NASA MQ-9 *Ikhana*

Human Factors: Pilot Perspective

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50 YEARS

NASA *Ikhana* Project

Ikhana **= Native American Choctaw word for**

“Intelligence”, “Learning”, “Awareness”.

N870NA

My Intent

- To relate personal experiences and cite examples where there are shortfalls in UAS human-machine interfaces.
- Not to discredit a relatively mature, reliable, robust UAS: the MQ-9
- Help educate rule makers, policy makers, decision makers.

To Fly What Others Only Imagine

Dryden Flight Research Center

NASA Dryden...A history of UAS Research

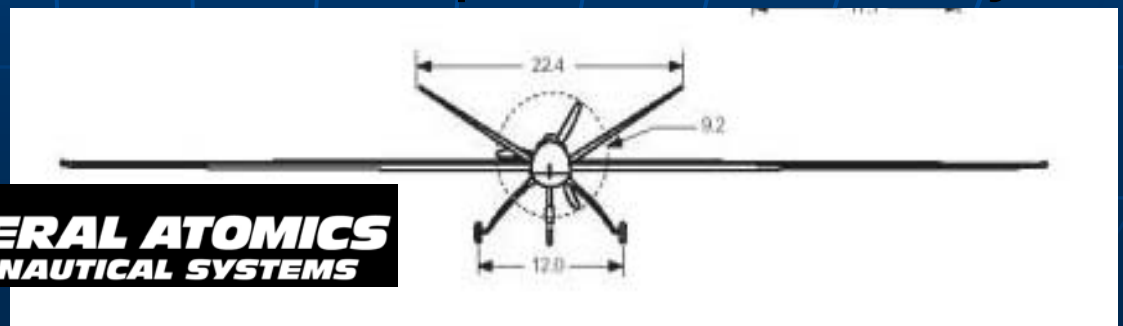
What's a Predator?

MQ-1 *Predator*

- 2,500 lb
- 48 ft wing
- Piston engine
- Single string

MQ-9 *Reaper (Predator-B)*

- 10,500 lb
- 66 ft wing
- Turboprop engine
- Triple redundancy



GENERAL ATOMICS
AERONAUTICAL SYSTEMS

What's a Predator?
What's the point?

- Different Mishap Histories
- Different reliability
- Different redundancies
- Different: engine, airframe, performance, navigation…
- Same: cockpit, command & control link

- Informed decisions in Rule-making

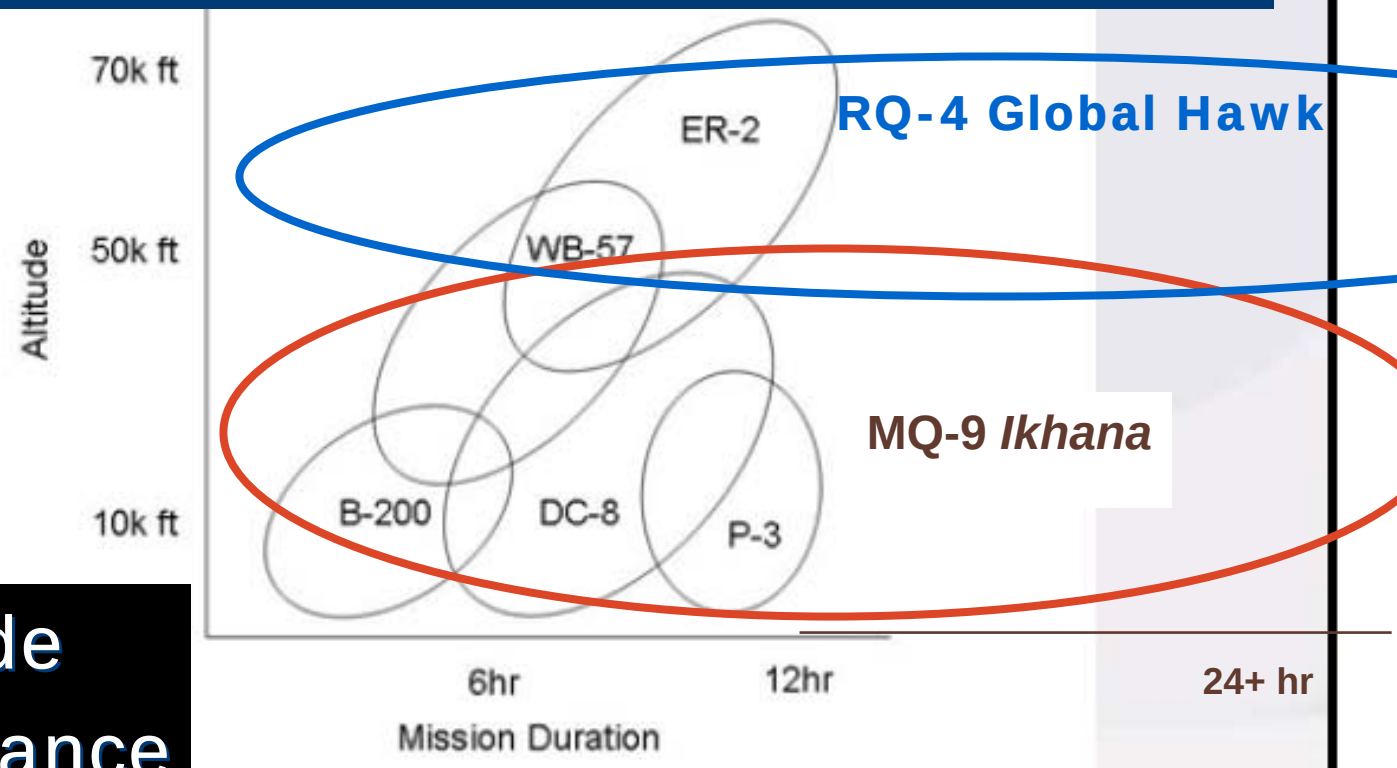
NASA MQ-9 ***Ikhana***

- No “Skyball”

Notional Flight Envelopes

Why does NASA need UAS?

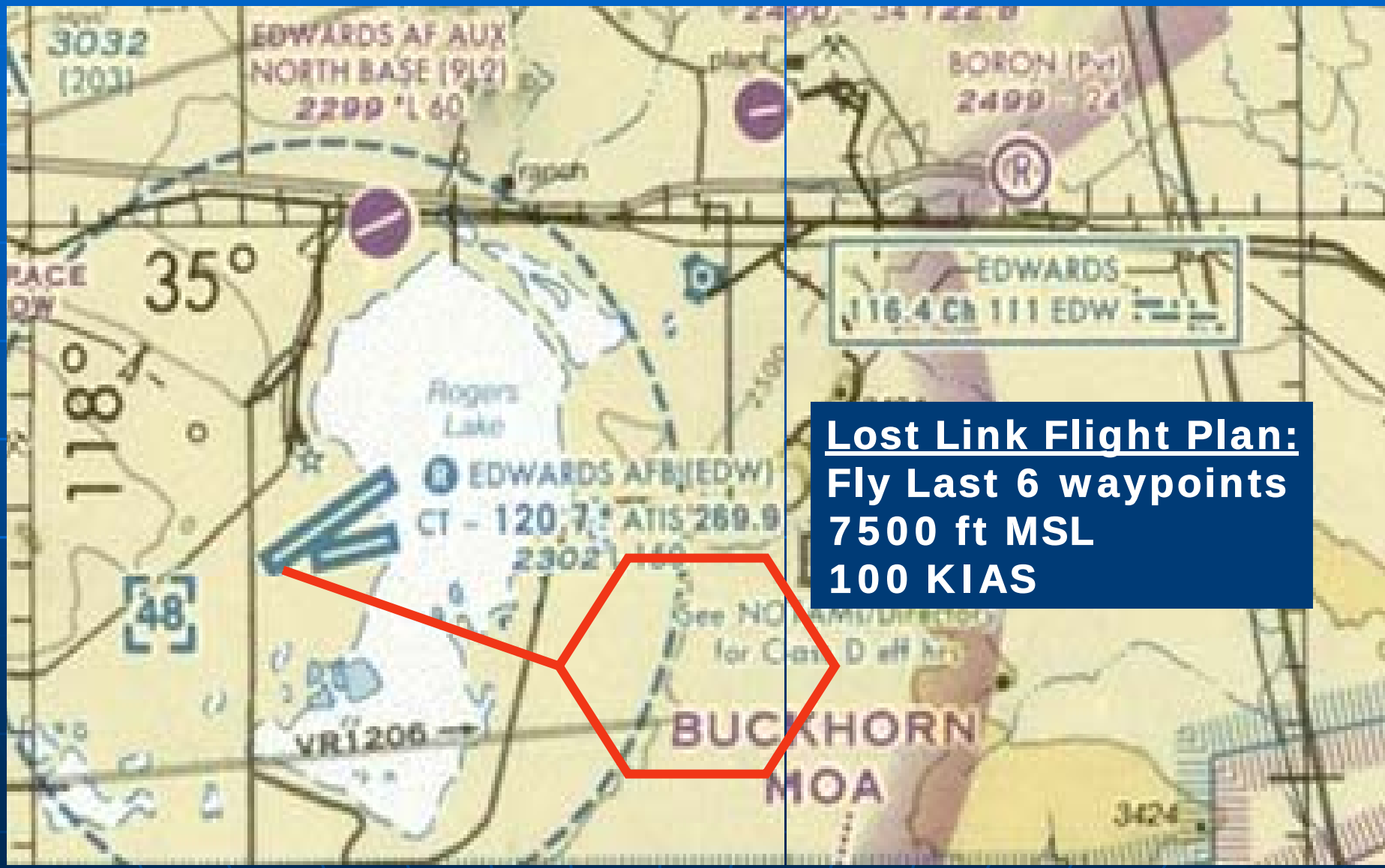
Atmospheric Science requires diurnal cycles



- Altitude
- Endurance
- Data link

Suborbital Science Program

Lost Link Flight Plan



Lost Link Flight Plan:

Fly Last 6 waypoints

7500 ft MSL

100 KIAS

Initial power-up, fueling, engine start, and local area flying

Ground Control Station

Over The Horizon Ku-band SatCom

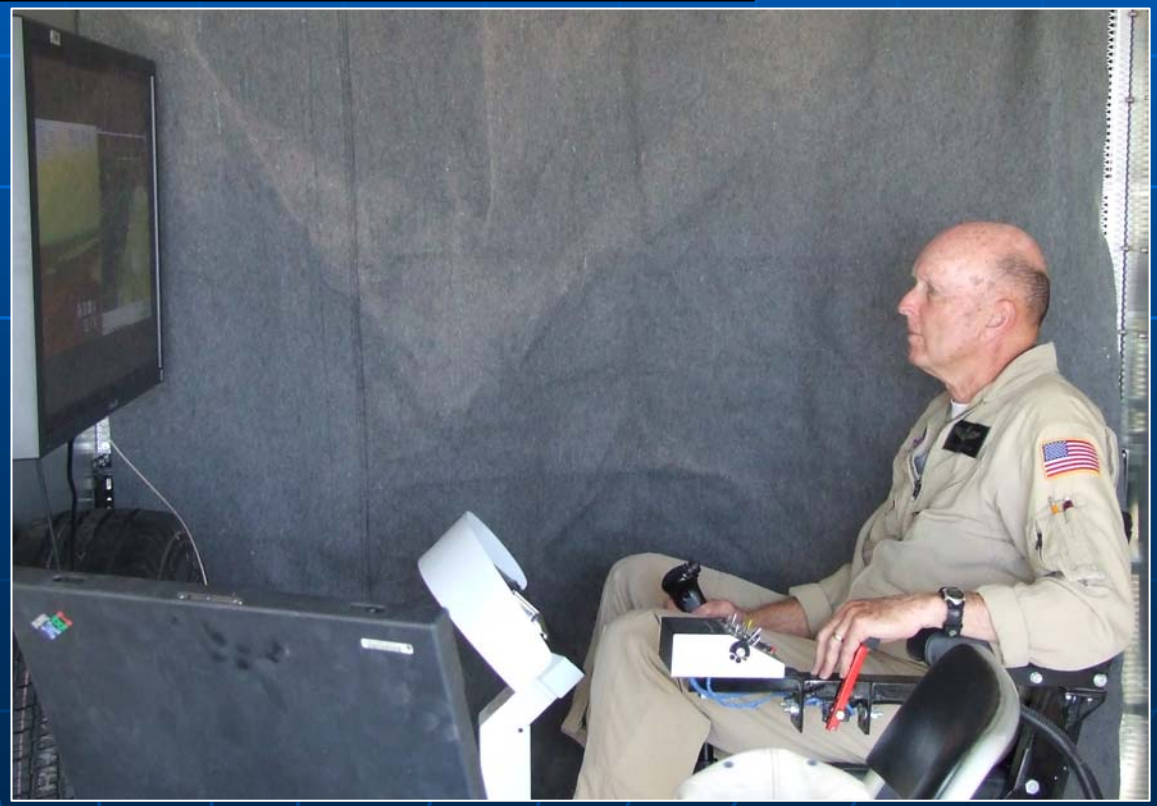
Approx 2-sec delay


• MQ-9 Ground Control Station


The cockpit environment…
The control room is IN the cockpit!

Risk Reduction: “Fly a Camera”

The G.U.T.



What if…

Expensive Car

Remotely Driven?

So, what's it like to fly these?

Well….What if you stepped into your cockpit…

…and you lost 4 of your 5 senses?

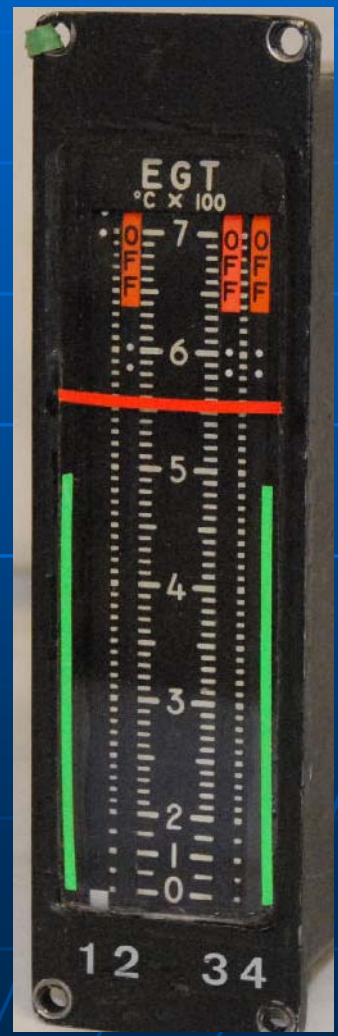
You only have *vision!*

Only 1 sense?

- You ***can't hear*** the engine rpm fluctuating
- You ***can't feel*** vibrations, accelerations or motion
- You ***can't smell*** the fuel leak
- You ***can't taste*** the electrical fire
- AND, you ***lose vision*** in one eye, 30º FOV!
- WELCOME to UAS flying!

Humans are analog, tactile, visual

What about the displays and controls?



Simple

Piper Cub

Complex

B747 Engine Displays

Digital data…

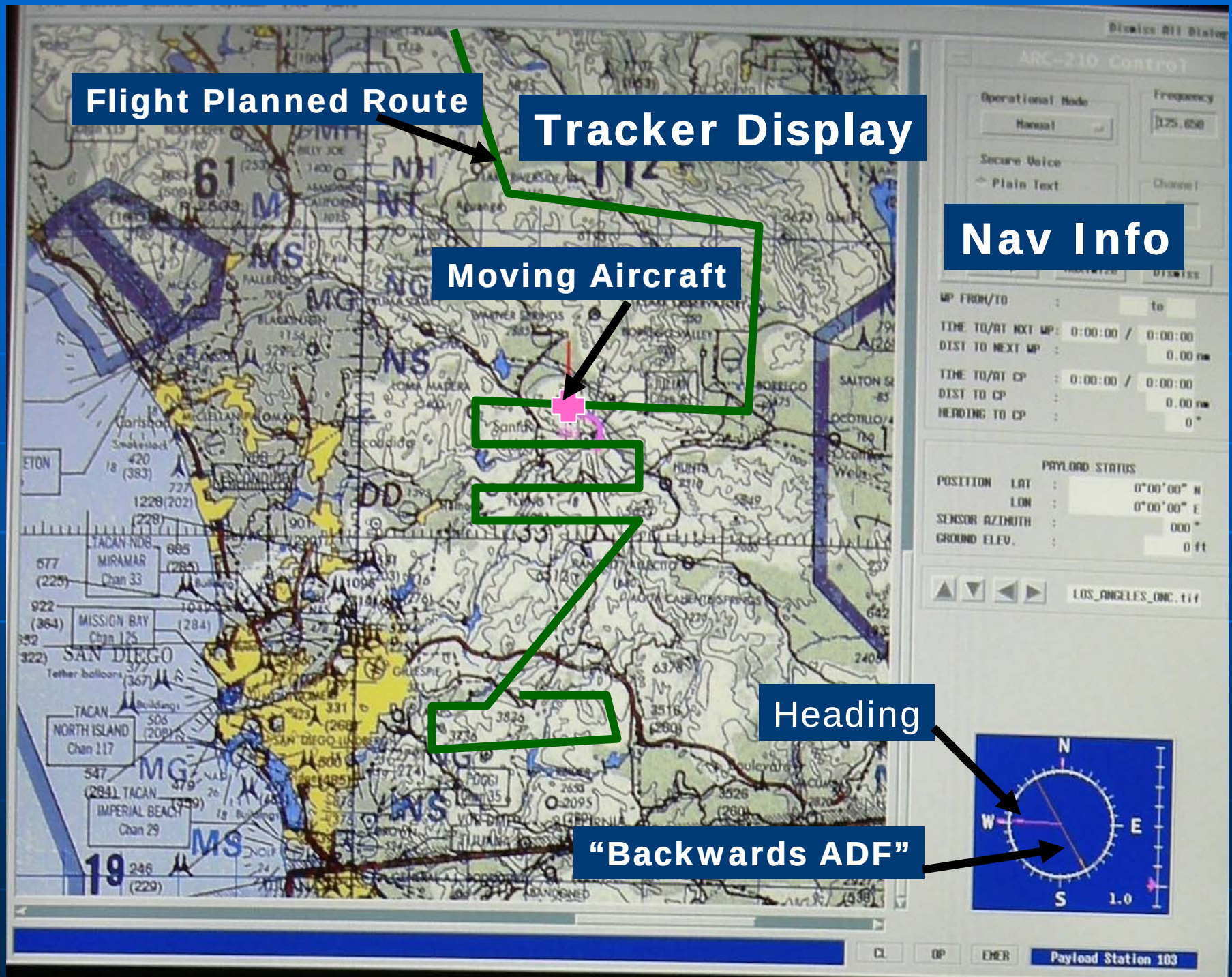
Displayed in Analog format

Use of the Tactile sense

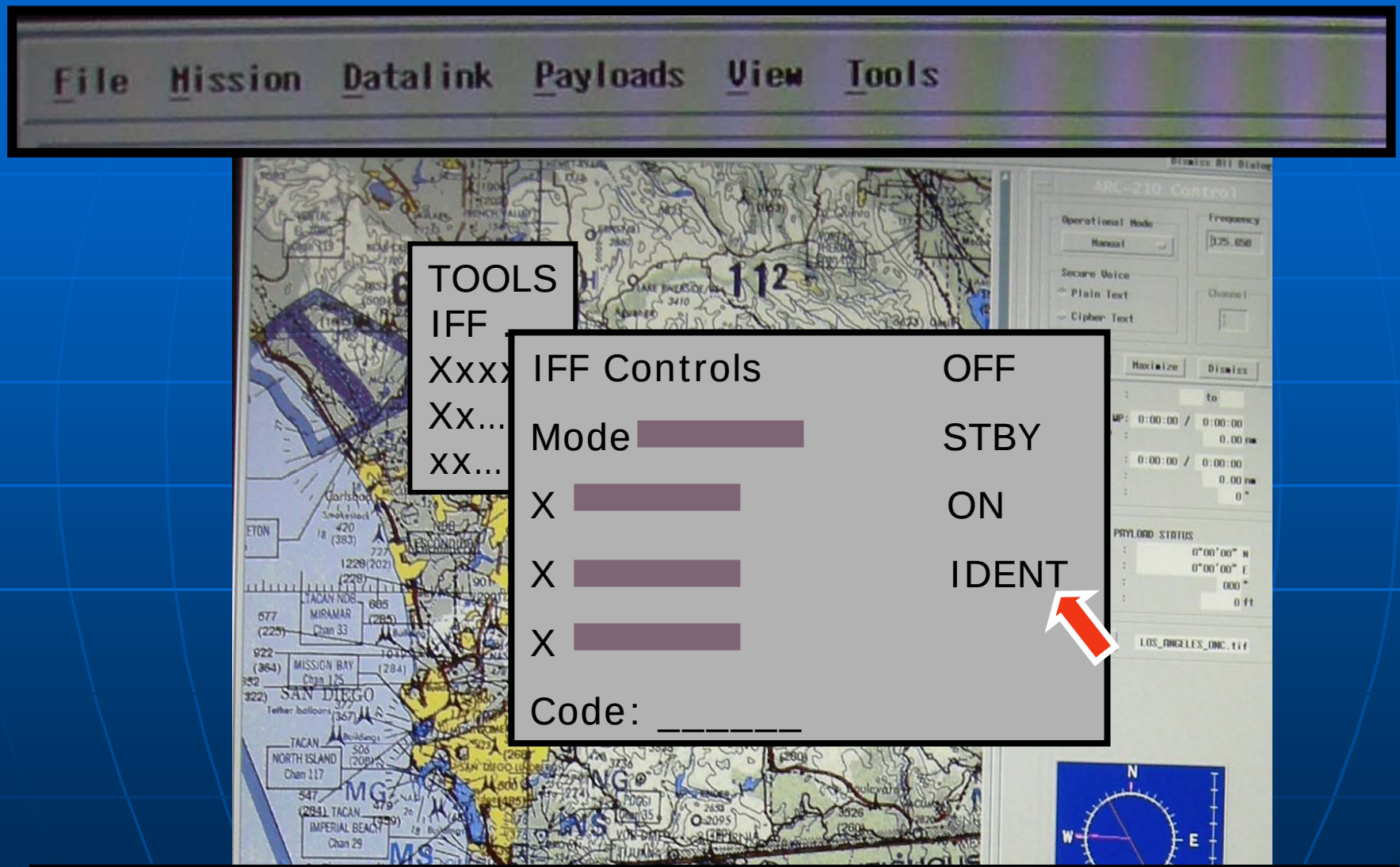
“Continous Sight” is not always *Required*

Welcome to the Digital World


Maps And Systems Controls
Camera View And HUD
Systems Displays And Controls
Recorders
Landing Gear Switch
Radios
Flaps And Engine Controls
Control Stick
Track Ball

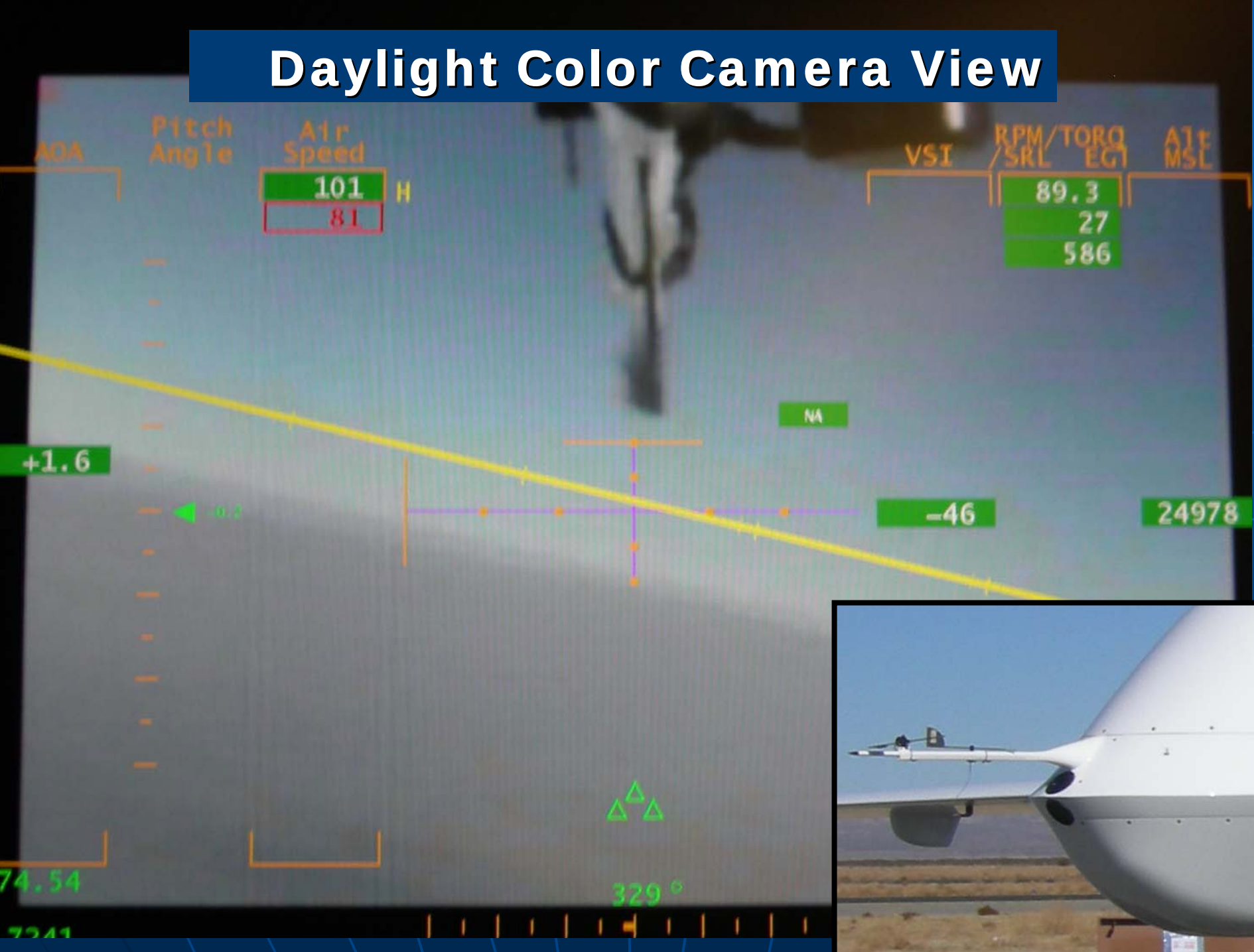

Flight Planned Route
Tracker Display
Moving Aircraft
Nav Info
Heading
"Backwards ADF"
N
W
E
S
1.0
Payload Station 103

- IFF “Ident” response

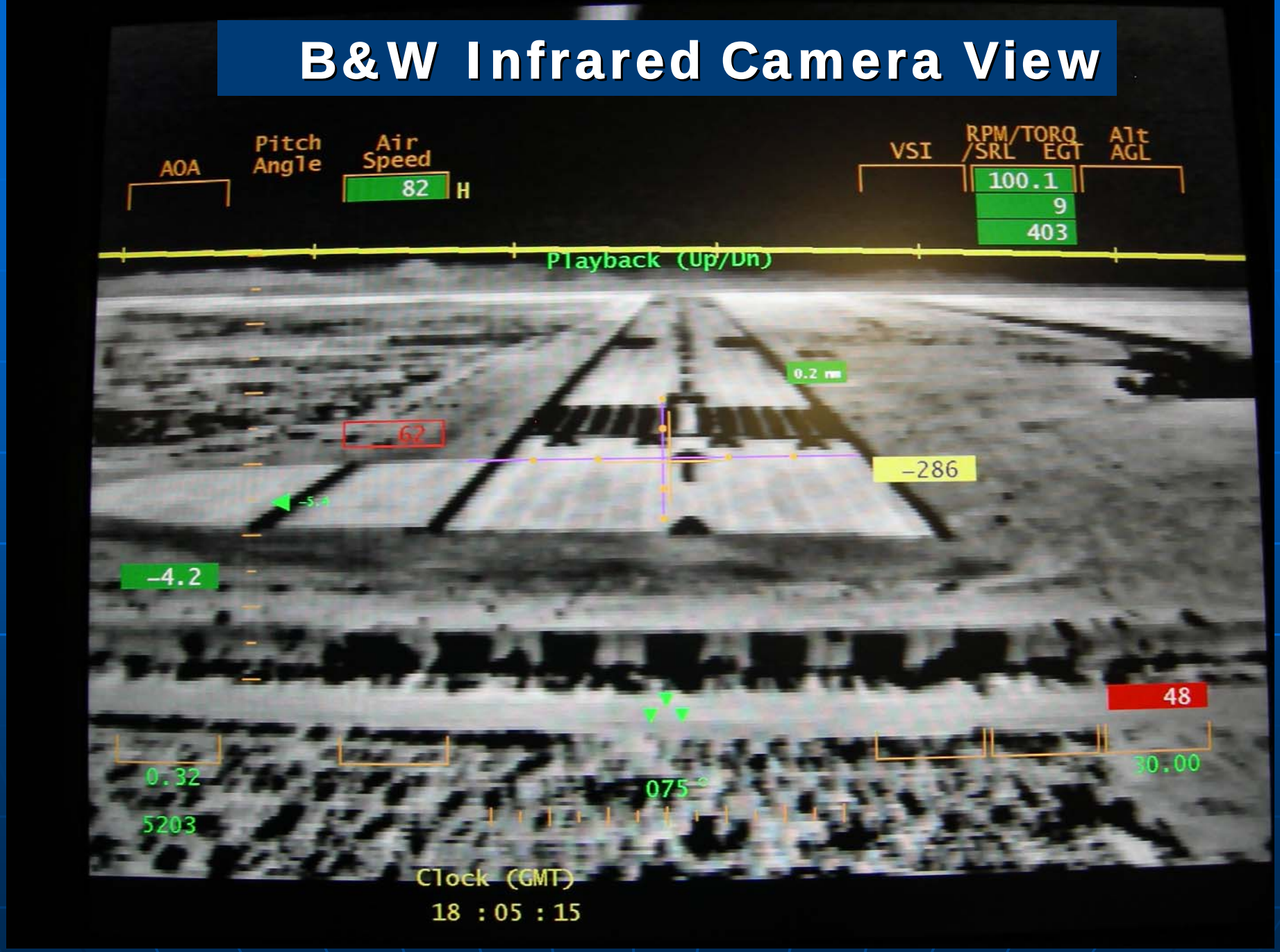


Notional Configuration

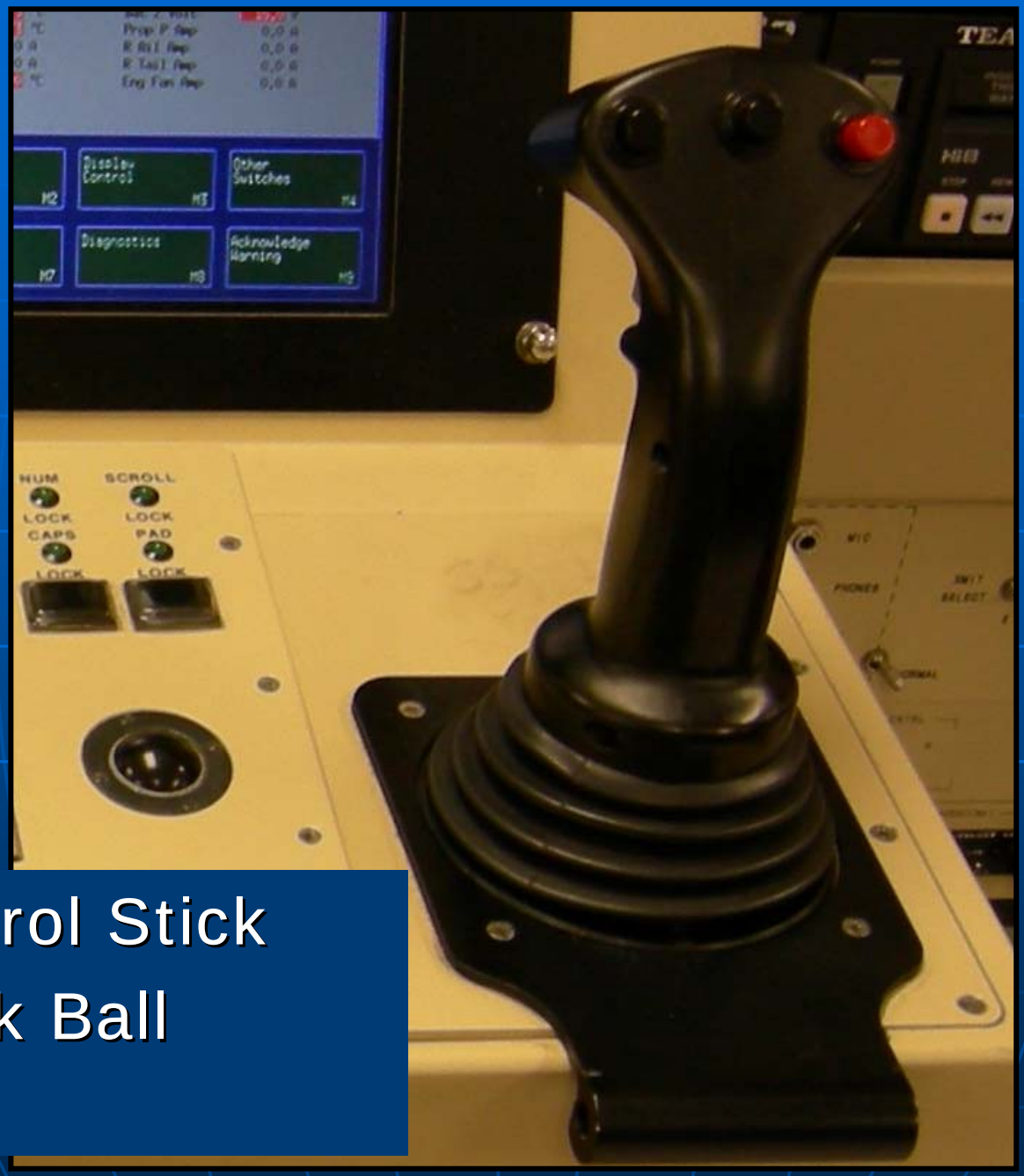
Daylight Color Camera View



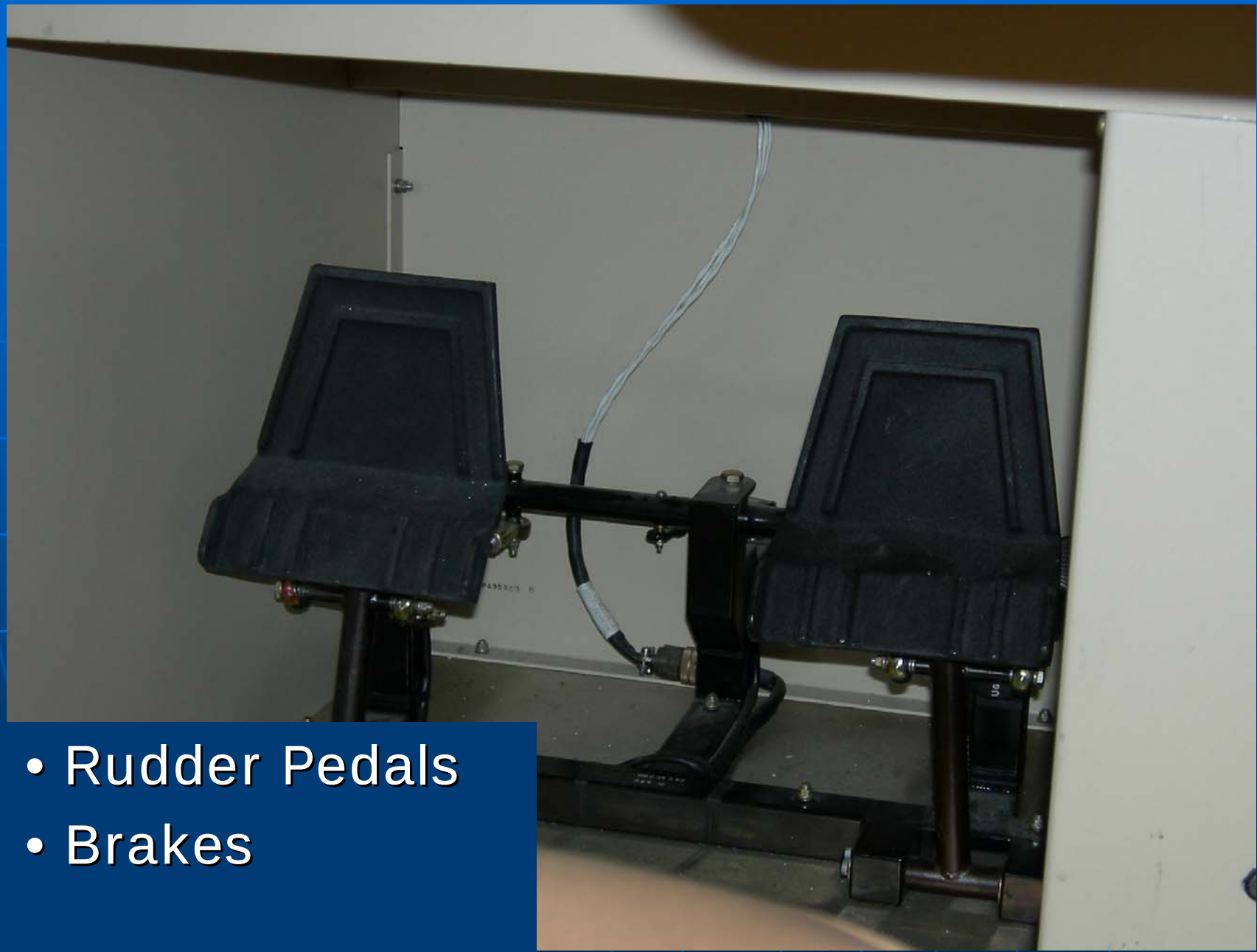
B&W Infrared Camera View



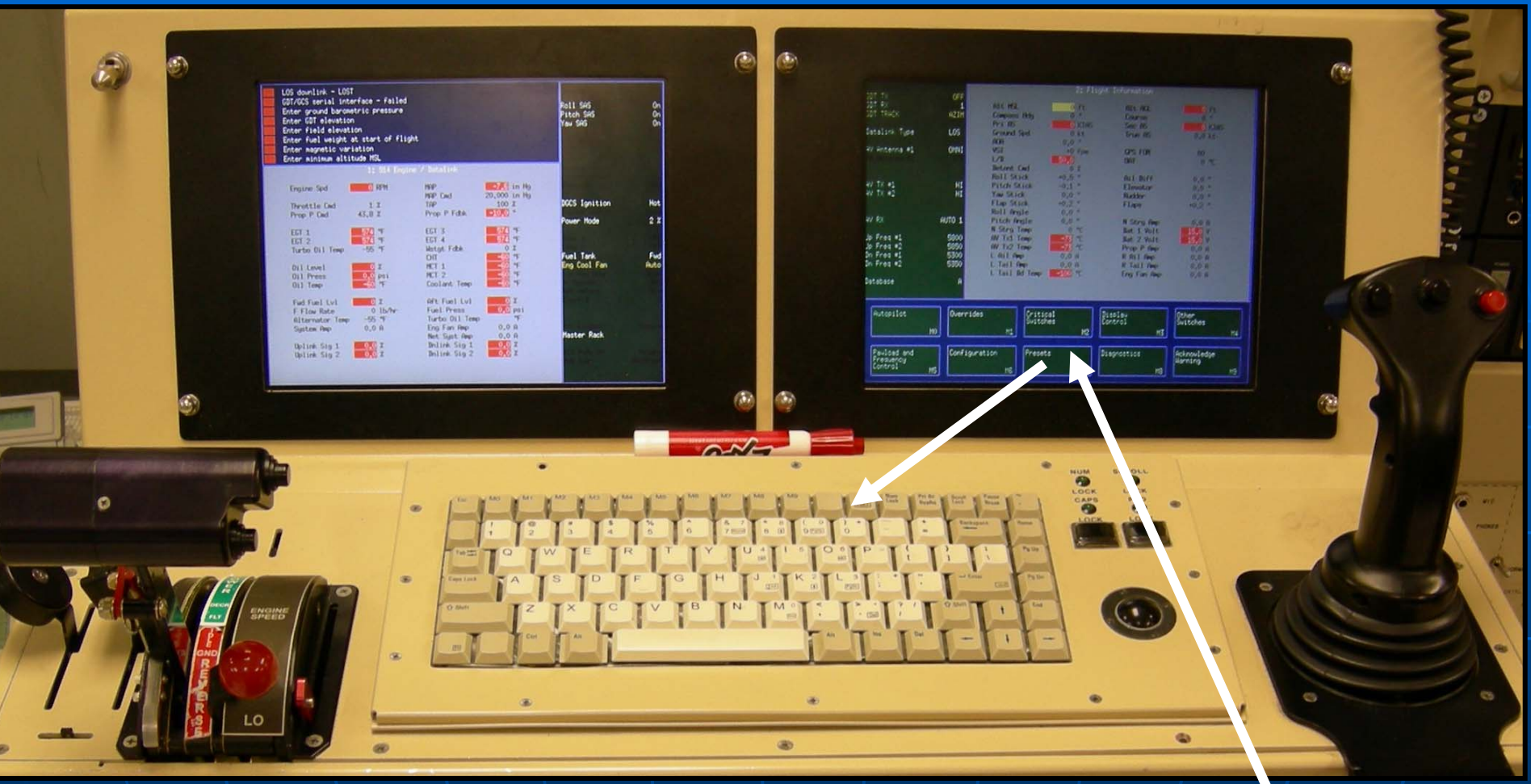
- Flap Handle
- Engine controls



- Control Stick
- Track Ball



- Rudder Pedals
- Brakes



- Systems Display Screens
- Keyboard Controls

Menu Switches

Example of control switch labeling issues

Q: How do I
TURN ON the Fuel Heaters?

Fuel Heat
Inhibit

Disable / Enable M99

Notional Configuration

Note: This has been changed to
“Fuel Heat – ON / OFF”

To meet FAA Requirements for flight in the National Airspace...

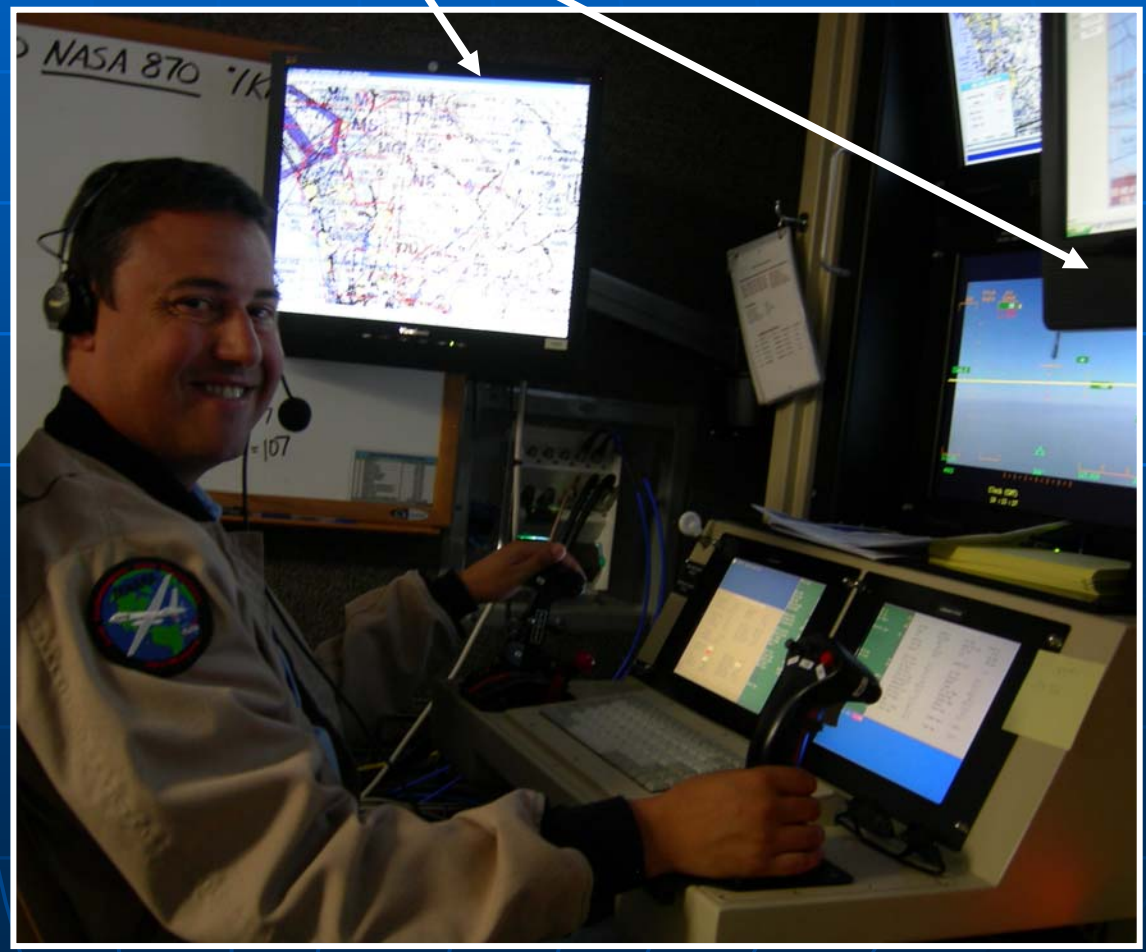
Additional displays installed

Prescribed routes over the fires

Range Safety Keep-out Zones

IFR Navigation Charts

Weather depiction



Flaring to land

What are your clues to precision?

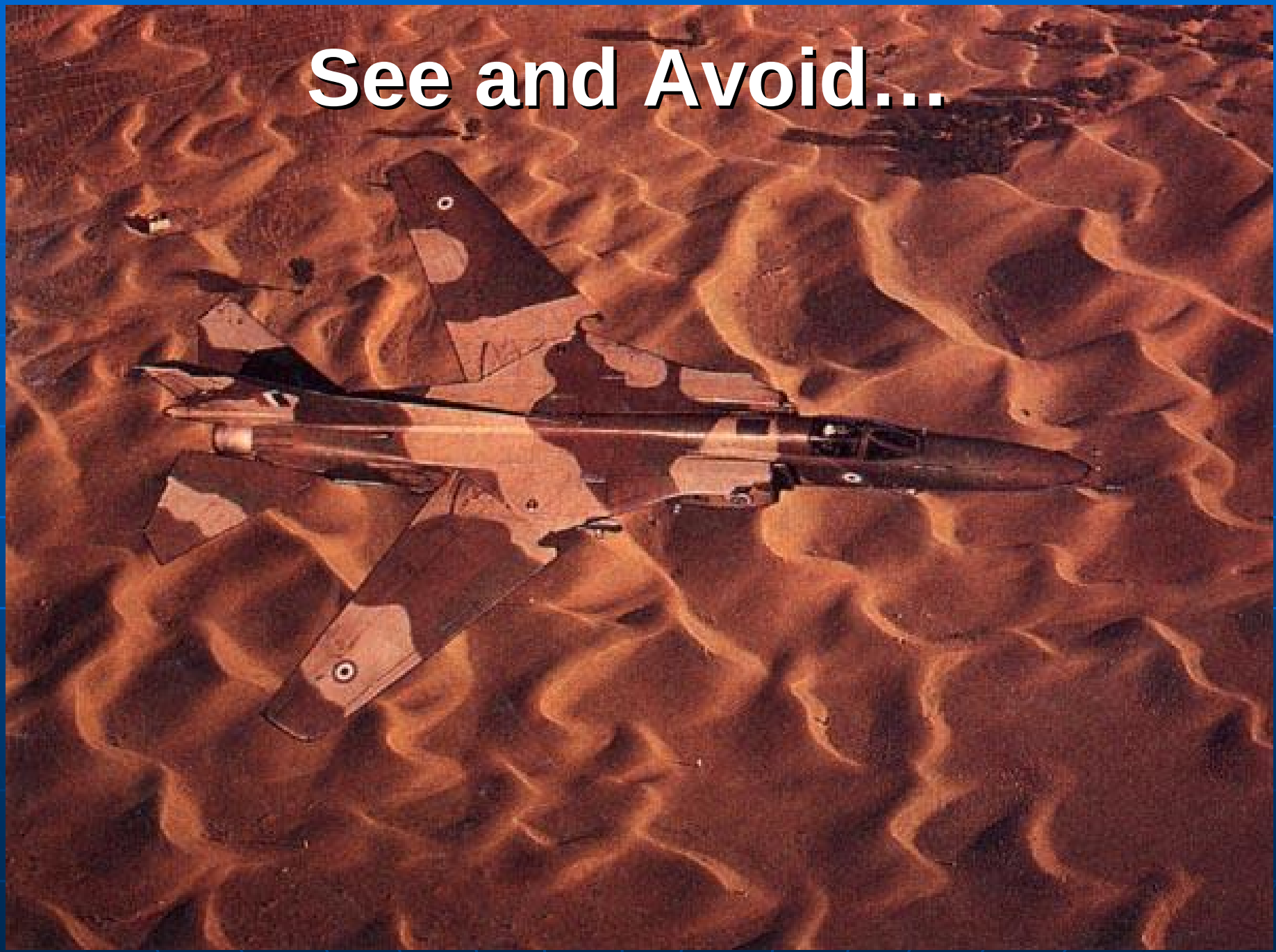
Approach…Flare…Land

Is it more than a visual task?

- Peripheral views
- Sink rate
- Sound
- Ground contact

Peripheral vision is important.

See and Avoid…



The challenges of “see and avoid”

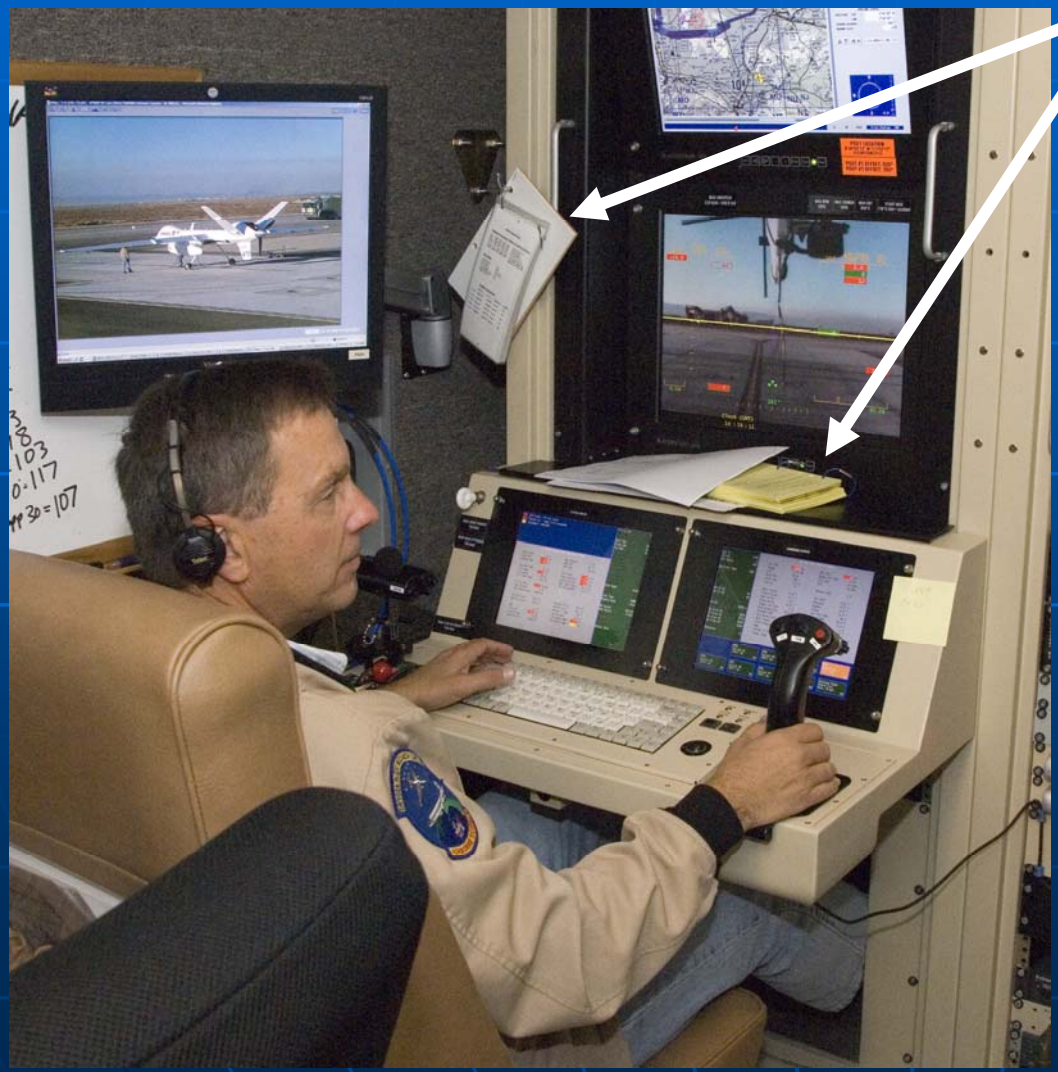
- Light
- Contrast
- Color
- Texture
- Distance
- Motion
- Shape
- Reflectivity
- Atmosphere
- Acuity

See (Sense) and Avoid

- Cessna pilots can't see up,
- Piper pilots can't see down...and
- Predator pilots can only see forward.

- Paint EVERY plane **international orange?**
- Increase external lighting?
- Generate contrails?
- Require binoculars in the cockpit?

Where do you place your charts, checklists, etc?



A kneeboard may not work here

What about boredom and fatigue?

Automated flight plans……Long duration flights

How can we improve the system?

- Engine sound
- Precision Altimeter
- Peripheral vision
- TCAS
- Force feedback
- Motion cues
- Improved displays and “switchology”
- Autoland

Issues and thoughts

- Welcome the emergence of regulations, policy decisions, and rule-making… but be careful.
  - Not all UAS are created equally
    - Vehicle-specific factors, capabilities, mishap histories
  - Crew qualification, training, currency, proficiency
    - USAF standards, FAA guidelines
- The overhead for missions is far from “file and fly”, but getting better.
  - Frequency management
- SAFETY and efficiency:
  - Systems improvements
  - Human Factors Engineering
  - Sleep shifting

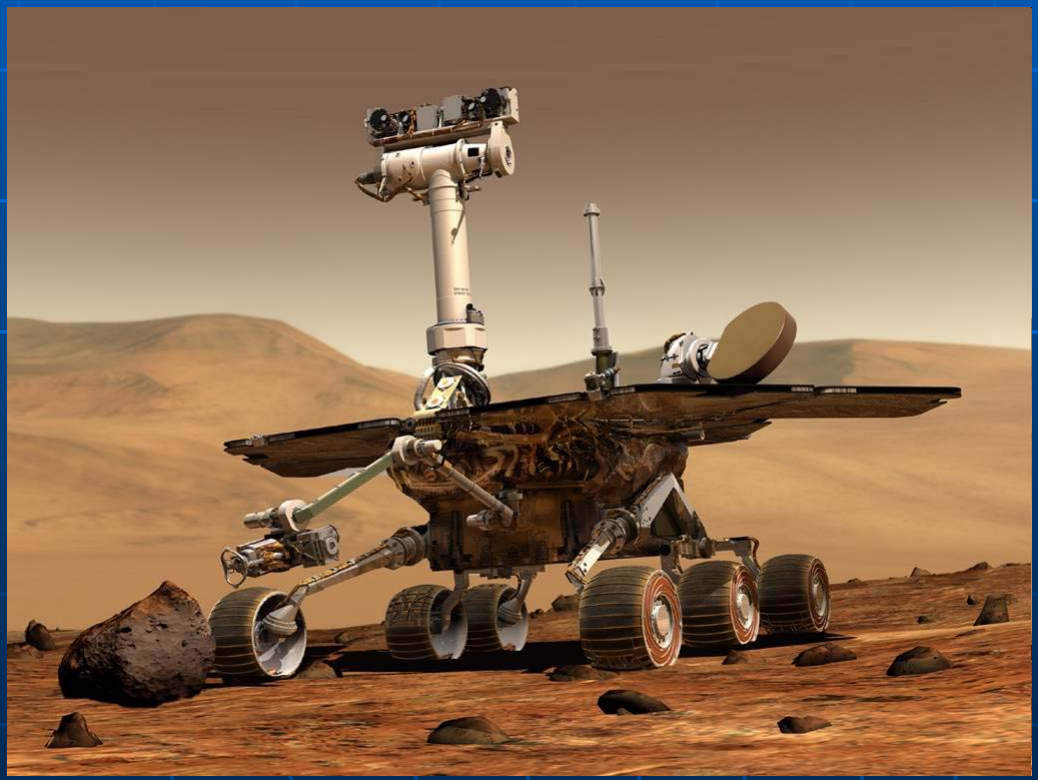
At some point, the rule-makers must account for progress in technology

Q: Robots or Humans?

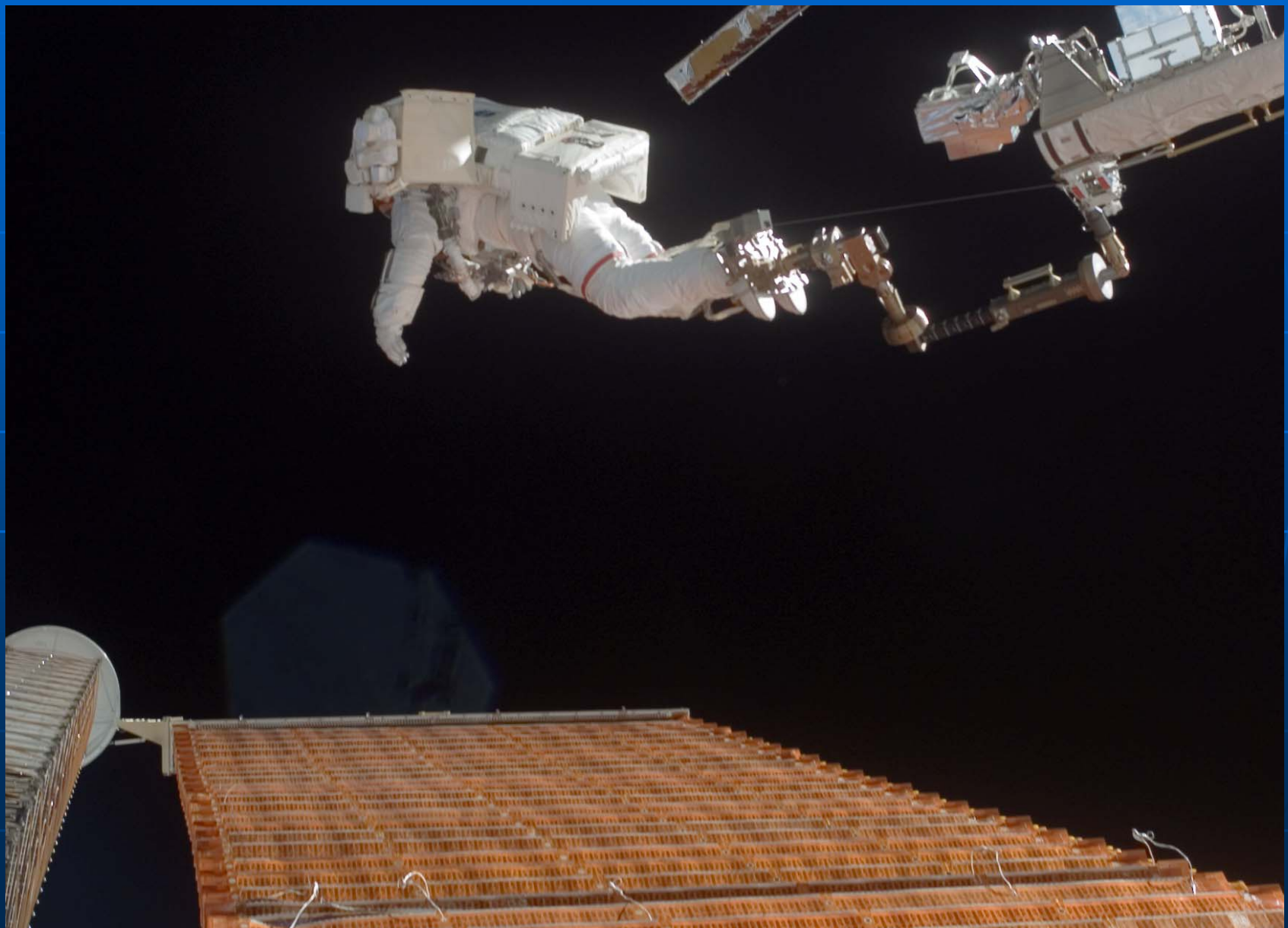
"Intelligence, utility, and endurance"

…vs…

"judgment, innovation, and adaptability"



A: Both, as required



Risk Management and Mitigation….
…vs. Risk Aversion

"If it's perfect safety you're looking for, you will do well to sit on the fence and watch the birds…"

- Wilbur Wright, 1901

Acknowledgements

NASA
Ames Research Center
Mountain View, CA

Fire Mission Pod

GENERAL ATOMICS
AERONAUTICAL SYSTEMS

Thanks!