Advancements in FSTD Fidelity & Evaluation

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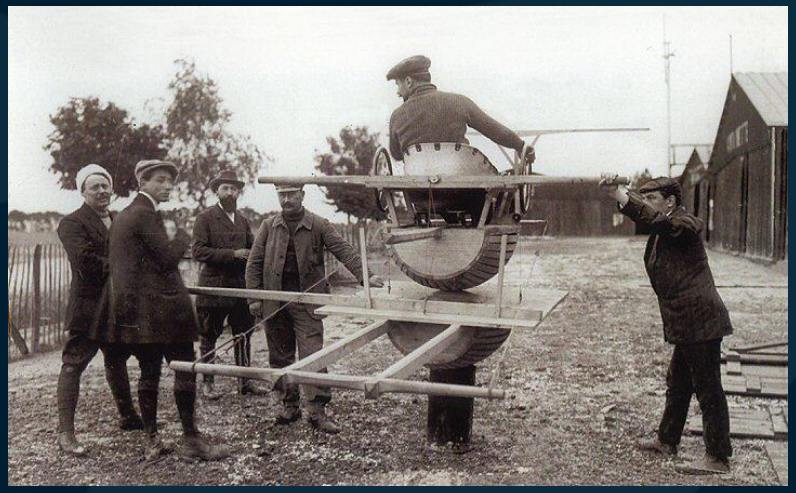
  - Other Pilot Cue Fidelity and Evaluation

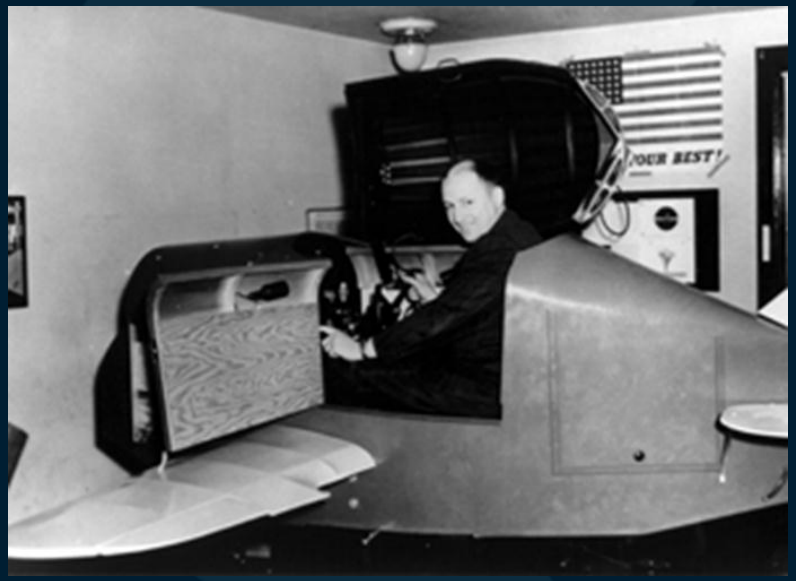
One Caveat

- This presentation will NOT cover the Motion/No Motion debate as it applies to training

- This Presentation WILL Discuss the work done by the IWG MTT towards the “evaluation and standardization” of Motion Cueing as well as recent trends and future Motion Cueing enhancements

A Brief Walk Down Memory Lane





Today's Standard - The "all electric" FFS

FAA Advanced Simulation Plan

- Mid 70's - LOFT concept introduced as a form of Simulator Training for a complete crew
- 1980 – FAA Advanced Simulation Plan (ASP) (Non-visual, Visual, Phase 1, 2, 3)
- 1980 - LOFT concept allowed under FAA ASP (AC 120-35s) to provide most or all flight crew training in simulators
- Phase 1, 2 & 3: Note: It was the intent of our forefathers, back in the late 70's and early 80's, that Phase 1, 2 & 3 would be eventually "phased" into one FFS device (ie. Phase 3)

Evolution of FSTD Standards

- ICAO 9625 Ed. 3: Why did we do it?

CIVIL & MILITARY FLIGHT
SIMULATOR QUALIFICATION
TIME FOR AN UPGRADE?

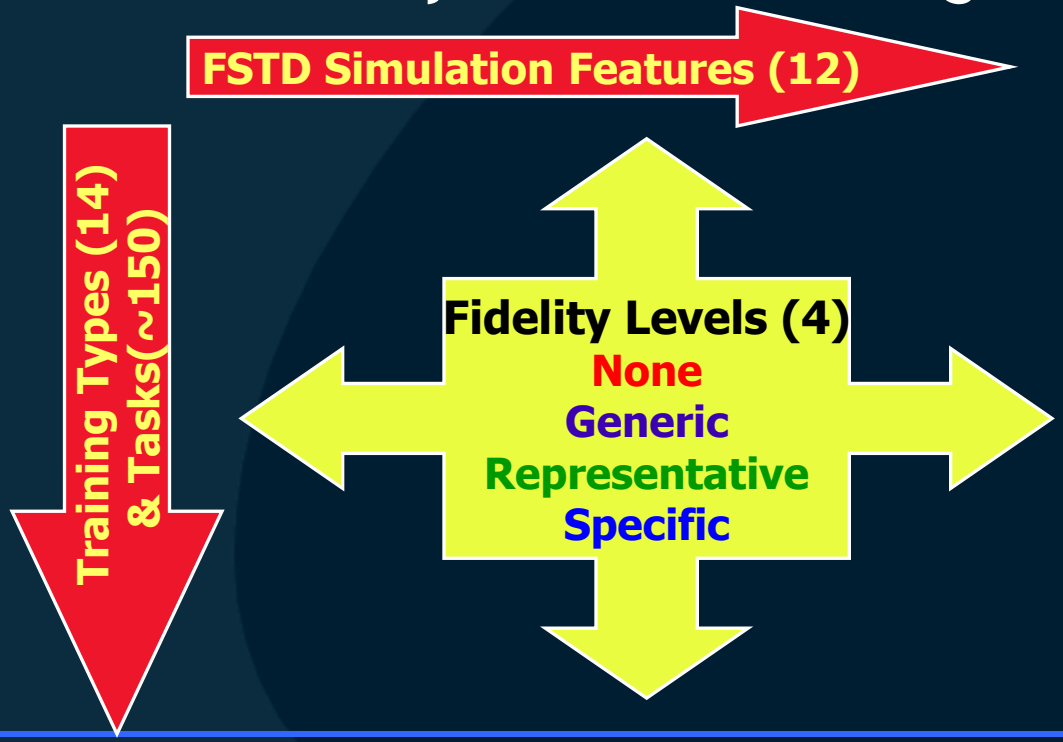
Wednesday 9th – Thursday 10th November 2005
Institute of Physics, London W1

- **Regulatory changes**
  - EASA from JAA
  - FAA Part 60
- **Lack of harmonization**
  - Lower Level Devices
  - Rotary wing FSTDs
- **New aircraft types**
  - A350, B787 ,VLJ
- **New training types**
  - MPL
- **New technologies**
  - Electric Motion
  - LCOS Projectors

Current regulations increasingly out of step with emerging FSTD technologies and new pilot training methodologies

ICAO 9625 Ed. 3 Summary (cont.)

- ICAO 9625 Ed. 3: What did we do?
  - Started with a Training Needs analysis - training tasks and types to support licensing and rating requirements
  - Defined FSTD fidelity based on Training Needs



ICAO 9625 Ed. 3 Summary (cont.)

- ICAO 9625 Ed. 3: What did we achieve?

CURRENT → **HARMONISED**

FAA	JAA	ICAO
A	A	
B	B	
C	C	
D	D	Level II
PC ATD		
NG DSD		
Basic ATD	BITD	
Adv ATD		
FTD 1	FNPT I	
FTD 2	FNPT II	
FTD 3	FNPT MCC	
FTD 4	FTD 1	
FTD 5	FTD 2	
FTD 6		
FTD 7		

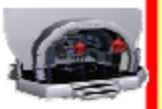
■Full Flight Simulator

ICAO
Type VII
Type VI
Type V
Type IV
Type III
Type II
Type I

26 vs 7 Device Types

ICAO 9625 Ed. 3 Summary (cont.)

- ICAO 9625 Ed. 3: Non Ab-initio Training in Full Task FSTDs (2 types only)

Training Type, rating or licence	PPL, MPL1, CPL	IR	CR	MPL2	TR, ATPL IO, RO, RL	MPL3	TR, ATPL MPL4 RE, RO, RL IO, CQ
							
FAA	FTD L2/L3 + Visual			FTD L3/L5 + Visual	FTD L6 + Visual		Level D(+)
EASA	FNPT I,II			FNPT II MCC	FTD LII + Visual		Level D(+)
ICAO	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII

Training (T) | Proficiency (TP)

ICAO 9625 Ed. 3 Achievements

- ICAO 9625 Ed. 3 enables...
  - Expansion of international standards from highest to lowest level Flight Simulation Training Devices (FSTD)
  - Full Task and Part Task training device evaluation methodology
  - Evaluation of ANY type or vintage of FSTD for training suitability
  - A methodology to incorporate future innovative Technologies (non-prescriptive)
- But probably most importantly...
  - Reduction of the harmonization challenge from 26 to 7 FSTD types

Total Annual Cost to Training Industry for Additional FFS Qualifications

- Initials Qualifications
  - Initial qualifications incl. fee (58): US $3,596,000.00
  - Qualification fees, no eval. (19): US $ 315,400.00
- Recurrent Qualifications
  - Recurrent qual. incl. fee: (1186): US $ 24,906,000.00
  - Qualification fees, no eval. (395): US $ 2,093,000.00
- All additional qualifications: US $ 30,910,400.00
- Estimated additional US $1M - $2M for Lower Level Devices (ie. FTD, FNPT)

Cost of Lack of Mutual Recognition Conclusion

- Direct annual excess cost to the Aviation Training Industry through the lack of Mutual Recognition of FSTD qualifications

US $32,000,000.00* Annually!!

*Note: this is believed by many to be a conservative figure

Motion Fidelity Improvements

- Established a Motion Task Team consisting of Motion System industry experts – Regulators, Line Pilot, Aircraft OEMs, FSTD OEMs, Motion System OEMs, Academia (researchers)

IWG Motion Task Team

Team Leader

James Takats

- **Update ICAO 9625 Edition 2**
- **Define Motion Technical Requirements and Validation Tests for all FSTD Types**
- **Define Motion Technical Requirements and Validation Tests for *NEW* Motion Developments**

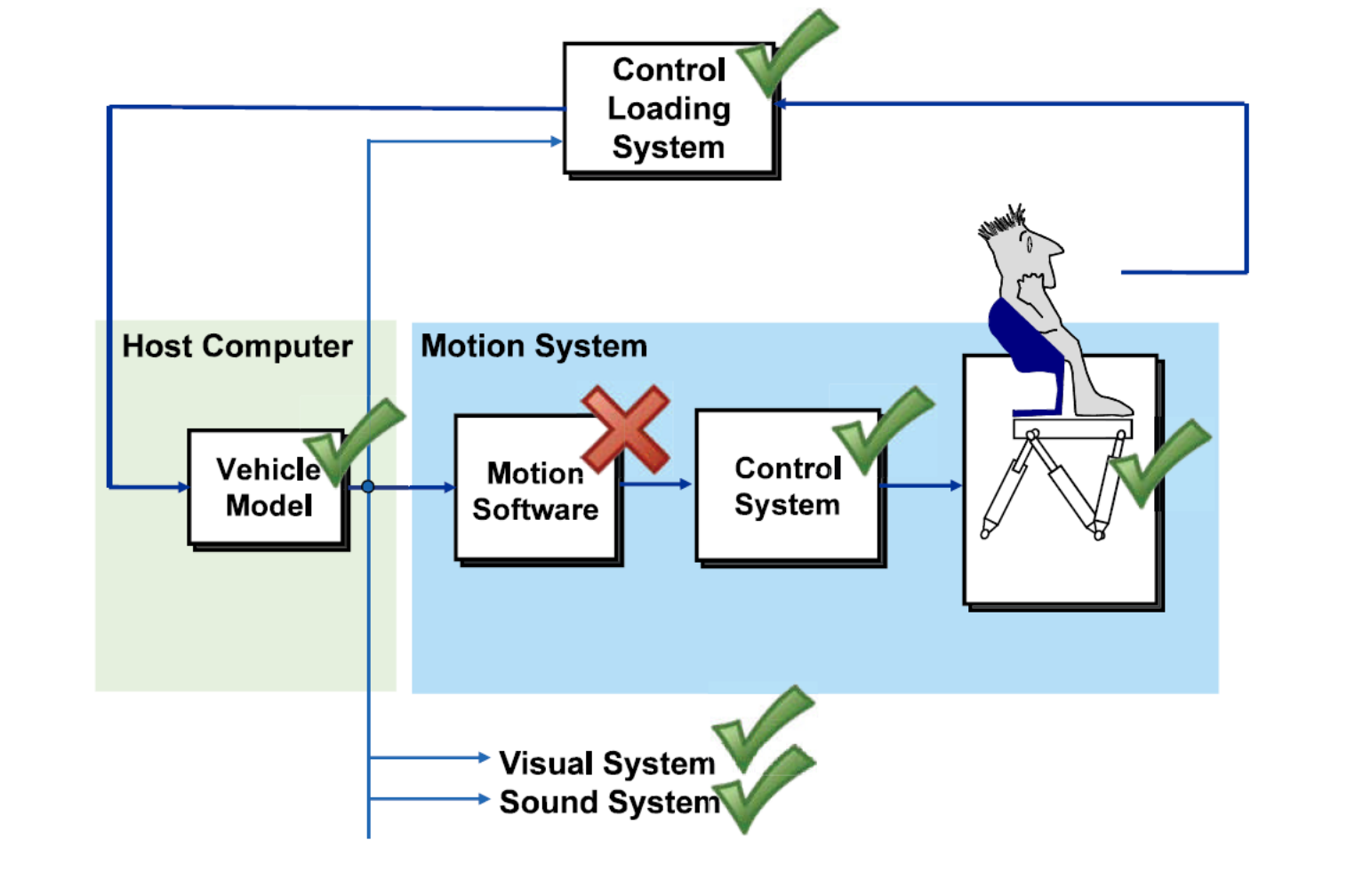
Major MTT Meetings

First MTT meeting – London 2006
London 2007, Montreal 2008, Lafayette 2009, Tampa 2010, Orlando 2011, Dallas (Sept 2012)

Advanced Motion Cueing Evaluation & New Developments

- Issues:
  - Simulator motion tuning is currently SUBJECTIVE
  - We only objectively test the motion system's mechanical performance, NOT the Cueing (note: only some vibrations/buffets)
  - With no objective requirements for motion cueing, defining what is good or poor motion has been subjective and questionable
  - Motion Cueing between like devices is inconsistent
- Results:
  - Motion versus no-motion debate
  - Significant difference in motion "feel" between otherwise identical simulators, yet up until now there is no way to "Quantify" this, or "a way to match to airplane performance"

Current Simulator Objective Evaluation



The Art of Tuning Motion Systems – Meet the Wizard!!

- How Do We Tune Motion Systems Today?

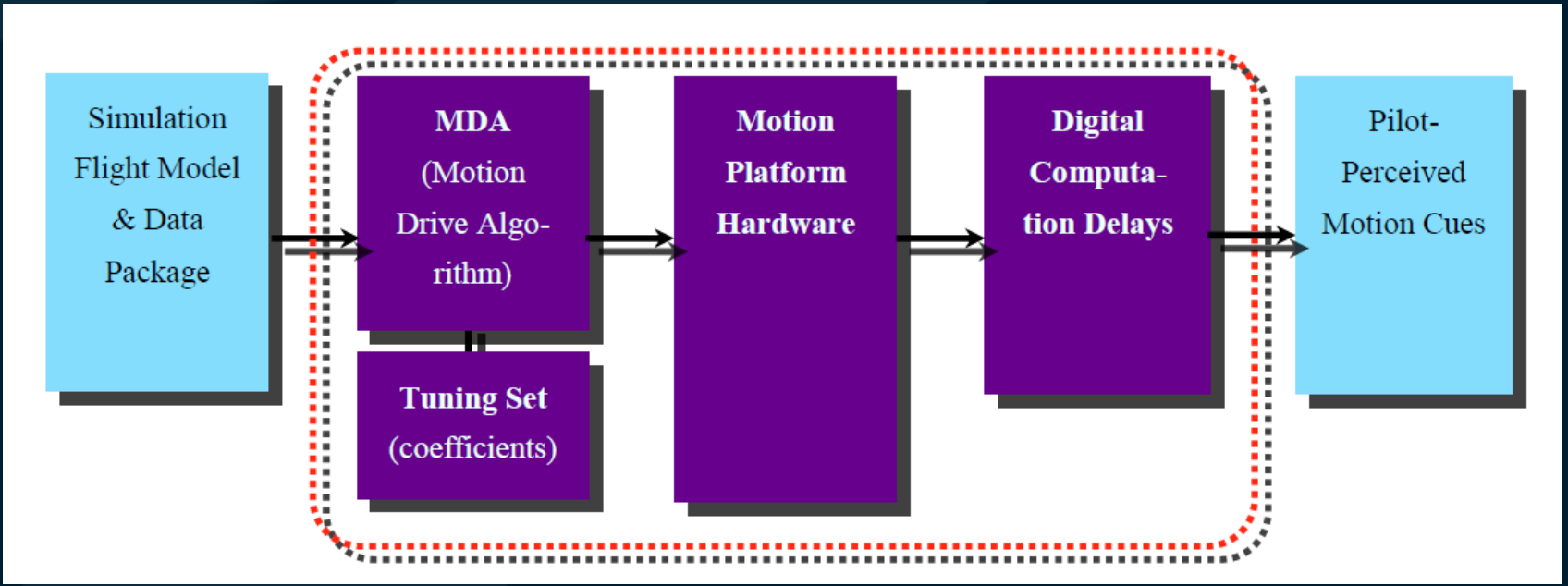
Joe Test Pilot

Motion Wizard

Objective Motion Cueing Test

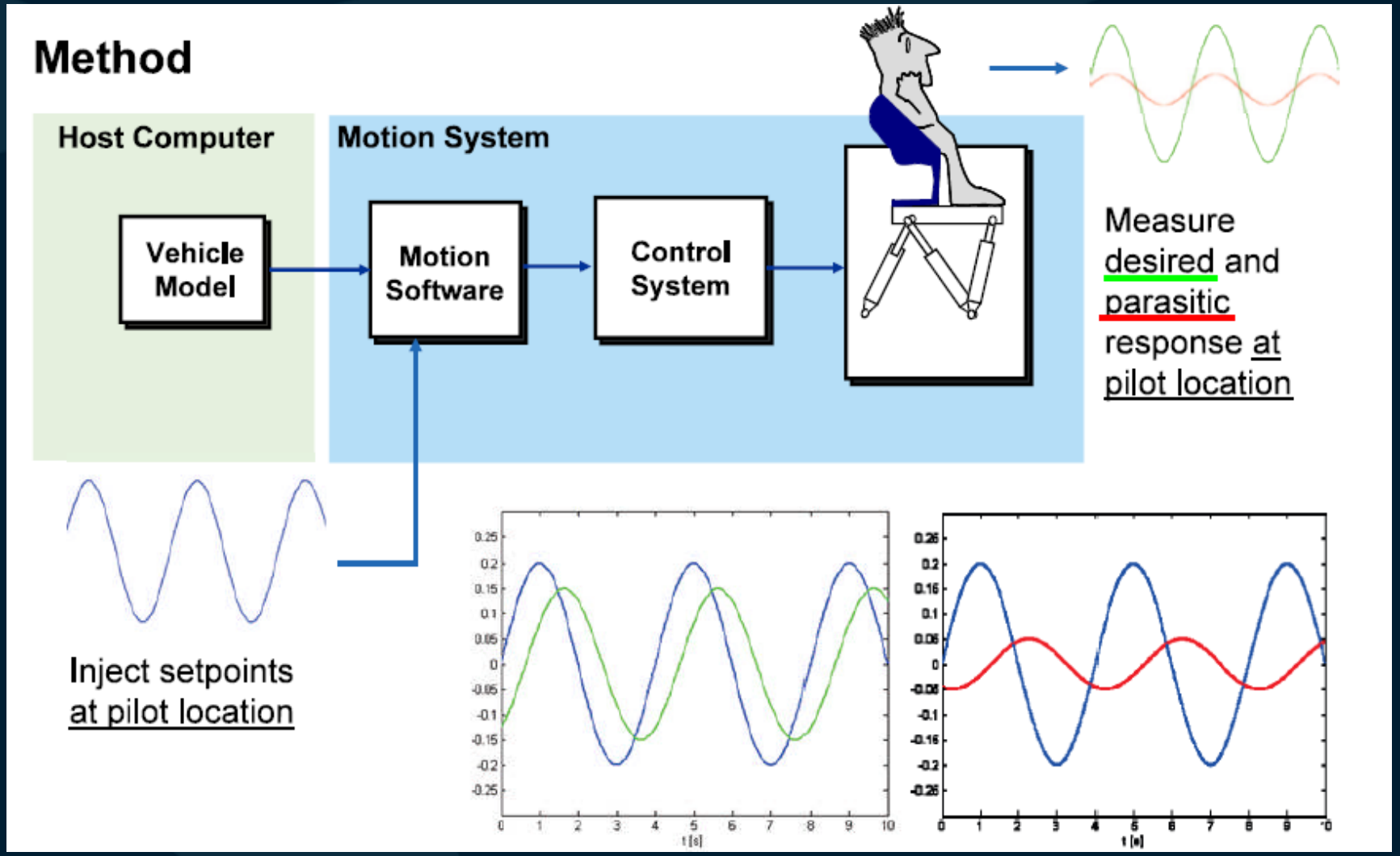
- 2006 - Ruud Hosman and Sunjoo Advani proposed…
  - "Revised Civil Simulator Standards – An Opportunity for Technological Pull", AIAA 2006-6248
  - It uses as a basis, but expands upon well recognized research done in motion cueing throughout the years (ie. Sinacori – Schroeder)
- 2009 – "ICAO 9625 Ed 3 – "Frequency Domain-based Objective Motion Cueing Test"
  - This FD OMCT is currently in the Beta Testing Phase (through industry sponsorship)
  - Note: A complimentary "Time Domain (TD) based OMCT is also being evaluated by the MTT

Motion Cueing System

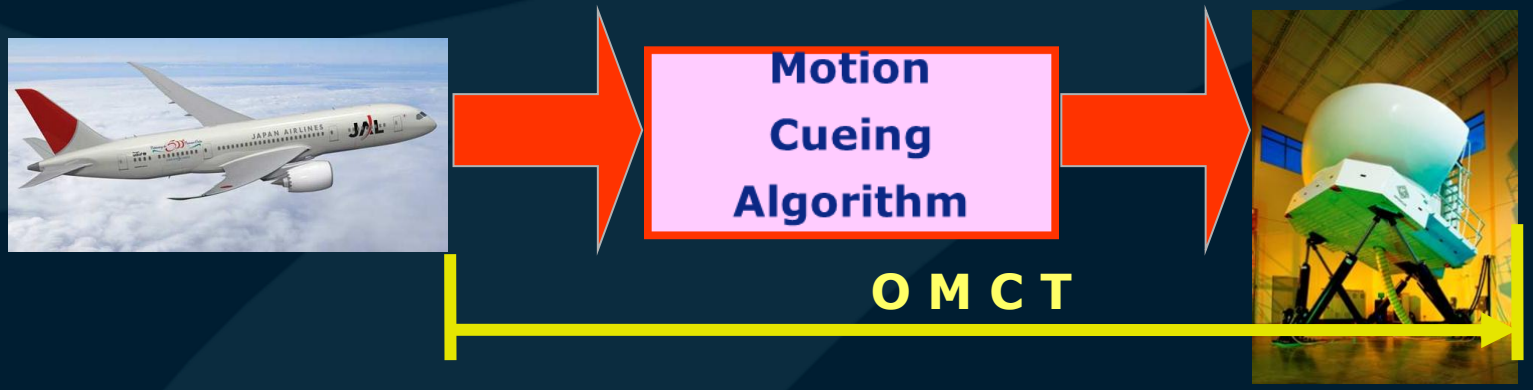


Motion Cueing System of a Flight Simulator

Objective Motion Cueing Test Block Diagram



Objective Motion Cueing Test



- In the frequency range that pilots manually control, we need the simulator to respond with:
  - Relatively high gain
  - Relatively low phase
- OMCT is END-TO-END test of motion cueing performance
  - Motion Cueing Algorithm
  - Motion System Response (all 6 DOF)
  - Motion Transport Delay
  - OMCT bounds the acceptable gain & phase in End-to-End response

Objectively Tuning Motion Systems – "Still have the Wizard!!"

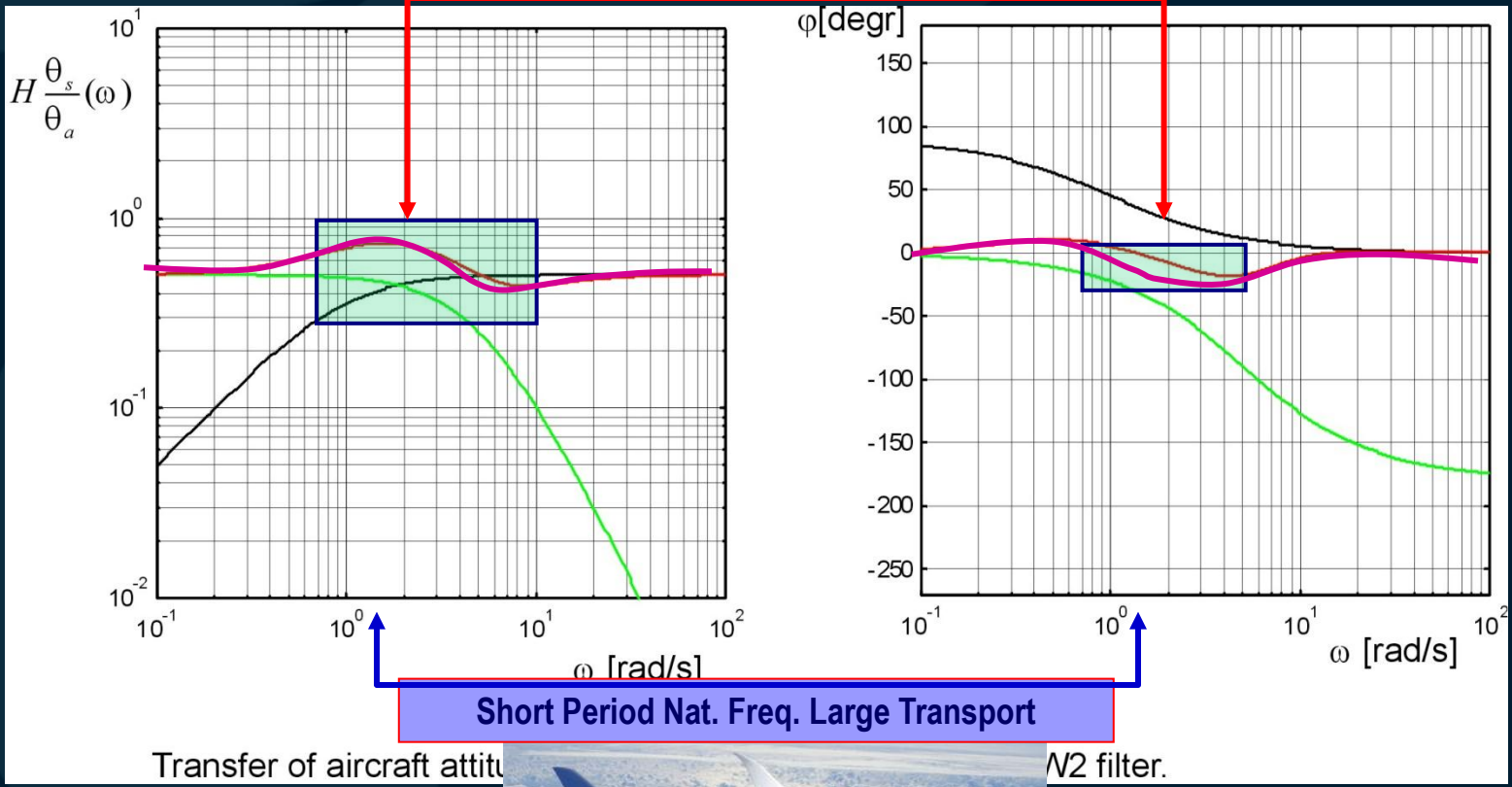
- Change in filter settings (Tuning by the Wizard), improved the Objective & Subjective Motion Cueing behavior

- Verified subjectively by experienced flight crews

Motion Wizard

Objective Motion Cueing Test Result

Motion Criterion Advani-Hosman (1 rad/s to 2.5 X A/C) Gain and Phase Distortion Boundaries



Short Period Nat. Freq. Large Transport

Transfer of aircraft attitu /N2 filter.

Objective Motion Cueing Test Conclusions

- OMCT is currently in a Beta Test phase with an established OMCT Validation Plan. More testing and evaluation is ongoing (through industry sponsorship)
- The work that has been done so far is VERY promising
  - Much improved correlation between Aircraft Motion and Simulator Motion (within the physical limitations of the Motion Platform Geometry)
  - Consistent Motion Cueing between like simulators
- OMCT incorporates Motion Cueing Software, Latency and Motion Platform Hardware - end to end

Cost of Motion Case Study

- Sim Aircraft Type X – Business Class Part 60 Level D FFS Includes OEM Data, Aircraft Parts, Simulator Parts (Level D Visual, etc.), Recurring Labor, Licensing, and Fee - $7,333,000
- Sim Aircraft Type X – Business Class Part 60 Level 6 FBS (no Motion) Includes OEM Data, Aircraft Parts, Simulator Parts (Level D Visual, etc.), (no Motion Capable Frame), Recurring Labor, Licensing, and Fee - $5,875,140
- Level 6 FBS = approx. 75-80% of Cost of a Level D FFS*
- Cost of Training – Simulator device cost to about and average of 25% of the annual cost of training
  - Therefore cost savings for utilizing a Level 6 FBS (Level D with no Motion) is approx. 5%-7% of the cost of training*

*Note: not including additional facility size cost

Other FSTD Cueing Fidelity Enhancements

- Visual – Image Generators, Databases, Display Systems and Projection Technology Advancements
- Motion Cueing
  - New Electric Motion technology provides a much higher frequency response than Legacy systems allowing for improvements in Motion Cueing performance (both Control and Awareness cues) and reduced Throughput Delay
  - Motion Cueing Algorithm Optimization
    - Various optimization techniques currently being utilized

Other FSTD Cueing Fidelity Enhancements (cont.)

- Sound – Sound and Aural Cueing Technology Advancements
  - "Dynamic" Sound Testing and Evaluation Techniques
- Throughput Delay / Latency
  - Faster Computation Systems, Interfaces etc. provide for the ability to reduce the Simulator's overall throughput delays (less than 100ms) improves overall Simulator fidelity (as low as 50ms to 70ms is possible)
- Environmental Simulation Improvements (ATC, Weather effects, etc…) enhance Simulator training realism

Conclusion

- Expect great enhancements to FFS capability just as industry will rely more on training devices to bring the next generation pilots into the global inventory
- We as an industry need to be able to adapt and take advantage of training capability enhancements
- Improved simulation/fidelity in support of achieving clearly defined training objectives will improve the overall training product

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