INTEGRATED HELMET AUDIO VISUAL SYSTEM FINAL REPORT BRIEFING

Joint Strike Fighter Office

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JOINT STRIKE FIGHTER
U.S. NAVY U.S. MARINE CORPS U.S. AIR FORCE


DEPARTMENT OF THE NAVY
UNITED STATES OF AMERICA


DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA


UNITED STATES
MARINE CORPS


ARMSTRONG LABORATORY


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Office


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"TRACK"
IHAVS


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PROBLEM STATEMENT

- Increased information – optimize presentation to pilot
  - Present technology is limited by aircraft-fixed head-up displays (HUD)
- Future weapons provide off-boresight employment envelope
  - Air intercept missile
  - High speed anti-radiation missile (HARM) Block 6
  - Joint direct attack munition (JDAM)
  - Joint standoff weapon (JSOW)
- Increased threat drives requirement for off-boresight capability
- Precise targeting capability required

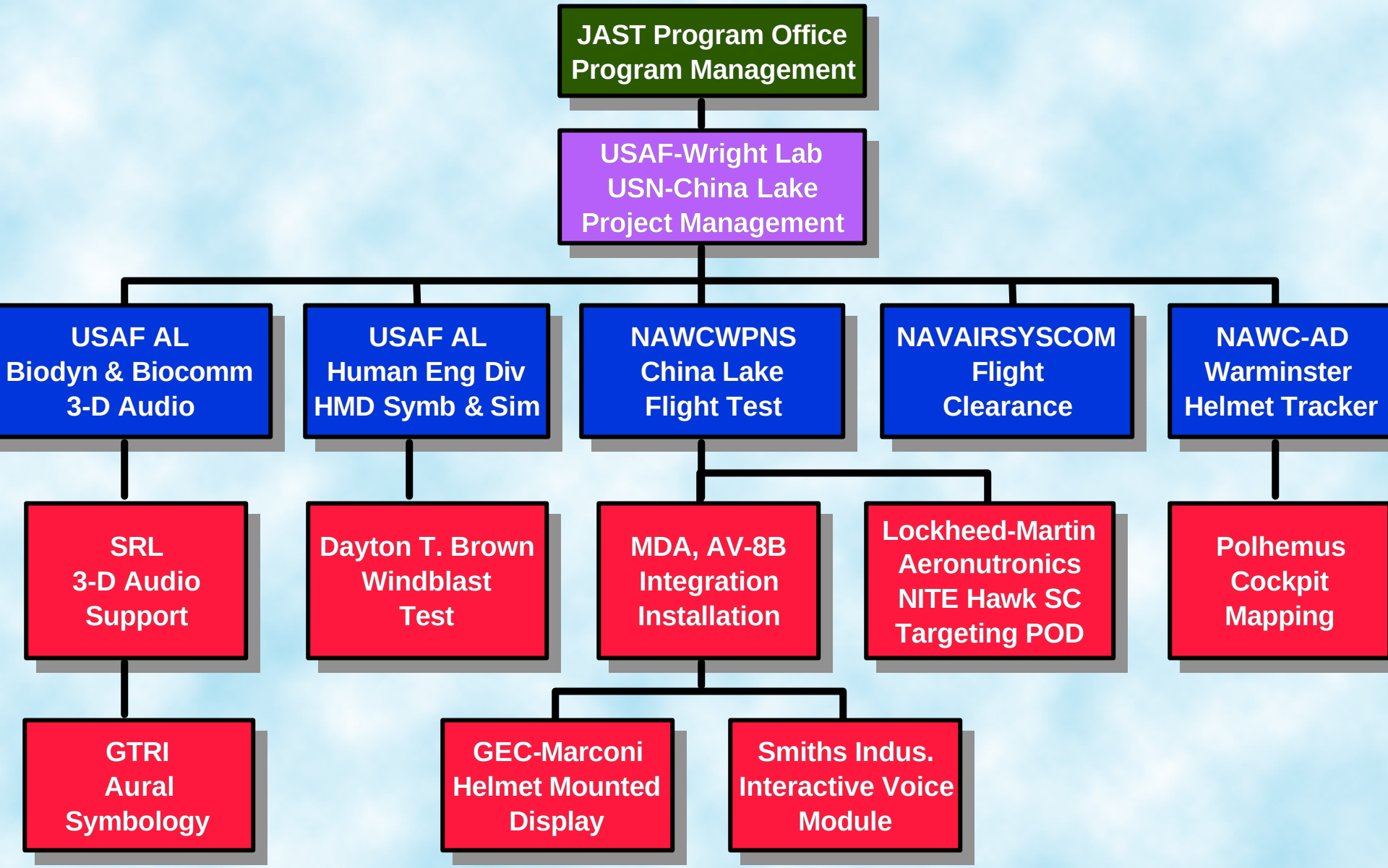
OBJECTIVES & GOALS

- Reduce workload and increase situational awareness
- Use HMD for navigation and mission tasks
- Display and evaluate sensor imagery on HMD
- Evaluate HMD weapon delivery potential
- Compare HUD vs HMD performance
- Evaluate 3-D audio threat management
- Demonstrate utility of voice interface technology
- Investigate HMD and 3-D audio designation point cueing
- Integrate the technologies into one human systems interface

PROJECT SUMMARY

- IHAVS increased situational awareness and decreased workload
- Successful demonstration of IHAVS potential
- Enhanced air-to-ground mission effectiveness
- IHAVS is the basis for the next generation human systems interface for the tactical strike fighters of tomorrow

IHAVS PHASE 1 ORGANIZATION



SYSTEM INTEGRATION

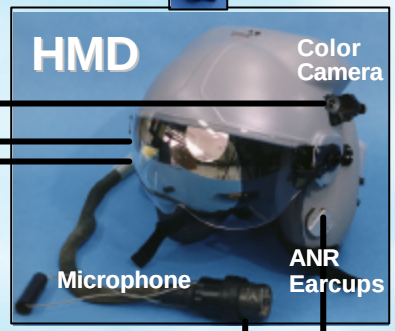
- TAV-8B, first aircraft to incorporate IHAVS
- Integrated several technologies into one human systems interface
- IHAVS team first ever to integrate these technologies
- Significant aircraft modifications were required
- Installation was completed in 4 months, enabling system refinements to be accomplished

SYSTEM DIAGRAM

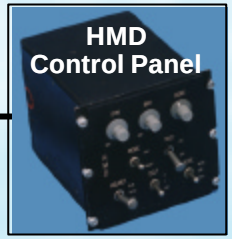
Tracker Source

Tracker Sensor

Quick Disconnect



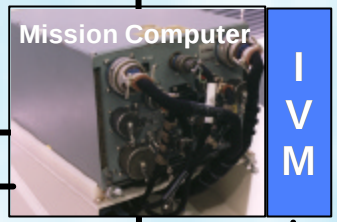
Serial Data Bus



TPOD Video

1553 MUX

HMD Camera & Graphics



1553 MUX

1553 MUX

1553 MUX

Serial Data Bus

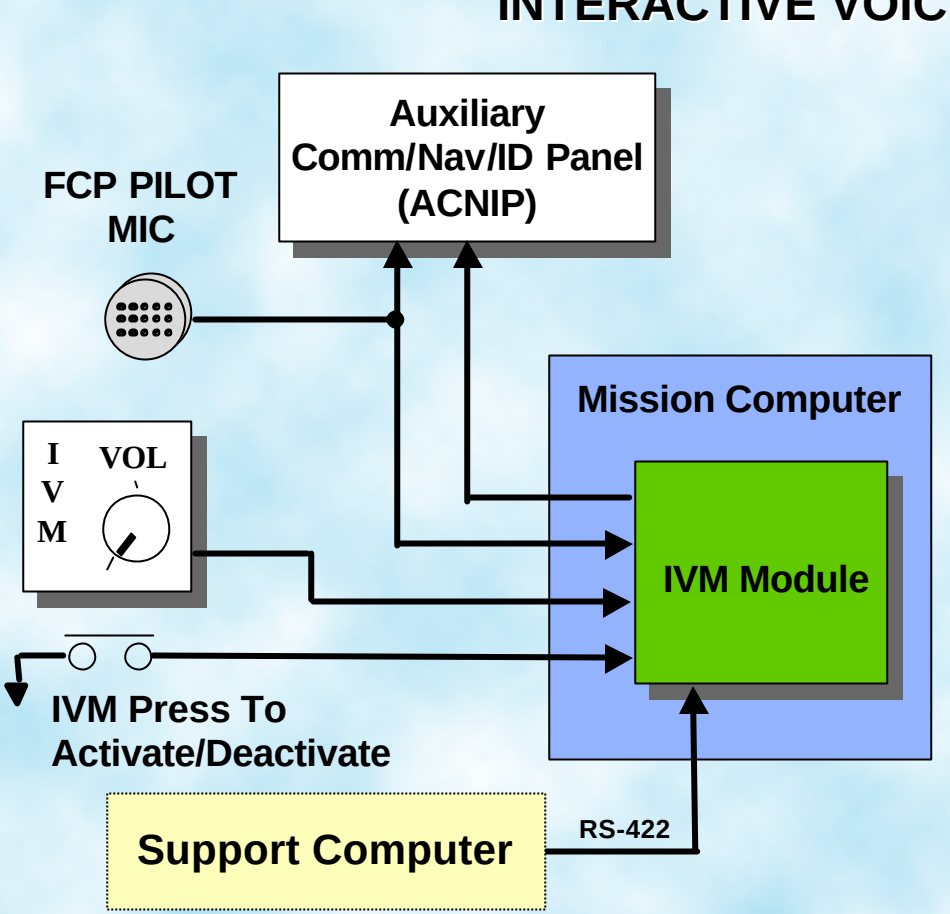
SYSTEM INTEGRATION

HELMET MOUNTED DISPLAY

- 40° FOV, binocular, 100% optics overlap
- 24° X 24° TPOD video display capability
- On-boresight virtual HUD
  - Navigation and attack symbology
  - RWR threat symbology
- Off-boresight mode
  - Attitude, altitude and airspeed symbology
  - Targeting and look-to symbology
  - RWR threat reported at azimuth & fixed elevation

SYSTEM INTEGRATION

INTERACTIVE VOICE MODULE



Press To
Activate/Deactivate

Voice
Commands

- Update
- Designate
- ECM
- Map
- Stores
- 76
- 82
- Report Combat
- Track
- Pod
- Course
- Helmet

Digital Voice
Outputs

COMBAT STATUS

- Combat
- Air-To-Ground
- Master Arm
- Weapon

ERROR

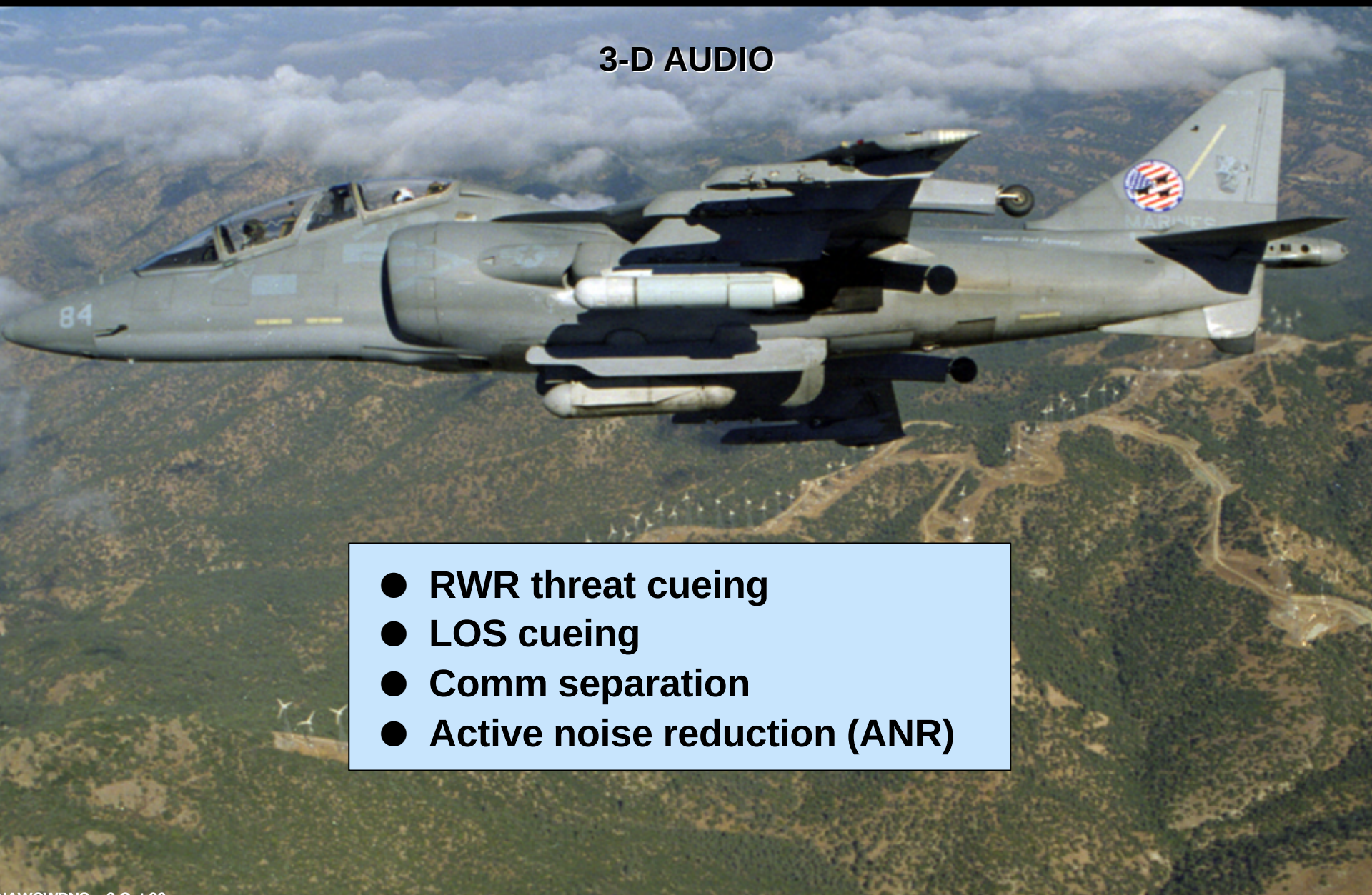
SYSTEM INTEGRATION

TPOD SYSTEM

- Self cooled (SC) targeting pod
  - Based on the F/A-18 NITE Hawk pod
  - Off-boresight sensor for targeting and designating
- Cockpit interface
  - HMD raster capable
  - Multi-function display video
  - Commanded by HOTAS or IVM

SYSTEM INTEGRATION

3-D AUDIO

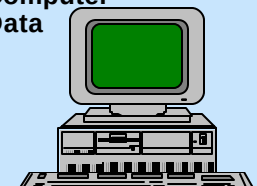


- RWR threat cueing
- LOS cueing
- Comm separation
- Active noise reduction (ANR)

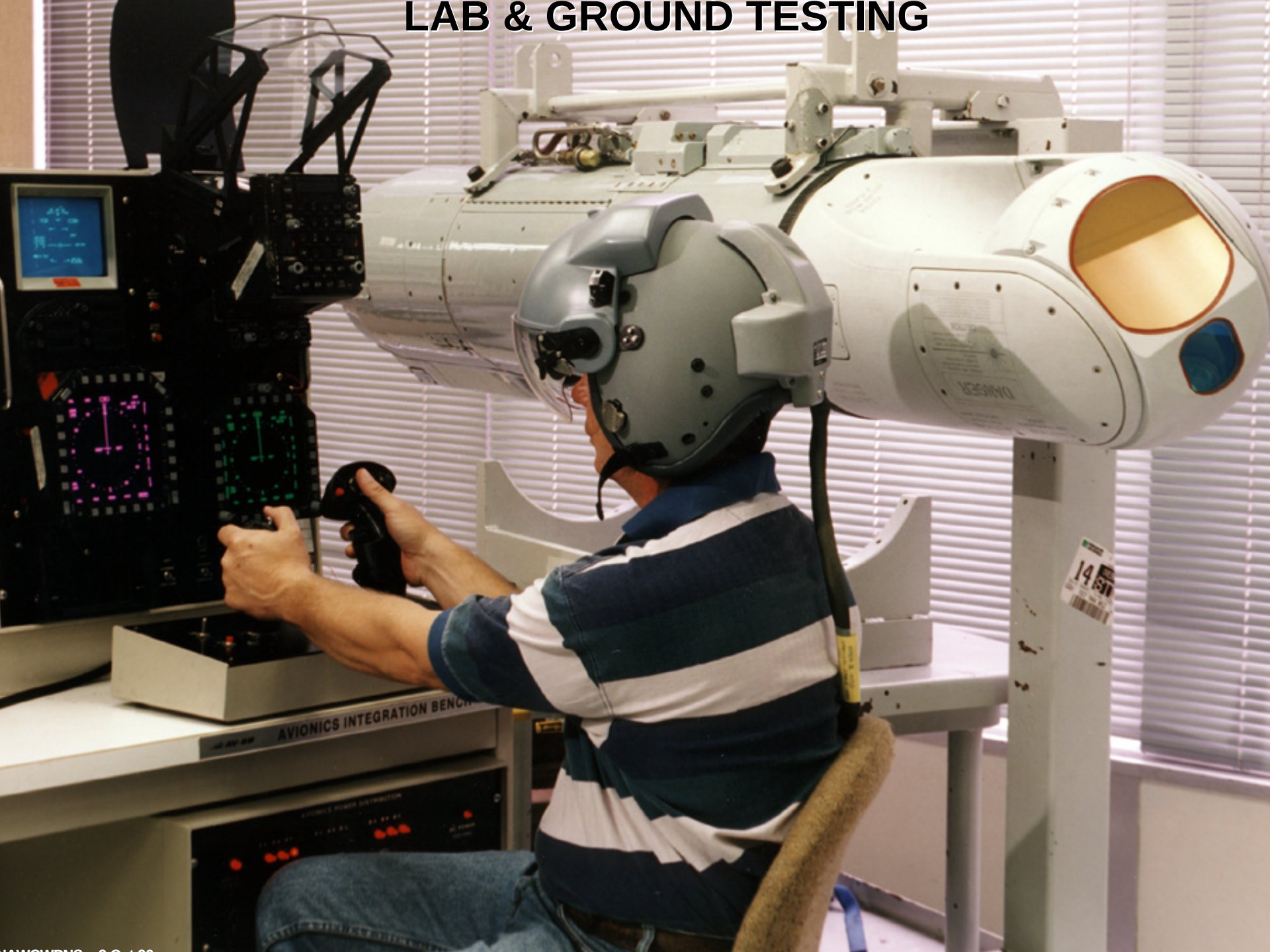
IHAVS DATA COLLECTION

INSTRUMENTATION POD

Computer Data



LAB & GROUND TESTING

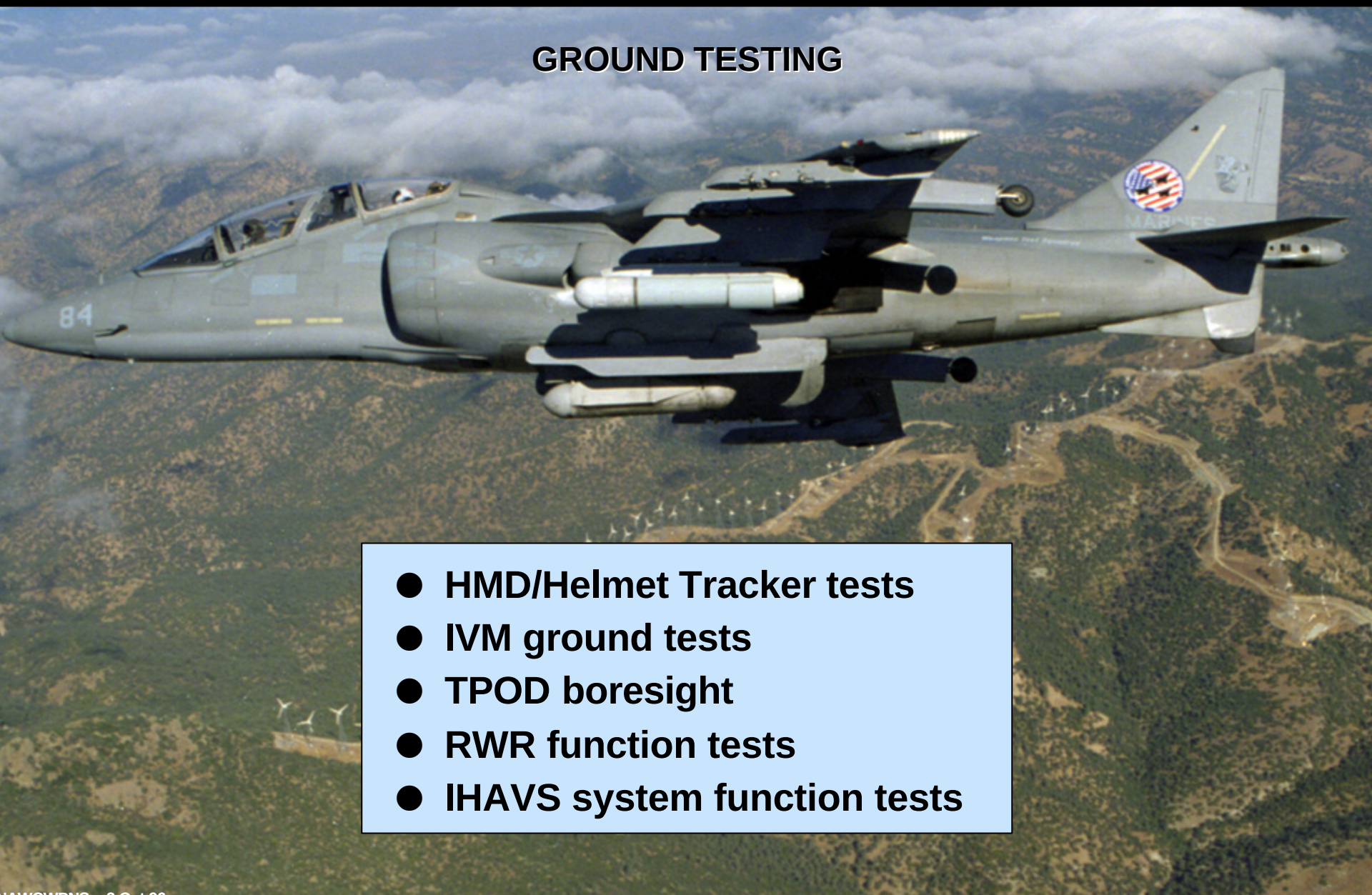


LAB & GROUND TESTING

LAB TESTING

- HMD symbology simulation and training
- Pilot audio response testing
- Auditory symbology
- Systems integration hot bench

LAB & GROUND TESTING



GROUND TESTING

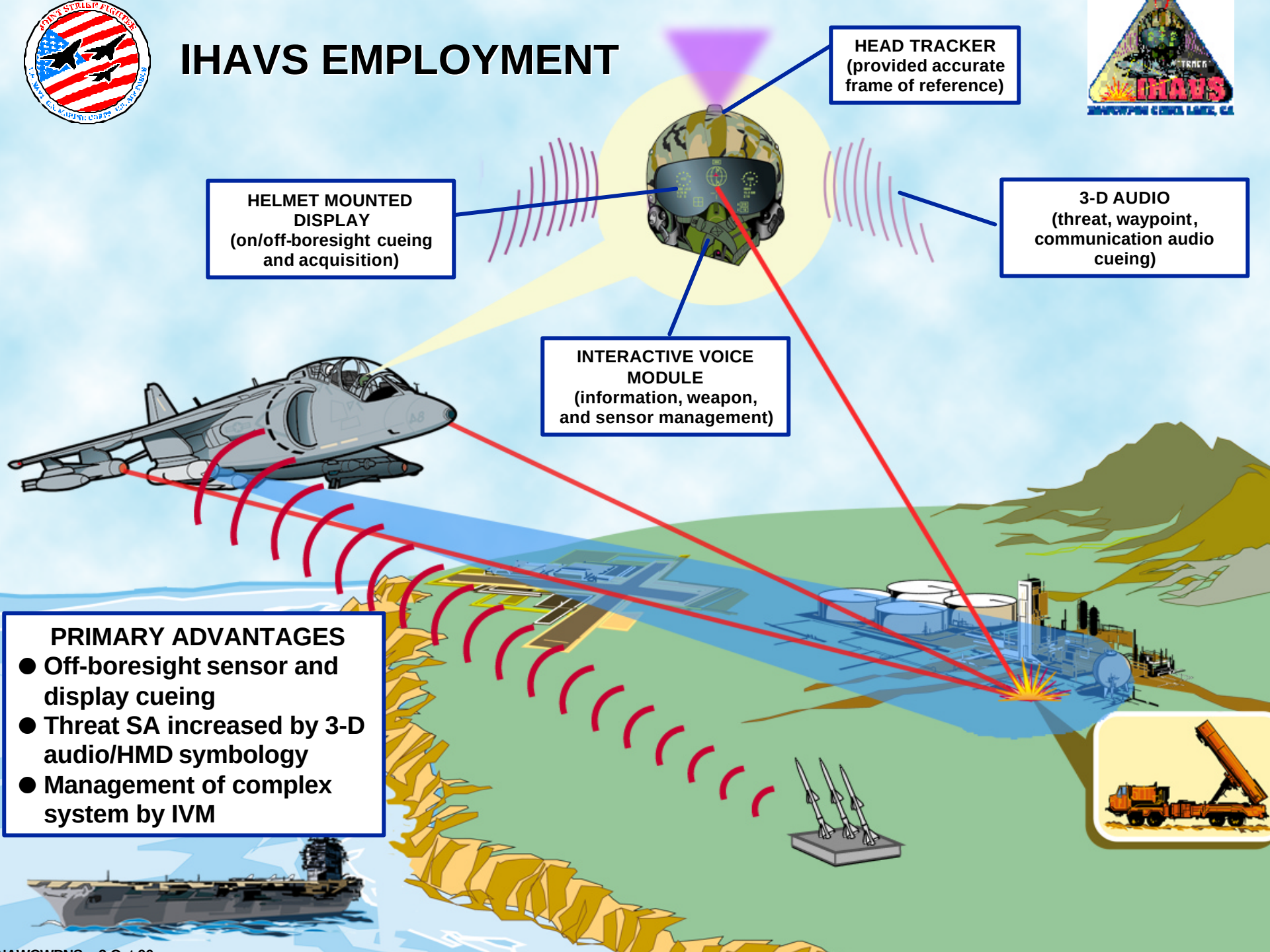
- HMD/Helmet Tracker tests
- IVM ground tests
- TPOD boresight
- RWR function tests
- IHAVS system function tests

TRAINING

PILOT TRAINING

- Academics
- Simulator
- Five flights each
- IHAVS systems training
- Pilots were comfortable and adequately prepared for test

IHAVS EMPLOYMENT



PRIMARY ADVANTAGES

- Off-boresight sensor and display cueing
- Threat SA increased by 3-D audio/HMD symbology
- Management of complex system by IVM

IHAVS LIMITATIONS

- Project scope limited demonstration technologies
- Tracker not state-of-the-art (SOA)
  - –Twelve-year old technology
- Alternate TPOD was not SOA
- OFP had limited TPOD support
- Symbology not optimized – better available
- Fixed elevation on RWR without range
- Helmet not optimized
  - –Visor, weight, cg

IHAVS FLIGHT TEST PLAN

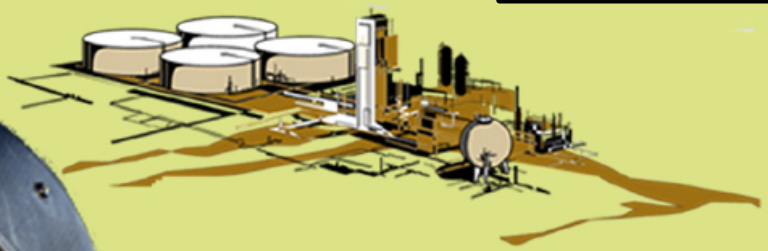
IHAVS FLIGHT TEST EVENTS

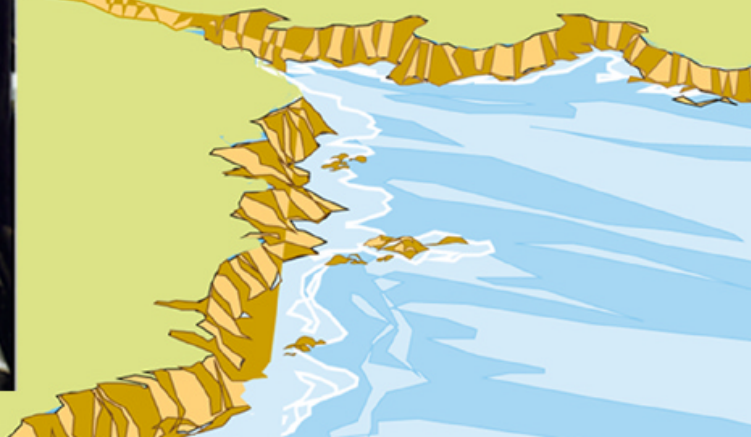
Event no.	Flights	Purpose
1	1 / pilot	Aircrew Familiarization
2	1 / pilot	Non-IHAVS - Weapons Delivery (HUD)
3	1 / pilot	IHAVS System Demonstration - Weapons Delivery (HMD)
4	1 / pilot	Non-IHAVS - Tactical Ingress (HUD)
5	1 / pilot	IHAVS System Demonstration - Tactical Ingress (HMD)
6	1 / pilot	IHAVS - Tactical Ingress at Low Altitude, Pre-Planned Targets
7	1 / pilot	IHAVS - Tactical Ingress at Medium Altitude, Targets of Opportunity
8	1 / pilot	IHAVS System Demonstration - Threat Reaction

EVENT #2 NON-IHAVS – WPNS DEL (HUD)

30°DB MK 76

4 X GAUT
- INS DESIG
2 X GCIP





EVENT #3 IHAVS SYSTEM DEMO – WPNS DEL (HMD)

30°DB MK 76

4 X GAUT
- INS/HMD DESIG
2 X GCIP

IHAVS FLIGHT TEST PLAN

EVENT #4 NON-IHAVS – TACTICAL INGRESS (HUD)

Run	System	Ingress	Target[a]	Weapon[b]	Delivery	Mode
1	NITE Hawk	Med Alt	PP: SA-2	IMAV	MAX RNG	AGM
2	NITE Hawk	Med Alt	PP: Tactical Vehicle	LMAV	MAX RNG	AGM
3	HUD	Med Alt	PP: Industrial Site	MK 82	30 deg dive	GAUT
4	HUD	Med Alt	TOO: Tactical Target	MK 82	30 deg dive	GCIP
5	HUD	Low Alt	PP: Tactical Target	Mk 82	10 deg dive	GAUT
6	HUD	Med Alt	TOO: Tactical Target	Mk 82	30 deg dive	GCIP

[a]PP = pre-planned target.

[b]Simulated.

NON-IHAVS – TACTICAL INGRESS (HUD)

NAVIGATION / FORMATION
THREAT SA

AA MODE

EXECUTE DELIVERY

TARGET SA
(IDENTIFY)

NAVIGATION / FORMATION
THREAT SA

ACTION IF LOW ALT
(TYPICALLY 4-6 NM)

TARGET SA
(DETECT / RECOGNIZE)

NAVIGATION / FORMATION
THREAT SA

UPDATE SYSTEM

√ WPNS STATUS
(STORES / FUZES / MA)

AG MODE

NAVIGATION / FORMATION
THREAT SA

IHAVS FLIGHT TEST PLAN

EVENT #5 IHAVS SYSTEM DEMO – TACTICAL INGRESS (HMD)

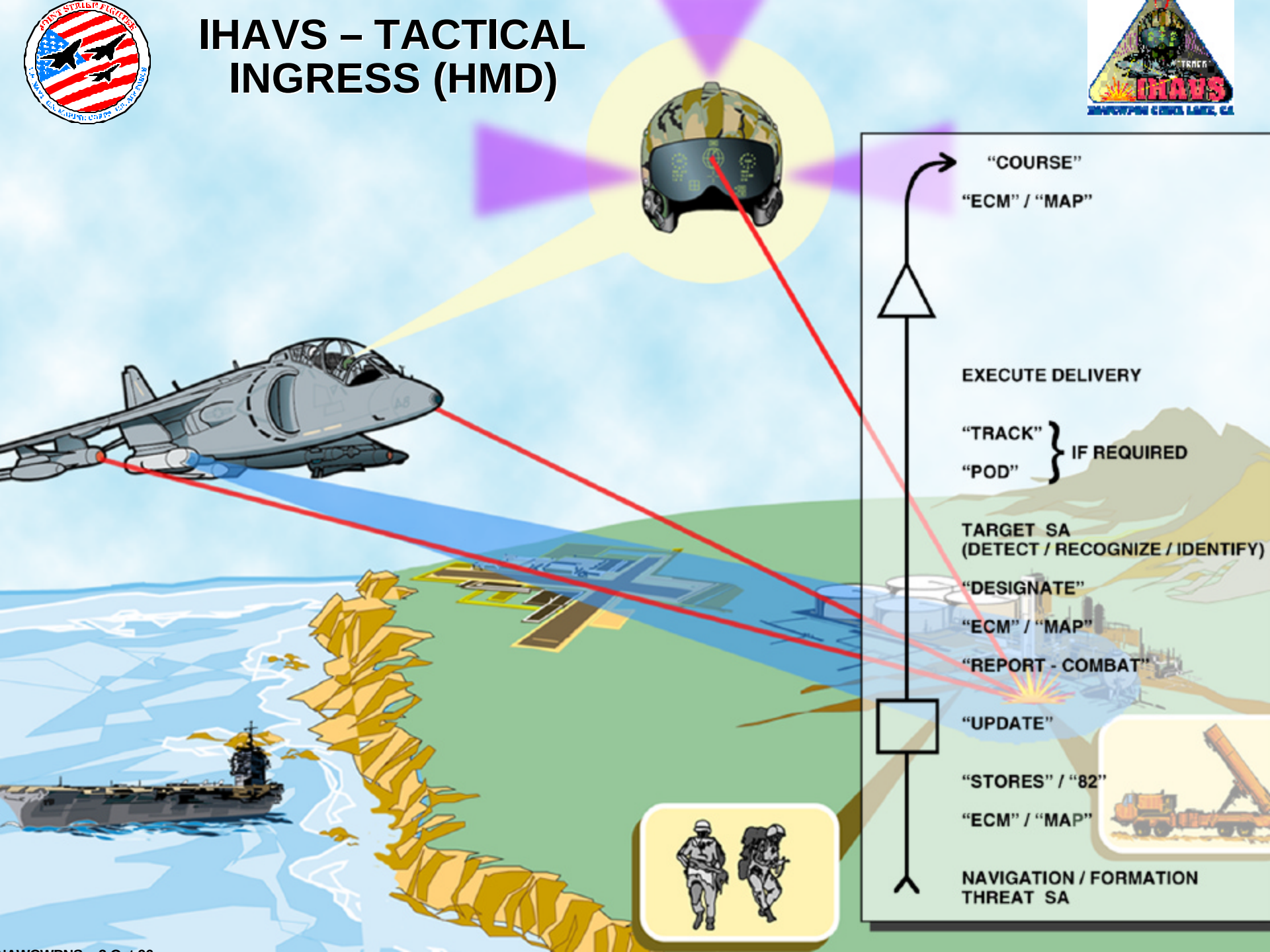
Run	Target	Weapon	Delivery	Mode
1	PP: SA-2	IMAV	MAX RNG	AGM
2	PP: Tactical Vehicle	LMAV	MAX RNG	AGM
3	PP: Industrial Site	IMAV	MAX RNG	AGM
4	PP: Tactical Target	Mk 82	30 deg dive	T-AUTO
5	PP: Tactical Target	Mk 82	30 deg dive	GAUT
6	PP: Tactical Target	Mk 82	30 deg dive	GAUT

IHAVS FLIGHT TEST PLAN

EVENT #6 TACTICAL INGRESS AT LOW ALT – PREPLANNED TGTS

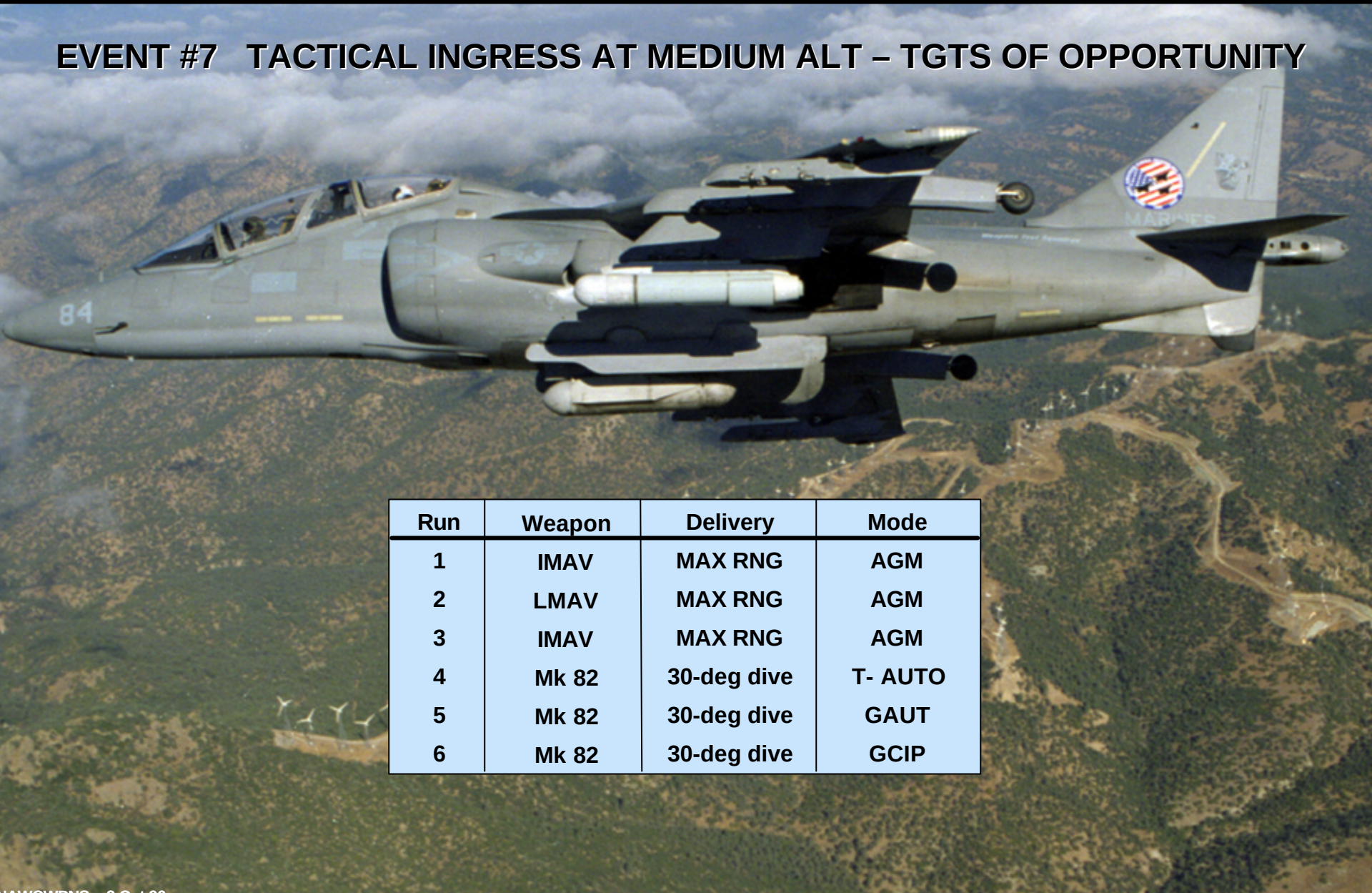
Run	Target	Weapon	Delivery	Mode
1	PP: SA-2	IMAV	MAX RNG	AGM
2	PP: Tactical Vehicle	LMAV	MAX RNG	AGM
3	PP: Industrial Site	IMAV	MAX RNG	AGM
4	PP: Tactical Target	Mk 82	10-deg dive	T-AUTO
5	PP: Tactical Target	Mk 82	10-deg dive	GAUT
6	PP: Tactical Target	Mk 82	10-deg dive	GCIP

IHAVS – TACTICAL INGRESS (HMD)



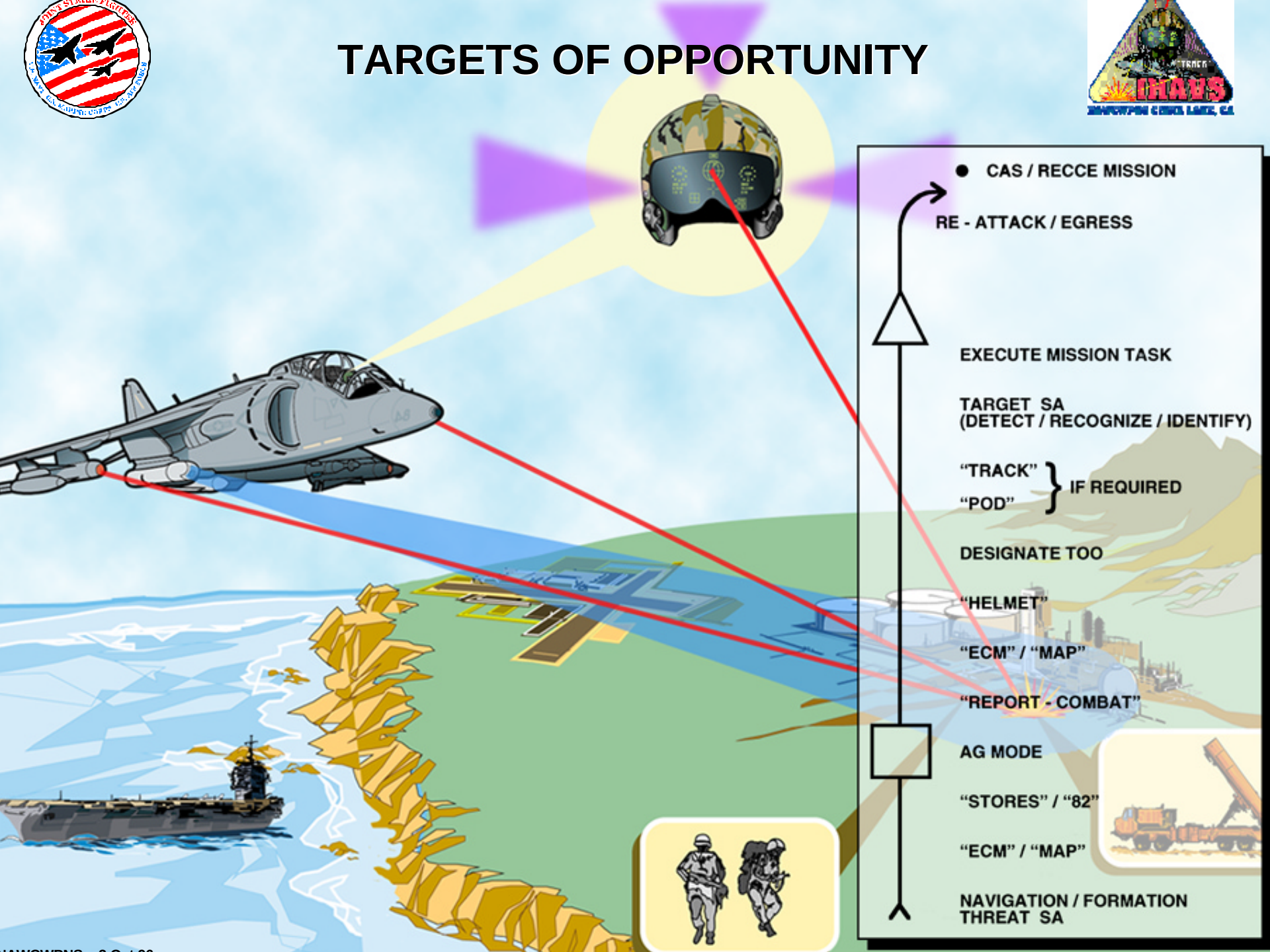
IHAVS FLIGHT TEST PLAN

EVENT #7 TACTICAL INGRESS AT MEDIUM ALT – TGTS OF OPPORTUNITY



Run	Weapon	Delivery	Mode
1	IMAV	MAX RNG	AGM
2	LMAV	MAX RNG	AGM
3	IMAV	MAX RNG	AGM
4	Mk 82	30-deg dive	T- AUTO
5	Mk 82	30-deg dive	GAUT
6	Mk 82	30-deg dive	GCIP

TARGETS OF OPPORTUNITY



IHAVS FLIGHT TEST PLAN

EVENT #8 IHAVS-EW THREAT MANAGEMENT

Run	Pass	Direction	System	Route	Threat Array
1	1	Outbound	Non-IHAVS	A	1
1	2	Inbound	IHAVS	A	2
2	1	Outbound	Non-IHAVS	B	3
2	2	Inbound	Non-IHAVS	B	1
3	1	Outbound	Non-IHAVS	C	2
3	2	Inbound	IHAVS	C	3
4	1	Outbound	IHAVS	A	1
4	2	Inbound	Non-IHAVS	A	2
5	1	Outbound	IHAVS	B	3
5	2	Inbound	IHAVS	B	1
6	1	Outbound	IHAVS	C	2
6	2	Inbound	Non-IHAVS	C	3

RESULTS

NON-IHAVS – TACTICAL INGRESS (HUD)

- Workload affected due to increased head-down time
- HUD was a head “magnet”
- Attack tactics driven by limited HUD FOV
- Audio threats required to be cross-checked with visual cues
- One MFD in TAV-8B limited pilot access to information
- HOTAS affected pilot workload (proficiency/PVI)

RESULTS

IHAVS PRE-PLANNED TARGET ENGAGEMENTS (HMD) (GOODS)

- Off-boresight symbology cues resulted in early visual detection of target area
- IVM provided capability to manipulate the IHAVS
- TPOD provided an off-boresight sensor for targeting
- 3-D audio/HMD provided effective audio/visual threat cueing
- ANR resulted in a more quiet cockpit environment
  - –Lab results indicated approximately 10-15 dB reduction

RESULTS

IHAVS PRE-PLANNED TARGET ENGAGEMENTS (HMD) (OTHERS)

- "Jitter" and "latency" in HMD distracted overall system operation
- Helmet would shift on pilot's head - symbology fadeout
- IVM would not recognize or mis-recognize voice commands
- TPOD resolution was poor and target tracks were difficult
- TPOD would break lock during maneuvering

RESULTS

IHAVS TARGETS OF OPPORTUNITY ENGAGEMENTS (HMD) (GOODS)

- HMD provided additional flexible attack options
- HMD symbology provided means of marking/re-acquiring target
- HMD off-boresight attitude/airspeed/altitude cues more useful
- IVM effective for sensor management when working properly
- 3-D audio provided additional threat SA

RESULTS

IHAVS TARGET OF OPPORTUNITY ENGAGEMENTS (HMD) (OTHERS)

- "Jitter" and "latency" in HMD a problem
- HMD symbology not optimized due to project limitations
  - –Distinct symbology
  - –Clutter off-boresight
- IVM recognition rates degraded during maneuvering

RESULTS

THREAT MANAGEMENT (GOODS)

- Better threat SA
  - –Less head-down time
- Localization; 3-D audio with HMD symbology
- Better use of mission cross-check time

RESULTS

NON-IHAVS – WEAPONS DELIVERY (HUD)

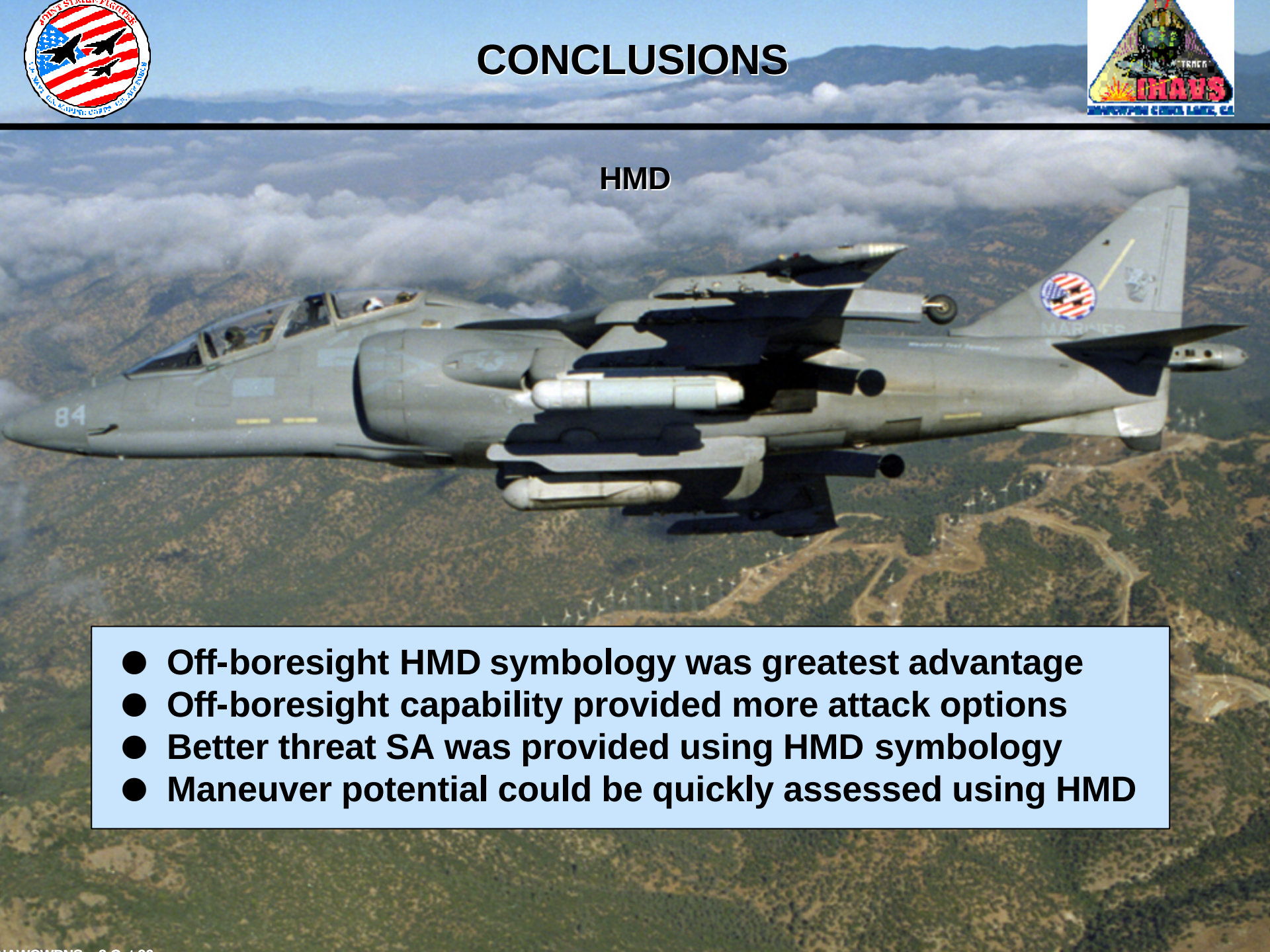
- Miss errors were consistent with Fleet AV-8B performance
- TAV-8B provided a stable weapons platform
- HUD presentation was satisfactory for bomb deliveries
- Slew anomalies resulted in degraded GAUT bombing accuracy

RESULTS

IHAVS - WEAPONS DELIVERY (HMD)

- Bombing accuracy could be better with less system “noise”
- Accurate symbology placement was degraded
- Ability to accurately follow steering symbology degraded
- Double imaging and symbology fadeout would occur
- IVM was helpful when working properly

CONCLUSIONS



HMD

- Off-boresight HMD symbology was greatest advantage
- Off-boresight capability provided more attack options
- Better threat SA was provided using HMD symbology
- Maneuver potential could be quickly assessed using HMD

CONCLUSIONS

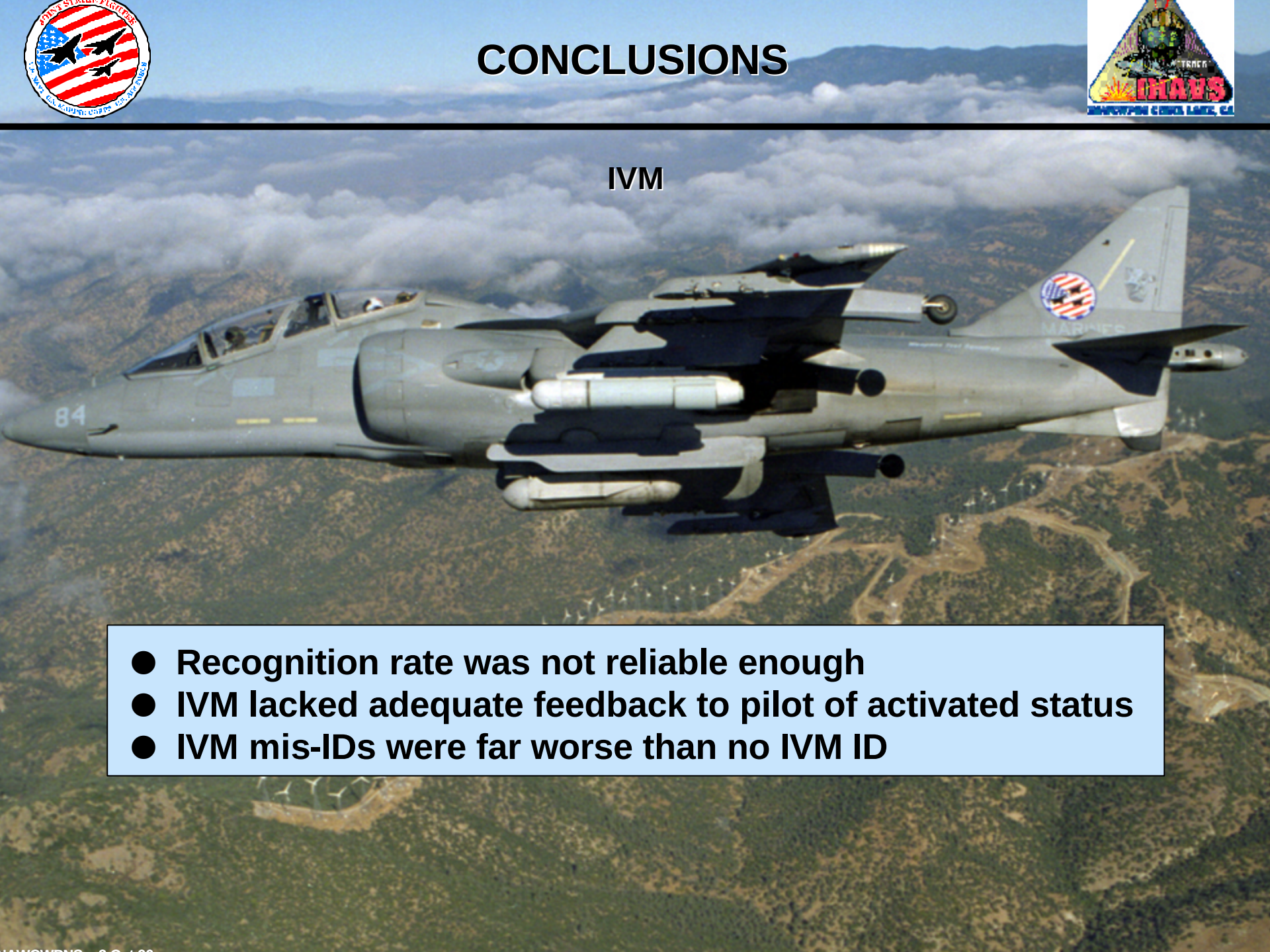
HMD

- “Jitter” and “latency” degraded HMD
- HMD symbology did not incorporate latest AG and navigation cues
- HMD symbology had cues similar in appearance
- Helmet was too heavy and would move on pilot’s head during maneuvering
- Helmet required pilot boresighting on ground and inflight

CONCLUSIONS

- Provided a simple/intuitive means of managing information and sensors
- Words were easily learned compared to mastering a complex HOTAS mechanism

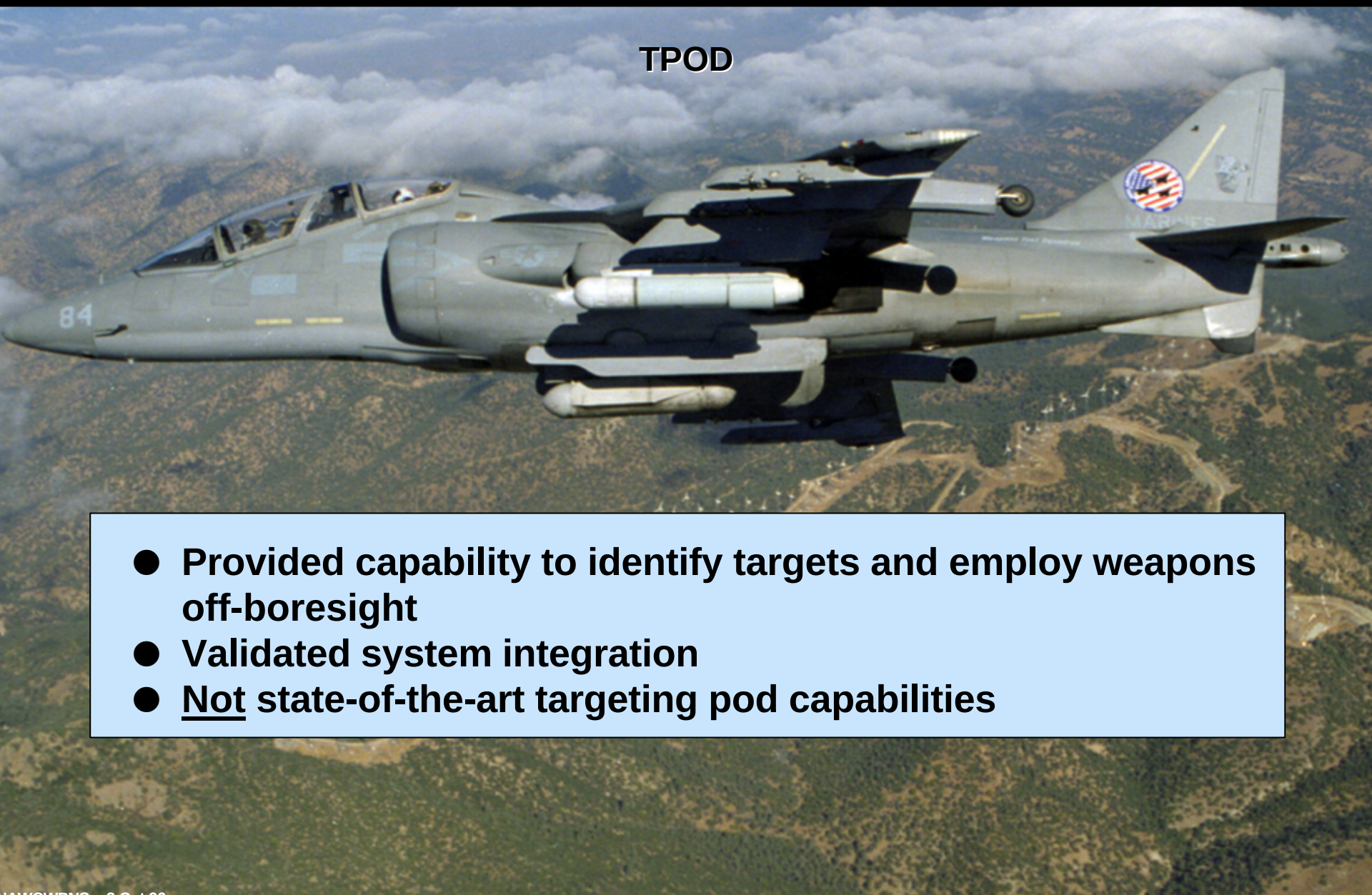
CONCLUSIONS



IVM

- Recognition rate was not reliable enough
- IVM lacked adequate feedback to pilot of activated status
- IVM mis-IDs were far worse than no IVM ID

CONCLUSIONS



- Provided capability to identify targets and employ weapons off-boresight
- Validated system integration
- Not state-of-the-art targeting pod capabilities

CONCLUSIONS

3-D AUDIO

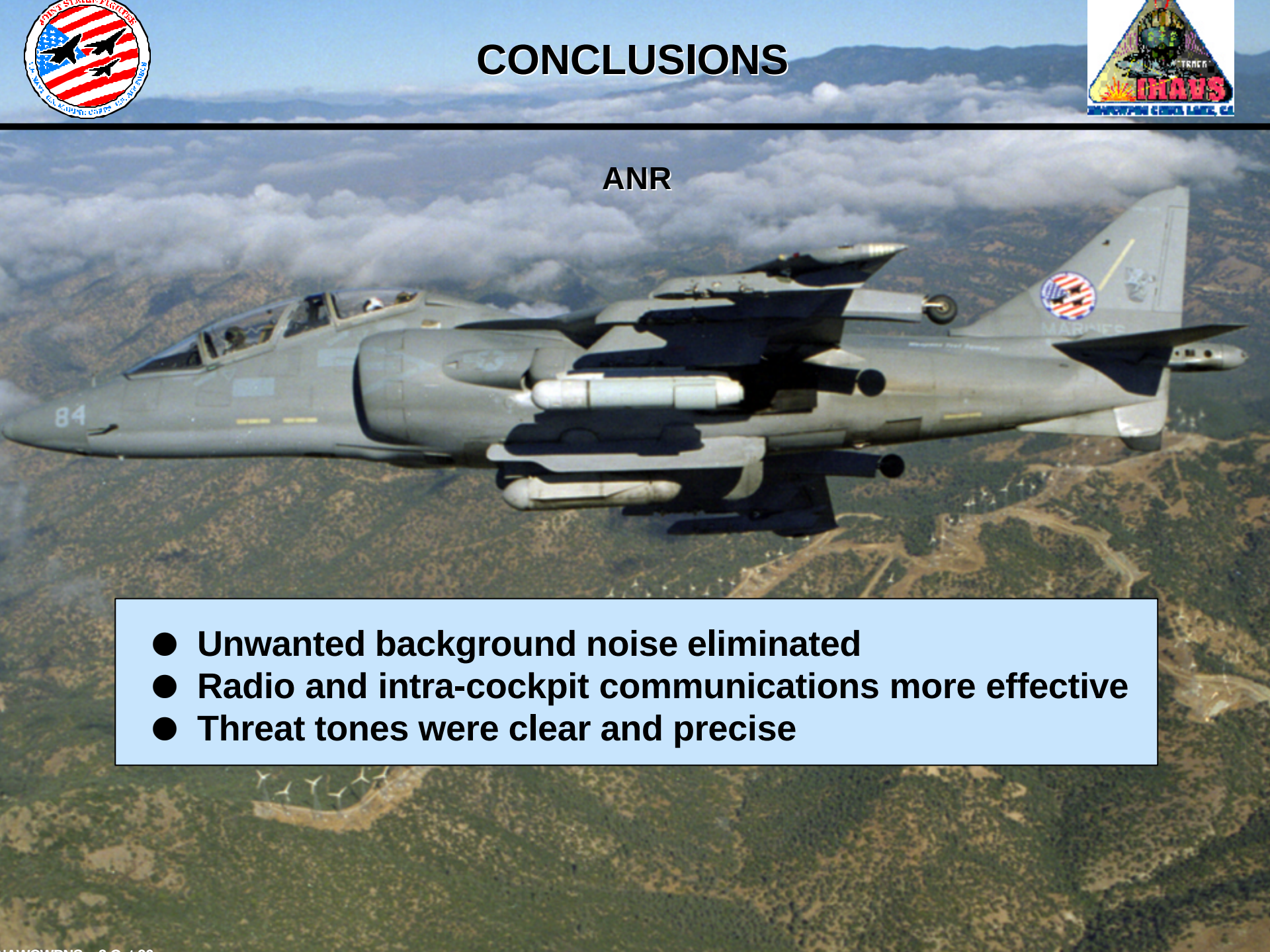
- 3-D auditory cues with visual cues increased pilot SA
  - –Validated laboratory studies
- Threat cueing, spread communication, and waypoint directional cueing demonstrated successfully

CONCLUSIONS

3-D AUDIO

- True 3-D is required to include elevation/azimuth/range to be provided by systems utilizing audio
- System allowed localization of only two threats by pilots

CONCLUSIONS



ANR

- Unwanted background noise eliminated
- Radio and intra-cockpit communications more effective
- Threat tones were clear and precise

CONCLUSIONS

IHAVS

INCREASED SITUATIONAL AWARENESS/DECREASED WORKLOAD

- HMD provided on/off boresight symbology, flight/attitude awareness
- IVM provided simple capability to manage information/multiple sensors
- TPOD provided off-boresight identification and targeting capability
- 3-D audio system with ANR supplemented visual cues

RECOMMENDATIONS

HMD

- "Jitter" and "latency" must be similar to that of HUD
- Symbology requires more study and in-flight evaluations
- HMD capable helmets with the same weight of present day helmets should be developed
- Should not lose symbology during maneuvering
- Should require a simple and reliable boresight capability

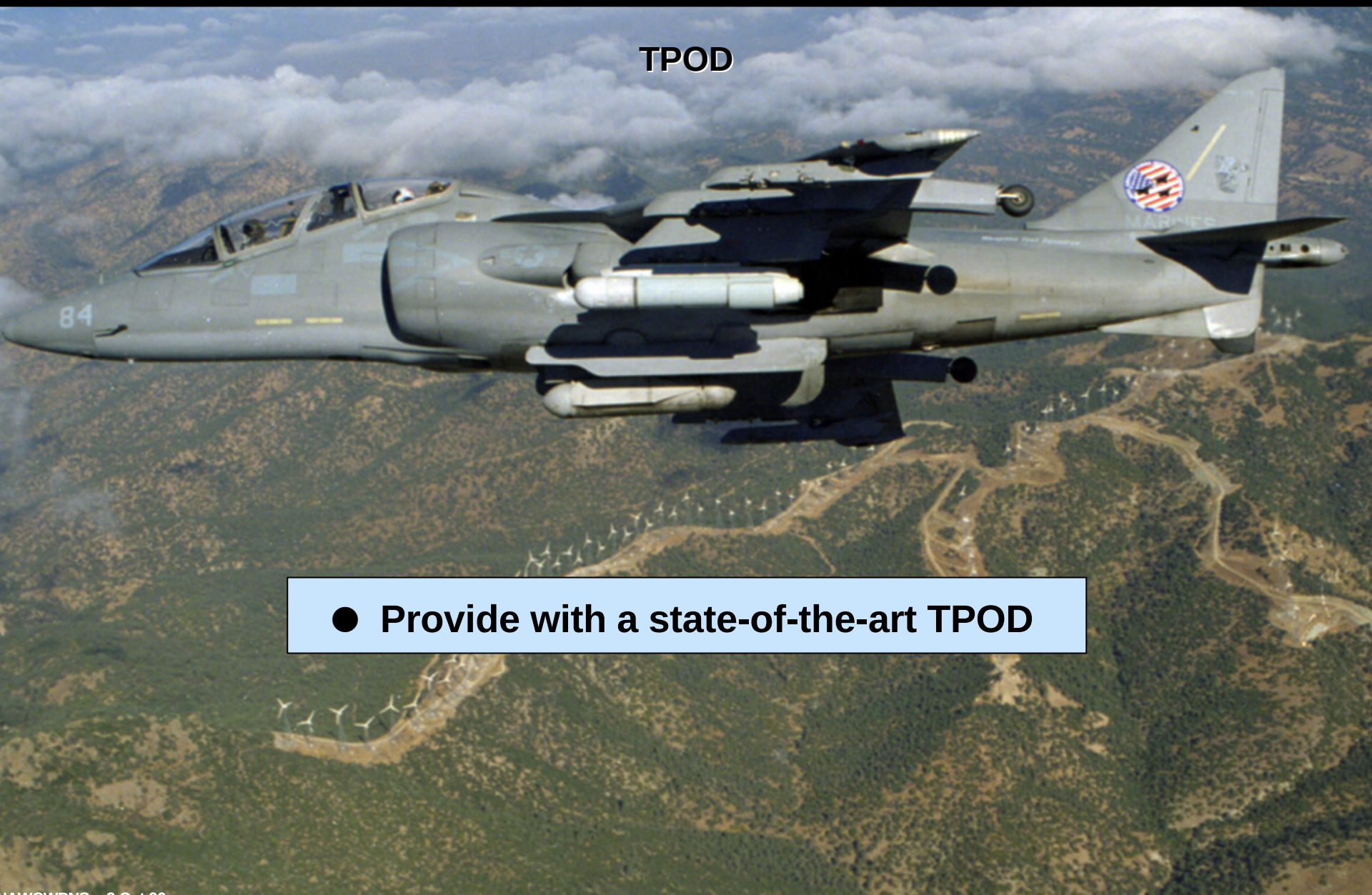
RECOMMENDATIONS

IVM

- Develop a simple, robust, and reliable IVM system
  - –Larger vocabulary
  - –Able to recognize words under different stress, breathing, and *g* conditions
  - –Require minimal pilot training
- Must be as reliable as present day HOTAS switchology

RECOMMENDATIONS

TPOD



- Provide with a state-of-the-art TPOD

RECOMMENDATIONS

3-D AUDIO

- Develop systems capable of supporting 3-D audio (azimuth, elevation, range)
- Continue to develop and evaluate 3-D audio system to improve multiple localization

RECOMMENDATIONS

ANR

- Ready for incorporation

RECOMMENDATIONS

- Continue supporting development and flight testing of IHAVS technologies
  - –IHAVS increased SA and decreased workload
  - –Successful demonstration of IHAVS potential
  - –Enhanced air-to-ground mission effectiveness
  - –IHAVS is the basis for the next generation human systems interface for the tactical strike fighters of tomorrow

JSF OPERATIONAL BENEFITS

Enhanced navigation through:

- **Elimination of flyover of waypoints/INS update points +**
  - **–HMD symbology cues/designate/slew off-boresight**
  - **–TPOD off-boresight capability**
- **Providing HMD sensor imaging +**
  - **–Decreases head-down time**
  - **–Spatial orientation needs to be considered**

JSF OPERATIONAL BENEFITS

Enhanced weapon employment:

- **Quicker/easier target acquisition through off-boresight cueing +**
  - **–HMD symbology**
  - **–TPOD limitations (especially mask zones)**
- **Reduced target designation time through HMD imaging +**

JSF OPERATIONAL BENEFITS

Enhanced weapon employment (continued):

- **Longer range missile launches +**
  - **–Great potential for JSOW, JDAM, HARM Block 6**
- **Increased potential for multiple kills per pass +**
  - **–Depends upon OFP capability**
  - **–HMD/TPOD/Radar Symbology**

JSF OPERATIONAL BENEFITS

Reduced aircrew workload and increased safety and survivability:

- **Voice control of communication, navigation, IFF, sensor weapon, and countermeasure systems +**
  - **–Simplicity - HOTAS vs IVM**
  - **–Reliability must be that of HOTAS**
  - **–Data/target/countermeasures/sensor management**

JSF OPERATIONAL BENEFITS

Reduced aircrew workload and increased safety and survivability (continued):

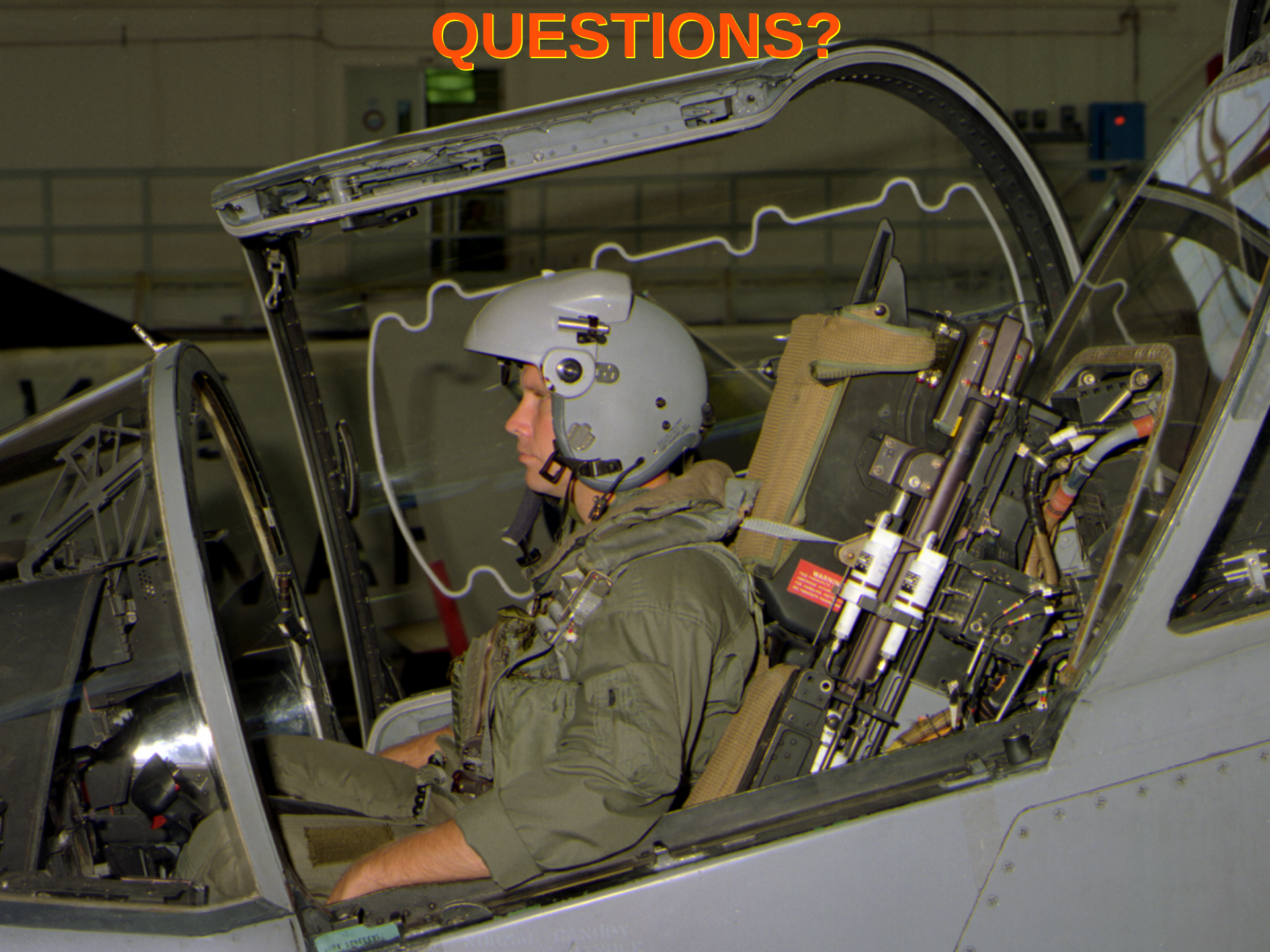
- **3-D cueing: threat [+] ; target info [–] ; course info [+]**
  - **–Cross-check requirement is decreased**
  - **–Need true 3-D system**
- **Potential for continuous display of aircraft performance parameters [+] / [=]**
  - **–Symbology needs to be optimized, minimize clutter**

JSF OPERATIONAL BENEFITS

IHAVS increased spatial orientation and tactical SA:

- **Increased mission effectiveness +**
  - **–System needs refinement**
  - **–What/when/where of attitude references needs to be further investigated**

QUESTIONS?



RESULTS

THREAT MANAGEMENT (OTHERS)

- Fixed elevation with azimuth, no range
- Could only clearly separate two threats