Software Technology Conference (STC 2002)

U.S. AIR FORCE

Three Years Using Earned Value for Software Development: *Lessons Learned*

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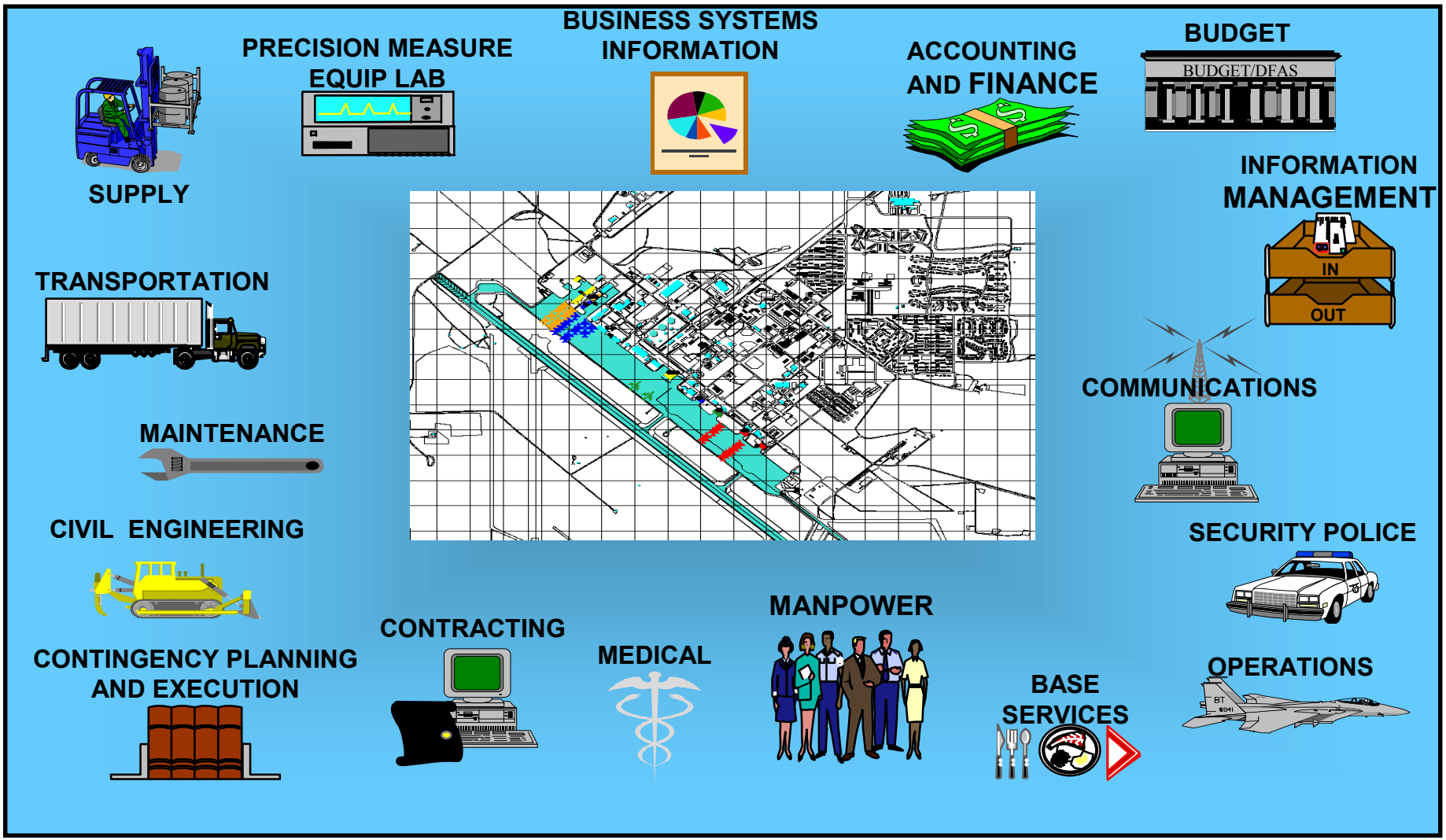
USAF Standard Systems Group (SSG)

Our Mission

Acquire, Develop, Integrate, Implement and Sustain…
secure combat support information systems and networks for the Air Force, Department of Defense components, and Federal Government agencies

CMM Level 3

We Build and Sustain Information Systems



Why We Chose Earned Value

1. Relates cost, schedule and software engineering technical accomplishment into single set of metrics
2. Yields measurements that are valid, timely, and auditable
3. Supplies managers with information at a practical level of summarization
4. Implicitly indicates product quality
5. Integrates well with other software metrics
6. Establishes historical database for better future estimating and planning
7. Increases our software development maturity

Aligns well with our business goals

Our Journey

Automated Tools

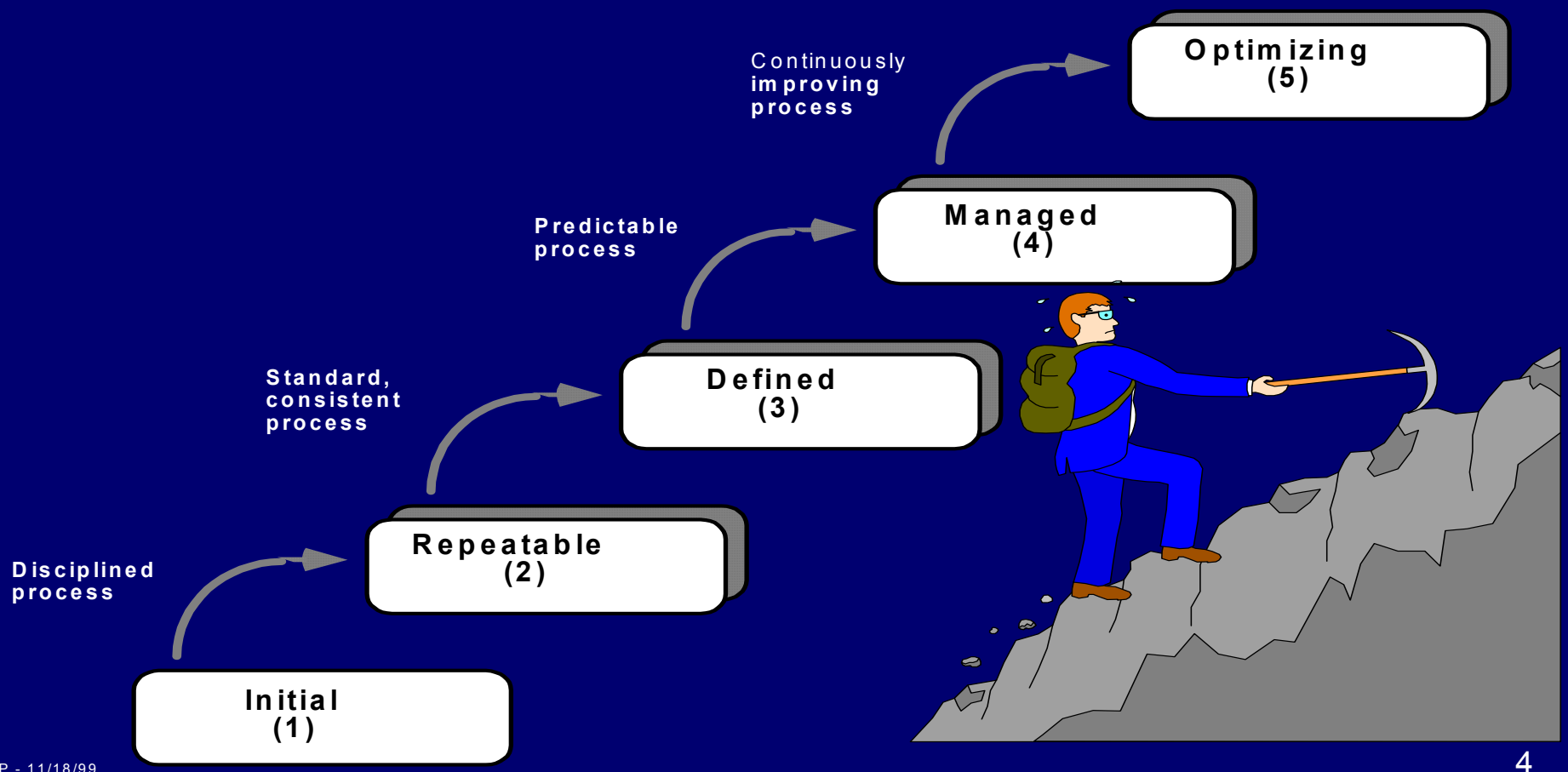
WBS

SEP

CMM

Capability Maturity Model:
What needs to be done

The Five Maturity Levels



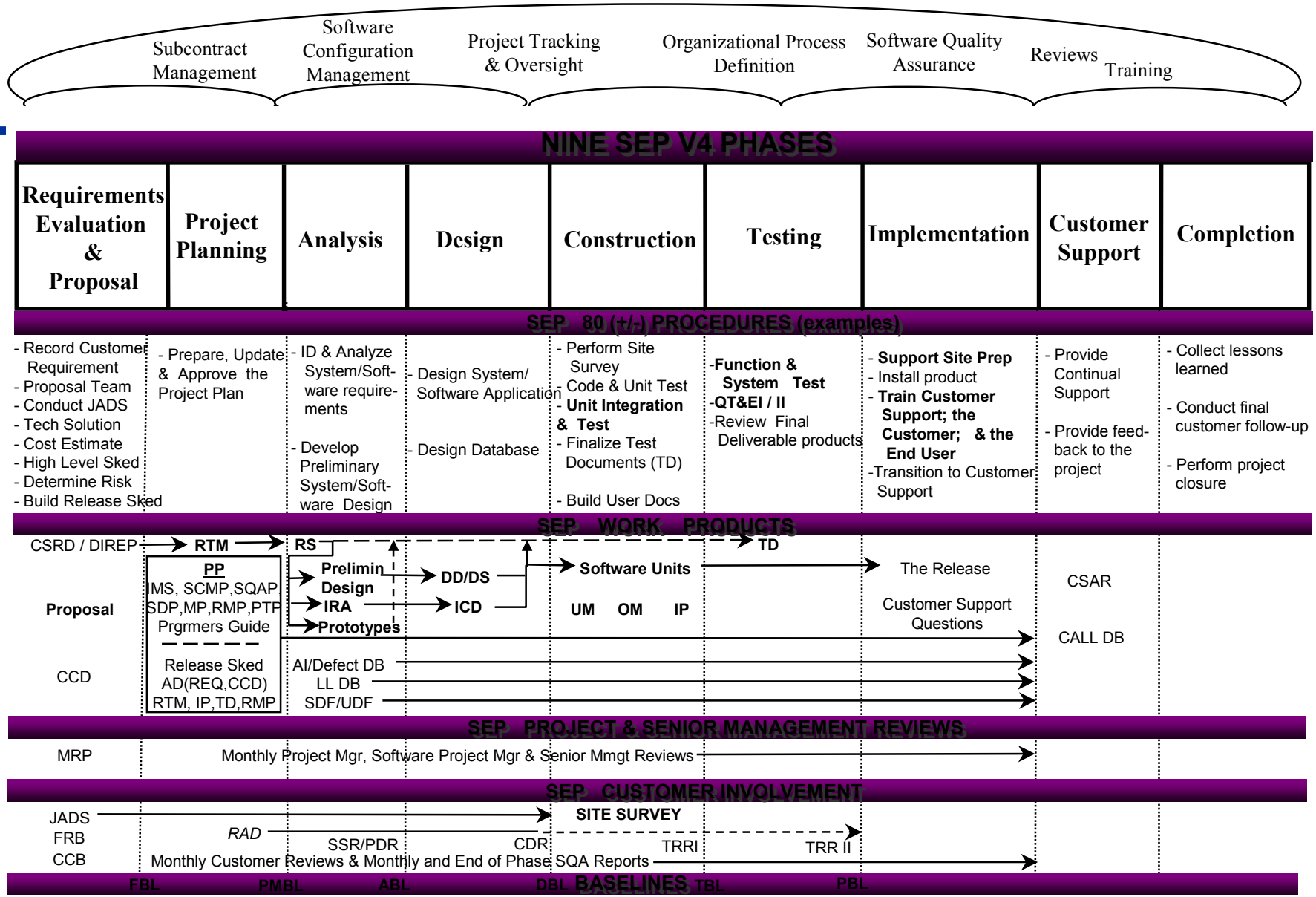
Our Journey

SEP

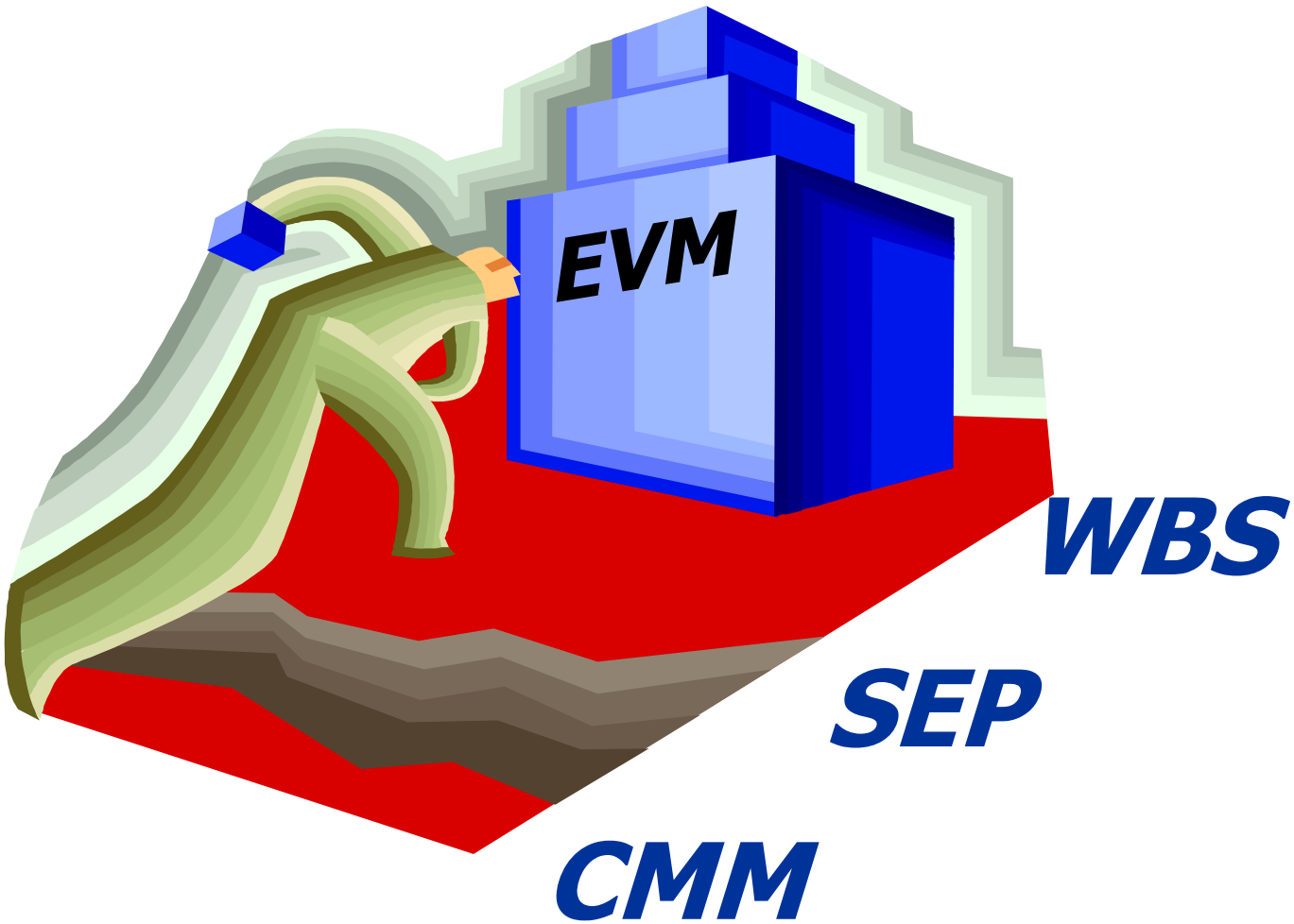
CMM

Our Software Engineering Process (SEP)

How to do it



Our Journey



SEP WBS

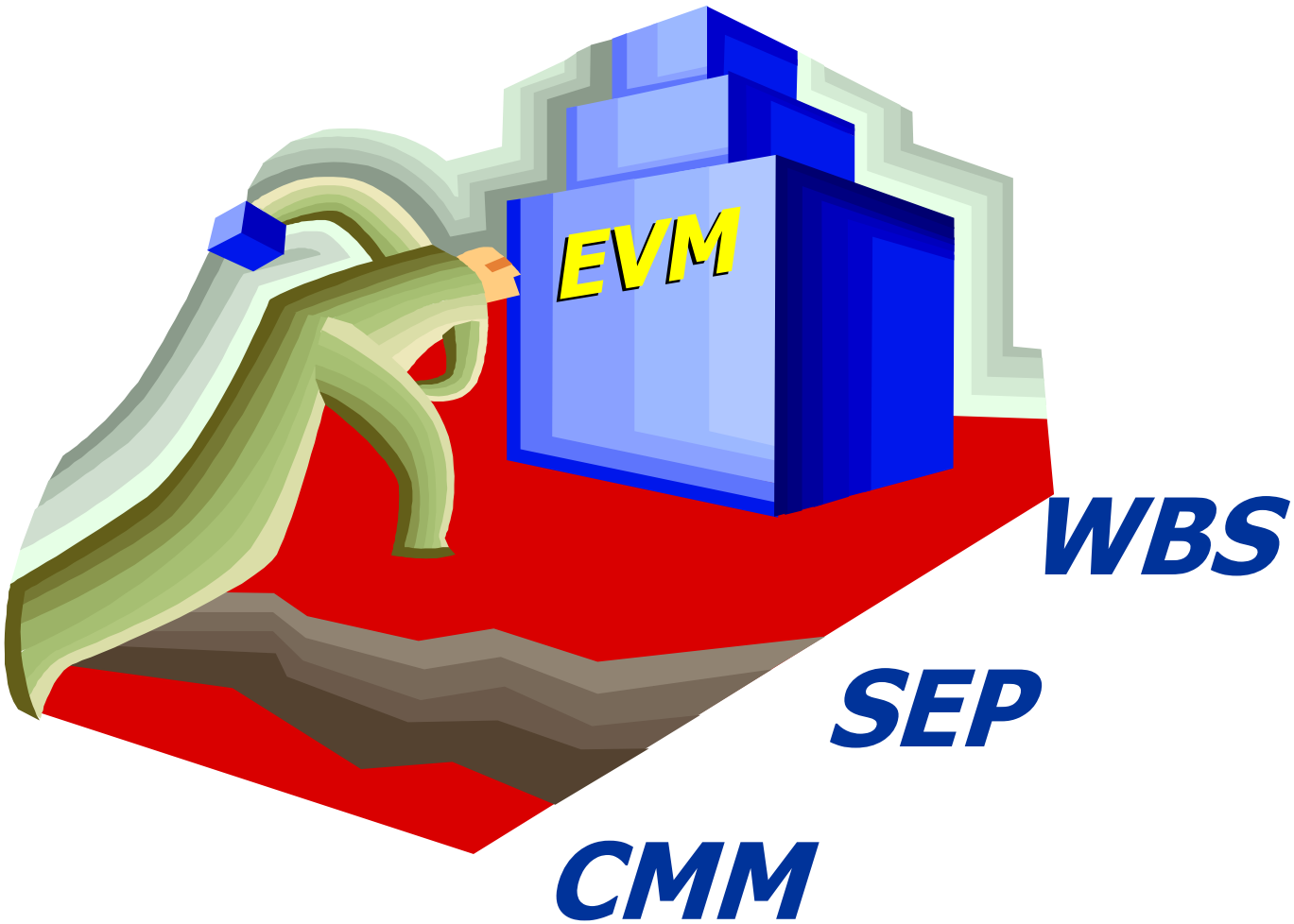
What work products

LEVEL	WBS ELEMENTS	NEW	SUSTAINMENT
1	Automated Information System	X	X
2	Prime Mission Product	X	X
3	Hardware for Implementation	X	X
3	COTS Software for Implementation	X	X
3	Database	X	X
3	CSCI #1 (Use Name)	X	X
4	CSCI # 1 Integration Test Scripts and Peer Review Minutes	X	X
4	Module # 1(Use Name), Code and Peer Review Minutes	X	X
4	Module # 1 Test	X	X
5	Unit Test Script for Module #1 and Peer Review Minutes	X	X
5	Unit Test Report for Module #1	X	X

Sample

MIL-STD 881B Refined to a Level 5

Our Journey



Uniqueness of Software Development: On Estimating

Hardware

Repetitive product line

- Define Requirements
- RDT&E
- Freeze design
- Plan-Schedule
- Construction & Test
- Characteristics
  - Population size= many
  - Accurate estimates

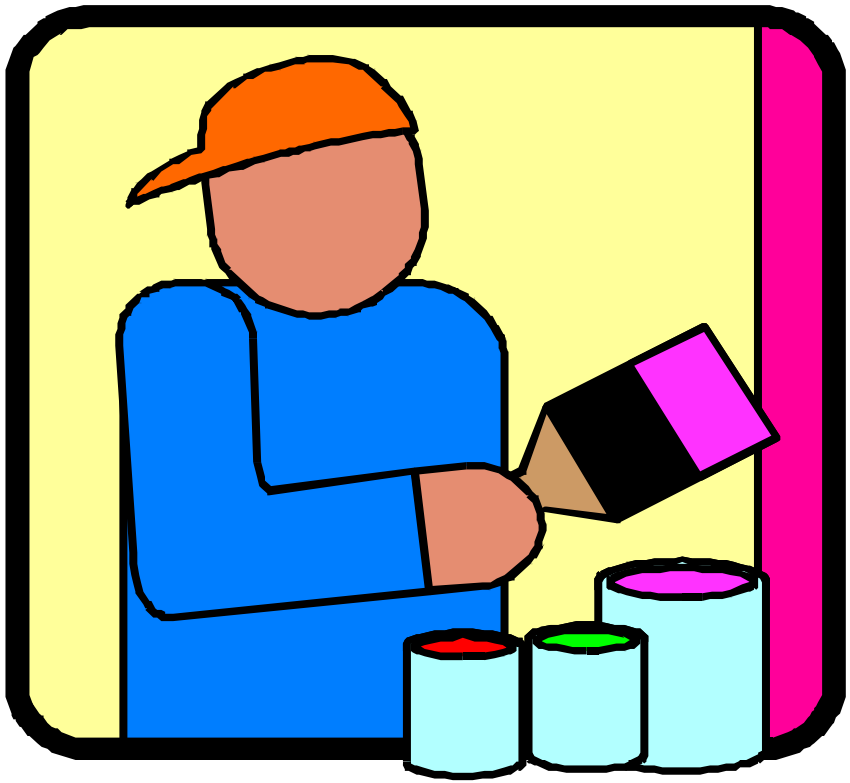
Software

One of a kind prototype

- Outline Requirements
- Plan-Schedule
- Analysis & Design
- Construction & Test
- Baseline design
- Characteristics
  - Population size= 1
  - Estimates ???

Uniqueness of Software Development: On Earning Value

(I'm 80% Complete with Coding)



Hardware

Software

Our Journey

WBS

SEP

EVM:
Planning Policies
Tracking Policies

CMM

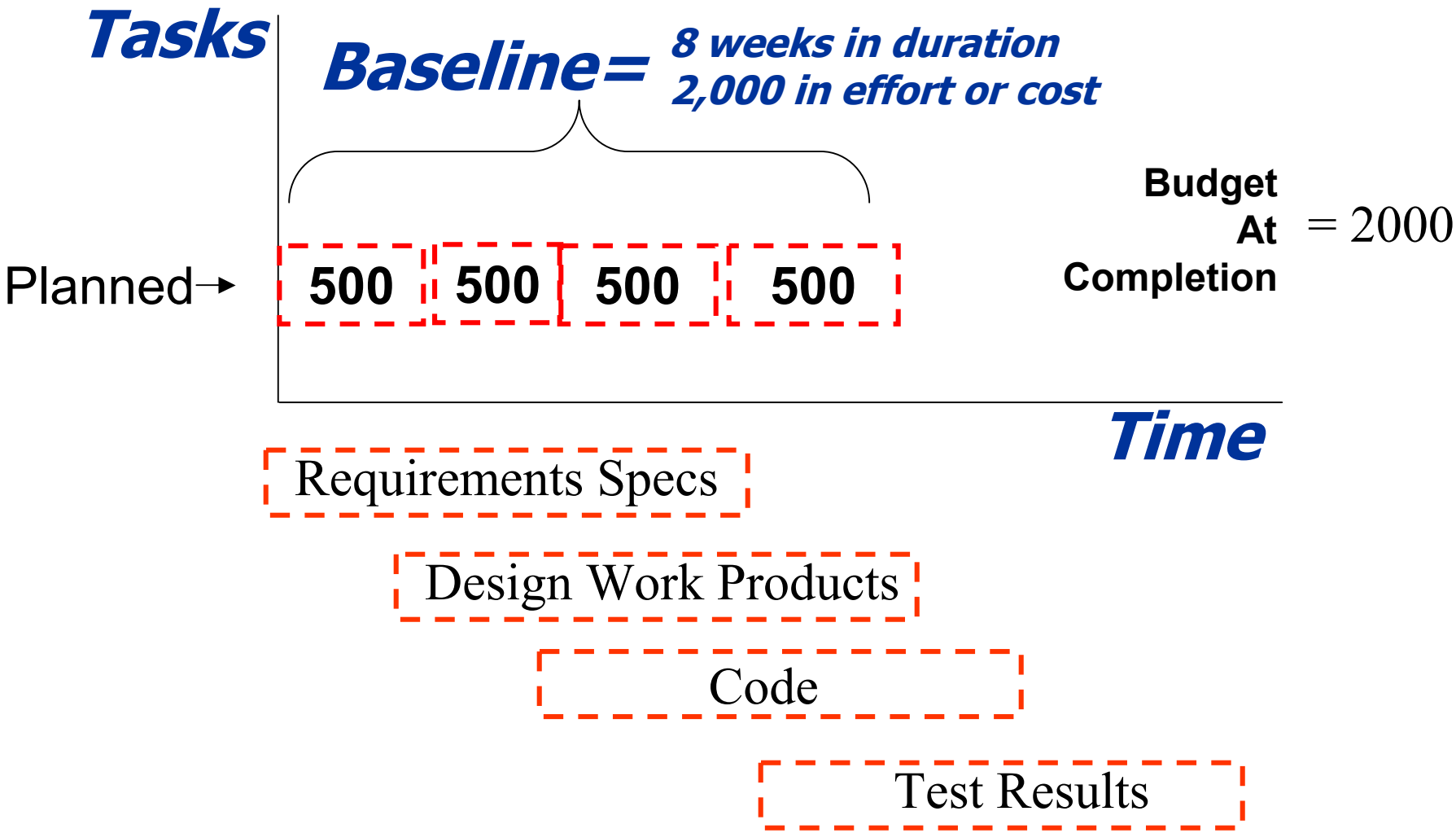
EVM Planning Policies

- Each system or software release is a project requiring a tailored WBS
- All projects except purely sustainment and Time & Materials”:
  - >$300K should consider using EV
  - >$1M must unless wavered
- Useful for >1,500 labor hours and >42 work days in duration

EVM Planning Policies

- **80% of WBS is product-oriented**
  - **Down to a level 5 indenture as necessary**
    - Required at a Level 5 for coding (Construction Phase)
  - **Ex: SRS, Design Docs, drafts, modules, screens, reports, DB tables, SQL scripts, etc.**
  - **2 week work packages—aggregate up or refine down**
- **Other 20% is Level of Effort (low risk areas)**
    - Project Tracking and Oversight, Configuration Management, Quality Assurance, Subcontract Management, etc.
- **Resources are assigned to the work packages establishing the Baseline which is captured in our Automated Tool**

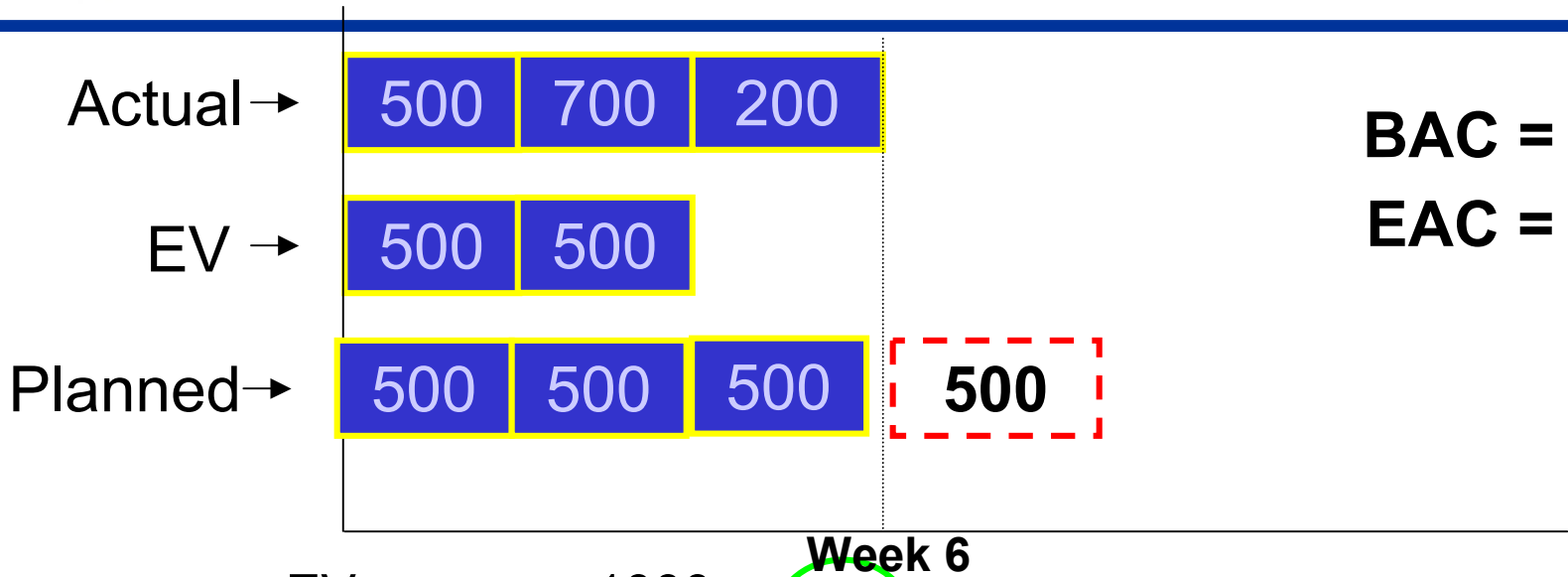
EVM Planning in SEP



EVM Tracking Policies

- **Awarding Earned Value**
  - **0-100% method for Product-Centric work package**
    - Objective accomplishment of the work package (not earned until peer reviewed or tested)
  - **$ earned as a $ spent for LOE (PT&O, CM, SQA, etc)**
- **Once work package is closed, must use rework codes**

EVM Tracking in SEP



BAC = 2,000

EAC = 2,808

$$CPI = \frac{EV}{Actual} = \frac{1000}{1400} = .71$$

CV = EV - Actual = 1000 - 1400 = -400

$$SPI = \frac{EV}{Planned} = \frac{1000}{1500} = .67$$

SV = EV - Planned = 1000 - 1500 = -500

Our Journey

Automated Tools

WBS

SEP

EVM:
Planning Policies
Tracking Policies

CMM

Our EVM System

Functional Requirements

System Requirements

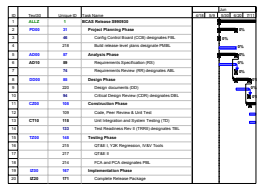
SEP WBS Template

PM

Planning

Cost & schedule Estimate

Automated Tool



Updates actual technical accomplishment

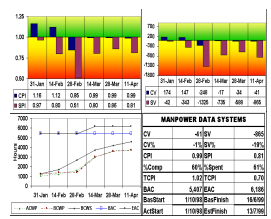
Capture Baseline

Value Earned

Tracking

Compares: actual to plan

Project Team keeps track of actual effort



Automated Tool:
Collects Actual Costs

Developer/2000 Forms Runtime for Windows 95 / NT

File View Print Reports Maint Process Help Window

JLIM 103 - Labor Adjustment Form

Labor Group: BICA BICA Labor Period: 23 01-JUN-1999 05-JUN-1999

Employee Name	Type	Cost CTR	Status
ALLISON, CHERI L	MIL	2BICAS	CERTIFIED
TACKETT, CHRISTOPHER E	MIL	2BICAS	CERTIFIED
TALLEY, KALET D	MIL	2BICAS	CERTIFIED

Submit Adjustments

Clear Adjustments

Exit

Scheduled Hours 32.0

PC	Week 1 SUN	MON	TUE	WED	THU	FRI	SAT	Week 2 SUN	MON	TUE 06/01	WED 06/02	THU 06/03	FRI 06/04	SAT 06/05	JON	Project	Account
										8	8	8	8	0			
M3										8.00	8.00	8.00	8.00		PI SPO	Sep00	AD100043

Adjustments:

M3										-8.00							
															Job Order Number		
										8.00	8.00	8.00	8.00		32.00		

Cannot alter offset records - Enter a new labor record.

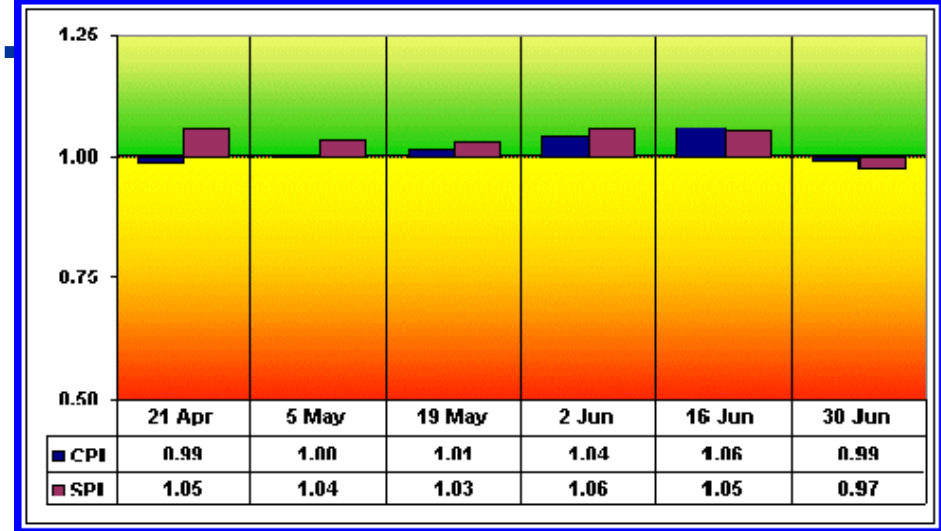
Record: 2/2

Laborer keeps track of time spent on work products

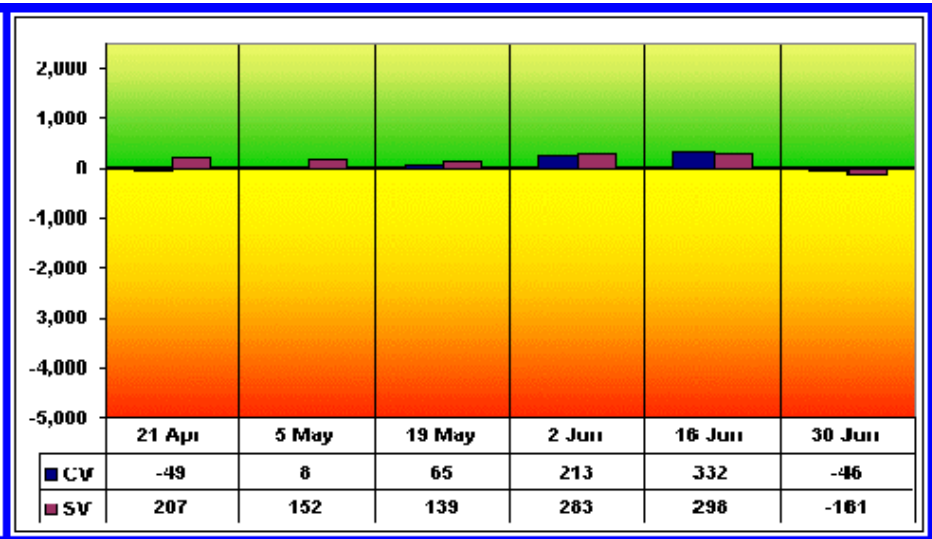
Accurate recording of time assures accurate paycheck

Automated Tool:

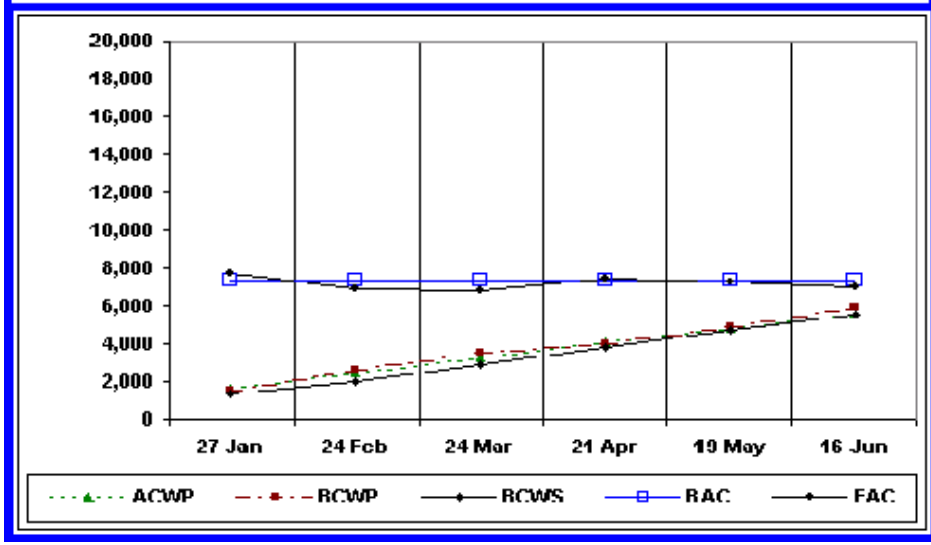
Compares Plan to Value to Actual



	21 Apr	5 May	19 May	2 Jun	16 Jun	30 Jun
CPI	0.99	1.00	1.01	1.04	1.06	0.99
SPI	1.05	1.04	1.03	1.06	1.05	0.97

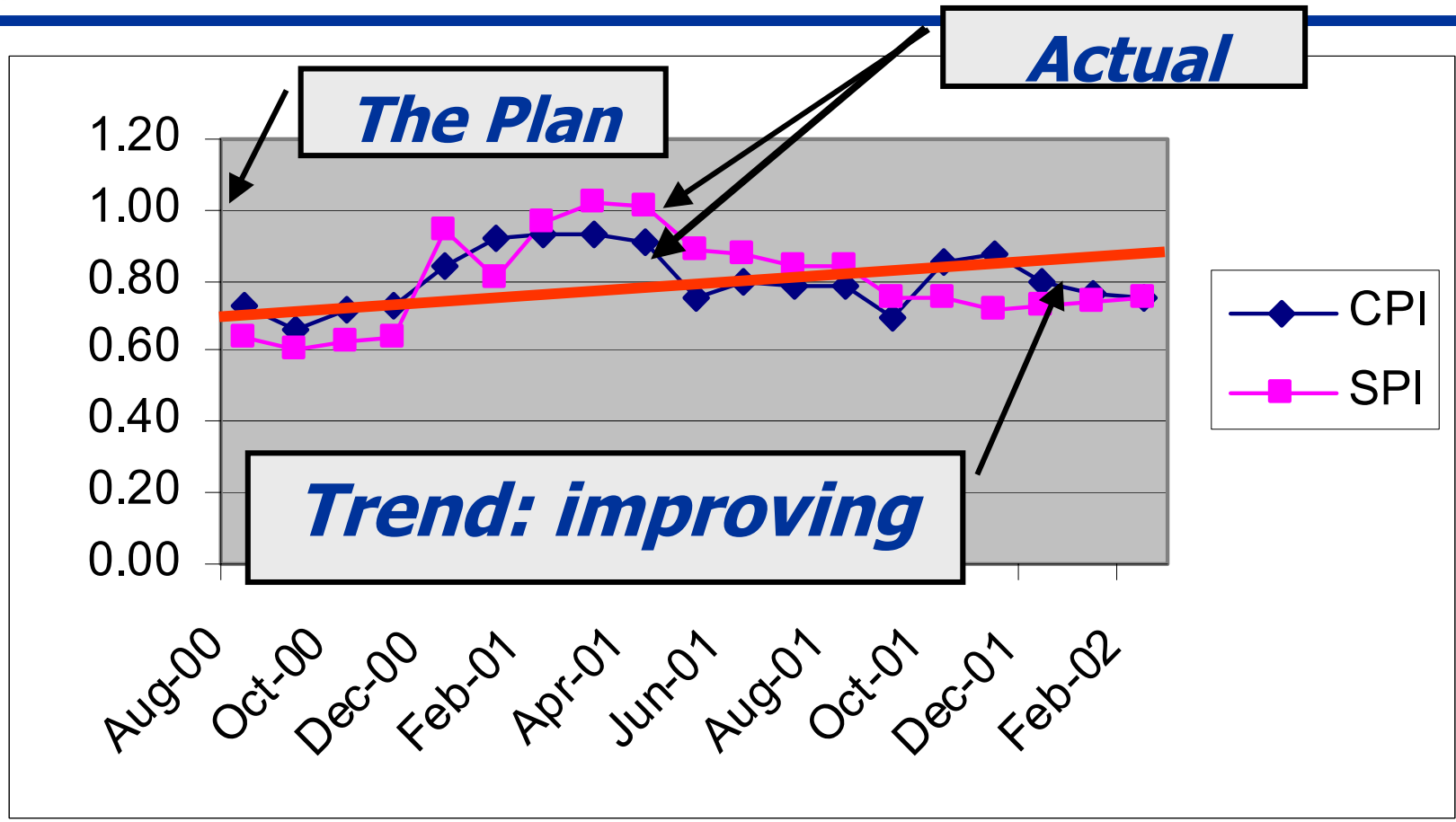


	21 Apr	5 May	19 May	2 Jun	16 Jun	30 Jun
CV	-49	8	65	213	332	-46
SV	207	152	139	283	298	-161



BEMIS/OCT00 FRB GRP1			
CV	-46	SV	-161
CV%	-1%	SV%	-3%
CPI	0.99	SPI	0.97
%Comp	80%	%Spent	80%
TCPI(BAC)	1.03	TCPI(EAC)	0.99
BAC	7,400	EAC	7,458
BasStart	1 Nov 00	BasFinish	28 Sep 01
ActStart	1 Nov 00	EstFinish	13 Sep 01

Improving our SEP



32 +/- projects reporting, total of $20M

Two primary reasons: better estimates & better execution

Lessons Learned

Not All Pain Is Gain.

Lessons Learned:

Program Manager's Perspective

- **Common, documented, up-front understanding**
- **Objectively demonstrate accomplishment**
- **Implicitly indicates product quality**
- **Understanding of project risks and variables to be better planner in next and proactive in current**
- **Integrates well with / adds more weight to other software metrics**
- **Leave a legacy to next Program Manager**

Lessons Learned:

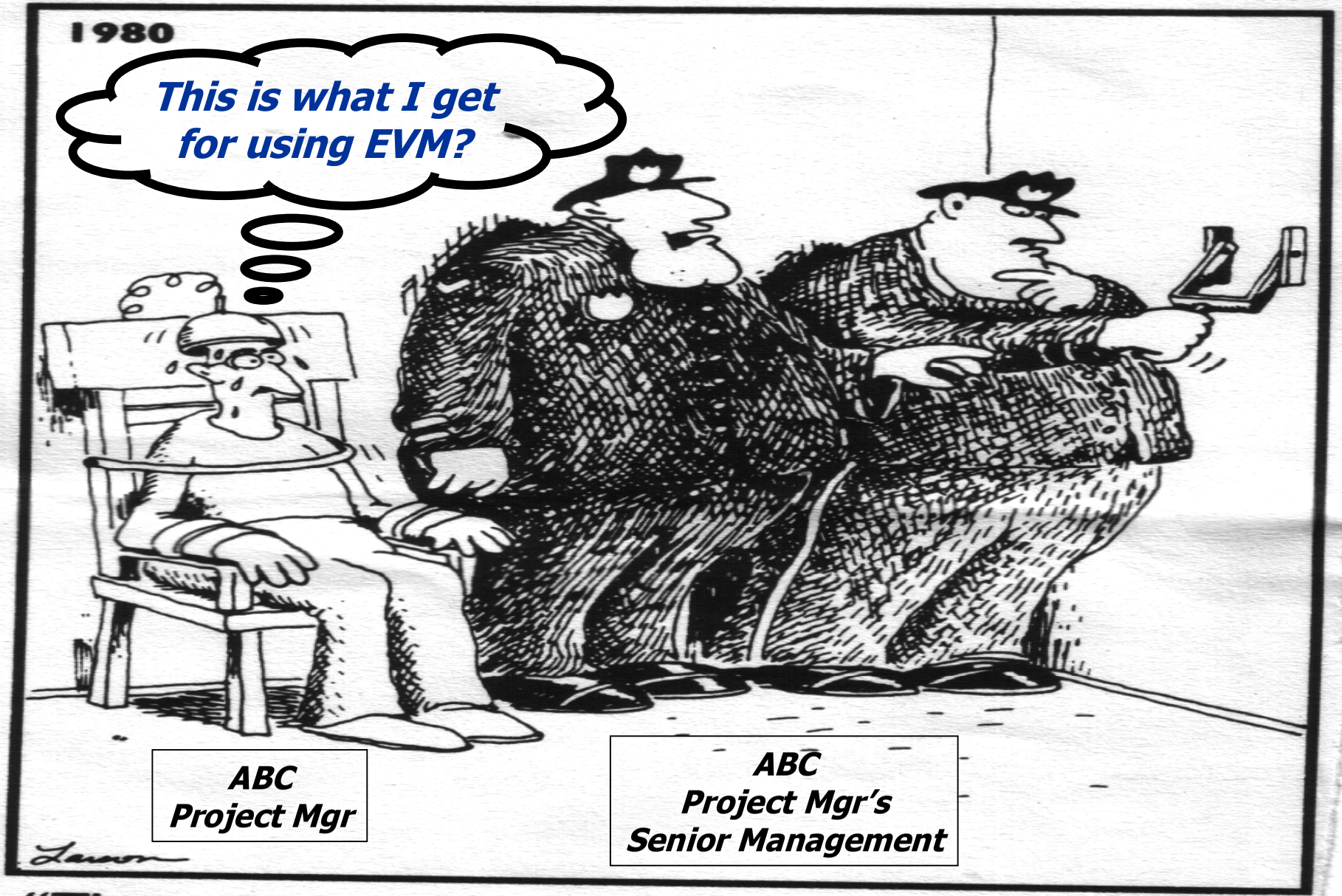
Senior Management Perspective

- **Senior Managers shouldn't need detailed cost & schedule data if project within EV boundaries**
- **Accurate accounting of labor = accurate charging of Customers**
- **Quality work products are being accomplished**
- **True, objective picture which can be rolled up to represent the entire organization**

Lessons Learned:

Senior Management Perspective

- **Accurately forecast future costs**
  - **Within 20% of project start the Estimate At Completion (EAC) can be statistically forecasted**
  - **But Program Managers must balance EAC against his/her own estimates using "best professional judgments"**
    - If PM's judgment is less than statistically calculated EAC, then PM must describe how this is to be accomplished
- **EVM is critical in accomplishing continued maturation of software development**
  - **Addressing the Quantitative Project Management Key Process Area in the CMMI**
- **Knows that cultural change does not happen overnight**



"The contact points must be dirty. ... Just click it up and down a few times."

Lessons Learned:

Customer's Perspective

- **Project is earning the incremental value that was mutually agreed to at project start**
- **If project ahead**
  - **Planned risks have not occurred**
  - **Opportunity to receive refund or deliver early**
- **If project behind**
  - **Risks have been realized, prepare to make a decision**
    - Cancel project (but keep value added to date)
    - Add more money, schedule, or reduce performance goals

Lessons Learned:

Customer's Perspective

- **An argument for labor hours versus $**
  - **Inherent delay in obtaining $**
    - from automated accounting sources—up to months late from expenditure to verification
    - versus the next day for certified labor
  - **Including "Other Direct Costs (travel, hardware purchases, etc) as measured by $ tends to lessen the sensitivity of measurement**
    - Ex: including a $1M in hardware purchase with a $1M of labor
  - **Can get Contractor labor hours but can't get actual dollars by labor category**

Summary

With the gradual implementation of our EVMS the learning process is providing:

- **Useful management tool (not accounting tool)**
- **An increasingly better source of estimates**
- **Management decisions BEFORE systems get out of control.**

Example of Faulty EVMS?

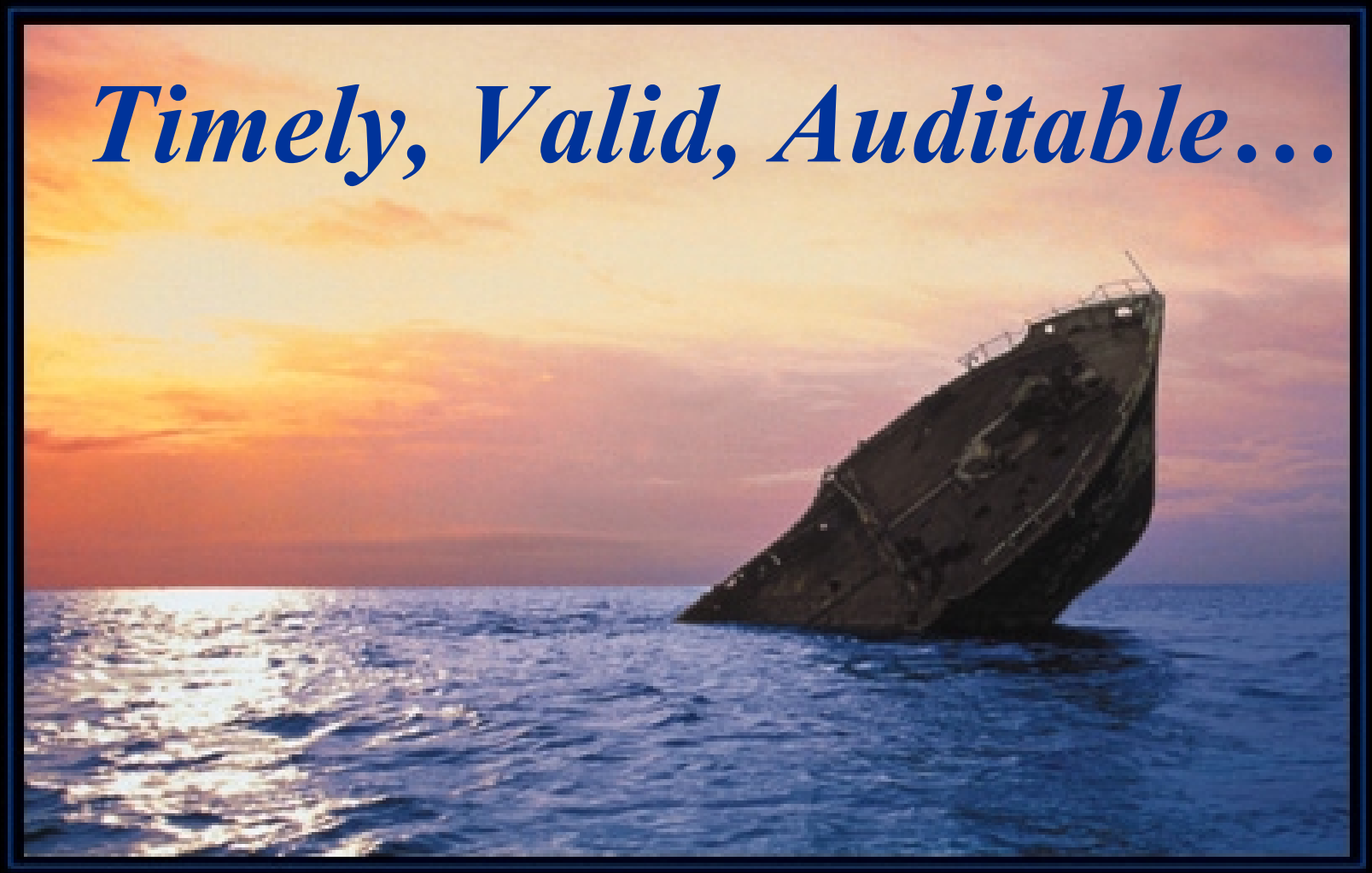
On 9 June 00, Contractor ~~ABC~~ informed the Government they had not made any progress during the last few weeks and the project was somewhere between **65-80% complete**, not the **91% complete** they formally reported to the Government.

…had presented inaccurate data to the Government in their **earned value data**--a stop work order was issued.

An internal assessment reported only **48.7% complete…** contractor submitted a proposal for **$2.4M to complete**.

Well documented work products & 380,000 LOC built

Signed
Government P.M.



MISTAKES

It Could Be that the Purpose of Your Life Is
Only to Serve as a Warning to Others.

To Recap Our Journey

- **Used CMM as Foundation**
- **Defined our processes in our SEP**
- **Tailored our SEP into a refined WBS and Addressed the Uniqueness of Software Development**
- **Implemented automated support tools which enforces and reinforces good EVM**
- **Succeeding in Improving our Processes**
- **Continually applying Lessons Learned to our Processes, Tools, People**

EVM is answering the question oft posed to Government Agencies: *"what are we getting for what we are spending?"*

Standard Systems Group

U.S. AIR FORCE

Three Years Using Earned Value

Questions?

Barry Morton
SSG Software Factory