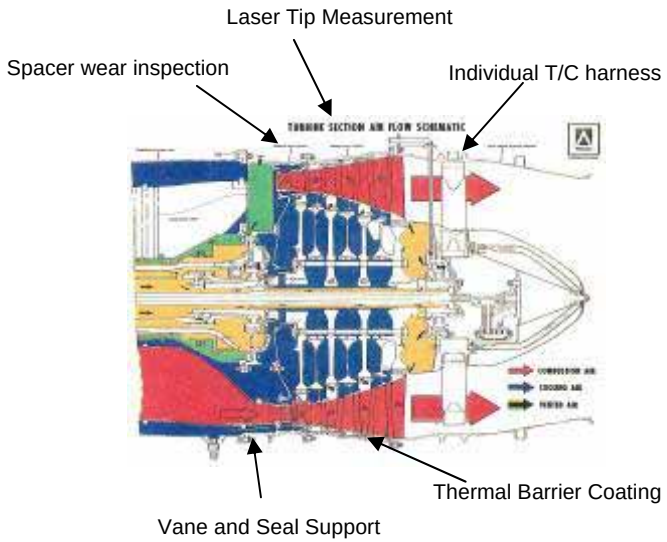
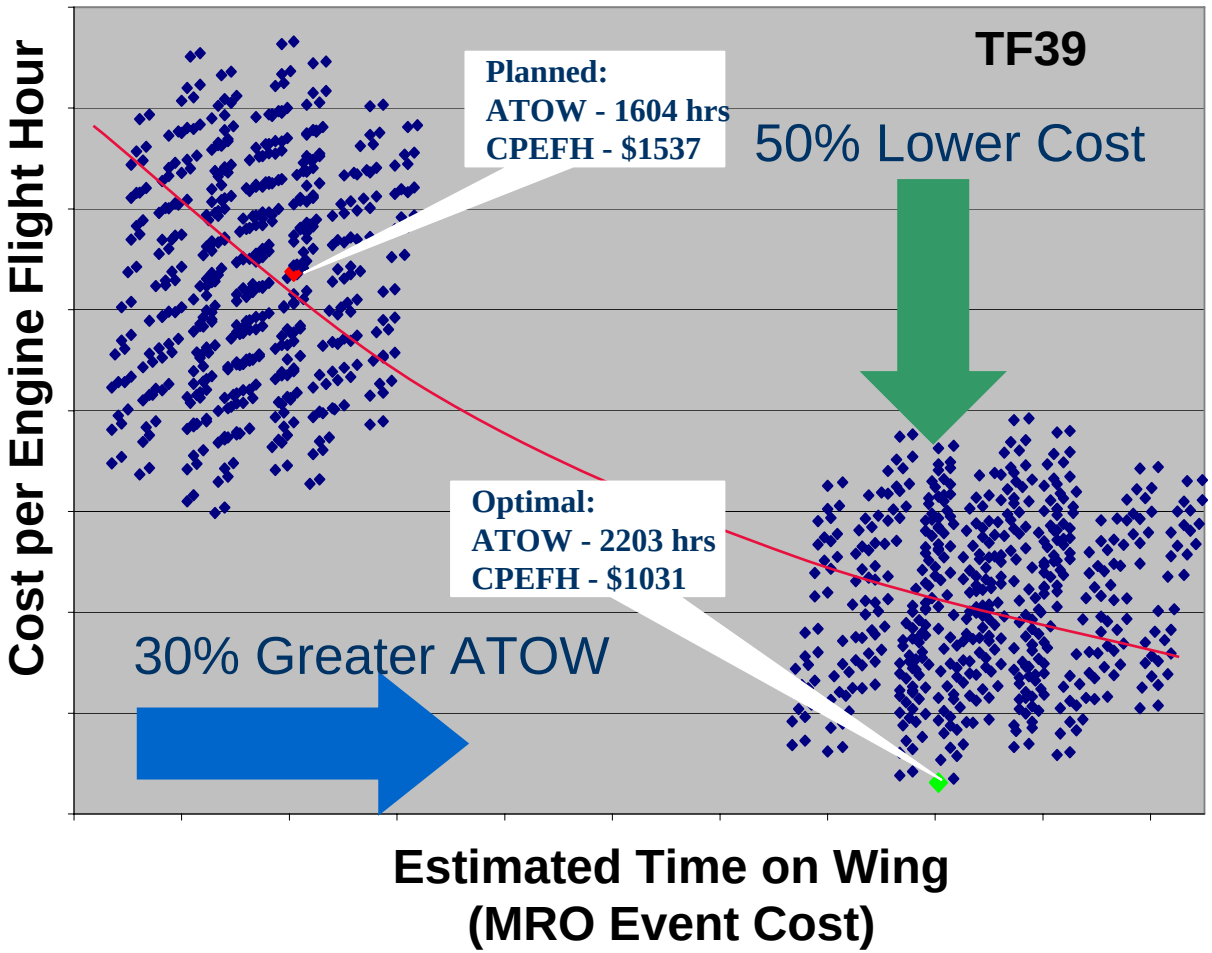
RCM Workscope Optimization

- Typical workscopes focus on LLPs and published technical data only:
  - Short term focus
  - Lack of real world feedback
- Difficult to manage workscope(s) over entire life of engine:
  - Huge number of variables
    - ***typically*** 16,000 choices
  - Opportunistic maintenance - hundreds of options
  - Very complex problem
- Reliability and cost modeling has created realistic optimization capability - RCM:
  - Accumulate and scrub actual operating data
  - Use model to calculate cost per hr and average time on wing (ATOW) for each possible workscope scenario
  - Select workscope with lowest cost per engine flying hour (CPEFH)

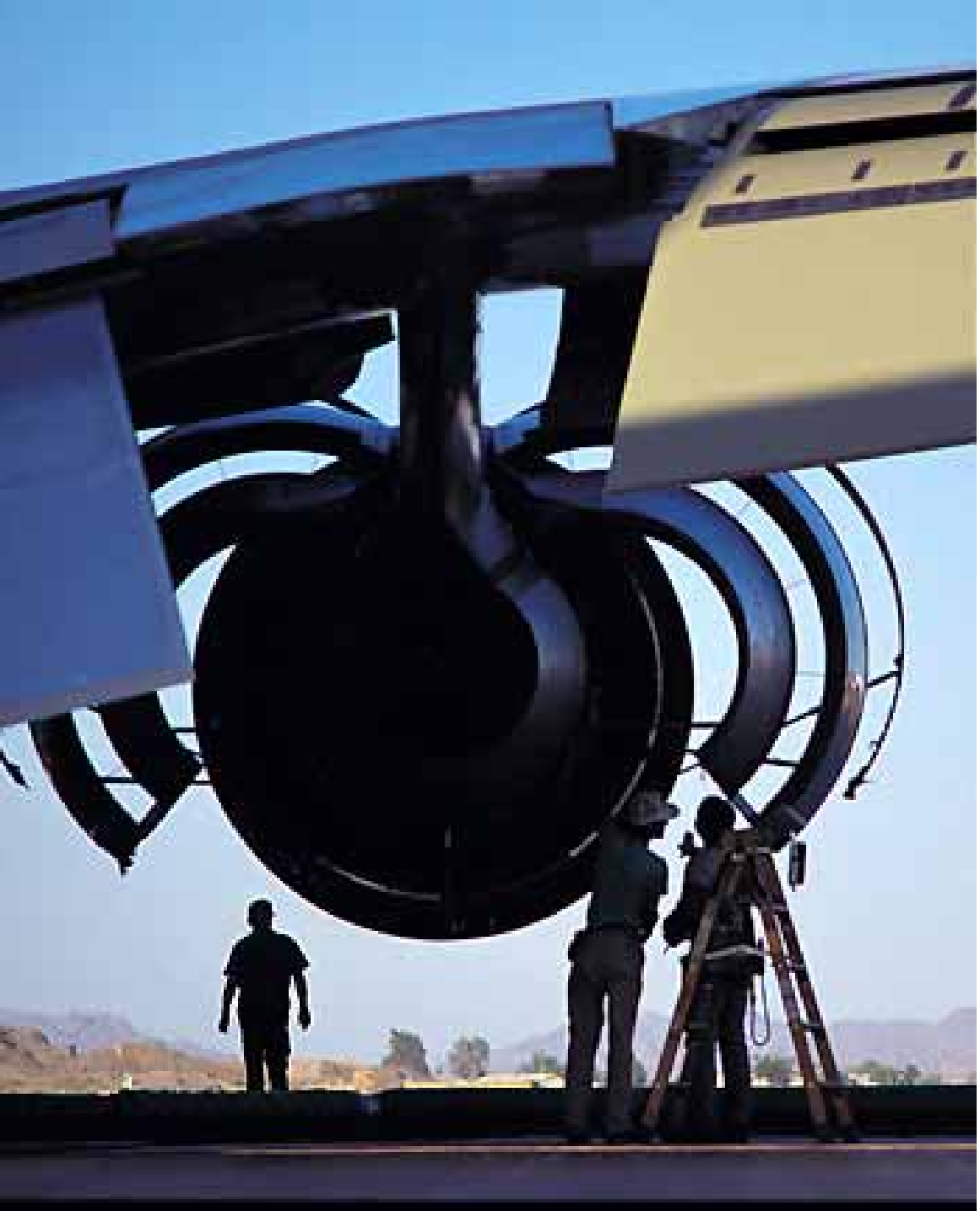


RCM determines the workscope required to give highest Average Time on Wing (ATOW) for lowest Cost Per Engine Flight Hour (CPEFH)



- Workscope optimization is not intuitive due to large number of options (2^{13})
- Algorithm developed to find optima
- Significant cost and ATOW gains
- In use today on certain USAF engines

Engineered Workscope Optimization Highlights Potential Benefits

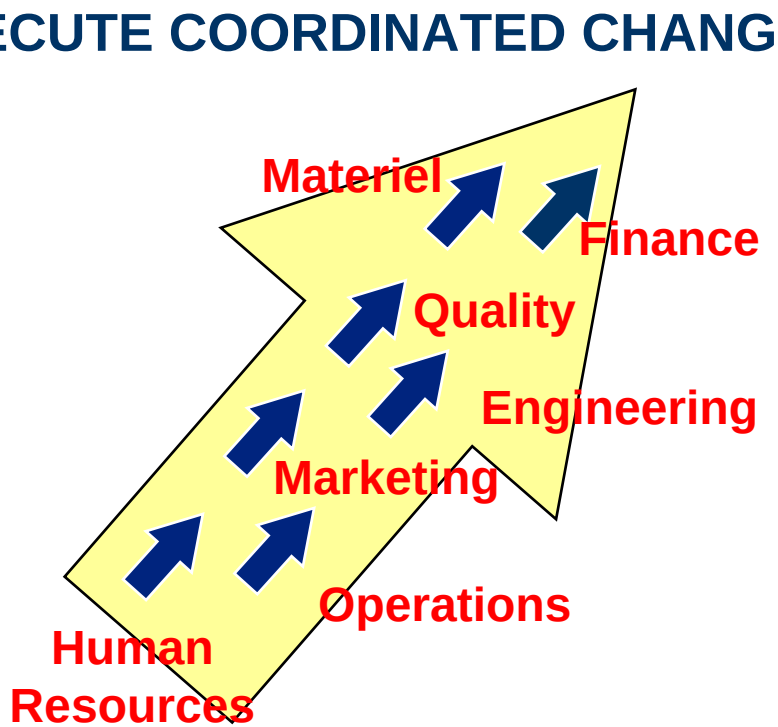


So…we can use RCM to generate a unique workscope, specifically for optimum readiness value…

HOW DO WE IMPLEMENT THIS IN A REAL WORLD MRO ENVIRONMENT?

A Lean / Cellular™ Maintenance Facility Transformation can make it possible ...

A Systems Engineering Approach to MRO Transformation™



Over 15 Years of Transformation Experience
Over 160 cell redesigns to date around the world

Because Key Elements of Lean / Cellular™ MRO drive process ownership up...

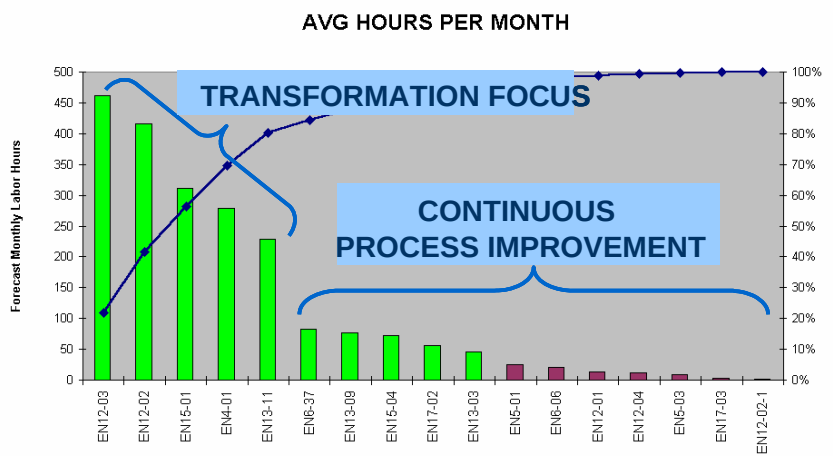
Visual Factory for Lean / Cellular MRO

Multi-Skills and Comprehensive Training

TOPIC, SKILL, TASK / EMPLOYEE	Bench	EDM	Welding	Quality Inspect	Grinding	Lathe	Manual Plasma	Plasma Prep	F.P.I.	Soft Blast	Stress Relieve	Conventional Mill	Seam Welding	Cleaning	O.J.T. Training	F.A.I.	Management Training	Back-up Cell Leader	Material Handler	Planner	DATE OF NEXT EMPLOYEE DEVELOPMENT PLAN
Norm	☐					☐				☐		☐		☐							June-00
Mitch							■	■		■				■	■	■					June-00
Nick	☐				☐									☐							June-00
John	■					■				■			■	■	■	■					June-00
Rick							☐	☐		☐				☐							June-00
Jeff			☐								☐										June-00
Todd	☐									☐				☐							June-00
Travis	☐	☐								☐				☐							June-00
Diana				☐												☐					June-00
Brian			☐								☐										June-00
Rick	☐					☐				☐		☐		☐		☐					June-00
Blaine	☐				☐					☐				☐							June-00
Geoff																					June-00
ACTUAL	7	1	2	1	2	2	2	3	0	8	2	3	1	9	2	5	3	1	1	0	
REQUIRED	7	1	2	1	3	2	2	3	1	8	2	3	2	9	7	5	3	1	1	1	
TO BE TRAINED	0	0	0	0	1	0	0	0	1	0	0	0	1	0	5	0	0	0	0	1	

Identified for training ☐
Presently being trained ☐
Requires experience ☐
Fully experienced ☐
Able to train / supervise ■

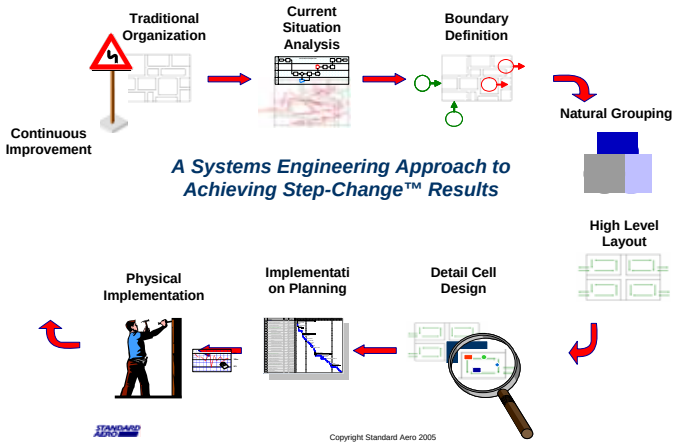
Focused Data Driven Analysis



Hands On and Computer Simulation

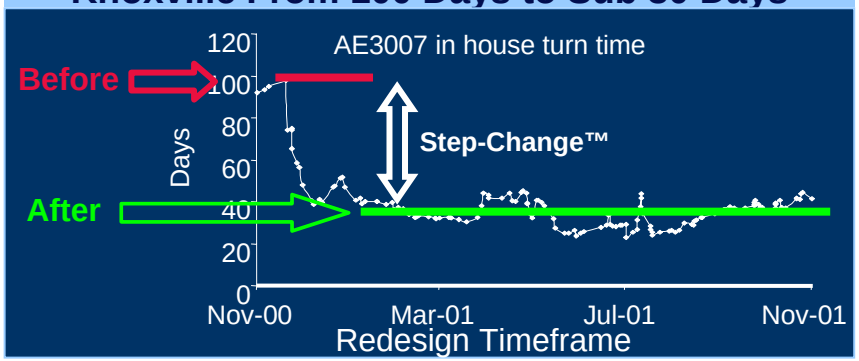
And vastly increase the speed and degree to which changes to work scoping can be made

Comprehensive Systems Engineering Approach to Step-Change™ & Sustainment

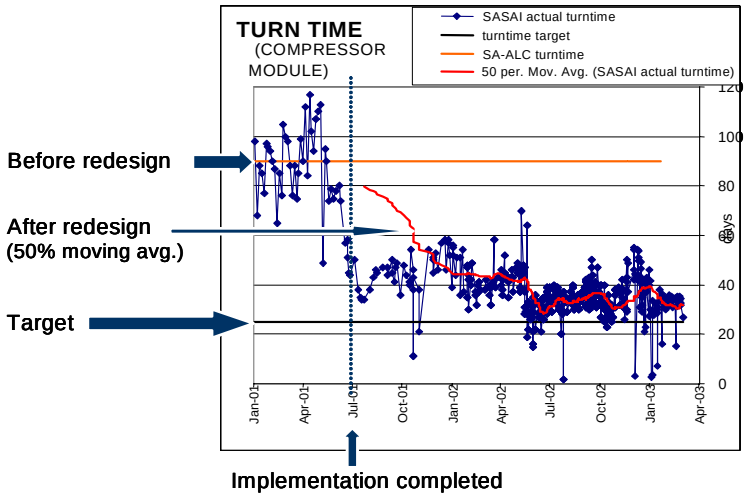


Typical Process Shop Ownership 25-40%
Lean / Cellular MRO Cell Ownership >85%

Regional Airline Fan – AE3007 Knoxville From 100 Days to Sub 30 Days



C-130 / P-3 Powerplant – USAF T56 San Antonio, TX From 100 Days to 30 Days



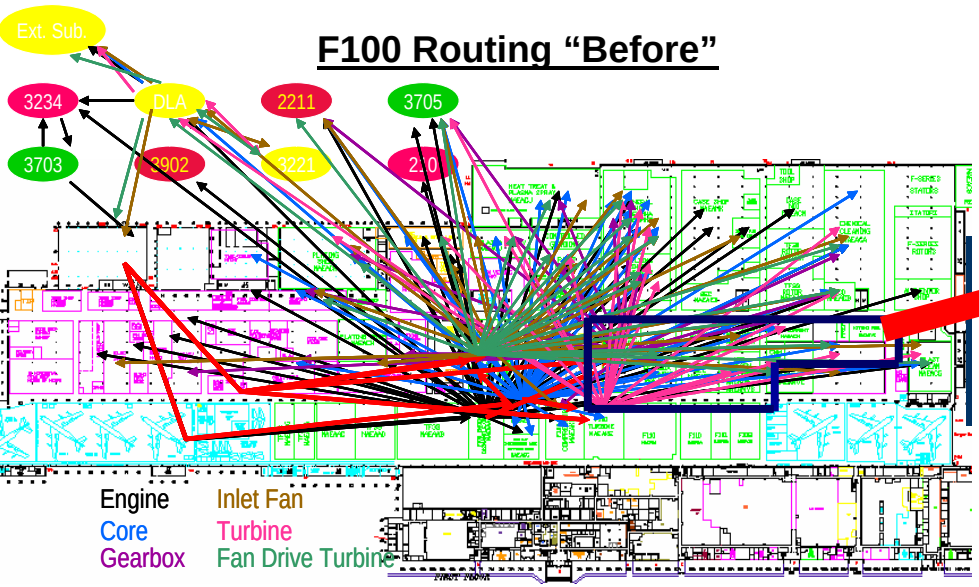
Performance Measure	Before (1999)	After (2001)
Turn around time	90 + days	< 30 days
1st pass fill rate	50%	>90% +
Back order days	15-25 days	<5 days
ENMCS	Red	Green
War Ready Engines	Red	Green
Water reuse	0%	85%

Typical “legacy” MRO operations can make workscope changes difficult…

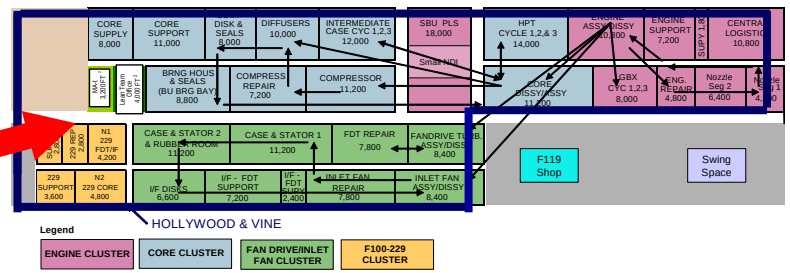
OC-ALC Initiatives

F100 Engine	*Today*	*After Redesign*
Rear Gearbox housing	15.0 miles travel	2.3 miles travel
1st stage Fan Assembly	48 ownership changes	3 ownership changes
Forklifts required	24	3
Material handling carts required	256	5
Core Engine Turn Time	113 days	35 days

F100 Routing “Before”



F100 Routing “After”

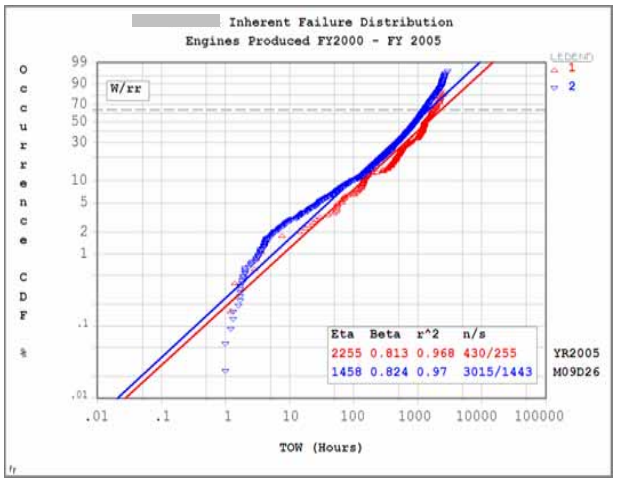


Footprint Reduced to Single 320K SF Area, 25 Production, 5 Supply, 4 Support Lean Cells

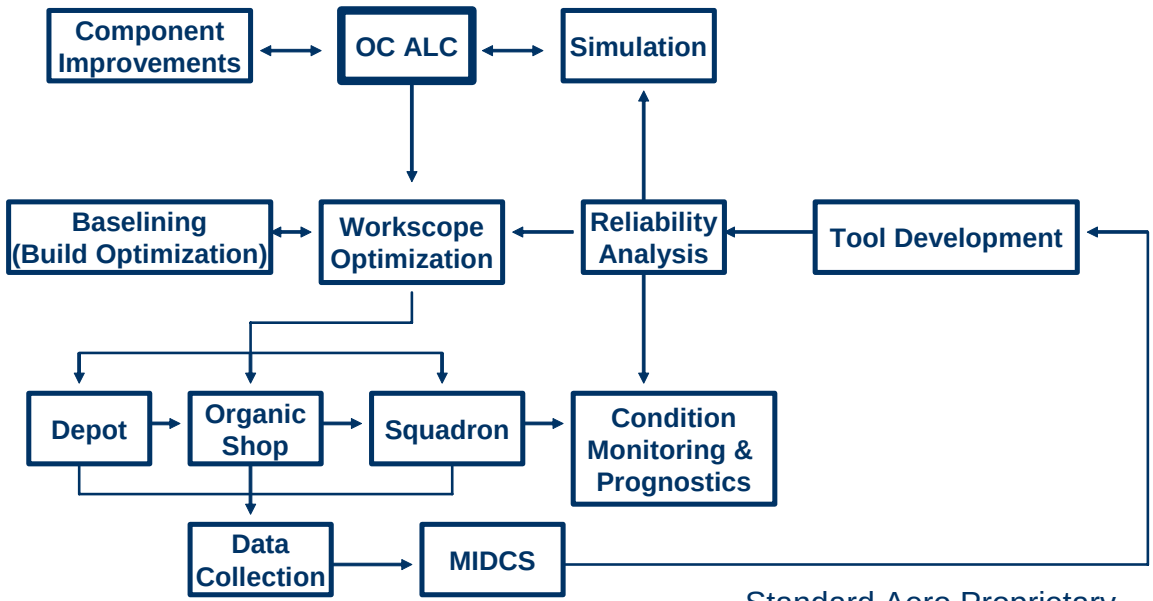
Combining RCM and Lean/Cellular MRO Integration makes substantial improvement possible

Inherent Reliability (ATOW)					
	Type/Model "X/1" USAF		Type/Model "X/2" USAF		Type X/1 Other Customer
	Standard Aero	Organic	Standard Aero	Organic	Standard Aero
ATOW	2,159	1,363	2,526	1,618	2,246

Weibull analysis: Standard Aero Workscoped Engines have 50% higher Inherent ATOW than organically produced engines



Source & Analysis: CEMS Report E314. Suspensions from E314 and current times from E118 reports. Filtering: Engines installed after FY00; < 4 hours per day; negative TOWs eliminated



Providing Best Value Readiness for the WARFIGHTER!

Systems Engineering RCM + **Enterprise Lean / Cellular MRO**