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Department: ETPS
A presentation on: Cockpit Development & Assessment,
a Test Pilot School perspective
To: European Flight Test Working Group

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Cockpit Development & Assessment, a Test Pilot School perspective

Terts “Stevie” van den Berg

Empire Test Pilots’ School (ETPS)
Fixed Wing Flight Test Tutor

30 October 2013

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Overview

- ETPS & Systems Curriculum
- Design & Test Cycle
- Cockpit Assessment
- Systems Assessment
- Reporting
- Examples

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Empire Test Pilots' School

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ETPS background -1

- Unique UK MOD training facility since 1943
- MOD Boscombe Down, UK
- Aircraft Test & Evaluation Centre
- Partnership UK MOD and QinetiQ
- UK MOD and foreign customers training
  - Test Pilots (TP)
  - Flight Test Engineers (FTEs)
  - Rotary and Fixed Wing tracks

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ETPS Aircraft

46 aircraft types, incl. QE aircraft in 2012

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ETPS Graduate Courses -1

- Class A (1 year) [Class B (6 months)]
  - Meets EASA CAT-1 rating requirements [CAT-2 FT]
- Ground School
  - 400 (50 systems)
- Flying
  - 110 hours, 15 types
- Content
  - Stability & Control, Handling Qualities
  - Performance
  - Systems

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ETPS Graduate Courses -2

- Specific Course Objectives:
  - *teach a philosophy which can be applied to any type of flight testing*
  - *develop sound academic background to flight test*
  - *teach and practice airborne test techniques*
  - *develop skills in the analysis and presentation of flight test results*
  - *develop a broad knowledge of all aviation matters*
  - *promote team building skills by providing the opportunity of working with pilots and FTEs from a wide variety of nationalities and backgrounds*
  - *for FTE students, to teach and develop the skills required to operate in the airborne environment*

Systems Exercises -1

1. Cockpit Assessment (any type in hangar)
2. Intro to Workload (CBT)
3. Intro to Systems (KingAir, Gazelle, Tornado)
4. Integrated systems (ASTARS)
5. ACAS (KingAir, A109)
6. Night Vision (test house)
7. Head Mounted Display (F16 rig, Bell 205, MAT Huey, Apache)
8. Integrated Flight Decks/FMS (Airbus, Boeing, Merlin)
9. Military Systems (Gripen, C130J, Apache)
10. Preview (relevant type)

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Systems Exercises -2

- Cycle: Groundschool > Demo > Exercise
- Syndicates vs Individual
- Exercise Cycle
  - Planning, Execution, Reporting
- Systems
  - Quantitative/Performance assessment
  - Qualitative assessment
  - Design and Interface development

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Acquisition, Development & Test Cycle

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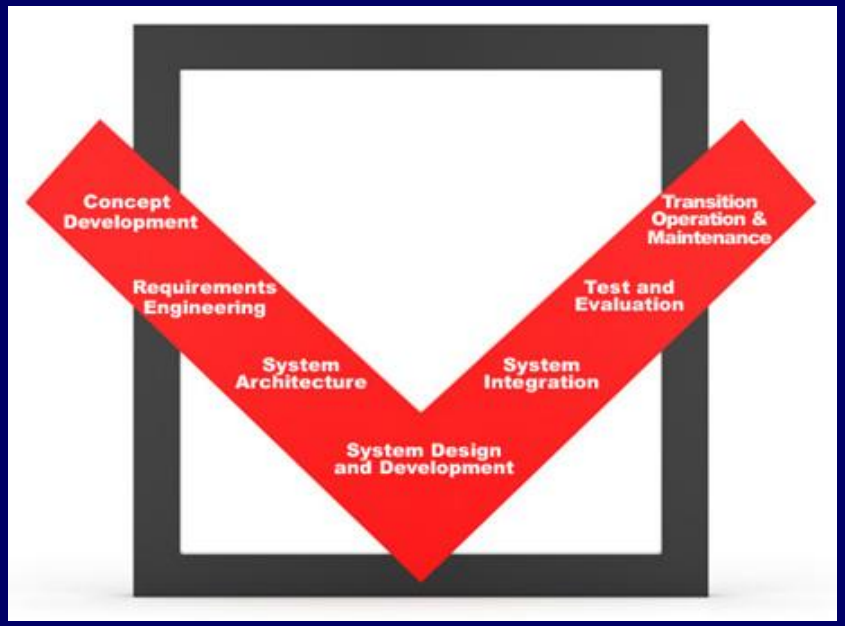
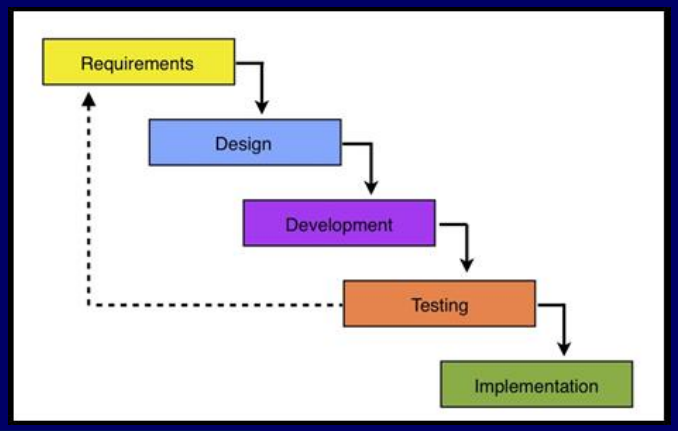
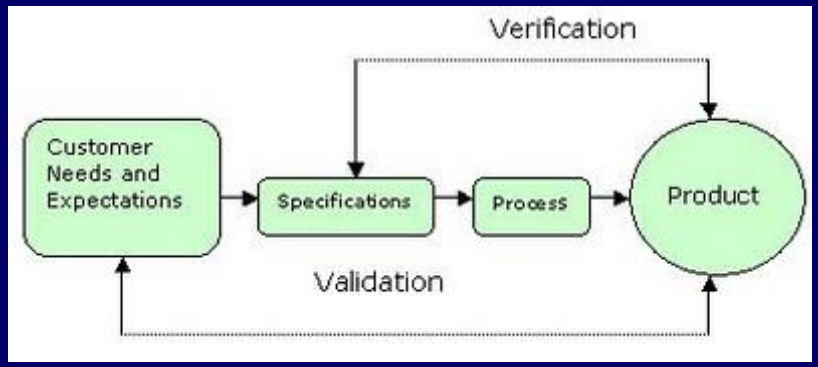
Life Cycle, V-model







DT&E
vs
OT&E

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Lifecycle

- Iterative design & evaluation process
- Initial design

  vs
- In-service:
  - Changes of Role
  - Changes of capability
  - Modifications
  - Changes of population
- Assess Suitability of Operational Role

Test Type vs Standard (vs customer?)

• Experimental T&E	Research objectives
• Developmental T&E	Design specs/requirements
• Operational T&E	Key User Requirements*
• Certification	CS/FAR series, MilSpec, DefStan 00-970
• Acquisition	Key User Requirements*
• Acceptance	Contract

* Critical Operational Issues
(operational effectiveness, suitability)

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Roles

- Need for Role definition
- Need for Task definition
- Need for Authority Specification?
- Need for Design Specification/description?

Aircraft Role

&

Tester Role

Development & Test Assets -1

- Operator/Testpilot involvement
- Continuous assessment loop
  - Drawing board, Powerpoint
  - Mock-up
  - Rig, Simulator
  - Virtual Reality
  - Cockpit
    - Ground Test
    - Flight Test: DT&E, OT&E

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Development & Test Assets -2

- All have their pros & cons
  - Levels of efficiency, realism, flexibility
  - Limitations, cost, availability
- All have their Value and Place in time

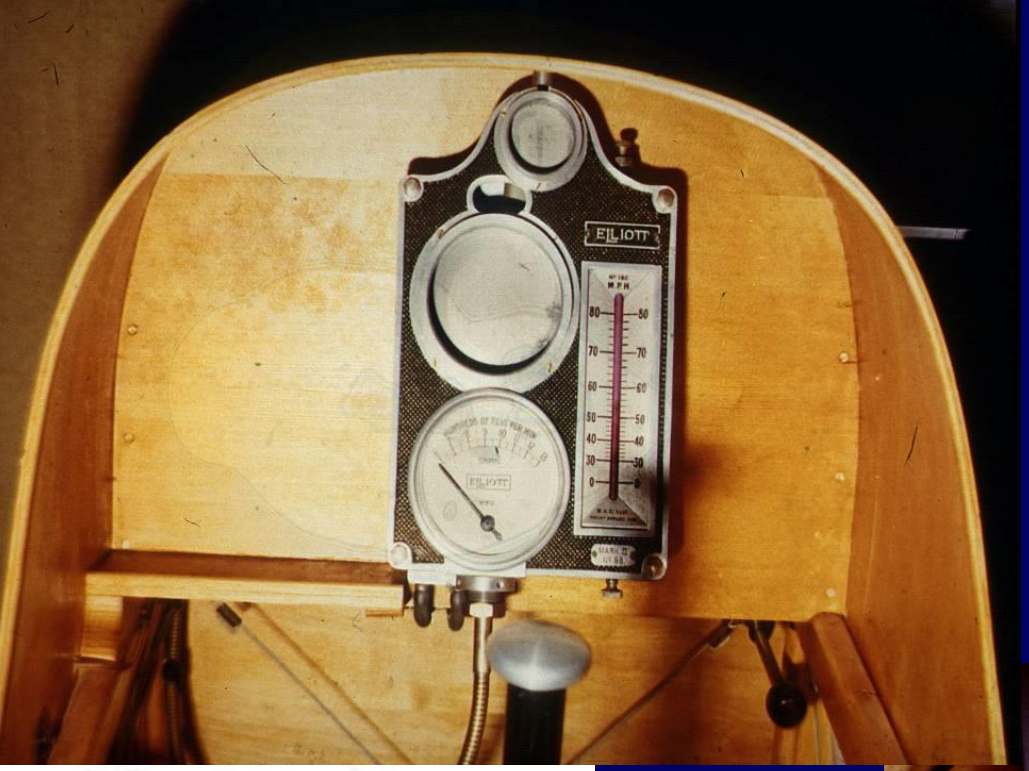
- Essential:
  - Changes to developers and testers
    - Obtain continuity to maximum extent
  - Design trade-off/priorities
    - Keep record of design decisions

Cockpit Assessment

Purpose of Cockpit

- 3 basic functions:
  - Control
  - Information
  - Accommodation

- Suitability
  - Depends on Role



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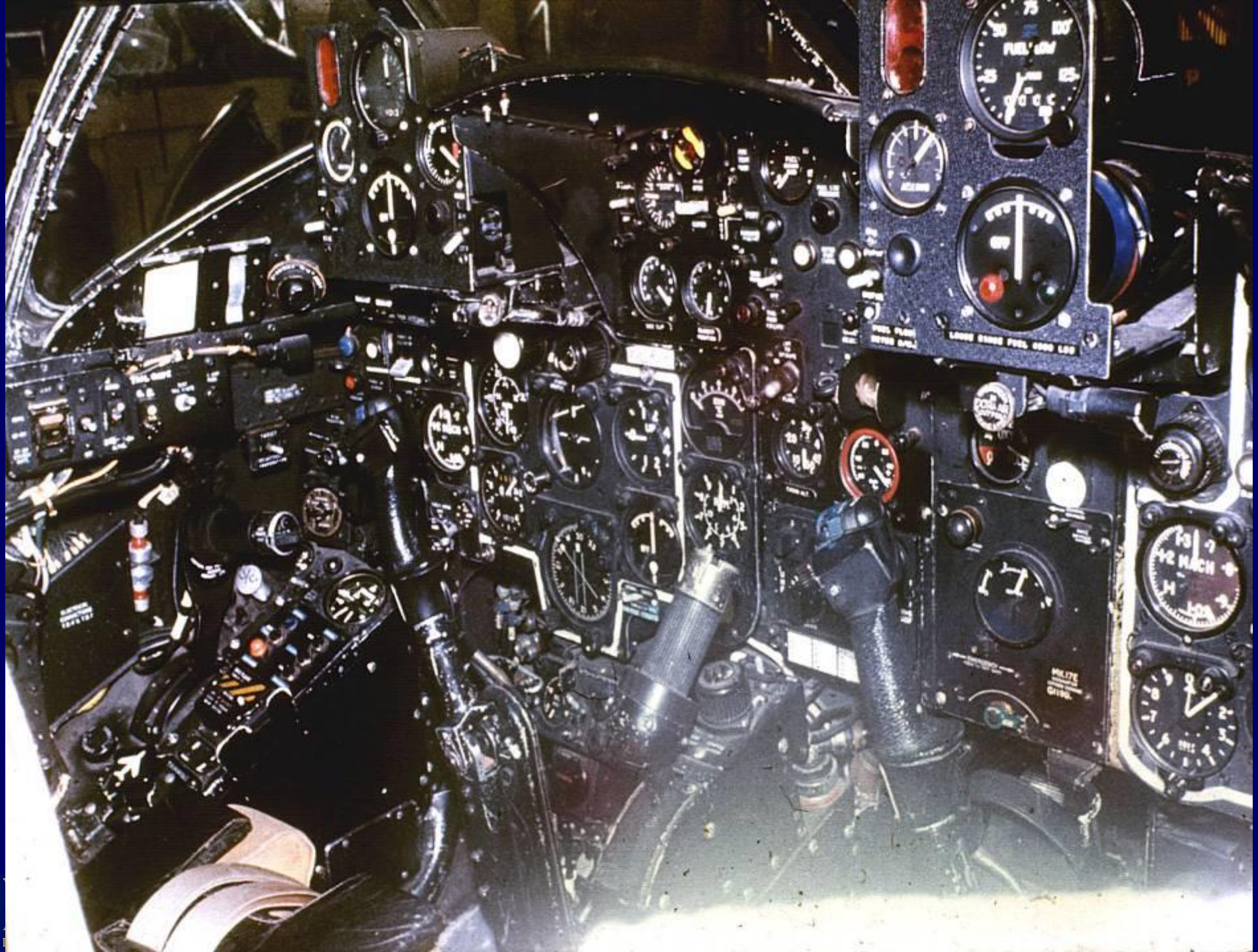
FUEL FLOW
LARGE RANGE FUEL GOOD LOG
MACH


7872
OXYGEN
FLAPS

All very different cockpits, but they may each be (un)satisfactory for the Role

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Cockpit Design

- Cockpit design
  - Ergonomics / Human Factors
  - Human Machine Interface (HMI or PVI)
  - Physical & Mental component
- Elements
  - Control: Steering, Systems
  - Information: Display video, Audio, Tactile
  - Accommodation Environment, Field of View, Lighting, Access, Comfort, “Basic” needs

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Assessment Objectives

- To determine if cockpit provides suitable environment for effective and efficient operation and control of the aircraft and its systems during the mission
  - Assess suitability for a Role
  - Identify Design specs/assumptions
  - Define scope/conditions
  - Identify shortcomings/deficiencies
  - Role Relate
  - Recommend improvements or further testing

Typical Cockpit Assessment items -1

- Opening/Closing doors/canopies
- Normal entry/exit
- Seat adjustment (DEP/REP)
- Strap-in
- Field of Regard/View
- ……..

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Cockpit Ingress

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Emergency Egress …..

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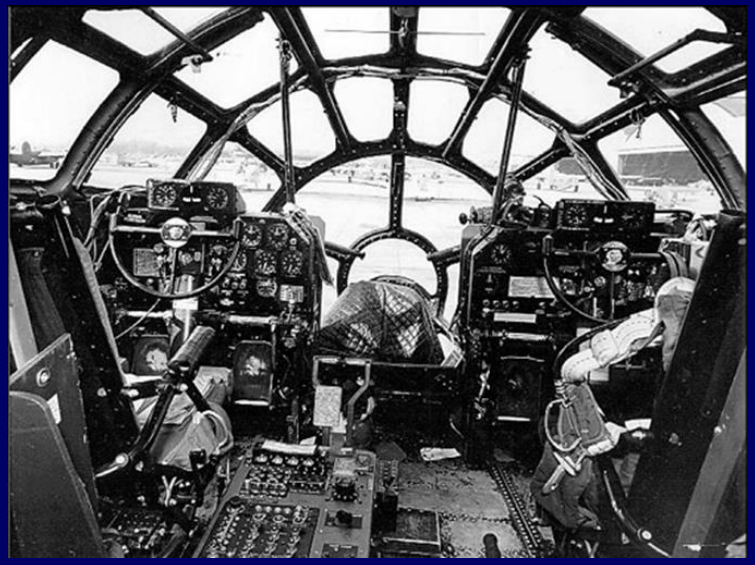
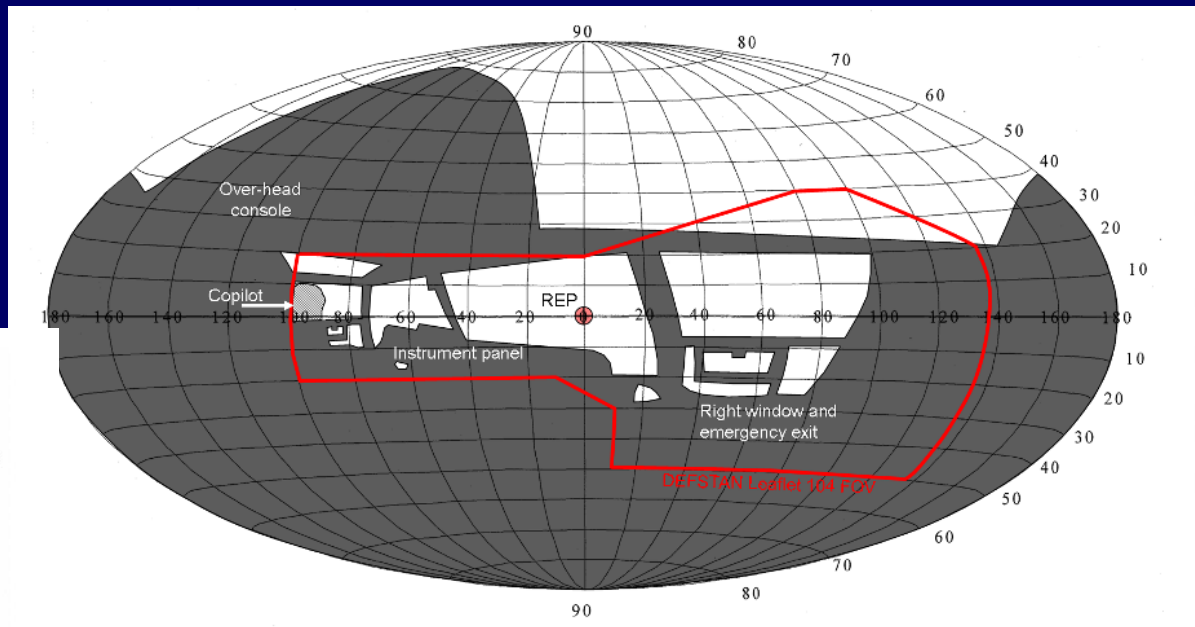
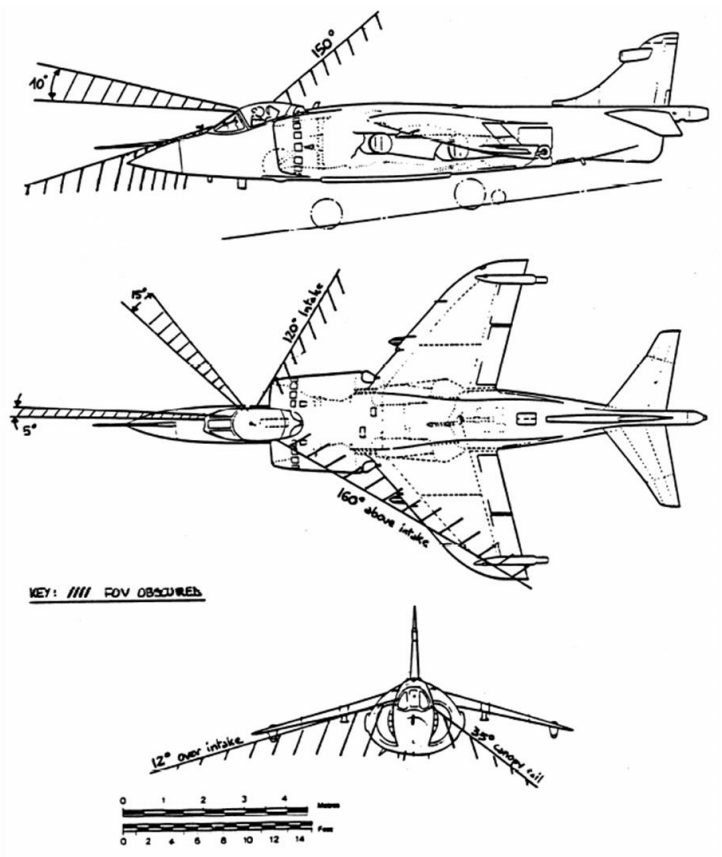
Why is FoV important?



Field of View plot (DEP/REP)





Typical Cockpit Assessment items -2

- Aircraft Inceptors/Flying Controls
  - Reach, adjustment
  - Deflection, fouling
- Actuators/Controls
  - Buttons, Switches, Knobs, Cranks, Levers, etc
  - Location, Reach, Feel, Shape, Labelling, Colour, Operation
- Displays/Instruments:
  - Location/Priority, Arrangement, Grouping
  - Size, readability, scaling, info/failure/limit presentation
  - Visibility/Lighting
- Warning/Attention getting, incl. tactile + audio

by David Jorge Aguirre Grazio

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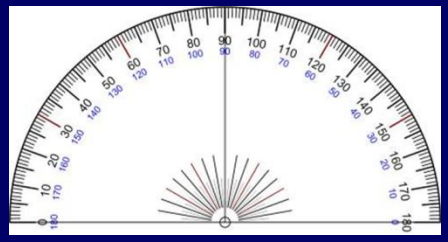
Considerations/Limitations

- Static vs Dynamic: often done on ground/sim/rig
- Environment
  - Day/night, Lighting, wind/precipitation, hangar/ship/platform, vibration, temp
- Variation in anthropometrics
- Flying Clothing
- “Fly” representative tasks
  - Operational tasks
  - Normal/emergency proc’s
- Multiple evaluators: opinion

Assessment Tools

- Tasks/Testcards
- Flight Manual, checklist
- Inclinometer, Protractor, String, pencil
- Tape measure, Stopwatch
- Camera
- Flight Gear



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Cockpit Assessment: Risks

- Aircraft Safe for Maintenance
  - Ejection seat, Canopy, Gear pins
- Operating APU
  - Noise
- Electrical/Hydraulic systems
  - Switches live with power off or battery on
  - Fire extinguisher buttons, Hook release
  - Flaps
- Operating Flight controls
  - Irreversible vs Reversible, cordon
- Operating at height

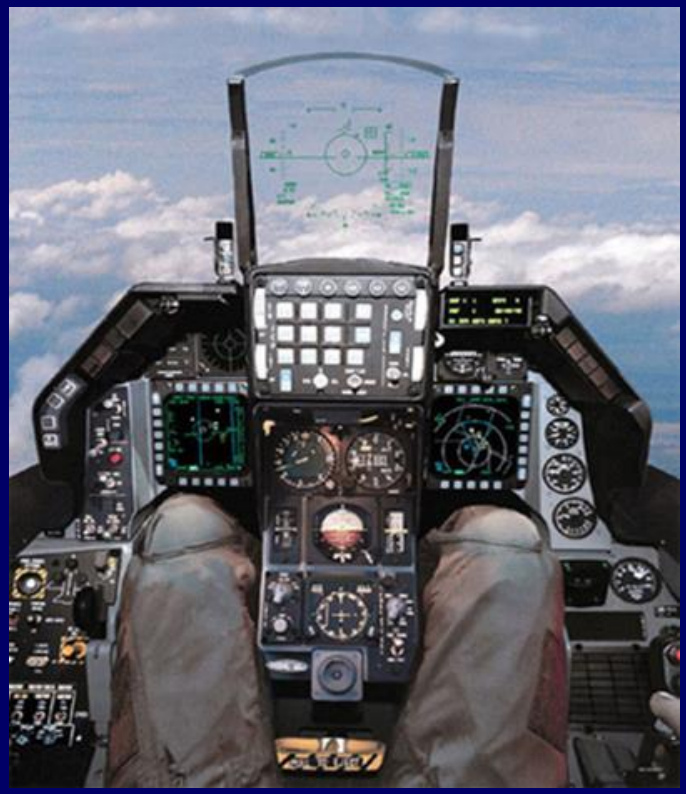
Cockpit vs Systems

- Non-MFD:
  - Assess operations of separate navigation, comms, transponder subsystems
  - powering on/off, testing, changing modes, codes, settings and frequencies

- MFD:
  - Assess hardware
    - Controls, reach
  - Assess displays
    - visibility
  - Don’t assess software functionality and menu structure

Test Plan

- Objectives
- Requirements
- Scope/Conditions
- Tasks
- Methods
- Recording
- Risks
- Test Cards



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Systems Assessment

System vs Roles/Tasks: Questions

- Descriptions for both?
- Expertise in both?
- Experience with both?
- Crew concept/roles?
- Standalone vs Integrated system?
- External signals/input/support required?
- Performance and/or HMI?

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HMI/PVI

- Control and Display
- Information:
  - clear, timely, correct, unambiguous
  - Not too little/early, too much/late, incorrect, ambiguous, confusing etc
- Representative Tasks and Environment
- Ground vs Flight
  - build up
- Setting options: low end, middle and high end

Test data: generic questions

1. Effectiveness
   - can I accomplish something I need/want to
2. Efficiency
   - can I accomplish this quick and easy
3. Error
   - can I accomplish this without chance of making an input/output error
4. Inadvertent
   - can I accomplish this without messing up something else

Test Data

- Quantitative:
  - Measurements: FoV, Reach, Head movement
  - Time required
  - Actions/Steps required
  - Workload?
- Qualitative:
  - Subjective
    - Opinion, Background, Experience, Culture, Bias
    - Multiple testers
  - Workload?

Taskload vs Workload

- Taskload:
  - Task demands
  - Objective measure (number of operations, cycle time)
- Workload:
  - Experience of the task demands (i.e. a feeling)
  - Subjective measure (perceived level of cognitive and physical load)

Subjective Workload Ratings

- Can be used “real-world” (vs “simulated”)
- Administered during/after task execution
  - Non-intrusive to primary task
  - Ease and speed of application, low cost
  - Risk of “fading”: assign immediately after task
- Multi-dimensional: more complicated
- Uni-dimensional: simple and quick
  - Usually ordinal and non-linear
  - Flight Test: sensitivity, simplicity, non-intrusiveness

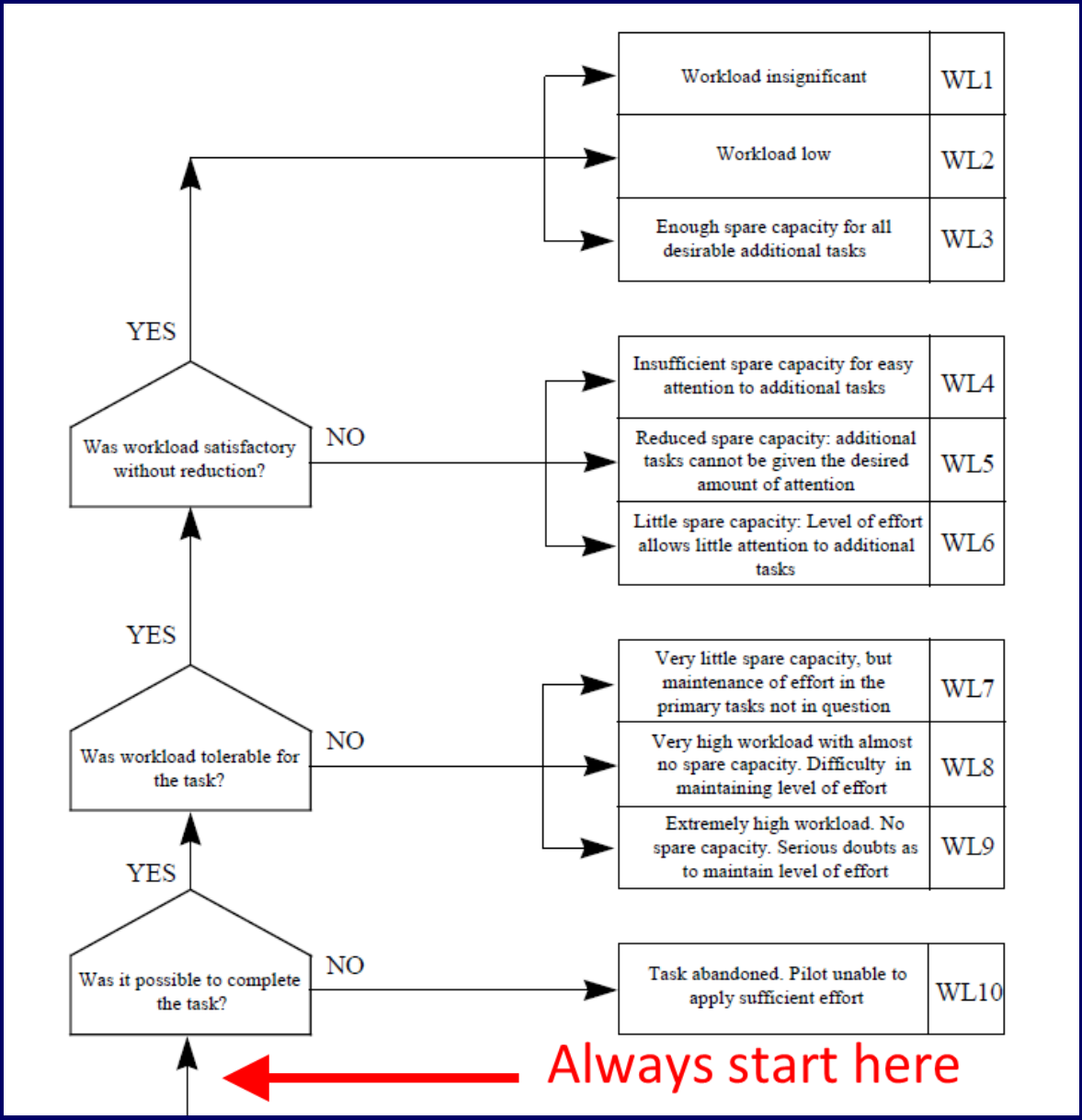
Multi-dimensional

- Good diagnosticity, relatively complex, interval data
- Example: NASA TLX
  - Derives an overall WL rating based on 6 sub-scales
    1. Mental Demand (+ perceptual activity)
    2. Physical demand (physical activity)
    3. Temporal demand (time pressure)
    4. Effort (how much work)
    5. Performance
    6. Frustration level

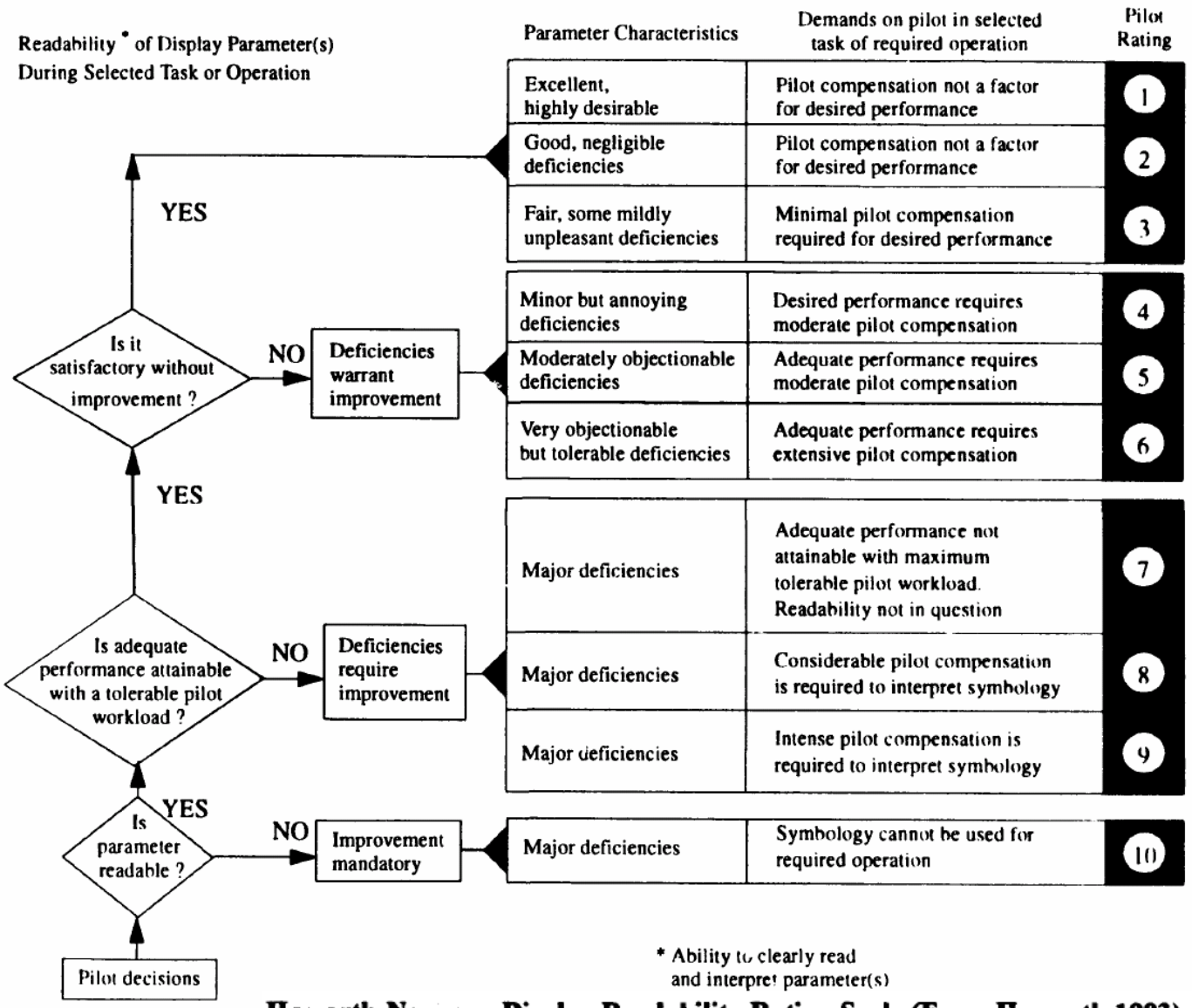
Uni-dimensional

- Easy, simplicity, sensitivity
- Low diagnosticity, ordinal, non-linear
- Examples
  - Modified Cooper-Harper (MCH)
  - Bedford
  - Subjective Workload Assessment Technique (SWAT)
  - Subjective Workload Dominance (SWORD)
  - Malvern Capacity Estimate (MACE)

Bedford Workload Rating Scale



Display Readability Scale



Haworth-Newman Display Readability Rating Scale (From Haworth 1993)

Tolerances

- Applying Desirable vs Adequate tolerances
  - 100 vs75% of time
  - <½ dot vs <1 dot
  - <20 vs <30 sec
  - Used on MCHs

- Bottom Line: Need clearly defined tasks

Examples of Tasks

- Context: Manual ILS in crew concept
  - PF tasks:
    - Primary task: Maintaining LOC/GS on speed
      - physical, mental, temporal, performance
      - so not just the aircraft handling
    - Secondary task: listening radios/crew, read back, checks
  - PNF tasks:
    - Primary Task: Programming ILS box, no error, <20 sec
    - Secondary: monitor instruments, making radio calls etc.

Test Reporting

7-part paragraph

1. Test and Test Conditions
2. Present the Data
3. Analyse & Discuss the Data
4. Role Relate
5. Conclude
6. Recommend
7. Specification Compliance

*optional: supporting imagery

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Reporting considerations

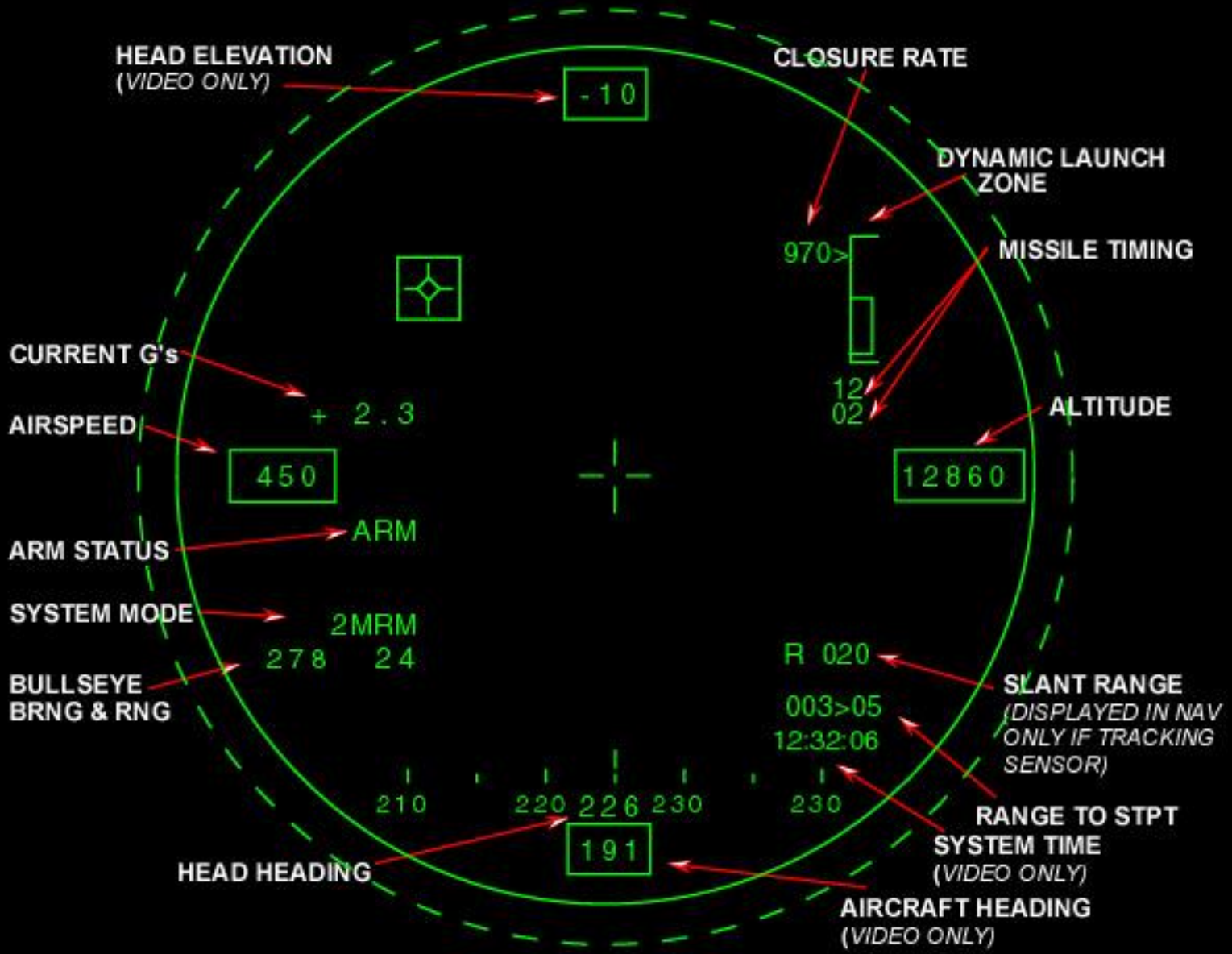
- Detailed data and analysis
  - Ratings used to standardise and categorise, still need to describe and analyse results
- Unambiguous
- Scope, Limitations
  - To include detail on hardware/software config
- Repeatable
  - Seat adjustment, DEP/REP
  - Anthropometrics
  - Task, Methods, Environment

A few Examples

Yak-52 Gear/Flap design


G-BXAK

F-16 M3 HMD design




DANGER
EJECTION
SM-9

F-16 HSI to COTS E-HSI modification

1. ORIGINAL EHSI DISPLAY

2. REVISED BASELINE EHSI DISPLAY

- Yellow Hdg Marker
- Outer Portion of Hdg Marker Moved Beyond Heading Tics
- HDG and CRS Labels on Knobs
- CRS Arrow Made Thinner and Moved Outward to 5-Degree Hdg Tics
- Allow CDI Deflection Beyond Two Dots
- CDI Lengthened, Gap Created Between Course Needle and CDI (See 4 below)
- PLS Replaced with ILS (consensus)
- Digital Heading Indication Removed
- Triangular Compass Indices Replaced with Bold Tic Lines

Bottom Line

- Test crew involved in design cycle from start
- Understand Requirements and Role
- Assess by executing representative tasks
- Understand limitations
- Maintain records of results and decisions
- Identify assessment risks
- Testing is not a trick, but a philosophy
- Never forget who the real customer is ….

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The User

Questions & Discussion

Questions & Discussion

Questions & Discussion

Questions & Discussion

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