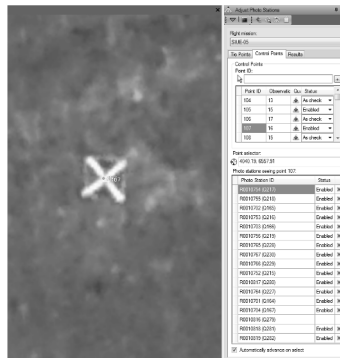
- The professional must understand:
 - Drone/UAS performance & capabilities
 - Imaging sensors
 - Computer Vision (CV) image processing and pitfalls
 - Map accuracy quality control and assurance
 - How to design a project to meet project requirements

Process

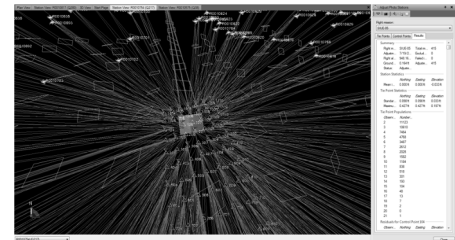
Pixel Matching (Autocorrelation)



Measure Targets



Computer Vision & Bundle Adjustment



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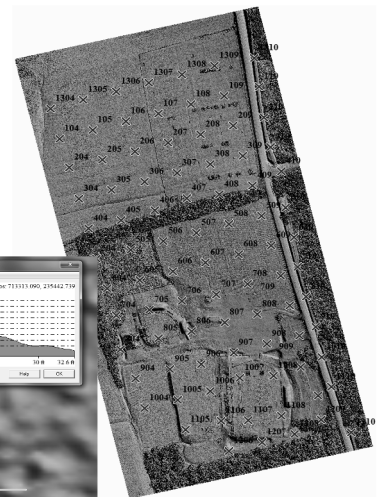
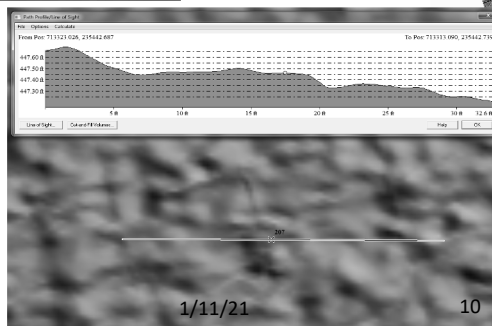
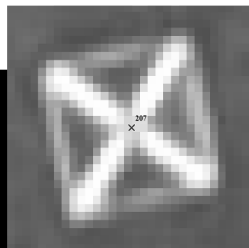
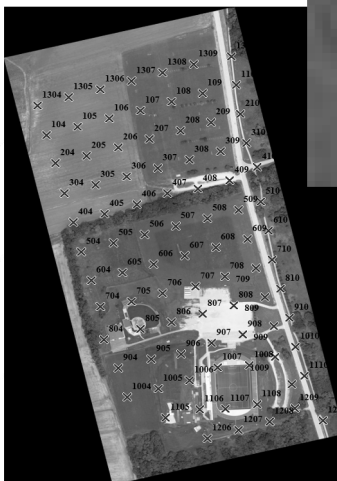
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Independent Map Testing



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Mission Planning

- Design a mission to accomplish desired map accuracy and quality of deliverables required to accomplish goals of project

Geo-Referencing

- None (or one lat/long)
- Ground control points (GCPs)
- Navigation grade GNSS
- Real time kinematic (RTK) GNSS
- Post processed kinematic (PPK) GNSS



Sensors & Lenses



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Digital Terrain Model Surveying Grade



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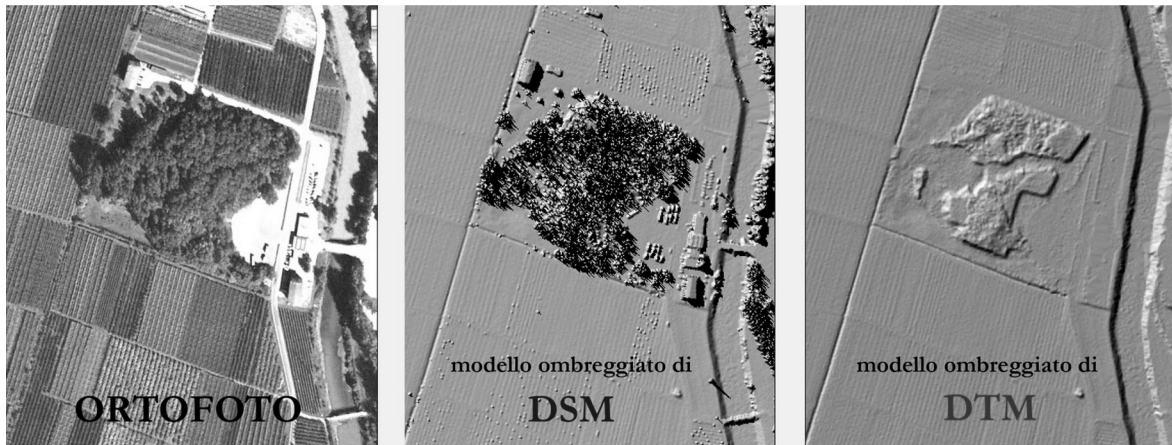
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Quality Drone/UAS Data



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Professional Evaluation of Quality

- Error, accuracy, precision
- Published standards
- Industry acceptance
- Professional knowledge
- Mapping or surveying?
- Standard of care

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Map Accuracy



OLD – Based on Map Scale (paper)

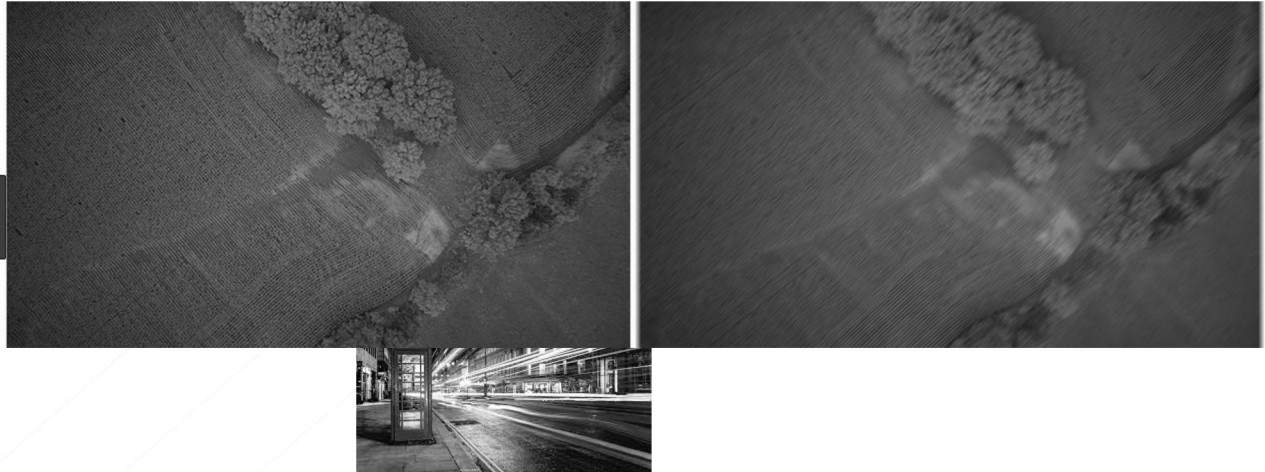
NEW – Digital based on ground sample distance (GSD)

- Horizontal Industry Standards
- Vertical Industry Standards
- ALL RMSE converted to 95% Confidence Levels

Demonstrate Competency

- Professional Land Surveyor
 - Land Surveyor in Training
 - (State Licensed)
- National Society of Professional Surveyors (Certification)
 - Surveyor Technician
 - Federal Surveyor (CFedS)
- ASPRS (Certification)
 - Photogrammetrist
 - Mapping Scientist Remote Sensing
 - Mapping Scientist GIS/LIS
 - Mapping Scientist Lidar
 - Mapping Scientist UAS
 - GIS/LIS Technologist
 - Lidar Technologist
 - Remote Sensing Technologist
 - Photogrammetric Technologist
 - UAS Technologist

Motion Blur (for example)



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Local Laws

- There are drone laws that apply only to certain regions, cities, or counties within a state
- ...so don't think that the FAA is the only "law" you should be complying with

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Let's Talk About Commercial Operation

- Requires Part 107 Operator License
- sUAS must weigh less than 55 lbs. (25 kg)
- VLOS operation only (PIC and active operator)
- VO allowed as alternate
- Unaided vision (no binoculars!)



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Part 107 License

- May not fly sUAS over persons - changing
- Daylight ops only (also civil twilight, i.e. 30 min before sunrise to 30 min after sunset, local time with anti-collision lighting) - changing
- Maximum altitude 400 ft above ground level (AGL), if a structure, 400 ft above structure within 400 ft horizontally of structure

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Part 107 License

- Minimum weather visibility of 3 miles from operator/control station
- Operations in class B, C, D, E airspace allowed with ATC permission
- Operations in class G airspace OK w/o ATC
- Each person only operates one aircraft at a time

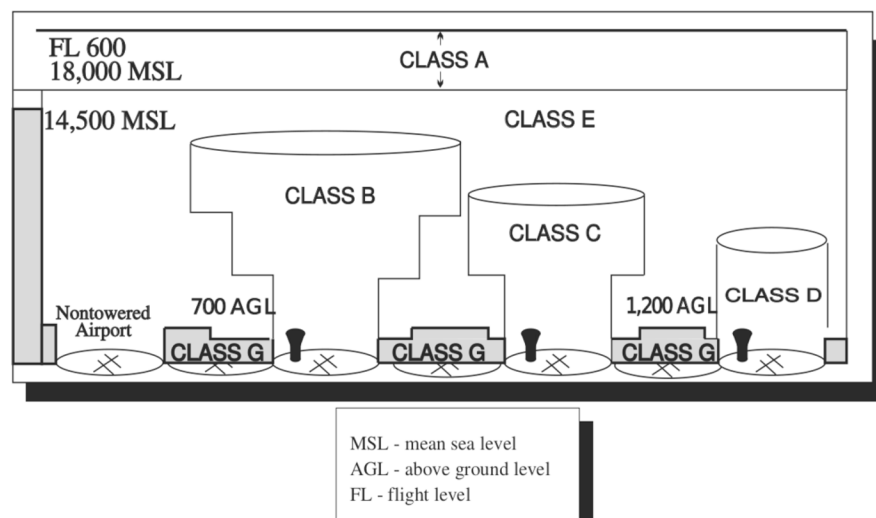
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Part 107 License

- Mandatory pre-flight inspection (record keeping!)
- Self-evaluate physical/mental condition to ensure safe flight
- Aircraft must be registered; foreign registered is OK if they meet requirements of part 375

Part 107 License

- Demonstrate aeronautical knowledge
- Pass knowledge test, or hold a part 61 pilot certificate for manned aircraft with small FAA course
- Be vetted by TSA
- 16 years of age minimum

Part 107 License

- Remote pilots must provide sUAS for inspection or testing on demand from FAA
- Also provide records/documents on demand
- Report within 10 days any incident involving serious injury, loss of consciousness or property damage of \$500 or more

That Thing About Accidents

- PIC must report any sUAS accident to FAA no later than 10 days after ...:
- Serious injury to any person or any loss of consciousness; or
- Damage to any property, other than the small unmanned aircraft, unless one of the following conditions is satisfied:
 - The cost of repair (including materials and labor) does not exceed \$500; or
 - The fair market value of the property does not exceed \$500 in the event of total loss.

Part 107 License

- Conduct pre-flight inspection of aircraft and control station to satisfy the pilot it can be operated safely
- Only fly aircraft that are properly registered with FAA

sUAS Registration

- You must register the drone unless under 0.55 lbs (8.8 oz.)
- Easy to do online: submit email address, physical and mailing addresses, and have credit card to pay fee
- \$5 covers you for three years

Once Registered

- Label with registration number
- Carry certificate with you whenever you (or whoever) fly
- Engraving, permanent label, permanent marker on outside surface of drone are all OK

Model Aircraft

- Part 107 does not apply to model aircraft that are flown under the Exception for Recreation Flyers
-

Flights Near Airports

- For flight near airports in controlled airspace, operators must receive airspace authorization prior to operation
- Authorizations come with altitude limitations and may include other operational provisions
- Controlled airspace and other flying restrictions can be found on FAA's B4UFLY app

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FAA Drone Zone

- <https://faadronezone.faa.gov/#/>

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Automated Authorizations Through LAANC

- Part 107 remote pilots can get airspace authorization for altitudes below the posted UAS Facility Map grid altitudes automatically from a LAANC service supplier
- LAANC: Low Altitude Authorization and Notification Capability

The Test

- Aeronautical topics
- List published by FAA
- Most enroll in an online school like <https://www.dronepilotgroundschool.com>
- Exam fee is \$160, certificate good for 2 years

If You Haven't Figured It Out

- Learn the terminology of flying
- Learn the acronyms (flying & FAA & unique drone-related ones)

SAFETY

- Many aspects
 - Of the people flying
 - Other (innocent) people
 - Other people's property
 - YOUR property (the sUAS)
 - Includes how not to get killed



Aircraft Safety

- Things wear out
- Especially rotatory and vibratory things
- Know the weak points
- Understand lifespans (MTBF)
- Understand visual inspection

Personnel Safety

- Train, train, train
- Don't be forgiving during training
- If there is a failure, retrain and retest
- Keep up with manufacturer's and FAA bulletins

Personnel Safety

- Make sure the whole crew understands all aspects
- Cross-training is important
- Learn the traffic rules of the air

Personnel Safety

- Immediate right turn
- Immediate land
- Orderly landing
- Stay in place or orbit in place
- Making decisions that opt for safety rather than convenience or speed or any other factor

Insurance

- Insurance usually requires you to follow safety procedures
- Insurance companies are still learning
- If there are a list of conditions for flight stated by the insurance company, follow them!
- Don't follow, have a loss, and don't expect insurance to step in!

Insurance

- When you violate FAA rules or state or local laws, it is the same situation as robbing a bank
- The insurance on your device usually is void while you are committing an illegal act
- The law is to be yet tested on how illegal is illegal
- I don't think you want to be the test case

And Then, the Licensing Board

- If you are committing illegal acts while flying a drone...
- What is the licensing board going to think?

Some Basic Rules

- Know your market
- Know your customer
- Select your drone(s)
- Select your sensors (you have to know what you want to achieve)



Some Rules...

- Is your company committed to process and safety?
- Will you invest in training and re-training?
- Will you invest in preventive maintenance and inspection?

Some Rules...

- Select qualified people
- These days many are already FAA Remote Pilots
- If not, do they know about the program?



Some Rules...

- Are you willing to pay to get them trained, licensed and then trained again on the aircraft you will fly?
- Are you willing to have more than one person trained? (cross training is important)



Some Rules...

- Who will do flight planning and design?
- Who will do the operations including ground control?
- Who will do photo processing and product generation?

Some Rules...

- Who will be involved in a quotation?
- Will you have a checklist for quoting that includes training and compliance with board, insurance, FAA and state and local laws?

National Map Standards (NSSDA)

- How do you comply with these?
- Why are these important?

Studies to Achieve Standards

- Flight heights (pixel size)
- Control point spacing
- Other factors: lighting (shadows!), terrain types, weather, camera quality
- Making adjustments for terrain relief

Understand How Software Works

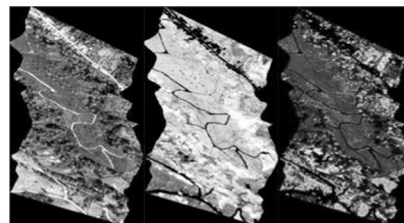
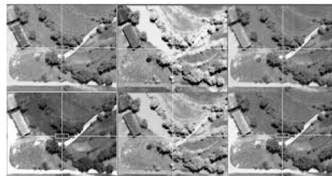
- Close range photogrammetry is different from traditional photogrammetry (but also similar)
- Understand what controls you have
- If it doesn't handle ground control, as a surveyor, you don't want it

Getting Measurement-Correct Results

- Selection of aircraft
- Selection of sensor
- What is the ground resolution you need to achieve (function of camera system and flying height AGL)?

Products

- Volumes, areas, counts, change monitoring
- NIR and other products
- LiDAR, hyperspectral and multispectral imaging products



Good Luck

- sUAS: legitimate area of expertise for surveyors to supply unique deliverables used by private industry, governments and private individuals
- Tread carefully, grow carefully

What Makes Drones Professional?

- The model of drone/UAS is arbitrary (sort of)
 - Consumer?
 - Prosumer?
 - Professional?
- The use of a drone/UAS and process of creating accurate deliverables requires
Professional Supervision and Intervention

About seminar presenter Joseph V.R. Paiva

Dr. Joseph V.R. Paiva, is principal and CEO of GeoLearn, LLC (www.geo-learn.com), an online provider of professional and technician education since February 2014. He also works as a consultant to lawyers, surveyors and engineers, and international developers, manufacturers and distributors of instrumentation and other geomatics tools, as well being a writer and speaker. One of his previous roles was COO at Gatewing NV, a Belgian manufacturer of unmanned aerial systems (UAS) for surveying and mapping during 2010-2012. Trimble acquired Gatewing in 2012. Because of this interest in drones, Joe is an FAA-licensed Remote Pilot.

Selected previous positions Joe has held includes: managing director of Spatial Data Research, Inc., a GIS data collection, compilation and software development company; senior scientist and technical advisor for Land Survey research & development, VP of the Land Survey group, and director of business development for the Engineering and Construction Division of Trimble; vice president and a founder of Sokkia Technology, Inc., guiding development of GPS- and software-based products for surveying, mapping, measurement and positioning. Other positions include senior technical management positions in The Lietz Co. and Sokkia Co. Ltd., assistant professor of civil engineering at the University of Missouri-Columbia, and partner in a surveying/civil engineering consulting firm.

Joe has continued his interest in teaching by serving as an adjunct instructor of online credit and non-credit courses at the State Technical College of Missouri, Texas A&M University-Corpus Christi and the Missouri University of Science and Technology. His key contributions in the development field are: design of software flow for the SDR2 and SDR20 series of Electronic Field Books, project manager and software design of the SDR33, and software interface design for the Trimble TTS500 total station.

He is a Registered Professional Engineer and Professional Land Surveyor, was an NSPS representative to ABET serving as a program evaluator, where he previously served as team chair, and commissioner, and has more than 30 years experience working in civil engineering, surveying and mapping. Joe writes for *POB*, *The Empire State Surveyor* and many other publications and has been a past contributor of columns to *Civil Engineering News*. He has published dozens of articles and papers and has presented over 150 seminars, workshops, papers, and talks in panel discussions, including authoring the positioning component of the Surveying Body of Knowledge published in *Surveying and Land Information Science*. Joe has B.S., M.S. and PhD degrees in Civil Engineering from the University of Missouri-Columbia. Joe's volunteer professional responsibilities include president of the Surveying and Geomatics Educators Society (SaGES) 2017-19 and various *ad hoc* and organized committees of NSPS, the Missouri Society of Professional Surveyors, ASCE and other groups.

GeoLearn is the online learning portal provider for the Missouri Society of Professional Surveyors, and surveying professional societies in Kansas, New York, Texas, Pennsylvania, Wisconsin, Arizona and Oklahoma. More organizations are set to partner with GeoLearn soon.

Dr. Paiva can be reached at joepaiva@geo-learn.com or on Skype at joseph_paiva.

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