Here Comes the Suns – Flight Safety for Unmanned Aircraft Over Active Heliostat Fields

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Concentrating solar power (CSP) plants can have hundreds of thousands of mirrors with associated support and actuation mechanisms, spread over a large land area, making tuning, inspection and maintenance a daunting challenge. Unmanned aircraft systems (UAS) can move a camera or other sensors systematically across large solar field areas, making them a desirable asset for CSP plant operators. This work represents an initial experiment studying safe operating conditions for UAS flight over operating solar field.

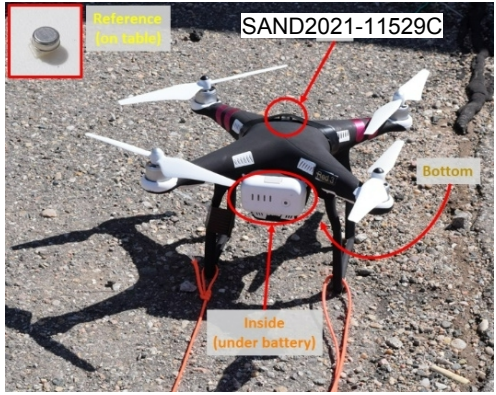
An operating CSP field has regions of high solar flux, which can present a potential flight hazard. The solar flux varies in concentration and is widespread across the field. UASs flying over an operating heliostat field will inherently encounter areas of increased solar flux. Irradiance intensities near the receiver may reach 3,000 kW/m^2, which can cause immediate spontaneous combustion in many materials, but lower flux concentrations may also cause the UAS to operate incorrectly. *How can we conduct flight operations over an active heliostat field while avoiding hazardous conditions due to solar flux?*

Solar Flux Intensity

Heliostats are designed to focus sunlight onto a central receiver. Since the reflected beam diameter varies linearly with the distance from the heliostat, the flux intensity grows with the square of this distance. Similar reasoning applies to the ensemble of reflected beams, yielding a first-order estimate of flux intensity growing with the square of the altitude, indicating that the flux intensity grows slowly at first and then rapidly as altitude approaches the receiver height.

How much flux can this UAS tolerate?

- We painted a DJI Phantom 3 to maximize absorption. Flight log records battery & Electronic Speed Controller (ESC) temperatures.
- iButton temperature sensors (logging @ 1hz) placed on top, bottom and inside (battery compartment) the aircraft with a reference sensor on table in direct sunlight.
- Individual heliostat mirror facets reflect multiple suns on aircraft.

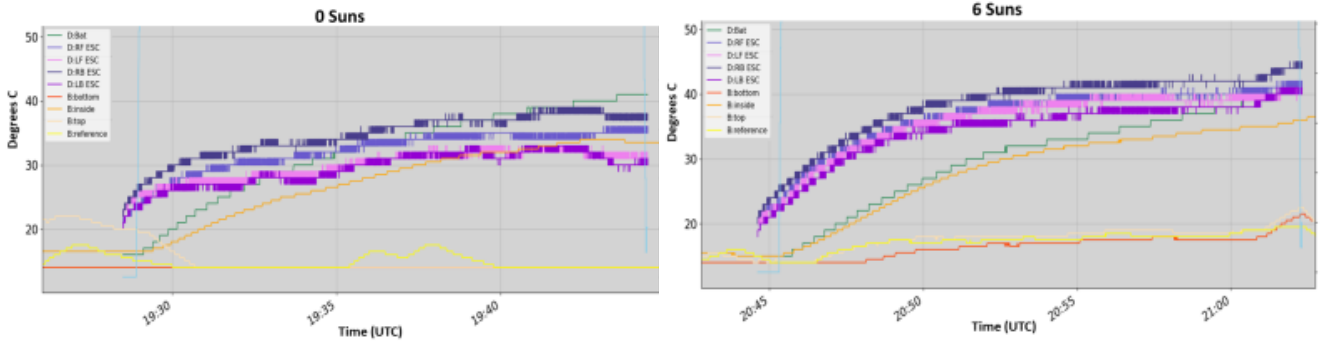


Conditions:

- Zero to 6 suns (5 mirrors)
- Ambient ~10°C
- Breeze ~7km/h

Initial results

- No damage to the UAS was observed.
- Six-sun plot exhibits higher and faster-rising ESC temperatures.



Near Future Plans

- Conduct more flights utilizing a full heliostat to accomplish higher flux concentrations of 10's to 100's of suns.
- Add IR Imaging / Thermography

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