
Benefits to the Evolution of High Maturity Software Development: A 15 Year Case Study

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Agenda

- **A brief history of the Flight Software Element (FSWE)**
- **Overview of the FSWE software process**
- **Changes to High Maturity**
- **Changes to the FSWE software process**
- **CMMI as a Vehicle to Meet Customer Needs**
- **Benefits to USA, our Customers, and Software Acquisition**



Functional Structure of Onboard Software

Preflight
Initialization
Checkout

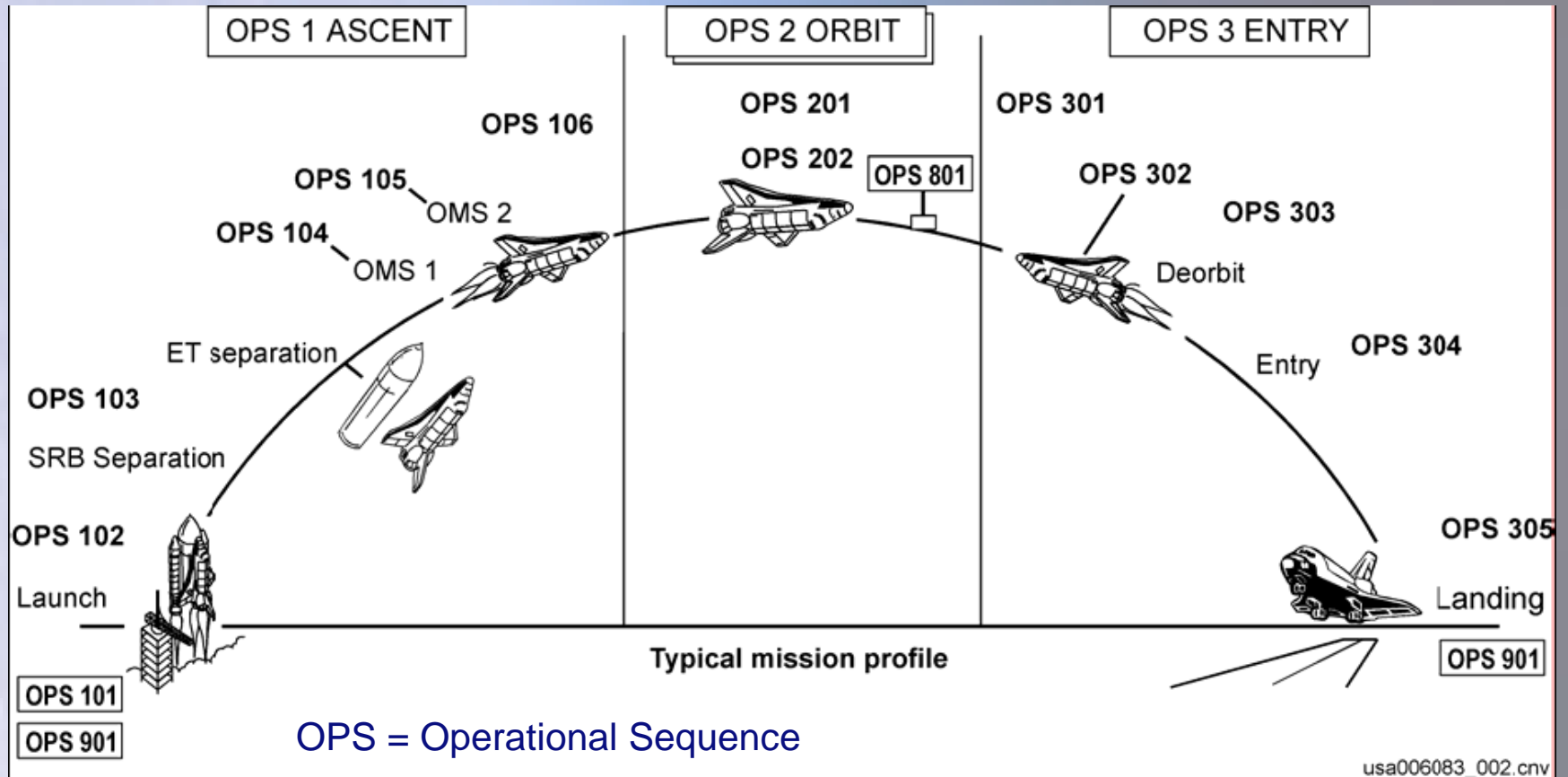
Ascent /
Abort

On-Orbit

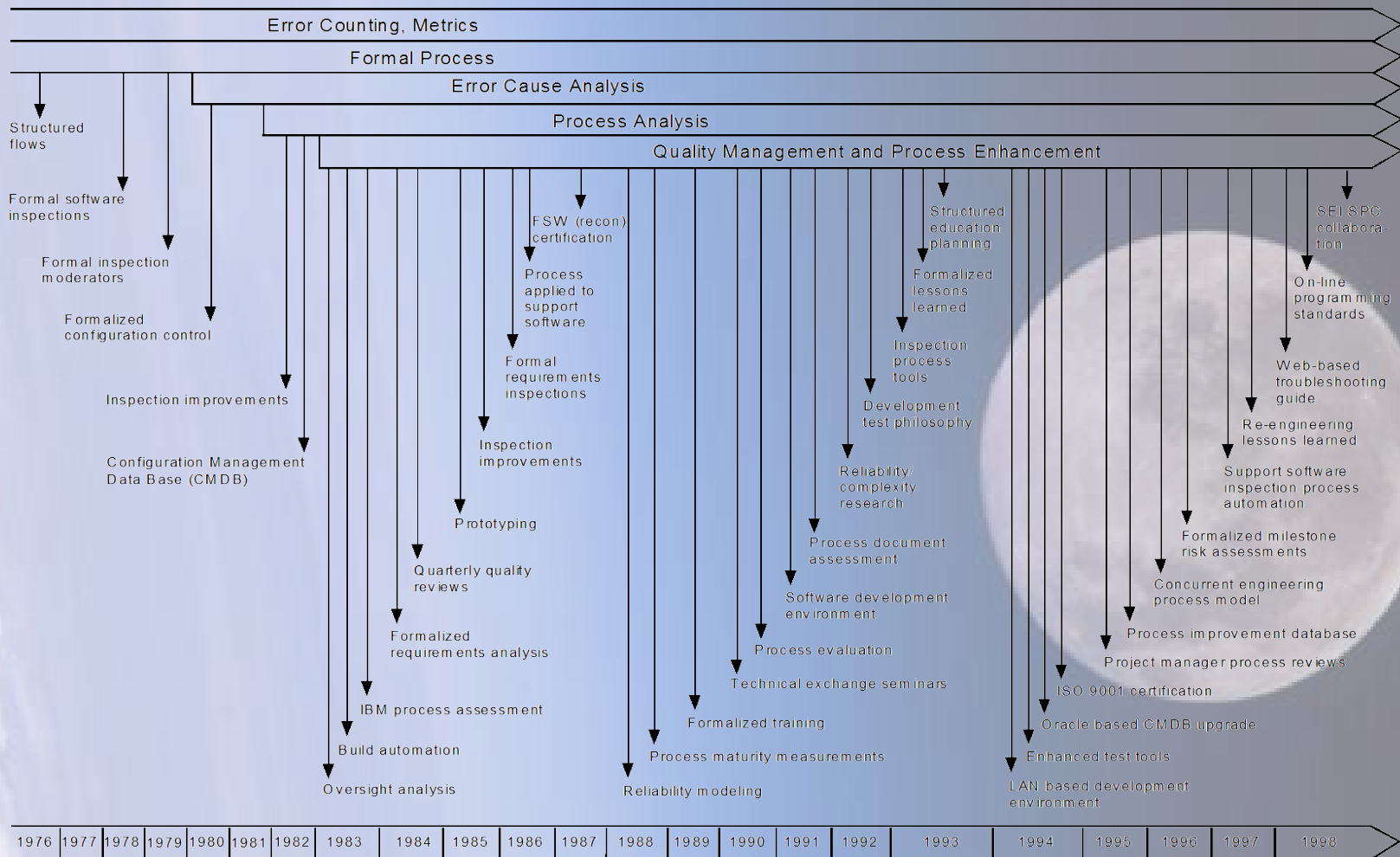
On-orbit
Systems and
Payload
Management

Entry

Mass
Memory
Utility



Continuous Process Improvement Started in 1976

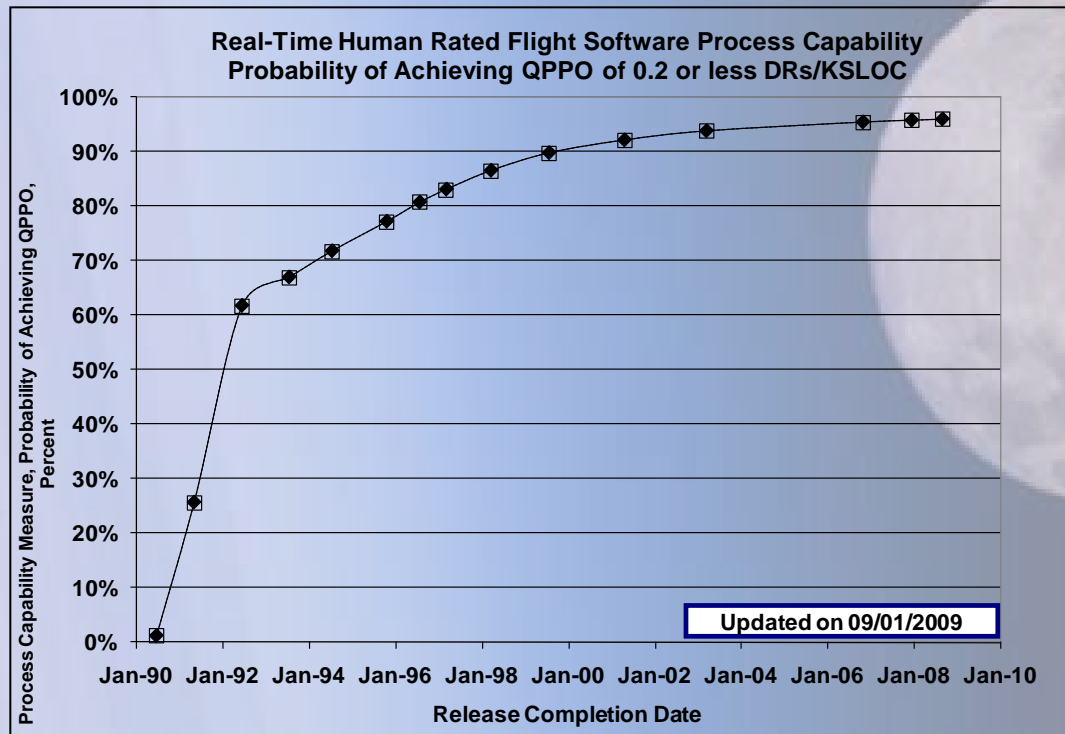


↑ Recognized as CMM Level L5 1989



Evolution of Capability

- The FSW Organization has practiced the elements of high maturity for over 20 years.
- From a quality perspective, our understanding of common and special cause variation within our processes has allowed us to optimize our quality to a world-class level



Evolution Cont.

- Today there are three major business areas in the FSW Organization
 - Real-Time Human Rated Software
 - Develops On-Board Guidance/Navigation/Control/Support Systems software for the Space Shuttle
 - Mission Critical Application Tools
 - Develops ground support software simulation/testing environments for Human-Rated Shuttle Software Validation and Mission Support Activities
 - Avionics Integrated Laboratory Support Software
 - Develops ground support software simulation/testing which are integrated with Shuttle Hardware to Validate Human-Rated Shuttle Software and Mission Support Activities
- Our CMM/CMMI ratings began with Human-Rated Software and evolved over the years to include all three.

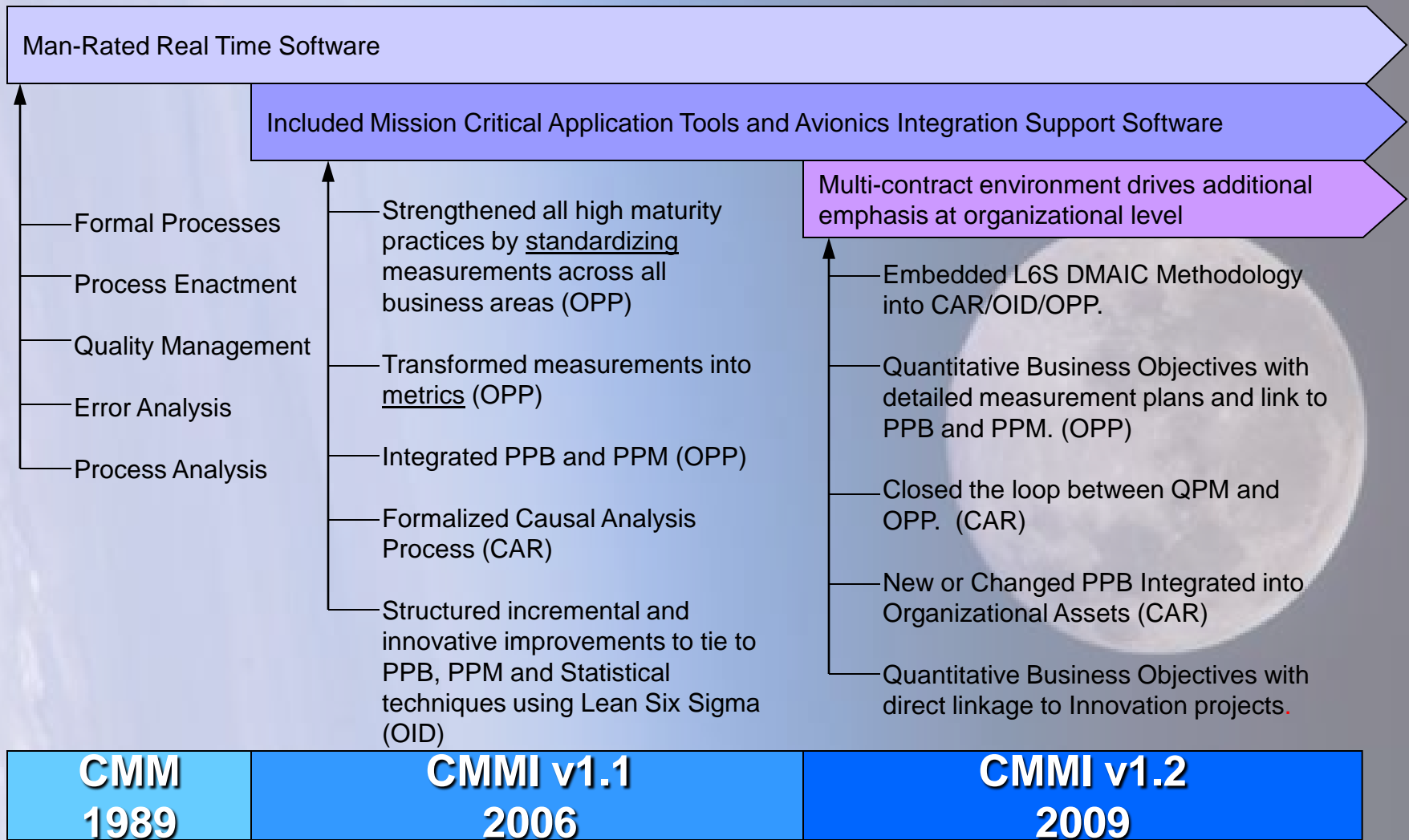
High Maturity Evolution: Model Changes L4

CMM	CMMI 1.1	CMMI 1.2
Quantitative Process Management	Quantitative Project Management	Quantitative Project Management
<u>Control the process</u> performance of the project quantitatively	Quantitative management clarified to center around <u>statistical techniques</u>	Focus on the use of <u>performance baselines and models</u> in active project management
Software Quality Management	Organizational Process Performance	Organizational Process Performance
<u>Define</u> quantitative quality goals for project products and <u>achieve those goals</u>	<u>Establish performance baselines and models</u> for the organization's standard process	Focus on PPB and PPM <u>tie to business objectives</u> and use of <u>statistical techniques</u>

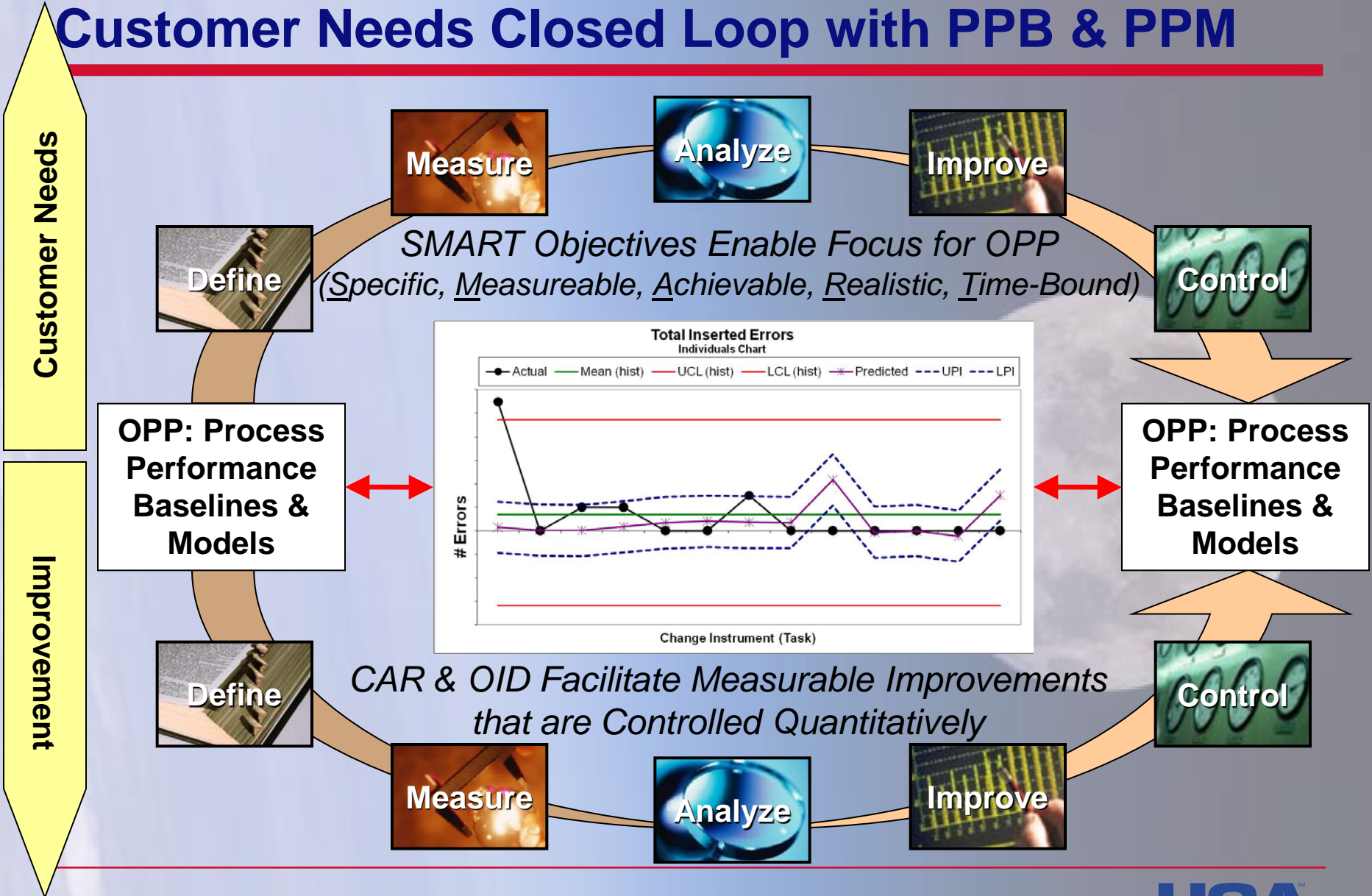
High Maturity Evolution: Model Changes L5

CMM	CMMI 1.1	CMMI 1.2
Defect Prevention	Causal Analysis and Resolution	Causal Analysis and Resolution
<u>Identify the cause of defects and prevent them from recurring</u>	Amplification on <u>causal analysis and resolution</u> activity	<u>Tie causal analysis and resolution to a “quantitatively managed” process</u>
Technology Change Management	Organizational Innovation and Deployment	Organizational Innovation and Deployment
<u>Identify new technologies and transition them into the organization</u>	<u>Select and deploy incremental and innovative improvements that measurably improve</u> processes and technology	Improvements show measurable <u>statistical significance</u>
Process Change Management		<u>Tie to business objectives</u>
<u>Improve the software processes with the intent of improving software quality</u>	<u>Tie to PPB and PPM and Statistical techniques</u>	

Evolution of the Flight Software Organization



Customer Needs Closed Loop with PPB & PPM



Overall Benefit

- **Process improvement driven more by changes in business environment rather than changes in the CMMI**
 - In the past, we have had only a single customer where Quality was paramount.
 - Today's Market, as well as future market, Cost is becoming equally as important.
- **Changes to the CMMI provided more focus direction for applying high maturity to the organization's business needs**
- **While the improvements we have made benefited the market of their time, those methodologies can be translated to help provide customers with overall best-value**
 - **Tailor-able Cost and Quality given the needs of the customer**
 - **Processes with historically proven capability**

Acquisition Strategy

- A High Maturity Organization should be able to provide
 - Reliable and predictable quality
 - Tailored to your specific capability needs
 - Substantiated cost with the ability to optimize
 - Tailored based on your dynamic budget
 - Consistent predictable results
- Do not rely merely on the CMMI rating
 - Look at the application of PPBs and PPMs
 - Review the organization's business objectives and benchmarks against those objectives



BACKUP CHARTS



Comparison of CMM and CMMI Goals

Quantitative Process Management	Quantitative Project Management
The quantitative process management activities are planned.	The project is quantitatively managed using quality and process-performance objectives.
The process performance of the project's defined software process is controlled quantitatively.	The performance of selected subprocesses within the project's defined process is statistically managed.
The process capability of the organization's standard software process is known in quantitative terms.	

Comparison of CMM and CMMI Goals

Software Quality Management	Organizational Process Performance
The project's software quality management activities are planned.	Select the processes or subprocesses in the organization's set of standard processes that are to be included in the organization's process-performance analysis
Measurable goals for software product quality and their priorities are defined.	
Actual progress toward achieving the quality goals for the software products is quantified and managed.	

Comparison of CMM and CMMI Goals

Defect Prevention	Causal Analysis and Resolution
Defect prevention activities are planned.	Root causes of defects and other problems are systematically determined.
Common causes of defects are sought out and identified.	Root causes of defects and other problems are systematically addressed to prevent their future occurrence.
Common causes of defects are prioritized and systematically eliminated.	

Comparison of CMM and CMMI Goals

Technology Change Management	Organizational Innovation and Deployment
Incorporation of technology changes is planned.	Process and technology improvements, which contribute to meeting quality and process-performance objectives, are selected.
New technologies are evaluated to determine their effect on quality and productivity.	Measurable improvements to the organization's processes and technologies are continually and systematically deployed.
Appropriate new technologies are transferred into normal practice across the organization	
Process Change Management	
Continuous process improvement is planned.	
Participation in the organization's software process improvement activities is organization-wide.	
The organization's standard software process and the projects' defined software processes are improved continuously.	

Criteria for Audits of CMMI High Maturity Appraisals

- The SEI is currently performing audits of all CMMI High Maturity appraisals. The following are the criteria being used for these audits. These criteria in no way limit the application of the model or its intent or judgments made during an appraisal, nor do they relieve the organization from fully implementing the model.
- As defined in the SCAMPI v1.2 Method Definition Document Section 1.1.3, these criteria refers to the instantiations in the representative sample that are identified as either focus projects, non-focus projects, or other organizational level instantiations with a scope that includes the high maturity process areas.

Audit Criteria

- **Organizational Process Performance**
 - **(SP 1.1) Show the relationship between the business objectives and the processes selected for process performance analysis.**
 - **(SP 1.2) Show the analysis and rationale for deciding what data to include in the process performance analysis.**
 - **(SP 1.3) Show the relationship between business objectives and Quality and Process Performance Objectives (QPPOs).**
 - **(SP 1.4) Describe Process Performance Baselines (PPBs) in terms of central tendencies and variation for the processes selected for analysis.**
 - **(SP 1.5) Describe at least one Process Performance Model (PPM) in terms of the processes included, the controllable inputs and the predicted outputs. The model must be statistical or probabilistic in nature rather than deterministic, i.e., the model considers uncertainty and predicts that uncertainty or range of values in the outcome.**

Audit Criteria

- **Quantitative Project Management**
 - **(SP 1.2) Describe how the projects created their defined process by using PPBs and/or PPMs to predict the ability of the processes selected to meet the project's QPPOs.**
 - **(SP 1.3) Describe the project's rationale for selecting subprocesses to be statistically managed.**
 - **(SP 1.4) Show how at least one project used process measures as inputs to a PPM used to actively manage the project.**
 - **(SP 2.2) Show that at least one project applied statistical methods to identify and remove special causes of variation from selected subprocesses.**
 - **(SP 2.3) Show how projects monitor the capability of selected subprocesses.**

Audit Criteria

- **Causal Analysis and Resolution**

- (SP 1.2) Demonstrate that at least one of the defects or problems selected for analysis was related to a quantitatively managed process, where “quantitatively managed” is as defined in the glossary.

- **Organizational Innovation & Deployment**

- SP 2.3) Demonstrate that the effects of at least one improvement were measured for statistical significance.

