



Flash Memory Summit

# Data needed from Drones? Yes, and the data is rich. Recovery of a drone.

Will DeLisi, NAND Flash Recovery Specialist, DriveSavers  
Josey Santana, Data Recovery Engineer, DriveSavers

# Drone Data Recovery



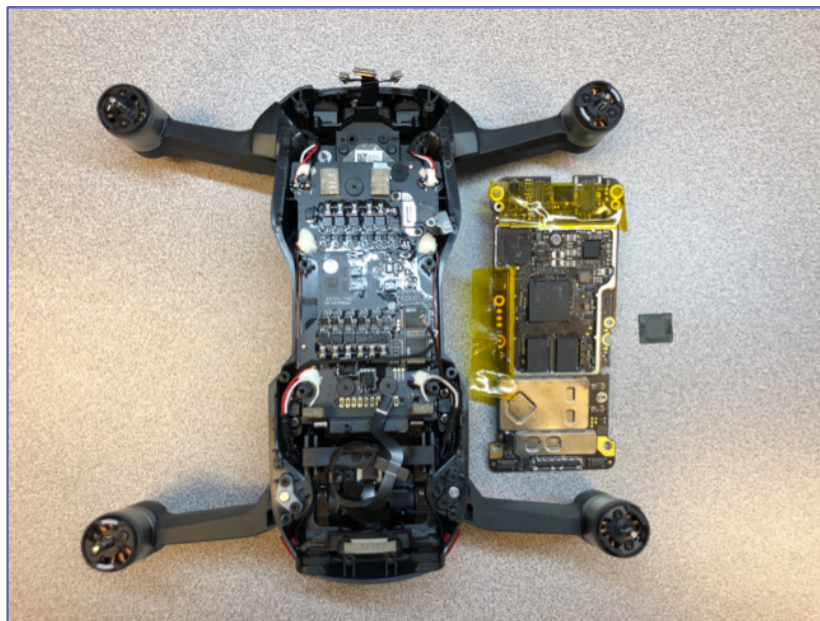
# Deconstruction: Typical Drone





Flash Memory Summit

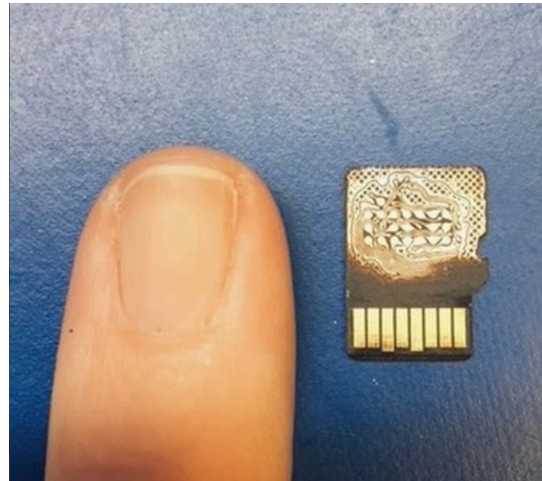
# Deconstruction of DJI Mavic Air



# Deconstruction: Typical Drone

## Removable – Micro SDXC

- Stores photo and video files
- Monolith memory
- Very difficult to recover

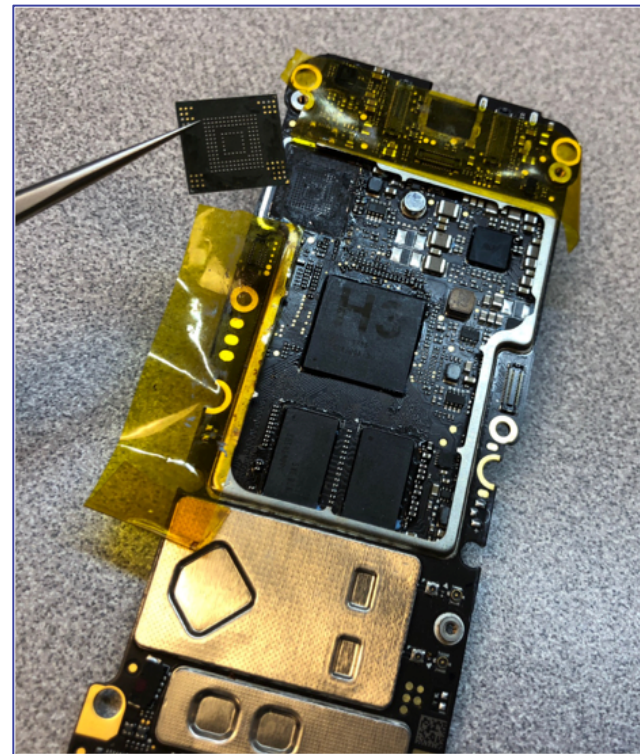




Flash Memory Summit

## Deconstruction of DJI Mavic Air

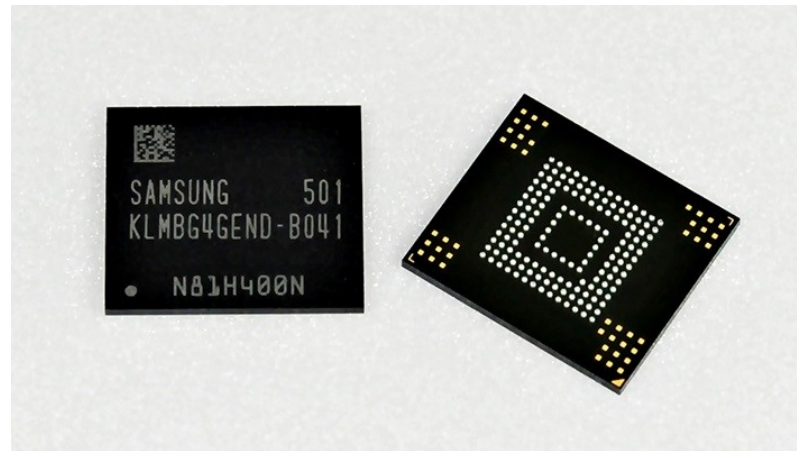
- Embedded eMMC memory
- Non removable
- Partitioned memory allowed single eMMC chip to act as both (embedded type) and (removable type)



# Deconstruction: Typical Drone

## Embedded – eMMC Card

- Stores metadata
- Drone operating system
- Monolith memory
- Very difficult to recover  
(failed controller)



# Types of Data Obtained

- Video and photo files







# Types of Metadata Obtained

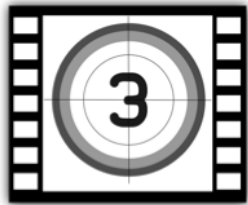
- GPS data
- Take off and landing times
- Metadata to cross-reference video and location information

```
99 IMAGE 5 storage_downsample_down_left 320 240 1 -1 0
100 IMAGE 5 storage_downsample_down_right 320 240 1 -1 0
101 IMAGE 5 storage_downsample_front_left 320 240 1 -1 0
102 IMAGE 5 storage_downsample_front_right 320 240 1 -1 0
105 IMAGE 5 storage_downsample_rear_left 320 240 1 -1 0
106 IMAGE 5 storage_downsample_rear_right 320 240 1 -1 0
68 LOG 1 pure_log_test 0 0
70 CURVE 1 oa_output 45 oa_index uint32 oa_time_stamp uint32 dist_00 int32 dist_01 int32 dist_02 int32 dist_app_00 int32 dist_app_01 int32 dist_app_02 int32 dist_app_03 int32
time_delay_0 uint32 calc_delay_0 uint32 stop_sig_0 uint32 tunnel_0_xr float tunnel_0_yd float tunnel_0_xl float d_tunnel_0_yd float d_tunnel_0_xl float d_tunnel_0_yr float d_tunnel_0_xr float
d_tunnel_0_yd float cnt_dist_in_safe_0 int32 safe_counts_0 int32 speed_0 float dist_10 int32 dist_11 int32 dist_12 int32 dist_app_10 int32 dist_app_11 int32 dist_app_12 int32
dist_app_13 int32 time_delay_1 uint32 calc_delay_1 uint32 stop_sig_1 uint32 tunnel_1_xl float tunnel_1_xr float tunnel_1_yd float tunnel_1_yr float d_tunnel_1_xl float d_tunnel_1_xr float
d_tunnel_1_yd float d_tunnel_1_yr float cnt_dist_in_safe_1 int32 safe_counts_1 int32 speed_1 float oa_altitude float
72 CURVE 1 cnn_output 23 cnn_index uint32 cnn_time_stamp uint32 water_img_idx uint32 sky_f_img_idx uint32 sky_b_img_idx uint32 water_prob float water_height int32
water_cam_normal int32 water_gps_nums int32 iswater_vo int32 iswater_vo_s int32 iswater_land int32 water_gps_lack int32 sky_sensor_0 int32 sky_gps_sensor_1 int32 sky_gps_nums_0 int32
sky_gps_nums_1 int32 sky_makeup_res_0 int32 sky_makeup_res_1 int32 sky_test_hon_0 int32 sky_test_hon_1 int32 sky_detect_num_0 int32 sky_detect_num_1 int32
71 CURVE 1 acc_dbg_info 37 i_cit_0 float i_cit_1 float i_cit_2 float i_cit_3 float i_cit_4 float i_cit_5 float i_cit_6 float i_cit_7 float i_cit_8 float i_cit_9 float i_cit_10 float i_cit_11 float i_cit_12 float i_cit_13 float i_cit_14 float i_cit_15 float i_cit_16 float i_cit_17 float i_cit_18 float i_cit_19 float i_cit_20 float i_cit_21 float i_cit_22 float i_cit_23 float i_cit_24 float i_cit_25 float i_cit_26 float i_cit_27 float i_cit_28 float i_cit_29 float i_cit_30 float i_cit_31 float i_cit_32 float i_cit_33 float i_cit_34 float i_cit_35 float i_cit_36 float i_cit_37 float i_cit_38 float i_cit_39 float i_cit_40 float i_cit_41 float i_cit_42 float i_cit_43 float i_cit_44 float i_cit_45 float i_cit_46 float i_cit_47 float i_cit_48 float i_cit_49 float i_cit_50 float i_cit_51 float i_cit_52 float i_cit_53 float i_cit_54 float i_cit_55 float i_cit_56 float i_cit_57 float i_cit_58 float i_cit_59 float i_cit_60 float i_cit_61 float i_cit_62 float i_cit_63 float i_cit_64 float i_cit_65 float i_cit_66 float i_cit_67 float i_cit_68 float i_cit_69 float i_cit_70 float i_cit_71 float i_cit_72 float i_cit_73 float i_cit_74 float i_cit_75 float i_cit_76 float i_cit_77 float i_cit_78 float i_cit_79 float i_cit_80 float i_cit_81 float i_cit_82 float i_cit_83 float i_cit_84 float i_cit_85 float i_cit_86 float i_cit_87 float i_cit_88 float i_cit_89 float i_cit_90 float i_cit_91 float i_cit_92 float i_cit_93 float i_cit_94 float i_cit_95 float i_cit_96 float i_cit_97 float i_cit_98 float i_cit_99 float
78 CURVE 1 plane_output 16 pl_index uint32 pl_status int32 pl_error int32 pl_outlier_cnt uint32 pl_calc_timestamp uint8 pl_is_slope uint8 pl_slope_angle float pl_x float pl_y float pl_z float
pl_is_water_for_landing uint8 pl_call_error uint8 pl_image_status uint8 pl_oa_height float pl_vo_height float pl_fu_height float
73 CURVE 1 monodepth_output 29 mono_idx uint32 mono_s0 float mono_s1 float mono_s2 float mono_s3 float mono_s4 float mono_time0 float mono_time1 float mono_time2 float mono_time3 float mono_time4 float mono_e0 float mono_e1 float mono_e2 float mono_e3 float mono_e4 float mono_cnt0 uint32 mono_cnt1 uint32 mono_cnt2 uint32 mono_cnt3 uint32 mono_cnt4 uint32 mono_solver0 float mono_solver1 float mono_solver2 float mono_solver3 float mono_brake uint32 mono_speed float mono_dist_to_brake_point float mono_calc_delay float
4294967295 LOG hg_detection_log
4294967295 LOG hg_navigation_log
4294967295 LOG hg_hand_tracking_log
4294967295 LOG hg_hand_tracking_check_log
97 CURVE 1 image_status 6 image_status_0 uint8 image_status_1 uint8 image_status_2 uint8 pollute_0 uint8 pollute_1 uint8 pollute_2 uint8
98 CURVE 1 fc_load 12 cur_apl_ctrl_mode uint8 cur_ctrl_device uint8 e_vo_flag_navi uint8 restrict_state uint16 num_of_losed_log uint16 link_state uint8 fc_ctrl_mode uint8 fc_ratio uint8
battery_remaining uint8 cnt uint8 motor_start_err_code uint16 fc_timestamp uint32
94 CURVE 1 ist_of_dbg_info 40 ist_cmid uint8 ist_dir uint8 ist_flag uint8 ist_dist_ori_msb uint8 ist_dist_ori_lsb uint8 ist_dist_tempcail_msb uint8 ist_dist_tempcail_lsb uint8
ist_dist_ambcail_msb uint8 ist_dist_ambcail_lsb uint8 ist_magnitude_exp uint8 ist_magnitude_msb uint8 ist_magnitude_lsb uint8 ist_magnitude_lsb uint8 ist_temperature_offset uint8
ist_temperature_coef_msb uint8 ist_temperature_coef_lsb uint8 ist_ref_magnitude_msb uint8 ist_ref_magnitude_lsb uint8 ist_dist_compensation_factor uint8 ist_ambient_level uint8
ist_kf_output_cov uint8 ist_kf_output_velocity_msb uint8 ist_kf_output_velocity_lsb uint8 ist_kf_output_status uint8 ist_dist_output_msb uint8 ist_dist_output_lsb uint8
ist_kf_input_accz_byte_0 uint8 ist_kf_input_accz_byte_1 uint8 ist_kf_input_accz_byte_2 uint8 ist_kf_input_accz_byte_3 uint8 ist_kf_input_accz_byte_4 uint8 ist_kf_input_accz_byte_5 uint8
ist_kf_input_accz_byte_6 uint8 ist_kf_input_accz_byte_7 uint8 ist_kf_input_accz_byte_8 uint8 ist_kf_input_accz_byte_9 uint8 ist_kf_input_accz_byte_10 uint8
95 CURVE 1 ti_tof_dbg_info 80 ti_down_cmid uint8 ti_down_dir uint8 ti_down_flag uint8 ti_down_dist_ori_msb uint8 ti_down_dist_ori_lsb uint8 ti_down_dist_tempcail_msb uint8
ti_down_dist_tempcail_lsb uint8 ti_down_dist_ambcail_msb uint8 ti_down_dist_ambcail_lsb uint8 ti_down_magnitude_exp uint8 ti_down_magnitude_msb uint8 ti_down_magnitude_lsb uint8
ti_down_sensor_temperature uint8 ti_down_temperature_offset uint8 ti_down_reserve1 uint8 ti_down_reserve2 uint8 ti_down_reserve3 uint8 ti_down_reserve4 uint8 ti_down_reserve5 uint8
ti_down_ambient_level uint8 ti_down_kf_output_cov uint8 ti_down_kf_output_velocity_msb uint8 ti_down_kf_output_velocity_lsb uint8 ti_down_kf_output_status uint8
ti_down_dist_output_msb uint8 ti_down_dist_output_lsb uint8 ti_down_kf_input_accz_byte_0 uint8 ti_down_kf_input_accz_byte_1 uint8 ti_down_kf_input_accz_byte_2 uint8
ti_down_kf_input_accz_byte_3 uint8 ti_down_barometer_msb uint8 ti_down_barometer_lsb uint8 ti_down_current_mode uint8 ti_down_frame_counter uint8 ti_down_reserved5 uint8
ti_down_reserved6 uint8 ti_down_reserved7 uint8 ti_down_reserved8 uint8 ti_down_reserved9 uint8 ti_down_reserved10 uint8 ti_top_cmid uint8 ti_top_dir uint8 ti_top_flag uint8
ti_top_dist_ori_msb uint8 ti_top_dist_ori_lsb uint8 ti_top_dist_tempcail_msb uint8 ti_top_dist_tempcail_lsb uint8 ti_top_dist_ambcail_msb uint8 ti_top_dist_ambcail_lsb uint8
ti_top_magnitude_exp uint8 ti_top_magnitude_msb uint8 ti_top_magnitude_lsb uint8 ti_top_sensor_temperature uint8 ti_top_temperature_offset uint8 ti_top_reserve1 uint8 ti_top_reserve2 uint8
ti_top_reserve3 uint8 ti_top_reserve4 uint8 ti_top_reserve5 uint8 ti_top_ambient_level uint8 ti_top_kf_output_cov uint8 ti_top_kf_output_velocity_msb uint8 ti_top_kf_output_velocity_lsb uint8
ti_top_kf_output_status uint8 ti_top_dist_output_msb uint8 ti_top_dist_output_lsb uint8 ti_top_kf_input_accz_byte_0 uint8 ti_top_kf_input_accz_byte_1 uint8 ti_top_kf_input_accz_byte_2 uint8
ti_top_kf_input_accz_byte_3 uint8 ti_top_barometer_msb uint8 ti_top_barometer_lsb uint8 ti_top_current_mode uint8 ti_top_frame_counter uint8 ti_top_reserved5 uint8 ti_top_reserved6 uint8
ti_top_reserved7 uint8 ti_top_reserved8 uint8 ti_top_reserved9 uint8 ti_top_reserved10 uint8
96 CURVE 1 sonar_dbg_info 32 sonar_cmid uint8 sonar_dir uint8 sonar_flag sonar_info uint8 sonar_confidence uint8 sonar_data_count uint8 sonar_dist_msb uint8 sonar_dist_lsb uint8
```



Flash Memory Summit

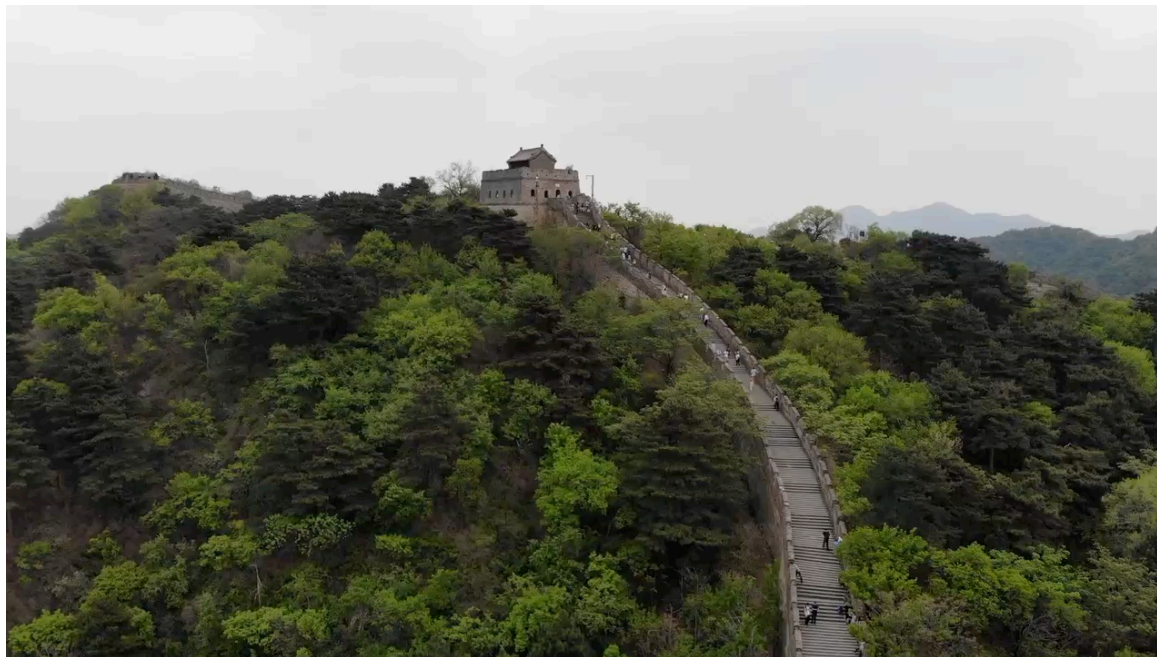
## Real World Applications



- Events that occur once in a lifetime, such as weddings and graduations
- Professional entertainment industry footage that would be too expensive to reproduce
- Electronic evidence for use in a criminal or civil case



# Example: Recovered Footage



# Camera Card Data Recovery

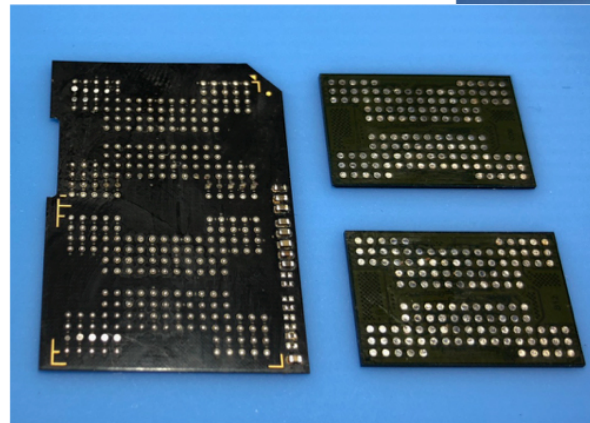




Flash Memory Summit

## Deconstruction

- Lexar 128GB SD was not being recognized
- Unknown controller
- Two chips found within the card





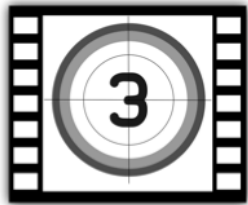
## Types of Data Obtained

- Video files (very large files)
- The files became corrupt during the recovery process
- We spent 3 days repairing the damaged video data that was recovered



Flash Memory Summit

## Real World Applications



- Events that occur once in a lifetime, such as weddings and graduations
- Professional entertainment industry footage that would be too expensive to reproduce
- Electronic evidence for use in a criminal or civil case



# Recovered Footage



Flash Memory Summit 2018  
Santa Clara, CA





Flash Memory Summit

# DriveSavers

Data Recovery • eDiscovery • Digital Forensics



[www.drivesavers.com](http://www.drivesavers.com)  
800.440.1904

Will DeLisi, NAND Flash Recovery Specialist, DriveSavers  
Josey Santana, Data Recovery Engineer, DriveSavers