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UNITED STATES NAVY

Can We Safely Keep it Simple?

First Flight of a Major Aircraft Upgrade

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Overview

- Basic aircraft
- The upgrade
- First flight issues and risks
- Risk mitigation
- First flight
- Lessons learned

Basic Aircraft

- US Navy C-2A (R) Greyhound

  (aka “COD”, carrier onboard delivery)
  - Dual piloted, medium range
  - Twin turboprop
  - Reconfigurable for cargo/passenger
- First delivered in 1965 (19)
- Re-procured C-2A delivered in 1985 (39)
- Carrier and shore-based (NOT a GA aircraft)


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The Upgrade

C - communications

N – navigation

S – surveillance

/

A – air

T – traffic

M - management

Purpose of CNS/ATM

- CNS/ATM was to certify the aircraft in these areas:
  - RNP RNAV – Provides navigation accuracy, containment, integrity and appropriate alerts for operating in airspace where advanced civil navigation mandates are emerging.
  - Mode S – For operating in airspace where Mode S surveillance (ID) is being mandated (Europe). Includes both Elementary and Enhanced Surveillance requirements.
  - 8.33 kHz Channel Spacing – For operating in European airspace where 8.33 kHz is mandated at high altitudes.
- And not degrade any legacy capabilities

CNS/ATM Upgrade included

- New navigation suite
- New transponder
- Upgraded radio
- New Flight Management System (FMS)
- MAJOR cockpit upgrades
  - Glass displays
  - Lighting
  - New backup gyro
- Mod did NOT directly affect: engines, hydraulics, external aircraft mold-line, flight controls*

* Input to autopilot was modified


Legacy Cockpit


CNS/ATM
Cockpit

First Flight Issues

- Test asset had not flown in almost a year
- Required Functional Check Flight of basic aircraft systems
- First flight with new navigation, IFF, comm suite
- First flight with glass cockpit

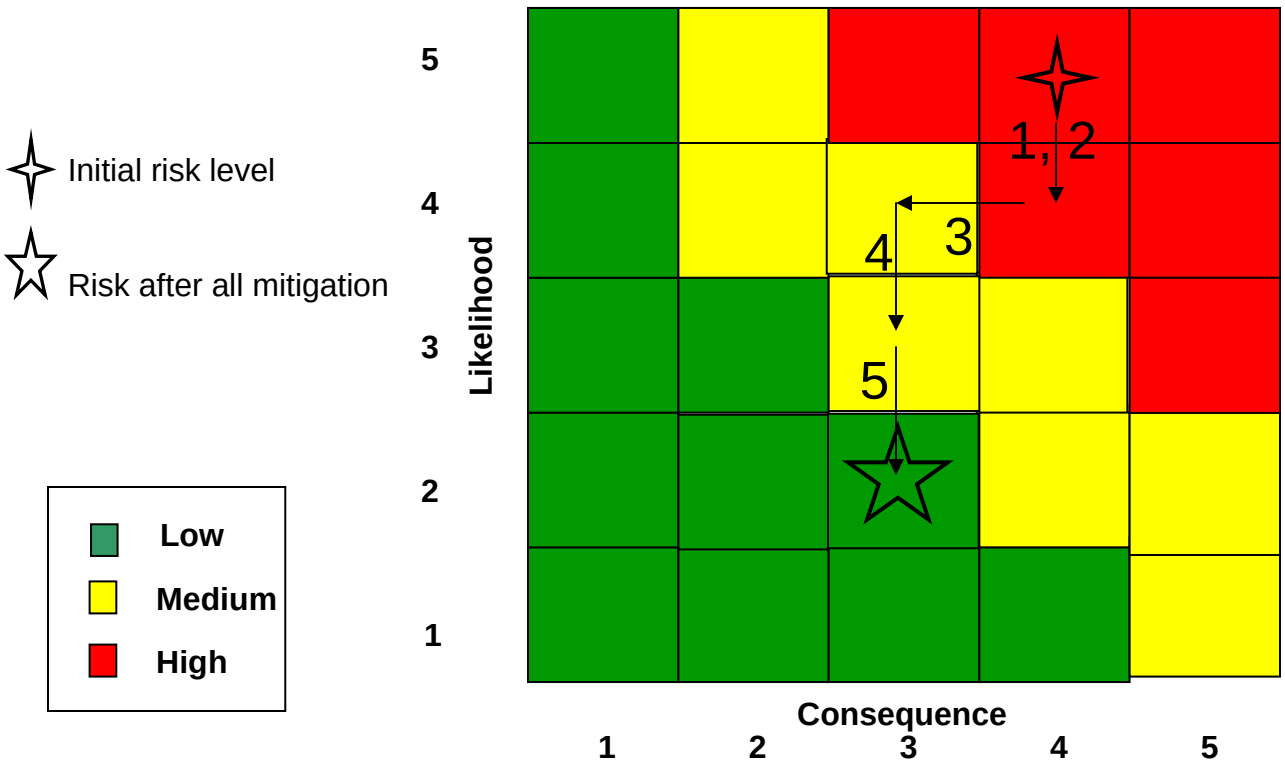
First Flight Risks

- Failure of navigation sources
- Failure of FMS
- Failure of displays
- Basic aircraft post-maintenance failure

- **Risk: Failure of CNS/ATM component during first flight**
- **Description: Components fail due to new component design or integration.**
- **Mitigation:**
  1. **COTS products**
  2. **No mod to pitot static system**
  3. **Legacy AOA system remains installed**
  4. **Reuse baseline software**
  5. **Extensive lab and ground test**

Initial risk level

Risk after all mitigation

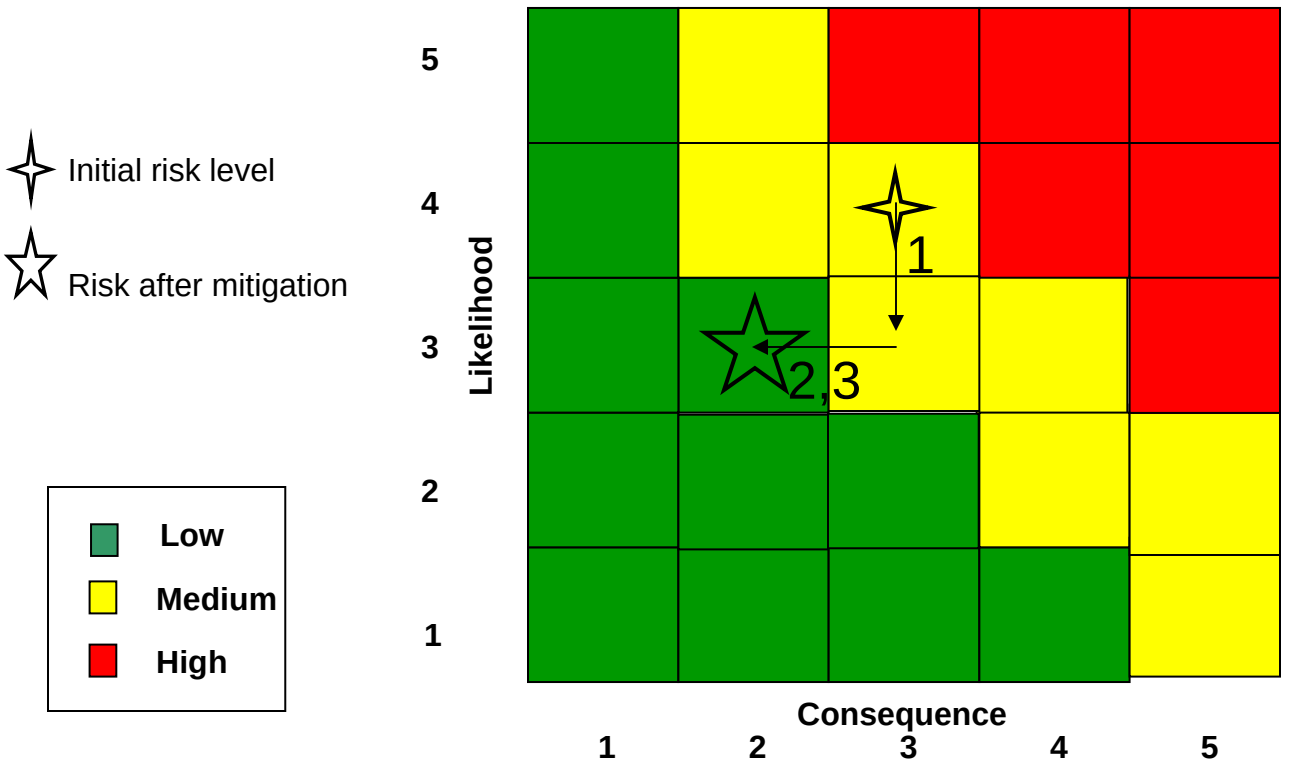


Mitigations lower likelihood & consequence of new component failures.

- **Risk: Potential for non-program-related aircraft system failure**
- **Description: Aircraft has not flown for almost 1 year, functional check flight requires new components**
- **Mitigation:**
  1. **Extensive FCF ground test**
  2. **Red-line FCF flight procedures approved**
  3. **Utilize two FCF qualified aircraft commanders w/ CNS/ATM training**

Initial risk level

Risk after mitigation



Mitigations lower likelihood & consequence of non-CNS/ATM failures.

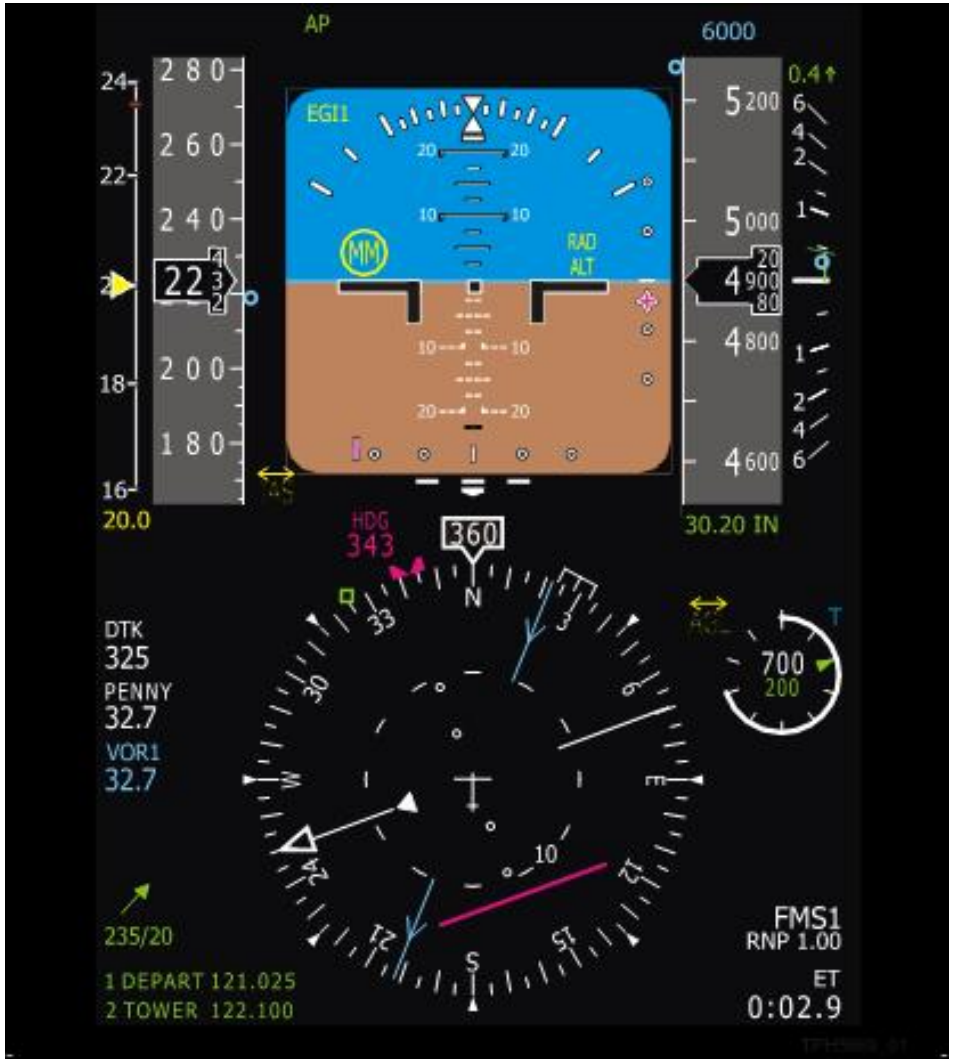
CNS/ATM Risk Mitigation

- Risk mitigation required reducing consequence to go from medium to low risk.
- What about instrumentation, monitoring or Safety Chase?
  - None reduce the consequence efficiently
- What do we need to fly an airplane day/VMC?
  - Airspeed, stall warning, energy state

Why AOA?

- For C-2 aircraft, in Day/VMC, reliable AOA gauge is all you really need to land
  - Provides precise airspeed/attitude
  - Provides stall warning
  - With known IHP can estimate ROD
- Legacy AOA system remained in cockpit
  - Not a part of the potentially compromised pitot/static system
  - Requires AOA probe and gauge only

AOA Displays



Preparation for First flight

- Test planning including hazard analysis
- Extensive Lab test*
- On-aircraft ground test*
- Day/VMC weather restriction
- Familiar field
- Baseline software for nav and FMS already flying in another aircraft*
- New glass flight displays were modified COTS*
- No change to pitot static system*
- Legacy AOA intact*
- New COTS Emergency standby display
- CNS/ATM Procedures Trainer available for pilots

First Flight

- 23 Oct 2007
- FCF required 3 separate flights
- Cockpit video recording of displays for post-flight review
- No safety-of-flight instrumentation
- No real-time monitoring
- Data bus recording for nav/IFF not working for 1st flight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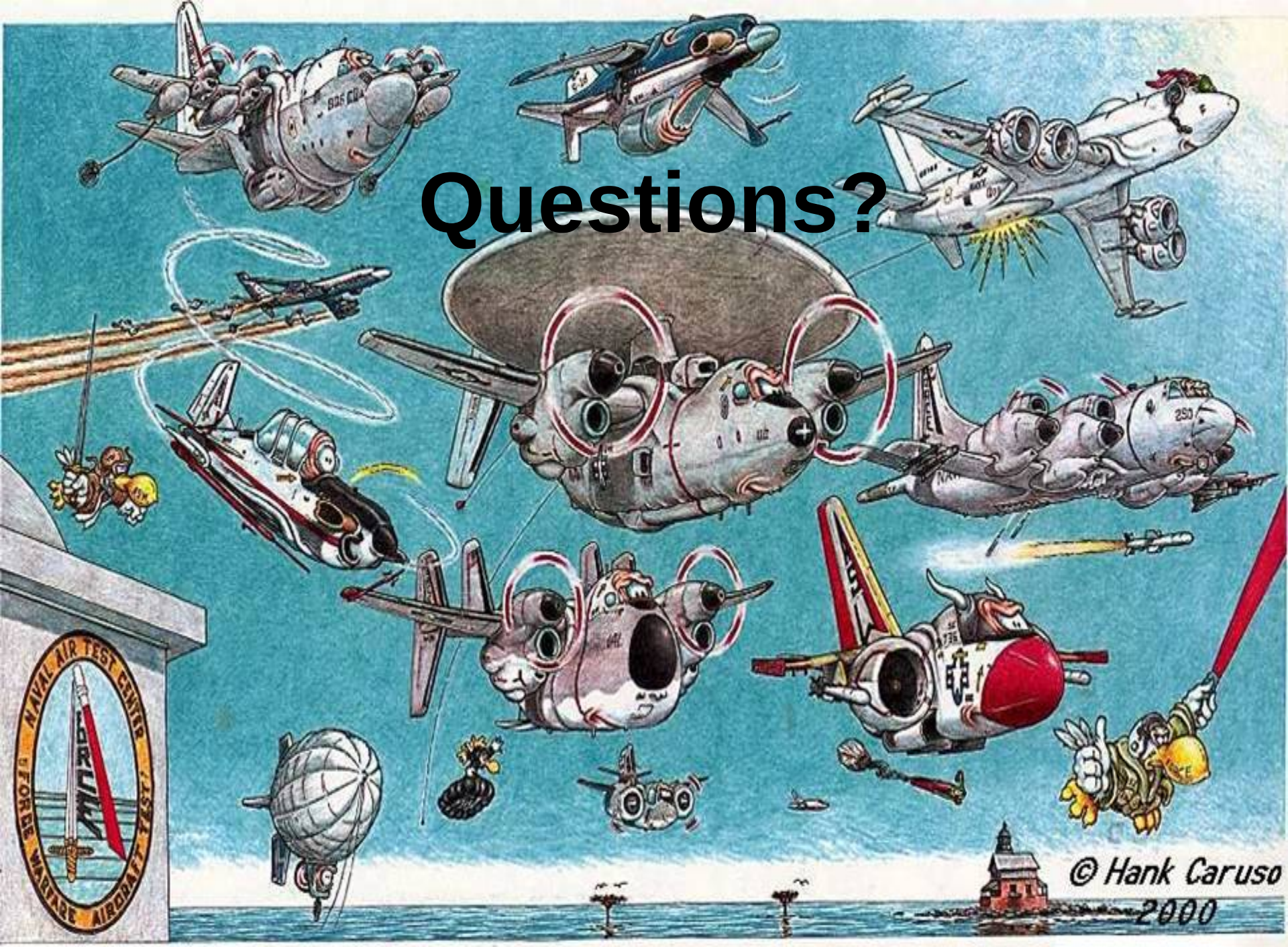
Lessons Learned

- Instrumentation and monitoring can improve safety. However, keeping it simple and providing a safe viable alternative kept the test program on schedule and under budget.
- Early tester involvement in the design process led to the decision to keep the legacy AOA gauge and eventually simplified the requirements for mitigating first flight risks.
- Overcoming engineering's resistance to keeping it simple can be challenging at best.


Questions?
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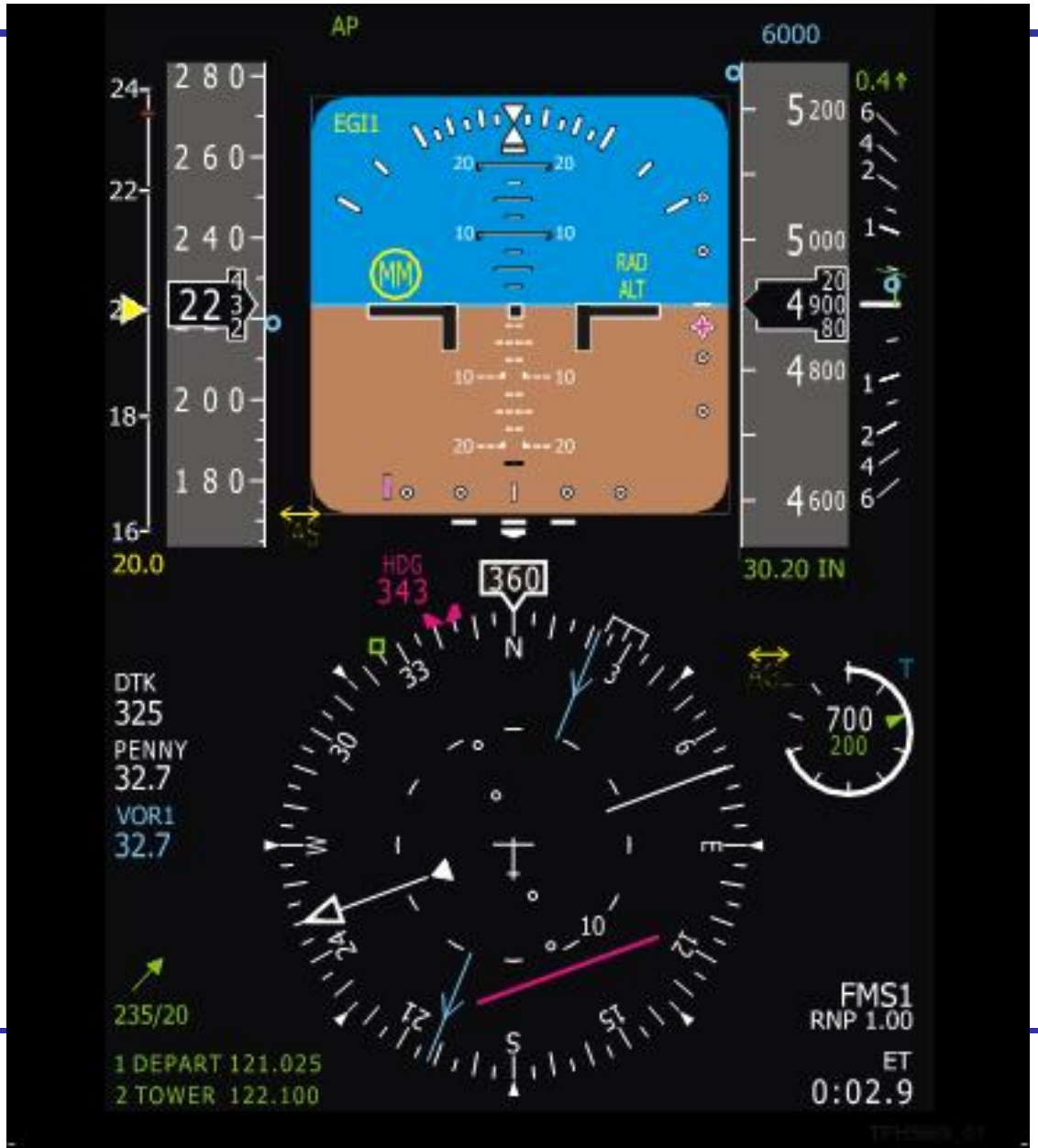
Backup slides

New Primary Flight Display



New Emergency Standby