

Mission Planner for GEOINT Data Acquisition

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Abstract—Across all North Atlantic Treaty nations there is a very well implemented way of military thinking when preparing for war or for crisis operations. Starting from scratch we consider first the military intelligence, afterwards looking for planning, carrying out the operation, and finally assessing the whole campaign. The real first step of this process is the Geospatial Intelligence (GEOINT). In order to collect, analyze, and disseminate as much intelligence as possible, the military maps will look for integrating data from different aerial and spatial sensors. Having in mind that not all the enemy's soil could be surveyed by us, we are trying to match pan-sharpened digital pictures taken by Copter Unmanned Air Vehicles with images taken by commercial satellites and to extend by induction, using the relationship between the different levels of grey of the multi-sensors final products, the geographical knowledge management over the white spots.

Index Terms—Multi-sensors, GEOINT, mission planner, pan-sharpened images.

I. INTRODUCTION

NATO'S GEOSPATIAL INTELLIGENCE (GEOINT)

PREPARATION OF THE ENVIRONMENT

The process of joint intelligence preparation of operational environments based on the environmental analytic method of the geospatial intelligence (GEOINT):

i. Knowledge about enemy's environment means to collect basic data needed to outline the real location of the operation, mission or zone of critical interest. In this respect political, physical, and broadly ethnic boundaries should be delimited. The facts might include national grid coordinates, geographical latitude and longitude, some vectors, relative altitudes, natural limits (mountain ranges, rivers, and shorelines), etc. These data and facts serve as the very foundation for the specific NATO's GEOINT product.

ii. Narrate all the influences of the operational environment means that we are looking for providing descriptive information about the mission environment. First of all we must identify real natural conditions, scope of the infrastructure, and several cultural factors. We have to consider all size of the details that may affect a potential mission in the zone: bad weather, lush vegetation, deteriorated roads, number of facilities, reluctant population, and different languages, social behavior, ethnic conflicts, religious fanatics, and local political factors. Consider laying this information onto the foundation developed by now.

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iii. Campaign assessment of the potential threats and alleged hazards mean to update the GEOINT product we have to add intelligence, weaknesses, strengthens, and threat data, drawn on the map from multiple intelligence disciplines, onto the development and descriptive information layers. This kind of information includes: the order-of-battle; the size, scope and strength of the enemy or of the real threat; the enemy's military doctrine; the kind, the nature, the real strength, the actual capabilities and the hidden intent of the zone insurgent groups; the potential effects of possible chemical/biological threats. This step requires strong cooperation, and collaboration with national security community counterparts.

iv. Foundation of the analytic conclusions. In order to complete this step we ought to integrate all information from the previous steps to be able to develop such analytic conclusions. The emphasis is based mainly on the struggle of developing predictive analysis. In this final step, the geographical intelligence analyst may create certain models to ease him to examine and to reassess the likely or potentially next movements or actions of the threat, the impact over us of those actions, and the feasibility and the real impact of our countermeasures to deter all those actions.

II. INTEGRATION OF GEOSPATIAL INTELLIGENCE GATHERED WITH MULTISENSORS

"We are talking about a science named photogrammetry dealing with measurements made starting from photos taking into account that it is mandatory to recover the points at the terrain exactly on their positions" [1].

"The ASPRS (American Society for Photogrammetry and Remote Sensing) tried to define the science of photogrammetry as not only the art but the technology and also the science of gathering accurate data about real objects and physical environment using the act of recording, afterwards measuring and finally interpreting photo images" [2].

"As an interdisciplinary science, photogrammetry includes projective geometry and optics" [3].

"When borrowing from the recording technique the images and from the digital mastering methods applied in remote sensing, digital photogrammetry appears.

The digital model represents an important step in the evolution of photogrammetry. Digital photogrammetry is a deep step in the designing of the automatization, as well as in the introduction of data in the spatial component of the Geographic Information System (GIS)" [4].

"There is an algorithm called Levenberg-Marquardt which is dealing with a bundle adjustment that minimizes what we call the sum of the squares of errors. Looking for more sophisticated algorithms one could use symmetries. But the real aim is to use techniques belonging to without contacting measurements in order to determine changeable

characteristics and the modular shapes of non-rotating [5], [6] and rotating structures [7], [8].

Closing the gap between the different resolutions of images geographically referred on geospatial information systems (GIS) will enable the direct flow of information between the higher resolution images to the other images building as such a pattern to be used in the reconstruction of the poorer resolution image in order to build up a new GEOINT product, anywhere within the operational environment.

Mission Planner is a quasi-new software platform used to prepare and to plan the copter UAVs flights in order to collect digital images and remote data over a potential crisis environment.



Figure 1. Mission Planner software

The Mission Planner does, of course, a lot more than its surname.

Some of the features will be thereby mentioned: point-and-click a waypoint entry, able to select mission commands from several drop-down menus, capable to download mission log files and ready to analyze them, prepared to configure settings for the airframe, meant to interface with a PC flight simulator to create and to draw a full hardware-in-the-loop copter UAV simulator.

Mission Planner is, also, a full-featured ground station application for the exploit and management of the so-called Ardu-Pilot open sources autopilot project.

III. WHAT IS IN FACT MISSION PLANNER?



Figure 2. Mission Planner ground station

Mission Planner could be defined itself as a ground control station for wing, copter and any other kind of robot. We have to notice that Mission Planner is compatible with Windows only. Mission Planner can be used both as a real configuration utility and/or as a dynamic control supplement

for any autonomous robot vehicle. Throughout the current paper we will specify just a few things one can do with Mission Planner: to load the software into the autopilot that controls a robot vehicle deployed at ground or airborne; to be able to setup, configure, and tune any robot vehicle launched at air and/or at land for its best performance; to be prepared to plan, save and load completely independent missions and/or operations into any autopilot robot vehicle with a simple point-and-click way-point entry on the downloaded maps; to extract, download and analyze mission logs created by any autopilot robot airborne and/or grounded vehicle; to be ready to interface with a PC flight simulator to be prepared to create a full hardware-in-the-loop copter UAV simulator.

Having in mind that with a close telemetry hardware one can: be able to monitor such a copter vehicle's status while deployed in mission or/and in operation; be able to record in real time telemetry logs which contain for sure much more data and information than the on-board copter autopilot logs; to be in the mood to view and to analyze the whole telemetry logs. Mission Planner is in fact a free, open-source, community-supported software application designed and developed for the open-source copter autopilot project. Clicking at one's choice the Help icon at the top of the Mission Planner browser interface one could see how a brand new screen with general data and information about help within Mission Planner will open. The "Check for Updates" button will check online for available updates to the Mission Planner software manually. Mission Planner, indeed, automatically checks for updates and upgrades upon start up and notify the user if an update is already available. It is needed always to run the most current version of the Mission Planner software. Moreover, the check box "Show Console Window (restart)" enables the console window during the operation of the Mission Planner software. That window shows to everybody the Mission Planner software activity and is to be considered primarily for diagnostic purposes. It shows sometimes some of the most interesting information and/or data. A restart of such Mission Planner software is required for the option to take immediately effect. The online support for Mission Planner software comes for free from the community of passionate users. All of the documentation is created and exhibited by kind users who volunteer their time.

If you have any questions, first of all look through the table of contents for a topic that may address somehow your question. Next, try looking for a website search. If you are still in the position to need help, then the community forums are for sure the place to go. There you will find friendly users, developers, indeed. There are two primary forums online. The so-called diy-drones forum has existed for many years and has a very large community of members and numerous general topics."[9] The APM forum is quite brand new and it is more specific to the ardu-pilot and ardu-kind of vehicles. Usually, you can resolve or you can get an answer to any question on a forum. Sometimes someone will be able to discover a bug and can or wish to confirm the problem arisen on a forum. If one has discovered a bug, he should use the forums to request it to be logged as an official issue. One of the volunteer developers will normally be glad to do so, indeed. If someone sees a need to change or enhance the documentation, he or she is persuaded to let the volunteer community to know about it –

again and again using the online forums of free users. Any suggestions are welcome and there are dozens of qualified software editors who can implement your suggestions. We suggest you to use the table of contents at the top of each page to navigate the Mission Planner software Manual – and, of course, the contents of the copter vehicle specific areas. This section of the website contains information and data on how to use Mission Planner software as a “general” received application. However, some of the inbuilt pages will, also, have some copter vehicle specific information. Those web pages will, also, be contained in the specific copter vehicle’s section of the website. Information and/or data that is primarily specific to a particular copter vehicle will be only located in that copter vehicles sections so, if you cannot find information there, try the section of the website for the exact copter vehicle you are using for your research or your work. Once you’ve installed the Mission Planner onto your computer, connect the autopilot board to your computer using the micro USB cable. Be sure that you use a direct USB port on your computer.



Figure 3. Mission Planner USB plug

Normally, Windows operating system should automatically detect online and install the correct driver software, indeed. Open afterwards the *Mission Planner* and select the COM port drop-down on the upper-right corner of the software screen. Select AUTO or the specific port for your board. Set the Baud rate to **115200** as shown below. Do not hit **Connect** just yet.

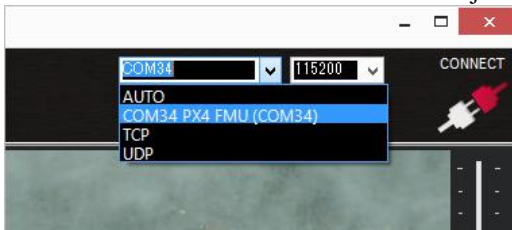


Figure 4. Mission Planner baud rate



Figure 5. Mission Planner baud rate

On the Mission Planner’s software Initial Setup and/or Install Firmware pop-up screen, one should select the appropriate icon that matches the needed framework. Answer of course with yes when it asks you: “Are you sure?”

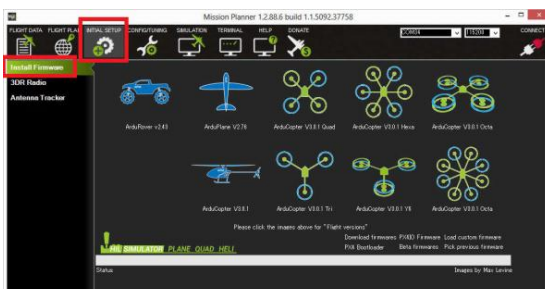


Figure 6. Mission Planner firmware install

After the Mission Planner software is going to detect which board someone is using, it will ask him to unplug the board, to plug it back in and then to press OK within no more than a few seconds.



Figure 7. Mission Planner firmware install

If nothing wrong happens and all goes well one will see some status appearing on the bottom right including some of the following words: “erase...”, “program...”, “verify...” and “upload done”. In this case one could claim that the firmware has been successfully uploaded to the board, indeed.

IV. CONNECTING MISSION PLANNER TO THE SO-CALLED AUTO-PILOT

Here we have to explain how to connect the *Mission Planner software* to an auto-pilot in order to receive telemetry and control the copter vehicle functions. To establish a connection one must first choose the best communication method and/or channel he wants to use, and then set up the physical hardware on the copter vehicle and, also, Windows operating system, as a device, drivers. One can connect the PC and the auto-pilot using regular USB cables. The driver for such connection hardware must be present on Windows operating system as this makes the connection’s COM port and the default data rate available to *Mission Planner software*.



Figure 8. Connection using Radio

On *Mission Planner software*, the regular connection and the data rate are set up using the drop down boxes in the upper right portion of the screen.

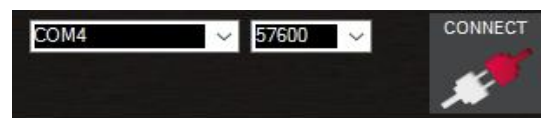


Figure 9. Connection screen

Once someone has attached the USB or the Telemetry Radio, the Windows operating system will automatically

assign to his auto-pilot a COM port number, and that will be shown in the drop-down screen menu, indeed. The most appropriate data rate for the connection is of course, also, set (normally the USB connection data rate is set to 115200 and the radio connection rate is to be set at 57600). After selecting the desired port and the needed data rate one should then press the Connect button to connect to the auto-pilot. After the connecting issue has been successfully established, Mission Planner software will look for downloading parameters from the auto-pilot and the button will change to Disconnect as shown below in the Figure 10:

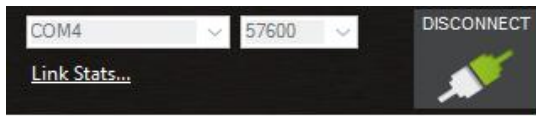


Figure 10. Disconnection screen

“If the Mission planner software is in the situation not to be able to connect, one should check that the correct baud rate is used for the selected method (115200 on USB or 57600 on Radio/Telemetry). If one is using a COM port on Windows operating system, he/she needs to check that the connection’s COM port exists in the Windows Device Manager’s list of serial ports. If one is using a USB port, he/she should try a different physical USB port. If someone is using a UDP or TCP connection, he/she should check that the firewall is not blocking the IP traffic. One should also ensure that the auto-pilot controller board has the most appropriate Ardu-Pilot firmware installed and has booted correctly from scratch” [10].

V. MISSION PLANNING

Here we provide a bunch of information about Mission Planning, and about how to creating automated missions/operations that will run exclusively when the Ardu-Pilot is set to AUTO mode.

Also we consider here to demonstrate mission planning using **Mission Planner**, a fully-functional Windows-based Ground Control Station (GCS).

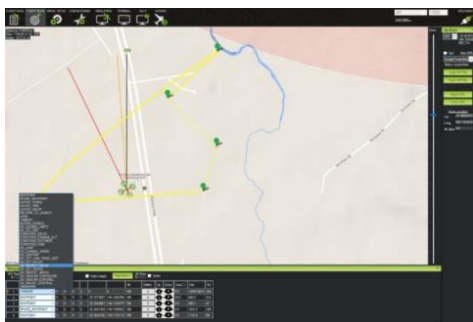


Figure 11. Mission Planner software: Flight Plan Screen

VI. PLANNING A MISSION WITH WAY-POINTS AND EVENTS

For the copter UAV vehicle, the home position is set as being the location where the copter vehicle was initially armed. This means, indeed, that if one executes an RTL in copter vehicle, it will return, of course, to the location where it was primarily armed, so he/she should arm his/her copter in the location he/she wants it to return to. In the screenshot below, a copter unmanned aerial vehicle’s mission starts with an auto takeoff to 20 meters altitude. Then the copter

UAV goes to WP 2 rising to 100 meters altitude on his way, where he waits for 10 seconds. Afterwards, the unmanned craft will proceed to WP 3 (descending to 50 meters altitude on the way). Finally, the UAV returns to the initial launch position. Because the default altitude is set to the level of 100 meters, the return to launch will be at the same 100 meters. After reaching vertically the launch position, the copter craft will land. The mission assumes that the launch position is set at the home position.



Figure 12. Copter: Mission Planning

Someone can enter further way-points and other Mission Planner software external commands. Within the dropdown menus on each row, anyone could select the command he/she want. The column heading will change in order to show one what data need to be available that command requires. Latitude and Longitude can be entered by clicking on the map. Altitude is relative to the launch altitude/home position, so if someone set 100 m, e.g., it will fly 100 m above him. The Default Altitude is the default altitude when one is looking for entering new way-points. It is, also, the altitude RTL (return to launch) mode will fly at if someone has Hold Default ALT checked, indeed. If one don’t have that checked, the aircraft will try to maintain the altitude it was at when one switched on RTL. Verify the height means that the Mission Planner software will use the Google Earth topology data to adjust the desired altitude at each way-point to reflect the height of the ground beneath. So, if one’s waypoint is on a hill, if this option is selected, the *Mission Planner software* will increase the ALT setting by the height of the hill. This is a good way to make sure one don’t crash into the mountains. Once one is done with his mission, he should select Write and it will be sent to APM and saved in the EEPROM. He can confirm that it’s as he wanted by selecting the command: Read.

Someone can save multiple mission files to his/her local hard drive by selecting Save WP File or read in files with Load WP File in the right-click menu:



Figure 13. File Load / Save

Someone can have the *Mission Planner software* create a specific mission for him/her, which is useful as a function like mapping missions, where the copter aircraft should just go back and forth in a “lawnmower” pattern over a selected area to collect photographs. To be able to do this, in the right-click menu someone need to select Polygon and to draw a box around the area he/she want to produce a map. Then he/she should select the command: Auto WP, Grid. Following the dialog box process someone should be ready to select altitude and spacing. The *Mission Planner software* will then generate a mission that looks something like this, below.

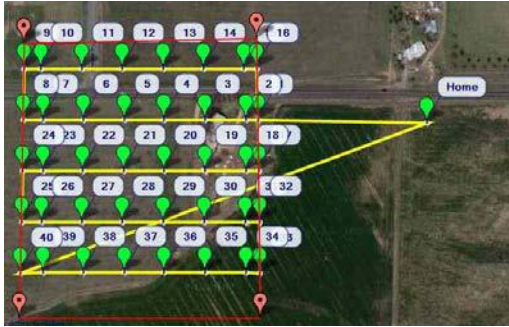


Figure 14. Mission Planner auto-generated grid

Afterwards, the *Mission Planner software* provides a filtered list of the commands that are the most appropriate for the current copter vehicle type, and adds a few column headings for the parameters that need, also, user-supplied values, indeed. These parameters include navigation commands to travel to way-points and loiter in the vicinity, DO commands to execute specific actions (for example taking pictures), and, of course, condition commands that can control when DO commands are able to run.



Figure 15. LOITER_TURNS command with headings for number of turns, direction, and location to loiter around

VII. CAMERA CONTROL AND AUTO MISSIONS IN MISSION PLANNER

Here we are looking for to describe Ardu-Pilot’s camera and gimbals’ commands, and to explain how these can be used in Mission Planner software to define camera survey missions / operations. The whole bunch of instructions assumes that the camera shutter/ gimbals have already been correctly connected and properly configured. Planning for a camera mission is almost exactly the same thing as planning any other mission / operation with way-points and presumed events. The only remarkable difference is that in a camera mission / operation someone should specify commands to trigger the camera shutter at way-points or at regular intervals as the vehicle moves with a certain speed. If the shooting camera is mounted on a gimbal, someone can, also, set the gimbal orientation, or make it track a particular point or area of interest. For simple missions / operations one can manually specify the required way-points and camera commands. For more complex paths and grid surveys the Mission Planner software makes things easy by providing tools to automatically generating the required mission / operation for arbitrary regions. The final mission with way-points and camera triggers looks like this, as follows:

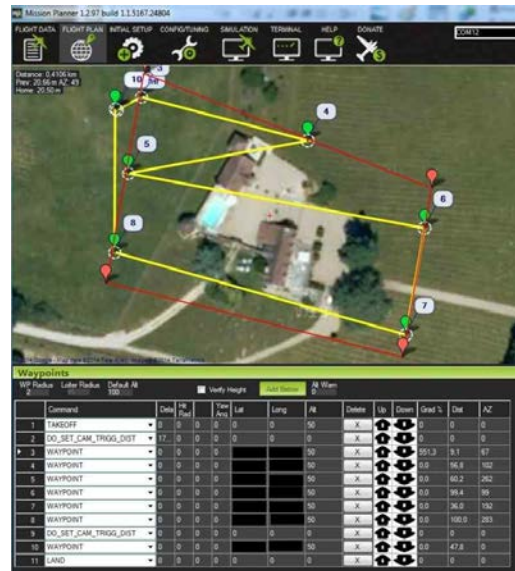


Figure 16. The final test mission.

The test mission depicted in Figure 16, above, was run. It generated 15 images, which have been stitched together. A thumbnail of the composite image is shown below.

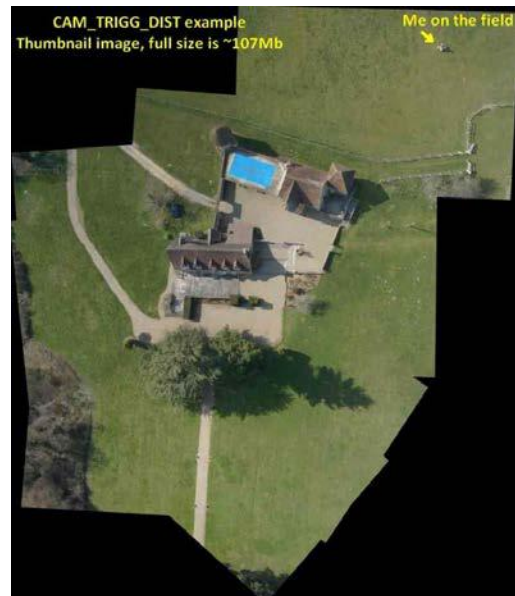


Figure 17. The composite image

VIII. RALLY POINTS

Typically, when a plane or copter UAV enters Return to Launch (RTL) mode (normally triggered by an auto-pilot fail to be safe), the default behavior is to return to the Home point, but there are often cases when that is not desirable. For example, it may be an area full of people or a private owned property and a system running in RTL mode may very likely to be in a state that merits extreme caution. It is, also, highly possible that the flight plan is large enough not to allow the aircraft enter RTL mode. In such case it is undesirable to traverse all the way back to the point of takeoff. For this reason we now support the creation of multiple Rally Points. Should an aircraft enter the comeback command (RTL), by hazard, and Rally Points have been defined then it will proceed to the closest Rally Point, rather than proceeding to the initially Home position. Copter UAV will then loiter at that location and the copter will perform automated landing there.



Figure 18. A flight plan with Rally Points. Rally Points are denoted with Purple place markers

IX. GEO-TAGGING IMAGES WITH MISSION PLANNER SOFTWARE

Within this paragraph someone could see how to Geo-tag images using the *Mission Planner software* to inject data from telemetry logs into their EXIF tags. Geo-tagging images make it easier to photo-merge the so many pictures taken during a camera mission / operation, and this it is very important for applications including photogrammetry, ortho-photo generation, 3D terrain modeling, etc.

The *Mission Planner software* provides two methods for geo-tagging the photos from a mission log.

X. CAM MESSAGES FROM DATA FLASH LOG

The Ardu-Pilot can trigger a camera during pre-programmed missions / operations or by RC activation using the `DO_DIGICAM_CONTROL` or `DO_SET_CAM_TRIGG_DIST` commands. Corresponding CAM messages are stored in the data flash log and can be used by Mission Planner software to add accurate geo-tag information to images.

XI. TIME OFFSET

Using the difference in time of the so-called camera internal clock and the clock of the system in order to determine where a certain image in the log was taken, and subsequently match it to the information linked to the GPS, we found out a brand new method of superposing the log timestamp to the image timestamp.

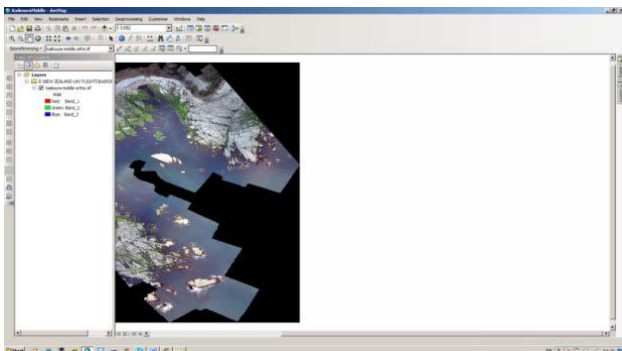


Figure 19. New Zealand shore UAV pan-sharpened image on ArcGIS software

The above image is planned and obtained with a copter UAV vehicle through Mission Planner software. It is a result of my own ERASMUS+ PhD candidate Training at the Technical University of Crete, Chania (Χανιά), Greece, School of Mineral Resources Engineering (MRED) between August the 21st and October the 20th 2017, at the Spatial Informatics research group of the Geodesy and Geomatics Engineering Laboratory (SenseLab), under the supervision of Asst Prof Panagiotis PARTSINEVELOU, and Eng Aggelos ANTONOPOULOS. The new software used is ArcGIS 10.2.2 Arc MAP and the image could not be loaded into such software without being geographically referred on WGS84. The aim of using both images taken from satellites and copter UAVs is to be able to fill the gaps of information for a brand new GEOINT product in an enemy remote area with a lot of blind spots. For example we need to know with high accuracy how the shore is in the north-east part of the above picture and we cannot use copter UAVs but satellites images, only.

XII. CONCLUSION

The challenge for a researcher comes from the huge discrepancy between the pixels taken from sensors, the satellite one and the UAV one. One sensor got a pixel covering about 10 meter the side of the square facing the another sensor of which pixel is covering about a half inch (1.27 cm) the side of the square. Transforming the copter UAVs colored images into levels of grey and comparing with the satellites levels of grey someone could induce a brand new GEOINT product transforming the satellites panchromatic images into colored images. Such a product will increase at least twice the precision of the newly obtained GEOINT layer.

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