

Off-Grid Hybrid Systems: Maintenance Costs

Scott Canada
**Arizona Public Service/
Pinnacle West**
Phoenix, AZ

Larry Moore
John Strachan
Hal Post
Sandia National Laboratories
Albuquerque, NM



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TOPICS

- APS remote solar program overview
- Importance of maintenance records
- Actual maintenance costs
 - Scheduled maintenance
 - Unscheduled maintenance
- Life Cycle Cost (LCC) Analysis
- Lessons learned

Off-Grid Hybrid Systems

- Arizona Public Service -- service via leased systems
- 62 systems installed 1996-2002
- Sized to provide 2.5-10 kWh per day in four configurations
- Includes propane generator & battery storage



Program Elements

- 4 Standard Packages of Leased Systems
- Emphasis on quality components and installations
- Configured & Tested prior to installation
- Quarterly & Emergency O&M provided
- Purchase of systems option
- Field Information on O&M collected

System Configuration (Packaged)

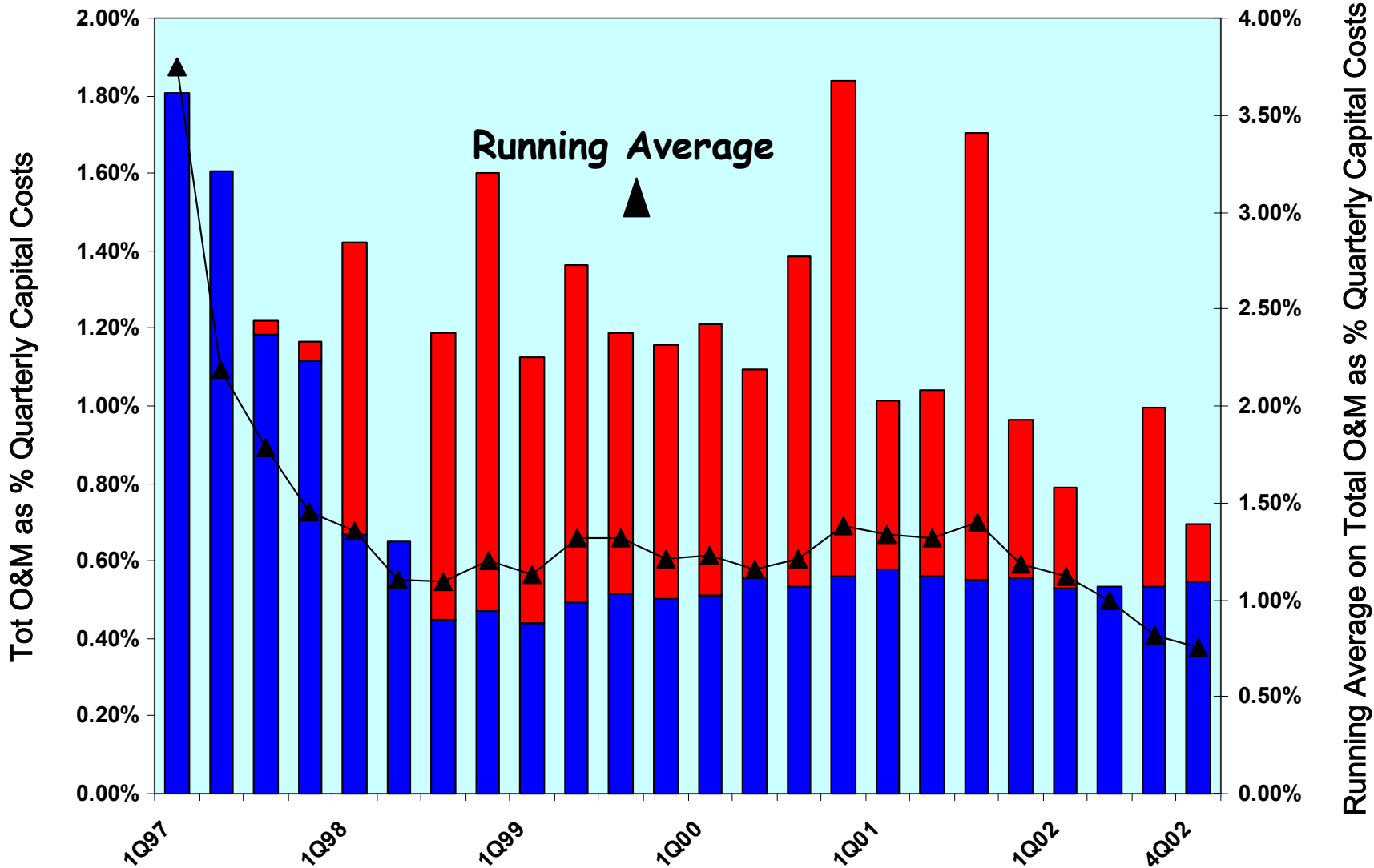
System	2.5	5	7.5	10
PV Watts	570	1140	1710	2280
System Voltage	12 Vdc	24 Vdc	48Vdc	48Vdc
Battery Storage Capacity (kWh)	10.8	22.6	33.4	43.2
Inverter Size Continuous Watts	Trace 2500	Trace 4000	Trace 4000	Trace 4000
Inverter Output Volts	120/240	120/240	120/240	120/240
Battery Charger Amps/Volts	40/ 12V	40/ 24V	40/ 48V	40/48V
Battery Charge Controller	Trace C40	Trace C40	Trace C40	Trace C40
Basic System without generator*	\$10,900	\$17,200	\$24,800	\$28,000
Standard System/7kW generator*	\$17,300	\$23,600	\$31,200	\$34,400

*Most Recent Prices

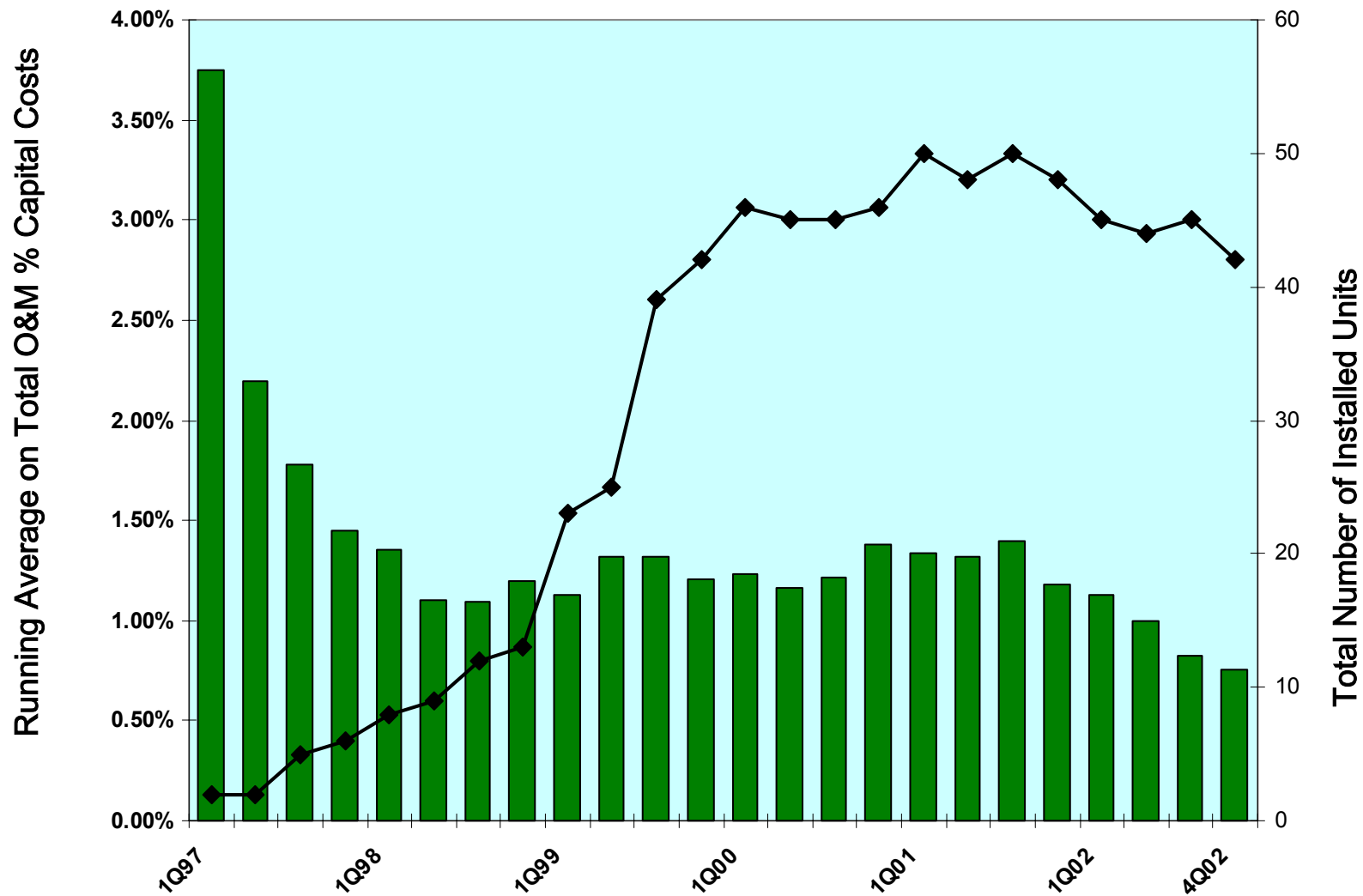
Importance of Records

- To understand the maintenance costs:
 - Understand total system cost
 - Develop means to reduce these costs

Total O&M (Schd + Unschd) as % Quarterly Capital Cost and Running Avg on Total O&M



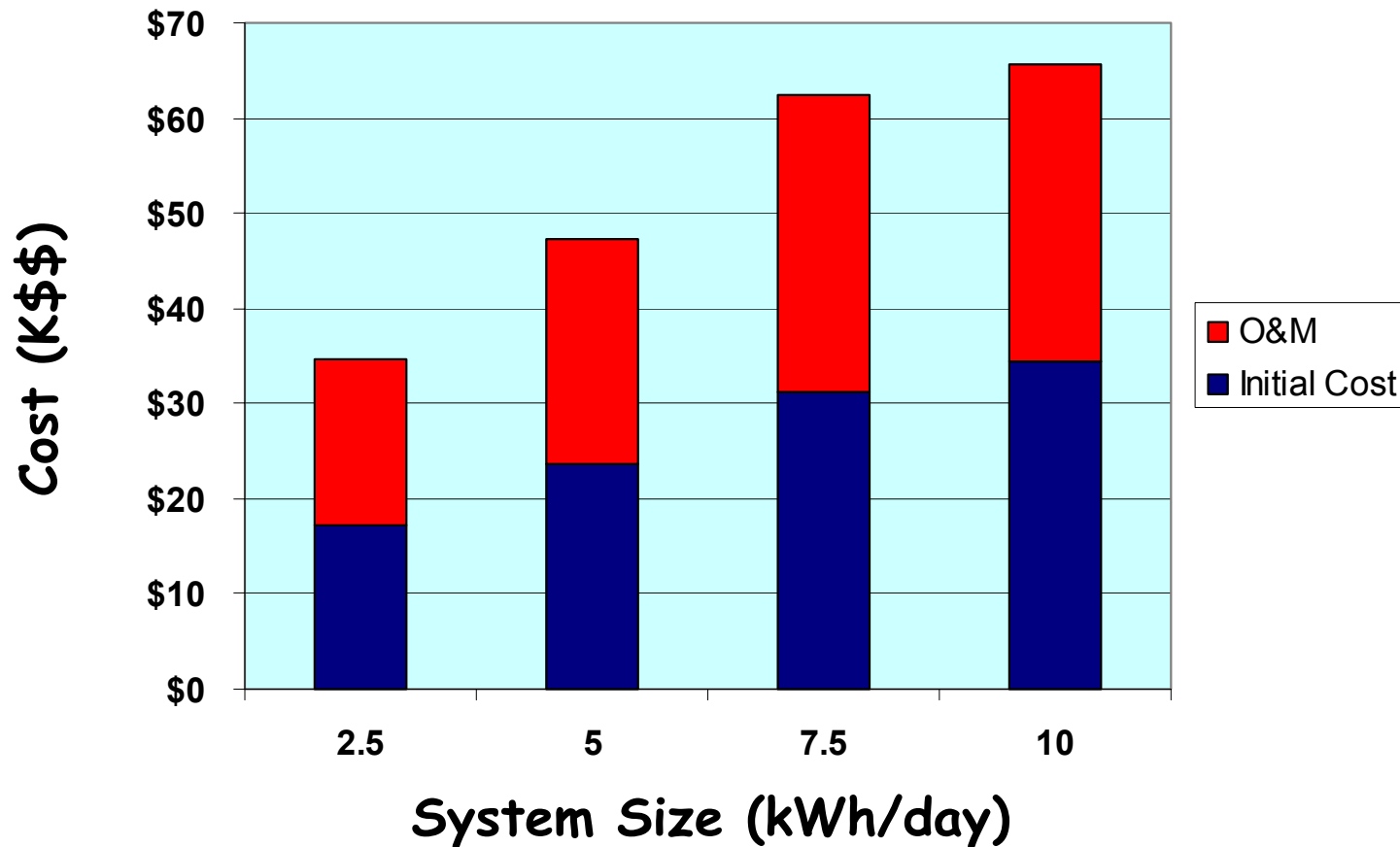
APS/Pinnacle West (Data from Fielded Systems): Running Average on Total O&M and Number Units Installed



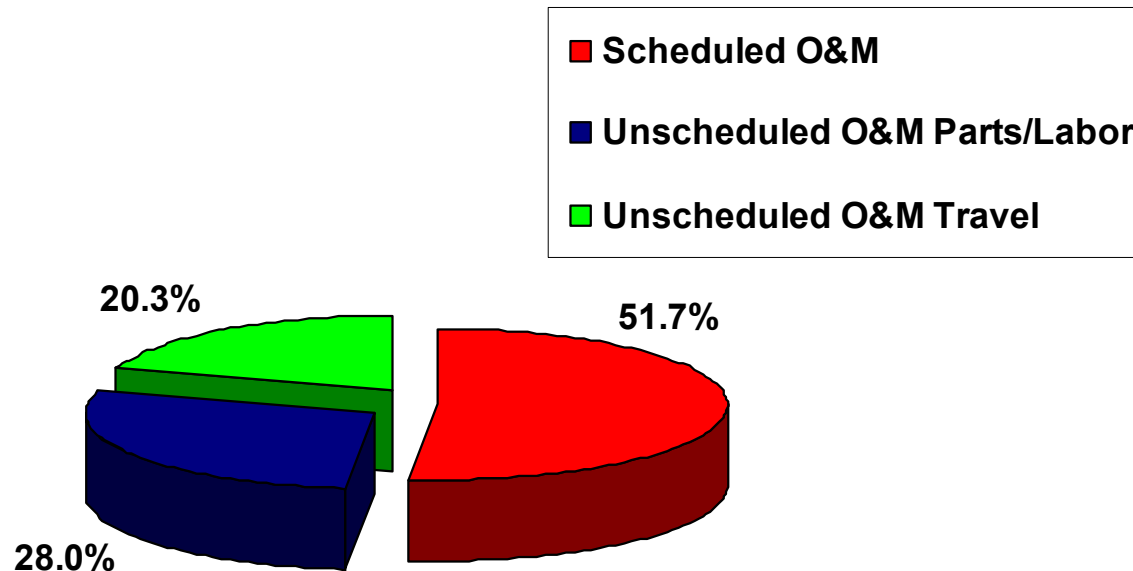
Total O&M (Schd + Unschd) as % Quarterly Capital Cost and Running Avg on Total O&M

- Average Annual O&M cost ~ 5-6% of Capital Cost (Does not include battery replacement)
- O&M costs stabilized about 2 years into the program reflecting increased number of systems and maintenance experience
- O&M costs decreased during last year of program reflecting maintenance experience

25 Year LCC Costs Compared to Initial System Cost

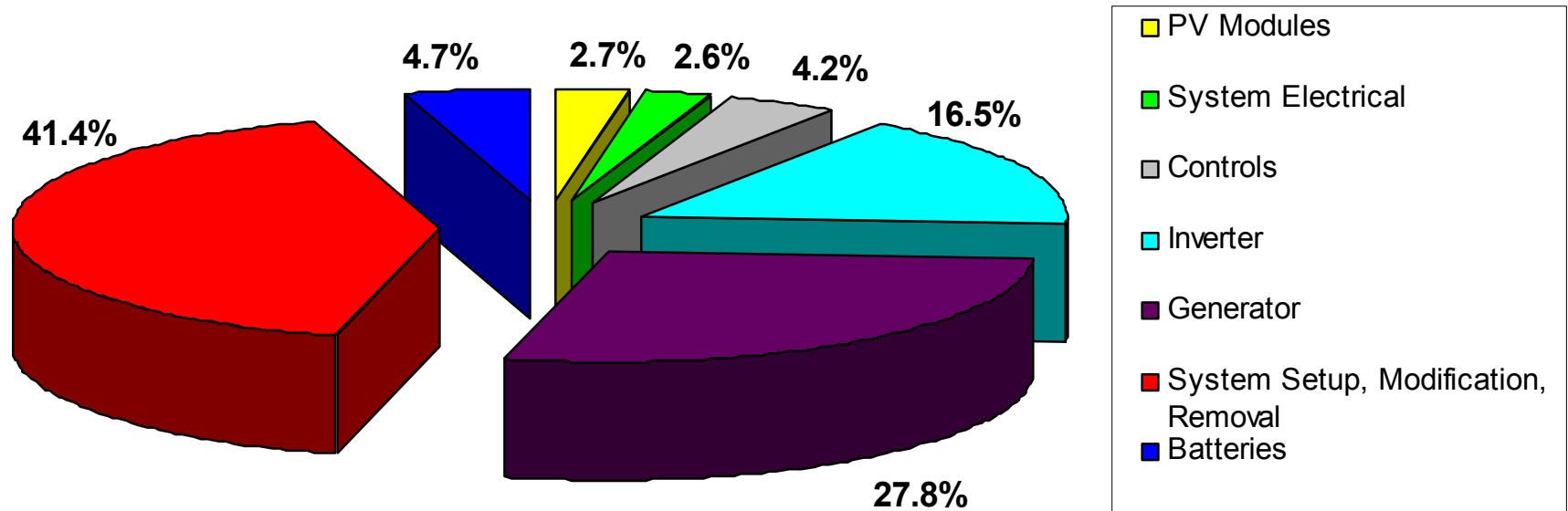


Total (Sch & Unsch) Maintenance



Travel was ~42% of Unscheduled O&M - All Categories

Unscheduled Maintenance Cost by Component (% of Total Unscheduled O&M)



Lessons Learned - Program

- The Off-Grid residential system program:
 - Capital and labor intensive systems
 - Widespread geographically
 - Limited but viable off-grid customer base
 - Provided negligible contribution to portfolio requirements
- O&M costs were not tracked in sufficient details for system and component failure rates to be determined

Lessons Learned - Program

- Limit packaged systems to standardized 5 & 10kWh/day
 - Utilize same hardware – controller, inverter, modules and batteries
 - Simplify O&M, reduce/eliminate modifications
 - Reduce inventory

Lessons Learned - Customer

- Select appropriate customer
- Expand customer education on operation, maintenance and limits of energy output.
- Service area must be reduced to avoid high travel costs – travel costs are approximately 42% of unscheduled O&M.

Lessons Learned - Contracts/Agreements

- Tiered rate structure – charge appropriately for excessive generator runtime created by over consumption.
- Minimum one year lease arrangement with significant deposit required – reduce system setup, modification, & removal costs which are 42% of unscheduled O&M costs
- Deductible service fee – reduce nuisance calls & give incentives to the customer to correctly operate the system.

Lessons Learned - O&M Program

- Total annual O&M costs for these systems are approximately 5-6% of the initial capital cost
 - Scheduled O&M activity must reduce unscheduled O&M costs
 - Tracking O&M activity important for early identification of problems
 - Increase preventative actions to reduce emergency calls

Lessons Learned - Components

- Generator/Inverter must be performance matched & extensively tested before installation— these components account for approximately 45% of unscheduled O&M
- Undersized generators source of significant O&M problems prior to mid-2001
- Conservative design to reduce long-term O&M costs

Lessons Learned - Components

- PV modules, charge controller and system wiring relatively small O&M costs
- Operational trade off in battery and generator usage
- Systems must be metered so that output may be conveniently monitored by owner

Areas Where Further Work Can be done

- Best practices guide for O&M of off grid residential system
- Additional studies such as this to provide more O&M cost information
- Additional tools such as the database to track O&M costs

Conclusions

- Management of maintenance cost critical to successful fielded systems

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