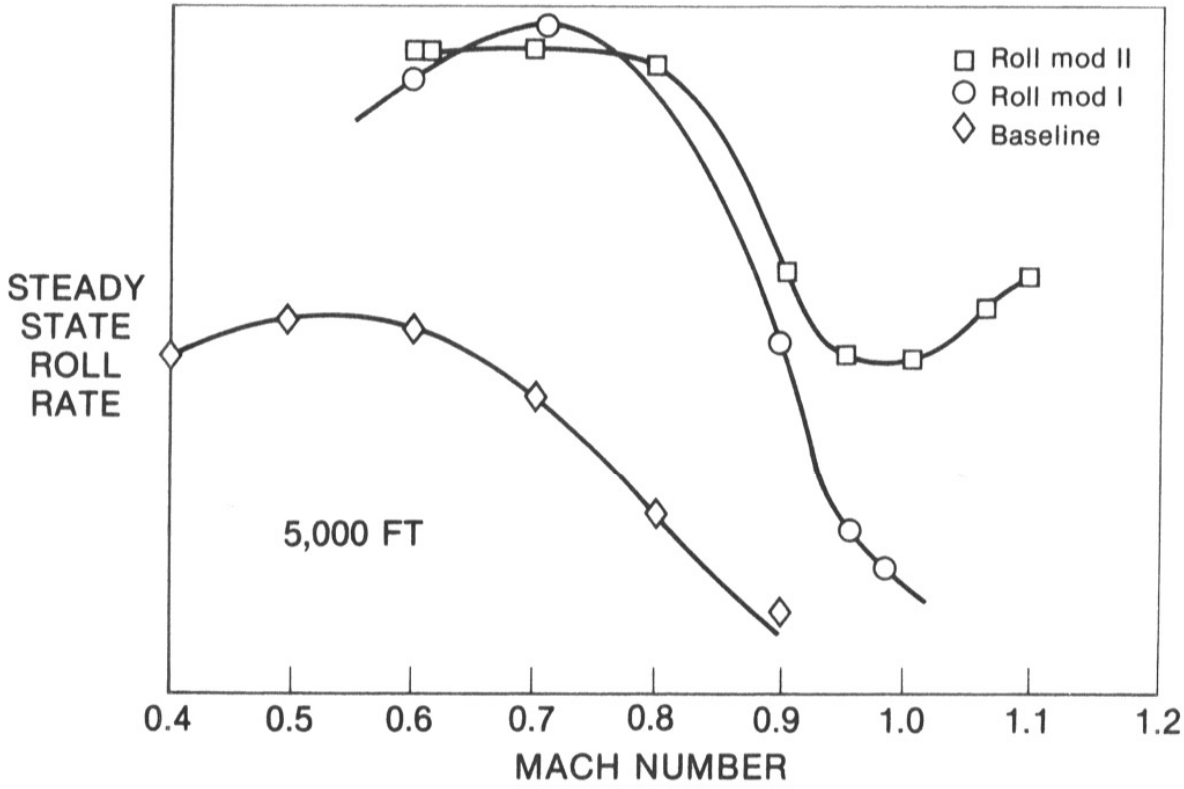
ROLL PERFORMANCE IMPROVEMENTS



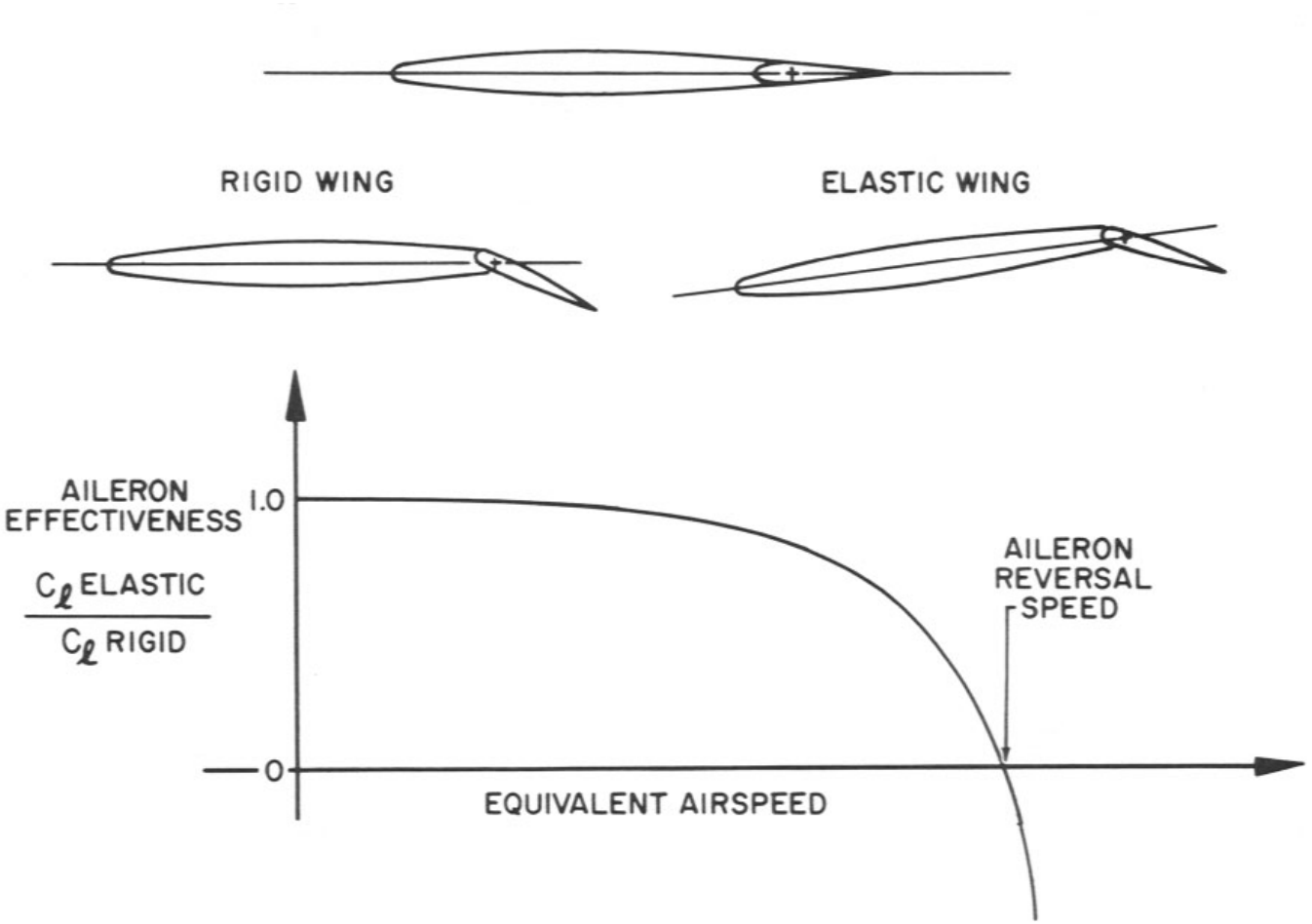
BASELINE - AILERONS/DIFFERENTIAL TAILS/RUDDERS

ROLL MOD I - ADDED DIFFERENTIAL FLAPERONS AND MODIFIED AILERON MACH/DYNAMIC PRESSURE SCHEDULES

ROLL MOD II - ADDED DIFFERENTIAL LEADING EDGE FLAPS FOR WING WARPING

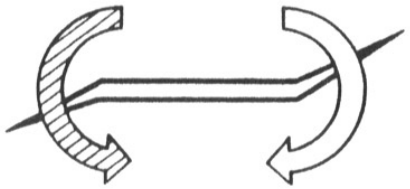
GP33-0509-8

AEROELASTIC CONSIDERATIONS
AILERON REVERSAL / FLEX-TO-RIGID RATIO



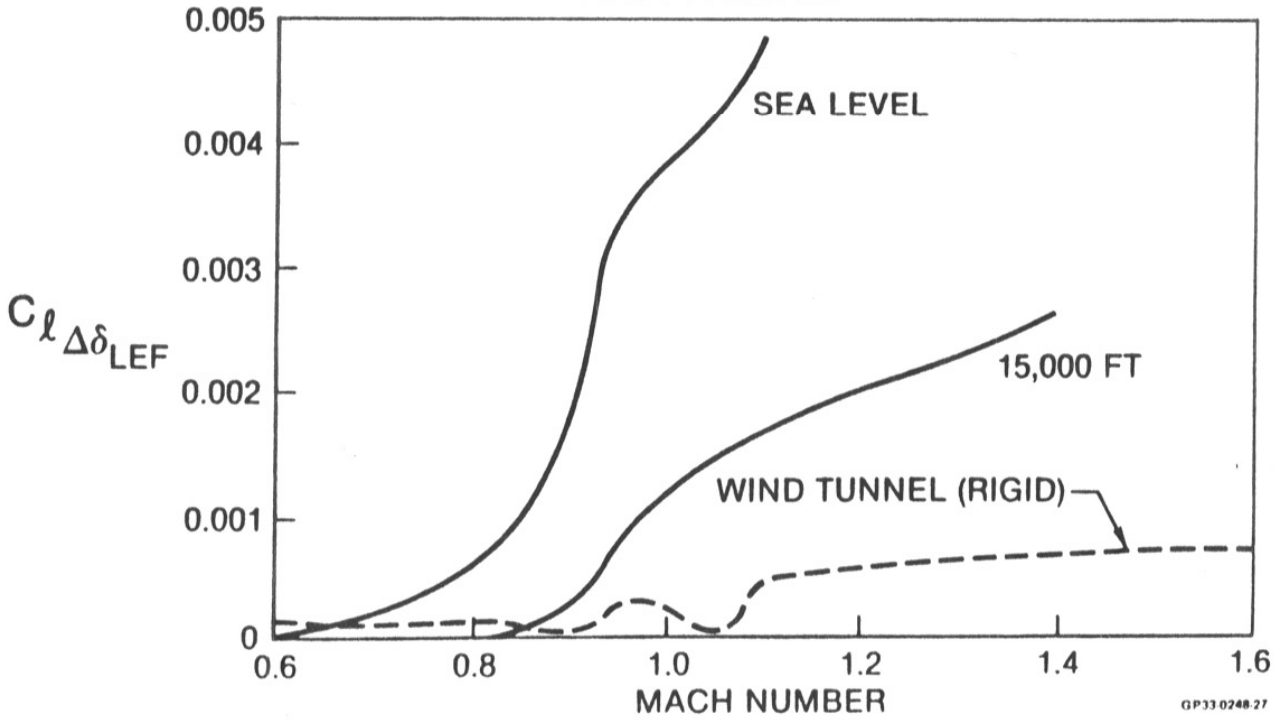
DIFFERENTIAL LEADING EDGE FLAPS

ROLL POWER

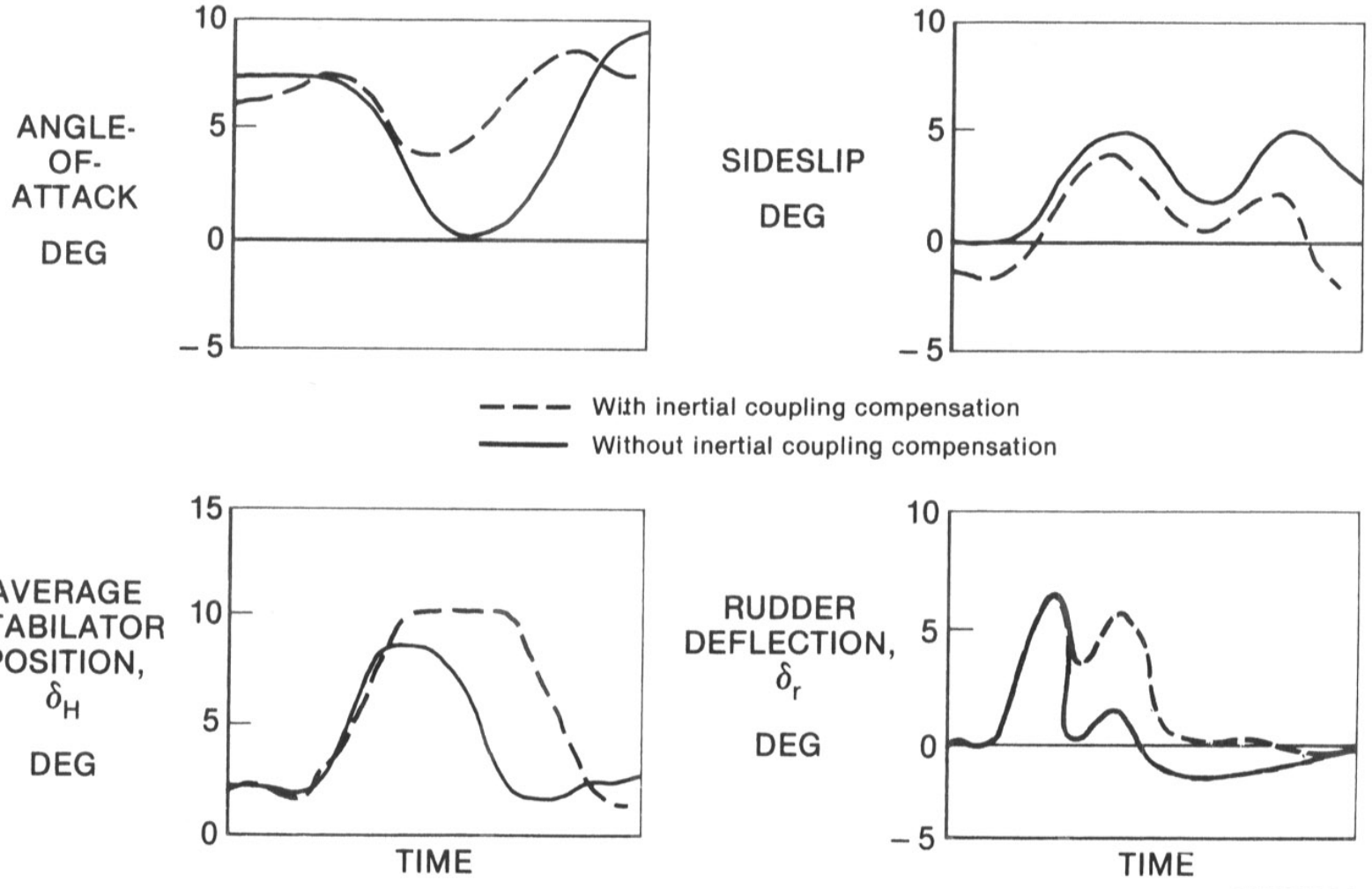


AILERON ROLL FORCE

FORCE DUE TO TWIST FROM LEF



EFFECT OF INERTIAL COUPLING COMPENSATION
360° FULL STICK ROLL

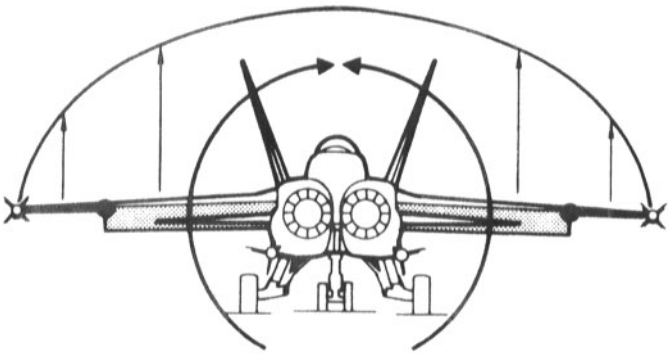


GP33-0509-9

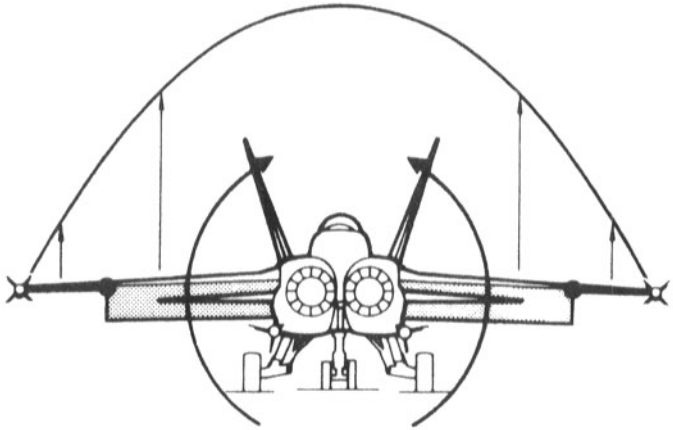
WING-FOLD AND WING-ROOT BENDING MOMENTS

INCREASED TRAILING-EDGE-FLAP DEFLECTIONS
REDUCE WING-FOLD AND WING-ROOT
BENDING MOMENTS

BEFORE



AFTER



GP33-0509-10

Structural Loads Control

The Digital Flight Control is Very Effective in Controlling Structural Loads

- Control Wing/Pylon Loads With Heavy Stores
- Control Wing-Fold and Wing-Root Bending Loads
- Redistribute Loads by Scheduling Control Surfaces
- Limit Loads by Scheduling Maximum Control Deflection
- Limit Maximum Load Factor - Pilot Over-Ride

INERTIAL COUPLING EQUATIONS AND COMPENSATION

EQUATIONS:

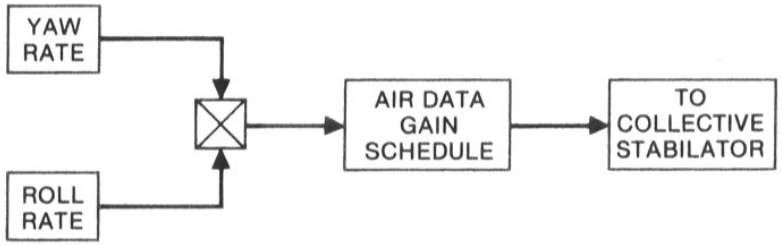
$$\dot{q} = \left(\frac{I_z - I_x}{I_y}\right) p\, r$$

$$\dot{r} = \left(\frac{I_x - I_y}{I_z}\right) p\, q$$

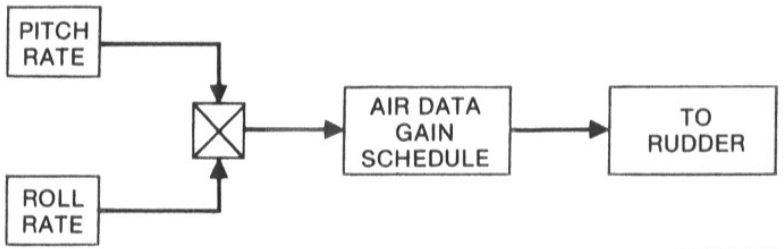
WHERE:

- q = PITCH RATE
- p = ROLL RATE
- r = YAW RATE
- I_x = ROLL MOMENT OF INERTIA
- I_y = PITCH MOMENT OF INERTIA
- I_z = YAW MOMENT OF INERTIA

LONGITUDINAL COMPENSATION FEEDBACK:

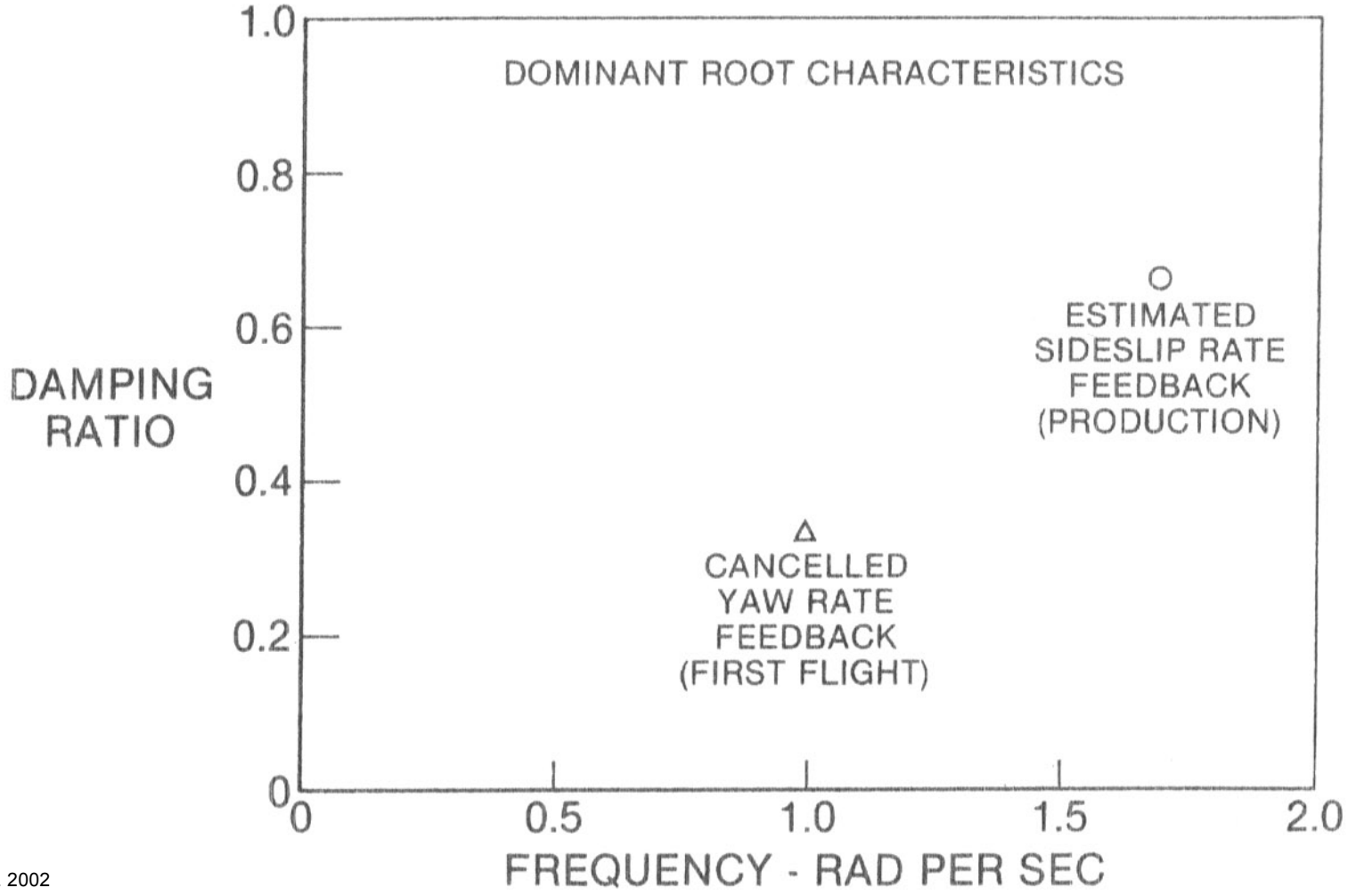


DIRECTIONAL COMPENSATION FEEDBACK:



GP33-0509-11

DUTCH ROLL MODE CHARACTERISTICS
POWER APPROACH CONFIGURATION



GP33-0887-5

Discussion of F/A-18 Flight Control System

Next Topic

- Systems Engineering
- Integrated Product Team

F/A-18E/F Development

A Brief Discussion on Systems Engineering From the Integrated Product Development Team Perspective

What is Systems Engineering ?

"Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs".

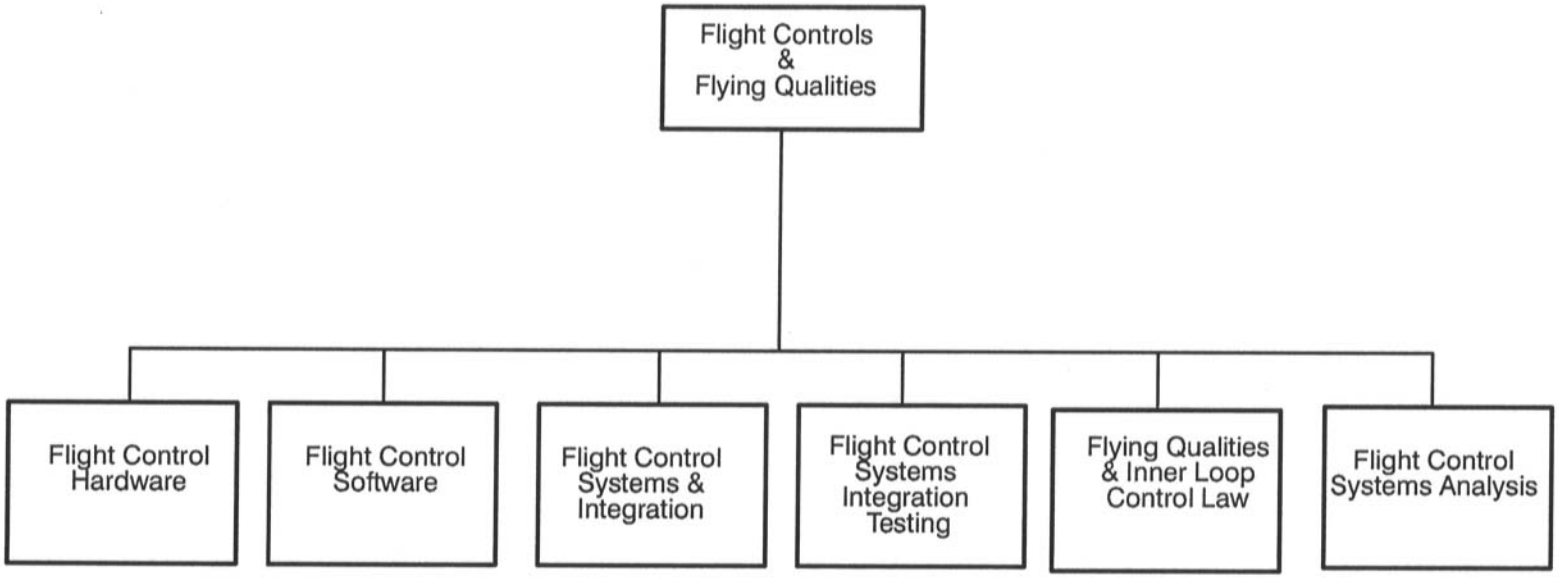
Reference: International Council On Systems Engineering

IPT TEAM LEADERS MUST MANAGE:
- **SYSTEM DESIGN AND DEVELOPMENT**
- **COST AND SCHEDULE**

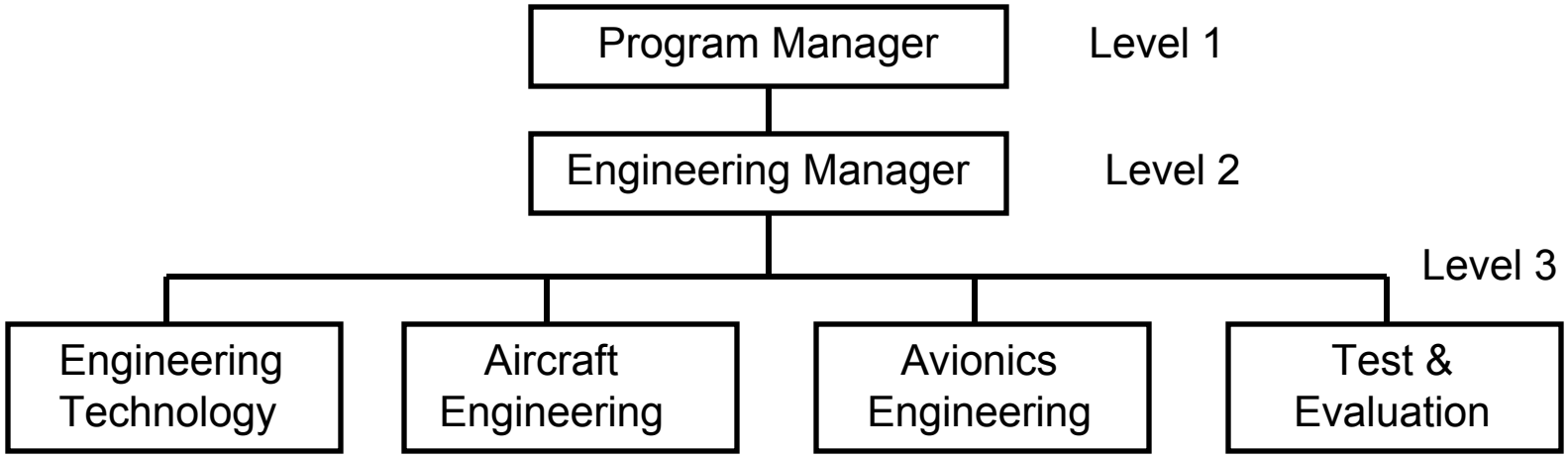
Flight Controls and Flying Qualities Team

Example of Level 4 IPT

Multidiscipline Flight Controls Team

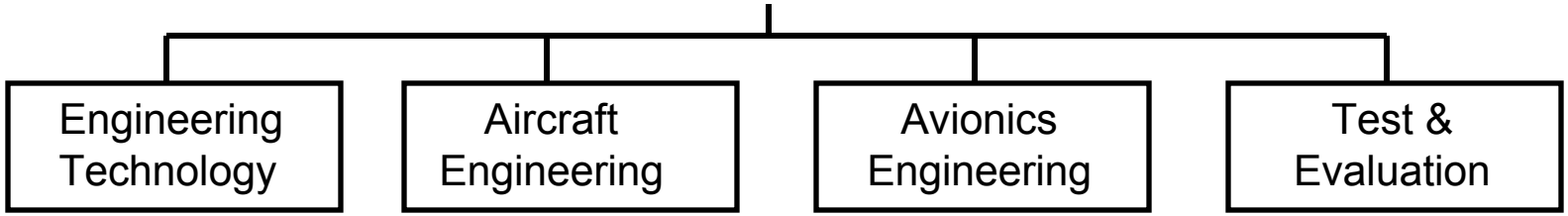


Before IPT - Functional Organizations



Aerodynamics	Structures	Electronic Sys.	Ground Test
Guidance & Cont.	Mechanics	Radar	Flight Test
Loads	Armament	Communication	Flight Safety
Matl. & Processes	Crew Station	Navigation	
Propulsion	Electrical	Electronics Lab.	
R & M	Fuel	Ground Support	
Thermodynamics	Hydraulics		
Strength	Landing Gear		
Structural Dyn.	Mfg. Engr.		

Before IPT - Functional Organizations



Engineering Technology	Aircraft Engineering	Avionics Engineering	Test & Evaluation
Aerodynamics *	Structures	Electronic Sys. *	Ground Test
Guidance & Cont. *	Mechanics	Radar	Flight Test
Loads	Armament	Communication	Flight Safety *
Matl. & Processes	Crew Station	Navigation *	
Propulsion	Electrical	Electronics Lab.*	
R & M *	Fuel	Ground Support	
Thermodynamics	Hydraulics *		
Strength	Landing Gear		
Structural Dyn.	Mfg. Engr.		

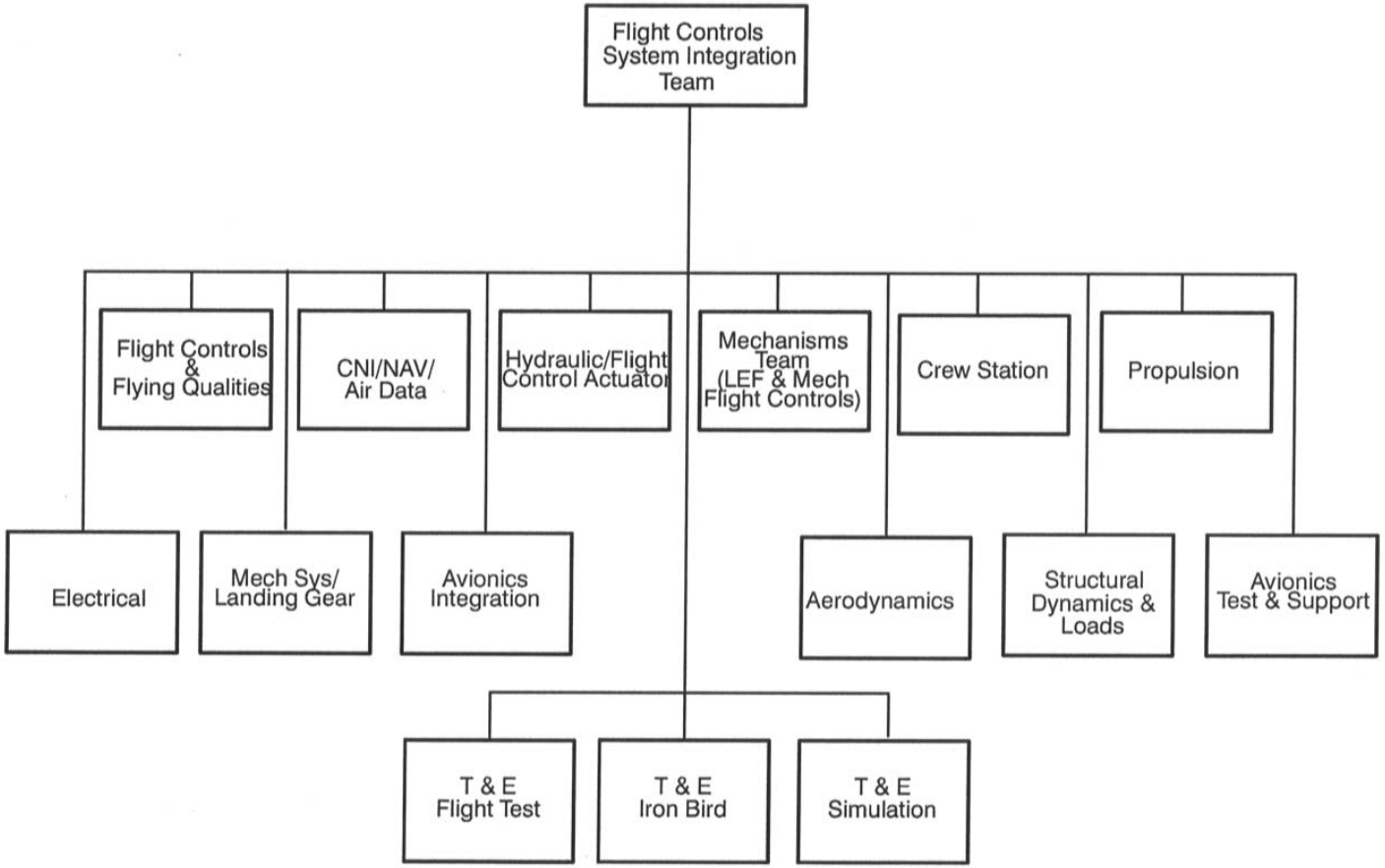
Note:

- Before IPT Cost and Schedule Was Allocated to Functional Groups
- The (*) Indicates Groups Represented in the Flight Controls & Flying Qualities IPT

Flight Controls and Flying Qualities IPT Major Products

- Flying Qualities Requirements
- Flight Control System Requirements
- System Design and Analysis Documents
- System/ Subsystem Interface Documents
- Flight Control Computer and Sensor Hardware
- System Software Design, Code, and Testing
- System Integration Test Requirements and Testing
- Coordination of FCS Integration Team

Flight Control System Integration Team



THIS IS NOT A FORMAL IPT !

Purpose - Horizontal Integration Across Program IPTs

- IPT Charters Included Support of FCS Integration Tasks
- All Teams Concur With FCS Development Plan

Integrated Product Team (IPT)

Responsibility
- Product Delivery
- Customer Supplier Relationship
- Processes
- Trades/Design Decisions

Accountability
- Technical Performance Measurands (TPM)
- Cost
- Schedule
- Risks

Authority
- Management of Multi-Disciplined Team
- Budget
- Performance Appraisals

Program Management Structure Needed to Support Systems Engineering and IPTs

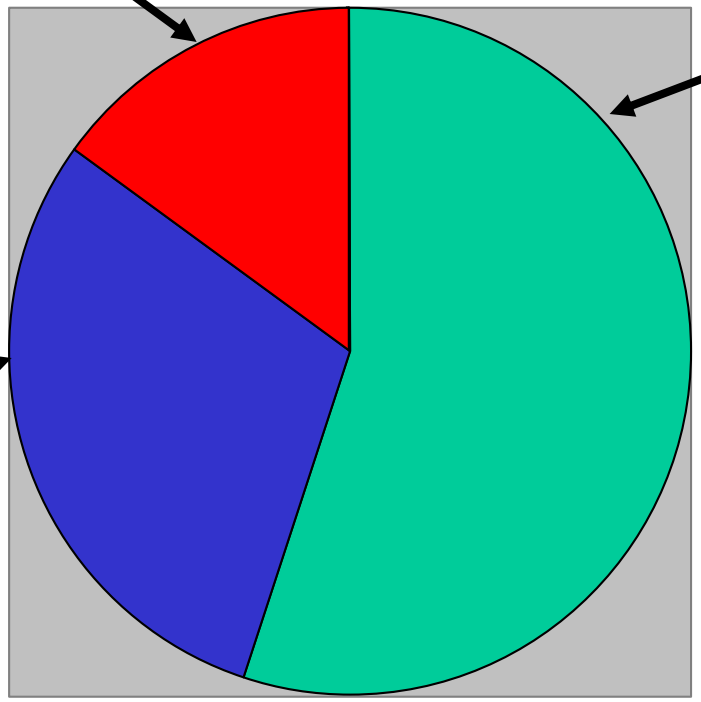
F/A-18E/F
Management Processes to Support IPT

- Requirements Flow Down
- Budget
  - Allocated to IPT
  - Management Reserve - Held at Program Manager Level
- Integrate Schedules
- Weekly Earned Value
  - DOD Cost & Schedule Control Systems Criteria (C/SCSC)
- Weekly Program Managers Meeting
  - Cost
  - Schedule
  - TPM
  - Problems / Issues
  - Risk Management
    - Likelihood / Consequence
    - Mitigation - Plan of Action and Milestones
  - Help Needed

IPT Organization and Management Processes Are Critical to Completing a Program on Schedule and Cost

IPT Tasks for Development of a New System

What We Don't Know
We Don't Know
• Pop-Up Risks
• Management Reserve



What We Know
• Planned and Scheduled Tasks

What We Know
We Don't Know
• Development Testing
  • Contractor
  • Suppliers
• Risk Reduction Tasks

IPT Budget Should Include Management Reserve Funds

Risk Management Status

- Assess Likelihood That Risk Will Happen (1=not Likely, 5=near Certainty)
- Assess Consequence of Risk Being Realized (1=min. Impact, 5=unacceptable)
- Determine Type of Risk: Schedule, Cost, or Technical

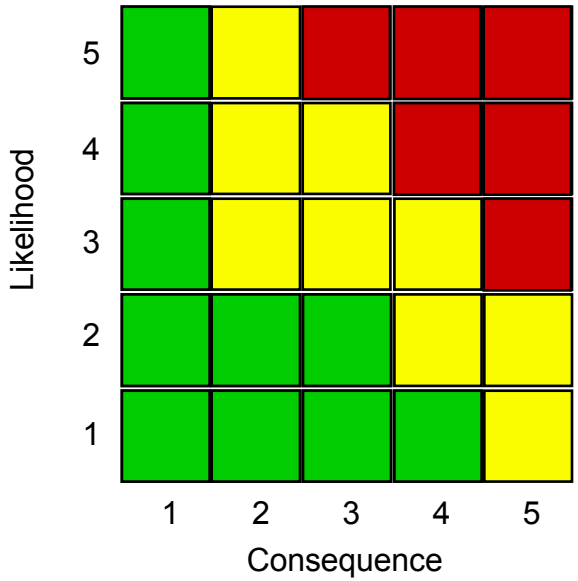
*Place **X** in One Cell*

Risk Type
(Check one)

☐ Schedule

☐ Cost

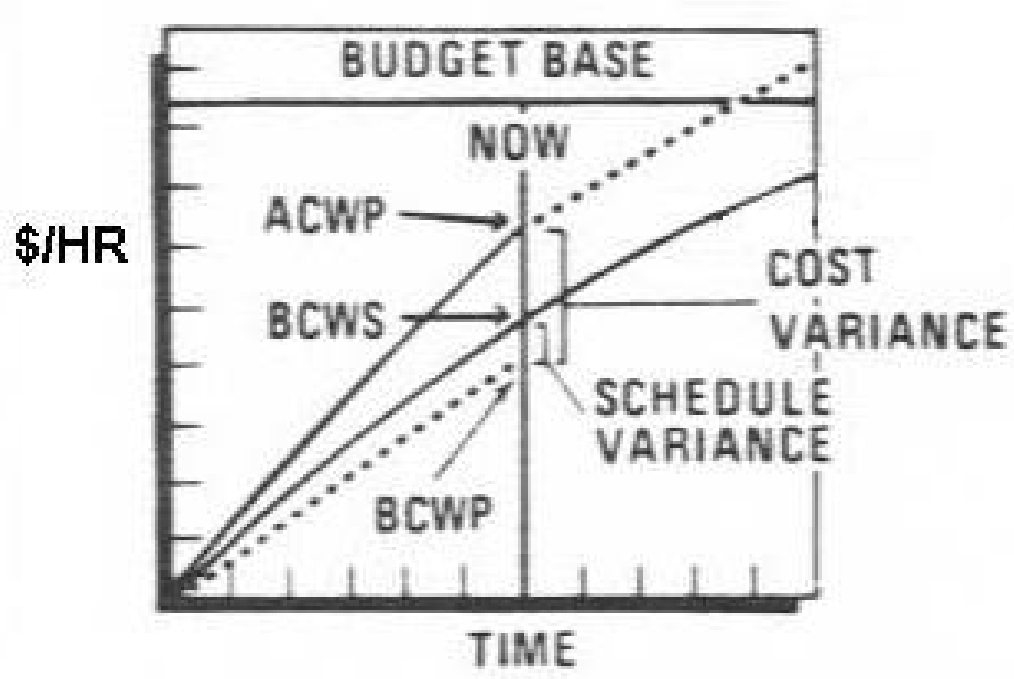
☐ Technical / Quality



Green = Low Risk
Yellow = Medium Risk
Red = High Risk

Each Risk Must Have a Mitigation Plan
- Statement of Risk
- Plan of Action
- Milestone Schedule

What is Earned Value Management ?



BCWS = Budgeted Cost of Work Scheduled
ACWP = Actual Cost of Work Performed
BCWP = Budgeted Cost of Work Performed

Cost Variance = BCWP - ACWP
Schedule Variance = BCWP - BCWS

Reference:Office of the Under Secretary of Defense
Acquisition Resources & Analysis, www.acq.osd.mil/pm/