Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

Situation Awareness and Ergonomics Design Issues

Overview of studies done at the Netherlands Aerospace Laboratory (NLR)

presented by

R.N.H.W. van Gent

OVERVIEW

- Situation Awareness with glass cockpits (from VINTHEC)
- Transition training for glass cockpits (from ECOTTRIS)
- Design for glass cockpits (from FAA- DATALINK)
- Conclusions

VINTHEC

(Visual INTeraction and Human Effectiveness in the Cockpit)

Objectives:

- Evaluate EPOG as indicator of SA
- Evaluate effectiveness of the measure in general
- Gather data in (ab)normal situations
- Develop methods for use of EPOG in civil flight simulators

What is Eye Point-of-Gaze?

Eye tracker + head tracker =

Eye Point-of-Gaze

- Surface number
- X & Y co-ordinate
- X, Y & Z position of eye
- Pupil diameter
- Time of day
- Duration of fixation

Full scale experiment, methods (1)

- **Ten crews (PF and PNF)**
- **Research Flight Simulator**
- **Flights Ams. < - > Lnd.**
- **Four abnormalities**

	Low WL	**High WL**
Low SA	Map shift	Flap asymmetry
High SA	Altitude bust	Gear unsafe

Results

- **Gear Unsafe (SA WL)**
  - This trained abnormality was handled by all crews as expected
- **Altitude Bust (SA wl)**
  - All crews immediately reacted to this abnormality
- **Flap Asymmetry (sa WL)**
  - Two crews landed without making a “go around”

Results (map shift) sa wl

- **Just before and after initiation of the MS recorded EPOG, reflected significant changes**
- **Two crews discovered the MS by themselves**
  - The fasted crew eight minutes after occurrence
- **Crews probably detected something awkward, but without identifying the actual abnormality**

VINTHEC conclusions

- Pilots are not always capable of judging their own SA, and performance, accurately
- Pilots will notice events but not recognise them
- Analysing EPOG contributes to a better understanding of SA
- EPOG shows potential as measure of Crew Resource Management (CRM) performance

ECOTTRIS

(European Collaboration On Transition Training for Improved Safety)

Goals :

- **Accident & incident analysis**
  – Training recommendations
  – Operational recommendations

- **Skill and Training Analysis**
  – Training requirements

Accident/Incident Review

- **Accidents/incidents reported on a number of databases across Europe**
  - mandatory reporting, confidential HF systems, accident reports, airline safety reports
- **Information can be used to identify issues associated with automation and training**
  - FAA used reports e.g. Cali, Strasbourg
  - NASA ASRS reports used in research

Results:

- **CRM 39%**
- **Incorrect setting 28%**
- **Monitoring/vigilance 27%**
- **Flight handling 21%**
- **Inadequate knowledge of a/c systems 18%**
- **Improper use of systems/instruments 15%**
- **Transition training and experience 11%**
- **Lack of mode awareness 6%**

Analysis of glass cockpit skills

- **Survey amongst 152 European pilots**
  - Based on described difficult situations and relevant data
  - The importance of skills needed to cope?
  - less or more training?
  - preferred training method /media?
- **Most important result: Almost nothing happens!**

Importance Ratings

rank	importance
1	knowledge of automation/ decision making
2	Crew Resource Management
3	manual flying/ determination of appropriate SOP's/ knowledge of SOP's
4	standard cockpit handling

Need / Priority for extra Training

rank	***need for training***
1	knowledge of automation
2	decision making
3	Crew Resource Management
4	manual flying
5	determination of appropriate SOP's
6	standard cockpit handling
7	knowledge of SOP's.

Concerns - 1

- **Trend towards reducing transition course lengths**
  - Pilots express a need for more training
  - Many pilots indicate a need for a higher level of expertise, especially in coping with difficult situations.

Reduction in training duration

Yr	Type	On A/C	Duration / sim. details
1970	B707	7-10 days	4 months /14 details
1975	L1011	7 days	4 weeks / 12 details
1980	B737	3 days	2 weeks / 10 details
1998	A320	Fly-out demo	12 days / 9 details

Concerns - 2

- **Increased reliability of systems**
  - exposure to malfunctions lower than with “steam gauge” aircraft.
  - system integration: consequences of malfunction(s) more complex
  - some skills will not be retained

Increased reliability of systems

- **F-28 MTBF of cockpit instrument 600hrs**
- **F-100 MTBF of cockpit instrument 6000hrs**
- **On the job experience/exposure therefore is reduced**

Concerns - 3

- **Gap between performance requirements during normal operation and non-normal operation**
  – reversion from “strategic mindset” to “tactical mindset”
  – aborting of strategic tasks in favour of tactical tasks

Concerns - 4

- **Manual flying skills are rated among the skills that most need extra training**
  - TCAS resolution manoeuvres
  - GPWS pull-up manoeuvres
  - Unusual attitude recoveries

Changing nature of aircraft operations

- **Continuous parameter setting vs Preprogrammed operating environment**
- **Direct vs Opaque feedback**
- **Information on top vs Information layered**

FAA Datalink study

- **Study aimed at finding Human Factors issues of the introduction of Datalink**

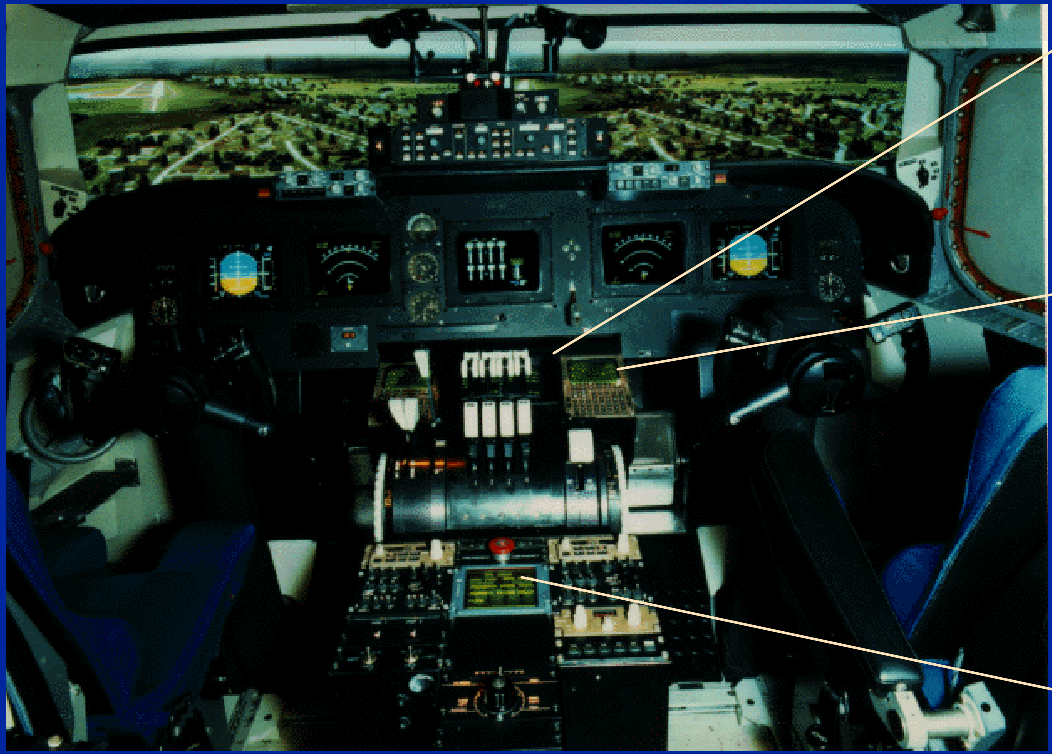
- **Expected advantages were:**
  - High SNR
  - Storage of messages
  - Auto-loading of messages
  - Reducing the RT congestion

- **Data Link may also have some drawbacks**
  - Longer reaction times
  - Loss of “Party Line”
  - More head-down time

PHASE -I

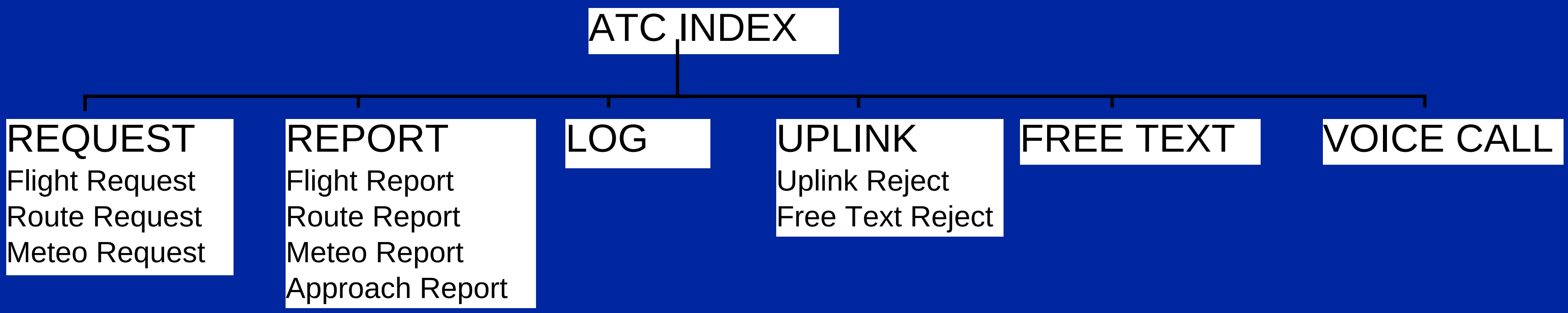
- **18 crews**
- **4 simulator flights lasting 2 hours each**
- **Each flight equipped with different communication device:**
  - RT
  - CDU
  - IDU
  - MFD
- **Realistic scenario**

PHASE - I (cont)



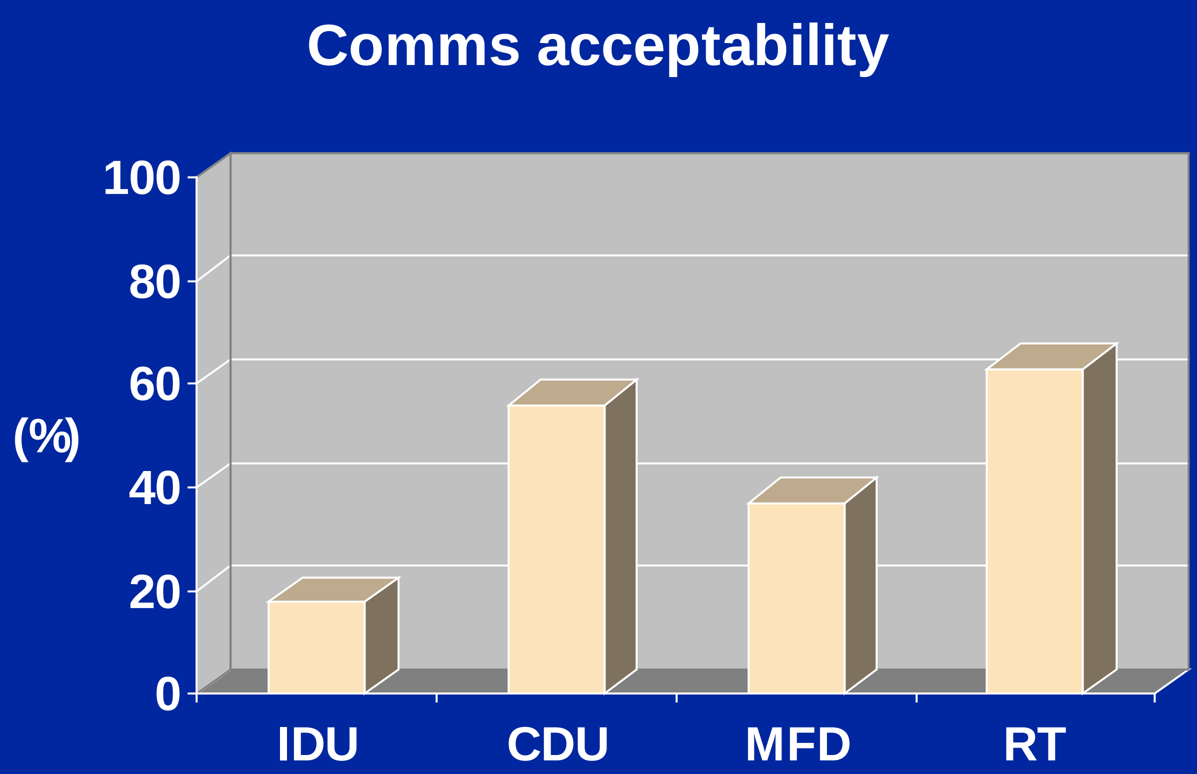
Research Flight Simulator

PHASE - I (cont)



Data Link menu

PHASE 1 RESULTS (cont)



PHASE - I (conclusions)

- **Only RT (63%) and CDU (56%) acceptable and only in low-workload flight phases**
- **Recommendations:**
  - Minimise downlink creation time !!!!!!!!
    - Minimising key entries
    - Minimising reports and requests
    - Using RT for non-routine comms
  - Provide crews with (party-line) info through other means (e.g. TCAS, ATCo plans)

PHASE II STUDY OBJECTIVES

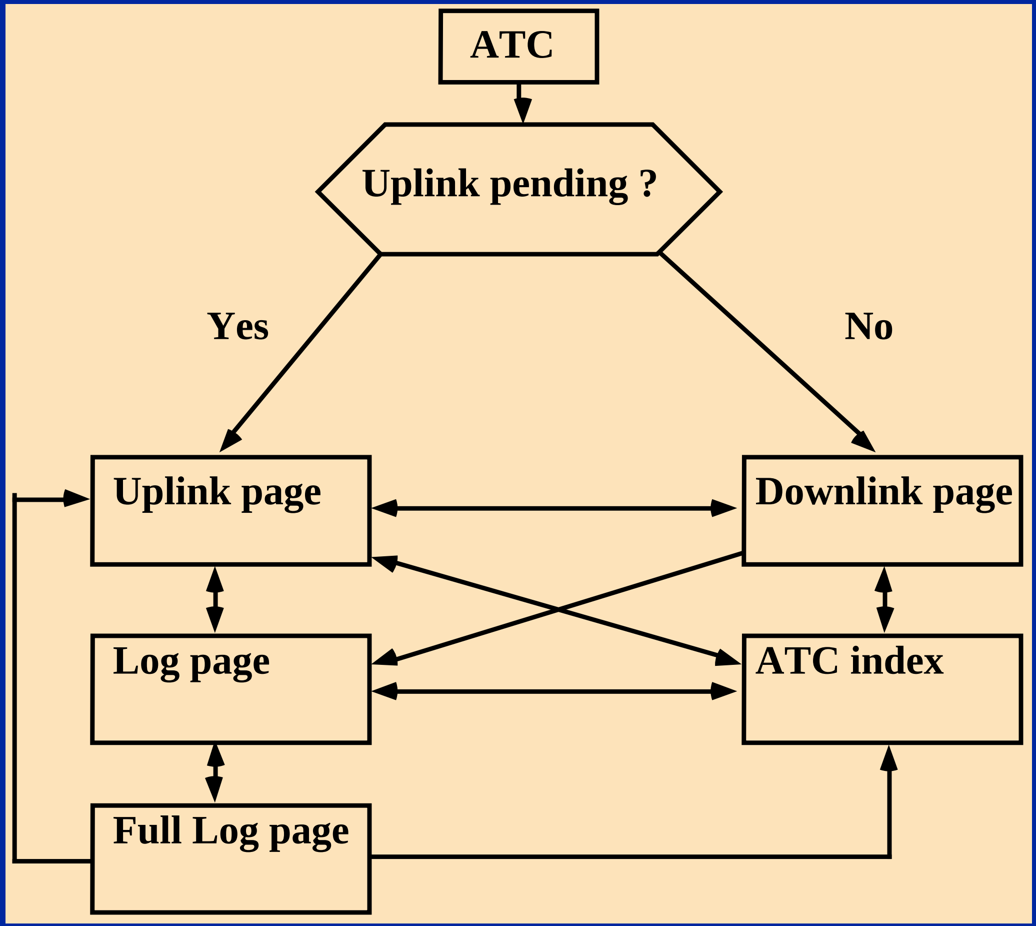
- **Validating the recommendations of the PHASE I study**
- **Studying the effects of different auto-loading ("gating") schemes with data link:**
  - autoloading radio frequencies
  - autoloading FMS data
  - autoloading MCP data

PHASE II METHOD

- **Experimental setup**
  - 9 crews participated
  - 6 flights per crew
    - (3 different gating * 2 PF inform. methods)
  - Flights Amsterdam -London and vica versa
- **Data link interface**
  - Gating
  - Downlink pages optimized for normal operations!!
    - default values by FMS
    - automatic page selection

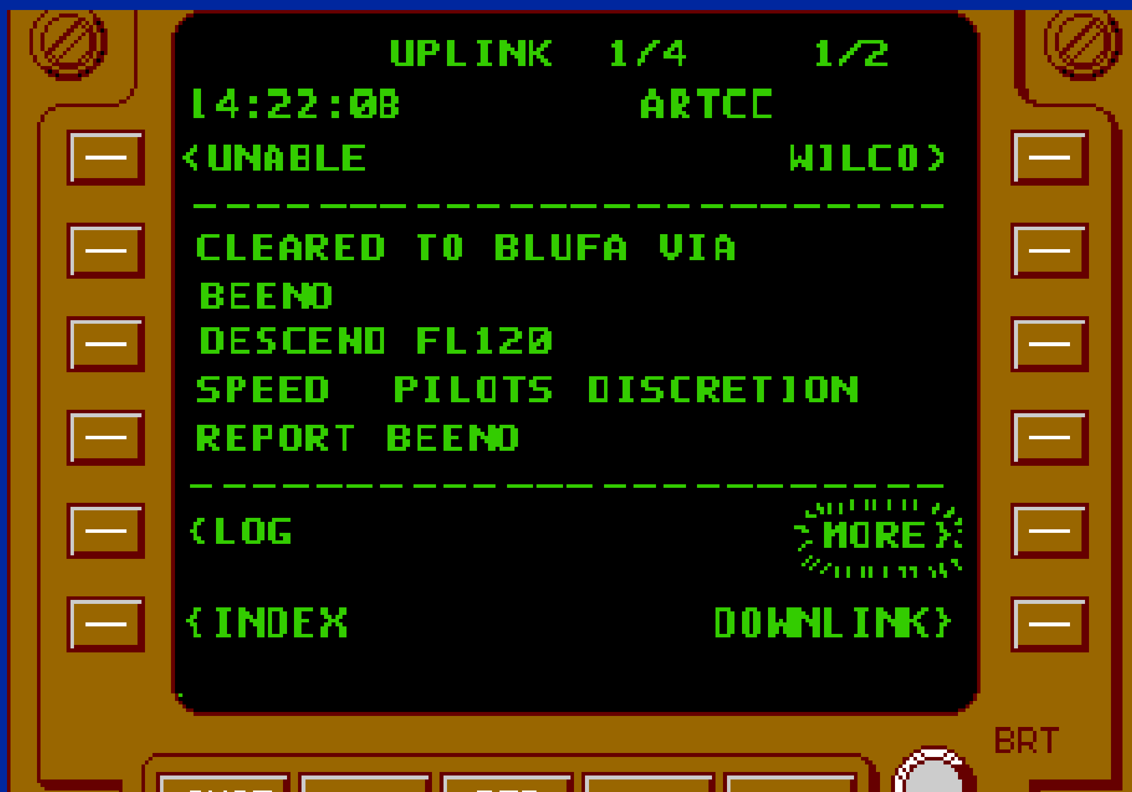
PHASE II METHOD (cont)

- Data link setup



PHASE II METHOD (cont)

- **Data link setup (uplink page)**



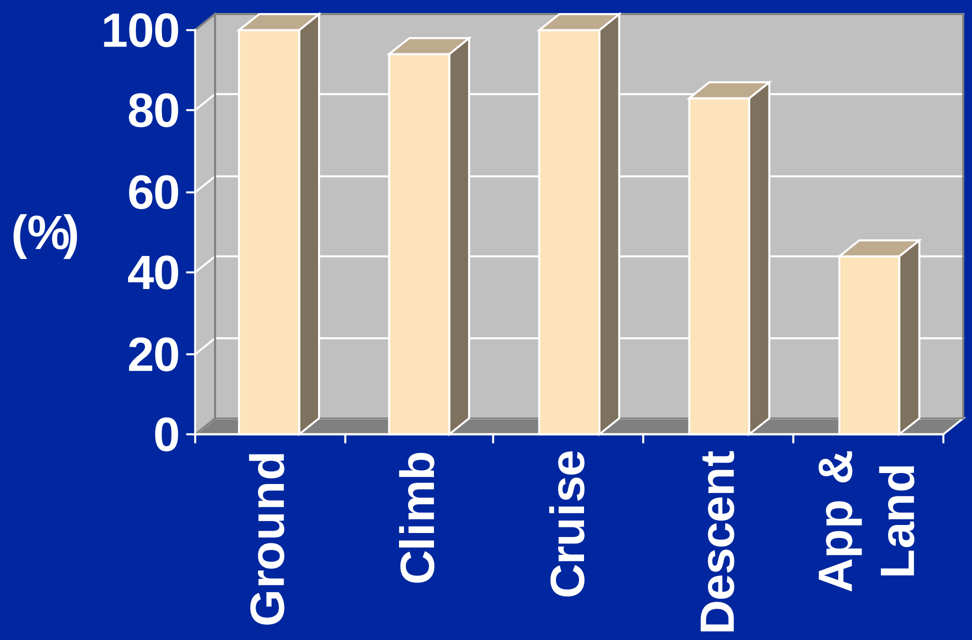
PHASE II METHOD (cont)

- **Data link setup (downlink page)**

RESULTS

- **Acceptability of data link: Overall= 94%**

Comms Acceptability



FAA-Datalink Conclusion

- **By adjusting page layout to actual use the overall acceptability is almost Doubled!!**
  - From 56% (phase I) to 94% (phase II)
- **Unfortunately changing the layout of pages is not simple**
  - Economy
  - Certification
  - Ever changing operations

Conclusions

- Crews seem to notice significant events but they do not recognise them
- Experience without exposure is not enough
  - Crews want more knowledge of automation, CRM skills and manual flying skills
- The effect of customising automation to the task (human centred automation) is very significant, but difficult to implement