RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

Refining the Effective Intensity Model for Use in Marine Visual Signals

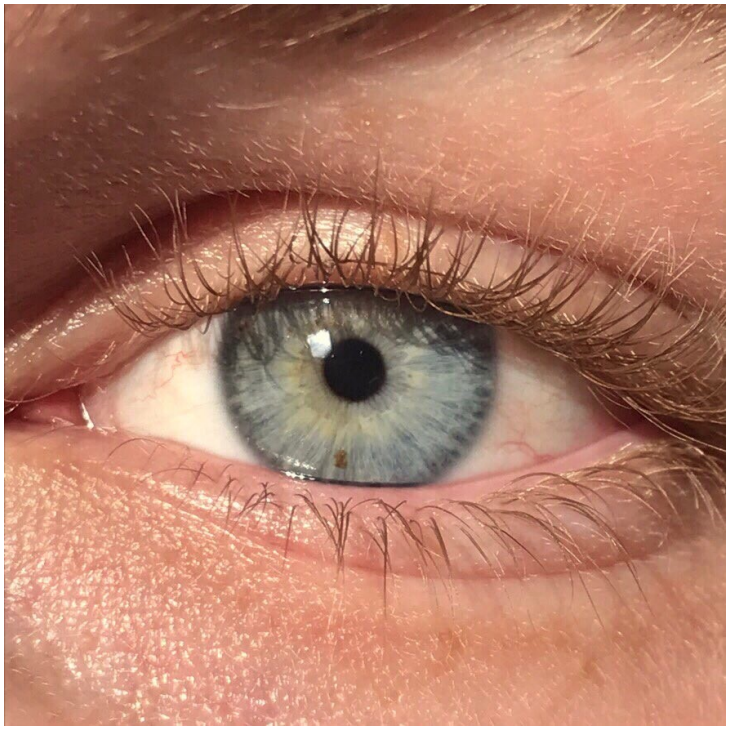
Dr. Alwyn I. Williams

9th October 2017

Effective Intensity for Marine Visual Signalling

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

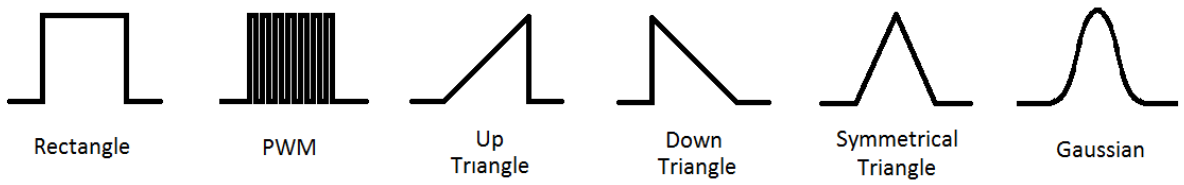
- Effective intensity models developed for signals at threshold of detection
- Higher illuminance threshold for marine visual signalling
  - 0.2 µlux at night
  - Robust detection and identification
- Apparent intensity is used to describe the “effective intensity” at the higher threshold of illuminance



Conspicuity of flashing lights

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

- Need to further understand how well flashing visual signals can be detected and identified by mariners
- R&RNAV have reviewed the methods of calculating **effective intensity** used to date:
  - Blondel-Rey
  - Schmidt-Clausen (Form Factor)
  - Modified Allard Method
- Difficulties with complex flash shapes



Modified Allard Method

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

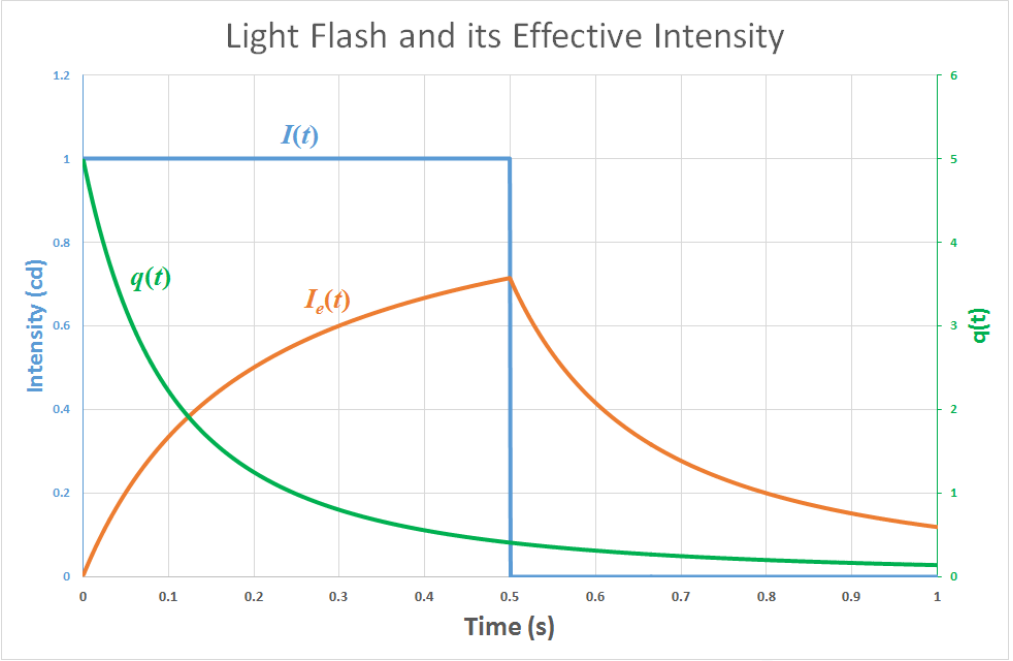
- Uses convolution method

$$I_e(t) = I(t) \otimes q(t)$$

where $q(t) = {}^{a}/_{(a+t)^2}$

and a = 0.2 s

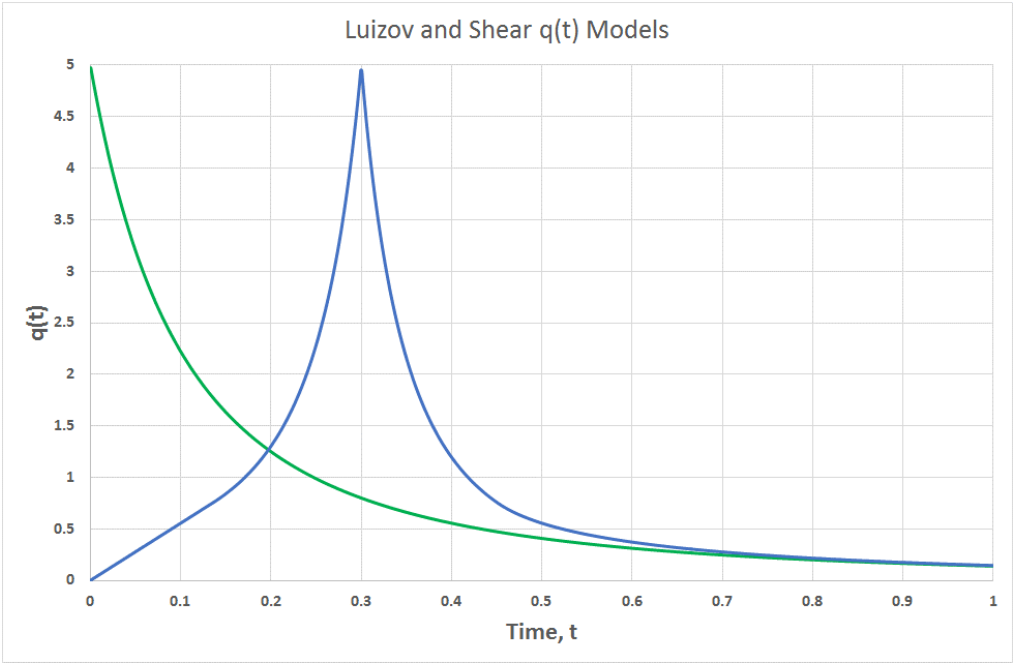
- Maximum value of $I_e(t)$ is the effective intensity



Modifying Modified Allard Method: Shear MAM

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

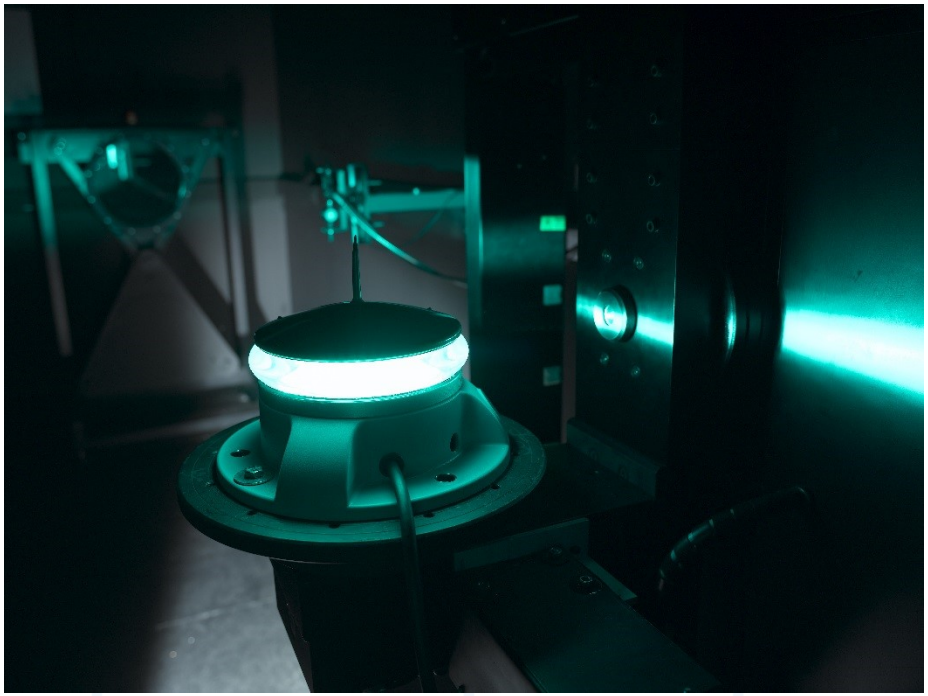
- Modified Allard Method uses the Luizov convolution function, $q(t)$
- Couzin suggests that sheared $q(t)$ better represents the human response
- Good match with initial observations with peak at 0.3 s



The Three Experiments

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

- Threshold in Darkroom
  - Effective intensity at illumination threshold
- Supra-Threshold in Darkroom
  - Apparent intensity with signal illuminance of 0,2 µlux
- Supra-Threshold in Light Range
  - Comparison of flashes at signal illuminance of 0,3 µlux to 1,5 µlux



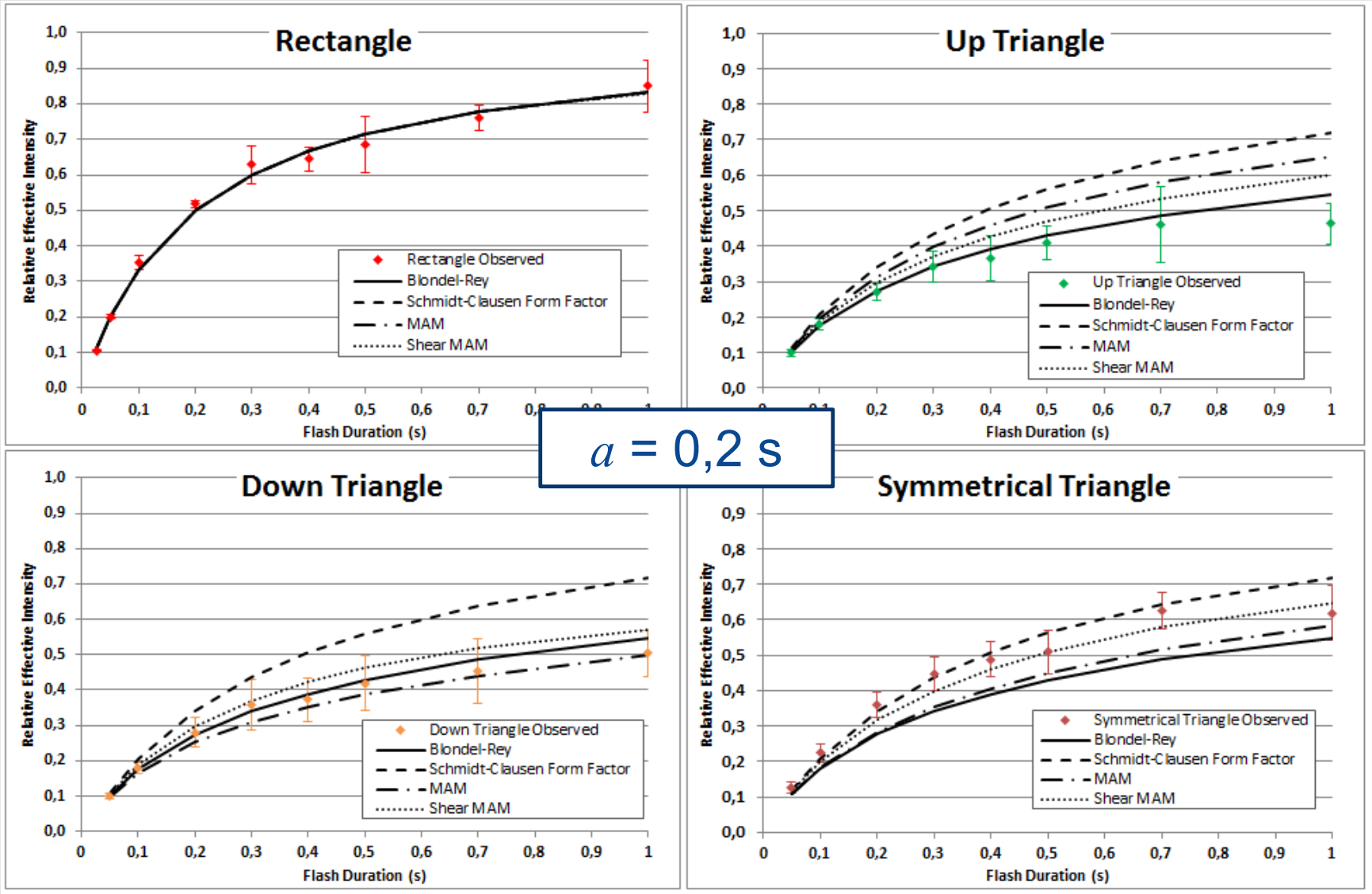
Threshold Darkroom Experiment

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

- Dark-adapted observer
- Measured the observer's illuminance threshold
  - Steady white light
- Views flashing white light at threshold of detection
- Observers adjust the flash intensity until it can only just been seen
- Intensity compared with steady light

Threshold Darkroom - Results

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland



Threshold Darkroom - Results

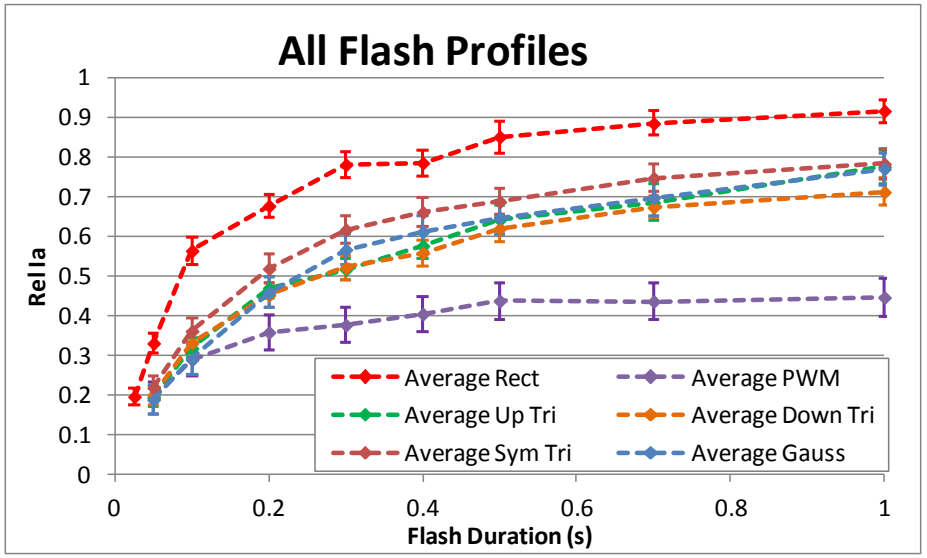
RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

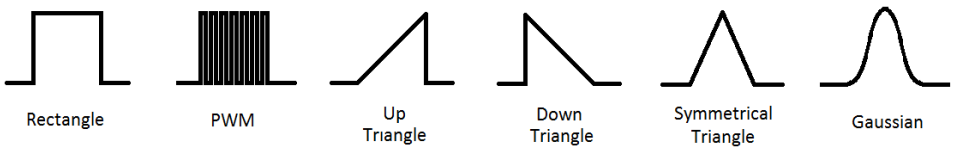
Flash Profile	Blondel-Rey	Schmidt-Clausen	Modified Allard Method	Shear MAM
Rectangular	0,0 %	0,0 %	0,0 %	-0,1 %
Up Triangle	+5,1 %	+31,6 %	+21,4 %	+13,7 %
Down Triangle	+1,7 %	+27,4 %	-6,7 %	+8,7 %
Symmetrical Triangle	-18,8 %	+1,4 %	-15,8 %	-6,5 %
Max All Profiles	**+5,1 %**	**+31,6 %**	**+21,4 %**	**+13,7 %**
Min All Profiles	**-18,8 %**	**0,0 %**	**-15,8 %**	**-6,5 %**
Spread	**23,9 %**	**31,6 %**	**37,2 %**	**20,2 %**

Supra-Threshold Darkroom Experiment

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

- Understand the apparent intensity based on flash shape.
- Perceived flash intensity relative to fixed intensity light
- Rectangular most effective for a given flash length
- Up and Down Triangle has almost no difference





Comparison of methods against observations

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

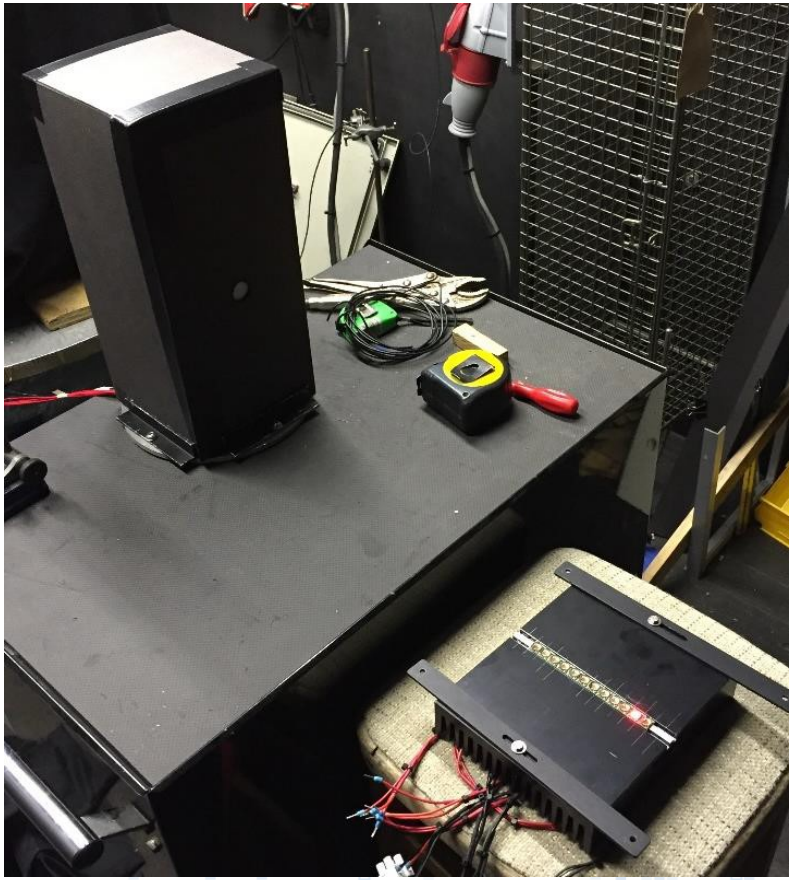
Flash Profile	Blondel-Rey	Schmidt-Clausen (Form Factor)	Modified Allard Method (Luizov)	Shear MAM
Rectangle	-1,9%	-1,9%	-1,9%	-1,6%
PWM	-3,6%	+31,5%	-1,9%	-4,4%
Up Triangle	-15,0%	+9,8%	+1,9%	-5,8%
Down Triangle	-13,8%	+10,8%	-24,4%	-5,3%
Symmetrical Triangle	-26,3%	+0,8%	-20,3%	-7,6%
Gaussian	-23,6%	-0,4%	-17,7%	-6,3%
Max All Profiles	-1,9%	+31,5%	+1,9%	-1,6%
Min All Profiles	-26,3%	-1,9%	-24,4%	-7,6%
Spread	24,4%	33,4%	26,3%	6.0%

a = 0,1 s

Supra-Threshold Light Range Experiments

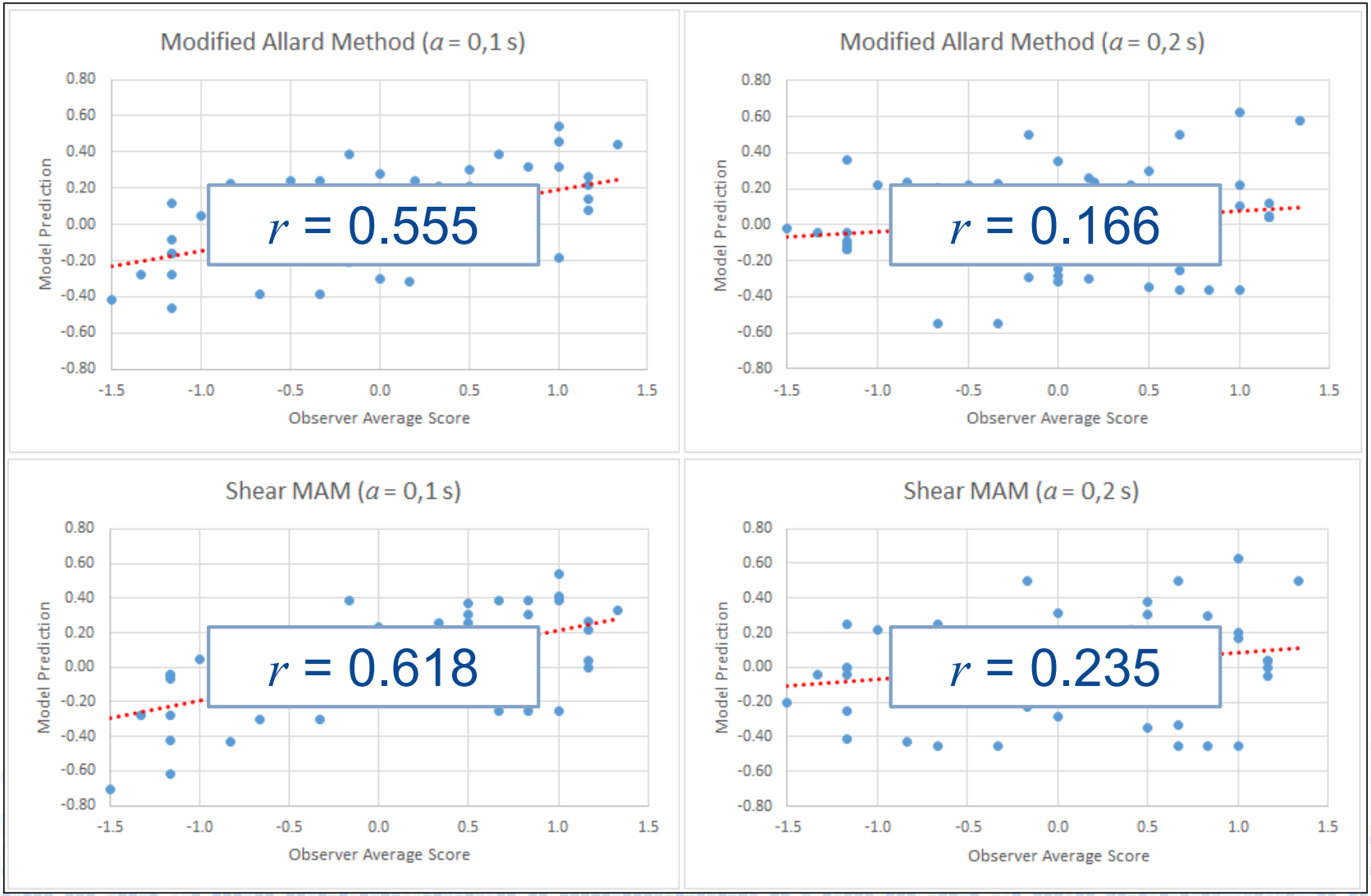
RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

- Further understanding of apparent intensity
- Different approach
  - Group of simultaneous observers
  - 64 m observation distance
  - Comparison of two flashes
    - Different shapes and intensity
  - Rerun with different combinations
- Compare observed differences with modelled differences



Comparison of MAM and Shear MAM with Observations

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland



Conclusions

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

- Apparent Intensity is different to Effective Intensity
- Models for Apparent intensity are more accurate when a = 0,1 s.
  - (With the exception of blue light, where a = 0,2 s)
- Modified Allard Method can be improved when dealing with complex flash shapes by using a Shear $q(t)$

RESEARCH & RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

Thank you

Alwyn Williams

alwyn.williams@gla-rrnav.org

Office: +44 (0) 1255 245134

Mobile: +44 (0) 7739 191253

Ian Tutt

Ian.tutt@lineone.net