PSYC305

Applied Cognition & Neuroscience

Aviation & Aerospace

There are problems on the ground too

Air Traffic Control (ATC)

Evolution of ATC

Spotters & Controllers communicate via telephone

Radio, maps & “shrimp boats”

Increased air traffic required “mental model” of aircraft – flight progress strips

Addition of radar after WWII
workload, sector controllers, & handoffs

Introduction of ARTS integrated displays and three-level division of labour

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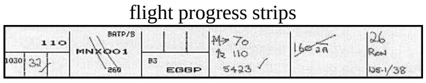
1st ATC Center 1935
Newark NJ
communication via phone
to spotters and other airports

ATC Controllers
update traffic on maps
by moving “shrimp boats”

NYC ATC Center 1942
flight progress strips



Physical representation of aircraft
call sign, origin, destination, etc.
To aid controller’s memory & mental model (like shrimp boats)

Introduction of radarscopes
after WWII

Washington Air Route Traffic Control Center 1955
Radar, shrimp boats, & flight strips

Automated Radar Terminal System (ARTS) Center
circa 1975

Incorporates data from radar & flight plans

Displays symbol & text that indicates:
- call sign, type of aircraft, destination airport, ground speed, altitude, scratchpad info

Some information on flight strips, some on display

Information updated by radar sweep; information vs. clutter

Three-level division of labour

1. ATC Towers
2. Terminal area approach control facilities (TRACONs)
3. En route centers: Air route traffic control center (ARTCC)

Tower Controller Tasks

- Issue clearance for aircraft to push back from gate
- Confirm schedules/flight plans
  (already done with flight services, dispatch)
- Takeoff/landing, prior assurance safe separation from other traffic
- Manage ground traffic to/from gate
- Hand off aircraft to/from TRACON

Tower Resources

- Vision: Need clear view of local airspace
  Issues of: Atmospheric perspective, fog, planes that look identical, night vision
- Flight strips: physical representation of aircraft, shows status, move around workstation based on status updates
- Communications: Radio -- always start with aircraft ID, all aircraft can hear messages, allows for a larger mental model of all aircraft position
- Handoffs: Voice used for accept/decline handoff (if runway is not clear), flight strips relayed between tower/radar room, pilot changes radio frequencies, contacts next group

Terminal area approach control facility (TRACON) Tasks

- Manage flow of departing aircraft from tower to en route controller
- Manage flow of arriving aircraft from en route controller to tower
- "Line up" aircraft at regular spacing (in three dimensions)
  1,000 ft vertical, 3-5 miles horizontal
- Different level TRACONS, depending on workload

Need to maintain "***the picture***" – situation awareness

TRACON Resources

- Vision: dark, low contrast environment (to maintain dark adaptation), do not see flights directly
- Automated Radar Terminal System (ARTS)
- Flight strips, present as a backup in case ARTS data tags are lost
- Radio communications, highly standardized ATC – pilot & ATC – ATC

En Route Center Tasks (Air Route Traffic Control Centers-ARTCC)

- Handle aircraft over long distances toward destination
- Handle aircraft over areas that do not have radar
- Assist pilots in navigating through navigation waypoints (VOR navigation signals)
- Maintain separation of 5 miles and 1,000 or 2,000 vertical
- Laid over top of any local TRACON sector
- Deliver aircraft to destination TRACON, without overloading the TRACON station

En Route Center Resources

(Similar to TRACON)
Flight strips
Radio communications
HOST computer, radar (plan view display/PVD), flight data, & "snail trail" of past trajectory

Flight Progress Strips

Two current views on FPS

Get rid of FPS	*Keep FPS*
Roadblock to automation	Inherent advantages
Reduced workload	Evolution/memory aid
Obsolete & anachronistic	comm/coord aid
	Good backup

Research:

Frequency of use — Interviews — Importance ratings

FPS markings

Strip mark	Importance	Frequency
Altitude coord	69	.47
Point out	60	.45
Cntl info (elim/rev)	29	.61
Issued altitude	55	2.90
Issued route	88	.69
Issued heading	68	.51
Issued speed	50	.46

Note that importance and frequency aren't the same!

Applied Cognitive Methods

What should you test?

What should you measure?

How should you collect the data?

How should you analyse the results?

Current Applied Cognitive Issues in ATC

Perception, temporal distortion, & channelised attention

Vigilance, distraction, habituation, & fatigue

Displays, symbology, communications, & problem solving

Shift changes & handovers

Workload, situation awareness, & stress

SITE Testing Planning Model

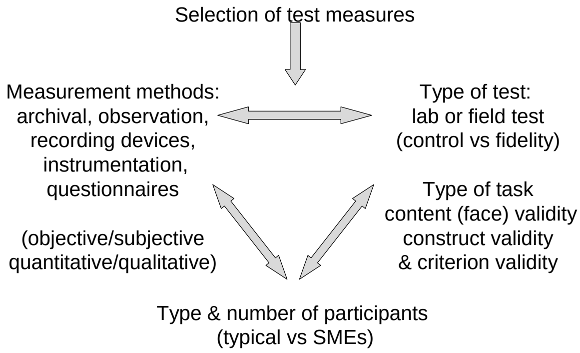
A test should include measures from each of the four categories.

Situation	Individual	Task	Effect
controls & displays	skill & experience	speed	success/failure
software usability	workload & fatigue	accuracy	user satisfaction/ dissatisfaction
design features	situation awareness	force	cost/benefit
system function or configuration	stress levels	timing	
time of day		sequence	

SITE is a method of planning tests to ensure you collect a complete set of data & paint a complete picture.

You are building a chain of logic, if any link is missing, the chain fails.

Testing planning issues



Measurement methods

Archival data: look for physical evidence in the environment -- wear patterns, notes & records, employee reports, repair invoices, injury reports, shipping/billing receipts, etc. Non-intrusive, but privacy can be an issue.

Direct observation: good for a variety of speed & accuracy measures, but requires a lot of observers & inter-observer reliability. Can also be intrusive (disruptive) to what you are trying to test.

Measurement methods

Recording devices: audio, video, or computer recordings of the test. Produces a permanent record of test, but expensive & data reduction takes a lot of effort, 1:10 ratio.

Instrumentation: counters connected to controls, keyboard loggers, instrumented vehicles, etc. Efficient and accurate, but no context recorded, may be difficult to interpret

Questionnaires: good for a wide variety of measures (only method for some measures) but questionnaire creation, if done correctly, takes a lot of work and is often subject of disagreement. Standardized questionnaires should be used where possible. Can be efficient but shouldn't be over-used.

	Objective	Subjective
Quantitative	# of lever presses, reaction time, height/weight	# correct, IQ score, SWAT score
Qualitative	hit or miss, crash, accuracy, task sequence	personality type, crash cause, attitude

Types of tests & tasks

Laboratory tests: use element tasks, part-task tests, & simulations. Careful manipulation of one element of the environment at a time provides lots of control to test experimental hypotheses. May have problems with fidelity and generalisation of results.

Field tests: use real or representative tasks. Try to re-create how real users interact with the environment while measuring changes in outcomes. Can provide good fidelity but may have problems inferring causality due to a lack of control.

content (face) validity: is the measure representative?
criterion validity: is the measure predictive?
construct validity: does the measure define the principle or theoretical elements?

Training SA in ATC

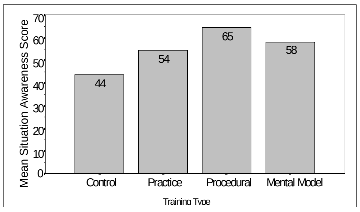
Luther & Charlton, 1999

Simulated ATC task

3 types of training

Practice
Procedural (if-then rules)
Mental model (general principles & goals)

Effects on SA



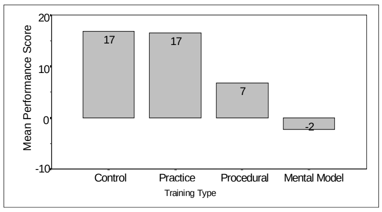
Training SA in ATC

Simulated ATC task

3 types of training

Practice
Procedural (if-then rules)
Mental model (general principles & goals)

Effects on error rate



Global Positioning System (GPS)

Largest ever satellite constellation (24+4)

Military and civilian users worldwide

Master Control, 3 ground antennas, 5 monitor stations

Evolutionary acquisition programme

High contact rate & precision orbits in 3 planes

Crew composition & training issues

Operator workload & situation awareness issues

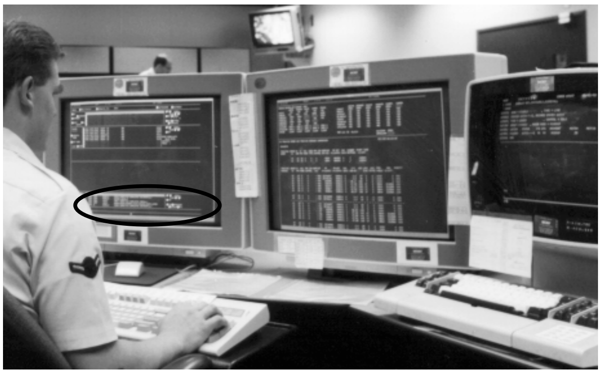
Test 1: 7 developmental SVs, 1 operational SV in pre-launch

Stress test (redundant contacts) + questionnaires

Position handbooks inaccurate, unequal workload in crew
command & message systems too slow
SDO & GSO couldn't manage more than 18 SVs
SAO had unmanageable workload peaks

Test 2: 6 developmental SVs, 3 operational SVs in orbit
operational software, reallocated crew duties

AWE system: too many messages, cryptic, scroll too small & too fast, led to very poor SA – system safety issue
Workload: better distribution, but 21 SV max for 50% of crew, workload unmanageable at 24 SVs, 4 simuls. not possible



The Problem of Criteria

How can you set a criterion for HF?

HF isn't a "mission" for space systems

Effect	Task	Individual	Situation
Did the system meet performance requirements? Were the users satisfied with system performance?	*Which operator tasks had the greatest impact on system performance? (or user satisfaction)*	*Which user characteristics affected task performance?*	*Which design considerations & environmental conditions affected the users & task performance?*

Use SITE as epidemiological structure

Test 3: 5 developmental SVs, 11 operational SVs in orbit
same software, larger crew size

AWE system: too many messages, cryptic, scroll too small & too fast, led to very poor SA – system safety issue
50% AWEs false or redundant, 10% of crew time
Workload: crew max at 22 SVs, need active workload management system for more satellites

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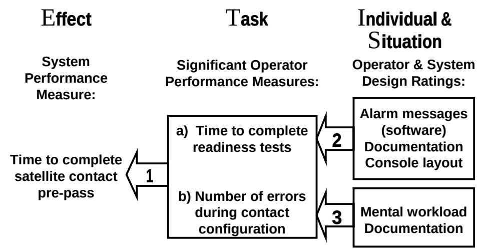

1. System performance was significantly predicted by the two tasks; $R2 = .36$, $F(2,27)=9.12$, $p<.001$
2. Performance on task A was significantly predicted by three HF design ratings; $R2 = .48$, $\mathbf{F}(3,12)=5.60$, $\mathbf{p}<.01$
3. Performance on task B was significantly predicted by two HF design ratings; $R2 = .68$, $\mathbf{F}(2,13)=16.66$, $\mathbf{p}<.001$

Test 4: 24 operational SVs in orbit
New AWE software, new duty scheduling software

Significant reduction in AWEs, 50% of AWEs still classified as false or redundant
Workload: active workload management throughout shift, workload acceptable at 24 SVs, 4 simuls. achieved regularly

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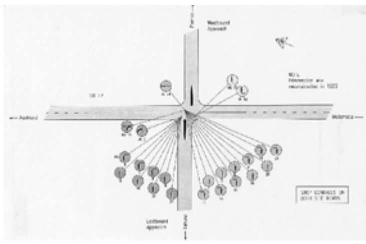
Case study 3:

Tahuna Paeroa Intersection at SH27

Staggered "T" intersection
East-bound and west-bound approaches regulated with STOP signs
Good sight lines
Twenty-four crashes at the site in five years (1995 through 1999)
Asymmetric pattern of crashes

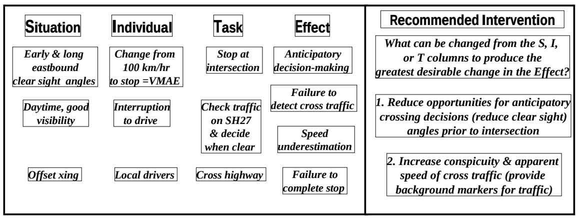


Methodology Selection:

Fidelity issue – need wide FOV & large data set

Use a combination of archival data & field tests

Human Factors Analysis: SITE technique



Design of Field Test: Before/after comparison

Phase 1 (Baseline) existing intersection conditions

Phase 2 (Evaluation) modified intersection with approach screen & highway markers

Measures of Effectiveness

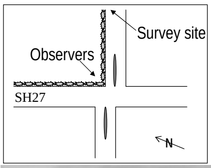
- Approach speed (25m). Requirement: 10% reduction in C80 speed
- Stop (dwell) times. Requirement: 50%increase in C20 dwell time
- Traffic detection (250m). Requirement: 10% increase in detection rate

Measures of Acceptance

- Ratings of approach screen. Goal: Mdn = "acceptable" & <20% "unacceptable"
- Ratings of markers. Goal: Mdn = "acceptable" & <20% "unacceptable"
- Ratings of intersection safety.

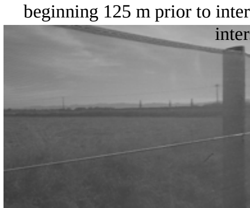
If 2 or more MOEs meet requirements = effective intervention
Also goal of 2 MOAs for acceptable intervention

Approach speeds and intersection dwell times collected by observers (inconspicuously located behind hedge).



Vehicle detection data & driver ratings collected by intercept survey located 500 m east of SH27, (not visible from intersection). Target vehicle was black 1964 EH Holden Special Station Sedan, located 150 m from intersection.

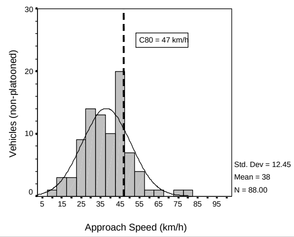
Approach treatment: 30% knitted shade cloth 2.1 m in height, beginning 125 m prior to intersection and ending 25 m prior to intersection

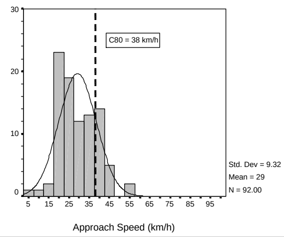


Roadside treatment: wooden markers 200mm wide by 1.2 meters tall, painted white and installed at 50 m intervals beginning 250 m prior to the intersection.

MOE 1. Approach speeds. The speed of east-bound vehicles measured 25 meters prior to the intersection. Requirement: a 10% reduction in the 80th percentile speed.

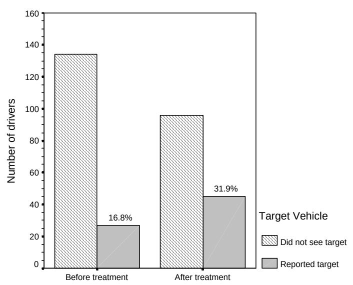
- 23.4% reduction in the 80th percentile speed.
- 10.95 km/h reduction in 85% percentile speeds (from 49.95 to 39 km/h).
- elimination of all approach speeds over 57 km/h.
- Rating: Met requirement.





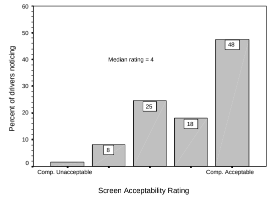
MOE 3. Traffic detection rates. The percent of drivers correctly reporting the presence and location of the target vehicle. Requirement: a 10% increase in detection rate.

- Increased from 16.8% prior to the treatment to 31.9%.
- Rating: Met requirement.

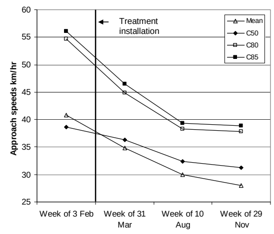


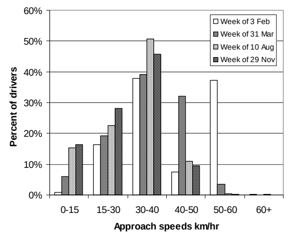
MOA 1. Ratings of approach treatment. Driver ratings of the acceptability of the screen treatment on a five-point equal interval bipolar rating scale ranging from “completely acceptable” to “completely unacceptable.” Goal: a median rating of “acceptable” or better with no more than 20% of the ratings in the unacceptable range.

- 56% of the drivers reported having noticed the screen
- Of drivers noticing, 48% rated the screen as “completely acceptable” (“5” on the 5 point acceptability scale).
- Only 1 driver rated the screen as “completely unacceptable”.
- Total of 4% of drivers in unacceptable range.
- Rating: Met goal.



Speeds stayed low, over 3 years later!





Laboratory 1 Results

Beeping cell phone experiment

Hypothesis: *Hazard warning tones broadcast on cellphone frequencies will overcome the negative effects of cell phone conversations on driver performance*

Comparison to “no conversation” & “standard hands-free”

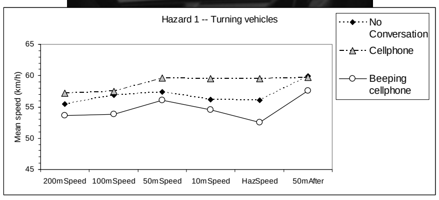
Group means posted on Moodle
“Psyc305Lab1Means.xls”

Another extension: Data forms due 2 April (via email)
Reports due 7 April (via FIC)

7-10 pages total
(typed & double-spaced)

Permission to include your results in a report to LTNZ

Laboratory 1 Results



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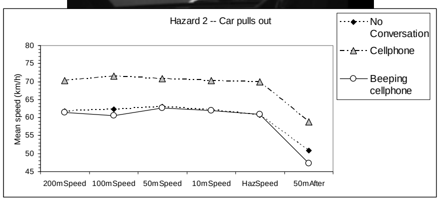

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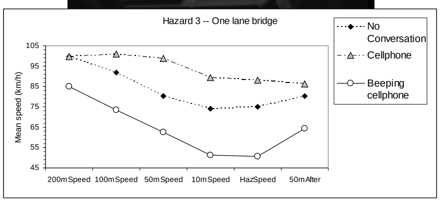

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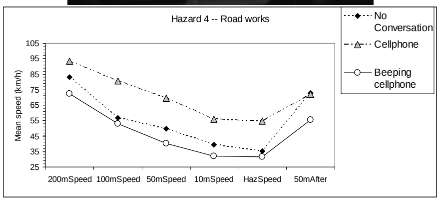

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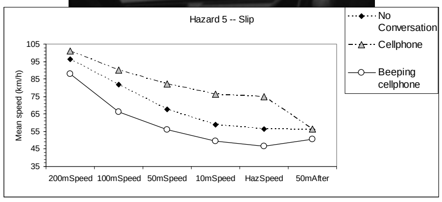

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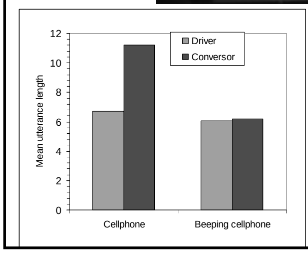

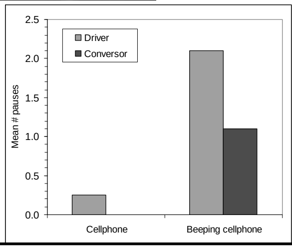

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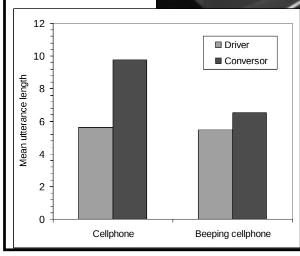

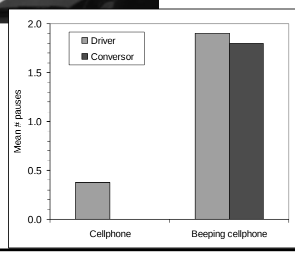

Laboratory 1 Results