11th Annual

NDIA System Engineering Conference

Enterprise Health Management Committee

Electronics Prognostics Technology Study

E-Prog Figure of Merit Application

23 October 2008

Briefing Topics

- The Background of NDIA Electronic Prognostics Studies
  - Why Electronic Prognostics
  - The Trail to The Current Application Study
  - NDIA Study Results
  - Some Electronic Prognostics Figures of Merit (FOM)
- Putting Numbers on the Figures of Merit
  - The Process for FOM Computation
  - The Results - Data, Analysis, Computation of FOM Values
- Application of the FOM Results to the Fleet
  - Air Force
  - DOD
- Next Steps

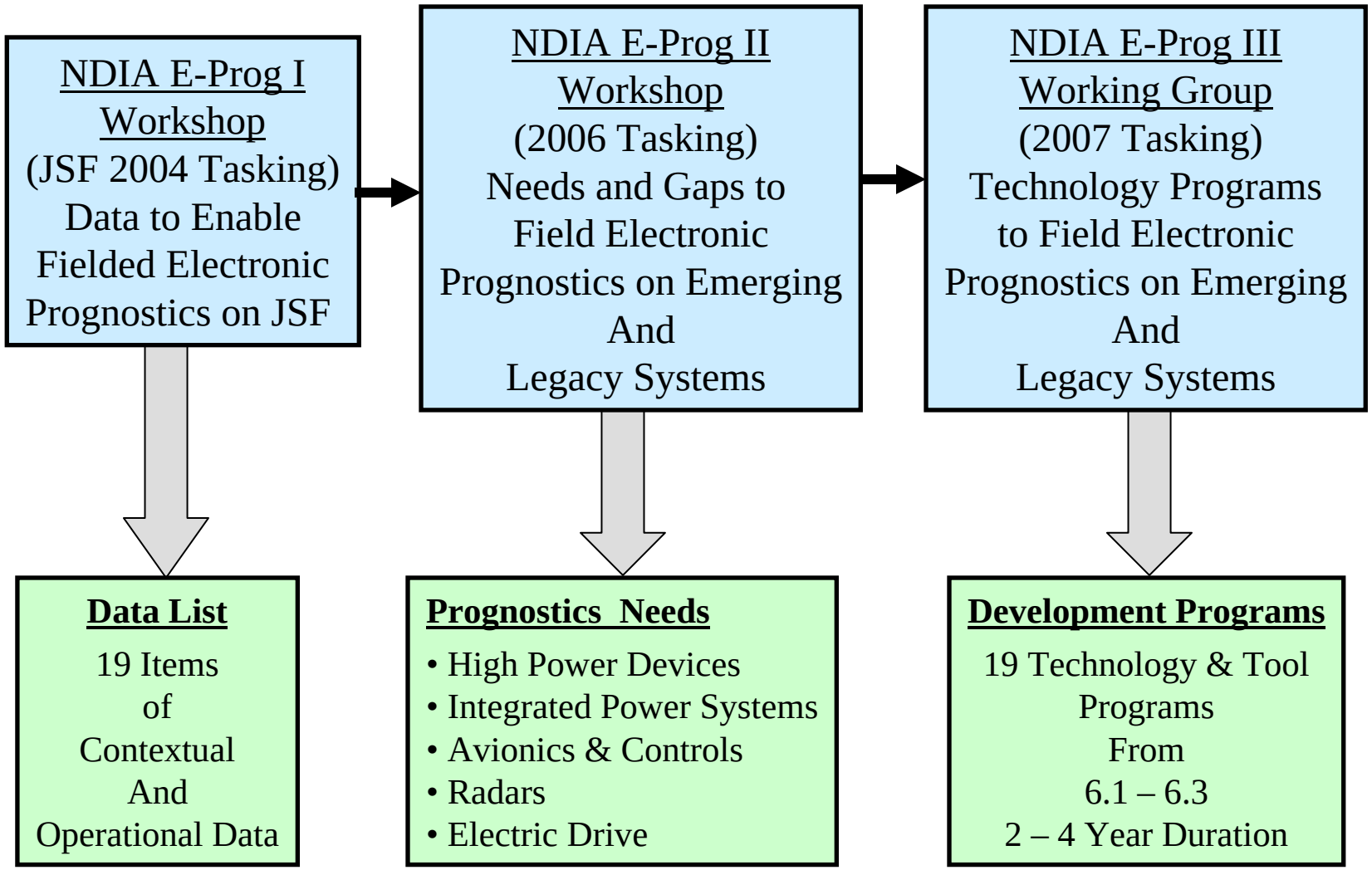
Why Electronics Prognostics

- Greater reliance on electronics and electrical based systems:
  - Navy – JSF, EMALS, AAG, Shipboard Weapons Loader, shipboard electric drive, Integrated Fight Through Power, ForceNet, linear motor elevators, etc.
  - Army – FCS Hybrid electric drive, soldier mounted electronics, MTRS, Net Centric Warfare, etc.
  - AF – JSF, F-22
- Enables users ability to operate and maintain increasingly sophisticated weapon systems
  - Prognostics provides advanced warning of deterioration as opposed to reporting failure
  - Potential to reduce downtime for unscheduled maintenance and reduce costly secondary damage associated with failures
  - Supports emerging distance support initiative
- Required technology to enable PHM, Performance Based Logistics, and Sense and Respond

Legacy VS Prognostics Health Management (PHM)
Summary of Expectations

		PHM Benefits
Maintainability		
	MFHB CND	79-82% Improvement
	MFHBME	13-14% Improvement
	MFHBR	3% Improvement
	MMH/FH	17-32% Improvement
Support Equipment		
	QTY Weight (Lbs.) Volume (cu ft)	Reduction of 6-10%
Manpower		
	QTY	Reduction of 46-52%
Logistics Footprint		
	C17 Loads, Tons	Reduction of 2-17%
Safety		
	Mishap Reduction	Reduction of 14-38
SGR		
	SGR (Initial/Sustained)	10 to 14% Improvement
Airframe/OML Restoration		
	Recurring Cost	$1.05B - $7.87B Cost Avoidance

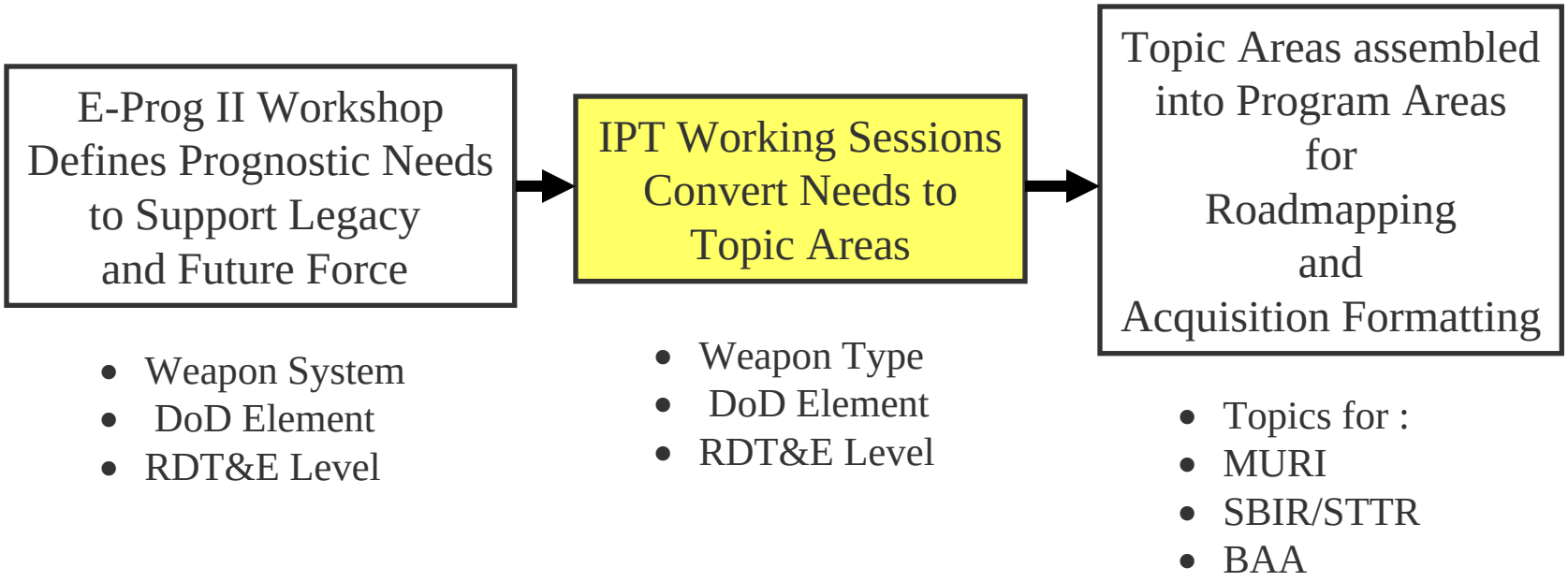
The Trail To The Current Application Study



NDIA Study Results
Post E-Prog II Workshop Process

- All Gov't Task IPT
- Developer and User Focus - not S&T
- Defined in Real Prognostic Terms Based on Repair and Logistics Delay Times
  - Prognostic Horizon - How much longer will it work before failing?
  - Confidence factor - % confidence that the estimated Horizon is right

PROCESS



E-PROG R&D PROGRAM EXAMPLE 1

Prognostics for Power Supplies and Converters

Program Rationale: This program area addresses the need for prognostics for all types of electronic power supplies and power converters. Sensed parameters, sensor performance characteristics, sensor configuration (built into or added on to the device), data analysis algorithms, degree of smart sensing and integration with other electronic and electromechanical prognostic technologies are all a part of this effort. The Verification and Validation of the prognostic technology are included as part of this program.

Key Program Elements*:*

- Implementable prognostics for power supplies/converter.
- Transition of current SBIR technology to wider applications.
- Development of additional technology where needed.
- Incorporate in new designs and appended/integrated in current designs

Horizon: T = 100 hr
O = 1000 hr

Confidence: T = 90%
O =95%

S & T Category	Estimated Duration (Years)	Budgetary Man-Years
6.1 Basic Research	0	0
6.2 Applied Research	2	16
6.3 Advanced Technology Development	2	16
6.4 Advanced Component Development	1	8
Total	5	40

Table 20. E-PROG Program 19 Development Plan

NDIA Study Results

Program Breakout by R&D Category and Product Type

E-Prog Description	6.1 Basic Research	6.2 Applied Research	6.3 Tech Demo	6.4 Tech Application	Prod. Type
1. Physics of Failure Model for Gates, Devices and IC's					**M**
2. Electronics Prognostics for High Power Switching Electronics					**PT**
3. BIP Prognostics for Devices and Circuit Boards					**PT**
4. Electronics/electro-optical Prognostics for Tactical Sensor Systems					**PT**
5. Generic Environmental/Operational Parameter Monitoring Module for Electronic Prognostics					**H**
6. Electronic Prognostics for C4ISR Systems					**PT**
7. Maintenance Mode/Prognostic Interaction Design Tool					**T**
8. Interconnection Prognostic Technology					**PT**
9. Electronic Interconnection Prognostic Design Tools					**T**
10. Electronics Prognostics Financial Modeling Tool					**T**
11. Tool for Logistics Impact of E-Prog					**T**
12. Prognostics for HCI Electronics/Electro-Optics					**PT**
13. Prognostics for Redundant Electronic Systems					**PT**
14. Electronic Prognostics Design Tool for Environmentally Tolerant Electronics					**T**
15. Electronics Life Usage Assessment and Prognostics - Electronic Prognostics Life Usage System (E-Plus)					**PT**
16. Data Enterprise System - Module to LRU Tracking for Electronics Prognostics					**PT**
17. Electronic Prognostics Reasoner Engine applicable to Device through System					**PT**
18. Electronic System Level Prognostic and RUL Tool Set					**T**
19. Prognostics for Power Supplies and Converters					**PT**

M = Model, H = Hardware, PT = Prognostic Technology, T = Tool

NDIA Study Results
Road Map

Man Year Summary By FY

	FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	Total
6.1 Total	41	45	26						112
6.2 Total	28	48	112	80	32				300
6.3 Total	0	20	20	72	88	60	8		268
6.4 Total	0	0	8	16	20	44	44	8	140
Totals	69	113	166	168	140	104	52	8	820

- **Nearly 70% of Program is 6.2 & 6.3 - only 14% of Program is 6.1**
- **Benefits of effort start to be realized in FY3**
- **Majority of effort is completed within 4 – 5 years**

Some Electronic Prognostics
Figures of Merit

Potential Areas Where Electronics Prognostics Could Offer Significant Benefits to Advanced Military Systems

Benefit Area	FOM Metric
Total cost of ownership reduction	% Reduction in Support Cost, Material & Labor
Reduction of cost of false removals	% Reduction & Cost Savings on Spares & NFF/RTOK
Improved system availability	% Reduction in NFMC and Recovered Sorties

Putting Numbers on the Figures of Merit
The Process

- Select a Program for FOM Analysis
  - Fielded Air Force Fixed Wing (F/W) Aircraft
  - High Mission Electronics Content
  - Analysis of 50 Mb Support Data from Approximately Wing Size Sample
  - Analyzed a 2 Year Operational Period, Annualized Results

- The Analysis Approach
  - Calculate the Component Parameter Values
    - **Mission Aborts from Electronic Causes – Replacement Weapon Systems to Reestablish the Mission Rate**
    - **MMH for Electronics Maintenance – Reductions from Embedding E-Prog**
    - **Excess Spares Usage and Inventory – Due to lack of Embedded E-Prog**
    - **NFF/RTOK Rate –Material and Labor Cost due to lack of Embedded E-Prog**
  - Assemble the Component Parameter Values into The FOMs

Putting Numbers on the Figures of Merit

Analysis of Expected Savings From Embedded Electronic Prognostics

Calculated Component Parameter Values

- **Mission Aborts from Electronic Causes**
  - **NMC Aborted Takeoffs + In-flight Aborted Missions = 55 (8%)**
    2 Additional A/C per Wing)
  - **NFMC Missions (Prior to Takeoff and In Flight) = 335 (47%)**

- **NFF/RTOK Rate – Related Material and Labor Cost**
  - **Total Maintenance = 33,000 MMH**
  - **Total Electronic Maintenance = 5,300 MMH (LRU Replacement) = 16% of Total MMH**
  - **NFF and FD/FI = 4,630 MMH (87% of Electronic MMH or 14% of Total MMH)**
  - **NFF / RTOK Rate 14-22% (18%Avg.) = Equivalent of 4 Electronic Systems in Pipeline**

Putting Numbers on the Figures of Merit

The Results

Component Parameter Values Assembled into FOM

Total cost of ownership reduction (Support Cost For Example W/S)	**Reduction in Support Labor = 14%** **Reduction in Electronic Support Material =18% (4 electronic Systems per Wing)**
Reduction of cost of false removals	**Reduction & Cost Savings NFF/RTOK = 14%** **Reduction & Cost Savings on Spares = 18%**
Improved system availability	**Reduction in NMC = 8% (or 2 A/C per Wing)** **Reduction in NFMC = 47%**

FOM Results Applied to the FW A/C Fleet (Est.)

USAF Tactical FW A/C (2006) ---------- 2500
DOD Tactical FW A/C (2006) ---------- 3700
(From 2006 DOD GAO Study)
Est. Avg Unit Cost ---------- $ 40MM
Est. Avg Electronics Content ---------- $ 8MM
DOD Electronics Maintainers FW A/C Est.---- 12,500
DOD Labor Cost@$45KPer ---------- $ 560 Million
USAF is 30% ---------- $ 170 Million

Estimated Corporate Maintenance Indicators – USAF
(From 2006 DOD GAO Study)

Mission Capable Rate ---------- 81%
NMC-Maintenance ---------- 15%
Abort Rate ---------- 6%

Total cost of ownership reduction	**Reduction in Support Labor = 14% = $ 46 Million (USAF)** **Reduction in Electronic Support Material =18% = $ 101 Million (USAF)** **Reduction in Support Labor = 14% = $ 69 Million (DOD)** **Reduction in Electronic Support Material =18% = $ 150 Million (DOD)**
Reduction of cost of false removals	**Reduction & Cost Savings on Support Material =14% = $ 46 Million (USAF)** **Reduction & Cost Savings NFF/RTOK = 18%= $ 101 Million (USAF)** **Reduction & Cost Savings on Support Material =14% = $ 69 Million (DOD)** **Reduction & Cost Savings NFF/RTOK = 18%= $ 150 Million**
Improved system availability (DOD	**Reduction in NMC = 8% = $ 8 Billion (USAF)** **Reduction in NMC = 8% = $ 11.8 Billion (DOD)**

Recommended Next Steps

- **Expand Study to Classes of Weapon Systems**
  - **Select Best Payoff Classes (Troubled)**
  - **Prescribe Specific E-Prog Programs**
  - **Develop Specific Cost Benefit**
- **Develop Programs and Acquisition Strategy for the Prescribed E-Prog Technologies**
- **Execute Programs and Develop Technology Transition Plan**
- **Develop Metrics and Evaluate Results**
- **Repeat for Additional classes of Weapon Systems.**