

NDIA JSPE 2015
Cincinnati, OH

26 AUG 15

DISRUPTIVE INNOVATION: INI POWER SYSTEMS

Larry J. Markoski-CEO INI Power
NDIA Joint Service Power Expo 2015

Cincinnati, OHIO



***Session 11: Generators/Man portable
(South Meeting Rooms 232-233)***

□ Who we are

- Small U.S. Business in Morrisville, NC
- DOD Operational Energy focus

□ What we do

- Bridge Operational Energy Capability Gaps
- SOLVE WARFIGHTER PAIN POINTS!!

□ Why we do it

- Support the Warfighter
- Enhance Combat effectiveness

□ How we do it

- Boots on the ground observation
- Closed loop innovation strategy



Reduce JP-8 /Log Tail

Lighten the Load

a) Weight \approx fuel and maintenance

Enhance Combat/Mission Effectiveness

a) Safe/Simple/Reliable solutions

b) Easy for operator to maintain

c) Field maintainable / Field sustainable



Disruptive Innovation=

Rapid iterative development of cost effective material solutions that successfully bridge capability gaps while fulfilling established and emerging requirements

1MPG Capability Gap Emerges

Paradigm Shift from primary to rechargeable batteries to reduce logistics burden and cost:

- FY12 52% of DOD battery spend on rechargeables compared to 26% in FY05
- Handheld rechargeable mobile devices become ubiquitous and typically require less than 50W to recharge
- DOD battery chargers require 50-300W max power
- The smallest DOD generator is sized for 2kW and weighs 145lbs
- Wetstacking becomes common DOD terminology

Capability gap emerges for a reliable DOD generator with the following emerging requirements:

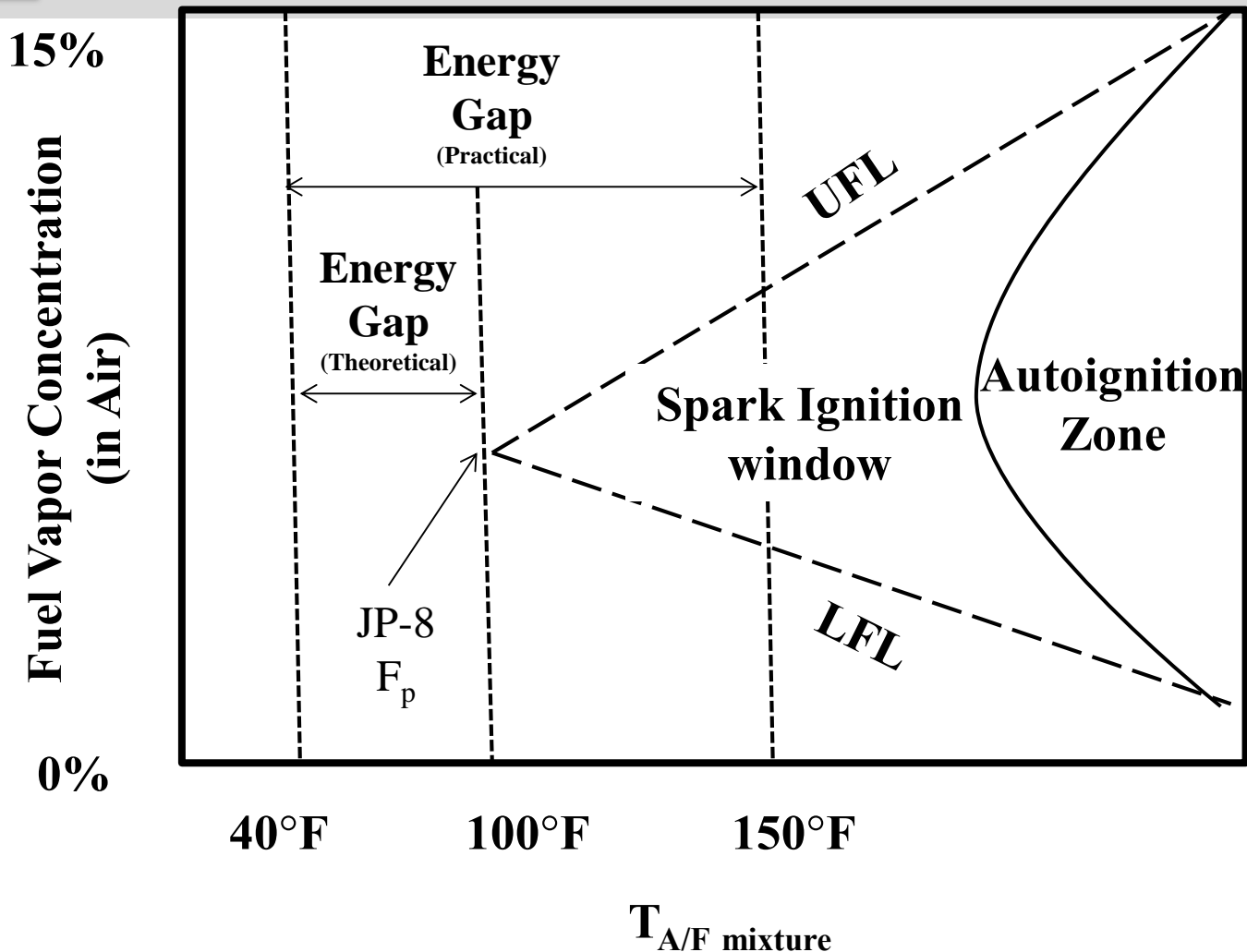
- weight <45lbs (one man portable)
- Right sized to the battery charger critical
- Produces 300W of minimum sustained power
- Quiet is better than loud
- Must be JP8 compatible



DOD Directive 4140.3 (1988) – ‘Single Fuel on the Battlefield’ initiative

- Jet Fuel differences:
 - JP-8 properties
 - < 3000 ppm sulfur; variance allowed in fuel properties including cetane number and distillation curve
 - Referee grade more specific
 - JP-8 is Jet-A1 with three additives
 - fuel system icing inhibitor (**MIL-DTL-85470**) , corrosion inhibitor and lubricity enhancer (**MIL-PRF-25017**) , and static dissipator additive
 - Jet-A1 has lower freeze point than Jet-A (-53 F vs. -40 F)

JP-8 and Spark Ignition Engines (Bridge the Gap)

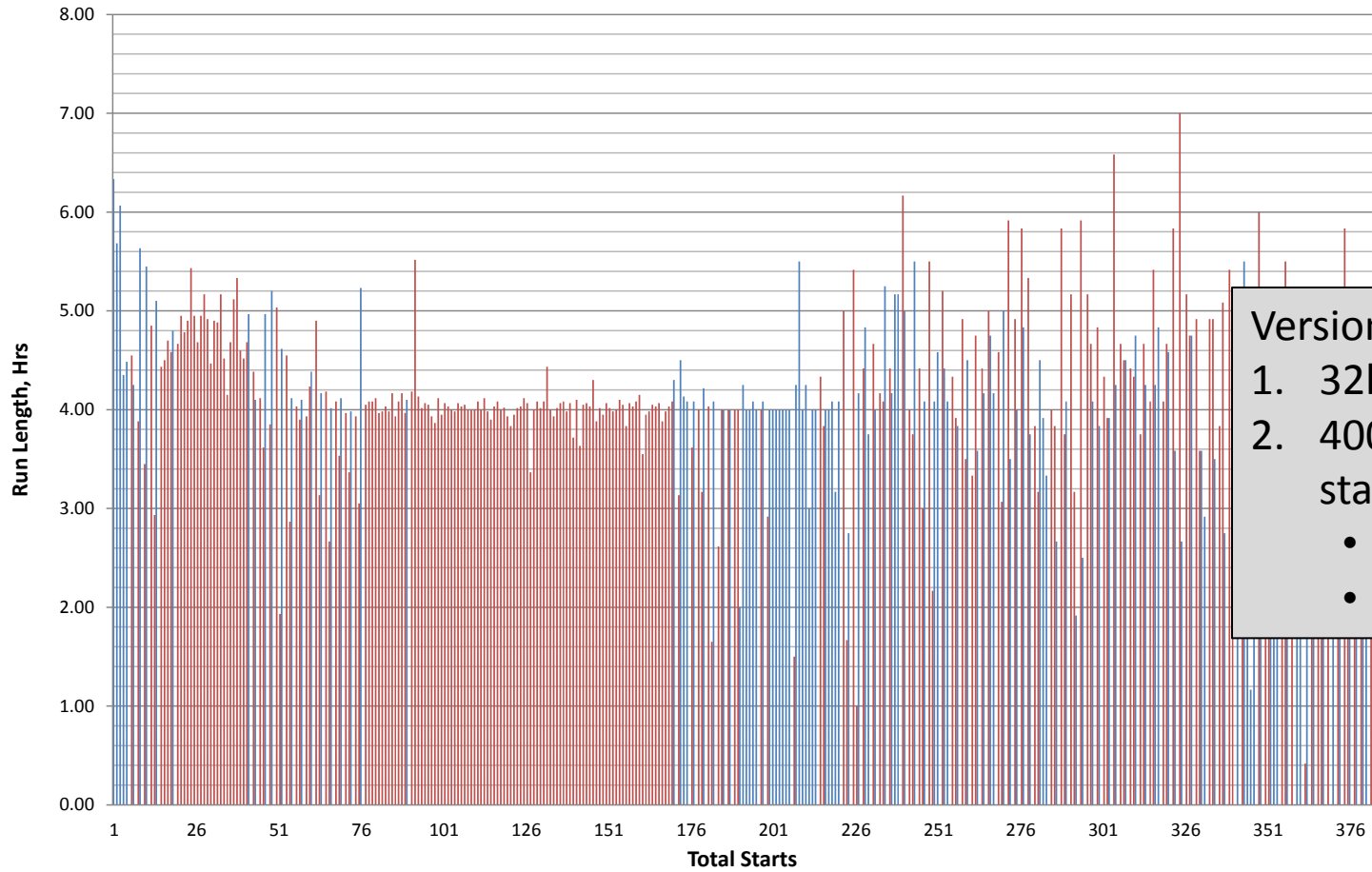


JP8 has both spark and compression ignition windows
4 cycle spark engines are light and quiet!

One Man Portable Flex Fuel Generator (1MPG)

Start Count and Run Length, Unit 1
Total Starts: 381, 25 May – 27 Nov 2012

■ 133 Cold Starts, Ether Required
 ■ 248 Restarts, Ether not Required



Version 2.0 nearly

1. 32lbs (MCOTS)
2. 400 consecutive cold starts (two methods)
 - Chemical and/or
 - Thermal

One Man Portable Flex Fuel Generator (1MPG)

Third Party Validated at Temperature Extremes:



-20°C Cold Start

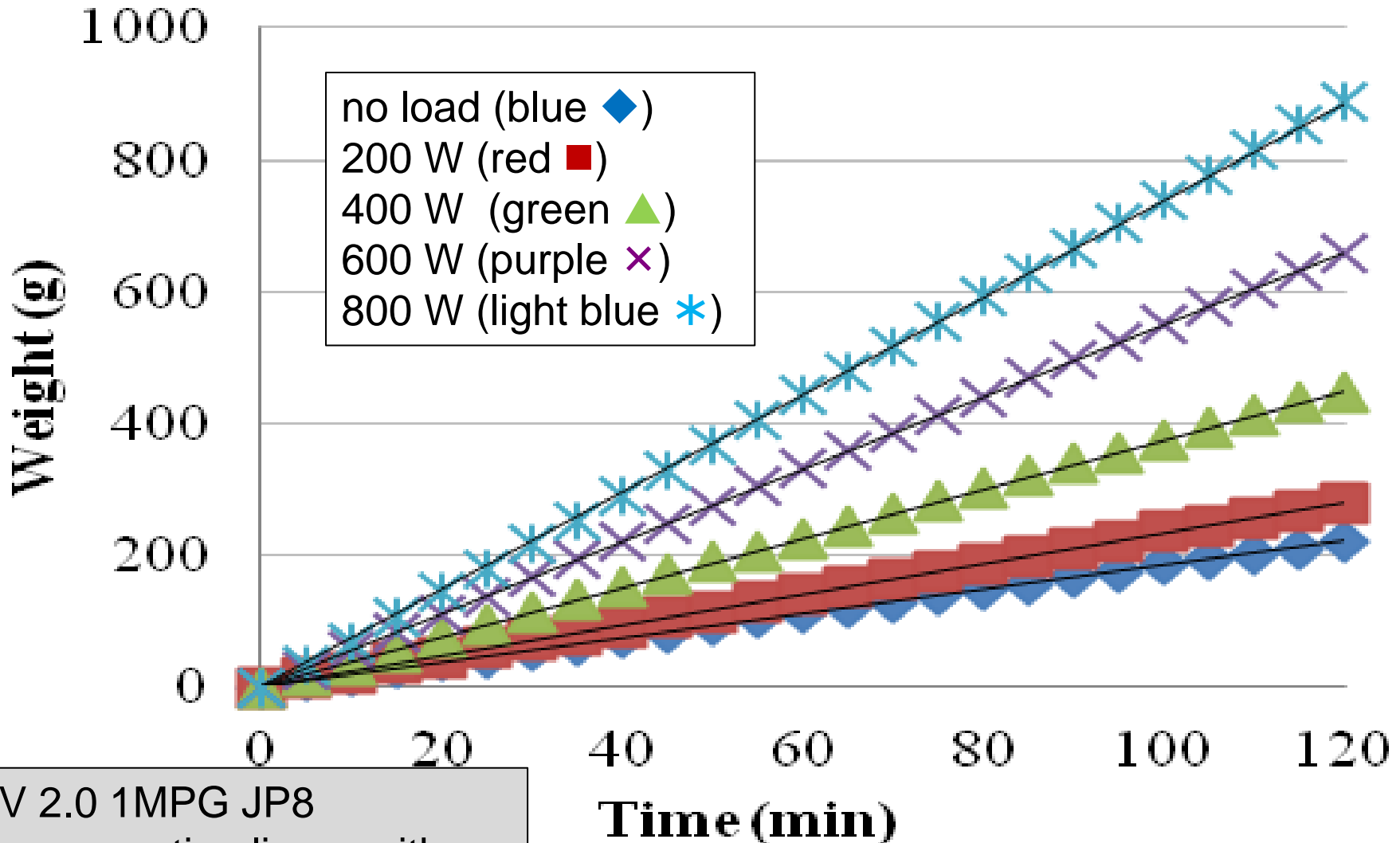


Performance Measurements



Battery Charging at 110°F

Fuel Consumption

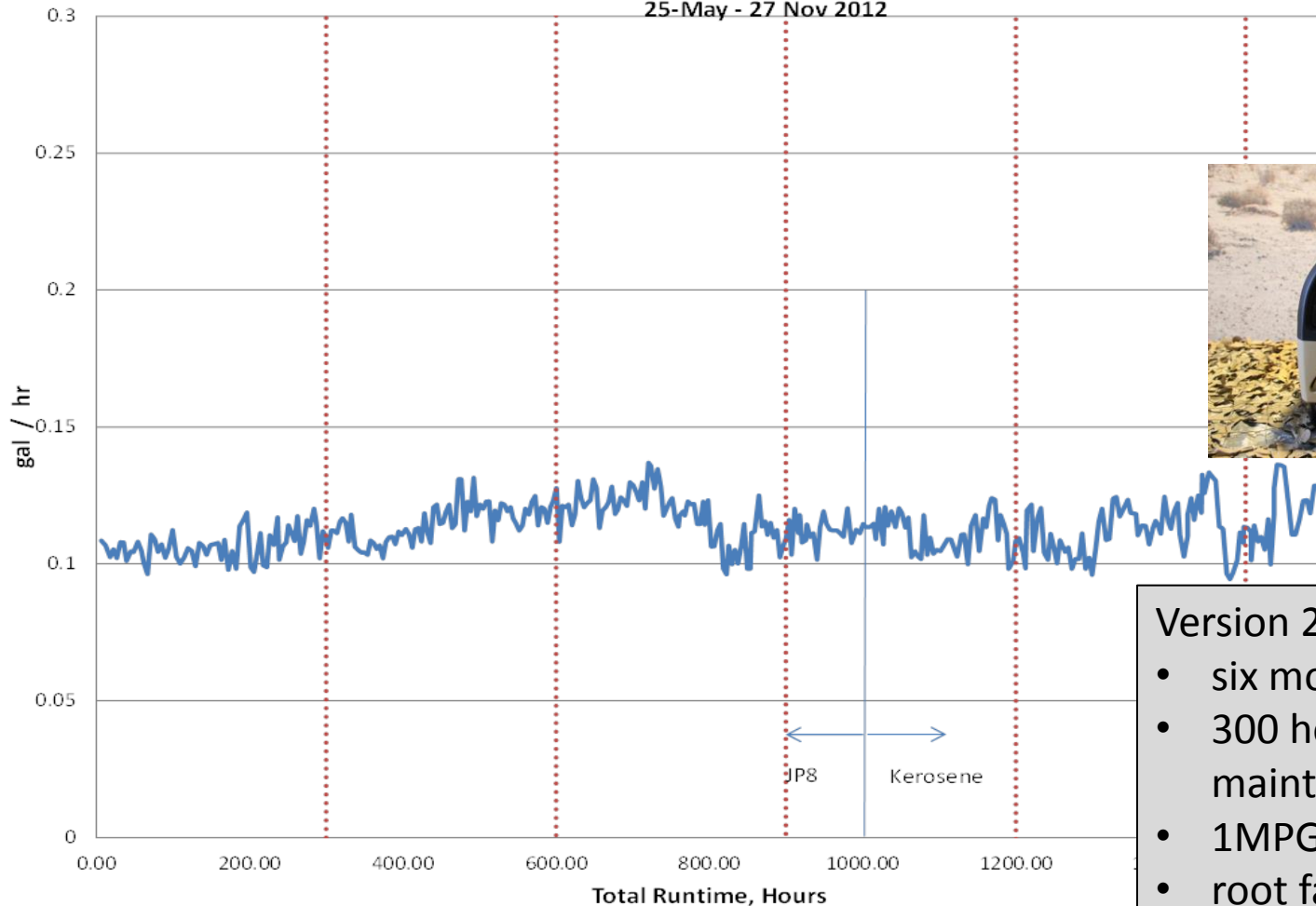


V 2.0 1MPG JP8
consumption linear with
load and time

One Man Portable Flex Fuel Generator (1MPG)

Unit 1, 1K Runtime vs Fuel Consumption (625W +/- 25W)

25-May - 27 Nov 2012



Maintenance Performed

- 300 hrs
- 600 hrs
- 900 hrs
- 1200 hrs
- 1500 hrs



Version 2.0 1MPG (CY12)

- six months development
- 300 hour simple maintenance
- 1MPG ran over 1800 hours
- root failure ID'd

V 2.0/2.1 conclusions

- ✓ JP8 requirement validated with 4 cycle spark engine
- ✓ Weight requirement validated
- ✓ Power requirement validated
- ✓ Fixed jet carburetor provides long life time with simple routine maintenance cycles
- ✓ NIE 14.1 favorable DP3



New or emerging requirements for V2.5

- 1) Need simple method to tune A/F ratio in the field
 - a) Lifetime improvements
 - b) EPA emissions/combustion efficiency
 - c) High altitude battery charging
- 2) F-24 validation(CONUS)

INI Intelli 1kW Flex Fuel Gen v2.5



CS15 ARMY 1MPG Increased Capabilities

CS15 1kW Flex Fuel Generator Enhancements:

- 1) High Impact Resistant Ether shroud (tool free)
- 2) fuel leaning valve (tool free)
- 3) carburetor jet screw (tool free)
 - red=sea level-5000ft
 - blue=5000-1000ft
- 4) Welded Exhaust
- 5) Improved Fuel Labeling (P.rimary/A.lternate/C.ontingency/E.emergency)



1.



2.



3.



4.

5.

FLEX-FUELS			
Primary Military	Alternate Civilian	Contingency*	Emergency*
1. JP-8	1. Gasoline	1. Diesel #2	1. Alcohol (95% or 2151 PROOF)
2. JP-5	2. Kerosene	2. F-76	2. Paint Thinner
3. JP-4	3. White Gas (CAMP FUEL)	3. F-54 (NATO)	3. Nail Polish Remover
4. F-34 (NATO)	4. RUBBING ALCOHOL (≥91%)	4. Jet A	4. BB-2590 Start**
5. F-38	5. DIESEL #1 (GASOLINE/DIESEL#2)	5. Jet A	5. Jet A
6. AVGAS	6. JET A	6. Propane (UPAK req'd)	6. F-34 (CAMP FUEL)
7. MORGAS	7. 50/50 (GASOLINE/DIESEL#2)	7. Jet A	7. Jet A
8. Any blend of above	8. Any blend of above	8. Propane (UPAK req'd)	8. F-34 (CAMP FUEL)
	9. PROPANE (UPAK req'd)	9. Jet A	9. Jet A
	10. JETBOIL (UPAK req'd)	10. Jet A	10. Jet A



FLEX-FUELS			
PRIMARY MILITARY	ALTERNATE CIVILIAN	CONTINGENCY*	EMERGENCY*
1. JP-8	1. GASOLINE	1. DIESEL #2	1. ALCOHOL (≥70% or ≥151 PROOF)
2. JP-5	2. KEROSENE	2. F-76	2. PAINT THINNER
3. JP-4	3. WHITE GAS (CAMP FUEL)	3. F-54 (NATO)	3. NAIL POLISH REMOVER
4. F-34 (NATO)	4. RUBBING ALCOHOL (≥91%)		
5. F-24	5. DIESEL #1 (GASOLINE/DIESEL#2)		
6. AVGAS	6. JET A		
7. MORGAS	7. 50/50 (GASOLINE/DIESEL#2)		
8. Any blend of above	8. Any blend of above		
	9. PROPANE (UPAK req'd)		
	10. JETBOIL (UPAK req'd)		

* Check oil level every 6-8 hours

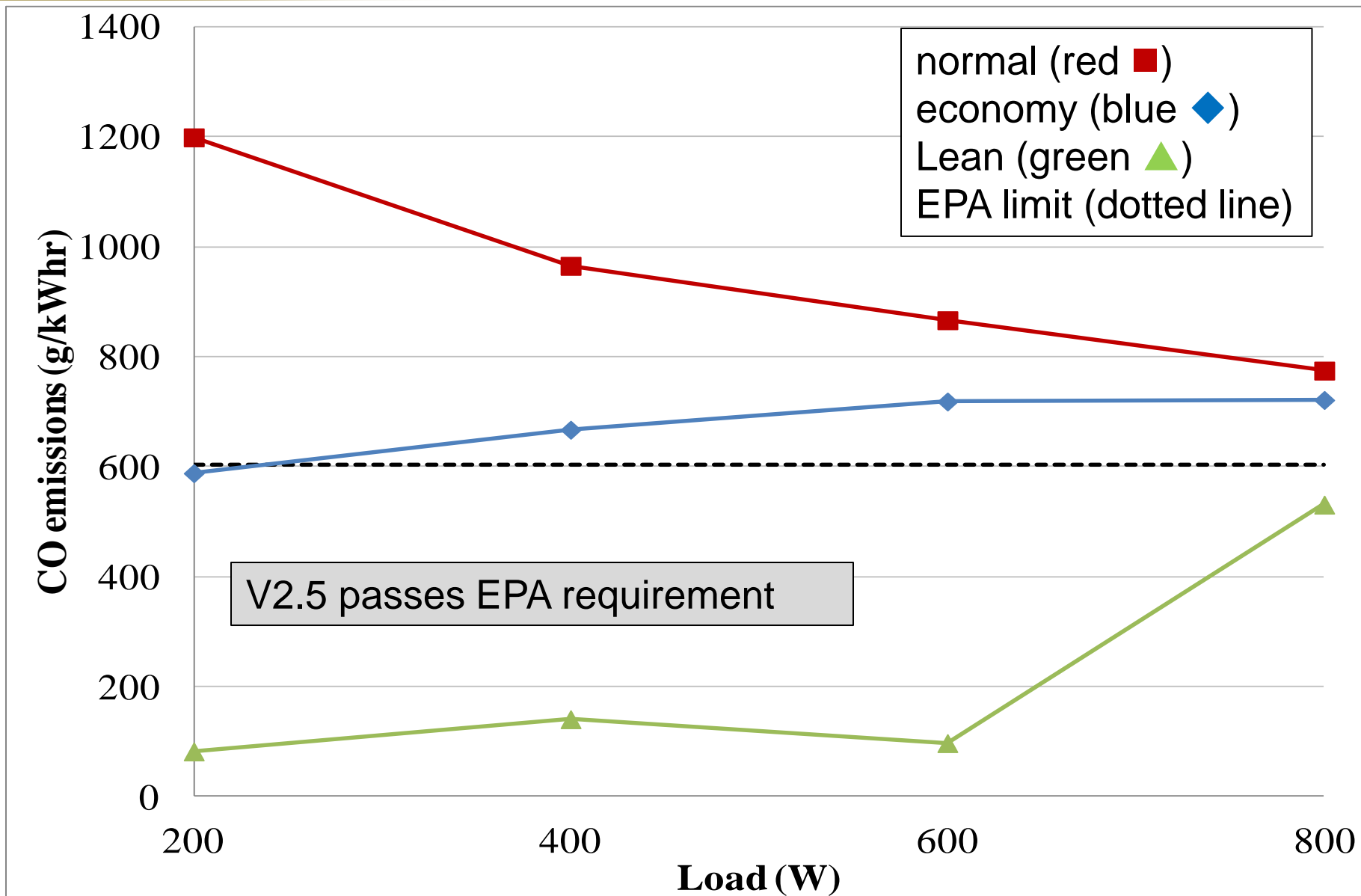
Autostart[†] or BB-2590 Start^{††}

1. JP-8
2. F-34

TASKR req'd
††Cable req'd



CO Emissions



V2.5 passes EPA requirement

Test Plan



Purpose:

- Verify INI Intelli 1kW Flex Fuel Generators v2.5 performance improvements over v2.1
- Verify flex-fuel capabilities

Three Tests:

- Test 1 (8-11 DEC 2014) - v2.5/multi-fuel verification
- Test 2 (5-10 JAN 2015) - v2.5 atmospheric testing
- Test 3 (09-12 FEB 2015) – Company Charging Capacity Test



Test 1



- **At Tobyhanna Army Depot Generator Shop**
- **08-11 December 2014**
- **Verification of v2.5 configuration and its ability to flex fuels**

Test 1 - Metrics



Date	FUEL (ml)	Fuel Consumed (ml)/GEN	AVG Total Run Time/GEN	AVG Tank Run Time (2500ml/.66gal)	AVG ml/hr	AVG GAL/Hr
8-Dec	JP-8	5000	11:31	6:21	430	0.11
9-Dec	DF-1	3000	7:51	7:20	378	0.10
10-Dec	GAS	2750	6:35	5:32	425	0.11
11-Dec	Kero	3500	8:29	6:35	413	0.11

Date	FUEL (ml)	AVG ENGINE RUN TIME (hrs)	AVG ENGINE TEMP (C)	AVG OUTPUT (Volts)	AVG LOAD (Amps)	AVG LOAD (Watts)	AVG HOSE TEMP (C)
8-Dec	JP-8	11.6	159.5	122.3	4.9	599.4	104.5
9-Dec	DF-1	7.9	156.2	122.2	4.9	599.9	97.0
10-Dec	GAS	6.5	161.1	122.3	4.7	573.2	97.5
11-Dec	Kero	8.5	163.7	122.2	4.9	599.7	104.2

1MPG V2.5 flex fuel validated for short durations

Test 2

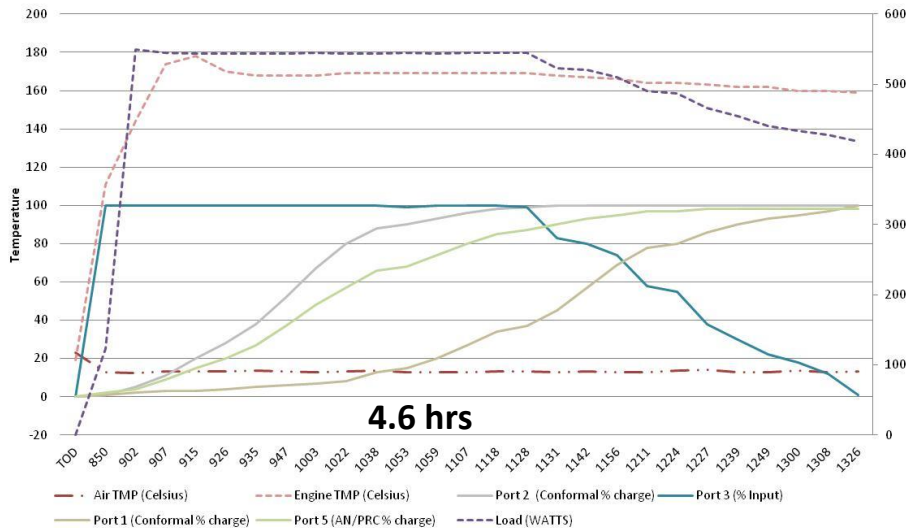


- **Electronic Proving Grounds Environmental Test Facility**
- **05-10 January 2015**
- **v2.5 Atmospheric testing (simulating 5000 feet & 10,000 feet)**
- **In parallel with the SPM-622 atmospheric testing**

Test 2 Day 2 – F-24

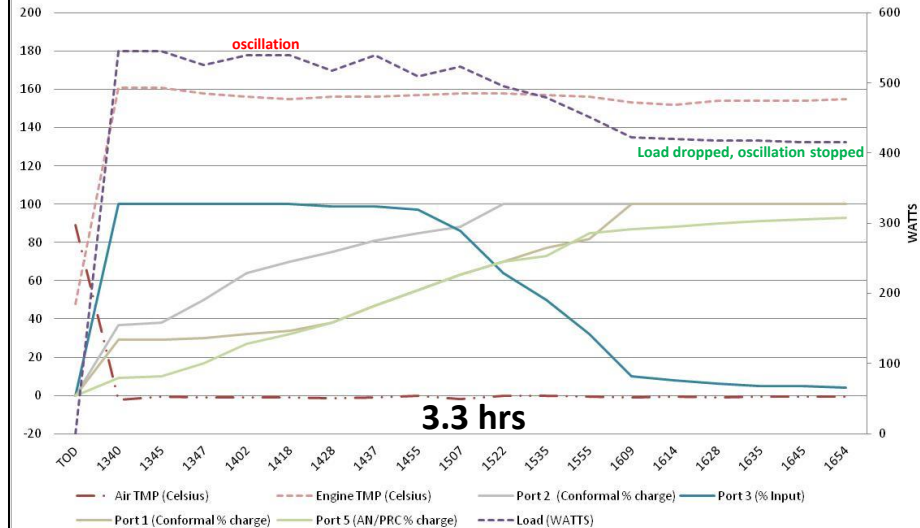


5,000 ft (12.8 C)
F24 FUEL
SMP Configuratin 2
Battery Configuration 1 (initial charge=0%)



- 5K altitude and ambient temp had no effect on running with F-24, generator performed very well
- Similar SPM battery charging pattern pulling 120W load for battery charging at ambient temperature
- 400W Light load remains constant

10,000 ft (-1.1 C)
F24 FUEL
SMP Configuration 2
Battery Configuration 2 (initial charge between 9-37%)



- 10K altitude had an affect on power production indicated by engine rpm and output power oscillation*
- When load dropped below ~420W oscillation stopped*
- Similar SPM battery charging pattern pulling 120W load for battery charging at freezing
- 400W light load remains constant



Generator Testing Key Finding



Test 1: S/N 01074 – 66.7 hrs	
01076 – 62.9 hrs	
01077 – 62.4 hrs	
Test 2: S/N 00991 – 40.2 hrs	
Total	232.2 hrs

- v2.5 is a marked improvement over v2.1
- Runs best with F-24 or JP-8
- Operator experience key to optimal performance
- Tweaks necessary for flexing fuels and high altitude performance

	Operation at 2000ft	Operation at 5000ft & 12C	Operation at 10,000 & -1C	Charging Profile Test
JP-8				Not Tested
F-24	Not Tested			
Gasoline				Not Tested
Diesel				Not Tested
Kerosene				Not Tested

- Flexing fuels comes with a maintenance cost
 - Oil changes become more frequent at much shorter intervals
 - Increase in random spark plug failures

* yellow indicates maintenance problems, red indicates eventual engine failure if PM not performed within 8-12 hours

V 2.5 conclusions

- ✓ F24 requirement validated with 4 cycle spark engine
 - ✓ JP8/F24 validated at high elevations and battery charging
 - ✓ A/F tuning works well
 - ✓ EPA small engine requirements met
- Need some tweaks for D1/D2



New or emerging requirements for V3.1

- USMC Autostart on JP8 from 0-40°C in less than 5 minutes
- USMC One man portable Autostart kit

USMC 1MPG POTENTIAL SYSTEM CONFIGURATIONS

Manual Start (manned)

Electric/Auto Start (unmanned)



1) Chemical Start: -20-55°C

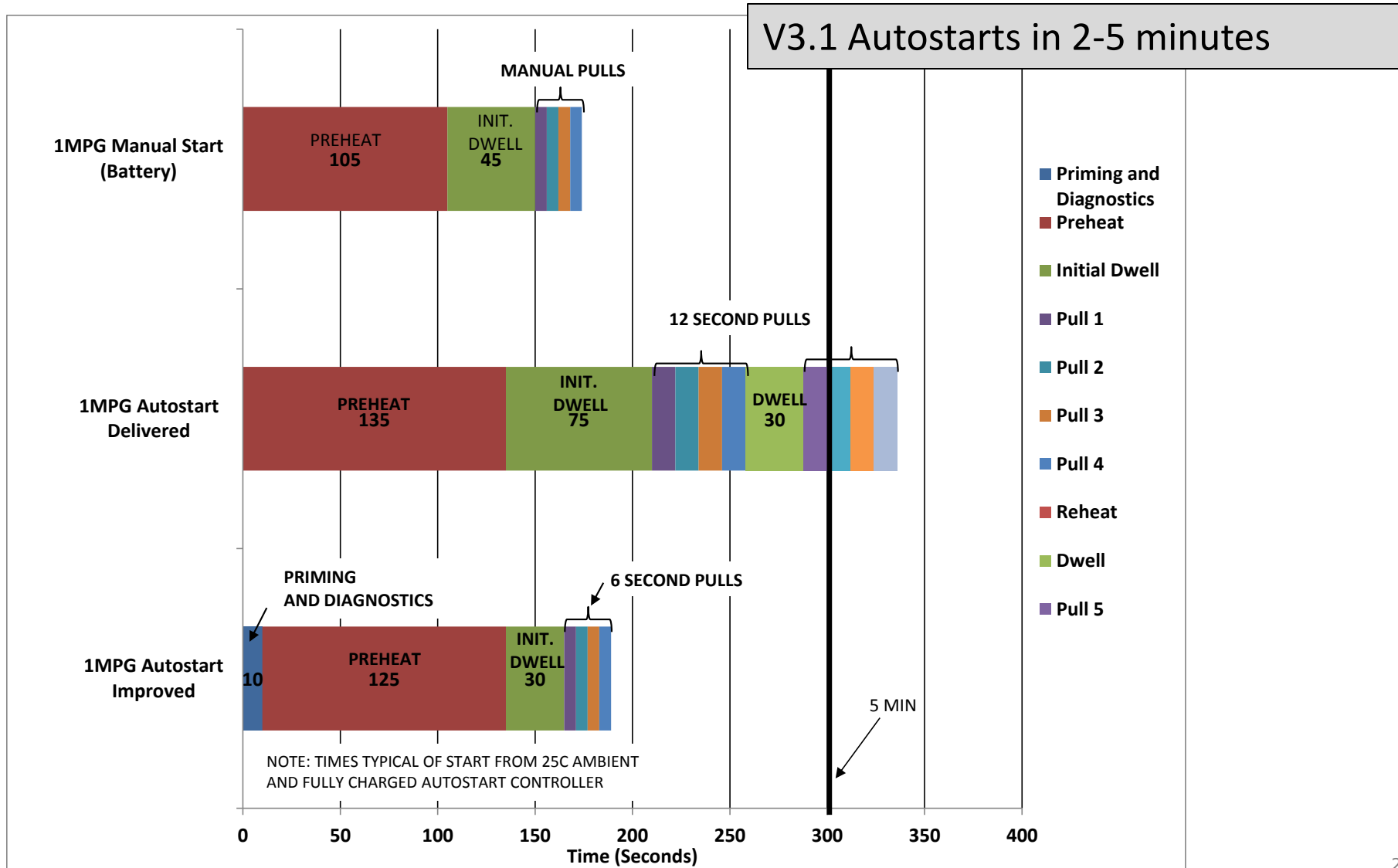


2) Thermal Start: 0-40°C



3) Autonomous Thermal Start: 0-40°C

1MPG AUTOSTART ON JP8



V 3.1 conclusions

- ✓ Autostart validated 3-5 minute start-up
- ✓ KPPs met for USMC 1MPG
- ✓ POR downselect



New or emerging requirements for V3.5 (PPG)

<30lbs

900W continuous power

28VDC (10A)

CONCLUSIONS

Keys to a successful disruptive innovation process:

- Identify the capability gap
- Embrace the requirements
- Lean forward with emerging requirements
- The faster you can iterate....the faster you can innovate
- Don't overlook the obvious
- Don't be afraid to fail!

1. US ARMY CERDEC
 - a) Early Funding
 - b) Testing/SAR development
2. US ARMY Rapid Equipping Force (REF)
 - a) Safety confirmation
 - b) Emerging requirements
3. US ARMY PM Soldier Warrior (SWAR)
 - a) Performance validation
 - b) Requirements development
4. Marine Corps Systems Command (MCSC)
 - a) Well defined and achievable KPPs
 - b) Supporting small business
5. **The entire INI Power Systems Team**

