PROCEEDINGS OF THE 11TH SYMPOSIUM ON THE GEOLOGY OF THE BAHAMAS AND OTHER CARBONATE REGIONS

Edited by
Ronald D. Lewis and Bruce C. Panuska

Production Editor:
Ronald D. Lewis

Gerace Research Center
San Salvador, Bahamas
2004

Front Cover: Close-up view of a patch-reef coral head in Grahams Harbor, north of Dump Reef. As shown here, Caribbean shallow-water reefs have declined since the mid-1980s and are now largely overgrown by fleshy green macroalgae and a variety of encrusting organisms. See Curran et al., "Shallow-water reefs in transition," this volume, p. 13. Photograph by Ron Lewis.

Back Cover: Dr. A. Conrad Neumann, University of North Carolina, Chapel Hill, NC, Keynote Speaker for the 11th Symposium and author of "Cement loading: A carbonate retrospective," this volume, p. xii. Photograph by Mark Boardman.

Copycat Production Center, Auburn University, Auburn, AL.

ISBN 0-935909-72-9

THE FEASIBILITY OF LOW-ALTITUDE AERIAL PHOTOGRAPHY IN THE BAHAMAS USING A TETHERED WEATHER BALLOON

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ABSTRACT

Low-altitude aerial photography has been used for decades in archeological, biological, and geological studies. Advantages over aerial photography from satellites or airplanes are (1) the high resolution of surface details provided, (2) a photography protocol that is specific to the research at hand, and (3) the relatively low cost. Here we describe a potentially useful apparatus that makes use of current technology while accommodating limited research budgets and the challenging weather conditions of the Bahamas.

Available technology for positioning a camera below the altitudes normally flown by airplanes include hand-held poles, tethered balloons, blimps, kites, and remote-controlled miniature airplanes. One company (Tern Style Aerial Photography, Atlanta, Georgia) uses a remotely operated, tethered, 18 ft blimp as the major platform. In a series of preliminary trials on San Salvador and in Alabama, we have used the same lightweight, 35 mm camera recommended by this company (the Canon EOS Rebel G with 35-80 zoom), but have replaced their heavy mechanical stage with a home-made plastic housing. This allows the payload to be lifted with an inexpensive, 8-ft, helium-filled weather balloon instead of one of their $1,600-5,000 blimps. Three nylon mooring lines are used to position the balloon-camera system, with an electrical shutter release cord attached to one of these. A wireless (surveillance) microvideo camera with attached transmitter weighing less than one ounce serves as a positioning camera, with the video output displayed on hand-held video camera.

Although launches to date have been preliminary, the results are encouraging. The balloon-camera apparatus can be operated in shallow water as well as on land; lightweight poles attached to the mooring lines could help to position the balloon when operating the system from a boat. Low-altitude aerial photography on San Salvador and other Bahamian islands, made possible by such a system, would be especially useful in archeological studies and in research in shallow-marine environments, but is also potentially useful in providing base maps for detailed geologic mapping.

INTRODUCTION

In spite of the increasing use of satellite imagery, there are still advantages to low-altitude (10-300 m) aerial photography. Principal among these advantages are (1) the high resolution of surface details obtained, (2) a photography protocol that is tailor made for a specific research project, and (3) the relatively low cost. The platform typically used for such purposes is a tethered helium- or hydrogen-filled balloon/small blimp or (less commonly) a kite.

For decades balloons have been used to achieve very-low altitude photographs of archeological sites (e.g., Noli, 1985) and low- to medium-height images for aquatic vegetation studies (Edwards and Brown, 1960; Schlott et al., 1990). They have also been used over shallow water in reefal settings (e.g., Rützler, K., 1978). Geological and environmental studies have made use of balloons and/or kites in remote areas where airplane or helicopter based photography would be too costly (Long and Belanger, 1978; Derksen, et al., 1997; Boike and Yoshikawa, 2003).

In a comparative study of available platforms, Boike and Yoshikawa (2003) observe that balloons are easier to operate than kites and allow for more precise camera positioning, but they caution that balloons require "an environment with little or no wind." The wind factor was our chief concern in beginning to explore the best way to do high-quality, yet inexpensive low-altitude aerial photography on San Salvador. Mean monthly wind speeds on San Salvador are commonly 10-15 km/hr (Shaklee, 1996; Gamble, 2004). Thus we anticipated that, while some days would be too windy for balloon flights, other days might be suitable. Our goal was to find a way to do low-altitude photography, over water as well as land, and to make this method available to the wide range of researchers who utilize the Gerace Research Center. We report our initial efforts here.

EQUIPMENT USED

We patterned our efforts after those of a company that specializes in low-altitude aerial photography: Tern Style Aerial Photography, Atlanta, Georgia <http://www.ternstyle.com>. Our goal was to emulate their photographic technology while cutting costs on the platform and delivery system. Thus, we used the camera and lens recommended by Tern Style: the Canon EOS Rebel 2000 with a 35-80 mm f/3.5-5.6 zoom lens (Figure 1). In addition to having excellent optics, the camera is very light weight (1 lb 6 oz, including zoom lens, batteries, and film), the shutter can be tripped remotely by an electronic switch, and the camera system is moderately priced at approximately $350.00. The remote shutter release, Canon's RS60-E3, is attached to the camera by means of 20-ft lengths of headphone extension cable available from Radio Shack ®.

Tern Style recommends a small, monochrome video camera for use in positioning the primary camera system. Because this would require a heavy coaxial cable to a video monitor on the ground, we replaced this camera with a wireless (surveillance) microvideo camera and transmitter, both weighing less than one ounce (Figure 2). A low-cost ($120) receiver (Figure 3) can pick up the signal from as far away as 750 ft (according to the manufacturer, Supercircuits, Inc., <http://www. supercircuits.com> and display the video on a camcorder. Instead of a mechanical camera stage, we used a home-made plastic housing constructed from two containers, one for the camera back and another for the lens (Figure 4).

Figure 1. The still camera used, Canon's EOS Rebel 2000 with a 35-80 mm zoom lens, weighing only 1 lb 6 oz with batteries and film.

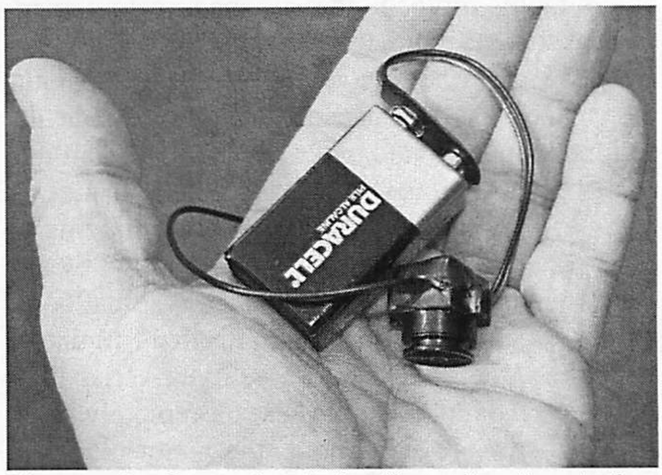

Figure 2. Supercircuits's "nanobug" wireless ATV video camera with attached transmitter. Wire at left is the antenna.

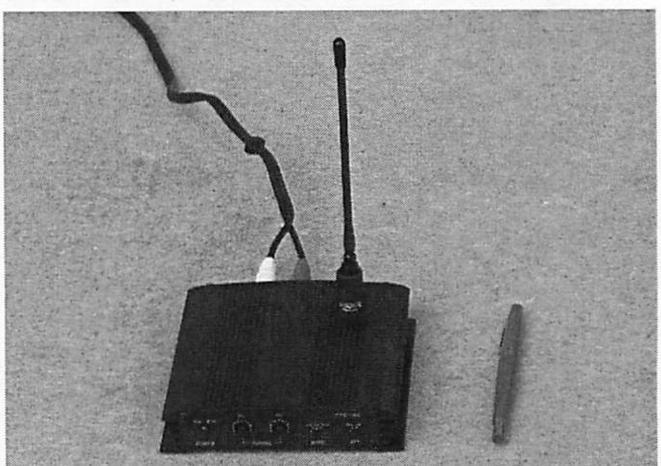
Figure 3. AM 900 MHz receiver for use with wireless micovideo camera above.

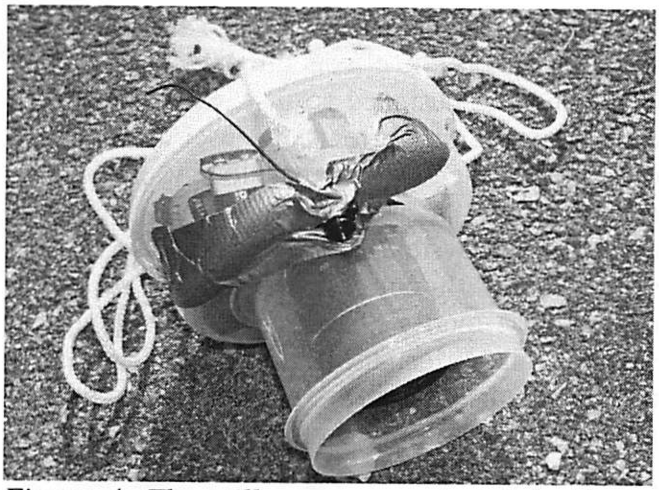

Figure 4. The still camera protected inside its plastic (Rubermaid®) housing, with holes cut in the bottom of each container. The microvideo camera-transmitter is attached by duct tape. Wire at top is the transmitter antenna..

The largest savings in cost was the platform itself. Whereas Tern Style uses a remotely operated, tethered, 18 ft blimp as their major platform ($1,600-5,000), we opted to substitute an 8 ft neoprene weather balloon ($18.95 plus shipping, Edmund Scientific's, Tonawanda, New York). When inflated with helium, the balloon is rated at 6 lbs of lift capacity, which was sufficient for our immediate purposes. The camera system was attached to the neck of the balloon by 3/16 in braided nylon rope (Figure 5), and three lengths of the same rope led from the balloon to three operators on the ground. The shutter release cord was attached to one of these ropes. Table 1 shows the weight and cost of each equipment item in the system. In addition, the cost of the helium is significant: $176 for refill of a 110 cu ft (4 ft) tank.

RESULTS OF INITIAL TRIALS

San Salvador

Our first attempt at launching a weather balloon on San Salvador was in March 2001, when we used hot air from a hair dryer to inflate the weather balloon. This did not provide enough lift, and the hot air distended one side of the balloon, making it unusable for more trials.

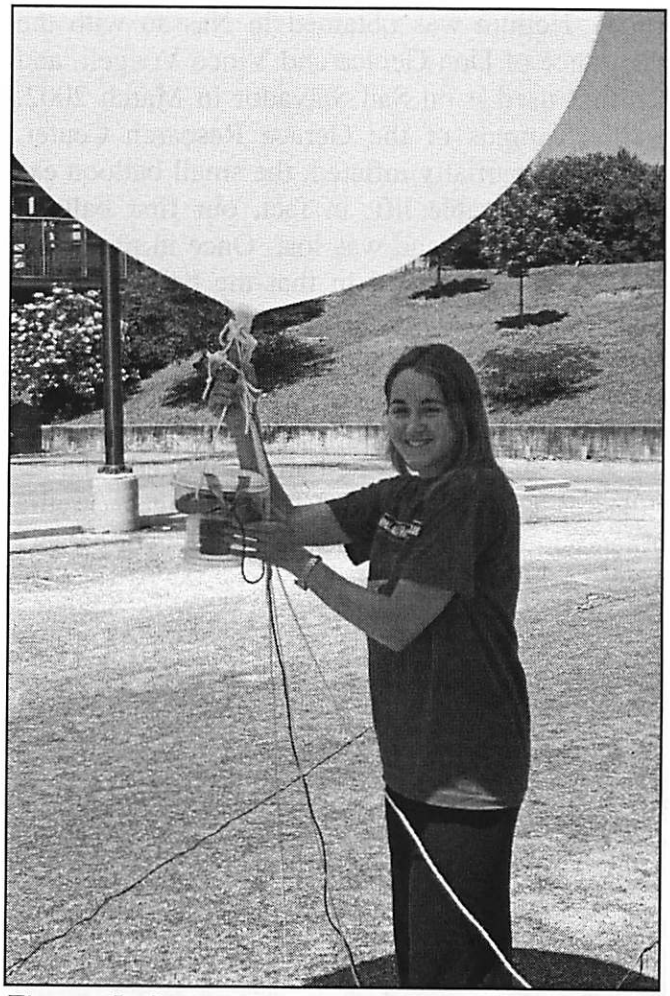

Figure 5. Loren· Petruny with the helium-filled weather balloon and attached camera at the Auburn University campus

Item	Weight	Cost
Camera (Canon EOS Rebel G) with zoom lens	1 lb 6 oz (615 g) (Includes batteries and film)	$350.00
Shutter release	N/A	$30.00
Shutter-release line (per 100 ft)	1 lb 10 oz (741 g)	$40/100 ft
Microvideo camera (w 9V battery)	2.0 oz (56 g)	$250
Video receiver	N/A	$120.00
Weather balloon	3.6 oz (103 g)	$19.00
Balloon lines (per 100 ft x 3)	12 oz (329 g) x 3 = 2 lb 4 oz (987 g)	$15/100 ft
TOTAL	5 lb 10 oz (2.5 kg)	$814

Table 1. Approximate weight and cost of equipment used. The cost of shipping and incidentals such as film and containers is not included.

Helium was obtained in Nassau with the assistance of Don Gerace and Vince Voegeli, and we first used it on San Salvador in March 2002, on the campus of the Gerace Research Center. Even only partially inflated, the small balloon exerted considerable lift; in fact, our first balloon escaped our grip and was lost. Once in place, the system was successful in that the balloon easily lifted the payload, and the camera could be operated remotely, but the gusty spring winds lead to a disturbing amount of camera movement. Video tape taken of the launch shows the camera swinging back and forth as the balloon rocked. The result was somewhat out-of-focus images (Figure 6), and a few that may show the affects of camera rotation (Figure 7).

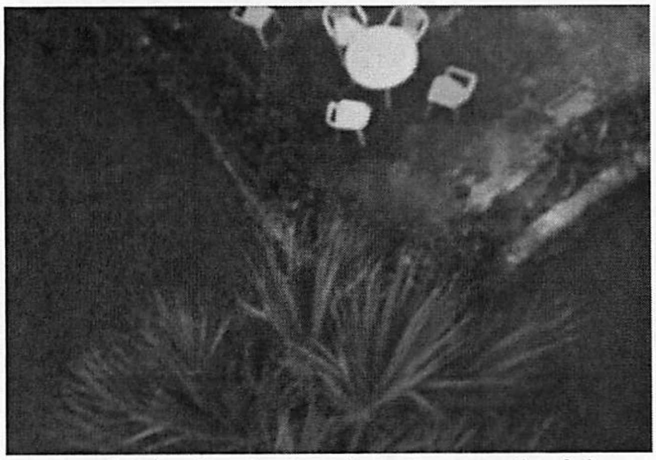

Figure 6. The faculty housing area north of the cafeteria, Gerace Research Center, from a height of approximately 50 ft.

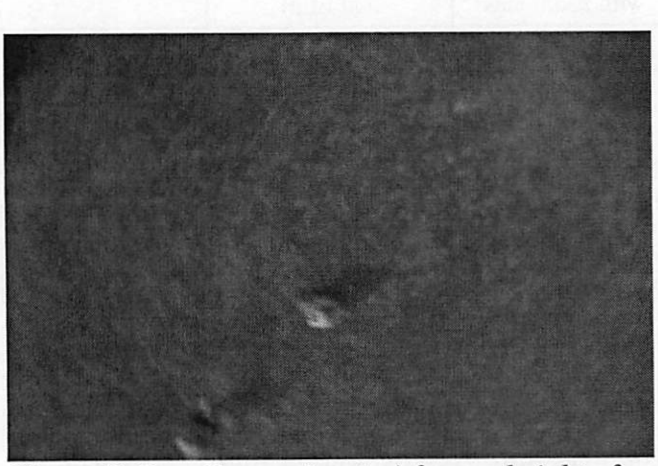

Figure 7. Don Gerace (center) from a height of approximately 70 ft, March 2002.

The unsatisfactory images from this trial were not simply the effects of camera movement. The camera is designed so that, when it is set in certain modes, it prevents the user from taking out-of-focus pictures by not allowing the shutter to open unless "focus lock" has been achieved by the autofocus system (Canon representative, personal comm.). In our case, the camera was set on one of these modes ("landscape"), allowing it to automatically select the shutter speed and aperture. (With the current system, we are not able to monitor these settings from our position on the ground, so we do not know what these settings were.) Thus, although the camera achieved "focus lock," apparently the shutter stayed open long enough to create the blurred images.

Auburn University Campus

Back at Auburn University, in Alabama, we used the video tape taken of the San Salvador launch to re-create the camera's movement in order to determine optimal shutter speed time. We experimented by holding the camera system and housing (Figure 4) by its ropes and swinging it by hand to simulate the rocking and rotational motions during the actual launch, while using the shutter release switch to test various shutter speeds. We found that shutter speeds of 1/500 and faster were very effective at "stopping" the motion of the camera: even though the camera was moving rapidly, the pictures taken were sharply focused.

The next trial was in a parking lot on the Auburn University campus (Figure 5) in May 2002. With the camera set at shutter-speed priority (Tv) and an exposure time of 1/500 second, and using ISO (ASA) 200 color print film, we launched the helium-filled balloon in a deserted parking lot with a mild breeze. This launch was very successful in terms of the still photographs obtained (Figures 8, 9). The known distances in the empty parking stalls allowed for height to be ascertained. At a height of approximately 100 ft, we noted a slowing in the rate of ascent, probably because the weight of the ropes tethering the balloon brought the total weight to near the lift capacity (Table 1).

Figure 8. Clear image of parking lot at Auburn University from a height of approximately 50 ft. (Parking stalls are 9 ft wide).

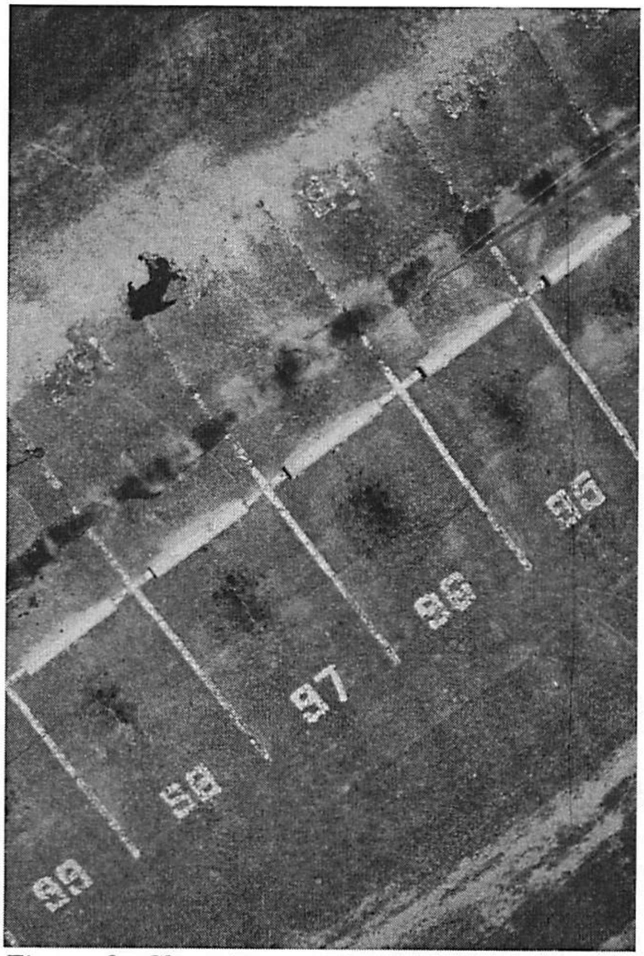

Figure 9. Clear image of parking lot at Auburn University from a height of approximately 98 ft.

DISCUSSION AND FUTURE PLANS

We chose to use a film camera because of the high resolution of 35 mm film and because of the good optics and light weight of the Canon EOS Rebel 2000 in particular. However, use of a film camera will always involve a compromise between film speed (increased resolution with smaller numbers), shutter speed (increased clarity of focus with faster speeds), and aperture settings (increased depth of field with higher numbers). Our results indicate that weather conditions on San Salvador should frequently be sunny enough to allow high-resolution ISO 200 or even ISO 100 to be used in combination with fast shutter speeds (1/500 to 1/750 sec) and aperture settings (f-stops) of 5.6 to 11, which should allow ample depth of field for most aerial photography. Depth of field should only be a problem for very low-altitude photographs or in cases where the camera is not level, that is, not pointing straight downward.

Thus, even with fast shutter speeds, camera movement in San Salvador's winds is still a problem in that it may cause the camera to shoot oblique-angle shots that are partly out-of-focus. Increased stability is also necessary to keep the camera on target.

In short, our initial experiments have shown that an inexpensive weather balloon can lift the camera of choice to an appreciable height, that the spotting video camera can give a general sense of field of view, and that fast shutter speeds can help to produce sharply focused images. However, the wind on San Salvador does pose a problem that has not yet been overcome.

Our future plans include efforts to (1) increase stability of the platform, (2) increase the lift-capacity to weight ratio, and (3) make the system easier to operate. A second, somewhat smaller, balloon will be added to the primary balloon and held in place by a sheath that will double as a parachute (as in Noli, 1985). The purpose is to approximate the shape of a blimp in an attempt to increase stability and prevent rotation. The added lift will accommodate a mechanical gambol mount for the camera, replacing the plastic housing and rope ties of our prototype. The heavy and cumbersome ropes will be replaced by kite line on spools (Noli, 1985), which will avoid past problems with tangled lines during launches. In addition, a fourth line will be added, as experiments have indicated that this will aid substantially in platform stability.

ACKNOWLEDGMENTS

We would like to thank Dr. Donald T. Gerace, Chief Executive Officer, and Vincent Voegeli, Executive Director, of the Gerace Research Center, San Salvador, Bahamas, for their assistance. Dr. Gerace has a long-standing interest in obtaining high-quality aerial photography of San Salvador. He followed our preliminary work closely, located a source of helium, and lent a helping hand when necessary. We thank Vince Voegeli for his invaluable help in the field, specifically for his help in procuring helium and his assistance with launches. We would also like to thank John Simms, Academic Program Assistant, Auburn University, and Auburn University students Taylor Logan, Jason Schein, and Chris Hooks for their assistance during launches. Useful suggestions for future improvements were made by Drs. Conrad Neumann and Chuck Messing during the conference presentation, and we thank them as well.

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