THIN-FILM CIGS ON FLEXIBLE PLASTIC SUBSTRATE

Victor Lee, President & CEO
In addition to historical information, this presentation contains forward-looking statements that are based on assumptions made by management regarding future circumstances over which the company may have little or no control and involve risks, uncertainties and other factors that may cause actual results to be materially different from any future results expressed or implied by such forward-looking statements. Please note that these forward-looking statements reflect our opinions only as of the date of this publication and we undertake no obligation to revise or publicly release the results of any revision to these forward-looking statements in light of new information or future events. Please refer to our SEC filings for a more detailed description of the risk factors that may affect our results. These documents are available at our website, www.ascentsolar.com, and at the SEC’s website, www.sec.gov.
Who Are We?

- Leading provider of flexible & lightweight thin-film solar modules specially designed for the Space/Near-space, Drone/UAV, Military, Transportation, Off-grid and Consumer Markets

- Corporate Vision: To deliver Clean and Innovative Power Solution for Everyone Everywhere

- Revolutionary and Proprietary flexible solar technology based on CIGS (Copper-Indium-Gallium-Selenium) on Plastic substrate
Company Snapshot

- **Founded:** Incorporated in 2005; IPO in July 2006
- **Headquarters:** Thornton, Colorado (~139,000 sf of production, warehouse and office space)
- **Headcount:** Approximately 80 employees
- **Technology:** Thin-Film CIGS on flexible, plastic substrate
- **Manufacturing:** Roll-to-roll manufacturing, monolithic integration & intelligent process-control
- **Status:** Commercially producing flexible PV modules & end-consumer products
Corporate History & Development Timeline

- Thin-film PV development begins at Martin Marietta Aerospace (MMA) in 1990
- MMA team formed ITN Energy Systems (1992) to develop thin-film on polyimide
- Completes IPO in July 2006

1990 - 2006

2007
- Begins construction of World Headquarters

2008
- 100 Most Innovative Technologies by R&D 100 Magazine

2009
- Commercial production begins based on rooftop application

2010
- Paradigm shift to focus on specialty PV market and consumer portable solar solutions

2011
- 50 Best Inventions in the World by Time Magazine

2012
- Awarded 100 Most Innovative Products (IT/Electronics Category) by R&D 100 Magazine

2013
- Successful launch of Superlight PV module for Silent Falcon UAS

2014
- GSA listed

2015
- Selected by Japanese JAXA for further evaluation for deep space mission

2016
- OEM for Energizer PowerKeep line of Solar Products

2017
- Energizer® PowerKeep
Certifications, Awards, and Accolades

- 2009 – NREL Certification for cell and module efficiency @ 14% & 11.4% respectively
- 2010 – Passed US Military Standard 810G Testing
- 2010 – IEC 61646 Certification
- 2010 – R&D 100 Magazine’s 100 Most Innovative Technologies
- 2011 – TIME Magazine’s 50 Best Inventions in the World
- 2015 – R&D 100 Magazine’s Top 100 Inventions (IT/Electronics)
## Patent Portfolio

<table>
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<th>Granted Patents (12-Oct-2017)*</th>
<th>US</th>
<th>Foreign</th>
<th>TOTAL</th>
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<td>Published Patent Applications (Active)</td>
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<th>TOTAL PATENTS &amp; APPLICATIONS (Pending &amp; Published)</th>
<th>US</th>
<th>Foreign</th>
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<tbody>
<tr>
<td></td>
<td>63</td>
<td>72</td>
<td>135</td>
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ASTI Proprietary Technology
What Makes Ascent’s PV Unique?

- **Lightweight**
  - ASTI panels weigh a small fraction of conventional c-Si panels
  - CIGS chemistry – highest thin-film conversion efficiency
  - Best Power-to-Weight Ratio (50 - 250 watt/kg)

- **Flexible**
  - Limitless applications compared to rigid based PV
  - Allows for easy Roll-to-Roll fabrication
  - More efficient use of equipment and manufacturing floor space

- **Durable** *(MIL-STD-810G and IEC 61646 certified)*
  - Inherent robust construction with redundant interconnects reducing failure points
  - Plastic substrate does not crack or shatter upon impact

- **Customizable** *(with Monolithic Integration)*
  - Simplified electrical and mechanical construction
  - Customized cell shapes easily integrated into manufacturing process

- **Meaningful Output in Small Area**
  - Higher voltages economically achieved in smaller areas
  - ASTI’s PV Voltage is more easily integrated into electronics than Discrete Cells
Meaningful Voltage In Small Areas

- Comparison of Discrete Cells vs Monolithically-Integrated Modules

Technology: Polycrystalline Silicon
- # of Cells: 1
- Voltage: Approximately 0.5 V
- Requires several cells interconnected
- Description: 15.6 cm x 15.6 cm
  
  Fragile, Single Point Failure

Technology: AST Monolithically-Integrated CIGS
- # of Cells: 16
- Voltage: Approximately 9.0 V
- Can be directly connected to load
- Description: 15 cm x 15 cm
  
  Flexible, Redundant Circuitry
Responds Better to Non-optimum Sunlight Condition

- Thin-film PV, such as CIGS, can respond better to “non-optimum” sunlight better than the traditional c-Si (crystalline silicon) solar cell
  - Off-angle (not directly facing the sun)
  - Overcast/Diffuse/Low light

- Ascent can adjust the construction of the ‘standard’ CIGS module to perform better under various conditions
  - Terrestrial (atmospheric attenuation in UV and IR)
  - High altitude/Space (high intensity due to no atmospheric attenuation)
  - Deep space (low intensity/low temperature)
  - Temperature extremes
Much Greater Tolerance To Shading and Damage

- ASTI’s modules are highly tolerant of shading and damage due to CIGS’s better response to defuse light condition and our monolithically-integrated construction of the modules on plastic substrate - **CIGS almost always operates when others STOP!**

**Damage Comparison**

*Ascent Solar’s CIGS Technology featuring Monolithic Integration*

Electricity flows around damage and shading to continue operating.

*Other Solar Technology*

Damage or shading can cause catastrophic failure or too little power to continue operating.
## Wide Applications In Multiple Premium Markets

<table>
<thead>
<tr>
<th>Consumer Portable Power</th>
<th>Drones/UVAs</th>
<th>Space &amp; Near-space</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High energy density</td>
<td>• Silent Falcon™ UAV</td>
<td>• Partnership with Vanguard Space Technologies</td>
</tr>
<tr>
<td>• Flexible plastic substrate, paper-thin and lightweight</td>
<td>• Customized packaging enables functionality in extreme conditions</td>
<td>• High Powered Space Ready PV</td>
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</tbody>
</table>

**Military/Defense**

- High power, shatterproof and durable
- Lightweight, flexible fabric surfaces
- Non-glare, non-reflective finish

*Energizer® PowerKeep Powered by Ascent SOLAR*

*MIL STD 810G Certified*

**Transportation**

- Durable in extreme conditions
- Extends capabilities of HEVs and EVs
- Power can offset/eliminate wasteful idling

**Off-Grid Structure**

- Lightweight and durable
- Cost efficient
- Reliable
- Highly mobile energy solution

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**Ascent SOLAR**

[www.silentfalconuas.com](http://www.silentfalconuas.com)

Overview of the PV Technologies & Market
### Overview of Photovoltaic Technologies

<table>
<thead>
<tr>
<th></th>
<th>First Generation</th>
<th>Second Generation</th>
<th>Third Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mono-Crystalline</td>
<td>Poly-Crystalline</td>
<td>CIGS</td>
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<tr>
<td>Production Efficiency</td>
<td>18%</td>
<td>15%</td>
<td>11%</td>
</tr>
<tr>
<td>Best Lab Efficiency</td>
<td>25%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Theoretical Limit</td>
<td>29%</td>
<td>29%</td>
<td>29%</td>
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<tr>
<td>Maturity</td>
<td>Mature</td>
<td>Mature</td>
<td>Launch</td>
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<tr>
<td>Flexibility</td>
<td>Rigid</td>
<td>Rigid</td>
<td>Flex/Rigid</td>
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<tr>
<td>Stability</td>
<td>Stable</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td></td>
<td>Crystalline Ribbon</td>
<td>Amorphous Silicon</td>
<td>Cadmium Telluride</td>
</tr>
<tr>
<td>Production Efficiency</td>
<td>12%</td>
<td>6%</td>
<td>11%</td>
</tr>
<tr>
<td>Best Lab Efficiency</td>
<td>16%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td>Theoretical Limit</td>
<td>20%</td>
<td>20%</td>
<td>29%</td>
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<tr>
<td>Maturity</td>
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<td>Flexibility</td>
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<td>Flex/Rigid</td>
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<td>Stability</td>
<td>Stable</td>
<td>Degrades</td>
<td>Stable</td>
</tr>
<tr>
<td></td>
<td>Crystalline</td>
<td>Organic</td>
<td>DSSC</td>
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<tr>
<td>Production Efficiency</td>
<td>6%</td>
<td>3%</td>
<td>2%</td>
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<tr>
<td>Best Lab Efficiency</td>
<td>13%</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>Theoretical Limit</td>
<td>20%</td>
<td>14%</td>
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<tr>
<td>Maturity</td>
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<td>Flexibility</td>
<td>Flex/Rigid</td>
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<td>Stability</td>
<td>Stable</td>
<td>Degrades</td>
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First Generation: Mono-Crystalline, Poly-Crystalline, Crystalline Ribbon

Second Generation: Amorphous Silicon, Cadmium Telluride, CIGS

Third Generation: Organic, DSSC

- Mono-Crystalline
- Poly-Crystalline
- Crystalline Ribbon
- Amorphous Silicon
- Cadmium Telluride
- CIGS
- Organic
- DSSC

**Notes:**
- **Production Efficiency**
- **Best Lab Efficiency**
- **Theoretical Limit**
- **Maturity**
- **Flexibility**
- **Stability**

**Technologies:**
- First Generation: Mono-Crystalline, Poly-Crystalline, Crystalline Ribbon
- Second Generation: Amorphous Silicon, Cadmium Telluride, CIGS
- Third Generation: Organic, DSSC

**Types:**
- First Generation: Mono- and Poly-Crystalline
- Second Generation: Amorphous Silicon, Cadmium Telluride, CIGS
- Third Generation: Organic, DSSC

**Stability:**
- Stable
- Degrades

**Flexibility:**
- Rigid
- Flex/Rigid
- Flex

**Launch Status:**
- Launch
- R&D

**Materials:**
- First Generation: Mono- and Poly-Crystalline
- Second Generation: Amorphous Silicon, Cadmium Telluride, CIGS
- Third Generation: Organic, DSSC

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**Ascent Solar Technologies, Inc.**


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Thin-Film PV Competitive Landscape

**Thin-Film Competitive Landscape**

- **Technology**
  - Amorphous
  - Polycrystalline
- **Structure**
  - Flexible
  - Rigid
- **Chemistry**
  - Silicon
  - CdTe
  - CIGS
- **Module Construct**
  - Flexible
  - Rigid
- **Substrate**
  - Plastic
  - Stainless Steel
  - Glass
- **Integration**
  - Monolithic
  - Discrete

**The Ascent Advantage**

- Flexible module
- Flexible encapsulant
- 11% efficiency (high volume)
- Parallel circuitry
- Lightweight

**Representative Companies**

- Ascent Solar
- First Solar
- Solar Frontier
- SunPower
- MiaSole
- Abound Solar
- solar_frontier
- Flexcell
- Applied Materials
- PowerFilm

_X_ = companies that have gone bankrupt or stopped operation

Source: All information above were obtained from published documents available on the internet
## Competitive Products Comparison

<table>
<thead>
<tr>
<th>Product</th>
<th>Ascent Solar</th>
<th>Flexcell</th>
<th>PowerFilm</th>
<th>Global Solar</th>
<th>Uni-Solar</th>
<th>SunPower</th>
<th>First Solar</th>
<th>MiaSolé</th>
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<tr>
<td>Flexible</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Rigid</td>
<td>Rigid</td>
<td>Yes</td>
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<tr>
<td>Technology</td>
<td>CIGS on Plastic (Monolithic)</td>
<td>a-Si on Plastic (Monolithic)</td>
<td>a-Si on Foil (Monolithic)</td>
<td>CIGS on Metal Foil (Discrete)</td>
<td>a-Si on Foil (Discrete)</td>
<td>Crystalline</td>
<td>CdTe on Glass (Monolithic)</td>
<td>CIGS on Metal Foil (Discrete)</td>
</tr>
<tr>
<td>Power Density (watts/meter²)*</td>
<td>80-100</td>
<td>22</td>
<td>35</td>
<td>33</td>
<td>67</td>
<td>181</td>
<td>108</td>
<td>129</td>
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<tr>
<td>Power to Weight (watts/kg)*</td>
<td>190-205</td>
<td>14</td>
<td>33</td>
<td>34</td>
<td>19</td>
<td>15</td>
<td>6</td>
<td>66</td>
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</table>

Ascent has the highest Power-to- Weight ratio and one of the greatest Power Density among the available flexible photovoltaic products.

*AST’s flexible CIGS and novel packaging are highly adaptable to various applications, thus power density and power-to-weight ratio can vary significantly with border width, etc. Range noted is specific to fully-laminated modules presently available with areal density ranging from 310-400 g/m².
Comparative Advantages

- Traditional Crystalline Panel
  - Rigid
  - Heavy
  - Glass
  - Costly Installation
  - Roof Penetrations
  - Unsightly

- Ascent’s Flexible CIGS Module
  - High Power
  - Customized Voltage
  - Lightweight
  - Ease of Integration
  - Stable Performance
  - Low Profile

- Other Flexible Thin Film
  - Lower Power
  - Preset Voltage
  - Limited Size Selection
  - Limited Customization
  - Degradation

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Unique Manufacturing Process
Ascent’s Unique Manufacturing Process

Thin-film Roll-to-roll Deposition Process

1. Back Contact
2. CIGS
3. Window
4. TCO
5. Completed PV Roll

Monolithic Integration

6. Patterning
7. Printing
8. Modules on a Roll

Module Manufacturing and Encapsulation

9. Assembly
10. Testing
11. Completed Module
**Discrete Process Vs Monolithic Integration**

**Discrete Process**
1. Deposition on a conductive material
2. Cut material into discrete units
3. “Shingle” cells and assemble module

**Monolithic Process**
1. Deposition on a isolating material
2. Laser scribe: does not cut substrate
3. Screen print leaves complete module; No Assembly Required
Monolithic Integration with Intelligent Process Control

- ASTI's Patented Monolithic Integration & Intelligent Process Control

Un-patterned Roll
Monolithic Integration Enables Customization

ASTI’s Patented Monolithic Integration & Intelligent Process Control

Ability to accommodate different module types/sizes in a given roll provides flexible manufacturing to address multiple markets

- Enables customization for specific product requirements (voltage, amp, form factor)
- Address multiple markets in same production line/run
Baseline Monolithic Integration Process

- Deposit Entire Thin Film Stack Prior to Patterning
  - Thin film deposition processes all adapted to roll-to-roll processing on polyimide substrates
  - Roll length limited to amount of material the sources can accommodate
Monolithic Integration Process (continued)

- P1 Scribe to Isolate Entire Thin-film PV Stack
- P2 to Provide Via to Back Contact
- P3 Scribe Isolates TCO
Monolithic Integration Process (continued)

- Dispose Resistive UV-Cured Ink
Monolithic Integration Process (continued)

- Dispose Metallic Grids

![Monolithic Integration Process Diagram]
Monolithic Integration Process (continued)

- Current Path
Monolithic Integration Process (continued)

- Current Path of Module Shows the Ability of the AST Monolithic Integration Process to Produce Series Interconnect to Add Voltage
Space and Near-space Solar Array
Space and Near-Space Market

- According to The National Security Space Office (NSSO), "Space-based solar power presents a strategic opportunity for America that merits significant further attention on the part of both the US Government and the Private sector" †

- Ascent is set to benefit from growing trends towards very large space-based solar arrays:
  - Our flexible and ultra-lightweight CIGS PV is uniquely positioned to compete At The System Level with present and future 'exotic' PV
  - Recent breakthrough in our new high-voltage (270V) solar module is specifically designed to address the needs for this high altitude aerospace market, where PV modules must deliver high voltage and power while maintaining low current and for the least possible weight

†National Defense Industrial Association
Partnership with Vanguard Space Technologies

- ASTI lightweight PV modules were selected by Vanguard Space Technologies, Inc. (Vanguard) in 2014 to create an ultra-thin, best power-to-weight ratio large space solar array.

- Vanguard had passed a key test milestone with its Thin Integrated Solar (THINS) PV technology, performed by the NASA Jet Propulsion Laboratory plasma facility, which is intended to power next-generation spacecraft.

PowerSolarSail project to Jupiter has been given green light to next phase, in part based on data from our PV in extreme environments

- -160°C to +190°C
  (-256°F to +374°F)
- 4% sunlight
- Radiation

To provide sufficient power at Jupiter (4%), array is sized to approx. 150kW AM0 1 sun

JAXA is paying NRE to develop PV for the deployment mechanism to utilize
ASTI CIGS Advantages for Space/Near Space Environment

- Reduced part count for ASTI CIGS compared to discrete cell technologies (all other non-monolithically integrated PV) equates to lower assembly cost
  - All cell-to-cell interconnects are created during the AST fabrication process
  - Only two connections per monolithically integrated module

- Reduced harness weight
  - Reduced string current/Increased string voltage reduces wire gauge of the harness
  - Weight reduction is directly related to reduced launch cost
    - Even more critical in multiple payload launches

- Inherent redundancy should provide greater resistance to catastrophic failure due to micrometeorites

- High Specific Power
  - Our CIGS on polyimide is approximately 1125 W/kg
Reduced Part Count – Critical to Aerospace Applications

42 cell string (14 x 3)

**Dimensions:**
166mm x 371mm (0.062 m2)

**Part Count:** 130
- 42 18% solar cells (54mm x 24mm)
- 42 dual-tipped interconnects
- 42 adhesive pads
- 4 bus bar tapes

**Output:**
- Vmax = 20.0V
- Imax = 470mA
- Pmax = 9.40W
- Voc = 22.1V
- Isc = 498mA
Reduced Part Count – Critical to Aerospace Applications

2 x 44 cell string (2P) CIGS

**Dimensions:**
294mm x 304mm (0.09 m2)

**Part Count:** 8
- 2 x 11.3% monolithically integrated CIGS modules (146mm x 304mm)
- 2 busbar tape with conductive adhesive
- 2 kapton tape for isolation
- 2 adhesive sheets

**Output:**
- $V_{max} = 20.2V$
- $I_{max} = 468mA$
- $P_{max} = 9.48W$
- $V_{oc} = 26.4V$
- $I_{sc} = 518mA$
A New Angle on PV – Solar Sails for Space/Deep Space

- Utilize Strength of Monolithic Integration to Solve Non-orthogonal Problems that No Other Company Can Do *(patent pending)*
  - Becoming an issue with several customers
    - Solar Sails
    - Delta-wing sUAV
    - Non-traditional applications
  - Variable pitch to match cell area/current
  - Module voltage (cell count) adjusted
Fixed-wing Drones and UAV Application
Aerospace │ Fixed-wing Drones/UAVs & Ground Stations

- Flexible monolithically integrated CIGS in production offers immediate solution to extending mission duration
  - Customer supplied single piece solution in protective covering
  - Areal density <400 g/m²
  - Specific power >205 W/kg
  - Co-curing during composite fabrication results in clean aerodynamic interface
- Increase flight time up to 50% with minimal increase in weight
- Larger module (unit) size reduces integration costs, increases system reliability and eliminates catastrophic failure common to single crystal PV
- Provide in-field charging between flights
- Easily customizable through monolithic integration for target voltage and current to various power management systems on UAVs and on various different wing designs
- Solar can also provide power for ground stations for both fixed and rotary wing UAV
Military Operation, First Responders & Emergency Management
Fully Burdened Cost of Fuel (The US Military’s Perspective)
Solar to become a significant source of fuel savings

### Battlefield Fuel Consumption
Generators are the Army’s single largest user of fuel on the battlefield during wartime.*


“Towards Developing Fully Burdened Costs” - Headquarters USMC
Edward Blankenship, PA&E
Randal Cole, Ph.D., CNA

### Fully Burdened Cost Of Fuel
The Fully Burdened Cost of Fuel is defined as the cost of the fuel itself plus the apportioned cost of all of the fuel delivery logistics and related force protection required for delivery

### Cost to Deliver Fuel to Forward Bases

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost Range</th>
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<tbody>
<tr>
<td>Convoy with Security</td>
<td>$9.20 - $11.81/gal</td>
</tr>
<tr>
<td>Convoy with Air Security</td>
<td>$15.63 - $18.59/gal</td>
</tr>
<tr>
<td>Air Drop</td>
<td>$28.94 - $30.78/gal</td>
</tr>
<tr>
<td>Air Drop with Security</td>
<td>Up to $400/gal</td>
</tr>
</tbody>
</table>

### Fuel Savings from Solar

- **Total Number of Gallons Consumed = 357-M**
- DoD reports that 5% solar adoption could save 17.8-M gallons of fuel

**Up to $1-billion in annual savings assuming average cost $50-gal**
■ Pocket Power USB Charger
  ▪ Designed to power devices such as Android Tactical Assault Kit (ATAK)
  ▪ 14W smart USB charger
  ▪ Featherlight® construction

■ Unattended Ground Sensors
  ▪ Micro-scale solar modules to support increasing use of sensors on the battlefield
  ▪ Provides increased ISR efficiency while mitigating risk of life of operator and of sensor asset

■ Solar Battery Charger
  ▪ Designed to charge most common military batteries
    ▪ BB2590, 148/152, conformal battery types
    ▪ Plug into existing Bren-Tronics®, Protonex® and similar systems

■ 120W Featherlight
  ▪ Plug-into existing systems

■ MilPak 60E
  ▪ Trialing with strategic end users for proof of concept
Public Sector Opportunity Snapshot

- **US Marine Corps**
  - Mission of USMC historically is to provide Expeditionary support via Air, Land and Sea; short-term engagements requiring utmost mobility
  - Heavily reliant on tow-behind Generators, current logistics cost of $500 to send 1 Gal of Fuel to front lines; legacy solar frowned upon
  - USMC Commandant directive to reduce weight carried by Marine (100+ lbs), eg. 20lbs batteries, 20lbs H2O

- **SOCOM (Special Operations Command)**
  - Has central authority over all DoD for planning & executing all covert and clandestine missions throughout world
  - Requirement for short/medium-term Intelligence, Surveillance & Reconnaissance (ISR) missions placing premium for operating as discreetly as possible

- **FEMA (Federal Emergency Management Agency)**
  - Coordinates Disaster response for large-scale US, tasked with being 1st on-ground within 10 hours after event
    - Examples: Hurricanes Sandy & Harvey, Gatlinburg (TN) fires
  - Typical use-case is remote/cut-off areas that are impeded logistically to restoring power, but for which safety of population is at significant risk without access
Military Specs Portable Solar Blanket - MilPak™ E

MIL STD 810G Testing PASSED:
• Low Pressure (Altitude)
• Transit Drop Shock
• Temperature Shock
• Vibration (Random)

High Temperature
• Low Temperature
• Salt Fog
• Blowing Rain
Summary

- Ascent’s CIGS technology offers unique advantages to existing technologies.

- Monolithic Integration on plastic substrate is a matchless technology and a key attribute to Ascent’s unique product.

- Unique value proposition in marketplace will enable Ascent to successfully compete without much margin erosion.

- Several Technology Improvement Programs in place in R&D to increase efficiency and reduce cost.
Ascent Solar Technologies, Inc.