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MTDC/FHP FY 98 Achievements

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Executive Summary

The Forest Health Protection Program at Missoula Technology and Development Center (FHP/MTDC) is designed to provide engineering and technical services to FHP Staff. During FY 1998, the program produced 13 documents including Forest Service reports (3), proceedings papers (8), and peer-reviewed journal articles (2). This production is possible due to the professional engineering and support staffs at MTDC and the consulting talent available through contracting. Continuum Dynamics, Inc. was particularly important to Program production this year. Pat Skyler, FHTET, (Region 5) is also a critical part of this team. The Program included various hardware development efforts. Three mechanical systems are currently being tested in Forest Service (FS) applications as a result of this year's efforts. One area of increased interest is in the use of insect pheromones in pest management strategies. The program includes two projects involving pheromone use. Following are project achievements and status.

Introduction

The FHP/MTDC Program is supported through the Forest Health Technology Enterprise Team (FHTET) at Fort Collins, CO, and Morgantown, WV. The Program Leader of the FHP Program at the Missoula Technology and Development Center is Dr. Harold Thistle. This was a year of transition with the program sponsorship starting out at Fort Collins under Dr. Bov Eav and ending the year at Morgantown, WV under Allan Bullard. The program intent is to have engineering and other specialized technical support available for FHP needs. The program this year consisted of six projects with many smaller efforts conducted under the general heading of Engineering Services.

The FHP/MTDC Program has operated at MTDC for almost 30 years in some form. Four of the Center's mechanical engineers played large roles in this year's program. There is substantial call for mechanical equipment in Forest Health Protection pest management activities. MTDC expertise is useful in designing prototypes and testing them, or in testing innovative off-the-shelf equipment. Most of the equipment projects involve modifying existing designs to accommodate new applications and testing these modifications.

The FHP/MTDC Program is also involved in collecting data and developing software algorithms to simulate pest management operations. Modeling the deposition and atmospheric dispersion of sprayed pest-control agents has been a primary part of the FHP/MTDC Program for many years and still is important. This work has been used extensively by the U.S. Environmental Protection Agency (USEPA) in developing pesticide application regulatory strategy. The application technology surrounding the use of insect pheromones in forest pest management was a large part of the program this year.

The program uses cooperators and partners whenever appropriate. We have cooperative work with U.S. Army, National Weather Service, Department of Energy, USEPA, and other U.S. Department of Agriculture groups, including Animal and Plant Health Inspection Service and Agricultural Research Service. We also work closely with both academics and industry. This year, two of the technical efforts were supported by outside funding at levels of 50% or greater. Industry is using ideas developed under two of the other development projects starting this fiscal year. This involvement by industry allows the Forest Service to get products it needs without having to get involved in production costs.

Engineering Services

Project Objective

The objective is to provide prompt engineering services on request, and to coordinate program planning support to the sponsoring Washington Office unit. At the request of FHP staff, the Center conducts special investigations and studies; participates in field programs; evaluates employee suggestions; contacts field personnel to determine instrumentation and equipment needs; delivers presentations on FHP methods at training sessions, meetings, and workshops; provides followup services on completed development projects and answers requests for information from field units, government agencies, and industry; publishes reports; and prepares manuscripts for journal publications.

Background/Rationale

MTDC represents a unique resource of people, knowledge, and professional and technical skills. It is the only source of mechanical and electrical engineers in the Forest Service, other than those in research. Historically, FHP has called on MTDC for immediate and short-term professional judgments, onsite support, contract specifications, equipment evaluations, drafting, editing, publication, and assistance in technology-transfer activities. Need for these services will—at a minimum—continue at current levels and probably will increase.

Achievements

❑ **Attend national meetings and workshops, present papers, and prepare manuscripts for journal publication.**

The FHP/MTDC Program had a very active year in the area of meetings and technology transfer. It is up to the FHP Sponsor and the MTDC Program Leader to decide whether given meetings further the program objectives. Generally, the criterion for external meeting attendance is to give a paper or presentation (preferably to be published) that transfers technology to the user community or that identifies other similar efforts that will facilitate completion of a given project. Internal meetings are attended as necessary to keep FS personnel updated on the nature of the program and progress with individual projects. External meetings attended this year include:

- *Gypsy Moth Review,* Annapolis, MD. Presented a paper and moderated a session on new technologies.
- *American Mosquito Control Association,* Reno, NV. Presented two technical papers.
- *North American Conference on Pesticide Spray Drift Management,* Portland, ME. Presented two technical papers.
- *Twelfth Annual Symposium on Geographic Information Systems,* Toronto, ONT. Presented two technical papers.
- *American Society of Agricultural Engineers,* Orlando, FL. Coauthored four papers. MTDC personnel presented two papers, and a contractor, Milt Teske of Continuum Dynamics, Inc., presented two papers.

Internal meetings attended this year:

- *FHTET Model Symposium,* Fort Collins, CO.
- *Spray Modeling and Application Technology Working Group,* Orlando, FL. MTDC chaired this meeting. Detailed meeting notes are in review and will be published. Meeting notes from the previous (FY 1997) meeting are available (Thistle and Skyler, November 1997).
- *FHTET Team Meeting,* Fort Collins, CO.
- *Bark Beetle Working Group,* Vail, CO. Gave a technical presentation on the pheromone dispersion project.

Other meetings:

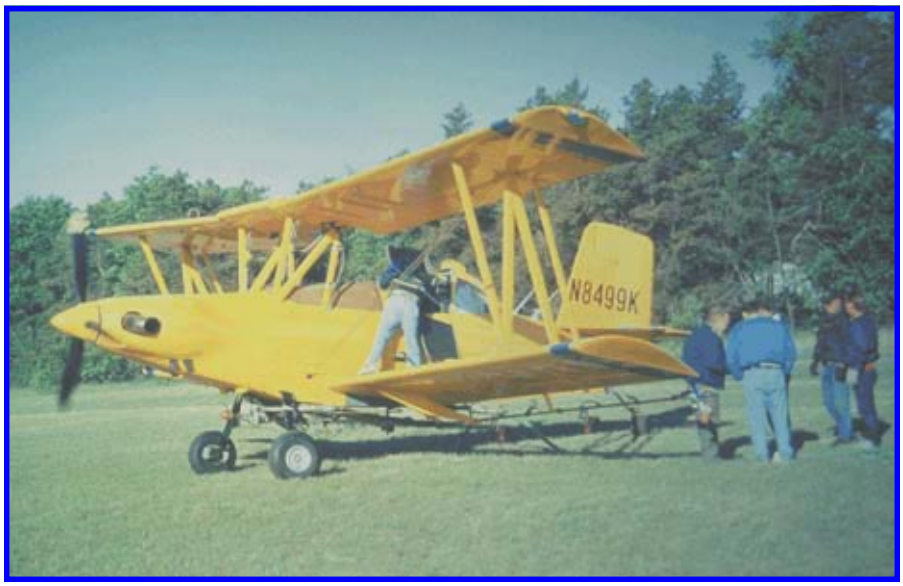
- *Mountain Meteorology for the Natural Resource Manager Editorial Board,* Salt Lake City, UT. Chaired this meeting.
- *U.S. Environmental Protection Agency Scientific Advisory Panel,* Washington, DC. Served as a panel member reviewing proposed EPA registration methods.

❑ **Seed orchard cone sanitation.** This was terminated as a project in FY 1997, but external cooperators including the Bureau of Land Management (Oregon State Office), the State of Oregon, the State of Washington, Georgia-Pacific Corporation, Plum Creek Timber Company, Roseburg Forest Products Company, Simpson Timber Company, Weyerhaeuser Company, Willamette Industries, and various groups within the Forest Service, came up with external dollars to keep the project going. The focus this year was on sweeper, vacuum, and rake technologies developed for cleaning golf courses. MTDC modified the Rake-O-Vac (the Toro Company) turf sweeping machine. The trailer tongue and power takeoff (PTO) were moved to one side to allow the machine to get closer to young trees without damaging the lower limbs. The Rake-O-Vac was a surplus item from the Veteran's Administration. The bristle pick-up head and the vacuum chamber needed

refurbishing. The machine was used to install test plots at the BLM's Horning Seed Orchard in Oregon in late September, and was used in conjunction with a flail mower. Insect emergence will be monitored in the spring. If this approach appears to be successful, further equipment modification may be necessary. The project is going on with interest from the Pacific Northwest Research Station, and is now over 65% externally funded.

❑ **Edge-flow modeling work.** The Agricultural Research Service is coordinating a large, multiagency effort to investigate the microclimate, habitats, water budget, and other technical issues, near woodland edges and windbreaks. These environments are becoming more and more prevalent at forest/urban/suburban/residential interfaces. The FHP/MTDC Program will coordinate with this larger effort.

❑ **DGPS in spray aircraft guidance.** This project was terminated in FY 1997, but there was ongoing interest in the general subject matter in FY 1998. The final report from the Harrisonburg spray aircraft guidance work was published (Thistle et al., December 1997). Three technical talks were given on this subject and one proceedings paper was published (Thistle et al., 1998b). The FY 1998 project on *Real-Time Modeling of Spray Drift* requires that the FHP/MTDC Program keep abreast of this technology. Technology transfer will continue as long as there is demand.



Schweizer AgCat used for agricultural spraying.

DGPS surveying.

❑ **Meteorological support of FHP operations.** Meteorological instrumentation was deployed in October 1997 on the Flathead National Forest in support of herbicide application. A role that has evolved for MTDC is technology transfer and training FS employees in current meteorological thinking regarding spray drift. Two technical talks were given on this subject and one proceedings paper was published (Thistle et al., 1998b).

❑ **Spray drift mitigation.** Deposition cards were dispatched to Region 5 in Hawaii to monitor spray drift associated with aerial spraying. Harold Thistle was invited to serve on the EPA's Scientific Advisory Panel (SAP) to review proposed new methods of evaluating the drift potential of individual compounds when registering pesticides. A proceedings paper (Thistle et al., April 1998), and a journal article (Teske et al., June 1998) that discuss new directions for work in spray drift modeling were produced.

Meteorological monitoring to determine herbicide spray conditions.

❑ **Stump applicator for feller-bunchers.** Annosum root rot affects conifers throughout the northern hemisphere. It is caused by the fungus *Heterobasidion annosum.* This fungus colonizes readily on freshly cut stumps and threatens all trees in a partially cut stand. Once a stand becomes infested, mortality can reach 10%. The primary method of controlling annosum is to treat stumps with borax powder immediately after cutting. MTDC designed a borax applicator system that attaches to feller-bunchers. The operator can treat the stump after felling the tree. The applicator uses an air compressor to deliver the powder from a hopper to a nozzle positioned behind the cutting head. A mechanism in the hopper controls the amount of borax being applied. The operator activates the system after positioning the nozzle over the stump. Because of its modular design, the applicator can be adapted to most feller-bunchers. This borax applicator was demonstrated to thinning contractors and FS personnel at the Savannah River Institute in New Ellenton, SC, in September. Michelle Cram-Fraedrich, Southern Region Health Pathologist, and Ron Bonar, Savannah River Timber Manager, hosted the demonstration. This project was supported about equally by the FHP/MTDC Program and by external cooperators.

Stump applicator.

Pheromone Dispersion

Project Objective

This project is to develop a simple algorithm to calculate the optimum spacing for passive pheromone sources. The passive pheromone sources have come into wide use in pest management. Generally, the sources are used in anti-aggregation, aggregation, or mating disruption strategies. Currently, pheromone sources are spaced based on experience and trial and error. This leads to a high failure rate in unfamiliar or unanticipated conditions. Through a systematic analysis of canopy density, in-canopy meteorology, and in-canopy dispersion, guidance on spacing and placement of pheromone sources can be developed.

Background/Rationale

This project follows up a joint study by the Pacific Northwest Research Station and Oregon State University. MTDC engineering expertise will be applied to analyze the in-canopy environment with respect to scalar dispersion and to develop an applied tool that uses the findings of this study to develop a model or matrix pest managers can use when placing pheromone sources.

Instrumentation used to determine pheromone dispersion in the canopy trunk space.

Achievements

FY 1998 was spent planning and conducting a field program to measure dispersion of a scalar quantity released in-canopy. This experiment is described in Thistle and Murray (June, 1998). The experiment was conducted in managed ponderosa pine on the eastern flanks of Mount Shasta near McCloud, CA. The approach taken was to release SF_6 as a tracer gas and measure the concentrations of the gas in the surrounding stand in a small area to ascertain changes in dispersion with varying meteorological conditions. The experiment was run from June 19 to July 1. The weather conditions were good and the measurement program coincided with a strong flight of pine beetles in the stand. Over 3,500 SF_6 samples were recovered. Since this was the first year of the experimental program, some mistakes were made that influence the quality of the data. The data have not yet been analyzed in detail, so the overall quality of the set is not known. It is clear that some data were lost due to leakage of the syringes and other data were lost due to contamination of the samples.

The data analysis to date indicates that differences in the overall dispersion patterns of the SF_6 tracer gas vary with the meteorology as expected. The in-stand temperature data are being used to correlate with bark beetle activity as monitored by the Pacific Southwest Research Station staff under the direction of Pat Shea. The canopy architecture data will be evaluated in a cooperative effort with Brian Strom, Southern Research Station, Pineville, LA .

Decision Support System Testing and Enhancement

Project Objective

Decision support systems (DSS) have been developed that use descriptions of meteorological processes and descriptions of the application methods and equipment to simulate dispersion and deposition of airborne materials. Analysis of data is ongoing and models have been improved and verified based on field trials. The objective of this project is to maintain leadership in the development of accurate, modern spray dispersion models and decision-support software.

Background/Rationale

MTDC has played an integral role in development of the FS spray dispersion models. The Forest Service Cramer-Barry-Grim (FSCBG) modeling system currently in use consists of two basic model types. The far-field model is Gaussian and has been adopted from U.S. Army models. The near-field model is a Lagrangian transport model that has been developed under contract to the Forest Service. A third model has been developed to describe transport in complex terrain. Both the near-field and the complex-terrain models have been developed under contracts that are overseen by MTDC.

Achievements

There was significant activity in this project this year. Much of the work was carried out through interaction with technical contractors, notably Continuum Dynamics, Inc. The work included an investigation of a method to calculate the drop size distribution of a given spray material (Teske and Thistle, May 1998). A discussion of the interaction of spray motion and the release point relative to the aircraft wing or rotor was produced (Teske et al., May/June 1998). The EPA is developing label guidance for pesticide applicators that may include nozzle-positioning guidance. This work aids this guidance development effort. A study was conducted using the FSCBG model to identify appropriate aircraft in given application scenarios (Teske and Thistle, 1998). An investigation into the most appropriate algorithm to model wake effects of spray aircraft was conducted. The algorithm currently used is based on the FS AgDisp model. A more sophisticated algorithm was run to examine details of the aircraft near wake (Teske et al., 1998).

Interest in modeling pesticide drift in complex terrain that is typical of FS operations was pursued this fiscal year. Work is focusing on using data that were collected in conjunction with a 1993 gypsy-moth spray project in the Wasatch Front of Utah. Runs are being prepared to assess performance of the ValDrift model by comparing the model results to deposition data collected during the program. A report should be ready in FY 1999.

A battery of tests to evaluate the existing FSCBG model are being designed to be conducted this fiscal year. The tests are designed to test model consistency and geometry. Though extensive testing of the model has been conducted, systematic testing of this type has not been performed independently of the developers.

Vortice generated by the wake of an aircraft.

FSCBG Real-Time Modeling

Project Objective

This project is to develop a system that will perform a simple set of calculations based on current ambient conditions and provide onboard notification to the applicator that the drift potential has increased. A combination of technologies has evolved to the point that this type of real-time warning system is now feasible. The DGPS aircraft guidance systems for aerial spraying have become remarkably sophisticated in the past 5 years and now provide the pilot with a real-time map and position display in the cockpit. Meteorological monitoring systems on an aircraft's wing that can provide high frequency, accurate meteorological information to the cockpit now exist. Finally, there are now basic computer technologies that make the necessary data integration and calculations fairly standard.

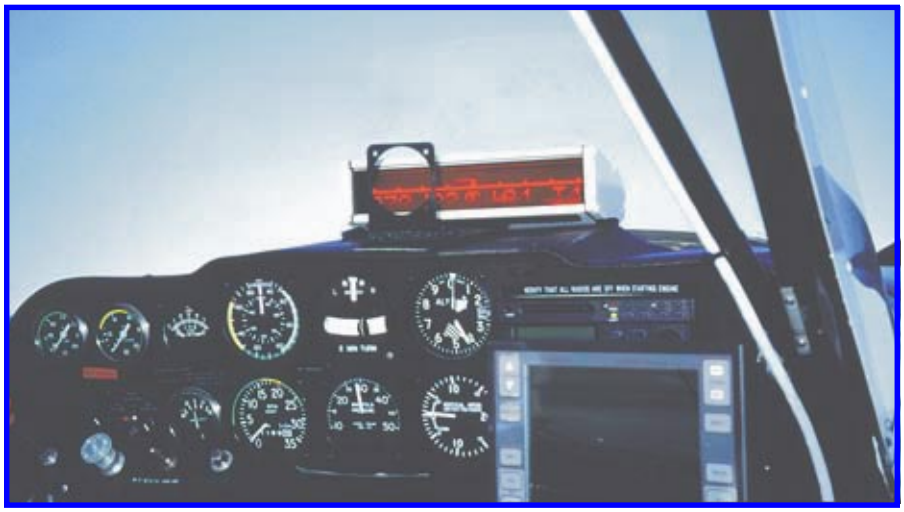
Background/Rationale

This project is an extension of MTDC work with spray aircraft guidance. The Center has discussed these ideas with several guidance systems manufacturers and believes that the majority of this development will take place in the private sector. The actual calculations will be based on the FSCBG model that has been developed by FHTET. This project will provide technical guidance to the private sector for this development. A successful system could greatly increase the tools available to the applicator to avoid drift off-target, increasing safety and avoiding unintentional environmental consequences.

Achievements

The firmware (hardware/software/interfaces) development that this project involves was largely handed off to industry this year. A presentation was given by Harold Thistle at the Gypsy Moth Review in Charleston, WV, in November describing components of this system. A meeting was held in Richmond Hill, Ontario in April with PicoDas, Inc. (developers of the AgNav spray aircraft guidance system). The intent of this meeting was to begin cooperative development. The outcome was that PicoDas would prefer to use public domain information and have their development proceed as a proprietary project. This was agreed upon, with the work the Forest Service had done being used as public information. Subsequently, two other aircraft guidance system developers have contacted MTDC and discussed developing their own real-time modeling capabilities.

A paper was presented (Thistle and Teske, 1998) discussing the mathematical basis for various approaches to this problem. The ongoing work will involve evaluation of algorithms developed by industry and investigation of more sophisticated techniques that could be used in the real-time algorithm.

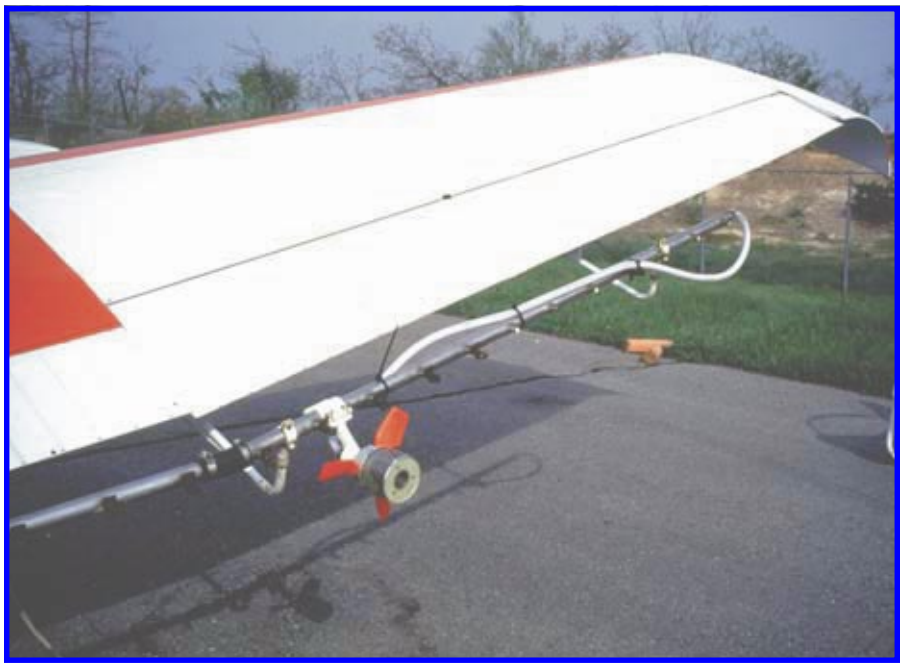


Cockpit-mounted DGPS aircraft guidance system.

Pheromone Application Equipment

Project Objective

This project is to investigate current aerial application methods for delivering gypsy moth mating disruption pheromones, specifically the Hercon Disrupt II flakes. Based on the results of the investigation, MTDC will either try to improve the current application system or develop a new one.



Wing-mounted spray system for pheromone application.

Background/Rationale

The application of Hercon pheromone flakes is unique. The impregnated flakes must be coated with a "sticker" for the flakes to stay in the canopy and release the pheromone. The current system uses two "pods," one mounted on each wing of the aircraft. Each pod carries small containers of sticker and a hopper to carry the pheromone flakes. The flakes are augered into a tube where they are mixed with the sticker and then augered into the airstream. The current pod system has many problems, including reliability issues, uneven swaths, and small delivery capacity.

Achievements

MTDC has investigated the pod system and determined that the best course of action is to develop a new delivery system where the flakes and sticker are premixed into a slurry, loaded into an agricultural aircraft hopper, and pumped into booms and sprayed. The Center has worked closely with Loveland Industries to develop a sticker whose properties will allow the flakes to remain suspended indefinitely and still have a viscosity low enough for the sticker to be pumped through the aircraft. The sticker has been tested several times successfully.

The other part of the problem is to develop a delivery system that can be mounted on the boom of the aircraft that will not clog and that will provide an even swath pattern. Several different conventional nozzle configurations were tested. None proved adequate to prevent clogging or deliver an even swath. An alternative to the nozzle system was to use an aerial applicator called a Micronair. The Micronair is a boom-mounted system in which a liquid is pumped into a cage that rotates at high speed. The mixture is propelled from the cage to create evenly spaced droplets. The Micronair spray system was modified and tested in Covington, VA, in the spring of FY 1998. It was able to pump the flake/sticker mixture and produced an even swath pattern. A test was then conducted in Staunton, VA, in the summer of FY 1998. After a few modifications, about 750 acres were successfully treated.

FY 1998 Achievements:

- November 1998—Attended *Gypsy Moth Disruption* meeting in West Virginia to report on project status and to receive project direction.
- January 1998—Tested new sticker in Dallas, TX, to determine flow problems through various check valves and nozzles.
- February/March 1998—Designed new application system and modified Micronair applicators.
- May 1998—Tested new applicator system in Covington, VA.
- July 98—Performed operational testing in Staunton, VA.

Stationary Tree Sprayer in Hemlock Protection

Project Objective

This project is to protect high-value hemlocks using the stationary tree sprayer technology that MTDC has had a large role in developing over the past 4 years. This technology has been tested on wild trees in the Sierra Nevada and in orchard settings in Wisconsin and North Carolina. Protection of hemlocks by this method will require some re-engineering of the existing technique, but it is viewed as having a high probability of success when it is integrated into a pest management program.

Background/Rationale

MTDC has demonstrated the usefulness of stationary tree sprayers in various settings and has developed expertise in installing these systems. Southern Region (8) requested that the Center investigate the use of this technology to help protect high-value hemlocks from hemlock woolly adelgid. The trees of interest are in national monuments, historic battlefield sites, high-use viewing areas, and so forth.

Achievements

Approaches to using this technology in hemlocks have been designed. Previous work has indicated that the most successful time to apply the insecticide is in the autumn. Installation is taking place at the end of October, 1998. Various nozzles and configurations will be tried to maximize coverage. This work is being coordinated with the National Park Service. The test trees will be 35- to 40-foot-tall hemlocks at an old mill site on the Blue Ridge Parkway.

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Thistle H.W., M.E. Teske and R. Reardon. 'Modeling of Aerially Released Sprays'. Proceedings of the Twelfth Annual Symposium on Geographic Information Systems. Adams/GIS World. Ft. Collins, CO April 1998.

Thistle H. and D. Murray. 'Experimental Design: Pheromone Placement Tracer Test'. USDA Forest Service Technology and Development Report 9834-2827-MTDC, Missoula, MT. June 1998.

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