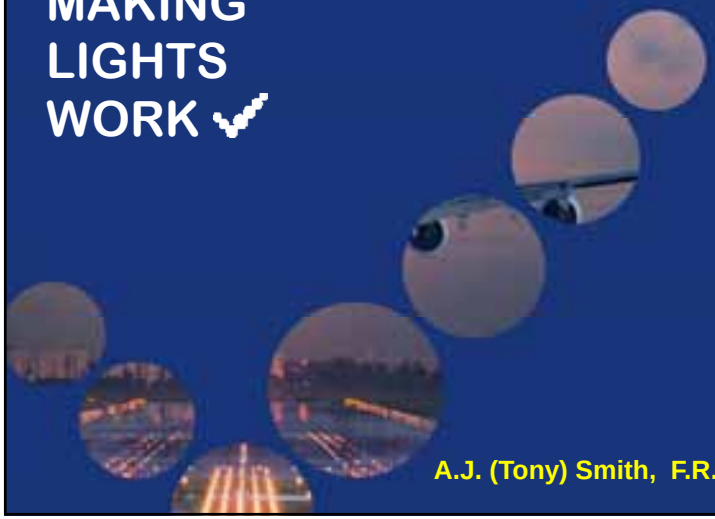
MAKING LIGHTS WORK



A.J. (Tony) Smith, F.R.Ae.S

MAKING LIGHTS WORK

Why have we got what we have got?
Are we sure that they are not over-specified?

Pilots must have the visual cues they need to operate their aircraft safely and efficiently at airports.
To make this happen it is necessary to;

- identify the worst-case operational specifications.
- meet the specifications with well-designed equipment.
- and maintain the specified performance at all times.

THE FUNDAMENTALS OF VISUAL AIDS

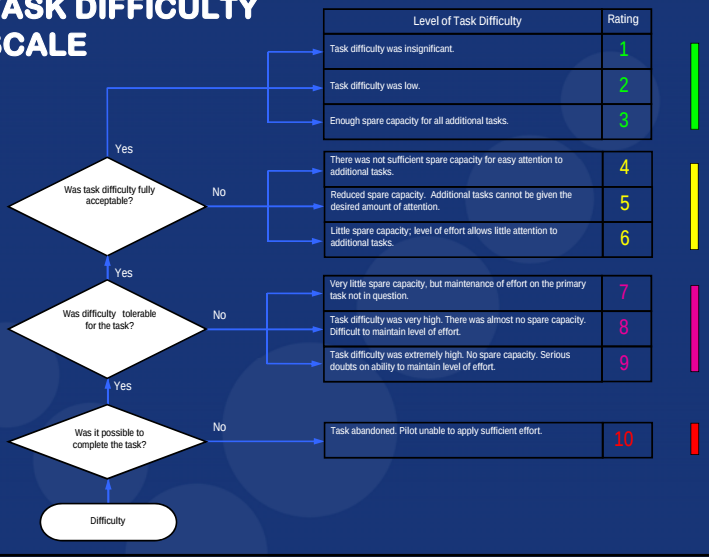
- The role of visual aids is to support the attainment of high levels of safety and regularity.
- Visual aids should augment or replace other information (the visual scene; non-visual)
- Using visual aids should require no special training. The signal should be instinctive.
- The information should be conspicuous, legible, comprehensible and credible.

THE DEVELOPMENT OF VISUAL AIDS

Any proposed new visual aid should;

- Meet a specified requirement by providing a new capability or improving what exists.
- Be developed by a team of researchers, engineers and pilots using studies, simulation, flight test.
- Be designed for the worst-case operational environment; be easy to maintain at full output.
- Be shown to be fit for purpose using quantitative data derived from instrumentation records or rating scales (beware of pilot opinion alone!)

TASK DIFFICULTY SCALE



Level of Task Difficulty	Rating
Task difficulty was insignificant.	1
Task difficulty was low.	2
Enough spare capacity for all additional tasks.	3
There was not sufficient spare capacity for easy attention to additional tasks.	4
Reduced spare capacity. Additional tasks cannot be given the desired amount of attention.	5
Little spare capacity; level of effort allows little attention to additional tasks.	6
Very little spare capacity, but maintenance of effort on the primary task not in question.	7
Task difficulty was very high. There was almost no spare capacity. Difficult to maintain level of effort.	8
Task difficulty was extremely high. No spare capacity. Serious doubts on ability to maintain level of effort.	9
Task abandoned. Pilot unable to apply sufficient effort.	10

APPROACH AND RUNWAY LIGHTING

- By the 1970's patterns of lights for use in low visibility had been adopted by ICAO.
- Operational experience showed that the light units then in use provided adequate visual cues when the visibility was at least 0.5 mile (Category 1 Precision Approach).
- However, the programme to progressively develop Precision Approach procedures to very low Decision Heights/ RVR (Cat 2/3) encountered problems, including issues related to a lack of adequate visual cues.

WHAT WERE THESE PROBLEMS?

- During early Category 2 and 3 operations pilots saw a much smaller segment of the approach and runway lighting, closer to the ground and for a significantly shorter time than is the case for Category 1 operations.
- Pilots reported incidents where all visual references were lost below the Decision Height.
- Flight data revealed an unacceptable level of overshoots and there were fatalities.

WHAT CAUSED THESE PROBLEMS?

- Initially it was assumed that the loss of visual references was due to characteristics of the fog. Subsequently it was shown that this was not the cause (except when there was a shallow, dense fog near the ground).
- Research identified two serious lighting deficiencies that caused the problems.
- These were; inadequate vertical beam-spread and poor maintenance.

FLYING FOG TRIALS #1

FLYING FOG TRIALS #2

FLYING FOG TRIALS #3

RESOLVING THE BEAM-SPREAD PROBLEM

- The ICAO Visual Aids Panel developed new beam-spread specifications. The vertical coverage of the approach and runway lights was increased by 3 degrees. This ensured that once acquired, visual cues should not be lost.
- Subsequent flight evaluations, using new, clean fittings showed that the new design overcame the problems; enhancing safety and regularity to the target levels.

RESOLVING THE MAINTENANCE PROBLEM

- In the UK the CAA, recognising the importance of maintenance, sponsored research to develop a mobile light performance monitoring system for runway (and taxiway) lighting.
- It was clearly demonstrated that, using such a system to check beam characteristics and setting angles, lighting can be maintained to the legally required levels specified by ICAO.

WHY MONITOR AND MAINTAIN?

- Lighting aids are part of a total system. All other system components (ILS, auto-pilot) are continuously monitored and maintained The same obligation exists for the lighting.
- Apart from safety, there are other benefits;
- Regular monitoring and remedial action actually reduces overall maintenance costs.
- Higher RVR values can be achieved.
- The number of lights can be reduced.

GOOD MAINTENANCE SAFE LIGHTING ✓

BAD MAINTENANCE UNSAFE LIGHTING ✗

DEVELOPING PAPI

(A FIT-FOR-PURPOSE GLIDE-SLOPE INDICATOR)

- I invented PAPI in 1975 as a tool for the evaluation of city-centre STOL operations.
- The VASI, then the standard visual aid had known deficiencies; variable signal colour and insufficient sensitivity to rapid height changes caused by wind-shear.
- Extensive trials demonstrated that the PAPI concept overcame these problems.

WHY PAPI REPLACED VASI

PAPI. A SAFE DESIGN

- Early trials had demonstrated that PAPI safely met the operational requirements.
- But, PAPI needed to be a “fail soft” aid.
- Loss of one lamp merely reduces intensity.
- Loss of one unit degrades information but is obvious. The aid is still useable.
- Accuracy can be ensured provided that an inclinometer can check the position of the optics. Aligning the box is not acceptable.

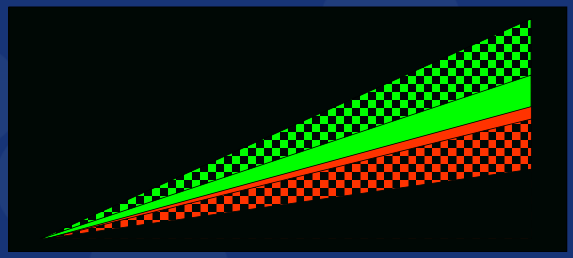
DEVELOPING HAPI

- Helicopters frequently operate at small pads where it is impractical to install PAPI.
- Traditional 3-colour sector lights can produce “false yellow” fly-down signals.
- Extensive flight trials in UK evaluated a number of signal format parameters - sector size, colour, steady, flash (rate, on/off ratio)
- Chosen format (HAPI) “fails soft” by using only 2 colours and one flash rate to provide 4 sectors. Colours are used in natural sense.

HELICOPTER APPROACH PATH INDICATOR

- Uses normal signal colour convention
- No yellow signal, (so, no false signal)
- Signal format takes account of human factors issues (colour and flash)

Too high (2hz)
Glide-slope (steady)
Slightly low (steady)
Too low (2hz)



WELL-DESIGNED SIGNAGE ADDS SAFETY

- Any lack of "situational awareness" makes ground movements difficult and dangerous.
- Effective signage is important for safety and regularity. To taxi at an unfamiliar airport can be a stressful activity!
- The adoption by ICAO of agreed standards for signage was a significant step in enhancing the safety of ground movements.
- As with other visual aids, good maintenance to sustain performance is important.

THE ICAO SIGNAGE SYSTEM IS...

- Conspicuous; by the choice of specified luminance and colour.
- Legible; by the choice of font, letter size and luminance ratios.
- Comprehensible; by letter layout, based on human-factors testing.
- Credible; by providing information that harmonises with data from other sources such as charts and ATC instructions.

TAXIWAY LIGHTS AND STOP BARS

- The intensity, beam-spread and spacing of high intensity centre-line lights were carefully chosen to enable pilots to taxi safely in all conditions. Pilots are alerted to the proximity of a bend by reduced spacing.
- Well maintained, switched taxiway lights together with stop bars can provide both guidance and control.
- Stop bars, traffic lights and signs form a "ring of red" around an active runway.

MY WISH LIST FOR THE FUTURE

- Redesign approach and runway lighting to reflect 21st century requirements, using new technology and reduce environment impact.
- Remove human factor anomalies; (1) replace red runway centreline lights with yellow, using LED, (2) make Holding Position signs addressable so that only the relevant sign is legible (and increase conspicuity by flash).
- Ensure that any new aid meets a real need; that it is conspicuous, legible, credible and comprehensible and can be fully maintained.

FINALLY...

- Regularity is expected, safety is demanded.
- Remember, visual aids were designed as an integral part of a safe operational system.
- Aircraft systems and the ILS are monitored and maintained to the specified standards.
- Visual aids are not over-specified. They are the right standard to maintain safety levels.
- Research, design, maintenance, regulation... safety is our collective responsibility…