



SAFE Europe, Bristol 2014

JSF F-35 Pilot Cooling Unit Development & Verification Update

Brendan Smith
Project Manager
Survitec Group

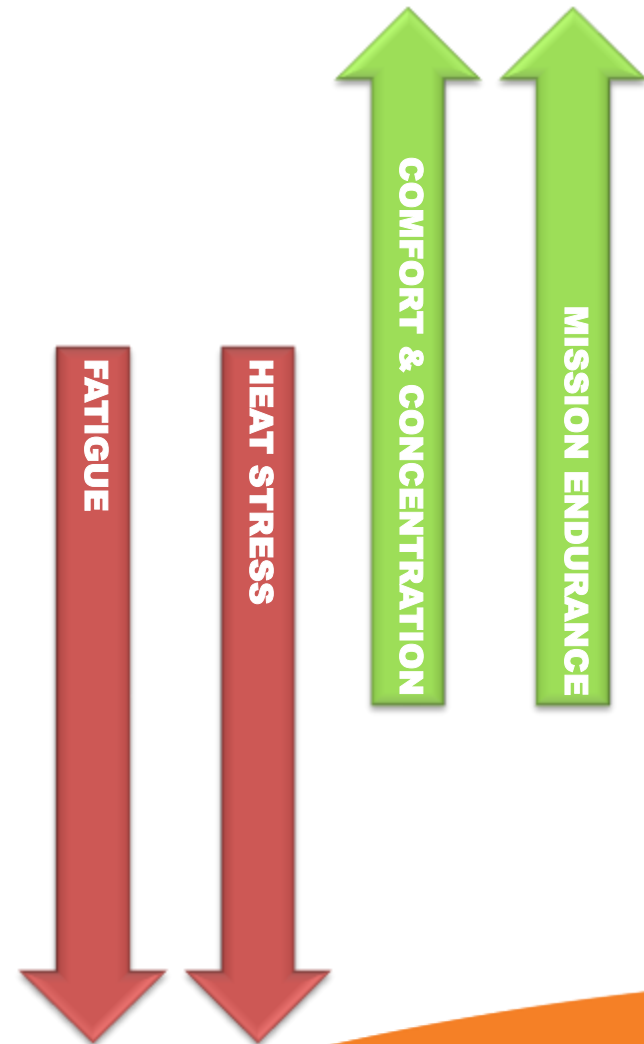




PCU Design

Design Objectives

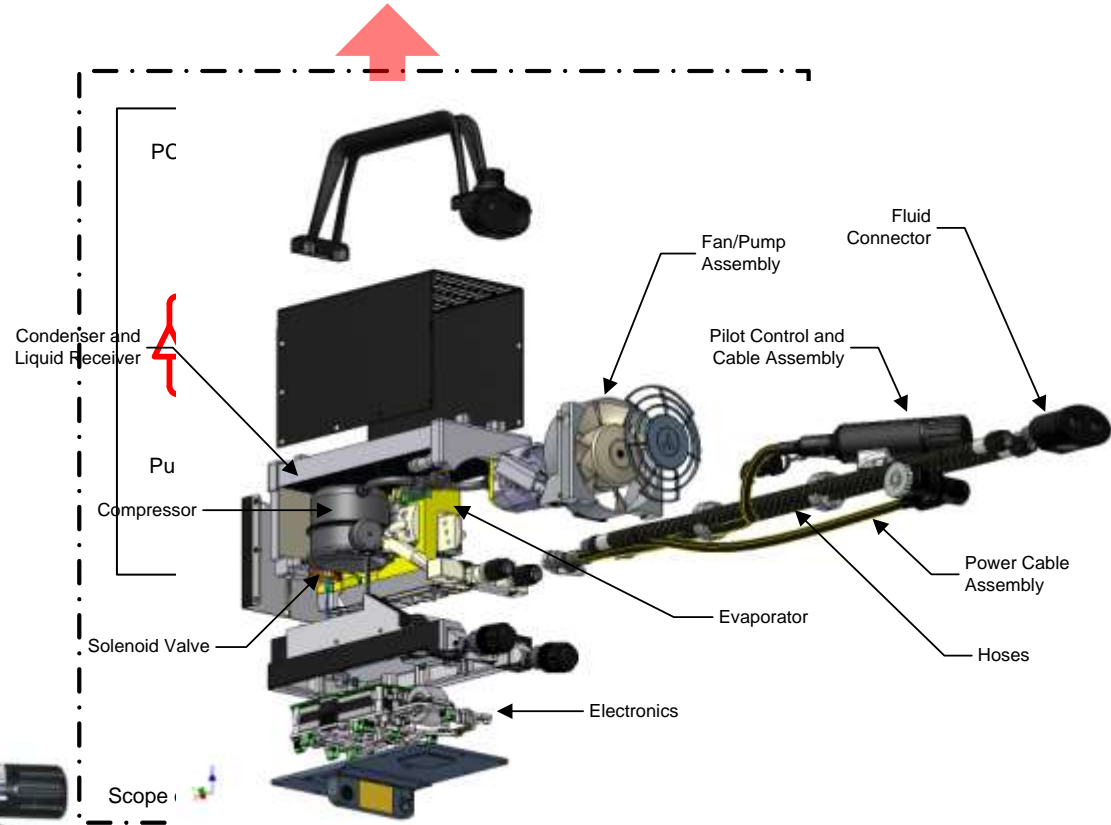
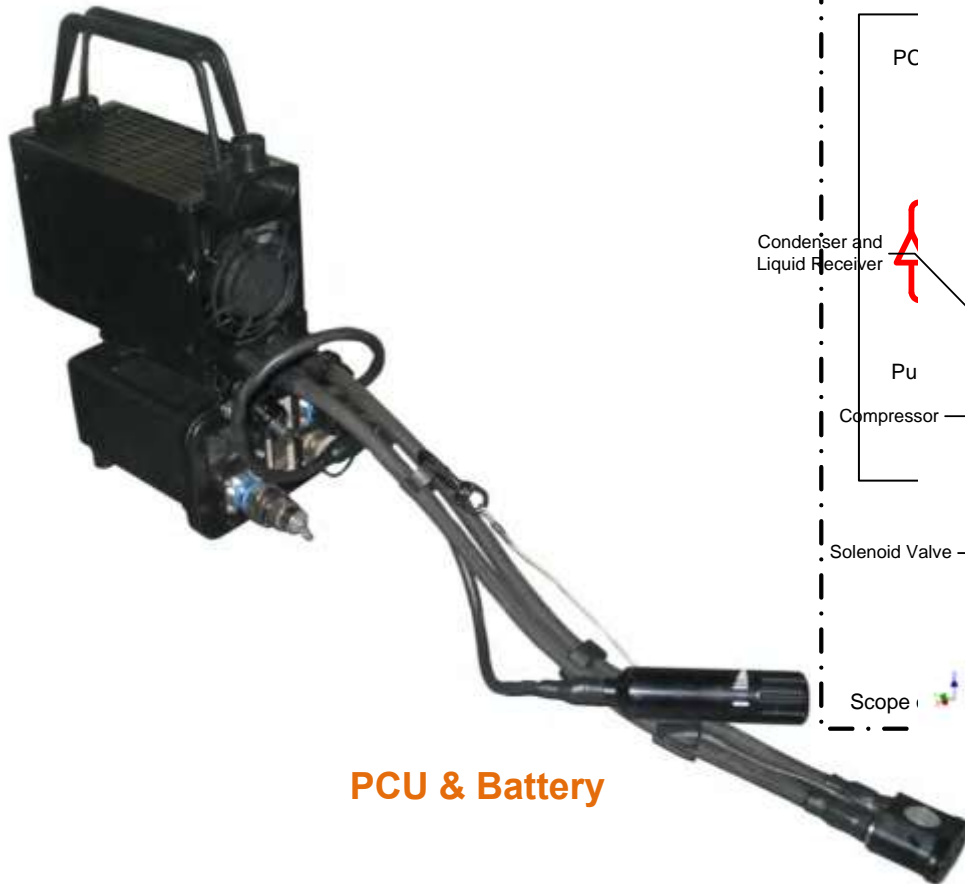
- Provide **compact, lightweight, portable** cooling capability for F-35 Pilot in all schedules of PFE
- F-35 PCU compact designed for **pre-flight ground use**, easily mounted **in the cockpit**
- PCU utilises optimised flow rate, with **low power requirement**. Pilot Control offers a **selectable temperature range**
- **Reduced size and mass** makes this PCU suitable for many platform applications
- Provides effective cooling improving Pilot **comfort and performance**
- Designed for **multi mission roles**





PCU Design

Product Overview



PCU Exploded View



PCU Design

Product Overview



PCU Battery Charging Unit



PCU Fluid Charging Unit



Fully Integrated System



Summer



Summer CB



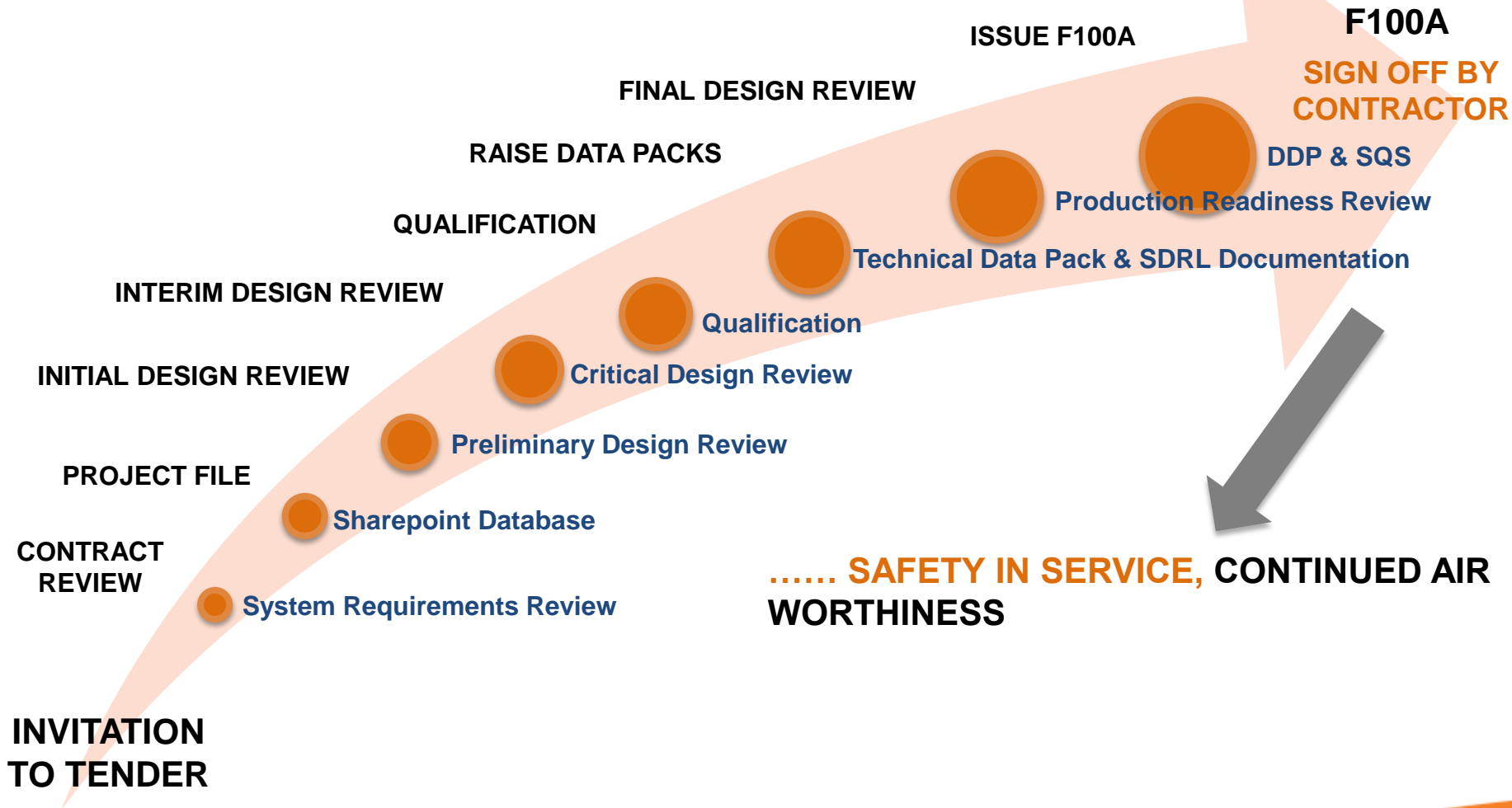
Winter Sea



Winter Sea CB



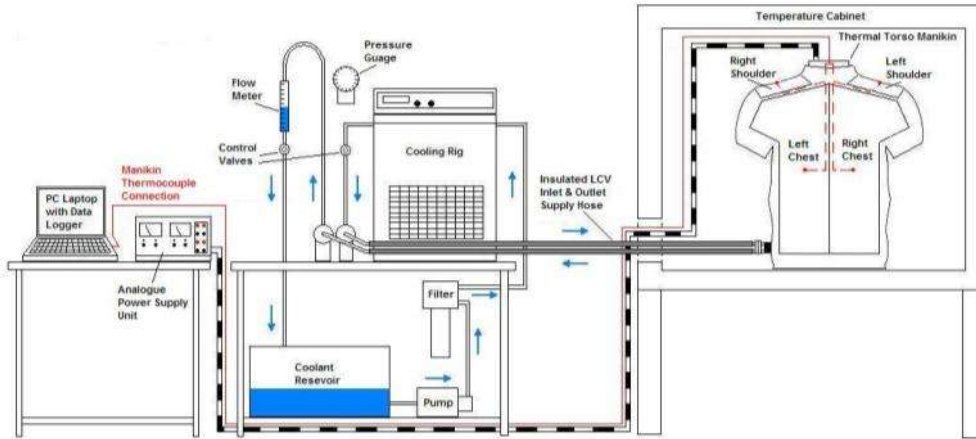
System Development & Demonstration





Fully Integrated System

Design of Experiments for Optimized Performance



TEST	COOLANT	HEAT EXTRACTION (WATTS)	T _{in} (°C)	AIR TEMP (°C)	FLOW RATE (L/MIN)	CLOTHING SCHEDULE	SOLAR LOAD (W/M ²)
A1 A2 A3	A		12 to 27	20 35 50	1.0	Winter/Sea No NBC	-
B1 B2 B3	B		12 to 27	20 35 50	1.0	Winter/Sea No NBC	-
C1 C2 C3	B		12 to 27	20 35 50	1.3	Winter/Sea No NBC	-
D1 D2 D3	B		12 to 27	20 35 50	1.6	Winter/Sea No NBC	-
E1 E2 E3	B		12 to 27	20 35 50	1.6	Sum/Land No NBC	-
F1 F2 F3	B		12 to 27	20 35 50	1.6	Winter/Sea No NBC	1120
G1 G2 G3	B		12 to 27	20 35 50	1.6	Winter/Sea With NBC	1120
H1 H2 H3	B		12 to 27	20 35 50	1.6	Sum/Land With NBC	1120
I1 I2 I3	B		12 to 27	20 35 50	1.6	Solar LCV & Clothing with worst Heat Extraction from F, G or H above	1120
J1 J2 J3	B		12 to 27	20 35 50	1.6	Silicon LCV & Clothing with worst Heat Extraction from F, G or H above	1120

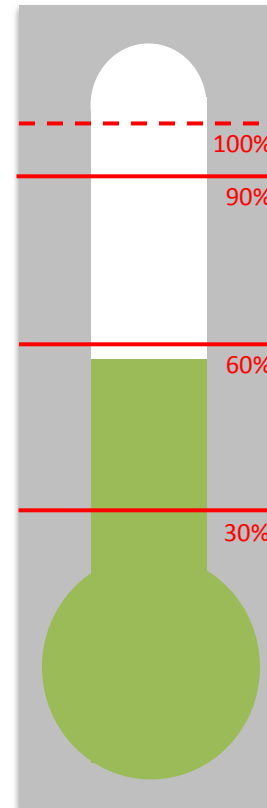




PCU Verification Status

SDD Verification

- 45 of 50 Qualification tests complete which include:
 - Mechanical Endurance
 - Explosive Decompression
 - Storage Temperature
 - Operating & Non Operating Temperature
 - Shock
 - Solar Radiation
 - Electrical Endurance
 - Chemical Biological
 - Cockpit Integration
 - Ejection/Escape System
 - Temperature / Altitude / Humidity
 - Rain
- Outstanding Qualification testing (April 2014):
 - Salt Sea Atmosphere, Sulphur & Nitrogen Oxide
 - Vibration / Temperature
 - Thermal Shock
 - Altitude
 - High Temperature

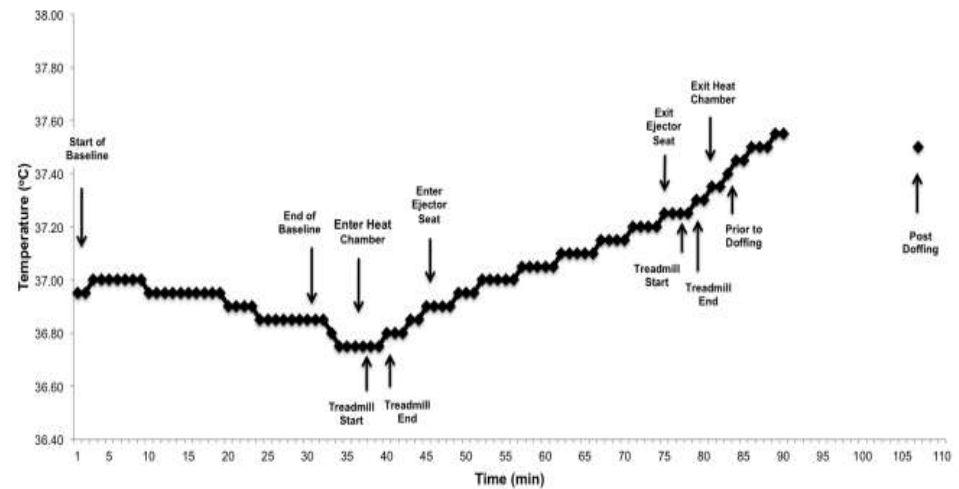




PCU Qualification

Thermal Burden

- Requirement:
 - Maintain body core temperature below 100.4°F (38°C) in an ambient temperature of 120°F (49°C) and 1120W/m² solar load
 - Represents worst case thermal burden scenario on the ground with canopy open
- Human subject testing conducted for PFE Qualification:
 - 6 subjects wearing Winter Sea CB max bulk schedule
 - Treadmill walk
 - Seat strap-in & rest
 - Treadmill walk
 - Laboratory cooling unit set up with PCU operating parameters
 - Follow-up human subject testing conducted with actual PCU
 - All testing resulted in body core temperature being maintained below 100.4°F (38°C)





PCU Qualification

Cockpit Integration

- Pilot Vehicle Interface trials conducted:
 - 2 PVI events conducted
 - 13 subjects; 8 Pilots, 5 non Pilot subjects (anthropometric extremes)
 - All 4 PFE schedules assessed
 - CB donning & doffing through simulated COLPRO
 - Pre flight walk out & checks
 - Cockpit ingress
 - Crew station manoeuvres & mobility checks
 - Simulated emergency egress
- Main findings for PCU:
 - Cooling Garment to PCU connector interface redesigned to overcome ergonomic challenges with 5th percentile CB ground maintainers during Pilot connection in cockpit





PCU Qualification

Ejection/Escape System Testing

- 7 Ejection tests with PCU hose assembly conducted
- Cooling Garment/PCU release lanyard system demonstrated to provide disconnection from Pilot across full speed range up to maximum 550 KEAS

CG/PCU disconnected 550 KEAS QUAL 13R Escape System Test



CG/PCU disconnected



PCU hose assembly post test



PCU Qualification

Chem Bio live agent & decontamination testing

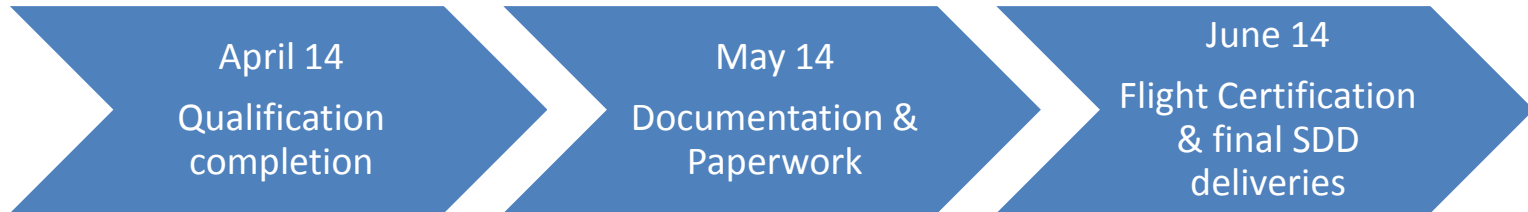
- **Part 1 – Testing for ingress into fluid circuit:**
 - Air was passed through coolant circuit whilst exposed to CB liquid or vapour challenges
 - **Liquid challenges** applied to areas/interfaces
 - **No significant ingress**
- **Part 2 – Testing for operation whilst contaminated & subsequent heated air decontamination:**
 - Agent exposure did not affect function of PCU
 - **Decontamination requirements achieved**
- **Cooling Garment to PCU fluid connector** – protected in CB Coverall breakout sleeve
 - Male Connector on CG always protected by breakout
 - Female Connector on PCU – risk of external contamination
 - Tests conducted where contaminated with liquid, wiped off and mated in breakout as per Part 1 test above
 - **No significant ingress**





PCU SDD Closure

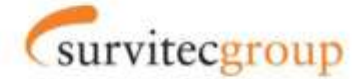
PCU Schedule





Questions?





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