Update on Royal Rainmaking Project, Thai Embassy, 2017

Email from Phisek Panupat <phisekp@thaiembdc.org>

Dear Dr. James Lee,

Thank you for showing interest in royal rainmaking project which is, since the beginning, under the auspices of the Royal Family of Thailand. King Maha Vajiralongkorn, then the Crown Prince, had accompanied HM the late King Bhumibol to observe the royal rainmaking experiments back in Aug 1969. HM King Bhumibol told the team how the experiments were important for unfortunate people who badly needed alleviation on drought.

Here to remind on HM's policy on royal rainmaking project: (1) the need to develop and improve rainmaking methods based on more scientific approaches for designing, operating, monitoring and evaluating, including the exploitation of computer technology in the study of cloud patterns, and in operations, to achieve the objectives of the project. (2) the role of weather modification or, rainmaking is an important component in the water resources management process, such as increasing the availability in water, in reservoirs, reducing pollution problems, and increasing water suppliers for public use, etc. (3) full cooperation and coordination among participating agencies and organizations is the significant element in achieving the project's goal.

As you may know, the RRP is under the authority of the permanent Department of Royal Rainmaking and Agricultural Aviation, Thailand's Ministry of Agriculture, who is the guardianship of the RRP since 1969. In the past, a number of countries have approached us, through the Thai Foreign Ministry, including Jordan, Australia and New Zealand, to name just a few.

I found the Department's website useful source on RRP and contains some readings below. Please visit http://www.royalrain.go.th/royalrain/en/index.

Should you need further information, please do not hesitate to let me know.

Sincerely,

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History of His Majesty the King's initiative project Royal Rainmaking

Background of "the Royal Rainmaking Project"

".. At that time, I looked up at the sky and saw that there were many clouds, but were all blown past the arid land. The solution lies on how to make those clouds fall as rain in the locality..." His Majesty King Bhumibol Adulyadej's initiative project "Royal Rainmaking" was derived during his visit of the 2nd to the 20th of November 1955 to fifteen dry and rough northeastern provinces.

On Monday, November 14th, 1955, while travelling by a green Dehaley Sedan car from Nakhon Phanom to Kalasin Province, passing Sakon Nakhon Province and the Phuphan mountain range, H.M. King Bhumibol Adulyadej noticed distress and hardship of his subjects and farmers who lacked water for consumption and agriculture. When he returned to Bangkok, he expressed his thoughts to M.R. Dehhbrihi Devakul, a renowned agricultural engineer.

Since 1955, after his initiative in weather modification for making rain, H.M. King Bhumibol Adulyadej spent fourteen years in researching, analyzing, and evaluating documents regarding meteorology and weather modification that were accepted by both domestically and by foreign countries until he was skilled and had confidence in realizing his ideas.Then, he expressed his ideas to M.R. Debbhri Devakul, an agriculture engineer who was an expert in research and invention at Ministry of Agricultural and Cooperatives. H.M. King Bhumibol Adulyadej also provided research papers and other information to M.R. Debbhri Devakul for supplementary study. One year later, H.M. King Bhumibol Adulyadej endorsed to finding a way to enable the flight seeding experiment.

The Theoretical Background

The first principle is to seed substances (sea salt) into the atmosphere by aircraft to absorb moisture, then use cold formula substances (dry ice) to make moisture condense and coalesce. (The initiative in weather modification for making rain)

The First Attempt at Royal Rainmaking

In 1969, the Ministry of Agriculture and Cooperatives established the Insecticide Aviation Unit, under the Rice Department. It was ready to support and respond to H.M. King Bhumibol Adulyadej's desire. M.R. Debbhri Devakul informed H.M. King Bhumibol Adulyadej of the eager preparedness to launch the experimental operation. Accordingly, H.M. King Bhumibol Adulyadej directed to conduct during the year of the first actual flight experiment on the first and second of July 1969.

The Ministry of Agriculture and Cooperatives appointed M.R. Debbrihi Devakul for the director of the project and head of the experimental group. M.R. Debbrihi Devakul chose Khao Yai National Park to be a suitable test site. He started the first trial flight by seeding substances (dry ice, or solid carbon dioxide) of which the size was not greater than one cubic inch at the top of clouds. The height of this cloud which soared dispersedly over the test site was not over than 10,000 ft. Then, the cloud physical shape obviously changed. The cloud mass coalesced and condensed. Its top was built up higher and it became a large rain cloud rapidly and moved following with the wind direction. Unfortunately, rain could not be observed due to mountain peaks obscuring the view. However, according to the follow-up by field surveys and information received and confirmed by the populace, there was rain over the target area, Khao Yai National Park. This event demonstrated that control of clouds was possible.

The Royal Activities on Rainmaking

As mentioned previously, His Majesty the King initiated the first rainmaking in Thailand, and supporting this work from the very beginning. His Majesty closely monitored the implementation of every step. When the royal rainmaking Unit faced some problems, His Majesty kindly gave suggestions to help solve problems such as His suggestions to conduct a test at Hua Hin every month, in order to get all year round information on the rainmaking, He also suggested training researchers so they would able to set up an operations plan according to local weather conditions. At times, His Majesty participated in the experiments and directed the operations. Before each operation, His Majesty would remind the working officers to study the weather conditions first. This is to avoid (inducing a subsequent depression) damaging to crops and property. His Majesty would encourage the operation if weather conditions were favourable in order to get more rainfall. He warned the operators to take care with some chemicals which could be dangerous to users etc. Following are just some examples of his numerous activities regarding to Rainmaking.

On August 20th,1969 His Majesty the King accompanied by His royal highness the Crown Prince visited Bo Fai Airport at Hua Hin to observe the 5th Royal Rainmaking experiment. His Majesty kindly told the operations team to bear the burden because the work was very important in helping the unfortunate people to alleviate drought. His Majesty suggested the operations team to study the information and factors of surface weather conditions, such as surface relative humidity charts for the area, and increasing surface relative humidity. His Majesty also demonstrated how to increase surface relative humidity to the operations team. To do that, His Majesty ordered a Palace fire truck to spray water up in the air.

Then he went into where water was being sprayed, holding a hygrometer to measure humidity without worrying his body would get wet. Apparently the hygrometer showed the relative humidity at the same level as his prediction. Moreover, His Majesty suggested the unit to increase the number of field observation units so that rainfall and other related information could be collected in greater detail.

Based upon that visit, the kind suggestions of His Majesty to the operations unit have been followed as scripture by the team and its successors up to the present time. These are:

1. Research and studying is important work which never ends.
2. Ignore critics which discourage the effort to develop.
3. Keep written records



On April 26th, 1971 His Majesty the King traveled to Bo Fai airport to observe rainmaking. At the airport, His Majesty the King awarded the Royal Rainmaking wing to the working team as a sign of goodwill toward them, and he also blessed the new rainmaking aircraft which was the first one the Ministry of Agriculture and Cooperatives procured it with its allocated budget. On this occasion, His Majesty the King allowed three officials from Australia to follow him to observe the rainmaking experiment. His Majesty had conversations and exchanged opinions with the three Australian officers without formality. The three Australian officers much appreciated His Majesty's kindness and praised him as an expert in the field of artificial rainmaking.

On October 19th, 1972 His Majesty the King directed the Royal Rainmaking demonstration at the Kaeng Krachan reservoir, Petchaburi province as a demonstration to three representatives of the Singapore Government. His Majesty was confident that the operation would result in rainfall on the reservoir. The Kaeng Krachan reservoir was chosen as the target area because its topographic and weather conditions were similar to that of Singapore. Subsequently the Singapore representatives could adopt the appropriate rainmaking methods to be practiced in Singapore. The Kaeng Krachan reservoir was considered to be the smallest and the most difficult target area the operation team had ever made. The Police Department's aircraft and the aircraft from the Ministry of Agriculture and Cooperatives were used in the demonstration. The Bo Fai airport was used as the operation base. His Majesty the King directed the operation by means of radio communication from the Kaeng Krachan area. By his expertise, there was rainfall to the reservoir within 5 hours of the operation, to the excitement and impressed Singaporean representatives.

During November 15-29th, 1972 His Majesty the King planed and directed the Royal Rainmaking from the Chitralada Palace through the Police Radio Network. The purpose of the operation was to increase the water level of the Bhumipol Dam at the end of the rainy season, as its water volume was lower than usual. There was no depression to activate rain at the time but the relative humidity was high enough to give a good chance for the rainmaking. The Ministry of Agriculture and Cooperatives aircraft were used in this operation and the dam's airfield was used as the operations base. The operation resulted in rainfall on the Dam and the catchment area every operating day. The water volume was increased by about 620 million cubic metres bringing up the water level of the

Bhumipol Dam to 150 centimeters higher than the level before the operation. The electricity generated by this amount of water has a high monetary value.

During July 13th to August 26th, 1974 His Majesty the King kindly called for a special Royal Rainmaking operation, and participated in the operation which was carried out in the northeastern region by a working group of the Ministry of Agriculture and Cooperatives. At that time drought was occurring in 16 provinces as rain was unusually late. The farmer lacked water to prepare rice seedling and most of the seeds that had already been sown and germinated had not received enough water. Some farmers were not be able to till their paddy fields for rice transplanting when their seedling were ready to be transplanted. It was the largest drought area which the Royal Rainmaking Project had ever undertaken. The total drought area of 17 million rai (2.72 million hectares), in 16 provinces was reported. The operation used 8 rainmaking aircrafts from the Ministry of Agriculture and Cooperatives, supported by large C-123 aircraft from the Royal Air Force, and 2 Porter aircraft from the Police Department. The rescue operation lasted 45 days. His Majesty the King planned and directed most of the daily operations. Before the operations, farmers could transplant rice seedling in only 5% of the total rice planting area. After the operation, there were reports from every province under the operation that farmers could prepare more seedlings, the dry seedbeds were saved, and the average rice transplanted area was increased by about 55% of the total rice planting area. In many provinces, almost all the rice growing area could be transplanted.

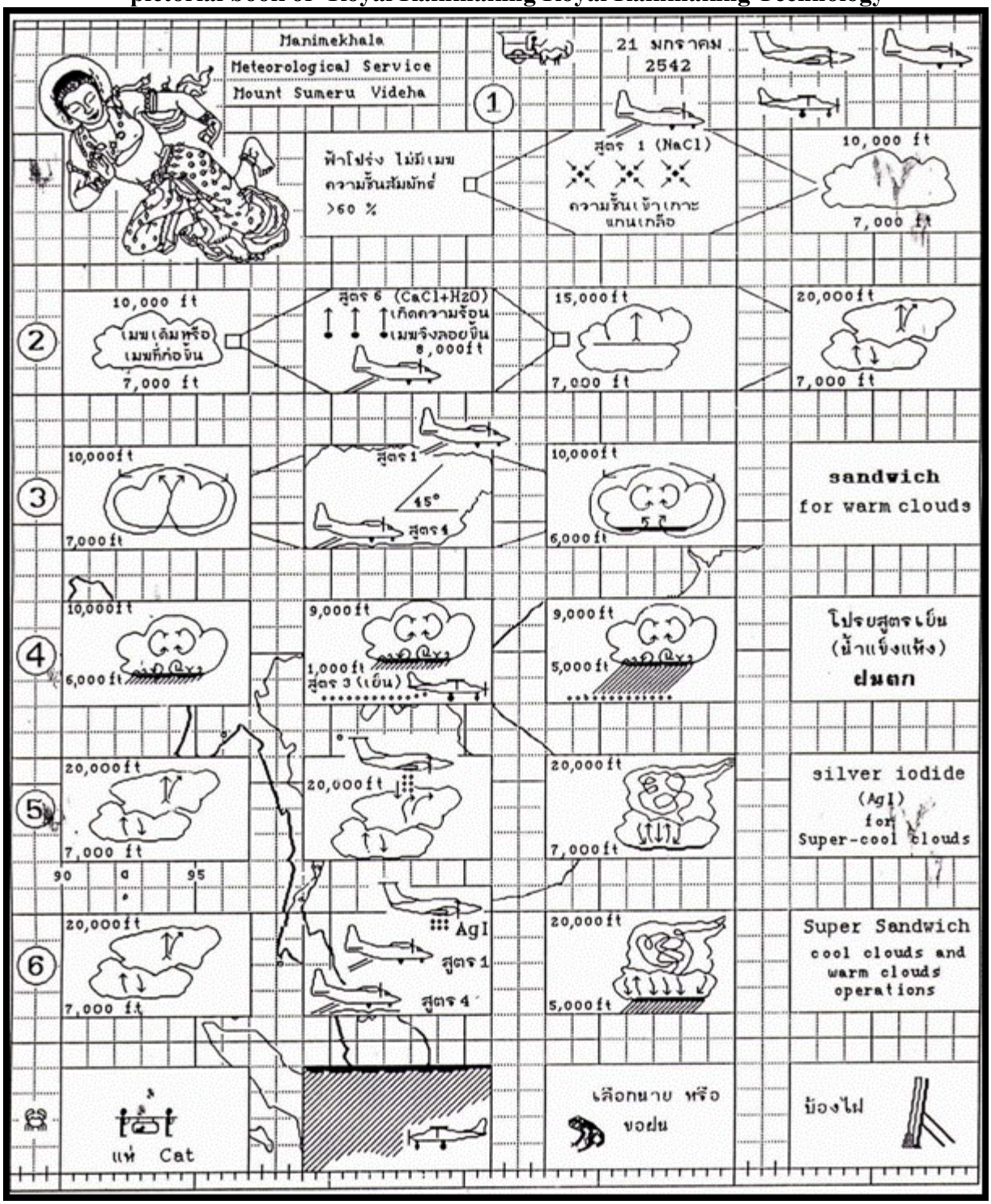
Royal Rainmaking Orthodoxy

In that to The Royal Rainmaking operations to moderate drought in 1999 were very successful, His Majesty King Bhumibol Adulyadej not only encouraged the officers to review the earlier Royal Rainmaking techniques, but also suggested that the officers continue to develop the Royal Rainmaking technology and techniques. With his intelligence and vision, he developed techniques to a higher level by a weather modification process called the "Super Sandwich Technique" to attack both warm clouds and cold clouds simultaneously. (The earlier Royal Rainmaking operation was used only for warm clouds.) Then he gave his own computer drawing as a guideline for Royal Rainmaking operations in order to combine technical knowledge and procedures for practice and understanding. For ease of understanding and operations, he summarized techniques and processes as drawings on one page of paper.

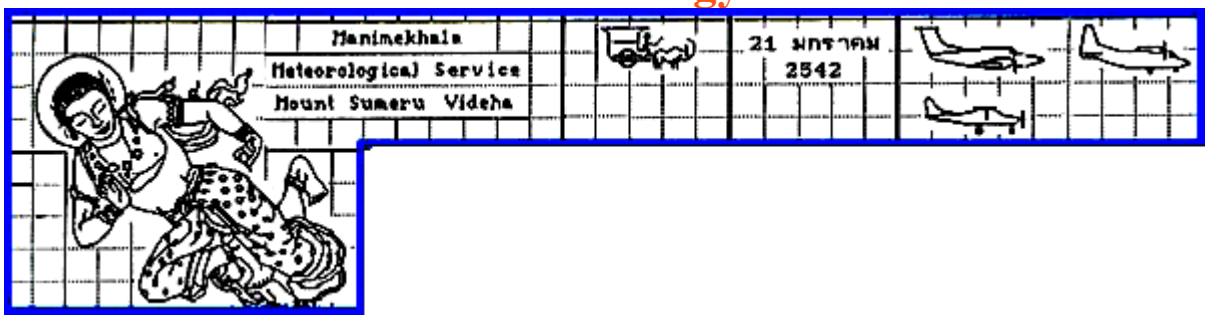
Weather modification by Royal Rainmaking technology was the latest innovation invented by His Majesty King Bhumibol Adulyadej and was originally used in Thailand.

A computer drawing by His Majesty King Bhumibol Adulyadej titled “Royal Rainmaking Technology” shows the process and weather modification methods to make rain from warm clouds and cold clouds. It was given to the rainmakers on March 21, 199 as guidelines in the operations.

pictorial book of ‘Royal Rainmaking Royal Rainmaking Technology’



The meaning of each picture of the royal rainmaking technology



The uppermost row of the Royal Rainmaking Technology

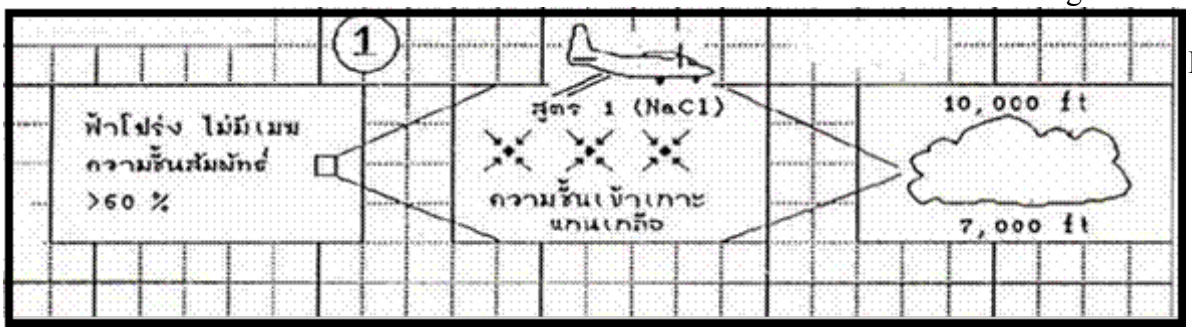
Frame 1: A goddess called "Manimekhala, a computer drawing by His Majesty King Bhumibol Adulyadej , is the chief of meteorological Service at Mount Sumeru Vedecha in Thai belief.

Frame 2. In Thai legend, Phra Indra is a supreme God who has an important role in providing rainfall for humans.

Frame 3. "March 21, 1999": His Majesty King Bhumibol Adulyadej went to Chaing Mai Province for royal duties on a plane on March 21, 1999. During his return to Bangkok, His Majesty noticed that it was possible to make rain from the clouds covering the lower northern part of Thailand. He took a picture of the clouds and gave it to the Special Royal Rainmaking Operations Team. In accordance with a royal command, the team launched a Royal Rainmaking operation to moderate the drought in the lower northern part and the Chao Phraya River basin.

Frame4. Three Aircraft: The following aircraft are appropriate (and available) for Royal Rainmaking operations in accordance to the 1through six processes of Royal Rainmaking Technology.

Type Aircraft	Number Available	Type Operation
SUPER KING AIR	3	Cold cloud seeding
CASA	14	Warm cloud seeding
CARAVAN	13	Warm cloud seeding

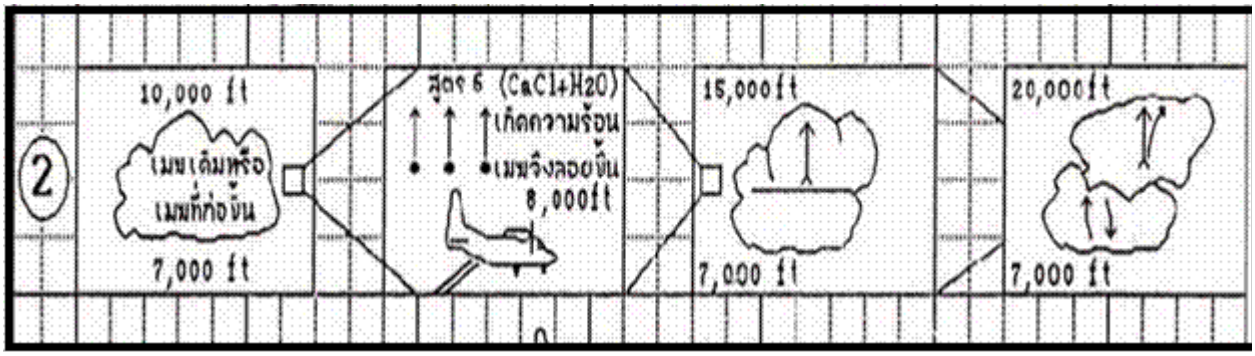


Row 1,

Frames 1-3 (Step I. Triggering)

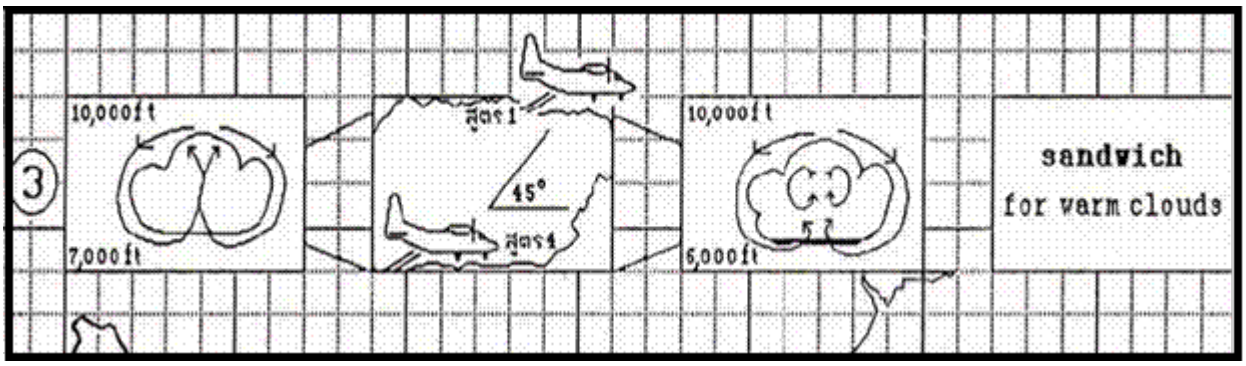
This step is to build up natural clouds vertically by using a warm cloud seeding aircraft dispensing tons of powdered sodium chloride (NaCl) to achieve cloud formation or condensation process and enrich the newborn clouds by upgrading the Cloud Condensation Nuclei (CCN) at an altitude of 7,000 feet above mean sea level. This step begins in a clear sky or a sky with only a few morning formed cumulus clouds with the average relative humidity of not less than 60 percent in the target area. Under these conditions, humidity (water vapor) in

the atmosphere will be absorbed by the Cloud Condensation Nuclei (CNN) to form clouds. These clouds can be formed into larger clouds whose tops can reach an altitude of 10,000 feet**.**



Row 2 Frames 1-4 (Step II. Fattening)

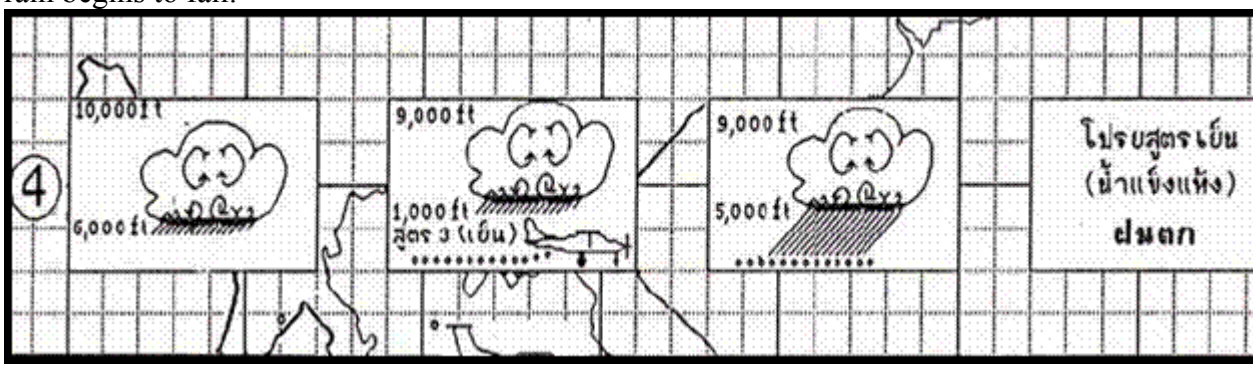
This step is to make both natural clouds and the clouds formed in Step I grow. This step begins when the cloud tops of the cumulus clouds reach 10,000 feet and the cloud bases are not higher than 7,000 feet above mean sea level. The step is done by a warm cloud seeding aircraft dispensing tons of powder of a few microns of calcium Chloride (CaCl2) into the clouds at a level of about 8,000 feet – or 1,000 feet higher than the cloud bases. Doing this causes heat from exothermic reactions - heat from the reaction of water vapor and CaCl2 and heat from sunlight - during condensation around CNNs. The heat expedites or enhances the updrafts of air masses in the clouds. The numbers of large raindrops increase continuously due to active collision and coalescence of cloud droplets. The cloud top of a warm cloud can reach an altitude of 15,000 feet faster than it does in nature. At this level, updrafts and downdrafts of air masses, condensation, and coalescence of cloud droplets continue to take places like chain reactions. If an updraft is strong enough, the cloud top can develop until it reaches an altitude of 20,000 feet, and is referred to as a cold cloud (A cold cloud is a cloud that is higher than 18,000 feet and has a temperature below 0o C.).



Row 3, Frames 1-4 (Step III. Attacking)

This step is to initiate rainfall from warms by cloud seeding techniques called the "Sandwich Technique." This is the case for warm cloud seeding. This is accomplished by dispersing tons of hydroscopic chemicals at two levels, at the cloud top and at the cloud base, at the same time. Sodium chloride powder of the Cloud Condensation Nuclei and endothermic-hydroscopic chemicals (in this case urea is used.) are dispersed into the loud at the top and base

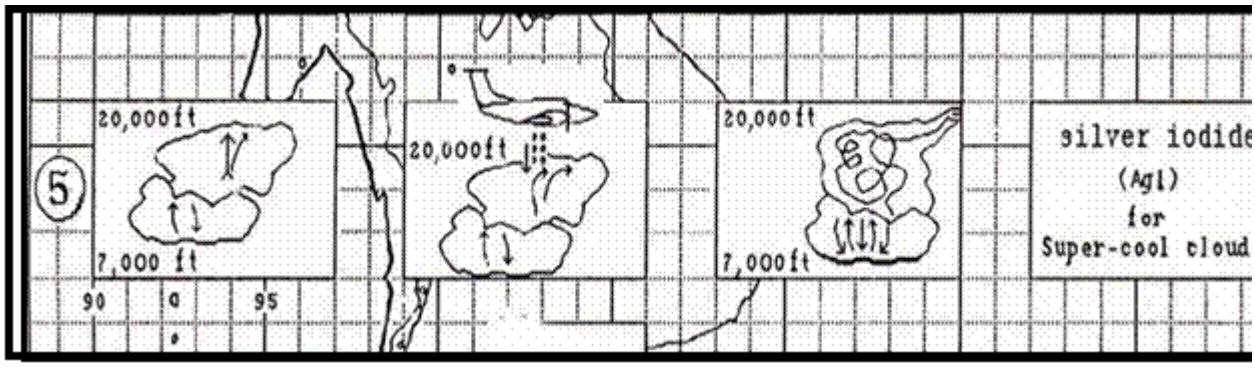
simultaneously. This is accomplished by flying aircraft together along the same track with the lower aircraft flying the track at an angle of 45o behind the higher aircraft. After seeding, heavy loading of larger raindrops descend toward the cloud base, the cloud becomes mature, and some rain begins to fall.



Row 4, Frames 1-4 (Step IV. Attacking)

This step is to maintain Step III and enhance rainfall to the ground. It is also to prolong the duration of rain by cooling the sub-cloud base air mass which results in a cut off of buoyancy and increases the downdraft and relative humidity and reducing the evaporation of raindrops. This step can be applied after Step III which may begin when the treated clouds from Step III move with the wind to cover the target area.

This is accomplished by dispersing dry ice flakes at a temperature of minus 78o C at approximately 1,000 feet below the cloud base in order to lower the air mass's temperature and cause higher relative humidity. This causes the rainfall rate to increase gradually, the cloud base lowers, and a much greater number of giant raindrops reach the ground.



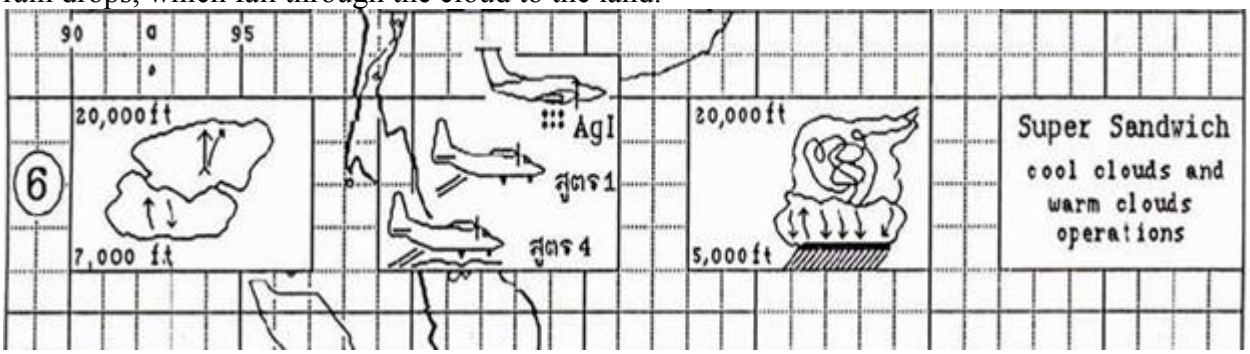
Row 5, Frames 1-4 (Step V: Glaciogenic Seeding or AgI Seeding)

This is the case of 'Attacking" by cold cloud seeding when only cold cloud seeding aircraft is available.

This process is done by ejecting flares of silver iodide (AgI) into the cloud top at an altitude of 21,500 feet with temperatures between -8oC to -12oC. Each flare produces a lot of silver iodide particles to causing freezing of the super-cooled droplets

The aim of this step is to initiate rainfall from cool clouds by supplying the artificial ice nuclei into a cold cloud top to produce ice grauples of the super-cooled cloud liquid water content (SLWC) in the updraft by freezing the super-cooled water droplets so they rime the rest of the cloud into grauplets. Then the graupels fall to the warm cloud level and melt into

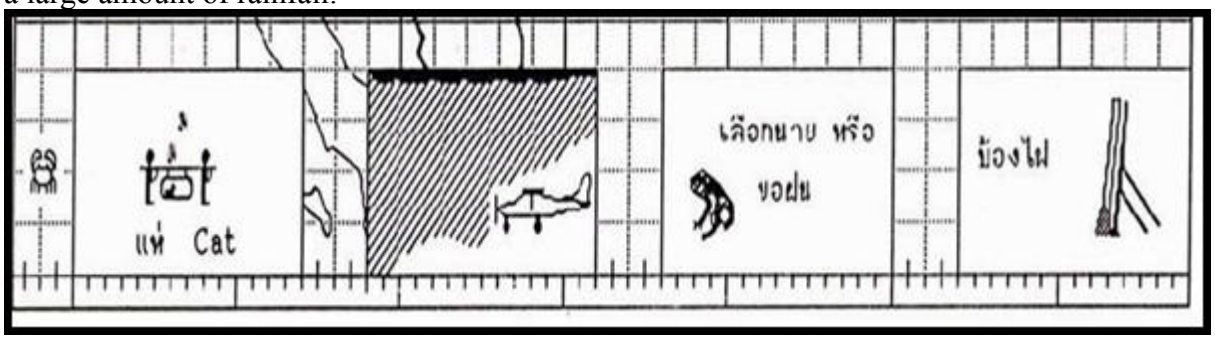
rain. Water vapor and droplets in warm clouds will combine with rain drops and become bigger rain drops, which fall through the cloud to the land.



Row 6, Frames 1-3 (Step VI: Super sandwich Attacking Technique)

This step is to initiate rainfall from either cold clouds or warm clouds by integration of Steps III, IV, and V. Thus, it can be used only when both cool cloud seeding aircraft and warm seeding aircraft are available.

The treated clouds produce heavy and continuous rain for an extended period resulting in a large amount of rainfall.



The last row of the Royal Rainmaking Technology drawing

Frame 1: Cat Procession

- Cat Procession to beg for rain has been carried on in Thailand since the ancient times. It is a local public relation, a psychological ritual for consoling and giving hope to people in severe drought areas that rain will come.

Frame 2: Rainmaking aircraft

- Rainmaking aircraft are vehicles used in applying Royal Rainmaking technology. The aircraft must fly through rain clouds to explore and follow-up on results. For successful rainmaking operations, the rainmaking making official and pilot must cooperate.

Frame 3: Frog

"The frogs who desire a ruler" is a Thai fable. A group of frogs in the story chose their ruler themselves in a stupid way. The author compares the frogs' sounds when they call to choose their ruler that they are calling for rain in reality. However, the frog sound is a prediction that rain will come.

If nothing happens frogs will be anxious and warn for attempts. If nothing happens, frogs die. If there is no rain, agriculture dies.

One of important quotes for rainmakers is you have to kiss a lot of frogs before you meet the prince.

Frame 4: "Sky Rocket"

Instead of aircraft (Perform the same mission as aircraft being technological vehicles to work in the sky.

Making rain by shooting skyrockets is a tradition, not a toy. Skyrockets go high, releasing smoke as an axle for humidity surrounding the axle, bringing rain clouds. The use of skyrockets is a scientific procedure.
