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## Display Illumination

### From Concept to Volume Production

**SID Meeting, Knebworth House, 1 April 2004**

**Mike Hanney CEng, MInstP, MSc  
Technical Director**

# Overview



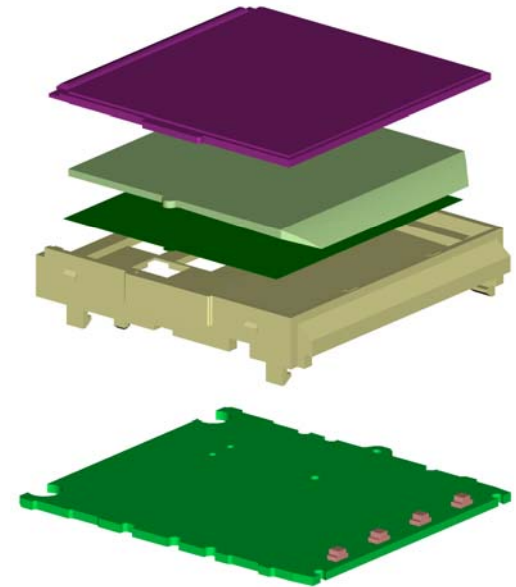
- **Product Development Process**
  - Design Process
  - Prototype tooling and test
  - Multi-cavity tooling
  - Production volume ramp-up and support
- **Product Examples - Volume and Size Scalability**

# Design Process - Specification

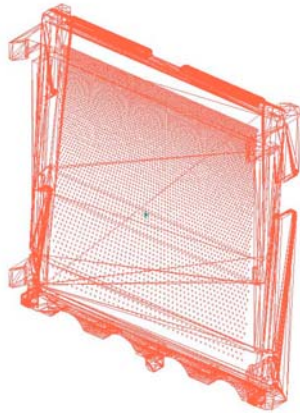


## Typical Inputs Required from Customer:

- Initial CAD models for the complete assembly (lightguide, lightbox, PCB, LCD, LED's, housings)
- Light source specifications? (type, supplier spec. sheet, placement tolerances, drive current)
- LCD specification? (transmission %, active area, viewing area)
- Illumination expectations? (Brightness, uniformity)
- What is the final product application? (viewing angles)



# LCD Illumination Design

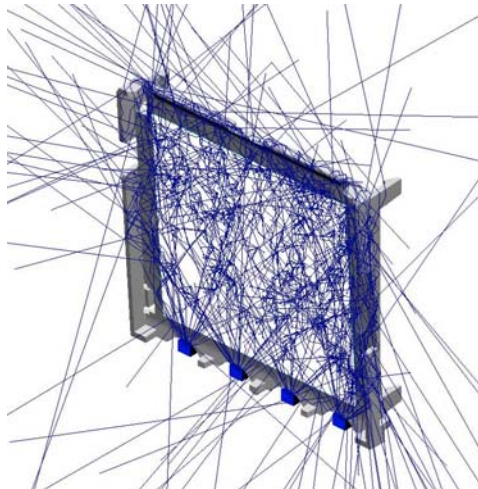


3D CAD models are transferred directly to 3D raytracing environments

LED simulation models are assembled

Material and surface finish scatter parameters are defined

Light control texture pattern area constructed

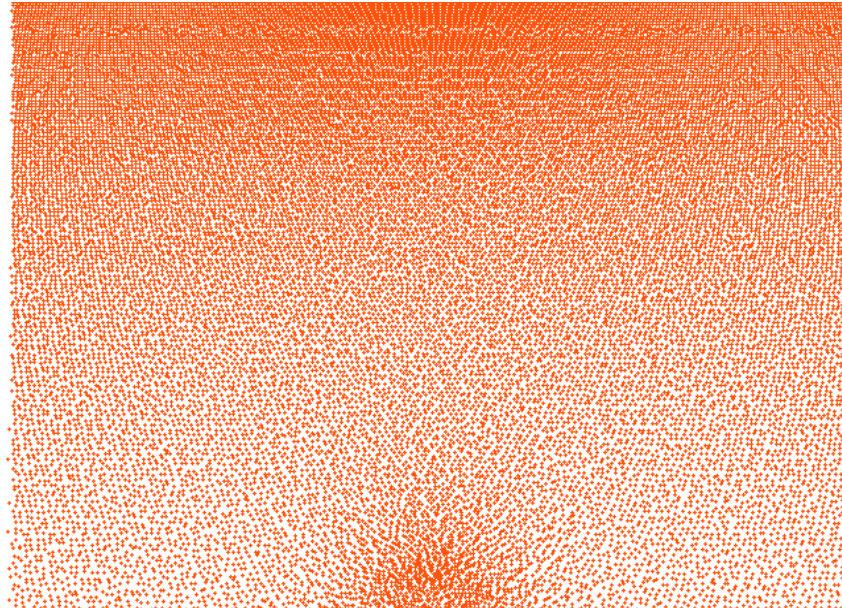
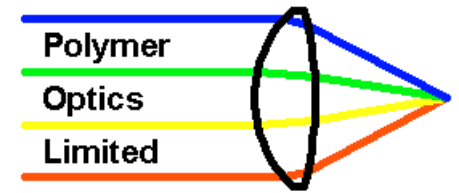


3D raytracing analyses launch between 2 and 10 million rays.

Radiometric target surfaces collect illumination performance data.

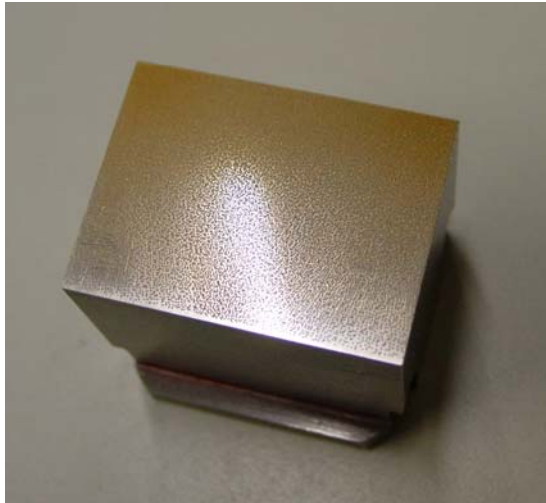
“Real-world” performance simulation

# LCD Illumination Design

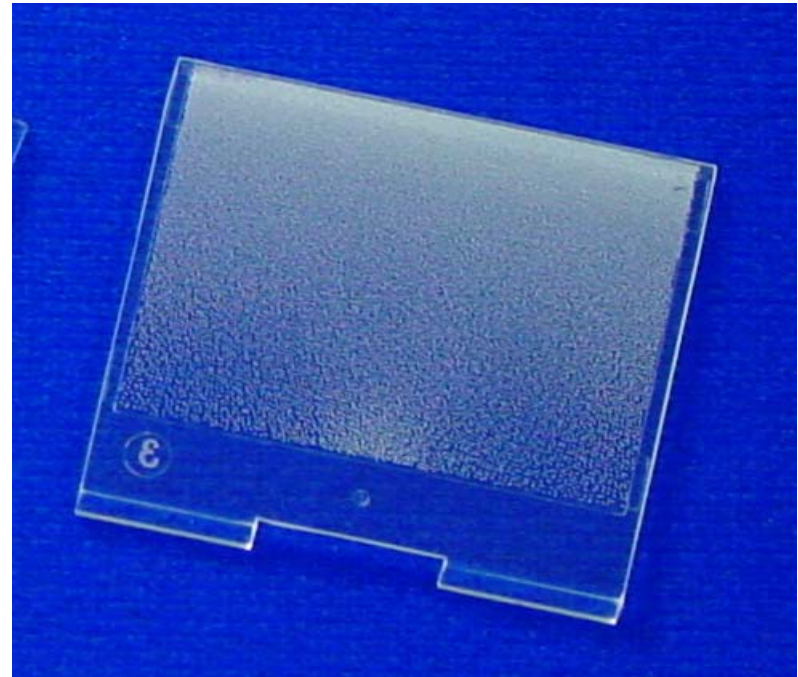


A typical dot pattern on a 35mm x 30mm display area has >40K dots

# Prototype Tooling and Test

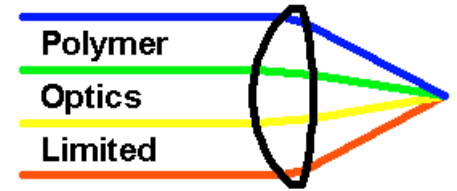


Laser patterned steel insert for prototype tool

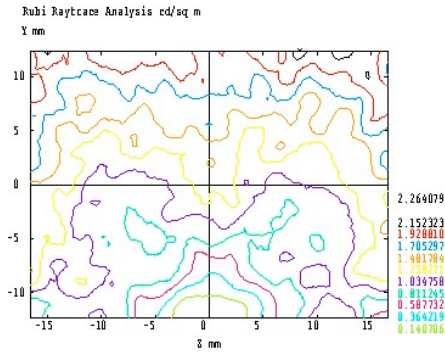


Injection moulded lightguide component with dot pattern replicated in it

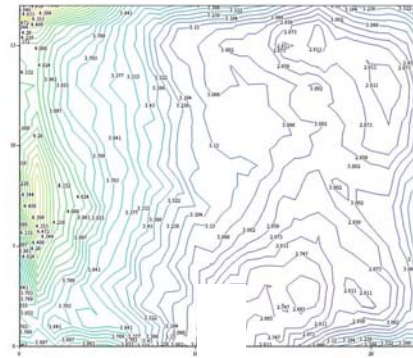
# Prototype Tooling and Test



### Analysis



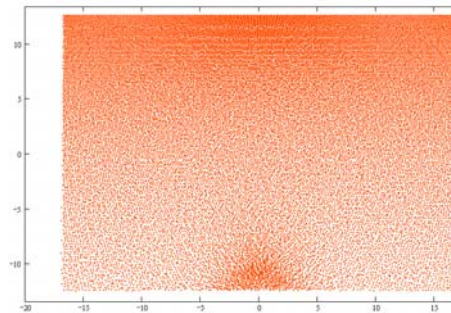
### Measurement



Closed-loop design  
and performance optimisation



### Optimised Display



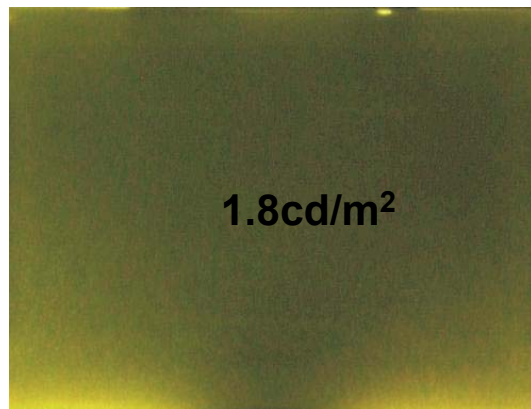
### Pattern Iteration

# Prototype Tooling and Test

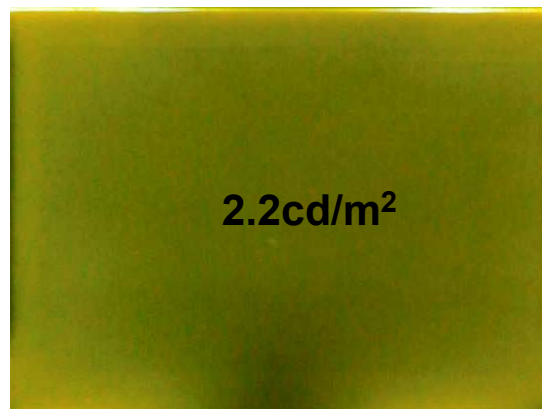


Iterative steps which improve evenness and overall efficiency

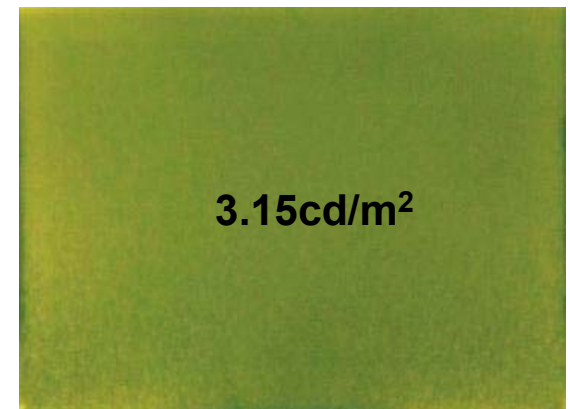
The dot pattern is modified at each iteration step to provide improved efficiency and evenness



1<sup>st</sup> Iteration:  
Linear Dot Pattern



2<sup>nd</sup> Iteration:  
2D Complex Dot Pattern



3<sup>rd</sup> Iteration:  
2D Complex Dot Pattern

# Multi-cavity Production Tooling



- POL concurrently designed with US based design teams
- Production tool made in Malaysia
- Laser etched inserts shipped from POL to Malaysia
- Test results and product samples supplied back to POL for fine tuning of the light control pattern.
- Set of 8 inserts (4 cavity tool + spares) supplied for production tool



Final volume produced satellite radio product



Laser patterned tool insert

# Multi-cavity Production Tooling



seno S230 shown in Charcoal



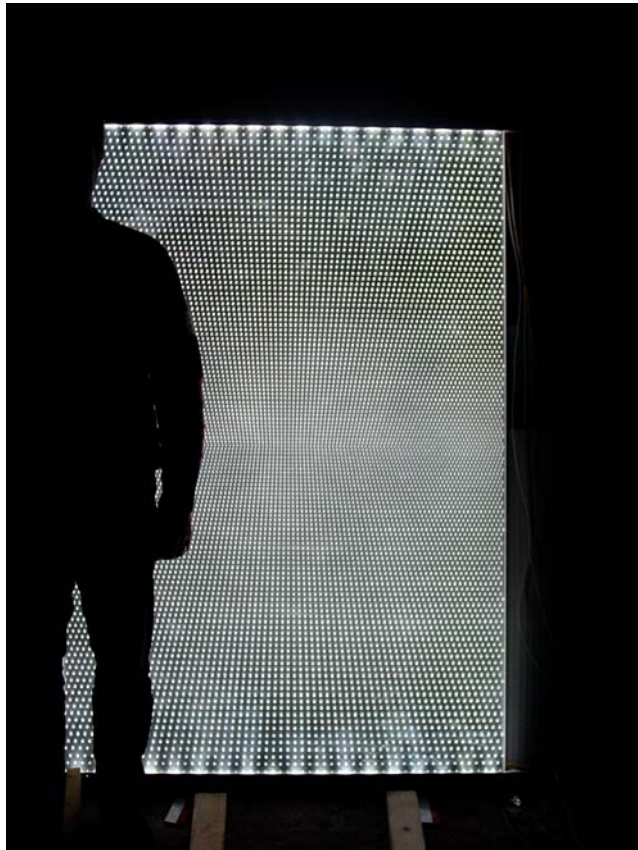
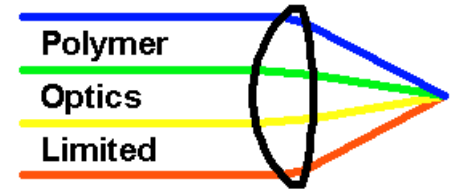
seno S200 shown in Pepper.

seno

- Lightguide design first made in Dec 2000 and developed on a single cavity tool.
- 8 cavity production tool made with POL laser etched inserts
- To Jan 2004 estimated 7 million lightguides produced from same tool.
- Feb 2004 new 8 cavity tool made in Singapore
- POL supplied further set of 8 laser etched inserts + 4 spares to support the new production tool.



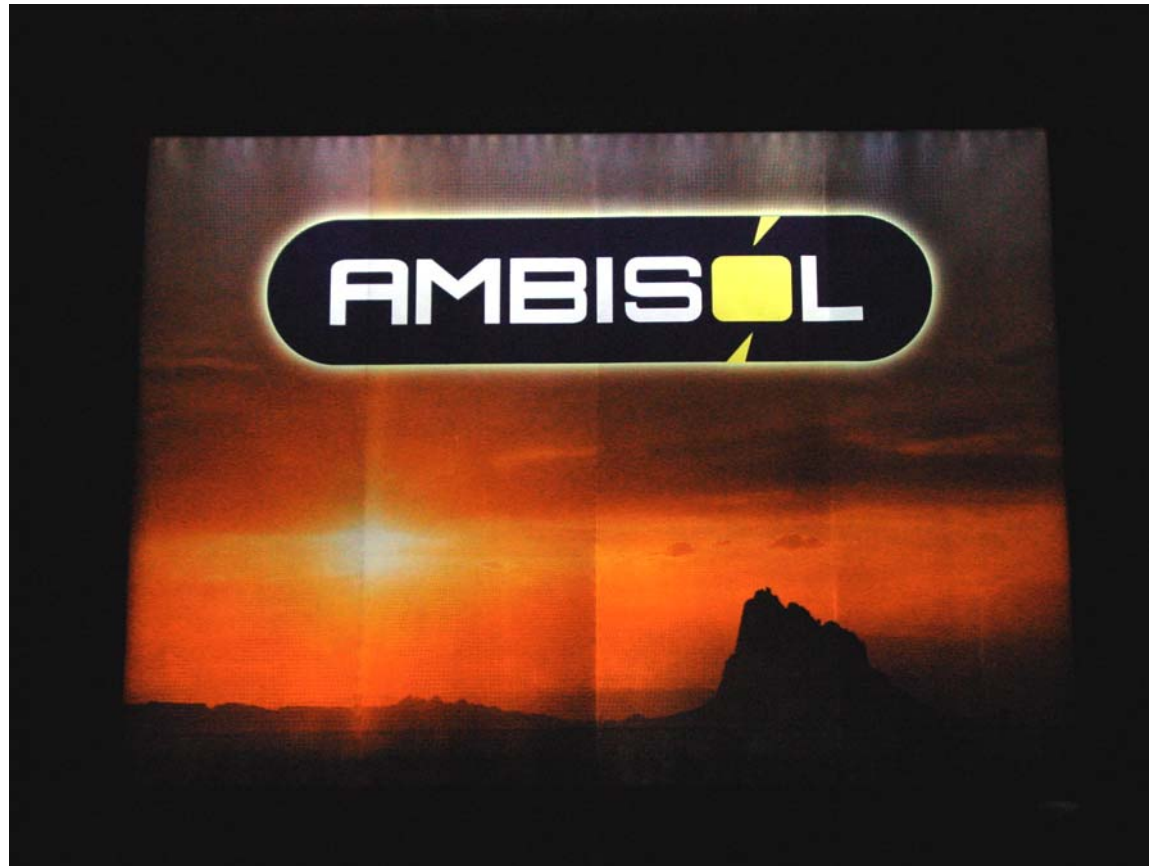
# Product Scalability



1800mm x 1200mm lightguide  
Directly machined pattern of 24000 dots



# Product Scalability



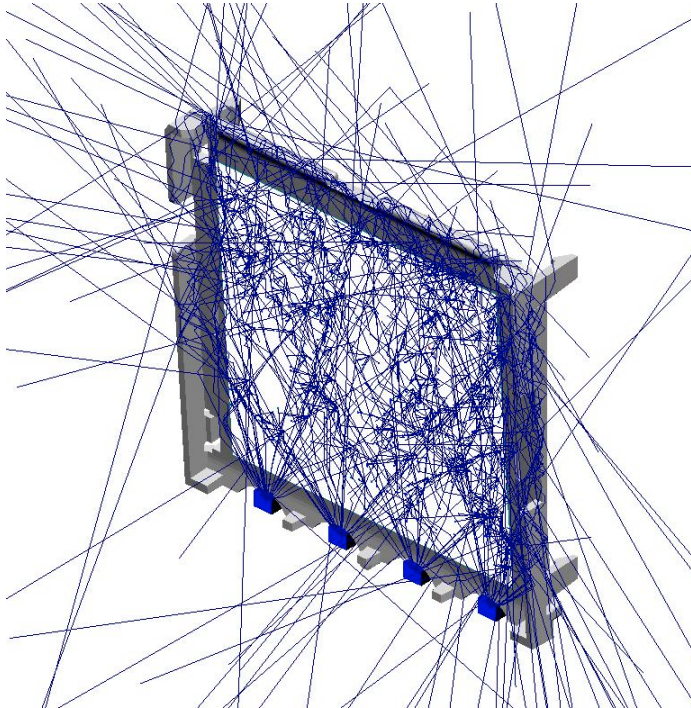
4m x 3m lightguide - 4 panels of 3m x 1m using directly machined dot patterns

# Summary



- Over many years, POL have continued to develop advanced optical design and analysis techniques for display illumination
- Laser machining can be used for initial prototype development tooling to multi-cavity production tooling
- POL have now developed direct machining techniques for plastics to produce larger lightguides in low volume
- Product sizes can now be developed from millimeters to meters
- Processes can be scaled in production volume from 1 to infinity

## From Concept to Volume Production



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