Balloon Telemetry and Communications from Small Balloon

LOCANS Conference April 27, 2006

Jerry Knoblach, CEO and Founder Space Data Corporation 460 South Benson Lane Chandler, Arizona 85224 (480) 722-2100 www.spacedata.net

Raised over \$75 M in Private Capital Commercialized High-Altitude Platform to Provide Rural Wireless Coverage Hold Nationwide Spectrum Assets Valued at \$140 Million M2M Network Operating in TX-OK Region for over 2 years Awarded a \$49 Million US Air Force Contract 75 Employees – Started in 2000

Outline

- Who is Space Data?
- What is Near Space and Why All the Recent Interest?
- Types of Near Space Platforms
 - Operating Today Free Drifters with wind steering by changing altitude
 - Future Platforms Stationkeeping Airships
- Space Data's Near Space Communications Platforms
 - DoD Demos: Combat SkySat, JEFX 06 Starfighter
 - DHS Demos: APCO 2006, Border Patrol 2007
 - Operational Programs: SkySite Commercial Network & NSCS Program
- Free Drifting Platforms: Operational Characteristics / Payload Capacity
- Free Drifting vs. Stationkeeping: The technical challenges
- Potential Mission Areas for Near Space UAV Platforms
 - Battlefield Communications
 - Civil Government
 - SIGINT / MASINT / IMINT Missions
 - Scientific Research



What We Do

SkySite[®] Platform at 100,000 ft

Fill gaps in terrestrial wireless networks providing ubiquitous coverage to

enterprises operating in rural areas,
wireless service providers, and
government agencies

for services and products including:

M2M / Telemetry Short Messaging Wireless E-mail Voice Broadband

Services



Moderns

PDAS Handsets

The Solution Simply Integrates 3 Proven Technologies

Integrated with proprietary altitude / network control & logistic systems

Weather Balloons

 20-Mile Altitude A Century of Experience Simple Logistics All Weather Operations FAA Acceptance of

two 6 lb payloads

Ever Shrinking Wireless Devices



 Base Station Radios are also Shrinking (i.e. RadioFrame) Expendable Infrastructure keeps pace with Moore's Law

GPS Network



- Precise Timing Location
 - Inexpensive



Weather Balloons: over 80 Years of Reliable Launch Experience with Worldwide Coverage

- 880 sites launch 2X/day over 800,000 / yr no incidents of Aircraft Damage
- FAA permits Nat'l Air Space (NAS) use by unmanned free drifting balloons if:
 - 1) Total payload mass suspended from balloon < 12 lb
 - 2) Each payload package must be < 6 lbs
 - 3) Payloads must separate with 50 lb force
 - Exceed these then: Notice to Airman + transponder + be < 50% overcast
- FAA bars winged UAVs from NAS (except limited Gov't appl. in remote areas)
 - Est. more than a decade & more than \$400 M to gain wide approval



Developing a UAS collision-avoidance system will be a more complex task than the development of TCAS. It took the aviation community more than a decade and about \$400 million to develop TCAS, notes Andrew Lacher, Mitre Corp. UAS program lead. Aviation Week 2-21-07



Responsive Launch from All Types of Platforms

- One person can launch in 20 minutes
- Logistics tail exists for air, sea, & land
- Routine: 12,410 launches without missing a flight at Minnesota NWS site
- Base of trained personnel exists:
 - Air Force flies balloons for forecasting
 - Army artillery units fly balloons for wind correction to fire control





Space Data's Coverage Solution

Our network consists of transceivers on weather balloons at 100,000 feet

- A single *SkySite[®]* covers everything under a 420-mile diameter circle
 - Single SkySite = 300 terrestrial towers
- Only 41 M2M or 200 Voice SkySites needed to cover the entire US
- Uses industry standard protocols:
 - Interoperates with existing carriers who utilize towers
 - Interoperates with existing user devices
- In 24 x 7 operations for the last 36 months
 - Over 170,000 flight-hours of cumulative near-space operations
 - Over 12,000 flights to date





Each SkySite rises to 100,000 feet and levels off. In the uniform winds at that altitude, a constellation of interlocking SkySites float in unison to blanket large regions with coverage. New SkySites are launched every 12-24 hours to replace the previous constellation which is taken down, recovered and reused.



Ample FCC Licensed Spectrum for Commercial Networks

- Nationwide 900 MHz spectrum for existing messaging, M2M & voice devices
- Won 20 MHz of broadband spectrum in key oil & gas areas at recent auction
- Kagan Media has appraised our spectrum at \$120.1 Million
 - Acquisitions of NPCS spectrum since appraisal raises value to \$140 Million
- Space Data controls 1.912 MHz of Nationwide NPCS spectrum
 - 65% of NPCS band more than all other carriers 48 nationwide voice compatible channels





= 50% JV Ownership except LA (0.1 MHz)



Space Data's Significant Operational Milestones



Space Data Near Space Experience

- 2004 Present: Commercial Telemetry Network Over 150,000 flight hours
- 2004 2005: Combat SkySat
- 2005 2006: JEFX 06
- Aug. 2006: \$49 M IDIQ Contract for Near Space Communications System

Space Data^{*}

Current Commercial Coverage: 11 Sites SkySite Platform Coverage Roaming Coverage through Verizon/Skytel

USAF Space Battlelab Combat SkySat Video





シノヨウ

Confidential / Proprietary / Copyright Space Data Corp 2007

Altitudes of Communication Platforms



Cost of and Coverage of Communications Platforms

• Near Space Platforms are very cost effective compared to the alternatives in both acquisition cost and operations cost

			FOV with		
			2 deg. Min		
			Elev		
		Presistance	Angle		
	Altitude	Without	(diameter		Cost per
Communications Platform	(km)	Replenishment	in miles)	Acq. Cost	Fit. Hr.
Tallest Tower	0.6	30 years	21	\$ 3.00	\$ 11
TARS Aerostat	5	30 days *	131	\$ 4.00	\$ 400
Predator UAV	8	16 hours	200	\$ 40.00	\$ 5,000
JSTARS	13	11 hours	300	\$ 244.00	\$ 20,000
Global Hawk UAV **	20	35 hours	405	\$ 67.00	\$ 26,500
U-2	21	10 hours	427	\$ 400.00	Expensive
Near Space Comm. System*	29	12 hours	544	\$ 0.01	\$ 833
LEO: Iridium, ISR, DMSP	781	8 years	3,500	\$2,640.00	\$ 37,671
MEO: GPS	20,355	7.5 years	10,265	\$ 227.00	\$ 3,455
GEO: DSP, SATCOM	35,795	12 years	10,971	\$ 250.00+	\$ 2,378

•Note: Aerostat Persistence is weather dependent, historical availability < 60%

Near Space Comm. System cost per flight hour is based on no recovery, recovery in the commercial system is 87%

** See <u>http://www.globalsecurity.org/org/news/2006/060806-flying-robots.htm</u> for costs per flight hour and

http://www.gao.gov/htext/d06222r.html for cost per air frame



Types of Near Space Platforms



Space Data Near Space Demonstrations

Combat SkySat JEFX'06 Project Marti Tactical Network Topology APCO 2006 DHS / Border Patrol



SkySat Demonstration, March 2005



Combat SkySat Demonstration – March 2005



Space Data Commercial SkySite® Platform (incl. parachute & GPS tracking)

Tether – separable by command

UHF Repeater based on military handheld radios (incl. parachute & GPS tracking)





Starfighter™: Space Data's Integrated Solution



- StarFighter Integrated Repeater
 - Modified our commercial technology to operate in Military UHF range
 - 225 MHz to 375 MHz
 - Multiple transceivers
 - Currently 2 channels
 - Expandable to 6 ch / 12 lb platform
 - Simpler launch & control no tether
 - Half the cost of Combat SkySat & twice the capacity
- Tactical Launch and Control System (TLCS) for field deployment
 - Payload control & status
 - Control up to four payloads
- Demonstrated at JEFX'06 in April 2006, TNT Summer 2006, Project Marti
- Arizona Air Nat'l Guard fully trained for mission with 100 flights to date











SkySite[®] Voice Repeater Kit

- Demonstrated at Assoc. of Public safety Comm. Officers (APCO) Conference – August 2006 in Orlando, Florida
- Responsive communications for disaster recovery operations





Border Protection

oace Data"

OBPORA

- Digital, encrypted voice for Border Patrol agents
- Covers deep canyons & extends battery life
- Supports agent comms. & tracking
- Can be responsively tasked to thwart terrorists crossings upon actionable intelligence



DHS Border Patrol Demonstration Planned for Summer 2007

Dual Payload SkySat Platform **Remote Ground Station** and mission launch NOC Land Line Chandler, AZ **RGS** acts as gateway **Recovery Vehicles**



Space Data Operational Near Space Systems

Commercial M2M Network Near Space Communications System Contract



Space Data's Commercial Machine-to-Machine Network

- Full Constellation provides ubiquitous coverage to > 20% of CONUS
- Tower-based urban coverage provided through roaming to SkyTel
- In operation for over 3 years focused on oil and gas markets
- Over 12,000 flights, over 150,000 flight hours, over 85% recovery rate

Commercial Coverage with 13 Launch Sites



Near Space Communications System (NSCS)

- Deployment contract with USAF SMC
 - \$49 M / 5 year IDIQ Contract
 - Awarded Aug. 2006
 - Free-floating Balloons
 - Comm Relay secure voice/data
 - Truck to carry lower 6-pound payloads to Near Space
 - Three Versions:
 - 225 375 MHz (UHF/FM)
 - 30 88 MHz (LVHF/FM)
 - UHF / VHF cross-band payload
 - 65,000 100,000 ft operation for
 6 to 12 hours
- Training materials and Ground Stations delivered 1Q07
- Active Programs
 - Initial comm. relay deployment quantities on order
 - SOUTHCOM
 - Joint Urgent Operational Need JS approved validation
 - CENTCOM
 - Quick Reaction Capability





NSCS Suspended Payload Configuration

Upper payload provides telemetry for suspended payload via low power RF link

Space Data StarFighter Payload

Tether – separable by command

Suspended Payload (configured with parachute & GPS tracker for recovery if needed)



Typical Near Space Platform Launches

Extensible Balloon (Synthetic Latex) -

- No extra film at launch to catch wind
- Thick and robust at launch and through jet stream, yet thin at altitude
- Capacity to 50 lbs of lift

Zero Pressure Film Balloons (PE) -

- Balloon must be big enough at launch to account for lifting gas expansion to 1% - 7% atmospheric pressure – extra film at launch
- Film thickness determined by launch loads

Capacity to thousands of pounds

Payload Range	Requirements	Crew Size	Max. Winds at Launch Site	
1 to 12 lbs	hand launch	1	45 kts	
13 to 50 lbs	two person hand launch	3	30 kts	
51 - 500 lbs	Rolling Platform or Crane Launch - Complex	5	15 kts	
over 500Rolling Platform or CranelbsLaunch - Very Complex		5	< 5 kts	

* Graphic courtesy of Aerostar

** Graphics courtesy of NASA Columbia Scien. Balloon Facility



HAAREX - 120 lb payload*



NASA Balloon >1,200 lb payload**



Stationkeeping: Designing for Peak Winds Compounds Physical Laws to Require Large Airships



- The Airship Size Compounding Cycle:
 - Wind speed triples and drag goes up 9 times, needing 9 times the thrust
 - This requires 9 times the electric power, thus 9 times solar array area
 - This weighs 9 times more increasing required volume of Airship by 9 times
 - This increases the frontal area of the airship by 4.3 increasing the drag
 - This requires 4.3 times more thrust ... and the compounding continues.
- Free Floaters are designed for the average wind speed
 - For one week a month the winds are three times normal. Thus, instead of 2 nominal launches per day up to 6 launches per day are needed. However this occurs only a couple days per month.
 Space Data*
- Stationkeepers must design for peak winds, thus they are large

Comparison of Airships / Balloons Size

- A dozen programs over 40 yrs have targeted lighter-than-air, propelled flight above 60,000 ft:
 - 3 programs succeeded
 - <10 hrs of powered flight
 - Max 10 MPH / 9 kg payload
- High Altitude Airship (HAA)
 - Prototype to fly in 2010: 150 kg / 3 kW payload
 - Operational HAA 500 ft 500 kg,10-20kW payload
 - No FY08 HAA funding
- Entering another Cicada Cycle?
 - SkyStation: 1990's
 - HAA: 2000's
 - ????: 2010's

Space Data's SkySite: At Launch At Altitude



Potential Applications

- Tactical Ground-to-Ground Comms.
 - Convoy Support
 - Special Operations
- Tactical Air-to-Ground
 - Supports low-flying aircraft
- Intelligence, Surveillance & Reconnaissance (ISR)
 - "Truck" to carry special payloads to altitude for SIGINT / MASINT Missions
 - SAR Imagery using BiStatic Radar swarm of near space platform receivers + comm sat as illuminator
 - Visual / IR Imagery
- High Bandwidth Data Relay
- Emergency Response
- Border Patrol Comm. / ISR
- Wildfire Comm. / Mapping
- Other satellite missions





Good Coverage in Challenging Topography

- 220 Mile link from bottom of Grand Canyon on Aug 3, 2006
 - Used 900 MHz, 2-way handheld radio
 - Only "5 palms" of sky visible
- LEO Sat phone only worked 2 out of 15 min
- Walls too high for GEO Sat Comms.

1770 ft

Havasu Canyon (no camping within 100 yards upstream /2 mile downstream)

Trail to Beaver Falls

& Park Boundary

1.4 Miles (no

overnight use)





SkySite at 80,000 Feet

Bridging Repeater

Critical interoperability between security agencies



Near-Space: High Resolution, Low Cost

QuickBird 60 cm natural color

\$60,000,000 vehicle \$15,000,000 launch

SkySite® natural color demo

\$600 for vehicle construction* \$50 launch*



* Not strictly an apples-to-apples comparison



Rules for Success in Near Space

• It is far easier to make the payload smaller than the platform bigger



1365 grams



93% Weight Reduction over 15 yrs.



2005: Motorola RAZR

95 grams

3 CDMA Radios Bluetooth Radio 1 GPS Radio 1.3 MPixel Camera MP3 Player TV Receiver...

- 1 Analog Radio
- Do not oversize the requirements platforms are inexpensive and responsive enough to simply fly more for more capacity
- Enhance today's Near Space platforms thru evolution not revolution:*
 - Attitude control in all axes
 - Searchlight Spot Beams
 - Solar Power
 - Improved recovery techniques
 - Trajectory correction propulsion
 - Larger payload capability

- Radios in all bands / protocols
- Real-time image downlinks
- OC-3 point-to-point links
- Crosslinks between platforms
- Synthesize a swarm of platforms
 into a large aperture Space Data*
- * Subject of Harvard Business School Case on Space Data Corp. Available at:http://www.hbsp.harvard.edu/

Small Near-Space Platforms: Possible Scientific Applications

- Atmospheric research above 100,000 feet: Space Data has achieved level float at 126,000 feet with rubber balloons
 - Lighting research elves, sprites ...
 - Can fly an array of balloons above thunderstorm
 Cheap / small enough to get struck by lightning
- "Model rocket" class launches from 125,000 ft to reach ~200,000 ft without launch range cost/constraints
- Monitoring of plumes at layers between 0 125,000 feet
 Pollution studies, bio-terrorism …
- Small optics pointing to space or to earth
 - Becoming very inexpensive as digital cameras evolve



Leverage Space Data's Commercial Operations for Scientific Flights

- Launch crews at 13 launch sites staffed 24 / 7
- 7 ground stations with T-1 backhaul covering SW region / 24/7 Net Ops
- Recovery crews in field to inexpensively recover payloads
- Licensed spectrum for longer ranges, GPS location of payloads on ground
- Volume production of radio systems designed for stratospheric operations
- Production of custom extensible balloons for larger payloads



The View from 100,000 Feet

Questions?

